

UNIT 3

TIMELINE

Heredity, Evolution, and Classification

The differences and similarities between living things are the subject of this unit. You will learn how characteristics are passed from one generation to another, how living things are classified based on their characteristics, and how these characteristics help living things survive.

Scientists have not always understood these topics, and there is still much to be learned. This timeline will give you an idea of some things that have been learned so far.



1753

Carolus Linnaeus publishes the first of two volumes containing the classification of all known species.



1905

Nettie Stevens describes how human gender is determined by the X and Y chromosomes.

1930

The planet Pluto is discovered.



1969

Apollo 11 lands on the moon. Neil Armstrong becomes the first person to walk on the lunar surface.

1859

Charles Darwin suggests that natural selection is a mechanism of evolution.



1860

Abraham Lincoln is elected the 16th president of the United States.

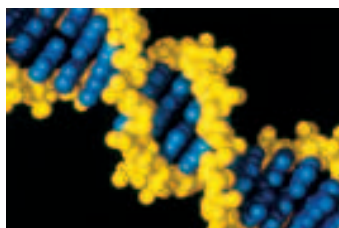


1865

Gregor Mendel publishes the results of his studies of genetic inheritance in pea plants.

1951

Rosalind Franklin photographs DNA.



1953

James Watson and Francis Crick figure out the structure of DNA.

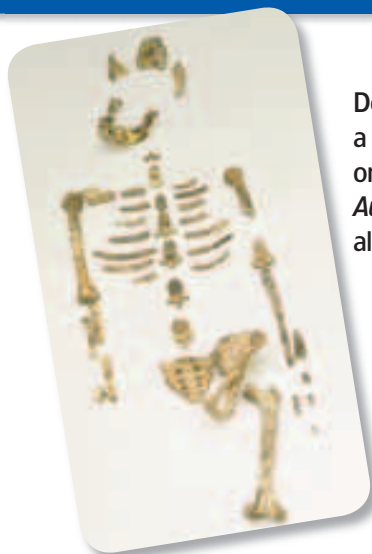


1960

Mary and Jonathan Leakey discover fossil bones of the human ancestor *Homo habilis* in Olduvai Gorge, Tanzania.

1974

Donald Johanson discovers a fossilized skeleton of one of the first hominids, *Australopithecus afarensis*, also called "Lucy."



1990

Ashanti DeSilva's white blood cells are genetically engineered to treat her immune deficiency disease.



2003

The Human Genome Project is completed. Scientists spent 13 years mapping out the 3 billion DNA subunits of chromosomes.

Heredity

Chapter Planning Guide

Compression guide:
To shorten instruction
because of time limitations,
omit the Chapter Lab.

OBJECTIVES	LABS, DEMONSTRATIONS, AND ACTIVITIES	TECHNOLOGY RESOURCES
PACING • 90 min pp. 112–119 Chapter Opener	SE Start-up Activity, p. 113 GENERAL	OSP Parent Letter ■ CD Student Edition on CD-ROM CD Guided Reading Audio CD ■ TR Chapter Starter Transparency* VID Brain Food Video Quiz
Section 1 Mendel and His Peas <ul style="list-style-type: none"> Explain the relationship between traits and heredity. Describe the experiments of Gregor Mendel. Explain the difference between dominant and recessive traits. 	TE Activity Trait Trends, p. 114 GENERAL SE School-to-Home Activity Describing Traits, p. 115 GENERAL TE Demonstration Flower Dissection, p. 116 BASIC TE Activity Mendelian Crosses, p. 116 ADVANCED SE Science in Action Math, Science, and Social Studies Activities, pp. 140–141 GENERAL	OSP Lesson Plans (also in print) TR Bellringer Transparency* CRF SciLinks Activity* GENERAL CD Science Tutor
PACING • 90 min pp. 120–125 Section 2 Traits and Inheritance <ul style="list-style-type: none"> Explain how genes and alleles are related to genotype and phenotype. Use the information in a Punnett square. Explain how probability can be used to predict possible genotypes in offspring. Describe three exceptions to Mendel's observations. 	TE Demonstration Ratios, p. 120 BASIC SE Quick Lab Making a Punnett Square, p. 121 GENERAL CRF Datasheet for Quick Lab* SE Quick Lab Taking Your Chances, p. 122 GENERAL CRF Datasheet for Quick Lab* TE Connection Activity Math, p. 122 ADVANCED SE Connection to Chemistry Round and Wrinkled, p. 123 GENERAL SE Model-Making Lab Bug Builders, Inc., p. 134 GENERAL CRF Datasheet for Chapter Lab*	OSP Lesson Plans (also in print) TR Bellringer Transparency* TR L13 Punnett Squares TR LINK TO PHYSICAL SCIENCE P109 The Periodic Table of the Elements* VID Lab Videos for Life Science CD Science Tutor
PACING • 45 min pp. 126–133 Section 3 Meiosis <ul style="list-style-type: none"> Explain the difference between mitosis and meiosis. Describe how chromosomes determine sex. Explain why sex-linked disorders occur in one sex more often than in the other. Interpret a pedigree. 	TE Activity Crosses, p. 126 GENERAL TE Connection Activity Math, p. 126 ADVANCED TE Activity Describing Meiosis, p. 129 BASIC TE Connection Activity Math, p. 129 GENERAL TE Group Activity Comparing Mitosis and Meiosis, p. 130 GENERAL TE Connection Activity Language Arts, p. 131 GENERAL SE Inquiry Lab Tracing Traits, p. 767 GENERAL CRF Datasheet for LabBook* LB Long-Term Projects & Research Ideas Portrait of a Dog* ADVANCED	OSP Lesson Plans (also in print) TR Bellringer Transparency* TR L14 The Steps of Meiosis: A* TR L15 The Steps of Meiosis: B* TR L16 Meiosis and Dominance* SE Internet Activity, p. 130 GENERAL TE Internet Activity, p. 133 GENERAL CD Science Tutor

PACING • 90 min

CHAPTER REVIEW, ASSESSMENT, AND STANDARDIZED TEST PREPARATION

- CRF** Vocabulary Activity* **GENERAL**
SE Chapter Review, pp. 136–137 **GENERAL**
CRF Chapter Review* ■ **GENERAL**
CRF Chapter Tests A* ■ **GENERAL**, B* **ADVANCED**, C* **SPECIAL NEEDS**
SE Standardized Test Preparation, pp. 138–139 **GENERAL**
CRF Standardized Test Preparation* **GENERAL**
CRF Performance-Based Assessment* **GENERAL**
OSP Test Generator, Test Item Listing

Online and Technology Resources



Holt
Online
Learning



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- Holt Calendar Planner
- Customizable Lesson Plans
- Printable Worksheets
- ExamView® Test Generator
- Interactive Teacher's Edition
- Holt PuzzlePro®
- Holt PowerPoint® Resources

KEY

SE Student Edition
TE Teacher Edition

CRF Chapter Resource File
OSP One-Stop Planner
LB Lab Bank
TR Transparencies

SS Science Skills Worksheets
MS Math Skills for Science Worksheets
CD CD or CD-ROM
VID Classroom Video/DVD

IT Interactive Textbook
* Also on One-Stop Planner
◆ Requires advance prep
■ Also available in Spanish

SKILLS DEVELOPMENT RESOURCES	SECTION REVIEW AND ASSESSMENT	CORRELATIONS
SE Pre-Reading Activity, p. 112 GENERAL OSP Science Puzzlers, Twisters & Teasers* GENERAL		National Science Education Standards UCP 2, 3; LS 1d, 2c
CRF Directed Reading A* BASIC , B* SPECIAL NEEDS IT Interactive Textbook* Struggling Readers CRF Vocabulary and Section Summary* GENERAL SE Reading Strategy Brainstorming, p. 114 GENERAL TE Support for English Language Learners, p. 115 SE Math Practice Understanding Ratios, p. 118 GENERAL TE Reading Strategy Paired Reading, p. 115 BASIC TE Inclusion Strategies, p. 117 ◆ MS Math Skills for Science What Is a Ratio?* GENERAL SS Science Skills Finding Useful Sources* GENERAL	SE Reading Checks, pp. 114, 117, 118 GENERAL TE Reteaching, p. 118 BASIC TE Quiz, p. 118 GENERAL TE Alternative Assessment, p. 118 ADVANCED SE Section Review,* p. 119 GENERAL TE Homework, p. 119 GENERAL CRF Section Quiz* GENERAL	UCP 1, 2; SAI 1, 2; ST 2; SPSP 5; HNS 1, 2, 3; LS 2b, 2e
CRF Directed Reading A* BASIC , B* SPECIAL NEEDS IT Interactive Textbook* Struggling Readers CRF Vocabulary and Section Summary* GENERAL SE Reading Strategy Paired Summarizing, p. 120 GENERAL TE Support for English Language Learners, p. 122 SE Math Focus Probability, p. 123 GENERAL MS Math Skills for Science Punnett Square Popcorn* GENERAL CRF Reinforcement Worksheet Dimples and DNA* BASIC	SE Reading Checks, pp. 120, 122, 124 GENERAL TE Homework, p. 123 GENERAL TE Reteaching, p. 124 BASIC TE Quiz, p. 124 GENERAL TE Alternative Assessment, p. 125 GENERAL SE Section Review,* p. 125 GENERAL CRF Section Quiz* GENERAL	UCP 2, 3; LS 2a, 2b, 2c, 2d, 2e; Chapter Lab: SAI 1; HNS 2; LS 2c, 2e
CRF Directed Reading A* BASIC , B* SPECIAL NEEDS IT Interactive Textbook* Struggling Readers CRF Vocabulary and Section Summary* GENERAL SE Reading Strategy Reading Organizer, p. 126 GENERAL SE Connection to Language Arts Greek Roots, p. 127 GENERAL TE Reading Strategy Prediction Guide, p. 128 GENERAL TE Support for English Language Learners, p. 128 TE Inclusion Strategies, p. 130 CRF Critical Thinking A Bittersweet Solution* ADVANCED	SE Reading Checks, pp. 127, 128 GENERAL TE Reteaching, p. 132 BASIC TE Quiz, p. 132 GENERAL TE Alternative Assessment, p. 132 GENERAL TE Homework, p. 132 ADVANCED SE Section Review,* p. 133 GENERAL CRF Section Quiz* GENERAL	UCP 4, 5; SAI 1; SPSP 5; HNS 2, 3; LS 1c, 1d, 2a, 2b, 2c, 2d; LabBook: UCP 2; SAI 1; HNS 2; LS 2b, 2c, 2e



www.scilinks.org

Maintained by the **National Science Teachers Association**. See Chapter Enrichment pages that follow for a complete list of topics.



Check out **Current Science** articles and activities by visiting the HRW Web site at go.hrw.com. Just type in the keyword **HL5CS05T**.



Classroom Videos

- **Lab Videos** demonstrate the chapter lab.
- **Brain Food Video Quizzes** help students review the chapter material.



Classroom CD-ROMs

- **Guided Reading Audio CD** (Also in Spanish)
- **Interactive Explorations**
- **Virtual Investigations**
- **Visual Concepts**
- **Science Tutor**



Holt Lab Generator CD-ROM

Search for any lab by topic, standard, difficulty level, or time. Edit any lab to fit your needs, or create your own labs. Use the Lab Materials QuickList software to customize your lab materials list.

Visual Resources

CHAPTER STARTER
TRANSPARENCY

Heredity

CHAPTER STARTER

Would You Believe . . . ?

It all started in ancient China. A fisherman caught an unusual carp. Usually these small freshwater fish are dull colored, but this one had a pale golden hue. It was too pretty to eat, so the fisherman took the fish home as a pet.

Months later, the fisherman caught another gold-fang carp. He kept the two fish in the same bowl. When the fish reproduced, the offspring were even more brightly colored than their parents. The first goldfish had been kept in the years that followed, people throughout China began keeping and breeding the new, orange-colored pets. Many became goldfish, minkies, choosing only the most handsome males

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BELLINGER
TRANSPARENCIES

Heredity

BELLINGER TRANSPARENCY

Section: Mendel and His Peas

You have probably noticed that different people have different characteristics, such as eye color, hair color, or whether or not their ear lobes attach directly to their head or hang down loosely. These characteristics are called traits. Where do you think people get these different traits? How do you think they are passed from one generation to the next?

Write your answers in your science journal.

Section: Traits and Inheritance

If you flip a coin, what are the chances that it will land on heads? tails? Suppose that you flip the coin, get heads, and then flip again. What are the chances that you will get heads again? What are the chances you will get heads two times in a row? five times?

Record your answers in your science journal.

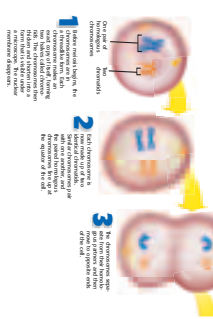
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TEACHING TRANSPARENCIES

Heredity

Steps of Meiosis: A

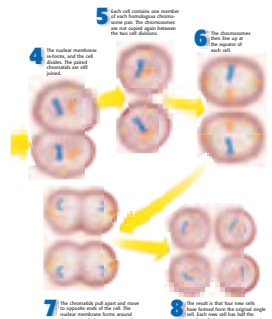
TEACHING TRANSPARENCY



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Steps of Meiosis: B

TEACHING TRANSPARENCY

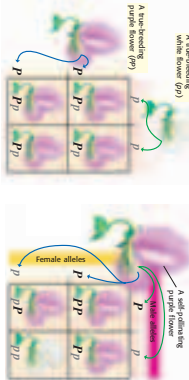


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TEACHING TRANSPARENCIES

Punnett Squares

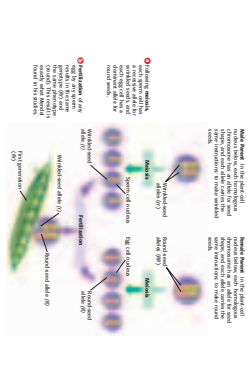
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Meiosis and Dominance

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The Periodic Table of the Elements

TEACHING TRANSPARENCY

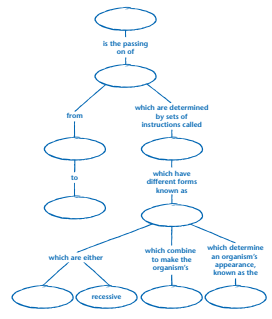
Chapter: The Periodic Table

CONCEPT MAPPING
TRANSPARENCY

Heredity

CONCEPT MAPPING TRANSPARENCY

Use the following terms to complete the concept map below: allele, parents, heredity, phenotype, genes, offspring, genotype, characteristics, dominant



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Planning Resources

LESSON PLANS

Lesson Plan

SAMPLE

Section: Waves

Pacing
Regular Schedule: with lab(2) days without lab(2) days
Block Schedule: with lab(1) 1/2 days without lab(1) 1/2 days

- Objectives**
1. Relate the seven properties of life to a living organism.
 2. Describe seven theories that can help you to organize what you learn about biology.
 3. Identify the tiny structures that make up all living organisms.
 4. Differentiate between reproduction and heredity and between metabolism and homeostasis.

National Science Education Standards Covered

- 1.Bioscience:** Cells have particular structures that underlie their functions.
1.B.1: Most cell functions involve chemical reactions.
1.B.2: Cells store and use information to guide their functions.
1.B.3: Cell functions are regulated.
1.B.4: Cells can differentiate and form complete multicellular organisms.
1.B.5: Species evolve over time.
1.B.6: The great diversity of organisms is the result of more than 3.5 billion years of evolution.
1.B.7: Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms as well as for the striking molecular similarities observed among the diverse species of living organisms.
1.B.8: The millions of different species of plants, animals, and microorganisms that live on Earth today are related by descent from common ancestors.
1.B.9: The energy for life primarily comes from the sun.
1.B.10: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.11: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.12: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.13: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.14: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.15: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.16: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.17: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.18: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.19: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
1.B.20: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

PARENT LETTER

SAMPLE

Dear Parent,

Your son's or daughter's science class will soon begin exploring the chapter entitled "The World of Physical Science." In this chapter, students will learn about how the scientific method applies to the world of physical science and the role of physical science in the world. By the end of the chapter, students should demonstrate a clear understanding of the chapter's main ideas and be able to discuss the following topics:

1. physical science as the study of energy and matter (Section 1)
2. the role of physical science in the world around them (Section 1)
3. careers that rely on physical science (Section 1)
4. the steps used in the scientific method (Section 2)
5. examples of technology (Section 2)
6. how the scientific method is used to answer questions and solve problems (Section 2)
7. how our knowledge of science changes over time (Section 2)
8. how models represent real objects or systems (Section 3)
9. examples of different ways models are used in science (Section 3)
10. the importance of the International System of Units (Section 4)
11. the appropriate units to use for particular measurements (Section 4)
12. how area and density are derived quantities (Section 4)

Questions to Ask Along the Way

You can help your son or daughter learn about these topics by asking interesting questions such as the following:

- What are some surprising careers that use physical science?
- What is a characteristic of a good hypothesis?
- When is a good idea to use a model?
- Why do Americans measure things in terms of inches and yards and meters?

ALSO IN SPANISH

TEST ITEM LISTING

The World of Science

SAMPLE

MULTIPLE CHOICE

1. A statement of a model is that
 - a. there are long enough to run.
 - b. they do not act exactly like the things that they model.
 - c. they are smaller than the things that they model.
 - d. they model certain things.
 Answer: d Objective: 1
2. The length 10 m is equal to
 - a. 100 cm.
 - b. 1,000 cm.
 - c. 10,000 cm.
 - d. 100,000 cm.
 Answer: b Objective: 2
3. To be valid, a hypothesis must be
 - a. testable.
 - b. supported by evidence.
 - c. made into a law.
 - d. both (a) and (b).
 Answer: d Objective: 1
4. The statement "Matter has a state on her side" is an example of
 - a. law.
 - b. hypothesis.
 - c. model.
 - d. prediction.
 Answer: b Objective: 2
5. A hypothesis is often developed out of
 - a. observation.
 - b. experiments.
 - c. both (a) and (b).
 - d. neither (a) nor (b).
 Answer: c Objective: 2
6. How many milliliters are in 0.5 L?
 - a. 500 mL.
 - b. 5,000 mL.
 - c. 50,000 mL.
 - d. 500,000 mL.
 Answer: a Objective: 2
7. A map of Seattle is an example of a
 - a. law.
 - b. theory.
 - c. model.
 - d. prediction.
 Answer: c Objective: 2
8. A lab has the safety items shown below. These items mean that you should wear
 - a. safety goggles and a lab apron.
 - b. safety goggles, a lab apron, and gloves.
 - c. safety goggles and gloves.
 - d. safety goggles and a lab apron.
 Answer: b Objective: 1
9. The law of conservation of mass says the total mass before a chemical change is
 - a. more than the total mass after the change.
 - b. less than the total mass after the change.
 - c. the same as the total mass after the change.
 - d. not the same as the total mass after the change.
 Answer: c Objective: 2
10. In which of the following areas might you find a geometer at work?
 - a. studying the chemistry of rocks.
 - b. studying the behavior of animals.
 - c. studying the atmosphere.
 - d. studying the structure of matter.
 Answer: d Objective: 2

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- Customizable lesson plans
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This Chapter Enrichment provides relevant and interesting information to expand and enhance your presentation of the chapter material.

Section 1

Mendel and His Peas

Gregor Mendel

- In 1843, in the city of Brunn, Austria (which is now Brno, a city in the Czech Republic), Gregor Mendel (1822–1884) entered a monastery. In 1865, Mendel published the results of his garden-pea experiments. Although Mendel's ideas are widespread today, few scientists learned of his work during his lifetime because there were few ways to distribute information. Mendel presented his findings in two lectures, and only 40 copies of his work were printed in his lifetime.
- When Mendel was elected abbot of the monastery in 1868, his duties prevented him from visiting other scientists or attending conferences where he could have discussed his results. Not until 1900, when Mendel's work was rediscovered by scientists in Holland, Germany, and Austria-Hungary, were his theories spread through the scientific community.



- Mendel's work was used to support Darwin's theory of evolution by natural selection and is considered to be the foundation of modern genetics. Mendel also made contributions to beekeeping, horticulture, and meteorology. In 1877, Mendel became interested in weather and began issuing weather reports to local farmers.

Is That a Fact!

- ◆ From 1856 to 1863, while studying inheritance, Mendel grew almost 30,000 pea plants!

Section 2

Traits and Inheritance

Punnett and His Squares

- Punnett squares are named after their inventor, R. C. Punnett. Punnett explored inheritance by crossing different breeds of chickens in the early 1900s, soon after Mendel's work was rediscovered.

Pollination

- Pollen can be transferred between plants by wind, insects, and a variety of animals. Some common pollinators are bees, butterflies, moths, flies, bats, and birds. Animals are attracted to the color of the flower, the patterns found on the petals, or the flower's fragrance. Pollen is an excellent food for some animals.



Is That a Fact!

- ◆ Male bees have only half the number of chromosomes that female bees have.

Section 3

Meiosis

Chromosomes

- Chromosomes are composed of genes, the sequences of DNA that provide the instructions for making all the proteins in an organism. During cell division, the duplicated chromosomes separate so that one copy of each chromosome is present in the two new cells.

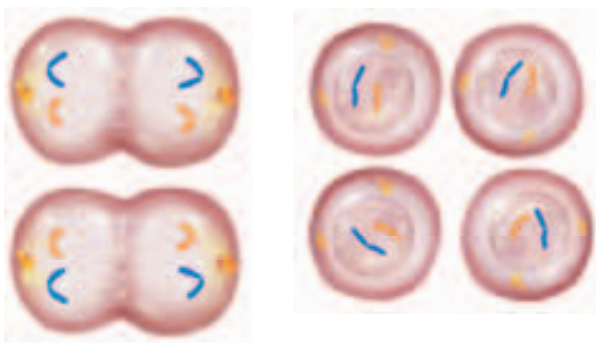


Walther Flemming

- Walther Flemming (1843–1905), a German physician and anatomist, was the first to use a microscope and special dyes to study cell division. Flemming used the term *mitosis* to describe the process he observed.

Mitosis

- In mitosis, a cell divides to form two identical cells. The steps of the process are similar in almost all living organisms. In addition to enabling growth, mitosis allows organisms to replace cells that have died or malfunctioned. Mitosis can take anywhere from a few minutes to a few hours, and it may be affected by characteristics of the environment, such as light and temperature.



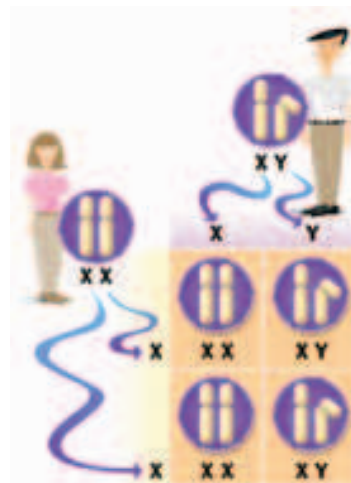
Meiosis

- Meiosis is not the same in all organisms. In humans, meiosis is very different in males and females. In males, meiosis results in four similar sperm cells. In females, however, only one functional egg is produced. The other resulting cells, which are known as *polar bodies*, are formed during the division of the original cell but do not mature.

Genetic Disorders

- A genetic disorder results from an inherited disruption in an organism's DNA. These inherited disruptions can take several forms, including a change in the number of chromosomes and the deletion or duplication of entire chromosomes or parts of chromosomes. Often, the change responsible for a disorder is the alteration of a single specific gene. However, some genetic disorders result from several of these genetic alterations occurring simultaneously. Diseases resulting from these alterations cause a wide variety of physical malfunctions and developmental problems.

- Cystic fibrosis (CF) is a disease for which one in 31 Americans carries a recessive trait. If two of these people have children together, there is a 25% chance that any child born to them will have the disease. CF affects the intestinal, bronchial, and sweat glands. In people with CF, these glands secrete thick, sticky fluids that are difficult for the body to process, impeding breathing and digestion. Due to improvements in diagnosis and treatment, median life expectancy for those with CF has improved from under 10 years in 1960 to an estimated 40 years for those born in 1990.



- Rubinstein-Taybi syndrome (RTS) is a complex genetic disorder whose characteristics include broad thumbs and toes, mental retardation, and distinctive facial features. This wide range of characteristics is believed to be linked to any one of a number of mutations in a gene responsible for providing the body with a protein called *CBP*. CBP is thought to be vital to the body's delicate metabolism. Because CBP greatly influences body processes, people with a problem producing CBP have a wide range of difficulties. Children with RTS can benefit from proper nutrition and early intervention with therapies and special education.

SciLINKS®

NSTA

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SciLinks is maintained by the National Science Teachers Association to provide you and your students with interesting, up-to-date links that will enrich your classroom presentation of the chapter.

Visit www.scilinks.org and enter the SciLinks code for more information about the topic listed.

Topic: **Heredity**
SciLinks code: **HSM0738**

Topic: **Phenotypes**
SciLinks code: **HSM1135**

Topic: **Dominant and Recessive Traits**
SciLinks code: **HSM0423**

Topic: **Meiosis**
SciLinks code: **HSM0935**

Topic: **Genotypes**
SciLinks code: **HSM0664**

Topic: **Genetic Diseases, Screening, Counseling**
SciLinks code: **HSM0651**

Overview

Tell students that this chapter will introduce heredity—the ways that traits are passed from parents to offspring. The chapter describes the ways scientists study heredity and the role of sexual reproduction.

Assessing Prior Knowledge

Students should be familiar with the following topics:

- scientific methods
- cells
- mitosis

Identifying Misconceptions

Students often hold onto misconceptions about inheritance, even after instruction. For example, they may believe that traits are inherited from only one parent or that environmentally caused characteristics may be passed on to offspring. Students tend to understand phenotype (physical traits) more easily than genotype. Finally, the process of meiosis, as it relates to the structure and location of chromosomes, is very complex. Most students require time and repeated exposure in order to comprehend all the parts and steps of meiosis. Assure students that the concepts of heredity are a foundation that will be built upon throughout their studies of life science.

Heredity

The Big Idea

Heredity is the passage of traits from one generation to the next.

SECTION

- 1 Mendel and His Peas. 114
- 2 Traits and Inheritance. 120
- 3 Meiosis. 126

About the



The guinea pig in the middle has dark fur, and the other two have light orange fur. The guinea pig on the right has longer hair than the other two. Why do these guinea pigs look different from one another? The length and color of their fur was determined before they were born. These are just two of the many traits determined by genetic information. Genetic information is passed on from parents to their offspring.

PRE-READING ACTIVITY

FOLDNOTES

Key-Term Fold Before you read the chapter, create the FoldNote entitled “Key-Term Fold” described in the **Study Skills** section of the Appendix. Write a key term from the chapter on each tab of the key-term fold. Under each tab, write the definition of the key term.



Standards Correlations

National Science Education Standards

The following codes indicate the National Science Education Standards that correlate to this chapter. The full text of the standards is at the front of the book.

Chapter Opener

UCP 2, 3; LS 1d, 2c

Section 1 Mendel and His Peas

UCP 1, 2; SAI 1, 2; ST 2; SPSP 5; HNS 1, 2, 3; LS 2b, 2e

Section 2 Traits and Inheritance

UCP 2, 3; LS 2a, 2b, 2c, 2d, 2e

Section 3 Meiosis

UCP 4, 5; SAI 1; SPSP 5; HNS 2, 3; LS 1c, 1d, 2a, 2b, 2c, 2d; Lab Book: UCP 2; SAI 1; HNS 2; LS 2b, 2c, 2e

Chapter Lab

SAI 1; HNS 2; LS 2c, 2e

Chapter Review

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

Science in Action

ST 2; SPSP 5





START-UP Activity

Clothing Combos

How do the same parents have children with many different traits?

Procedure

1. Gather **three boxes**. Put **five hats** in the first box, **five gloves** in the second, and **five scarves** in the third.
2. Without looking in the boxes, select one item from each box. Repeat this process, five students at a time, until the entire class has picked "an outfit." Record what outfit each student chooses.

Analysis

1. Were any two outfits exactly alike? Did you see all possible combinations? Explain your answer.
2. Choose a partner. Using your outfits, how many different combinations could you make by giving a third person one hat, one glove, and one scarf? How is this process like parents passing traits to their children?
3. After completing this activity, why do you think parents often have children who look very different from each other?

START-UP Activity

MATERIALS

FOR EACH GROUP

- boxes large, (3)
- gloves different types, (5)
- hats different types, (5)
- scarves different types, (5)

Safety Caution: Infestations of head lice are a common problem in schools. Sharing hats should be avoided during such a period. Jackets or sweatshirts could be substituted for hats in this exercise.

Answers

1. Answers may vary. There should be many different combinations. It is not likely that students will see all of the possible combinations.
2. Sample answer: eight new combinations (taken from the outfits of the two "parents") would be possible for the third person ("offspring"). This process is like inheritance because you are choosing combinations of hats, scarves, and gloves randomly. Traits are also passed from parent to offspring randomly. By combining the traits (outfits) of two "parents" (partners), there are many possible combinations of traits in the "offspring" (third person).
3. Sample answer: The number of possible genetic combinations is huge because we have so many genes.

Heredity
CHAPTER STARTER

Would You Believe . . . ?

It all started in ancient China. A fisherman caught an unusual carp. Usually these small freshwater fish are drab colored, but this one had a pale golden hue. It was too pretty to eat, so the fisherman took the fish home as a pet.

Months later, the fisherman caught another gold-fingered carp. He kept the two fish in the same bowl. When the fish reproduced, the offspring were even more brightly colored than their parents. The first goldfish had been born!

In the years that followed, people throughout China began keeping and breeding the new, orange-colored fish. Many became goldfish matchmakers, choosing only the most handsome males for their favorite fish. With each generation of hatchlings, the fish looked more and more distinctive. By 1500 c.e., when the first shipments of goldfish arrived in Japan, goldfish no longer resembled carp. In fact, they were so regal looking that the commoners in Japan were forbidden to keep them as pets.

Without knowing it, these early goldfish breeders were using the principles of genetics to create many new kinds of goldfish. In this chapter you will learn about heredity, the passing of traits from parents to offspring. You'll discover the principles that allowed beautiful goldfish to be bred from rather plain-looking carp.

Chapter Starter Transparency
 Use this transparency to help students begin thinking about heredity.

CHAPTER RESOURCES

Technology

- Transparencies**
 - Chapter Starter Transparency
- Student Edition on CD-ROM**
- Guided Reading Audio CD**
 - English or Spanish
- Classroom Videos**
 - Brain Food Video Quiz

READING SKILLS

Workbooks

- Science Puzzlers, Twisters & Teasers**
 - Heredity **GENERAL**

Focus

Overview

This section introduces the genetic experiments of Gregor Mendel. Students explore how crosses between different parent plants produce different offspring. Students are also introduced to genetic probability.



Bellringer

Present the following prompt to your students: “You have probably noticed that different people have different traits, such as eye color, hair color, and ear lobes that do or do not attach directly to their head. Where do people get these different traits?” (Many traits are inherited from parents and passed from parents to offspring through genes.)

Motivate

Activity

GENERAL

Trait Trends Create a large table to record the number of students with the following traits: widow’s peak, ability to roll tongue, and attached earlobes. Have pairs of students enter data for each other by adding tick marks on the table. Ask students if they can see any trends in the class data. If possible, compile data from several classes. **KS Kinesthetic/Interpersonal**

What You Will Learn

- Explain the relationship between traits and heredity.
- Describe the experiments of Gregor Mendel.
- Explain the difference between dominant and recessive traits.

Vocabulary

heredity
dominant trait
recessive trait

READING STRATEGY

Brainstorming The key idea of this section is heredity. Brainstorm words and phrases related to heredity.

heredity the passing of genetic traits from parent to offspring



Figure 1 Gregor Mendel discovered the principles of heredity while studying pea plants.

Mendel and His Peas

Why don’t you look like a rhinoceros? The answer to this question seems simple: Neither of your parents is a rhinoceros. But there is more to this answer than meets the eye.

As it turns out, **heredity**, or the passing of traits from parents to offspring, is more complicated than you might think. For example, you might have curly hair, while both of your parents have straight hair. You might have blue eyes even though both of your parents have brown eyes. How does this happen? People have investigated this question for a long time. About 150 years ago, Gregor Mendel performed important experiments. His discoveries helped scientists begin to find some answers to these questions.

✓ Reading Check What is heredity? (See the Appendix for answers to Reading Checks.)

Who Was Gregor Mendel?

Gregor Mendel, shown in **Figure 1**, was born in 1822 in Heinzendorf, Austria. Mendel grew up on a farm and learned a lot about flowers and fruit trees.

When he was 21 years old, Mendel entered a monastery. The monks taught science and performed many scientific experiments. From there, Mendel was sent to Vienna where he could receive training in teaching. However, Mendel had trouble taking tests. Although he did well in school, he was unable to pass the final exam. He returned to the monastery and put most of his energy into research. Mendel discovered the principles of heredity in the monastery garden.

Unraveling the Mystery

From working with plants, Mendel knew that the patterns of inheritance were not always clear. For example, sometimes a trait that appeared in one generation (parents) was not present in the next generation (offspring). In the generation after that, though, the trait showed up again. Mendel noticed these kinds of patterns in several other living things, too. Mendel wanted to learn more about what caused these patterns.

To keep his investigation simple, Mendel decided to study only one kind of organism. Because he had studied garden pea plants before, they seemed like a good choice.

CHAPTER RESOURCES

Chapter Resource File



- Lesson Plan
- Directed Reading A **BASIC**
- Directed Reading B **SPECIAL NEEDS**

Technology



- Transparencies
- Bellringer

Workbooks



- Interactive Textbook **Struggling Readers**

Answer to Reading Check

the passing of traits from parents to offspring

Self-Pollinating Peas

In fact, garden peas were a good choice for several reasons. Pea plants grow quickly, and there are many different kinds available. They are also able to self-pollinate. A *self-pollinating plant* has both male and female reproductive structures. So, pollen from one flower can fertilize the ovule of the same flower or the ovule of another flower on the same plant. The flower on the right side of **Figure 2** is self-pollinating.

Why is it important that pea plants can self-pollinate? Because eggs (in an ovule) and sperm (in pollen) from the same plant combine to make a new plant, Mendel was able to grow true-breeding plants. When a *true-breeding plant* self-pollinates, all of its offspring will have the same trait as the parent. For example, a true-breeding plant with purple flowers will always have offspring with purple flowers.

Pea plants can also cross-pollinate. In *cross-pollination*, pollen from one plant fertilizes the ovule of a flower on a different plant. There are several ways that this can happen. Pollen may be carried by insects to a flower on a different plant. Pollen can also be carried by the wind from one flower to another. The left side of **Figure 2** shows these kinds of cross-pollination.

SCHOOL to HOME

Describing Traits

How would you describe yourself? Would you say that you are tall or short, have curly hair or straight hair? Make a list of some of your physical traits. Make a second list of traits that you were not born with, such as "caring" or "good at soccer." Talk to your family about your lists. Do they agree with your descriptions?

Activity

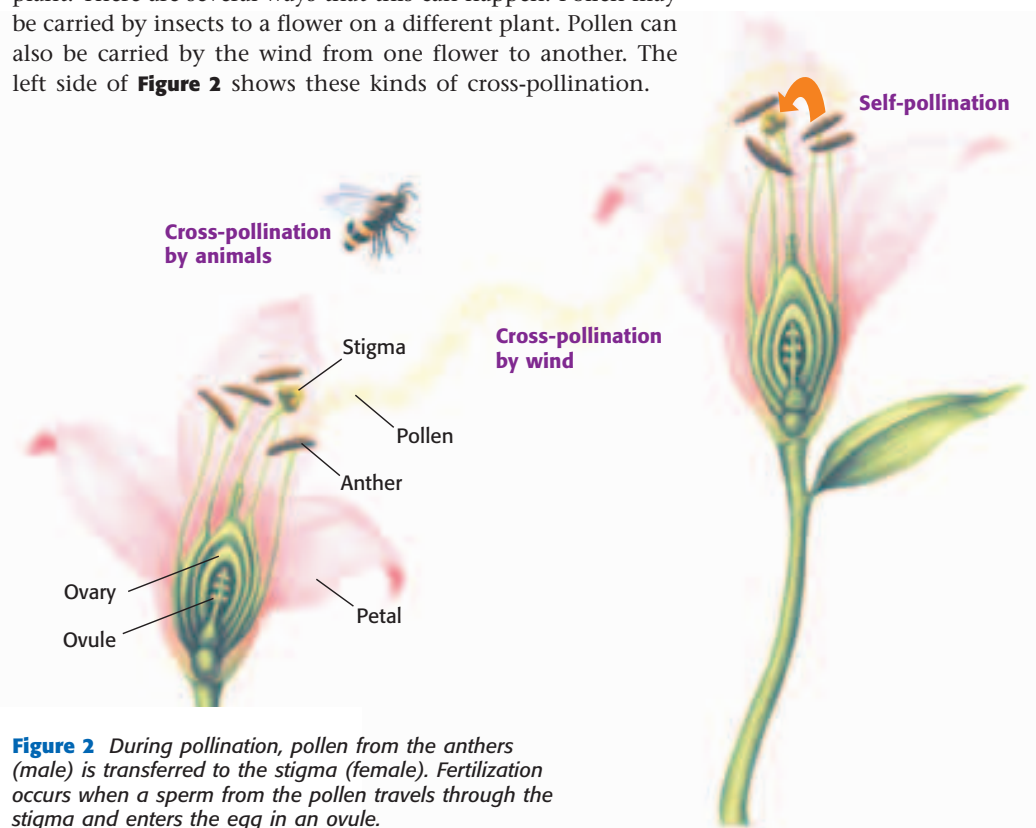


Figure 2 During pollination, pollen from the anthers (male) is transferred to the stigma (female). Fertilization occurs when a sperm from the pollen travels through the stigma and enters the egg in an ovule.

SUPPORT FOR

English Language Learners

Language of Genetics Many terms used in this section are specialized to the area of genetics. Students who are studying this field in English for the first time may not have encountered these words before. Have students read the section silently and note any words they do not understand. Then, ask them to read it again with a partner, discussing terms on their lists and trying to elicit their meanings from the surrounding context. They

should write the terms and meanings in their science journals as they are discovered. If there are any terms left undefined after the partner reading, ask students to share them with the class to see if anyone else can define them. Check journals, and have students make corrections as necessary. Potentially unknown words include: *trait, mature, generation, pass on, offspring, pollinate, self-, cross-.* **Verbal/Interpersonal**

Using the Figure—BASIC

Flower Fertilization Discuss the physical processes involved in the fertilization of the flowers illustrated in **Figure 2**. These flowers can be fertilized by another flower or can fertilize themselves. Compare this figure with **Figure 4** on the next page, and point out that removing the anthers from the flower makes it impossible for the plant to self-pollinate. **Visual/Verbal**

CONNECTION to Real World—GENERAL

Rapidly Growing Organisms

Mendel favored the garden pea because it grows quickly, allowing him to produce many generations within a short time span. Modern scientists favor yeast, bacteria, fruit flies, and mice for studies of heredity and genetics. Each of these organisms has a rapid rate of reproduction. However, rapidly-growing organisms can pose problems. For example, medical scientists face ongoing threats from strains of bacteria that develop resistance to common antibiotics. In some cases, medications that were once widely prescribed are no longer effective. **Logical/Intrapersonal**

Discussion — GENERAL

Scientific Methods Have students identify the use of scientific methods in Mendel's work.

- **Ask a question:** How are traits inherited?
- **Form a hypothesis:** Inheritance has a pattern.
- **Test the hypothesis:** Cross true-breeding plants and offspring.
- **Analyze the results:** Identify patterns in inherited traits.
- **Draw conclusions:** Traits are inherited in predictable patterns.
- **Communicate the results:** Publish the results for peer review.

Ask students, "Why weren't Mendel's ideas accepted for so many years?" (because of problems with the last step—other scientists could not easily read or understand his findings)

LS Logical/Verbal

Demonstration — BASIC

Flower Dissection Obtain a flower that has anthers and a stigma, such as a pea flower, a tulip, or a lily. Be careful because pollen can stain clothing and cause allergic reactions. Dissect the flower, and show students the anthers and the stigma. Ask students if this flower could self-pollinate. (yes, because it has both anthers and a stigma) Demonstrate how Mendel removed the anthers of his flowers and then used a small brush to transfer pollen from plant to plant.

English Language Learners

LS Kinesthetic

Seed Shape



Plant Height



Flower Color



Figure 3 These are some of the plant characteristics that Mendel studied.

Characteristics

Mendel studied only one characteristic at a time. A *characteristic* is a feature that has different forms in a population. For example, hair color is a characteristic in humans. The different forms, such as brown or red hair, are called *traits*. Mendel used plants that had different traits for each of the characteristics he studied. For instance, for the characteristic of flower color, he chose plants that had purple flowers and plants that had white flowers. Three of the characteristics Mendel studied are shown in **Figure 3**.

Mix and Match

Mendel was careful to use plants that were true breeding for each of the traits he was studying. By doing so, he would know what to expect if his plants were to self-pollinate. He decided to find out what would happen if he bred, or crossed, two plants that had different traits of a single characteristic. To be sure the plants cross-pollinated, he removed the anthers of one plant so that the plant could not self-pollinate. Then, he used pollen from another plant to fertilize the plant, as shown in **Figure 4**. This step allowed Mendel to select which plants would be crossed to produce offspring.

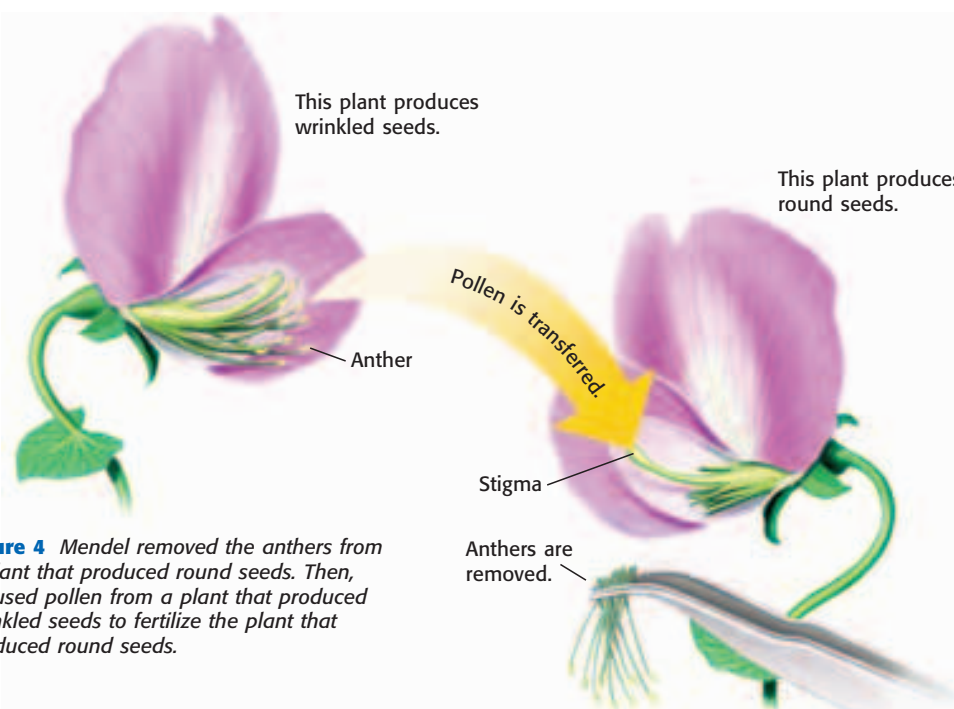


Figure 4 Mendel removed the anthers from a plant that produced round seeds. Then, he used pollen from a plant that produced wrinkled seeds to fertilize the plant that produced round seeds.

Activity

ADVANCED

Mendelian Crosses Give each student a purple bead (*P*) and a white bead (*p*), and ask students to perform a Mendelian cross. Tell students to begin the first generation with the allele combination *Pp*. Have students randomly "pollinate" with 10 other members of the class. To pollinate, one student should hide one bead in each hand. The partner should pick a hand. That hand

holds the allele from one parent. Partners should switch roles and repeat this step to determine the allele from the second parent. Students should record the genotype for each pollination. Have students tally the results and determine the ratio of white-flowering plants to purple-flowering plants that results from the matches.

LS Kinesthetic/Interpersonal Co-op Learning

Mendel's First Experiments

In his first experiments, Mendel crossed pea plants to study seven different characteristics. In each cross, Mendel used plants that were true breeding for different traits for each characteristic. For example, he crossed plants that had purple flowers with plants that had white flowers. This cross is shown in the first part of **Figure 5**. The offspring from such a cross are called *first-generation plants*. All of the first-generation plants in this cross had purple flowers. Are you surprised by the results? What happened to the trait for white flowers?

Mendel got similar results for each cross. One trait was always present in the first generation, and the other trait seemed to disappear. Mendel chose to call the trait that appeared the **dominant trait**. Because the other trait seemed to fade into the background, Mendel called it the **recessive trait**. (To *recede* means “to go away or back off.”) To find out what might have happened to the recessive trait, Mendel decided to do another set of experiments.

Mendel's Second Experiments

Mendel allowed the first-generation plants to self-pollinate. **Figure 5** also shows what happened when a first-generation plant with purple flowers was allowed to self-pollinate. As you can see, the recessive trait for white flowers reappeared in the second generation.

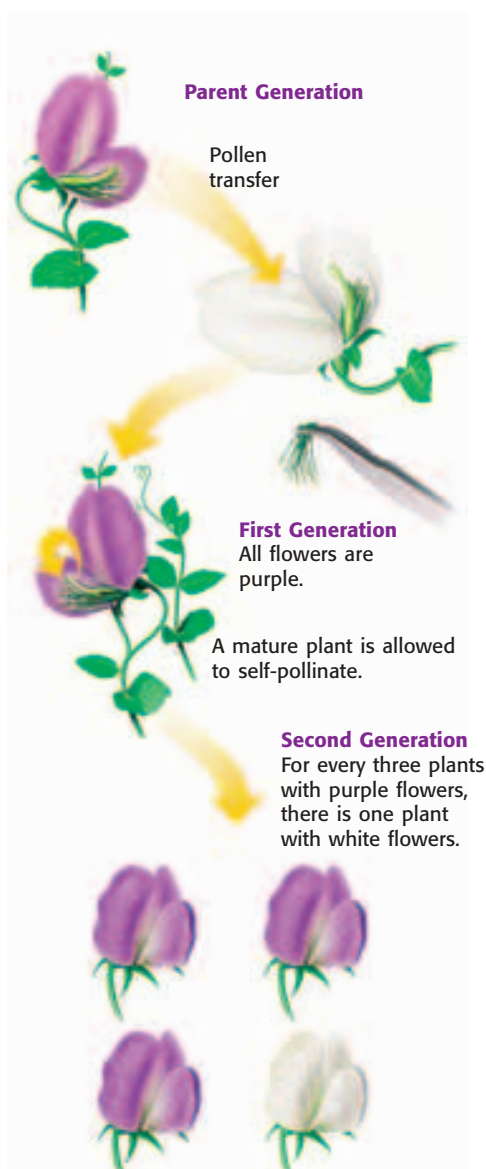
Mendel did this same experiment on each of the seven characteristics. In each case, some of the second-generation plants had the recessive trait.

✓ Reading Check Describe Mendel's second set of experiments.

Figure 5 Mendel used the pollen from a plant with purple flowers to fertilize a plant with white flowers. Then, he allowed the offspring to self-pollinate.

dominant trait the trait observed in the first generation when parents that have different traits are bred

recessive trait a trait that reappears in the second generation after disappearing in the first generation when parents with different traits are bred



MISCONCEPTION ALERT

Recessive Traits Students may believe that recessive traits are rare. Point out that either dominant *or* recessive traits may be more common in a population. For example, blond hair is a recessive trait, yet blond hair is very common in parts of Scandinavia. Conversely, dominant traits are not always the most common. For example, the trait of having six fingers on one hand is dominant!

Answer to Reading Check

During his second set of experiments, Mendel allowed the first-generation plants, which resulted from his first set of experiments, to self-pollinate. The recessive trait reappeared in the second generation.

INCLUSION Strategies

- **Learning Disabled**
- **Attention Deficit Disorder**
- **Developmentally Delayed**

Use this activity to physically model the abstract concepts of *recessive* and *dominant*. To prepare, gather sheets of two kinds of transparent film: clear and purple. Cut the sheets into rectangles that are small enough to handle. Make one rectangle of each type for each student in the class.

1. Tell students that they are going to serve as models of Mendel's experiment in **Figure 5**. Give half of the students two purple rectangles each. Announce that these students have purple flowers. Give the other half of the students two clear rectangles each. Announce that these students have white flowers. Announce that the class now represents Mendel's parent generation.
2. Have each student trade one rectangle with another student. Announce that these new combinations represent Mendel's first generation. Tell students to hold the rectangles together in front of a light. Tell students that the purple gene is dominant and that those who see purple through the rectangles have purple flowers. This generation all has purple flowers.
3. Finally, have students trade one rectangle randomly with another student. Announce that the class now represents Mendel's second generation. Have students count the number of “flowers” of each type, and compare these results to Mendel's.

Kinesthetic

English Language Learners

Close

Answers for Table 1 Ratios

Seed color	3.00:1
Seed shape	2.96:1
Pod color	2.82:1
Pod shape	2.95:1
Flower position	3.14:1
Plant height	2.84:1

Reteaching BASIC

Mendel's Experiments Have students re-enact Mendel's experiments using cups (to represent a plant), colored buttons or chips (to represent various alleles or genotypes), and colored strips of paper (to represent visible traits or phenotypes). Have students perform crosses by taking alleles from "parent" cups and creating "offspring" cups, deciding which traits would then become visible.

Kinesthetic/Logical English Language Learners

Quiz GENERAL

1. What did Mendel call the trait that appeared in all of his first-generation plants? (the dominant trait)
2. What is the probability of getting heads in a coin toss? (1/2)

Alternative Assessment ADVANCED

Story of a Scientist Have students create a comic book or short video drama about Mendel's life and work. Tell students to highlight his use of the scientific method and his habits as a scientist. **Interpersonal**

MATH PRACTICE

Understanding Ratios

A ratio is a way to compare two numbers. Look at **Table 1**. The ratio of plants with purple flowers to plants with white flowers can be written as 705 to 224 or 705:224. This ratio can be reduced, or simplified, by dividing the first number by the second as follows:

$$\frac{705}{224} = \frac{3.15}{1}$$

which is the same thing as a ratio of 3.15:1.

For every 3 plants with purple flowers, there will be roughly 1 plant with white flowers. Try this problem:

In a box of chocolates, there are 18 nougat-filled chocolates and 6 caramel-filled chocolates. What is the ratio of nougat-filled chocolates to caramel-filled chocolates?















Ratios in Mendel's Experiments

Mendel then decided to count the number of plants with each trait that turned up in the second generation. He hoped that this might help him explain his results. Take a look at Mendel's results, shown in **Table 1**.

As you can see, the recessive trait did not show up as often as the dominant trait. Mendel decided to figure out the ratio of dominant traits to recessive traits. A *ratio* is a relationship between two different numbers that is often expressed as a fraction. Calculate the dominant-to-recessive ratio for each characteristic. (If you need help, look at the Math Practice at left.) Do you notice anything interesting about the ratios? Round to the nearest whole number. Are the ratios all the same, or are they different?

Reading Check What is a ratio?

Table 1 Mendel's Results

Characteristic	Dominant traits	Recessive traits	Ratio
Flower color	705 purple 	224 white 	3.15:1
Seed color	6,002 yellow 	2,001 green 	?
Seed shape	5,474 round 	1,850 wrinkled 	?
Pod color	428 green 	152 yellow 	?
Pod shape	882 smooth 	299 bumpy 	?
Flower position	651 along stem 	207 at tip 	?
Plant height	787 tall 	277 short 	?

Answer to Math Practice

The ratio of nougat-filled chocolates to caramel-filled chocolates is 18:6, or 18/6, which can be reduced to 3/1. This fraction can be rewritten as 3:1 or 3 to 1.

Answers to questions on student page

All the ratios are about the same. They can be rounded to 3:1.

Answer to Reading Check

A ratio is a relationship between two different numbers that is often expressed as a fraction.

Gregor Mendel—Gone but Not Forgotten

Mendel realized that his results could be explained only if each plant had two sets of instructions for each characteristic. Each parent would then donate one set of instructions. In 1865, Mendel published his findings. But good ideas are sometimes overlooked or misunderstood at first. It wasn't until after his death, more than 30 years later, that Mendel's work was widely recognized. Once Mendel's ideas were rediscovered and understood, the door was opened to modern genetics. Genetic research, as shown in **Figure 6**, is one of the fastest changing fields in science today.



Figure 6 This researcher is continuing the work started by Gregor Mendel more than 100 years ago.

SECTION Review

Summary

- Heredity is the passing of traits from parents to offspring.
- Gregor Mendel made carefully planned experiments using pea plants that could self-pollinate.
- When parents with different traits are bred, dominant traits are always present in the first generation. Recessive traits are not visible in the first generation but reappear in the second generation.
- Mendel found a 3:1 ratio of dominant-to-recessive traits in the second generation.

Using Key Terms

1. Use each of the following terms in a separate sentence: *heredity*, *dominant trait*, and *recessive trait*.

Understanding Key Ideas


2. A plant that has both male and female reproductive structures is able to
 - a. self-replicate.
 - b. self-pollinate.
 - c. change colors.
 - d. None of the above
3. Explain the difference between self-pollination and cross-pollination.
4. What is the difference between a trait and a characteristic? Give one example of each.
5. Describe Mendel's first set of experiments.
6. Describe Mendel's second set of experiments.

Math Skills

7. In a bag of chocolate candies, there are 21 brown candies and 6 green candies. What is the ratio of brown to green? What is the ratio of green to brown?

Critical Thinking

8. **Predicting Consequences** Gregor Mendel used only true-breeding plants. If he had used plants that were not true breeding, do you think he would have discovered dominant and recessive traits? Explain.
9. **Applying Concepts** In cats, there are two types of ears: normal and curly. A curly-eared cat mated with a normal-eared cat, and all of the kittens had curly ears. Are curly ears a dominant or recessive trait? Explain.
10. **Identifying Relationships** List three other fields of study that use ratios.



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For a variety of links related to this chapter, go to www.scilinks.org
Topic: Heredity; Dominant and Recessive Traits
SciLinks code: HSM0738; HSM0423

Answers to Section Review

1. Sample answer: Heredity is the passing of traits from parents to their offspring. A dominant trait is a trait that is present in the first generation when parents with different traits produce offspring. A recessive trait is a trait that is not present in the first generation but often reappears in the second generation.
2. b
3. Self-pollination occurs when pollen from a particular plant is deposited on a stigma from the same plant. Cross-pollination occurs when the pollen and stigma are from two different plants.
4. Sample answer: A characteristic is something that has different forms in a population, and a trait is each one of the possible forms. For example, eye color is a characteristic in humans, and brown eyes, green eyes, and blue eyes are all possible traits.
5. Sample answer: During Mendel's first experiments, he crossed two plants that were true breeding for different traits. In each case, the offspring had the dominant trait.
6. During Mendel's second experiments, he allowed the plants that were the offspring from his first experiments to self-pollinate. In these cases, some of the second-generation plants had the recessive trait.
7. 7:2, or 3.5:1, brown to green; 2:7, or 1:3.5, green to brown
8. Sample answer: If Mendel had used plants that were not true breeding, the dominant trait would not have been as clear for each characteristic, and he would not have gotten such a clear 3:1 ratio. The concept of dominant and recessive may have stayed hidden for a longer period of time.
9. Curly ears are dominant because it is the trait that is represented in the first generation.
10. Sample answer: sociology, physics, and chemistry

Homework

GENERAL

Poster Project Have students create posters to illustrate Mendel's first and second experiments. Have each student demonstrate one of the seven traits that Mendel studied. Encourage students to use materials such as flowers, yellow and green seeds, or wrinkled and round peas. Each project should clearly identify the parents, the first generation, and the second generation.  **Visual/Logical**

CHAPTER RESOURCES

Chapter Resource File

- Section Quiz **GENERAL**
- Section Review **GENERAL**
- Vocabulary and Section Summary **GENERAL**
- SciLinks Activity **GENERAL**

Workbooks

- Science Skills
 - Finding Useful Sources **GENERAL**
- Math Skills for Science
 - What is Ratio? **GENERAL**

Focus

Overview

In this section, students distinguish between genotype and phenotype and use mathematical models to predict the results of genetic crosses. They also learn some exceptions to Mendel's rules of inheritance.

Bellringer

Have students respond to the following prompts: "If you flip a coin, what are the chances that it will land on heads?" ($\frac{1}{2}$ or 50%) "tails?" (same) "Suppose you flip the coin once, get heads, and then flip it again. What are the chances that you will get heads again?" (still $\frac{1}{2}$ or 50%) "Explain." (Each flip of the coin is independent of the last. The chances are the same on each flip.)

Motivate

Demonstration — BASIC

Ratios To review fractions and ratios, display three pennies and one nickel, and then ask students the following questions: "How many coins are there in all?" (4) "What fraction of the coins are pennies?" ($\frac{3}{4}$) "What fraction of the coins are nickels?" ($\frac{1}{4}$) "What is the ratio of pennies to nickels?" (3 to 1)

Visual/Verbal

Traits and Inheritance

Mendel calculated the ratio of dominant traits to recessive traits. He found a ratio of 3:1. What did this tell him about how traits are passed from parents to offspring?

What You Will Learn

- Explain how genes and alleles are related to genotype and phenotype.
- Use the information in a Punnett square.
- Explain how probability can be used to predict possible genotypes in offspring.
- Describe three exceptions to Mendel's observations.

Vocabulary

gene	genotype
allele	probability
phenotype	

READING STRATEGY

Paired Summarizing Read this section silently. In pairs, take turns summarizing the material. Stop to discuss ideas that seem confusing.

gene one set of instructions for an inherited trait

allele one of the alternative forms of a gene that governs a characteristic, such as hair color

phenotype an organism's appearance or other detectable characteristic

Figure 1 Albinism is an inherited disorder that affects a person's phenotype in many ways.

A Great Idea

Mendel knew from his experiments with pea plants that there must be two sets of instructions for each characteristic. The first-generation plants carried the instructions for both the dominant trait and the recessive trait. Scientists now call these instructions for an inherited trait **genes**. Each parent gives one set of genes to the offspring. The offspring then has two forms of the same gene for every characteristic—one from each parent. The different forms (often dominant and recessive) of a gene are known as **alleles** (uh LEELZ). Dominant alleles are shown with a capital letter. Recessive alleles are shown with a lowercase letter.

Reading Check What is the difference between a gene and an allele? (See the Appendix for answers to Reading Checks.)

Phenotype

Genes affect the traits of offspring. An organism's appearance is known as its **phenotype** (FEE noh TIEP). In pea plants, possible phenotypes for the characteristic of flower color would be purple flowers or white flowers. For seed color, yellow and green seeds are the different phenotypes.

Phenotypes of humans are much more complicated than those of peas. Look at **Figure 1** below. The man has an inherited condition called **albinism** (AL buh NIZ uhm). Albinism prevents hair, skin, and eyes from having normal coloring.



CHAPTER RESOURCES

Chapter Resource File

- Lesson Plan
- Directed Reading A **BASIC**
- Directed Reading B **SPECIAL NEEDS**

Technology

- Transparencies**
 - Bellringer
 - L13 Punnett Squares
 - LINK TO PHYSICAL SCIENCE** P109 The Periodic Table of the Elements

Workbooks

- Interactive Textbook** Struggling Readers

Answer to Reading Check

A gene contains the instructions for an inherited trait. The different versions of a gene are called **alleles**.

CONNECTION to Physical Science ADVANCED

Mathematical Models The Punnett square and the periodic Table are both mathematical models that were developed by scientists who observed numerical patterns. These models are used to organize scientific understanding of patterns and to make predictions. Show students the teaching transparency entitled “The Periodic Table of the Elements.” Discuss the ways that a Punnett square is similar.

 **Visual/Logical**

MISCONCEPTION ALERT

Invisible Phenotypes Students may overgeneralize the idea that a phenotype can be a visible trait. This idea may help students to differentiate phenotype from genotype, but remind students that phenotype is any trait that is inherited (in other words, a result of the genotype). However, not all such traits may be visible. Most traits are fundamentally expressed as chemicals produced by cells.

Answer to Quick Lab

Three of the offspring would have round seeds, and one would have wrinkled seeds.

Genotype

Both inherited alleles together form an organism's **genotype**. Because the allele for purple flowers (P) is dominant, only one P allele is needed for the plant to have purple flowers. A plant with two dominant or two recessive alleles is said to be *homozygous* (HOH moh ZIE guhs). A plant that has the genotype Pp is said to be *heterozygous* (HET uhr OH ZIE guhs).

Punnett Squares

A Punnett square is used to organize all the possible combinations of offspring from particular parents. The alleles for a true-breeding, purple-flowered plant are written as PP . The alleles for a true-breeding, white-flowered plant are written as pp . The Punnett square for this cross is shown in **Figure 2**. All of the offspring have the same genotype: Pp . The dominant allele, P , in each genotype ensures that all of the offspring will be purple-flowered plants. The recessive allele, p , may be passed on to the next generation. This Punnett square shows the results of Mendel's first experiments.

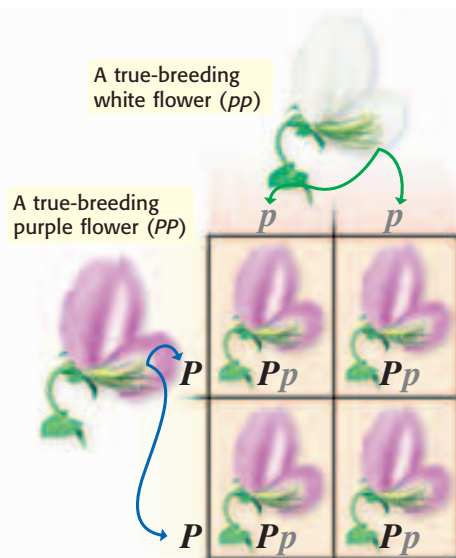


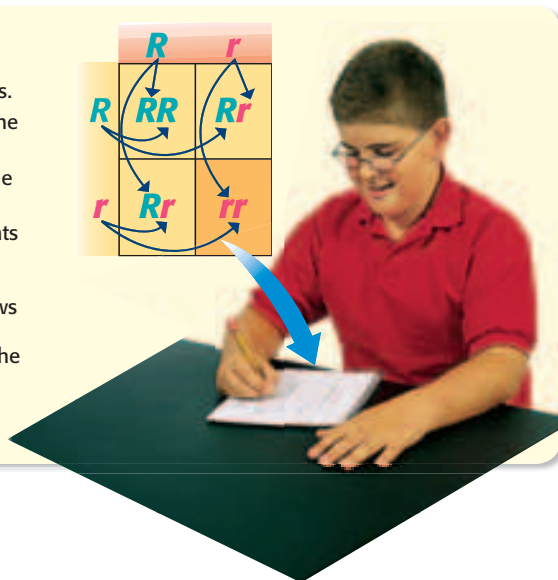
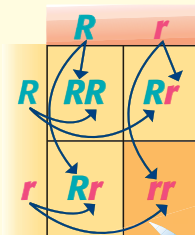
Figure 2 All of the offspring for this cross have the same genotype— Pp .

genotype the entire genetic makeup of an organism; also the combination of genes for one or more specific traits

Quick Lab

Making a Punnett Square

1. Draw a square, and divide it into four sections.
2. Write the letters that represent alleles from one parent along the top of the box.
3. Write the letters that represent alleles from the other parent along the side of the box.
4. The cross shown at right is between two plants that produce round seeds. The genotype for each is Rr . Round seeds are dominant, and wrinkled seeds are recessive. Follow the arrows to see how the inside of the box was filled. The resulting alleles inside the box show all the possible genotypes for the offspring from this cross. What would the phenotypes for these offspring be?



CHAPTER RESOURCES

Workbooks



Math Skills for Science

• Punnett Square Popcorn **GENERAL**



Q: What do you get when you cross a bridge with a bicycle?

A: to the other side

Teach, continued

Answers to Quick Lab

- Students should get bb on average $1/4$ or 25% of the time.
- $1/4$ or 25%
- $1/4$ (If brown fur results from genotype Bb , then brown fur is dominant, and white fur will result from the genotype bb .)

CONNECTION Activity

Math

ADVANCED

Probability of Independent Events

The probability of two or more independent events is the product of the individual probabilities. For example, the probability of getting heads in a coin toss is $1/2$, but the probability of getting heads twice in a row is $1/2 \times 1/2$, or $1/4$. Have students consider the following parent genotypes for pea plants: $PpRr$ and $Pprr$. Work out and discuss the probability of each possible combined phenotype. (For example, the probability of a plant with white flowers and round seeds is $1/4 \times 1/2 = 1/8$.) **LS Logical**

Answer to Reading Check

Probability is the mathematical chance that something will happen.

Quick Lab

Taking Your Chances

You have two guinea pigs. Each has brown fur and the genotype Bb . You want to predict what their offspring might look like. Try this to find out.

- Stick a piece of masking tape on each side of two quarters.
- Label one side with a capital B and the other side with a lowercase b .
- Toss both coins 10 times, making note of your results each time.
- How many times did you get the bb combination?
- What is the probability that the next toss will result in bb ?
- What are the chances that the guinea pigs' offspring will have white fur (with the genotype bb)?

probability the likelihood that a possible future event will occur in any given instance of the event

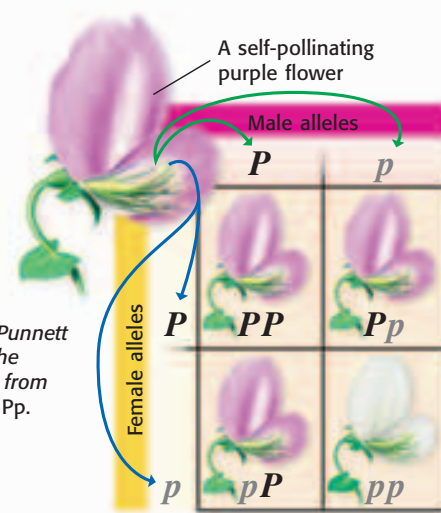


Figure 3 This Punnett square shows the possible results from the cross $Pp \times Pp$.

More Evidence for Inheritance

In Mendel's second experiments, he allowed the first generation plants to self-pollinate. **Figure 3** shows a self-pollination cross of a plant with the genotype Pp . What are the possible genotypes of the offspring?

Notice that one square shows the genotype Pp , while another shows pP . These are exactly the same genotype. The other possible genotypes of the offspring are PP and pp . The combinations PP , Pp , and pP have the same phenotype—purple flowers. This is because each contains at least one dominant allele (P).

Only one combination, pp , produces plants that have white flowers. The ratio of dominant to recessive is 3:1, just as Mendel calculated from his data.

What Are the Chances?

Each parent has two alleles for each gene. When these alleles are different, as in Pp , offspring are equally likely to receive either allele. Think of a coin toss. There is a 50% chance you'll get heads and a 50% chance you'll get tails. The chance of receiving one allele or another is as random as a coin toss.

Probability

The mathematical chance that something will happen is known as **probability**. Probability is most often written as a fraction or percentage. If you toss a coin, the probability of tossing tails is $1/2$ —you will get tails half the time.

Reading Check What is probability?

MISCONCEPTION ALERT

The Role of Chance Students' lack of understanding of mathematical probability may block their understanding of the random and independent sorting of genes that occurs during meiosis. Be careful that students do not overextend mathematical probabilities to predict the outcome of single events. It is correct to predict that an average of many outcomes will be similar to, but not exactly match, a probability ratio.

SUPPORT FOR

English Language Learners

Language of Probabilities When probabilities are discussed in English, specific language is used to convey how much chance there is that something could actually happen. Point out words such as *possible*, *probable*, *chance*, *likely*, and *random* as students are reading. Ask what they mean or provide examples if students do not know. Emphasize that these words have some subtle linguistic differences in meaning. **LS Verbal**

MATH Focus

Probability If you roll a pair of dice, what is the probability that you will roll 2 threes?

Step 1: Count the number of faces on a single die. Put this number in the denominator: 6.

Step 2: Count how many ways you can roll a three with one die. Put this number in the numerator: 1/6.

Step 3: To find the probability that you will throw 2 threes, multiply the probability of throwing the first three by the probability of throwing the second three: $1/6 \times 1/6 = 1/36$.

Now It's Your Turn

If you roll a single die, what is the probability that you will roll an even number?

Calculating Probabilities

To find the probability that you will toss two heads in a row, multiply the probability of tossing the first head ($1/2$) by the probability of tossing the second head ($1/2$). The probability of tossing two heads in a row is $1/4$.

Genotype Probability

To have white flowers, a pea plant must receive a p allele from each parent. Each offspring of a $Pp \times Pp$ cross has a 50% chance of receiving either allele from either parent. So, the probability of inheriting two p alleles is $1/2 \times 1/2$, which equals $1/4$, or 25%. Traits in pea plants are easy to predict because there are only two choices for each trait, such as purple or white flowers and round or wrinkled seeds. Look at **Figure 4**. Do you see only two distinct choices for fur color?



Figure 4 These kittens inherited one allele from their mother for each trait.

CONNECTION TO Chemistry

Round and Wrinkled Round seeds may look better, but wrinkled seeds taste sweeter. The dominant allele for seed shape, R , causes sugar to be changed into starch (which is a storage molecule for sugar). This change makes the seed round. Seeds with the genotype rr do not make or store this starch. Because the sugar has not been changed into starch, the seed tastes sweeter. If you had a pea plant with round seeds (Rr), what would you cross it with to get some offspring with wrinkled seeds? Draw a Punnett square showing your cross.

ACTIVITY

Homework

GENERAL

Punnett Squares Have students create Punnett squares for each of the different crosses in Mendel's experiments. Students should include the genotype and phenotype of each parent and each set of possible offspring. **Visual/Logical**

WEIRD SCIENCE

Many ordinary fruits and vegetables carry recessive genes for bizarre traits. For instance, a recessive gene in tomatoes causes the skin to be covered with fuzzy hair!

Answer to Math Focus

$3/6$ or $1/2$

Answer to Connection to Chemistry

You would cross it with a plant with wrinkled seeds (rr). Students should draw a Punnett square showing this cross.

	R	r
r	Rr	rr
r	Rr	rr

MISCONCEPTION ALERT

Exception to Mendel's Rules

Caution students not to assume that all inherited traits follow the examples studied by Mendel. For instance, a cross between a red-haired horse and a white-haired horse can produce a horse with both red and white hair. Such a horse is said to have a roan coat. This is an example of *codominance*—the expression of two phenotypes at the same time within the same organism. As in the case of incomplete dominance (which is when a heterozygote shows a phenotype that is intermediate between the homozygous traits), both alleles are visible in the offspring, and therefore neither allele is purely dominant.

Close

Reteaching BASIC



Exceptions Have students describe three exceptions to Mendel's heredity principles in their science journal. Verbal

Quiz GENERAL

In rabbits, the allele for black fur, B , is dominant over the allele for white fur, b . Suppose two black parents produce one white and three black bunnies.

- What are the genotypes of the parents? (The parents must both have the recessive allele, so they are both genotype Bb .)
- What are the possible genotypes of all four siblings? (White has genotype bb , and black may have BB or Bb .)

Alternative Assessment GENERAL



Tracing Traits Ask students to imagine two true-breeding animal parents that have different genetic traits. Have them assign three characteristics, such as tall or short and red nosed or blue nosed, to each parent. Have students label each characteristic as either dominant or recessive. Then, have students use Punnett squares to determine the possible genotypes and phenotypes for each trait in the parents' offspring and in a possible second generation.

Logical/Interpersonal English Language Learners

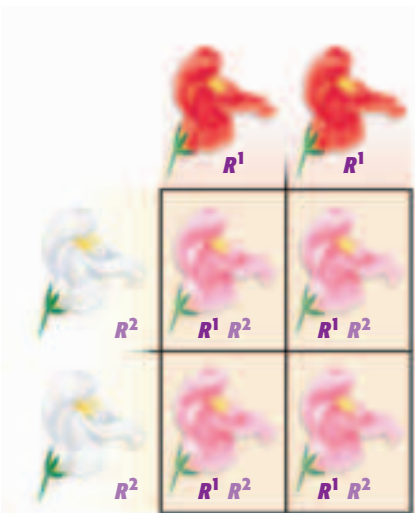


Figure 5 Cross-breeding two true-breeding snapdragons provides a good example of incomplete dominance.

More About Traits

As you may have already discovered, things are often more complicated than they first appear to be. Gregor Mendel uncovered the basic principles of how genes are passed from one generation to the next. But as scientists learned more about heredity, they began to find exceptions to Mendel's principles. A few of these exceptions are explained below.

Incomplete Dominance

Since Mendel's discoveries, researchers have found that sometimes one trait is not completely dominant over another. These traits do not blend together, but each allele has its own degree of influence. This is known as *incomplete dominance*.

One example of incomplete dominance is found in the snapdragon flower. **Figure 5** shows a cross between a true-breeding red snapdragon (R^1R^1) and a true-breeding white snapdragon (R^2R^2). As you can see, all of the possible phenotypes for their offspring are pink because both alleles of the gene have some degree of influence.

✓ Reading Check What is incomplete dominance?

One Gene, Many Traits

Sometimes one gene influences more than one trait. An example of this phenomenon is shown by the white tiger in **Figure 6**. The white fur is caused by a single gene, but this gene influences more than just fur color. Do you see anything else unusual about the tiger? If you look closely, you'll see that the tiger has blue eyes. Here, the gene that controls fur color also influences eye color.



Figure 6 The gene that gave this tiger white fur also influenced its eye color.



Round Peas Mendel found that round seeds were dominant over wrinkled seeds. However, at the microscopic level, this is a case of incomplete dominance. The R and r alleles actually seem to affect the amount of starch produced in the

pea. RR seeds have many starch grains that give them a full, round shape, but rr seeds have few starch grains and a wrinkled shape. Rr seeds have an intermediate number of starch grains—but enough for the pea to be full and round.

Many Genes, One Trait

Some traits, such as the color of your skin, hair, and eyes, are the result of several genes acting together. Therefore, it's difficult to tell if some traits are the result of a dominant or a recessive gene. Different combinations of alleles result in different eye-color shades, as shown in **Figure 7**.

The Importance of Environment

Genes aren't the only influences on traits. A guinea pig could have the genes for long fur, but its fur could be cut. In the same way, your environment influences how you grow. Your genes may make it possible that you will grow to be tall, but you need a healthy diet to reach your full potential height.

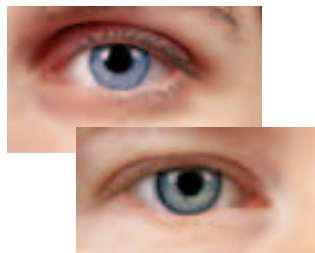


Figure 7 At least two genes determine human eye color. That's why many shades of a single color are possible.

Answer to Reading Check

In incomplete dominance, one trait is not completely dominant over another.

Answers to Section Review

1. Sample answer: Alleles are different versions of the same gene.
2. Sample answer: Genotype is the set of alleles an organism has inherited from its parents. Phenotype is the way the genes are expressed physically.
3. b
4. The genotype of an organism contains the two alleles for each characteristic. One allele of each pair was inherited from each of the organism's parents. The phenotype of the organism is the way the genotype affects the organism physically. For example, if an organism inherits one dominant allele for brown fur and one recessive allele for white fur, its phenotype will be brown fur.
5. incomplete dominance, one gene influencing more than one trait, and one trait being influenced by many genes
6. $1/6 \times 1/6 \times 1/6 = 1/216$
7. Approximately half of the offspring will have the phenotype of cleft chins (genotypes Cc), and half will not (genotypes cc).
8. BB, bb
9. Sample answer: a shade of gray

SECTION Review

Summary

- Instructions for an inherited trait are called **genes**. For each gene, there are two alleles, one inherited from each parent. Both alleles make up an organism's genotype. Phenotype is an organism's appearance.
- Punnett squares show all possible offspring genotypes.
- Probability can be used to describe possible outcomes in offspring and the likelihood of each outcome.
- Incomplete dominance occurs when one allele is not completely dominant over the other allele.
- Some genes influence more than one trait.

Using Key Terms

1. Use the following terms in the same sentence: *gene* and *allele*.
2. In your own words, write a definition for each of the following terms: *genotype* and *phenotype*.

Understanding Key Ideas

3. Use a Punnett square to determine the possible genotypes of the offspring of a $BB \times Bb$ cross.
 - a. all BB
 - b. BB, Bb
 - c. BB, Bb, bb
 - d. all bb
4. How are genes and alleles related to genotype and phenotype?
5. Describe three exceptions to Mendel's observations.

Math Skills

6. What is the probability of rolling a five on one die three times in a row?

Critical Thinking

7. **Applying Concepts** The allele for a cleft chin, C, is dominant among humans. What are the results of a cross between parents with genotypes Cc and cc?

Interpreting Graphics

The Punnett square below shows the alleles for fur color in rabbits. Black fur, B, is dominant over white fur, b.

	?	?	
?	Bb	Bb	
?	Bb	Bb	



8. Given the combinations shown, what are the genotypes of the parents?
9. If black fur had incomplete dominance over white fur, what color would the offspring be?

Developed and maintained by the National Science Teachers Association

For a variety of links related to this chapter, go to www.scilinks.org

Topic: Genotypes; Phenotypes
SciLinks code: HSM0664; HSM1135

MISCONCEPTION ALERT

Nature Versus Nurture Many students believe that characteristics acquired through the environment may be inherited, or believe that learned skills and behavioral similarities (perhaps learned from parents) are necessarily inherited. Although environment may influence the expression of genes, an organism may only pass on those genes that it was born with (unless there is a mutation in the genes of the sex cells).

CHAPTER RESOURCES

Chapter Resource File

- Section Quiz **GENERAL**
- Section Review **GENERAL**
- Vocabulary and Section Summary **GENERAL**
- Reinforcement Worksheet **BASIC**
- Datasheets for Quick Labs

Focus

Overview

In this section, students are introduced to meiosis and relate it to Mendel's findings. Students also learn about sex chromosomes and hereditary disorders.

Bellringer

Ask students to write a sentence for each of the following terms: *heredity*, *genotype*, *phenotype*.

(Sample answer: Heredity is the passing of traits from parents to offspring. The combination of an organism's alleles is its genotype. All of an organism's physical traits are its phenotype.)

Motivate

Activity

GENERAL

Crosses Have students model a cross between an organism with one pair of chromosomes and a member of the opposite sex of its species. Show the chromosomes in the cross as " $F_1F_2 \times M_1M_2$." Explain that F_1 and F_2 represent the father's chromosomes, and M_1 and M_2 represent the mother's chromosomes. Ask students, "If each parent contributes only one chromosome from his or her own pair to the offspring, what are the possible combinations in the offspring?" (F_1M_1 , F_1M_2 , F_2M_1 , and F_2M_2) **Logical/Visual**

What You Will Learn

- Explain the difference between mitosis and meiosis.
- Describe how chromosomes determine sex.
- Explain why sex-linked disorders occur in one sex more often than in the other.
- Interpret a pedigree.

Vocabulary

homologous chromosomes
meiosis
sex chromosome
pedigree

READING STRATEGY

Reading Organizer As you read this section, make a flowchart of the steps of meiosis.

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

Meiosis

Where are genes located, and how do they pass information? Understanding reproduction is the first step to finding the answers.

There are two kinds of reproduction: asexual and sexual. Asexual reproduction results in offspring with genotypes that are exact copies of their parent's genotype. Sexual reproduction produces offspring that share traits with their parents but are not exactly like either parent.

Asexual Reproduction

In *asexual reproduction*, only one parent cell is needed. The structures inside the cell are copied, and then the parent cell divides, making two exact copies. This type of cell reproduction is known as *mitosis*. Most of the cells in your body and most single-celled organisms reproduce in this way.

Sexual Reproduction

In sexual reproduction, two parent cells join together to form offspring that are different from both parents. The parent cells are called *sex cells*. Sex cells are different from ordinary body cells. Human body cells have 46, or 23 pairs of, chromosomes. One set of human chromosomes is shown in **Figure 1**. Chromosomes that carry the same sets of genes are called **homologous** (hoh MAHL uh guhs) **chromosomes**. Imagine a pair of shoes. Each shoe is like a homologous chromosome. The pair represents a homologous pair of chromosomes. But human sex cells are different. They have 23 chromosomes—half the usual number. Each sex cell has only one of the chromosomes from each homologous pair. Sex cells have only one "shoe."

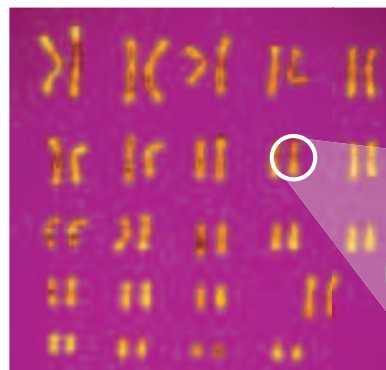
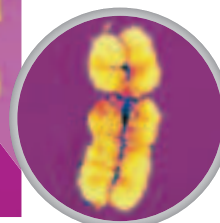


Figure 1 Human body cells have 23 pairs of chromosomes. One member of a pair of homologous chromosomes is shown below.



CHAPTER RESOURCES

Chapter Resource File

- Lesson Plan
- Directed Reading A **BASIC**
- Directed Reading B **SPECIAL NEEDS**

Technology

- Transparencies
- Bellringer

Workbooks

- Interactive Textbook **Struggling Readers**

CONNECTION Activity

Math

ADVANCED

Crosses In algebraic multiplication, some students use the mnemonic device FOIL (first, outer, inner, last). This device can be used to calculate genotype crosses. For example, the cross $X_1X_2 \times Y_1Y_2$ yields:

First: X_1X_2

Outer: X_1Y_2

Inner: X_2Y_1

Last: Y_1Y_2

Logical/Auditory

Meiosis

Sex cells are made during meiosis (mie OH sis). **Meiosis** is a copying process that produces cells with half the usual number of chromosomes. Each sex cell receives one-half of each homologous pair. For example, a human egg cell has 23 chromosomes, and a sperm cell has 23 chromosomes. The new cell that forms when an egg cell and a sperm cell join has 46 chromosomes.

✓ Reading Check How many chromosomes does a human egg cell have? (See the Appendix for answers to Reading Checks.)

Genes and Chromosomes

What does all of this have to do with the location of genes? Not long after Mendel's work was rediscovered, a graduate student named Walter Sutton made an important observation. Sutton knew of Mendel's studies, which showed that the egg and sperm must each contribute the same amount of information to the offspring. That was the only way the 3:1 ratio found in the second generation could be explained. Sutton also knew from his own studies that although eggs and sperm were different, they did have something in common: Their chromosomes were located inside a nucleus. Using his observations of meiosis, his understanding of Mendel's work, and some creative thinking, Sutton proposed something very important:

Genes are located on chromosomes!

Understanding meiosis was critical to finding the location of genes. Before you learn about meiosis, review mitosis, shown in **Figure 2**. Meiosis is outlined in **Figure 3** on the next two pages.

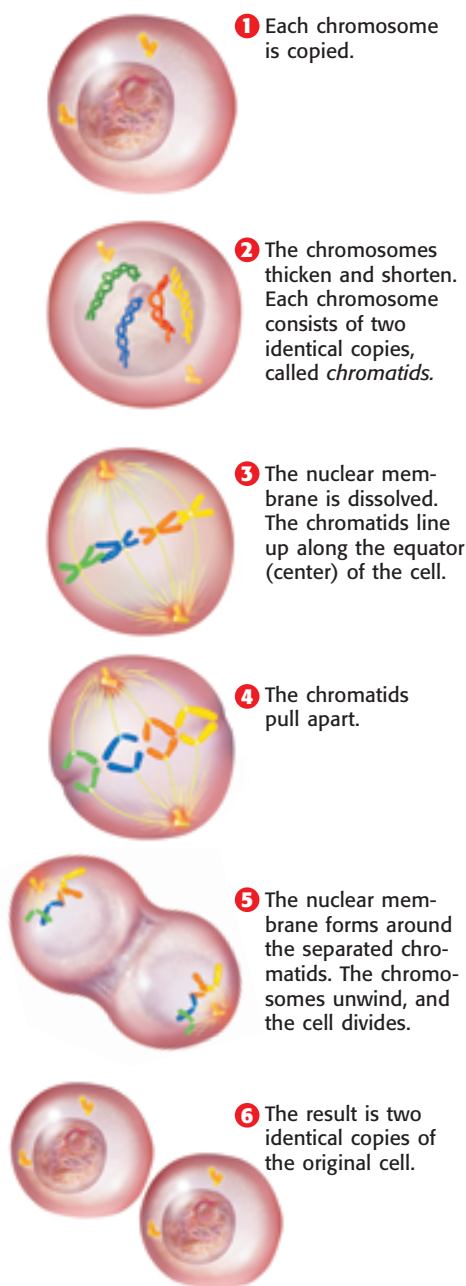
CONNECTION TO Language Arts

Greek Roots The word *mitosis* is related to a Greek word that means "threads." Threadlike spindles are visible during mitosis. The word *meiosis* comes from a Greek word that means "to make smaller." How do you think meiosis got its name?

Answer to Connection to Language Arts

Sample answer: Meiosis makes each of the daughter cells smaller than the parent cell. Also, there are fewer chromosomes in the daughter cells than in the parent cell.

Figure 2 Mitosis Revisited



Using the Figure — BASIC

Mitosis and Meiosis Have students examine **Figures 2** and **3** to compare what happens in each type of cell division. On the board, draw two identical cells, each of which contains four chromosomes. Label one cell "Mitosis," and label the other "Meiosis." Have students describe what happens in each stage of mitosis, and have them illustrate the stages on the board and in their **science journal**. (Using colored chalk might help distinguish between the dividing chromosomes.) Repeat the process for meiosis. Point out that mitosis results in two identical cells, each of which contains four chromosomes, and meiosis results in four cells, each of which contains two chromosomes. **Visual**

Answer to Reading Check
23 chromosomes

CONNECTION to Real World — ADVANCED

Aging and Cell Division

Research suggests a connection between aging, cell division, and mitosis. The ends of the chromosomes are protected by special sequences of DNA that do not seem to code for proteins but rather serve a function similar to that of the plastic tips on the ends of shoelaces. These structures, called *telomeres*, act as protective caps on the ends of the long strand of DNA that makes up each chromosome. However, with each cell division, the telomeres lose a little bit of material. At some point, the telomeres become so short that the cell can no longer divide. Eventually, the cell dies, which brings the organism one step closer to its inevitable end.

Science Bloopers

Wrong Number In 1918, a prominent scientist miscounted the number of chromosomes in a human cell. He counted 48. For almost 40 years, scientists thought this number was correct. In fact, not until 1956 were chromosomes counted correctly and found to number only 46.



Prediction Guide Before students read the passage about meiosis, ask them whether the following statements are true or false. Students will discover the answers as they explore the rest of the section.

- Mitosis is the only type of cell division. (false)
- Only cells that produce sex cells undergo meiosis. (true)
- Sex cells contain half the number of chromosomes that other body cells do. (true)

LS Verbal/Auditory

Answer to Reading Check

During meiosis, one parent cell makes four new cells.

Discussion

GENERAL

Predicting Problems Ask students what they think would happen if something went wrong during cell division and the sperm or egg cell ended up with either too few or too many chromosomes? (The fertilized egg, with too few or too many chromosomes, may die, or the growing embryo may have birth defects. Down syndrome occurs in humans when the offspring receives an extra twenty-first chromosome.)

LS Verbal/Logical

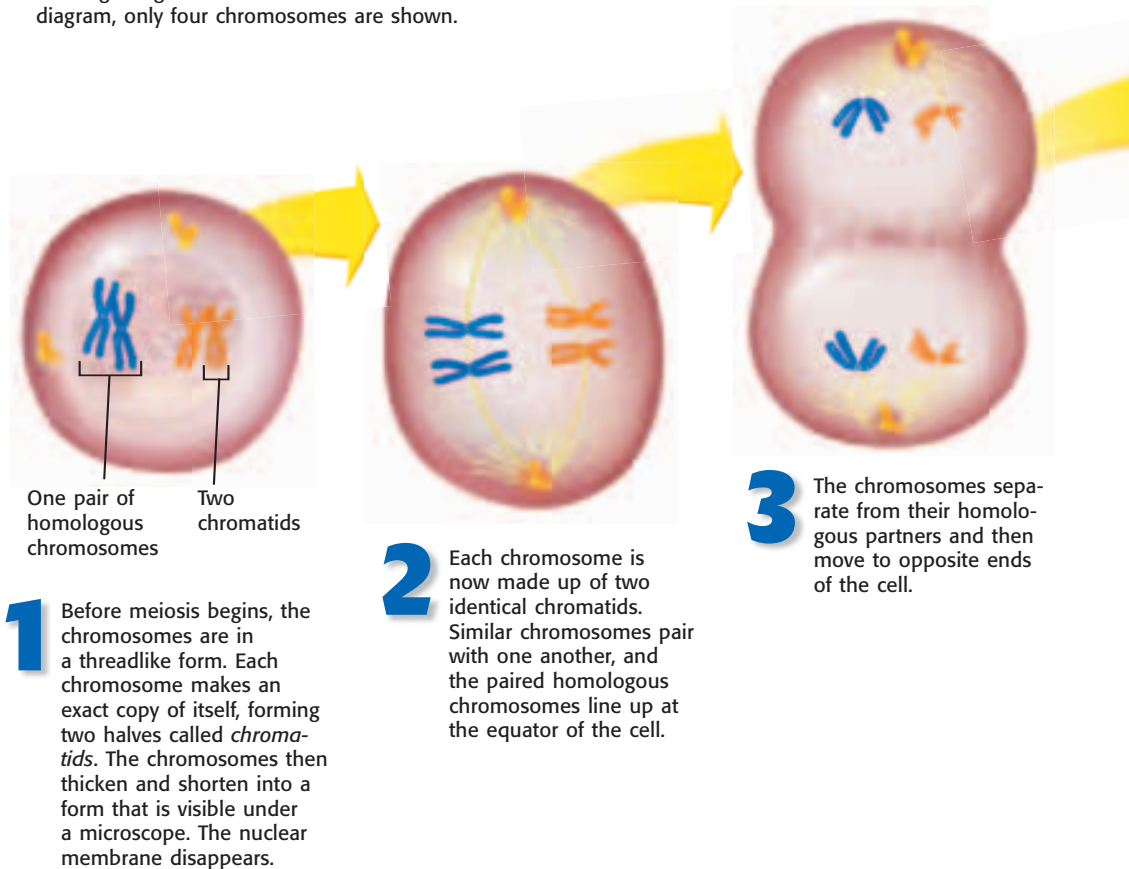
The Steps of Meiosis

During mitosis, chromosomes are copied once, and then the nucleus divides once. During meiosis, chromosomes are copied once, and then the nucleus divides twice. The resulting sperm and eggs have half the number of chromosomes of a normal body cell. **Figure 3** shows all eight steps of meiosis. Read about each step as you look at the figure. Different types of living things have different numbers of chromosomes. In this illustration, only four chromosomes are shown.

✓ Reading Check How many cells are made from one parent cell during meiosis?

Figure 3 Steps of Meiosis

Read about each step as you look at the diagram. Different types of living things have different numbers of chromosomes. In this diagram, only four chromosomes are shown.



CHAPTER RESOURCES

Technology



Transparencies

- L14 The Steps of Meiosis: A
- L15 The Steps of Meiosis: B

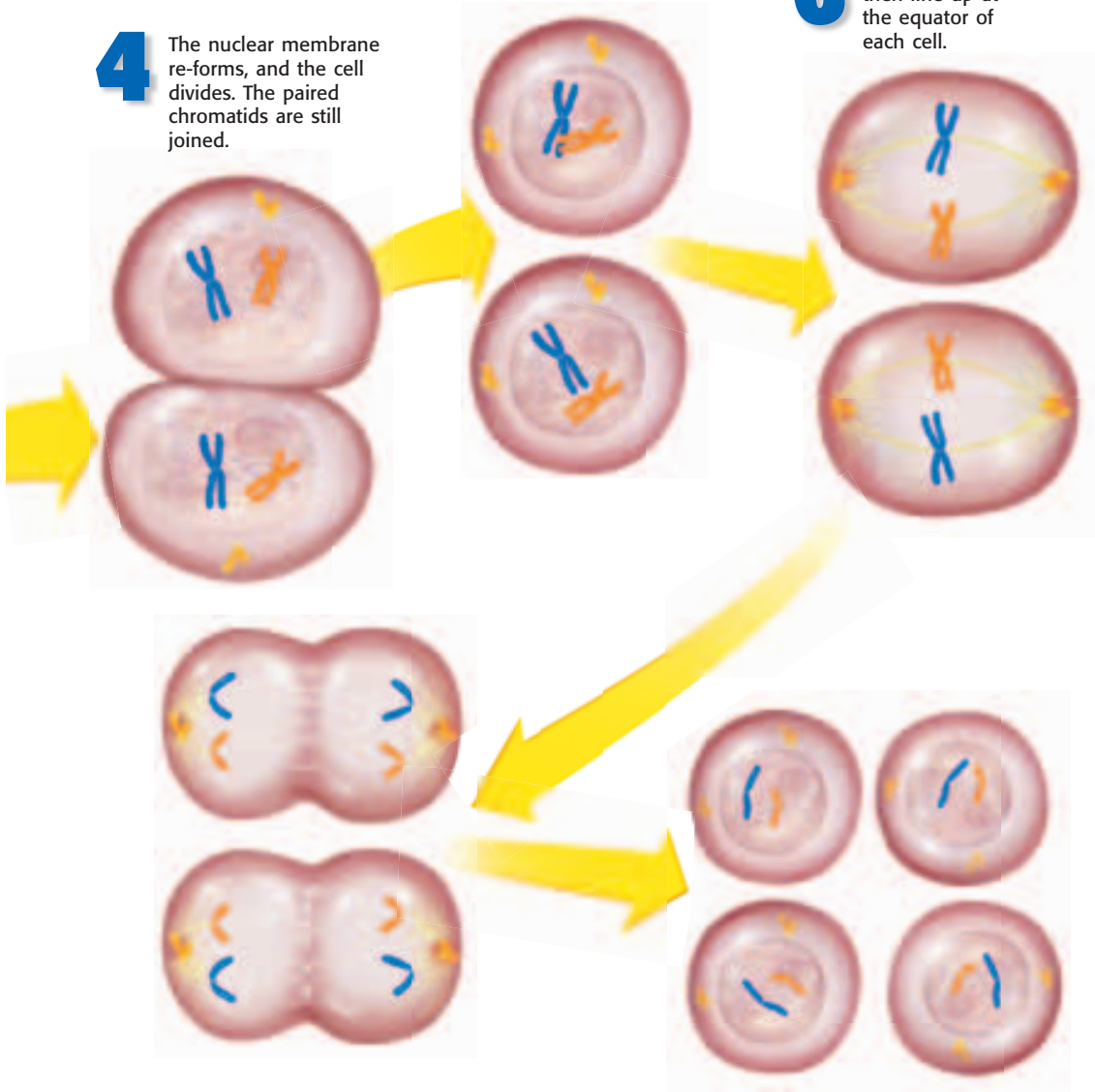
SUPPORT FOR

English Language Learners

Meiosis vs. Mitosis Because these terms can sound very similar, have students practice distinguishing between the two. Read several statements aloud that begin with either meiosis or mitosis. Ask students to hold up their right hand when they hear *meiosis* and their left hand when they hear *mitosis*. If there are some students who are still having trouble, provide them with additional statements so they can use the same technique to practice in a small group. **LS Verbal/Auditory**

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

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



6 The chromosomes then line up at the equator of each cell.

7 The chromatids pull apart and move to opposite ends of the cell. The nuclear membrane forms around the separated chromosomes, and the cells divide.

8 The result is that four new cells have formed from the original single cell. Each new cell has half the number of chromosomes present in the original cell.

ActiVity

BASIC

Describing Meiosis Have students write their own captions for the steps of meiosis illustrated here. They should use language and descriptions that will help them understand and remember the material.

LS Verbal/Visual

CONNECTION ActiVity

Math

GENERAL

Chromosome Number Meiosis and sexual reproduction have benefits for organisms because these processes maintain a variety of traits within a population. Meiosis and sexual recombination reshuffle the genetic material in each generation. Furthermore, the division of chromosomes during meiosis ensures that when the egg and sperm combine, the new organism has the same number of chromosomes as its parents. To explore these concepts, ask students the following questions:

- If the normal number of chromosomes for a certain organism is 30, how many chromosomes would be found in the egg or sperm cells? (15)
- What would happen if eggs and sperm were produced by mitosis instead of by meiosis? (The organism would produce sex cells with a full set of 30 chromosomes.)
- If the organism described above were to have offspring that also produced sex cells by mitosis, how many chromosomes would be found in the descendants after four generations? (first generation: 60; second generation: 120; third generation: 240; fourth generation: 480)

LS Verbal/Logical



Q: If human sex cells are created by meiosis, how are cat sex cells produced?

A: by meow-sis

MISCONCEPTION ALERT

Chromatids and Chromosome Pairing

Students often have difficulty keeping track of the differences between the way that chromatids and chromosome pairs move during mitosis as compared to meiosis. Caution students to note these differences as they compare mitosis and meiosis, and to analyze the ways that these differences are critical to each process.

INCLUSION Strategies

- Learning Disabled
- Attention Deficit Disorder

Have students make a flip book that animates the phases of meiosis. First, have students draw the events of meiosis in at least 15 sketches on sturdy cards. Explain that each drawing should vary only slightly from the one before it. When the book is flipped through quickly, the images should appear to be in motion, and students will be able to watch meiosis in action. This activity could be repeated to demonstrate mitosis.

Visual

English Language Learners

Group Activity — GENERAL

Comparing Mitosis and Meiosis Organize the class into small groups. Instruct each group to create a table listing the similarities and differences between mitosis and meiosis. Challenge groups to make the longest list possible in a limited time period. After their time is up, have groups report items from their lists. Discuss and correct items as you compile a single, large table for display in the classroom.

Visual/Verbal

English Language Learners

INTERNET ACTIVITY

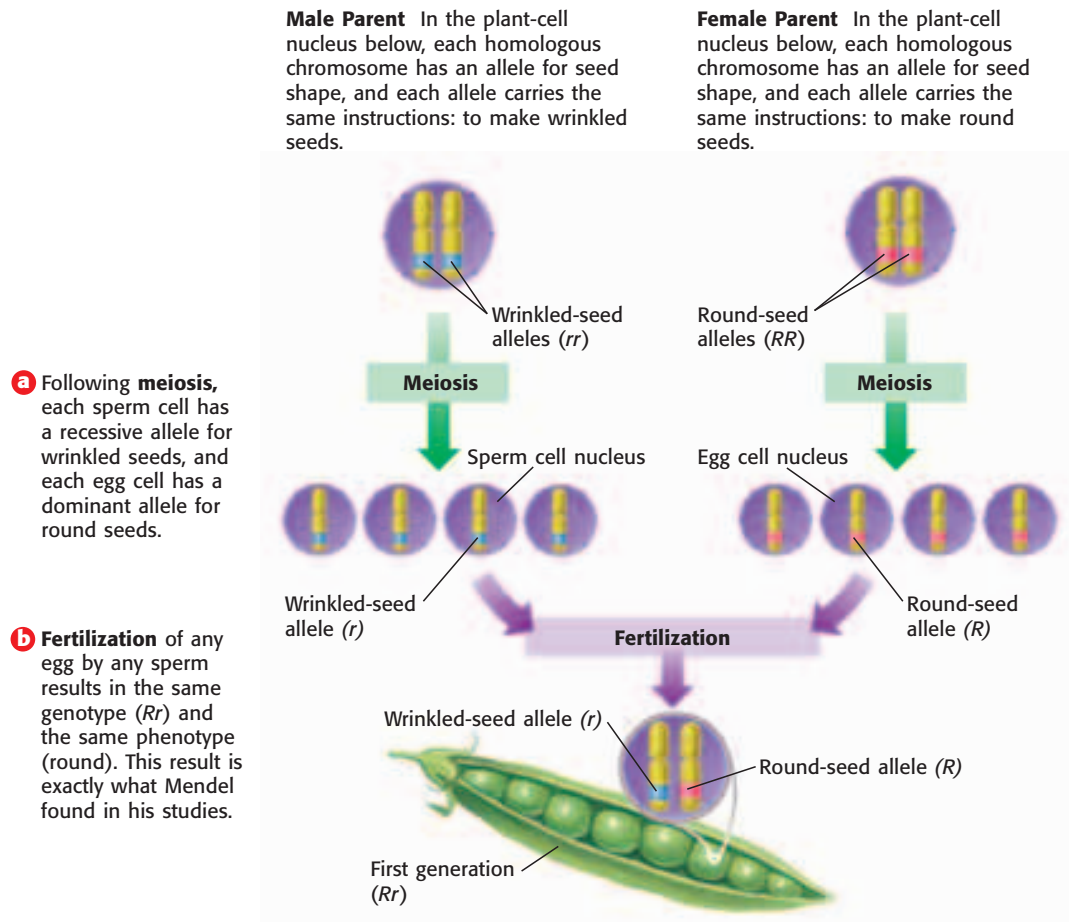
For another activity related to this chapter, go to go.hrw.com and type in the keyword **HL5HERW**.

Meiosis and Mendel

As Walter Sutton figured out, the steps in meiosis explained Mendel's results. **Figure 4** shows what happens to a pair of homologous chromosomes during meiosis and fertilization. The cross shown is between a plant that is true breeding for round seeds and a plant that is true breeding for wrinkled seeds.

Each fertilized egg in the first generation had one dominant allele and one recessive allele for seed shape. Only one genotype was possible because all sperm formed by the male parent during meiosis had the wrinkled-seed allele, and all of the female parent's eggs had the round-seed allele. Meiosis also helped explain other inherited characteristics.

Figure 4 Meiosis and Dominance



CHAPTER RESOURCES

Technology



Transparencies

- L16 Meiosis and Dominance

Is That a Fact!

Martin-Bell syndrome is a genetic disorder also known as *Fragile X syndrome*. It is one of the most common forms of inherited mental retardation. This disorder is a genetic condition associated with mental retardation and autism. The disorder is identified by flaws apparent in the long arm of the X chromosome.

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. But 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 the 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, as shown in **Figure 5**.

Sex-Linked Disorders

The Y chromosome does not carry all of the genes of an X chromosome. 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. The genes for certain disorders, such as colorblindness, are carried on the X chromosome. These disorders are called *sex-linked disorders*. Because the gene for such disorders is recessive, men are more likely to have sex-linked disorders.

People who are colorblind can have trouble distinguishing between shades of red and green. To help the colorblind, some cities have added shapes to their street lights, as shown in **Figure 6**. Hemophilia (HEE moh FIL ee uh) is another sex-linked disorder. Hemophilia prevents blood from clotting, and people with hemophilia bleed for a long time after small cuts. Hemophilia can be fatal.



Figure 6 This stoplight in Canada is designed to help the colorblind see signals easily. This photograph was taken over a few minutes to show all three shapes.

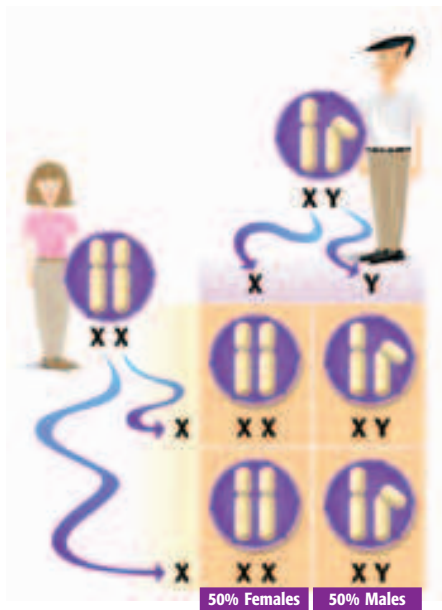


Figure 5 Egg and sperm combine to form either the XX or XY combination.

sex chromosome one of the pair of chromosomes that determine the sex of an individual

CONNECTION ACTIVITY

Language Arts

GENERAL



Chromosome Chronicle

Have students write an entry in their **science journal** to chronicle events in the “life” of a chromosome containing an allele for a specific trait. Have students describe the chromosome’s role in the parent organism, the first-generation offspring, and the second-generation offspring. Descriptions should define whether the trait is dominant or recessive, and they should include an analysis of the factors that determine the genotype and phenotype of the parent and the offspring. **Verbal**

CONNECTION to Real World

ADVANCED

Other Types of Genetic Disorders

Other types of genetic disorders include chromosomal disorders and somatic gene disorders. Chromosomal disorders are abnormalities in the number or structure of the chromosomes. These disorders are often severe and include Down syndrome, Turner’s syndrome, and Klinefelter’s syndrome. Somatic gene disorders are conditions in which gene abnormalities develop only in certain cells. Many forms of cancer are caused by a somatic gene disorder.

BRAIN FOOD

In human males, meiosis and sperm production take about nine weeks and occur continuously after puberty begins. In females, meiosis and egg production begin before birth and then stop until puberty. From puberty until menopause, one egg each month resumes meiosis and finishes developing. So, production of a mature egg may take up to 50 years!

MISCONCEPTION ALERT

Cells That Undergo Meiosis A common misconception is that all or many types of cells can undergo meiosis. Make sure students understand that meiosis occurs only during the formation of sex cells (egg or sperm cells).

Close

Reteaching

BASIC

Modeling Mates

Have students use Punnett squares to model several possible combinations of parents with sex-linked traits that are variously dominant and recessive.

Logical/Kinesthetic English Language Learners

Quiz

GENERAL

Are the following statements true or false?

1. Every one of the chromosomes is different between men and women. (false)
2. Men and women each have different numbers of chromosomes in their sex cells. (false)
3. If you looked inside a cell during mitosis and you could see the chromosomes lining up, you could tell whether the cell belongs to a man or a woman. (true)

Alternative Assessment

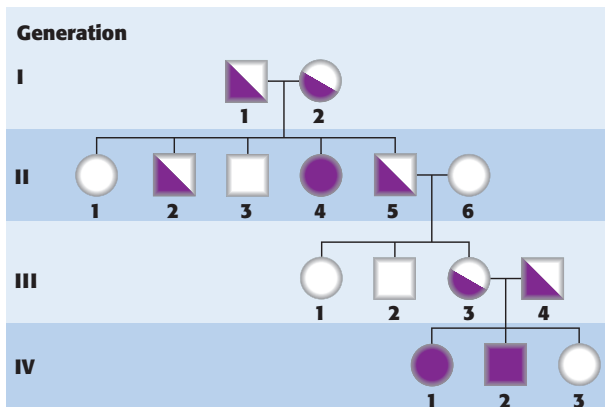
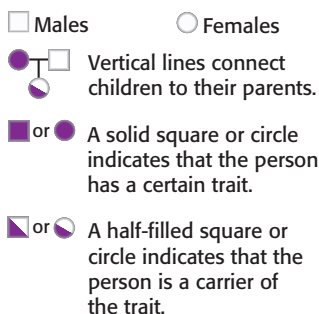
GENERAL



Meiosis versus Mitosis

Tell students that there will be a mock debate to decide whether mitosis or meiosis is "better." First, have the class discuss and agree upon a definition of "better." Then, have students choose a "side" and prepare a written argument that is supported by scientific facts. You may wish to allow volunteers to act out such a debate. **Verbal**

Figure 7 Pedigree for a Recessive Disease



pedigree a diagram that shows the occurrence of a genetic trait in several generations of a family



Figure 8 Roses have been selectively bred to create large, bright flowers.

Genetic Counseling

Hemophilia and other 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 make use of a diagram known as a **pedigree**, which 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 shown in **Figure 7** traces a disease called *cystic fibrosis* (SIS tik FIE broh sis). 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.

Pedigrees can be drawn up to trace any trait through a family tree. You could even draw a pedigree that would show how you inherited your hair color. Many different pedigrees could be drawn for a typical family.

Selective Breeding

For thousands of years, humans have seen the benefits of the careful breeding of plants and animals. In *selective breeding*, organisms with desirable characteristics are mated. You have probably enjoyed the benefits of selective breeding, although you may not have realized it. For example, you have probably eaten an egg from a chicken that was bred to produce more eggs. Your pet dog may be a result of selective breeding. Roses, like the one shown in **Figure 8**, have been selectively bred to produce large flowers. Wild roses are much smaller and have fewer petals than roses that you could buy at a nursery.

WEIRD SCIENCE

Gene therapy is an experimental field of medical research in which defective genes are replaced with healthy genes. One way to insert healthy genes involves using a delivery system called a *gene gun* to inject microscopic gold bullets coated with genetic material.

Homework

ADVANCED

Pet Pedigrees

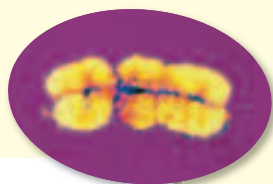
Have students obtain a copy of the pedigree of a thoroughbred animal from a professional breeder of dogs, cats, horses, or other animals. Ask students to write a paragraph explaining what information the pedigree provides about the animal and its ancestors.

Verbal/Interpersonal

SECTION Review

Summary

- In mitosis, chromosomes are copied once, and then the nucleus divides once. In meiosis, chromosomes are copied once, and then the nucleus divides twice.
- The process of meiosis produces sex cells, which have half the number of chromosomes. These two halves combine during reproduction.
- In humans, females have two X chromosomes. So, each egg contains one X chromosome. Males have both an X and a Y chromosome. So, each sperm cell contains either an X or a Y chromosome.
- Sex-linked disorders occur in males more often than in females. Colorblindness and hemophilia are examples of sex-linked disorders.
- A pedigree is a diagram used to trace a trait through many generations of a family.



Using Key Terms

- Use each of the following terms in the same sentence: *meiosis* and *sex chromosomes*.

In each of the following sentences, replace the incorrect term with the correct term from the word bank.

pedigree homologous chromosomes
meiosis mitosis

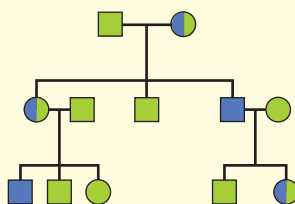
- During fertilization, chromosomes are copied, and then the nucleus divides twice.
- A Punnett square is used to show how inherited traits move through a family.
- During meiosis, sex cells line up in the middle of the cell.

Understanding Key Ideas

- Genes are found on
 - chromosomes.
 - proteins.
 - alleles.
 - sex cells.
- If there are 14 chromosomes in pea plant cells, how many chromosomes are present in a sex cell of a pea plant?
- Draw the eight steps of meiosis. Label one chromosome, and show its position in each step.

Interpreting Graphics

Use this pedigree to answer the question below.



- Is this disorder sex linked? Explain your reasoning.

Critical Thinking

- Identifying Relationships** Put the following in order of smallest to largest: chromosome, gene, and cell.
- Applying Concepts** A pea plant has purple flowers. What alleles for flower color could the sex cells carry?

SCILINKS **NSTA**

Developed and maintained by the
National Science Teachers Association

For a variety of links related to this chapter, go to www.scilinks.org

Topic: Meiosis; Genetic Diseases, Screening, Counseling

SciLinks code: HSM0935; HSM0651

Answers to Section Review

- Sample answer: At the end of meiosis, each sex cell will contain only one sex chromosome (either X or Y).
- During meiosis, chromosomes are copied, and then the nucleus divides twice.
- A pedigree is used to show how inherited traits move through a family.
- During meiosis, homologous chromosomes line up in the middle of the cell.
- a
- 7
- Answers may vary. Students' drawings should be similar to the diagram of meiosis in the student text.
- Sample answer: yes; The disorder seems to be sex linked because the females are carriers of the disease but only males have the disease itself.
- gene, chromosome, cell
- Sample answer: Because the purple gene (*P*) is dominant over the white gene (*p*), the genotype of the purple-flowered pea plant could be either *PP* or *Pp*. Thus, the possible alleles carried by the sex cells would be *P* or *p*.

INTERNET ACTIVITY

Essay

GENERAL

For an internet activity related to this chapter, have students go to go.hrw.com and type in the keyword **HL5DNAW**.

CHAPTER RESOURCES

Chapter Resource File

- Section Quiz **GENERAL**
- Section Review **GENERAL**
- Vocabulary and Section Summary **GENERAL**
- Critical Thinking **ADVANCED**

Bug Builders, Inc.

Teacher's Notes

Time Required

Two 45-minute class periods

Lab Ratings



Teacher Prep

Student Set-Up

Concept Level

Clean Up

MATERIALS

The materials listed on the student page are enough for a group of 3–4 students. For step 3, prepare 14 small paper sacks—representing paired parent alleles for each of seven characteristics—as follows:

1. Use the table in step 6 to decide the genotypes for each of the parent bugs' characteristics.
2. Cut 1 in. squares of paper to represent alleles. Use seven colors of paper—a different color for each characteristic. Cut enough squares so that each student will receive two alleles for each characteristic.
3. Label the alleles for each characteristic according to the genotypes you chose.
4. Label each pair of sacks with one of the seven characteristics. Place an equal number of alleles in each sack.
5. For each characteristic, label one sack "Mom" and the other sack "Dad." Have students draw one allele from each sack.

Using Scientific Methods

Model-Making Lab

OBJECTIVES

Build models to further your understanding of inheritance.

Examine the traits of a population of offspring.

MATERIALS

- allele sacks (14) (supplied by your teacher)
- gumdrops, green and black (feet)
- map pins (eyes)
- marshmallows, large (head and body segments)
- pipe cleaners (tails)
- pushpins, green and blue (noses)
- scissors
- toothpicks, red and green (antennae)

SAFETY

Bug Builders, Inc.

Imagine that you are a designer for a toy company that makes toy alien bugs. The president of Bug Builders, Inc., wants new versions of the wildly popular Space Bugs, but he wants to use the bug parts that are already in the warehouse. It's your job to come up with a new bug design. You have studied how traits are passed from one generation to another. You will use this knowledge to come up with new combinations of traits and assemble the bug parts in new ways. Model A and Model B, shown below, will act as the "parent" bugs.

Ask a Question

1 If there are two forms of each of the seven traits, then how many possible combinations are there?

Form a Hypothesis

2 Write a hypothesis that is a possible answer to the question above. Explain your reasoning.

Test the Hypothesis

3 Your teacher will display 14 allele sacks. The sacks will contain slips of paper with capital or lowercase letters on them. Take one piece of paper from each sack. (Remember: Capital letters represent dominant alleles, and lowercase letters represent recessive alleles.) One allele is from "Mom," and one allele is from "Dad." After you have recorded the alleles you have drawn, place the slips of paper back into the sack.

Model A ("Mom")

- red antennae
- 3 body segments
- curly tail
- 2 pairs of legs
- green nose
- black feet
- 3 eyes

Model B ("Dad")

- green antennae
- 2 body segments
- straight tail
- 3 pairs of legs
- blue nose
- green feet
- 2 eyes

Safety Caution

Remind students to review all safety cautions and icons before beginning this lab activity. Students should use caution with toothpicks and should not eat any of the materials used.

CHAPTER RESOURCES

Chapter Resource File

- Datasheet for Chapter Lab
- Lab Notes and Answers

Technology

- Classroom Videos
- Lab Video



- Tracing Traits



Ask a Question

1. There are 128 possible combinations. (Calculation: There are two forms of each of seven characteristics, so, $2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 2^7 = 128$)

Analyze the Results

1. Student ratios should be similar to the ratios determined when the alleles were selected by the teacher.
2. If any students have offspring bugs that look like one of the parents, have students compare the genotype of the offspring with the genotype of the parents. The offspring and parents look alike but still have different genotypes for some traits.

Draw Conclusions

3. Student answers should reflect the data on parent alleles that were recorded in step 5.
4. Students' answers should include Punnett squares based on the parental traits. Except for the results obtained by parental genotypes that are all homozygous recessive, students will see other possibilities for genotypes and phenotypes from the same parents.

Applying Your Data

Students should create Punnett squares to show the possible genotypes and describe phenotypes that follow the rules of dominance for each characteristic.

Bug Family Traits				
Trait	Model A "Mom" allele	Model B "Dad" allele	New model "Baby" genotype	New model "Baby" phenotype
Antennae color				
Number of body segments				
Tail shape				
Number of leg pairs				
Nose color				
Foot color				
Number of eyes				

DO NOT WRITE IN BOOK

4. Create a table like the one above. Fill in the first two columns with the alleles that you selected from the sacks. Next, fill in the third column with the genotype of the new model ("Baby").
5. Use the information below to fill in the last column of the table.

Genotypes and Phenotypes	
RR or Rr—red antennae	rr—green antennae
SS or Ss—3 body segments	ss—2 body segments
CC or Cc—curly tail	cc—straight tail
LL or Ll—3 pairs of legs	ll—2 pairs of legs
BB or Bb—blue nose	bb—green nose
GG or Gg—green feet	gg—black feet
EE or Ee—2 eyes	ee—3 eyes

6. Now that you have filled out your table, you are ready to pick the parts you need to assemble your bug. (Toothpicks can be used to hold the head and body segments together and as legs to attach the feet to the body.)

Analyze the Results

1. **Organizing Data** Take a poll of the traits of the offspring. What are the ratios for each trait?
2. **Examining Data** Do any of the new models look exactly like the parents? Explain.

Draw Conclusions

3. **Interpreting Information** What are the possible genotypes of the parent bugs?
4. **Making Predictions** How many different genotypes are possible in the offspring?

Applying Your Data

Find a mate for your "Baby" bug. What are the possible genotypes and phenotypes of the offspring from this match?



CHAPTER RESOURCES

Workbooks



Long-Term Projects & Research Ideas

• Portrait of a Dog **ADVANCED**



Holt Lab Generator CD-ROM

Search for any lab by topic, standard, difficulty level, or time. Edit any lab to fit your needs, or create your own labs. Use the Lab Materials QuickList software to customize your lab materials list.



Kathy LaRoe
East Valley Middle School
East Helena, Montana

Chapter Review



Chapter Review

Assignment Guide

SECTION	QUESTIONS
1	7, 13, 18
2	2, 4, 5, 8, 9, 11, 19–23
3	1, 3, 6, 10, 12, 14–17

ANSWERS

Using Key Terms

1. sex cells
2. phenotype, genotype
3. Meiosis
4. alleles

Understanding Key Ideas

5. d
6. c
7. b
8. b
9. c
10. c
11. b

USING KEY TERMS

Complete each of the following sentences by choosing the correct term from the word bank.

sex cells genotype
sex chromosomes alleles
phenotype meiosis

- 1 Sperm and eggs are known as ____.
- 2 The ____ is the expression of a trait and is determined by the combination of alleles called the ____.
- 3 ____ produces cells with half the normal number of chromosomes.
- 4 Different versions of the same genes are called ____.

UNDERSTANDING KEY IDEAS

Multiple Choice

- 5 Genes carry information that determines
 - a. alleles.
 - b. ribosomes.
 - c. chromosomes.
 - d. traits.
- 6 The process that produces sex cells is
 - a. mitosis.
 - b. photosynthesis.
 - c. meiosis.
 - d. probability.
- 7 The passing of traits from parents to offspring is called
 - a. probability.
 - b. heredity.
 - c. recessive.
 - d. meiosis.
- 8 If you cross a white flower with the genotype *pp* with a purple flower with the genotype *PP*, the possible genotypes in the offspring are
 - a. *PP* and *pp*.
 - b. all *Pp*.
 - c. all *PP*.
 - d. all *pp*.
- 9 For the cross in item 8, what would the phenotypes be?
 - a. all white
 - b. 3 purple and 1 white
 - c. all purple
 - d. half white, half purple
- 10 In meiosis,
 - a. chromosomes are copied twice.
 - b. the nucleus divides once.
 - c. four cells are produced from a single cell.
 - d. two cells are produced from a single cell.
- 11 When one trait is not completely dominant over another, it is called
 - a. recessive.
 - b. incomplete dominance.
 - c. environmental factors.
 - d. uncertain dominance.



Short Answer

12. Which sex chromosomes do females have? Which do males have?
13. In one or two sentences, define the term *recessive trait* in your own words.
14. How are sex cells different from other body cells?
15. What is a sex-linked disorder? Give one example of a sex-linked disorder that is found in humans.

CRITICAL THINKING

16. **Concept Mapping** Use the following terms to create a concept map: *meiosis*, *eggs*, *cell division*, *X chromosome*, *mitosis*, *Y chromosome*, *sperm*, and *sex cells*.
17. **Identifying Relationships** If you were a carrier of one allele for a certain recessive disorder, how could genetic counseling help you prepare for the future?
18. **Applying Concepts** If a child has blond hair and both of her parents have brown hair, what does that tell you about the allele for blond hair? Explain.
19. **Applying Concepts** What is the genotype of a pea plant that is true-breeding for purple flowers?



INTERPRETING GRAPHICS


Use the Punnett square below to answer the questions that follow.

	<i>T</i>	<i>t</i>
<i>T</i>	<i>TT</i>	<i>Tt</i>
<i>t</i>	<i>Tt</i>	<i>tt</i>

20. What is the unknown genotype?
21. If *T* represents the allele for tall pea plants and *t* represents the allele for short pea plants, what is the phenotype of each parent and of the offspring?
22. If each of the offspring were allowed to self-fertilize, what are the possible genotypes in the next generation?
23. What is the probability of each genotype in item 22?



Critical Thinking

16.  An answer to this exercise can be found at the end of this book.
17. Sample answer: A genetic counselor could test my spouse to see if my spouse is also a carrier of the recessive allele. The counselor could then predict what the chances are that we could have a child with the recessive disorder.
18. The allele for blond hair is recessive.
19. *PP*

Interpreting Graphics

20. *TT*
21. All the parents and offspring are tall pea plants.
22. Students should make two new Punnett squares. Self-fertilization of *TT* (*TT* × *TT*) will yield offspring that are all *TT*. Self fertilization of *Tt* (*Tt* × *Tt*) will yield offspring that are *TT*, *Tt*, and *tt*.
23. *TT* has a 100% probability with a *TT* parent and a 25% probability with a *Tt* parent. *Tt* has a 50% probability with a *Tt* parent and a 0% probability with a *TT* parent. The genotype *tt* has a 25% probability with a *Tt* parent and a 0% probability with a *TT* parent.

12. Females have two X chromosomes. Males have one X and one Y chromosome.
13. Sample answer: A recessive trait is a genetic trait that is expressed only if there is not a dominant allele present.
14. Sex cells have half the number of chromosomes as other body cells.
15. Sample answer: A sex-linked disorder is a disorder that is caused by a gene on one of the sex chromosomes and so is expressed in one sex more than the other. Color blindness is a sex-linked disorder found in humans.

CHAPTER RESOURCES

Chapter Resource File

- Chapter Review **GENERAL**
- Chapter Test A **GENERAL**
- Chapter Test B **ADVANCED**
- Chapter Test C **SPECIAL NEEDS**
- Vocabulary Activity **GENERAL**

Workbooks

- Study Guide
- Study Guide is also available in Spanish.

Standardized Test Preparation

Teacher's Note

To provide practice under more realistic testing conditions, give students 20 minutes to answer all of the questions in this Standardized Test Preparation.

MISCONCEPTION ALERT

Answers to the standardized test preparation can help you identify student misconceptions and misunderstandings.

READING

Passage 1

1. C
2. F
3. C



TEST DOCTOR

Question 2: This question primarily requires the reader to re-read the sentence in which the word is used, which clearly serves to define the word. Then, the reader must look among the possible answers for the one that most closely matches the meaning given in the sentence.

Question 3: This question requires a simple deduction from the final two sentences of the passage. The uses of "if," "then," and "therefore" are clear indicators of logical reasoning. Remind students to look for these kinds of indicators for these types of test questions.



Standardized Test Preparation

READING

Read the passages below. Then, answer the questions that follow each passage.

Passage 1 The different versions of a gene are called *alleles*. When two different alleles occur together, one is often expressed while the other has no obvious effect on the organism's appearance. The expressed form of the trait is dominant. The trait that was not expressed when the dominant form of the trait was present is called *recessive*. Imagine a plant that has both purple and white alleles for flower color. If the plant blooms purple, then purple is the dominant form of the trait. Therefore, white is the recessive form.

1. According to the passage, which of the following statements is true?
 - A All alleles are expressed all of the time.
 - B All traits for flower color are dominant.
 - C When two alleles are present, the expressed form of the trait is dominant.
 - D A recessive form of a trait is always expressed.
2. According to the passage, a trait that is not expressed when the dominant form is present is called
 - F recessive.
 - G an allele.
 - H heredity.
 - I a gene.
3. According to the passage, which allele for flower color is dominant?
 - A white
 - B pink
 - C purple
 - D yellow

Passage 2 Sickle cell anemia is a recessive genetic disorder. People inherit this disorder only when they inherit the disease-causing recessive allele from both parents. The disease causes the body to make red blood cells that bend into a sickle (or crescent moon) shape. The sickle-shaped red blood cells break apart easily. Therefore, the blood of a person with sickle cell anemia carries less oxygen. Sickle-shaped blood cells also tend to get stuck in blood vessels. When a blood vessel is blocked, the blood supply to organs can be cut off. But the sickle-shaped blood cells can also protect a person from malaria. Malaria is a disease caused by an organism that invades red blood cells.

1. According to the passage, sickle cell anemia is a
 - A recessive genetic disorder.
 - B dominant genetic disorder.
 - C disease caused by an organism that invades red blood cells.
 - D disease also called *malaria*.
2. According to the passage, sickle cell anemia can help protect a person from
 - F blocked blood vessels.
 - G genetic disorders.
 - H malaria.
 - I low oxygen levels.
3. Which of the following is a fact in the passage?
 - A When blood vessels are blocked, vital organs lose their blood supply.
 - B When blood vessels are blocked, it causes the red blood cells to bend into sickle shapes.
 - C The blood of a person with sickle cell anemia carries more oxygen.
 - D Healthy red blood cells never get stuck in blood vessels.

Passage 2

1. A
2. H
3. A



TEST DOCTOR

Question 2: The answer to this question comes from the second-to-last sentence in the passage. Weak readers often miss details from the middle parts of passages, and standardized tests sometimes probe for this kind of mistake with such questions. One strategy for this type of question is to form a question such as "From what problem can sickle cell anemia protect a person?" and then re-read or skim the passage with this question in mind.

INTERPRETING GRAPHICS

The Punnett square below shows a cross between two flowering plants. Use this Punnett square to answer the questions that follow.

	<i>R</i>	<i>r</i>
<i>r</i>		<i>rr</i>
<i>r</i>	<i>Rr</i>	

- What is the genotype of the offspring represented in the upper left-hand box of the Punnett square?
A *RR*
B *Rr*
C *rr*
D *rrr*
- What is the genotype of the offspring represented in the lower right-hand box of the Punnett square?
F *RR*
G *Rr*
H *rr*
I *rrr*
- What is the ratio of *Rr* (purple-flowered plants) to *rr* (white-flowered plants) in the offspring?
A 1:3
B 2:2
C 3:1
D 4:0

MATH

Read each question below, and choose the best answer.

- What is another way to write $4 \times 4 \times 4$?
A 4^2
B 4^3
C 3^3
D 3^4
- Jane was making a design on top of her desk with pennies. She put 4 pennies in the first row, 7 pennies in the second row, and 13 pennies in the third row. If Jane continues this pattern, how many pennies will she put in the sixth row?
F 25
G 49
H 97
I 193
- In which of the following lists are the numbers in order from smallest to greatest?
A 0.012, 0.120, 0.123, 1.012
B 1.012, 0.123, 0.120, 0.012
C 0.123, 0.120, 0.012, 1.012
D 0.123, 1.012, 0.120, 0.012
- In which of the following lists are the numbers in order from smallest to greatest?
F -12.0, -15.5, 2.2, 4.0
G -15.5, -12.0, 2.2, 4.0
H -12.0, -15.5, 4.0, 2.2
I 2.2, 4.0, -12.0, -15.5
- Which of the following is equal to -11?
A $7 + 4$
B $-4 + 7$
C $-7 + 4$
D $-7 + -4$
- Catherine earned \$75 for working 8.5 h. How much did she earn per hour?
F \$10.12
G \$9.75
H \$8.82
I \$8.01

INTERPRETING GRAPHICS

- B**
- H**
- B**



Questions 1 and 2: These questions require understanding of the term *genotype* and the ability to complete a Punnett square. Students who miss these questions may need to review these concepts.

Question 3: This question asks for the ratio of the genotype *Rr* to the genotype *rr*. If completed, the Punnett square would show 2 *Rr* and 2 *rr* genotypes. Thus, the ratio would be 2:2 (answer B). Students who miss this question may need to review the concept of ratios.

MATH

- B**
- H**
- A**
- G**
- D**
- H**



Question 6: This question is essentially a simple long-division problem, but students may get confused or discouraged by long division when the calculation extends for many decimal places. For this problem, students can save time if they recognize that they need only to find the answer in dollars and cents. Thus, they need to calculate to the thousandths place (\$8.823) and then round their answer to the nearest cent.

CHAPTER RESOURCES

Chapter Resource File



• Standardized Test Preparation **GENERAL**

State Resources



For specific resources for your state, visit go.hrw.com and type in the keyword **HSMSTR**.

Science, Technology, and Society

Background

Genetic research has spawned a flurry of debate over ethical, social, and legal issues surrounding the use of genetic information. These issues include the privacy and ownership of personal genetic information and the possibility that people will selectively breed or control the birth of their children based on genetic knowledge.

Weird Science

Teaching Strategy- **GENERAL**

Offer the following analogies to help students grasp the concepts discussed in this article.

- **Blueprints:** Show students sample construction blueprints. Explain that genes are like these plans for a building and that mutations are like mistakes in copying, reading, or building from the blueprints.
- **Recipes:** Show students a book of cake recipes. Genes are like recipes, and an organism is like a cake made according to a recipe. A mutation is like using a different ingredient or a different amount of an ingredient. The mutation may or may not “ruin” the “cake.”

Science in Action



Science, Technology, and Society

Mapping the Human Genome

In 2003, scientists finished one of the most ambitious research projects ever. Researchers with the Human Genome Project (HGP) mapped the human body's complete set of genetic instructions, which is called the *genome*. You might be wondering whose genome the scientists are decoding. Actually, it doesn't matter—only 0.1% of each person's genetic material is unique. The researchers' goals are to identify how tiny differences in that 0.1% make each of us who we are and to begin to understand how some differences can cause disease. Scientists are already using the map to think of new ways to treat genetic diseases, such as asthma, diabetes, and kidney disease.

Social Studies **ACTiViTy**

WRITING SKILL Research DNA fingerprinting. Write a short report describing how DNA fingerprinting has affected the way criminals are caught.

This is a normal fruit fly under a scanning electron microscope.



This fruit fly has legs growing where its antennae should be.



Weird Science

Lab Rats with Wings

Drosophila melanogaster (droh SAHF i luh muh LAN uh GAS tuhr) is the scientific name for the fruit fly. This tiny insect has played a big role in helping scientists understand many illnesses. Because fruit flies reproduce every 2 weeks, scientists can alter a fruit fly gene and see the results of the experiment very quickly. Another important reason for using these “lab rats with wings” is that their genetic code is simple and well understood. Fruit flies have 12,000 genes, but humans have more than 25,000. Scientists use fruit flies to find out about diseases like cancer, Alzheimer's, and muscular dystrophy.

Language Arts **ACTiViTy**

WRITING SKILL The mythical creature called the *Chimera* (kie MIR uh) was said to be part lion, part goat, and part serpent. According to legend, the Chimera terrorized people for years until it was killed by a brave hero. The word *chimera* now refers to any organism that has parts from many organisms. Write a short story about the Chimera that describes what it looks like and how it came to be.

Answer to Social Studies Activity

Sample answer: DNA fingerprinting has made it much easier to match genetic material (evidence) at a crime scene to the genetic information of one particular individual. DNA can be found in hair, saliva, blood, and small skin cells. The DNA is analyzed and then compared to the DNA fingerprint of particular individuals. When the DNA fingerprints match, police can be sure that the person was at the scene of the crime.

Answer to Language Arts Activity

The Chimera (or Chimaera) was said to be a savage beast that spat fire from its mouth. In classical Greco-Roman stories, it wreaked havoc on the ancient lands until it was killed by the hero Bellerophon, who rode his winged horse Pegasus. This basic story is among the most ancient myths and appears in many texts from Homer's *Iliad* to traditional fairy tales.

Careers

Stacey Wong

Genetic Counselor If your family had a history of a particular disease, what would you do? Would you eat healthier foods, get more exercise, or visit your doctor regularly? All of those are good ideas, but Stacey Wong went a step farther. Her family's history of cancer helped her decide to become a genetic counselor. "Genetic counselors are usually part of a team of health professionals," she says, which can include physicians, nurses, dieticians, social workers, laboratory personnel, and others. "If a diagnosis is made by the geneticist," says Wong, "then I provide genetic counseling." When a patient visits a genetic counselor, the counselor asks many questions and builds a family medical history. Although counseling involves discussing what it means to have a genetic condition, Wong says "the most important part is to get to know the patient or family we are working with, listen to their concerns, gain an understanding of their values, help them to make decisions, and be their advocate."



Math Activity

The probability of inheriting genetic disease A is $1/10,000$. The probability of inheriting genetic disease B is also $1/10,000$. What is the probability that one person would inherit both genetic diseases A and B?



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Careers

Background

Stacey Wong was born in Oakland, California, and grew up in the nearby suburb of Alameda. She received a B.S. in cell and molecular biology from UCLA and an M.S. in genetic counseling from California State University Northridge. More information about genetic-counseling careers can be obtained from the National Society of Genetic Counselors.

Answer to Math Activity

$$1/10,000 \times 1/10,000 = 1/100,000,000$$