SAINT LOUIS PUBLIC SCHOOLS

core curriculum
CURRICULUM RESOURCES

science biology 250

Contents

Rationale

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CURRICULUM RESOURCES

Science

Rationale

A comprehensive science program will help ensure that students can demonstrate proficient performance as outlined in the Missouri Grade-Level Expectations. Students will use scientific equipment and the processes of scientific inquiry throughout each course. They will also analyze the current and historical nature of the development of scientific knowledge as it applies to their course of study.

Instruction in each course will incorporate a hands-on, student-centered approach that seeks to address essential questions related to the major concepts of science. The curriculum will be driven by these essential questions, with the textbook used as a resource for teachers and students. In order to examine the major concepts of science, students will carry out investigations and communicate their findings.

Each course also aims to cultivate scientific literacy in students, as it is becoming increasingly necessary in our technology-oriented society. Scientific literacy entails being able to understand major scientific concepts, to think critically about logical arguments, to evaluate the validity of evidence provided in explanations, and to assess the consequences of decisions. A scientifically literate citizen will be better equipped to make decisions about issues that affect him or her as an individual and also society as a whole.

Course Description

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CURRICULUM RESOURCES

Biology 250

Students will acquire understanding of scientific concepts, knowledge of scientific facts, and proficiency in scientific process skills. Inquiry and critical thinking will be incorporated throughout the course. This course will also cultivate scientific literacy in students, as it is becoming increasingly necessary in our technology-oriented society.

The course will include a study of the scientific method, measurement, concepts from inorganic chemistry and organic chemistry foundational to certain areas of biology, cells, molecular transport, biochemical pathways, processes involved in the transmission of genetic material (including transcription, translation, mitosis, and meiosis), patterns of inheritance, population genetics, evolution, scientific classification, and ecology. A portion of the course will also be devoted to a science project. Students should present their science projects to their peers during class. Exemplary projects may be presented in school- or district-wide settings.

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Year at a Glance

Year at a Glance—Biology 250

The guiding questions of the biology course are, “How do organisms survive?” and, “How do organisms interact with each other and their environment?” Biology is the study of living things, ourselves, and the world around us. Students will engage in hands-on activities, inquiry-based investigations, problem solving, and direct instruction to acquire understanding of scientific concepts, knowledge of scientific facts, and proficiency in scientific process skills. Inquiry and the interaction of science and society will be themes that run throughout the course. An understanding of biology helps students to become aware of the world and to shape their values and decisions. Literacy will also be integrated throughout the course as students read text from various sources and explain their ideas and conclusions in writing using the *Step Up to Writing* approach. To solidify their understanding, students will design, conduct, and present scientific investigations at the end of the first semester.

UNITS	DATES
1. Tools and Processes of Science • Can an idea in science be proven? • How precise does a measurement need to be? • How do we know if a scientific investigation is valid?	August 20–31
2. Ecology • How are organisms dependent on each other and the environment? • How do humans affect the environment and organisms within it? • Why is the maintenance of a healthy balance in nature important to the survival of humans?	September 4–October 5
Benchmark Assessment 1	**Week of October 8**
3. Biological Evolution • How and why do organisms change over time? • Are organisms currently evolving? • Are “advanced organisms” better adapted to life on Earth than “primitive organisms”?	October 9–November 5

UNITS	DATES
4. Chemistry of Life • What conditions are necessary to sustain life on Earth? • How do atoms interact to form matter? • Which chemical compounds are important to biological processes?	November 6–30
Benchmark Assessment 2	**Week of December 3**
5. Science Project and Presentation • How are science and scientific inquiry important to our lives? • How can an experiment be improved? • How does viewpoint influence science?	December 4–17
6. Cells and Cellular Processes • If all living organisms are made of cells, why aren't they all alike? • How do cells maintain a balance between themselves and their environment? • How can a single cell carry out all the activities of life?	December 18–January 18
7. Biochemical Pathways • How do cells obtain, use, and change energy?	January 22–February 1
Benchmark Assessment 3	**Week of February 4**
7. Biochemical Pathways (continued)	February 5–12
8. Genetic Processes • Why do some organisms reproduce sexually and others reproduce asexually? • How are characteristics passed from parents to offspring? • Why are children both similar to and different from their parents and siblings?	February 13–March 24
9. DNA and Patterns of Heredity • How does DNA determine physical characteristics? • How has the discovery and study of DNA changed our lives? • Does heredity contribute to continuity or change?	March 25–May 6
Course Review and Reteaching	**Week of May 5**

UNITS	DATES
10. Diversity and Unity Among Organisms • What is the best way to organize the diversity found among organisms? • How are the different types of organisms on Earth similar to and different from each other?	May 7–June 29

Scope and Sequence

core curriculum
CURRICULUM RESOURCES

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Scope and Sequence

Biology 250

UNIT 1 (August 20–September 31): Tools and Processes of Science

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
August 20–23 (4 days)	1. Introduction to Biology (Lesson Planning Material, pp. 27–36)	Characteristics of Life Early Discoveries in Biology Biology and You	Holt, pp. 6–13	SC 3, 8 GLE 3.1.C.a, 8.1.B.a, 8.2.B.a, 8.3.B.a, 8.3.B.b
August 24–31 (6 days)	2. Problem-Solving Methods in Science (Lesson Planning Material, pp. 37–49)	Scientific Measurement The Scientific Method Graphing and Interpreting Experimental Data Designing a Controlled Experiment	Holt, pp. 14–20, 1030–1035	SC 7 GLE 7.1.A.a, 7.1.A.b, 7.1.A.c, 7.1.B.a, 7.1.C.b, 7.1.C.c, 7.1.D.b, 7.1.E.a

UNIT 2 (September 4–October 8): Ecology

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
September 4–13 (8 days)	1. What Is an Ecosystem? (Lesson Planning Material, pp. 53–64)	Parts of the Ecosystem Where Organisms Live Trophic Levels Food Webs and Energy Pyramids Biomagnification	Holt, pp. 340–342, 345–349, 365–367, 371–375, 391	SC 4, 8 GLE 4.1.A.c, 4.1.D.b, 4.2.A.a, 4.2.A.b, 4.2.A.c, 8.3.B.b
September 14–26 (8 days)	2. Community Interactions (Lesson Planning Material, pp. 65–80)	Interactions Among Species Competition Changes in Populations Succession	Holt, pp. 320–325, 343–344, 361–370	SC 4, 7 GLE 4.1.A.a, 4.1.A.b, 4.1.B.a, 4.1.B.b, 4.1.D.a, 7.1.B.a, 7.1.C.b
September 27–October 2 (4 days)	3. Nutrient Cycles (Lesson Planning Material, pp. 81–93)	Water Cycle Carbon Cycle Nitrogen and Phosphorus Cycles	Holt, pp. 350–354	SC 4, 8 GLE 4.1.C.b, 4.2.B.a, 4.2.B.b, 8.3.B.b
October 3–8 (3 days) **Benchmark Assessment 1** **Week of October 8**	4. Human Impact on the Environment (Lesson Planning Material, pp. 95–107)	Global Changes Habitat Destruction and Human Population Growth The Biodiversity Crisis	Holt, pp. 386–395, 406–407	SC 4, 5, 7, 8 GLE 4.1.C.a, 4.1.C.b, 4.1.D.a, 4.1.D.b, 5.3.A.c, 7.1.D.b, 7.1.E.a, 8.1.C.a

UNIT 3 (October 9–November 5): Biological Evolution

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
October 9–16 (6 days)	1. Examining the Fossil Record (Lesson Planning Material, pp. 111–122)	The Origin of Life Biological Evolution of Cells Multicellularity Benchmark 1 Review, Remediation, and Enrichment (2 days suggested)	Holt, pp. 251–269	SC 4, 7, 8 GLE 4.3.A.a, 7.1.B.a, 7.1.C.b, 7.1.E.a, 8.1.B.a
October 17–25 (6 days)	2. Darwin and Natural Selection (Lesson Planning Material, pp. 123–141)	Darwin's Voyage Natural Selection Patterns of Biological Evolution	Holt, pp. 276–282	SC 4, 7, 8 GLE 4.1.D.a, 4.1.D.b, 4.3.C all, 7.1.C.a, 7.1.D.b, 7.1.E.a, 8.2.B.a, 8.2.B.b
November 29– November 5 (6 days)	3. Evidence for Biological Evolution (Lesson Planning Material, pp. 143–156)	Fossil Record Comparative Anatomy and Embryology DNA Analysis Speciation	Holt, pp. 283–292	SC 3, 4, 7, 8 GLE 3.3.B.c, 4.3.A.a, 4.3.A.b, 4.3.C.d, 7.1.C.b, 7.1.D.a, 8.2.B.a

UNIT 4 (November 6–December 3): Chemistry of Life

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
November 6–13 (5 days)	1. Atoms and Chemical Bonding (Lesson Planning Material, pp. 159–170)	Atomic Structure and the Periodic Table Chemical Bonding Physical and Chemical Changes	Holt, pp. 28–30, 38–39	SC 1, 7 GLE 1.1.E.b, 1.1.F.a, 1.1.G.a, 1.1.H.c, 1.1.H.d, 7.1.E.a
November 14–20 (5 days)	2. Biologically Important Compounds (Lesson Planning Material, pp. 171–183)	Water Biomolecules Nutrition	Holt, pp. 31–37, 900–905	SC 1, 3, 7 GLE 1.2.A.b, 3.2.D.b, 3.2.F.d, 7.1.A.c, 7.1.B.a, 7.1.B.b, 7.1.C.a
November 26– December 3 (5 days) **Benchmark Assessment 2** **Week of December 3 (continued in next unit)**	3. Enzymes (Lesson Planning Material, pp. 185–201)	Enzymes and Chemical Reactions Factors that Affect Enzyme Activity	Holt, pp. 38–42	SC 1, 3, 7 GLE 1.2.D.a, 3.2.D.d, 3.2.D.e, 7.1.A.a, 7.1.A.c, 7.1.A.g, 7.1.B.a, 7.1.C.a

UNIT 5 (December 4–17): Science Project and Presentation

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
December 4–11 (6 days)	1. Science Project (Lesson Planning Material, pp. 205–221)	Formulating a Testable Question and Hypothesis Designing and Conducting a Valid Experiment Gathering and Analyzing Data Benchmark 2 Review, Remediation, and Enrichment (2 days suggested)	Holt, pp. 14–20, 1030–1035	SC 7 GLE 7.1.A.a, 7.1.A.b, 7.1.A.c, 7.1.A.f, 7.1.A.g, 7.1.B.c, 7.1.B.d, 7.1.B.f, 7.1.C.a, 7.1.C.b, 7.1.C.c
December 12–17 (3 days)	2. Presentations (Lesson Planning Material, pp. 223–234)	Student Presentations		SC 7 GLE 7.1.E all

UNIT 6 (December 18–January 18): Cells and Cellular Processes

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
December 18–January 4 (6 days)	1. Introduction to Cells (Lesson Planning Material, pp. 237–252)	Using the Microscope The Discovery of Cells Prokaryotic vs. Eukaryotic Cells	Holt, pp. 50–58, 1028–1029, 1032–1033	SC 3, 7, 8 GLE 3.1.E.a, 7.1.B.a, 7.1.B.c, 7.1.B.d, 8.1.B.a
January 7–14 (6 days)	2. Eukaryotic Cell Structure (Lesson Planning Material, pp. 253–264)	Eukaryotic Organelles Protein Production and Distribution	Holt, pp. 58–66	SC 3, 7 GLE 3.1.C.b, 3.2.A.a, 3.2.A.b, 3.2.A.c, 7.1.B.a
January 15–18 (4 days)	3. Transport Across Membranes (Lesson Planning Material, pp. 265–278)	Structure of the Cell Membrane Diffusion and Osmosis Active Transport	Holt, pp. 60–61, 74–86	SC 3, 7 GLE 3.2.A.b, 3.2.F.a, 3.2.F.b, 3.2.F.c, 7.1.A.a, 7.1.A.c, 7.1.B.a, 7.1.C.a

UNIT 7 (January 22–February 12): Biochemical Pathways

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
January 22–25 (4 days)	1. Energy and Plants (Lesson Planning Material, pp. 281–296)	ATP: The Energy Molecule of the Cell Light and Photosynthetic Pigments	Holt, pp. 94–99	SC 3, 7 GLE 3.2.D.a, 3.2.D.c, 7.1.A.a, 7.1.A.c, 7.1.B.a, 7.1.C.a
January 28–February 1 (5 days)	2. Photosynthesis (Lesson Planning Material, pp. 297–310)	Chloroplasts: Photosynthetic Plastids The Chemical Reactions of Photosynthesis	Holt, pp. 97–103	SC 3, 7 GLE 3.2.B.c, 3.2.D.a, 3.2.D.c, 7.1.A.c, 7.1.B.a, 7.1.C.a
February 4–12 (6 days) **Benchmark Assessment 3** **Week of February 4**	3. Cellular Respiration (Lesson Planning Material, pp. 311–324)	The Chemical Reactions of Cellular Respiration Anaerobic Respiration Rates of Respiration and Photosynthesis	Holt, pp. 103–110	SC 3, 7 GLE 3.2.A.a, 3.2.B.a, 3.2.B.b, 3.2.B.c, 3.2.D.a, 7.1.A.a, 7.1.A.c, 7.1.A.g, 7.1.B.a, 7.1.C.a

UNIT 8 (February 13–March 24): Genetic Processes

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
February 13–27 (9 days)	1. Cell Reproduction (Lesson Planning Material, pp. 329–342)	Chromosomes The Cell Cycle The Stages of Mitosis Cancer and Control of the Cell Cycle Benchmark 3 Review, Remediation, and Enrichment (3 days suggested)	Holt, pp. 118–132	SC 3, 7 GLE 3.3.C.a, 3.3.C.d, 7.1.B.a, 7.1.C.a
Febuary 28–March 6 (6 days)	2. Meiosis (Lesson Planning Material, pp. 343–359)	Stages of Meiosis Genetic Recombination During Meiosis Comparing Mitosis and Meiosis	Holt, pp. 128–132, 144–149	SC 3, 7 GLE 3.3.C.b, 3.3.C.c, 3.3.D.b, 7.1.C.a
March 10–24 (6 days)	3. Types of Reproduction (Lesson Planning Material, pp. 361–375)	Sexual vs. Asexual Reproduction Sexual Life Cycles Cell Differentiation	Holt, pp. 150–154, 419, 596–597	SC 3, 7 GLE 3.1.B.a, 3.1.B.b, 3.3.A.a, 3.3.C.a, 3.3.C.b, 3.3.C.c, 3.3.D.a, 7.1.B.a

UNIT 9 (March 25–May 6): DNA and Patterns of Heredity

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
March 25–April 1 (5 days)	1. Laws of Heredity (Lesson Planning Material, pp. 379–395)	Mendel's Laws Monohybrid and Dihybrid Crosses	Holt, pp. 162–176	SC 3, 7, 8 GLE 3.3.E.a, 3.3.E.b, 7.1.E.b, 8.2.B.a
April 2–7 (4 days)	2. DNA: The Molecule of Life (Lesson Planning Material, pp. 397–410)	History of the Discovery of DNA DNA Structure DNA Replication	Holt, pp. 190–200	SC 3, 7, 8 GLE 3.3.B.a, 3.3.B.d, 7.1.E.b, 8.2.B.a
April 8–16 (7 days)	3. How DNA Translates to Physical Characteristics: DNA–RNA–Protein (Lesson Planning Material, pp. 411–426)	Transcription Translation Regulation of Protein Synthesis Mutations	Holt, pp. 208–220	SC 3, 7 GLE 3.2.E.a, 3.2.E.b, 3.3.B.b, 3.3.B.e, 3.3.D.b, 3.3.D.c
April 17–25 (6 days)	4. Gene Technology (Lesson Planning Material, pp. 427–442)	Recombinant DNA Genetically Modified Organisms (GMOs) Applications of Genetic Engineering in Humans	Holt, pp. 228–242	SC 3, 7, 8 GLE 3.3.D.b, 8.1.B.a, 8.1.C.a, 8.2.A.b, 8.3.B.b, 8.3.C.b
April 28–May 6 (6 days) **Course Review and Reteaching** **Week of May 7**	5. Patterns of Heredity (Lesson Planning Material, pp. 443–458)	Non-Mendelian Inheritance Applied Genetics	Holt, pp. 175–182	SC 3, 7, 8 GLE 3.3.D.c, 3.3.E.b, 3.3.E.c, 7.1.C.b, 8.1.C.a, 8.2.B.a

UNIT 10 (May 7–29): Diversity and Unity Among Organisms

DATES	SECTION	TOPICS	CORE TEXTS	STANDARDS ALIGNMENT
May 8–20 (9 days)	1. Taxonomy and Classifying Organisms (Lesson Planning Material, pp. 461–472)	The Classification System How Organisms Are Classified Review, Remediation, and Enrichment (3 days suggested)	Holt, pp. 300–310	SC 3, 4, 8 GLE 3.1.E.a, 3.1.E.b, 3.3.B.c, 4.3.B.a, 4.3.B.b, 8.1.B.a
May 22–29 (6 days)	2. An Introduction to the Six Kingdoms and Viruses (Lesson Planning Material, pp. 473–484)	The Six Kingdoms Viruses	Holt, pp. 412–426, 434–441	SC 3, 7 GLE 3.1.E.a, 3.1.E.b, 7.1.B.a

Lesson Planning Material

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CURRICULUM RESOURCES

Unit 1 Tools and Processes of Science

- Can an idea in science be proven?
- How precise does a measurement need to be?
- How do we know if a scientific investigation is valid?

Scope and Sequence, page 17
Lesson Planning Material, pages 25–49

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

Unit 1 Section 1

INTRODUCTION TO BIOLOGY

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	Characteristics of Life	Holt, pp. 6–9
2		Early Discoveries in Biology	Internet Resources
3–4	2	Biology and You	Holt, pp. 10–13

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 8: Impact of Science, Technology and Human Activity

WHAT ALL STUDENTS SHOULD KNOW...

...for Standard 3

There is a fundamental unity underlying the diversity of all living organisms. (GLE 3.1)

CONTENT EXPECTATIONS

☐ 1. All organisms are composed of cells. (GLE 3.1.C.a)

☐ 2. There are a set of characteristics that all organisms share (i.e., cellular organization, reproduction, metabolism, homeostasis, heredity, responsiveness, growth and development). (GLE 3.1 *PR*)

...for Standard 8

The nature of technology can advance, and is advanced by, science as it seeks to apply scientific knowledge in ways that meet human needs. Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time. (GLE 8.1, 8.2)

CONTENT EXPECTATIONS

☐ 3. Advances in technology often result in improved data collection and an increase in scientific knowledge. (GLE 8.1.B)

☐ 4. Technological solutions to problems often have drawbacks as well as benefits. (GLE 8.1.C)

☐ 5. Scientific theories are developed based on the body of knowledge that exits at any particular time and must be rigorously questioned and tested for validity. (GLE 8.2.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Analyze the fundamental unity underlying the diversity of all living things. (GLE 3.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Explain whether an object is a living organism or not based on the seven properties of life (cellular organization, reproduction, metabolism, homeostasis, heredity, responsiveness, growth and development). (GLE 3.1 *PR*)

…for Standard 8

Identify and analyze theories that are currently being questioned, and compare them to new theories that have emerged to challenge the older ones. Discuss the scientific, technological, and political aspects of major challenges to society and describe how each of these aspects influences public policy formulation in dealing with these challenges. (Frameworks II.B.1.a, II.A.1.a)

PERFORMANCE EXPECTATIONS

☐ 2. Analyze the role of science and society as they interact to determine the direction of scientific and technological progress (e.g., prioritization of and funding for new scientific research and technological development is determined on the basis of individual, political, and social values and needs; understanding basic concepts and principles of science and technology influences debate about the economics, policies, politics, and ethics of various scientific and technological challenges). (GLE 8.3.B.a)

☐ 3. Identify and describe major scientific and technological challenges to society and their ramifications for public policy (e.g., global warming, the use of pesticides to control pests, cloning, and stem cell research). (GLE 8.3.B.b)

☐ 4. Identify and evaluate the drawbacks and benefits to a technological solution to a given problem. (GLE 8.1.B.a)

☐ 5. Identify how explanations (hypotheses, laws, theories) of scientific phenomena have changed over time as the result of new evidence (e.g., the theory of spontaneous generation). (GLE 8.2.B.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Characteristics of Life Day 1	CE 1, 2 PE 1	**Hands-On Activity/Lab:** Provide students with a collection of objects to study. They should make observations and record the observations in a data table. Students should use the observations to determine whether the objects are living or not. Then, they should compile a list of characteristics all living things share. Have students share their ideas with the class and make a list of the characteristics of life. *See Model Lesson*. (Goals 1.6, 1.8, 2.3, 4.1)
	CE 2 PE 1, 2	**Hands-On Activity/Lab:** Explain to students that people used to think that life spontaneously arose from nonliving matter, such as broth. Dissolve 2 beef bouillon cubes in separate flasks of hot water. Boil the bouillon in both flasks for several minutes. Seal one of the flasks with a rubber stopper and set the two flasks on a shelf in the classroom. Have students make predictions about what will happen. Have students observe the flasks every day for changes. (Goals 1.3, 3.5)
Early Discoveries in Biology Day 2	CE 3, 5 PE 5	Bring in copies of selected information in order to have students research Aristotle and his theory of spontaneous generation and the scientists (Redi, Spallanzani, and Pasteur) who tested the theory. They should identify the question and hypothesis for each as well as their conclusions. Discuss how and why the process of science and the development of theories change over time. Have students brainstorm a list of scientific theories they are familiar with. Emphasize how scientists build upon each other's work. (Goals 1.2, 1.6, 3.4)
	CE 3, 5 PE 5	Read students descriptions of Redi's and Pasteur's experiments, stopping at predetermined places to allow students time to write Free Responses (*SUTW*, p. 8-8). Have students simulate Redi's and Pasteur's experiments using similar materials to decide if spontaneous generation occurs. Have them make their own hypotheses about what will happen. (Goals 1.2, 1.3, 3.2)
Biology and You Days 3–4	CE 4 PE 2, 3, 4	Have students use the Internet and library resources to research an important, possibly controversial, topic in biology that affects their lives. They should then use a group decision-making process to develop and propose a governmental policy about this topic. Possible topics include: pesticides, animal testing of make-up, prenatal testing for genetic disorders, cloning organisms, and using stem cells for research. (Goals 1.2, 2.1, 2.3, 3.6, 3.8, 4.1, 4.3)
	CE 4 PE 2, 3, 4	Complete a jigsaw reading activity (*ER*, p. GPT-7). Give 4 or 5 different groups articles to read that relate to research in the field of biology. Have groups identify the main idea and interesting facts, generate follow-up questions, and discuss how the article is related to biology. Groups should then present their findings to the class. (Goals 1.5, 2.1, 2.3)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students come up with at least 5 examples of how organisms respond to stimuli. Magazine pictures could be used. In each case, students should identify the stimulus and the response.	Have students create a glossary, which they can build upon throughout the year. They should include all key terms and definitions. (ELL-8)	Have students research recent discoveries of new life forms. They should find out how and where these new organisms were discovered. They should also discuss the significance of the discoveries.
Have students draw a living organism. Have them present to the class their rationale for classifying it as living.	Have students write down words that they find in a dictionary that begin with the prefixes *bio-* and *liv-*. (ELL-1)	Have students work in groups to compile a list of different methods of research used by biologists (e.g., case studies, field investigations).
In groups, have students create posters demonstrating the work of one of the scientists (Redi, Spallanzani, or Pasteur), their questions and hypotheses, and what they contributed to the theory of biogenesis.	Have students conduct research about biologists from their home country and what they study. (ELL-3)	Have students research experiments about the origin of life. Then, have students hypothesize why theories change over time. Have them write summaries of the experiments that they research.
Have students illustrate Redi and Pasteur's experiments based on the descriptions that are read aloud, rather than write Free Responses.	Before simulating the experiment, discuss possible results and the conclusions that would be drawn from each of them. (ELL-2)	Have students stage a mock debate about the theories of spontaneous generation vs. biogenesis in the 1700s.
Have students develop a public opinion survey that will study people's views on a controversial topic related to biology.	Have students conduct research on a topic that is relevant in their home country. (ELL-3)	Have students research the laws of Missouri regarding the types of life support that must be provided to patients and who decides when life support can be turned off.
Provide students with excerpts of articles rather than complete articles.	Pull out important vocabulary terms from the articles and discuss them before distributing the articles. (ELL-2)	Give students articles from a scientific journal such as *Nature*.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology Chapter Resource File 1: Biology and You*

   Educational Resources, p. GPT-7

   Step Up to Writing, pp. 3-4 through 3-14, 8-8

2. **Internet Resources for Teachers**

   Teaching Bioethics
   www.accessexcellence.org/LC/TL/TBE/

3. **Internet Resources for Students**

   Microbiology Textbook: Spontaneous Generation
   www.bact.wisc.edu/Microtextbook/modules.php?op=modload&name=Sections&file=index&req=viewarticle&artid=282&page=1

   Spontaneous Generation
   http://biology.clc.uc.edu/courses/bio114/spontgen.htm

   Dictionary of the History of Ideas
   http://etext.lib.virginia.edu/cgi-local/DHI/dhi.cgi?id=dv4–39

   BBC News: Cosmetic Testing on Animals to Cease
   http://news.bbc.co.uk/1/hi/sci/tech/24295.stm

4. **Multicultural Resources and/or Activities**

   Have students conduct research about biologists (past and present) in different countries and what they study. Students should make presentations to the class explaining what the scientists study and how the research is significant. Examples include Humayun Abdulali (Indian ornithologist), Clodoveo Carrion Mora (Ecuadorian paleontologist), Marjorie Courtenay-Latimer (South African zoologist).

Suggested Assessments

1. Tell students that scientists have brought back soil samples from Mars. Have them describe at least 3 ways the soil could be tested to determine whether they currently contain living organisms.
2. Have students find articles from magazines or newspapers that relate to biology. Have them write a Paragraph Summary with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-14) of the article that discusses how the article relates to one or more of the themes of biology.
3. Have students design their own experiment to disprove the theory of spontaneous generation of organisms.
4. Have students complete the Themes of Biology Directed Reading worksheet (Holt *Biology Chapter Resource File 1: Biology and You,* pp. 1–2).

Sample Constructed-Response Item

Why is it important for organisms to maintain homeostasis? Provide an example to support your answer.

If an organism didn't maintain a stable internal environment it might get sick or die. If a person didn't sweat when he or she overheated, his or her body temperature would get too high and he or she might die.

Model Lesson (Traditional Roster): *Characteristics of Life*

Lesson Questions

What makes something alive?

How can you tell the difference between living and nonliving objects?

Materials

Various objects for study: soil, a flower, a fish, rocks, bubbles, candle with flame, shell, insect, sponge, nuts, pond organisms under a microscope, moldy bread in an enclosed dish, a plant, seeds, bubbles, activated yeast

Content and Performance Expectations

CE 1, 2; PE 1

Teacher's Notes

Observe safety measures when using biological specimens and/or an open flame. See the Missouri Secondary Science Safety Manual available online at http://dese.mo.gov/divimprove/curriculum/science/manuals.html.

Warm-Up

Introduction to Biology

- Have students define biology by looking at the prefix *bio*- and the suffix -*logy*.
- Have students write a response to the following prompt: How do we know whether something is alive?

Instruction

Living Versus Nonliving

▶ Definition of *Biology*	▷ Explain to students that biology studies themselves, other living things, and everything that affects living things, and that learning biology is vital to understanding the world around them. Tell students that living things are called *organisms*. ▷ Explain that it is not always easy to determine if something is alive but there is a set of characteristics that all organisms share.
▶ Making a Hypothesis	▷ Before starting the activity, have students make a hypothesis that answers the question, "How can you tell the difference between living and nonliving things?"

Characteristics of Life Lab Activity

▶ Making Observations	▷ Provide students with a collection of objects to study. ▷ Have students make observations to determine whether the objects are living or not. They should create a data table in their notebooks to record their observations. ▷ Students should determine whether each object is living or not. ▷ In groups, students should develop a list of traits that all the living organisms share. Then they should decide on some characteristics nonliving things share. ▷ Have students create a chart outlining the characteristics of living and nonliving things.
▶ Analysis	▷ Have students reformulate their hypotheses to reflect their observations.

Wrap-Up

- Making Conclusions
  - Have groups share their ideas with the class. Discuss why some objects were more difficult to classify than others.
  - Make a class list of the characteristics of life on the board.

Assessment

- Tell students that scientists have brought back soil samples from Mars. Have them describe at least three ways they could test the soil to determine whether it currently contains living organisms.

Homework Assignment

- Have students read Holt, pages 5–9 and complete the Section Review Questions. Students should also complete the Chapter 1 Concept Mapping Skills Worksheet (Holt *Biology CRF 1: Biology and You*, p. 17).

Teaching Resources

- Holt, pp. 5–9
- Holt *Biology Chapter Resource File 1: Biology and You*
- Spontaneous Generation
  http://biology.clc.uc.edu/courses/bio114/spontgen.htm

Unit 1 Section 2

PROBLEM-SOLVING METHODS IN SCIENCE

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	Scientific Measurement	Holt, pp. 1030–1033
2–3	2	The Scientific Method	Holt, pp. 14–20
4	3	Graphing and Interpreting Experimental Data	Holt, pp. 1034–1035
5–6		Designing a Controlled Experiment	Holt, pp. 16–18

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 1. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 2. Scientific inquiry includes the ability to formulate a testable explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)

☐ 3. Scientific inquiry includes evaluation of explanations (hypotheses, laws, theories) in light of scientific principles. (GLE 7.1.D)

☐ 4. The nature of science relies upon communication of results and justification of explanations. (GLE 7.1.E)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 7

Design and conduct a full scientific investigation including a comprehensive review of related literature: experimental design that is thoughtful and well-controlled, with adequate repeated trials, accurate measurement of data, some form of statistical treatment and display of data, and communication and defense of logical arguments supported by the finding. (Frameworks I.B.3.a)

PERFORMANCE EXPECTATIONS

- ☐ 1. Formulate testable questions and hypotheses. (GLE 7.1.A.a)
- ☐ 2. Analyze an experiment, identify its components (i.e., independent variable, dependent variables, control of constants, multiple trials), and explain their importance to the design of a valid experiment. (GLE 7.1.A.b)
- ☐ 3. Design and conduct a valid experiment. (GLE 7.1.A.c)
- ☐ 4. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., balances, metric rulers, graduated cylinders). (GLE 7.1.B.a)
- ☐ 5. Analyze experimental data to determine patterns, relationships, perspectives, and credibility of explanations (e.g., predict/extrapolate data, explain the relationship between the independent and dependent variable). (GLE 7.1.C.b)
- ☐ 6. Identify possible effects of errors in observations, measurements, and calculations on the validity of data and resultant explanations (conclusions). (GLE 7.1.C.c)
- ☐ 7. Evaluate the reasonableness of an explanation (conclusion). (GLE 7.1.D.b)
- ☐ 8. Communicate the procedures and results of investigations and explanations through data tables (allowing for the recording and analysis of data relevant to the experiment such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities) and graphs (bar, single, and multiple line). (GLE 7.1.E.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Scientific Measurement Day 1	CE 1 PE 4	**Hands-On Activity/Lab:** Review with students the different pieces of laboratory equipment found in a biology laboratory and demonstrate the use of each. Have students learn the names and functions of the different tools available to them. Review the SI (metric) system with students and set up stations around the room to have them practice making measurements of mass, volume, and length of different objects. (Goal 1.4)
	CE 1 PE 4, 6	**Hands-On Activity/Lab:** Have students work in pairs to practice converting units (e.g., meters to millimeters) and calculating the density of the different objects. Collect density data from each pair and have students calculate the average density for each object. Discuss why there might be differences in the data collected and the benefits of calculating averages. (Goals 1.7, 1.8)
The Scientific Method Days 2–3	CE 1, 2, 3 PE 1, 2, 3, 5, 6, 8	**Hands-On Activity/Lab:** Have students complete the Observing the Effects of Acid Rain on Seeds Exploration Lab (Holt *Biology,* pp. 24–25). Discuss the differences between facts, hypotheses, and theories. Have students brainstorm examples of each. Have students complete the Scientific Processes Active Reading Worksheet (Holt *Biology Chapter Resource File 1: Biology and You*, pp. 11–12). (Goals 1.3, 1.8, 3.4)
	CE 1, 2 PE 1, 4	**Hands-On Activity/Lab:** Have students complete a leaf observation activity. Give each group of students a ruler and a varied collection of leaves to study. As a group they should list as many quantitative and qualitative observations as they can in 5–10 minutes. Each group should then develop three testable questions and one hypothesis about the leaves. Each group should report results to the class. (Goals 1.1, 2.3, 3.5)
Graphing and Interpreting Experimental Data Day 4	CE 4 PE 5	Display a graph from a newspaper, magazine, or other source. Have students write Quotation and Responses (*SUTW,* pp. 8-11 through 8-12) where the left column contains observations of the graph and the right column contains predictions based on the observations. Discuss the benefits of having a "picture" of data. Have students identify the independent and dependent variable and explain the relationship between them. (Goal 1.6)
	CE 4 PE 8	Give students a set of data to plot on a graph. Give them a set of guidelines for constructing a graph: how to determine scale, labeling axes, creating a title. They should create their own graphs. They should write out a Process Paragraph for making a graph (*SUTW,* pp. 3-15 through 3-17). (Goal 1.8)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Review with students what each line on the meterstick represents. Have them make their own metric ruler on paper. Have students practice reading the meterstick.	Give students the outline of a meterstick on paper. It does not have to be to scale. They should then label a millimeter, centimeter, decimeter, and meter. Have them create a chart underneath their labeled meterstick defining the prefixes *milli-, centi-, deci-,* and *kilo-*. (ELL-1)	Send students on a metric scavenger hunt. Their goal is to find objects that will correctly match the descriptions given to them (e.g., an object that has a volume between 10 and 20 milliliters).
Drop two objects of similar size but different densities into a container of water. Before dropping them have students predict which of the two is denser and what will happen when they are dropped.	Review metric prefixes with a game. Divide the class into pairs and have them solve basic math problems that use the metric vocabulary. Points should be awarded based on speed and accuracy. (ELL-5)	In addition to calculating means (averages) for their data, have students calculate the standard deviation. The students should explain the significance of standard deviation and its relationship to sample size.
Show students the steps of the scientific method in the form of a flowchart. Have students trace the different paths that scientific investigations can follow.	Have students choose an animal and then create a list of quantitative and qualitative data to describe it. Have students exchange lists and guess the identity of the animal. (ELL-5)	Have students find a current news report about the work of a scientist, or have them research the discoveries of a famous scientist in the past. Students should draw a flowchart to represent the events leading to the scientist's conclusions. Students should use Two-Column Notes (*SUTW,* pp. 9-1 through 9-15) to discuss how these events demonstrate the steps of the scientific method.
In game format, provide the class with an observation, and have them classify it as either quantitative or qualitative.	At the beginning of class, have students generate a list of questions related to a given topic. As a class, divide them into testable and nontestable questions. (ELL-1)	Have students compare and contrast inductive and deductive reasoning by providing examples of each.
Display graphs with different curves. Discuss what these graphs show and how to interpret them. Have students make predictions based on them.	Have students complete Holt *Reading in the Content Area,* pages 111–114. (ELL-7)	Have students construct a chart listing the similarities and differences between circle graphs, line graphs, and bar graphs.
Give students graph examples. For each graph, have them label the type of graph, titles of the axes, independent variable, and dependent variable.	In groups, have students construct a bar graph of the dates of the month on which they were born (e.g., 2 students were born on the 1st of the month, 0 students were born from the 10th to 15th of the month). (ELL-5)	Have students create multiple types of graphs (bar, pie, etc.) with the same data. Have students determine the best type of graph for the set of data and justify their choice.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Designing a Controlled Experiment Days 5–6	CE 1, 2, 3 PE 1, 3, 4, 5	**Day 5/Hands-On Activity/Lab:** Have students carry out a brief investigation. From it, have them develop their own related question to form a hypothesis and design a controlled experiment. *See Model Lesson*. (Goals 1.2, 1.3, 1.6)
	CE 1, 4 PE 2, 6, 7, 8	**Day 6:** Have students create data tables to collect the data from their experiments. They should carry out their experiments and communicate the results of their experiments using appropriate data tables and/or graphs. After stating their conclusion, they should discuss sources of errors in their experiments as well as methods for improving the experimental design. (Goals 1.8, 2.1, 3.4)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students review the experiments of Redi and Pasteur. Ask them whether their experiments were controlled experiments. Have them identify the independent and dependent variables and the controls.	Have students add the new terms from this section to their glossary. (ELL-6)	Give students a list of possible materials and have them develop their own question to study in a student-designed controlled experiment.
At the beginning of class, review the components of a data table and a graph.	Provide students with sentence stems to describe sources of error in their experiments and ways to improve the experiments, such as, "One possible source of error in my experiment was…" (ELL-4)	Have students compare the results of their experiments with similar experiments.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology Chapter Resource File 1: Biology and You*

   Step Up to Writing, pp. 3-15 through 3-17, 8-11 through 8-12, 9-1 through 9-15, 10-20

2. **Internet Resources for Teachers**

   Introduction to Measurement Activity
   www.accessexcellence.org/AE/AEPC/WWC/1991/measurement.htm/

   Introducing Inquiry and the Nature of Science Lesson Plan
   www.nap.edu/readingroom/books/evolution98/evol6-a.html

3. **Internet Resources for Students**

   A Dictionary of Units (SI Measurement)
   www.ex.ac.uk/cimt/dictunit/dictunit.htm

   The Scientific Method
   www.biology.clc.uc.edu/courses/bio104/sci_meth.htm

   Measurement (basic measurement concepts and hw to convert between units)
   http://fp.uni.edu/mathcenter/measurement.htm

   How to Make a Graph
   http://astro.uchicago.edu/cara/outreach/resources/other/howtograph.html

4. **Multicultural Resources and/or Activities**

   Even though the metric (SI) system is the world standard today, humans have employed many other systems of measurement. Have students compare and contrast two different measurement systems used in the world (past or present) such as the Egyptian or Japanese measurement systems. Have students create visual displays of their findings.

   The United States is one of the few countries in the world does not use the metric system for everyday measuring. Discuss whether Congress should pass a law requiring the use of the metric system throughout the country. After the discussion, students should write a Five-Sentence Paragraph (*SUTW*, p. 10-20) to the following writing prompt: If the US did convert to the metric system, how should this change be implemented?

Suggested Assessments

1. Set up a lab practical to assess students' ability to use laboratory equipment and make accurate measurements.
2. Give students examples of different experiments. For each one, have them identify the independent variable, the dependent variable, and the control (if any).
3. Give students a set of data to plot on a graph along with a set of related questions for them to answer.
4. Have students complete the Analyzing Experimental Design Data Lab (Holt *Biology,* p. 20).

Sample Constructed-Response Item

The Best Tomato Company is experimenting with the best ways to grow tomatoes. The company wants to find out if adding iron to the soil will improve tomato growth.

1. **What is the hypothesis to be tested?**
2. **How would the control group be different from the experimental group?**
3. **What is the dependent variable in this experiment?**
4. **What is one example of qualitative data to be collected and one example of quantitative data to be collected?**

1. *Adding iron to the soil will improve tomato growth.*
2. *The experimental group will have iron added to the soil and the control group will not.*
3. *The growth of the plants is the dependent variable.*
4. *An example of qualitative data would be how healthy the plants look or the color of the tomatoes. An example of quantitative data would be the height of the plants or the number of tomatoes produced.*

Model Lesson (Traditional Roster):
Designing a Controlled Experiment

Lesson Questions

How do you design and conduct a controlled experiment?

What are independent and dependent variables?

What is the best way to communicate the results of an experiment?

How do sources of error affect experimental results?

Materials

Orange juice, orange soda, water, Vitamin C solution, test tubes, test tube racks, eyedroppers, graduated cylinders, graph paper, safety goggles, disposable gloves, indophenol solution

Content and Performance Expectations

CE 1, 2, 3; PE 1, 3, 4, 5

Teacher's Notes

Observe all safety measures. Indophenol may cause skin and eye irritation.

Warm-Up

Pre-Lab Questions

- ▶ Have students answer the pre-lab questions and then discuss their answers with their groups.

Instruction

Investigation

- ▶ Vitamin C Investigation
  - ▷ Review answers to the pre-lab questions.
  - ▷ Discuss the introduction and procedure with students. Answer any questions that students may have.
  - ▷ As students work on the investigation, circulate around the classroom to answer questions, assist students who are having difficulty, redirect students who are off-task, and ensure that proper safety procedures are followed.
  - ▷ This investigation can be carried out as a demonstration. Have students record the data, analyze the results, and answer the laboratory questions.

- **Designing an Investigation**
  - Approximately halfway through the class period, have students brainstorm a list of new questions related to this activity.
  - Have students briefly evaluate the feasibility of designing an experiment for each.
  - In pairs, have students choose one of the questions rated as feasible and design an investigation around it.
  - Discuss the parameters of the investigation (e.g., time constraints, materials available).
  - Have each pair of students turn in a copy of their problem, hypothesis, materials, and procedure for teacher approval. Approve and hand back to students either at the end of class period or the beginning of the next class period.

Assessment

- Have students identify the control group and variables in their experiments
- Have students demonstrate correct laboratory procedures.

Homework Assignment

- Have students complete the Vitamin C Investigation Part I activity sheet.
- Have students bring any additional supplies needed for the new investigation.

Teaching Resources

- Holt, pp. 14–20
- Holt *Biology Chapter Resource File 1: Biology and You*
- Holt *Biology Reading in the Content Area*, pp. 107–108
- Where is the antioxidant, Vitamin C?
  www.nasaexplores.com/show_912_teacher_st.php?id=031112155112

activity sheet

name ______________________ date ____________

Unit 1: Vitamin C Investigation Part I

Pre-Lab Questions:

Explain the difference between an independent variable and a dependent variable.

____

____

Explain the purpose of a control group in an experiment.

____

____

Introduction:

In this investigation, we will use the indicator indophenol to test various solutions for the presence of Vitamin C. The color of indophenol changes from dark blue to clear in the presence of Vitamin C. It can also change to violet or pink before becoming colorless.

The question addressed by the investigation is, "How will the level of Vitamin C in orange juice compare to the level of Vitamin C in orange soda?"

Hypothesis: ____

Materials Needed

orange juice, orange soda, water, Vitamin C solution, 4 test tubes, test tube rack, eyedroppers, graduated cylinder, graph paper, safety goggles, disposable gloves, 40 mL of indophenol solution *(Possible eye and skin irritant)*

Procedure:

1. Add 10 mL of indophenol solution into each of the four test tubes labeled with the following: Vitamin C, Orange juice, Orange soda, and Water.
2. Use an eyedropper to add one drop of the Vitamin C solution to the correct test tube. Swirl the test tube gently. Continue to add the Vitamin C solution drop by drop to the test tube, until a color change occurs. Record the number of drops used.
3. Repeat with the other three solutions. (Note: It is possible that the color change will not happen with one or more of the solutions.)

Data:

Create a data table to record the number of drops of test-liquid used in each solution (Vitamin C Solution, Orange Juice, Orange Soda, Water).

name ______________________ date __________

Results:

Graph the data on a piece of graph paper.

Using data from each group in the class, calculate the average number of drops used for each solution. Show your work.

Vitamin C Solution: ____________

Orange Juice: ____________

Orange Soda: ____________

Water: ____________

Explain how to determine from the data which of the four solutions has the most Vitamin C present.

____

____

____

Place the four solutions in order from the greatest to the least amount of Vitamin C present.

____

Laboratory Questions:

1. Explain how the data supported or did not support your hypothesis.

____

____

2. Explain why the Vitamin C solution was used.

____

____

3. Explain why the water solution was used.

____

____

4. Write one extension question.

____

5. Identify one possible source of error.

____

Unit 2 Ecology

- How are organisms dependent on each other and the environment?
- How do humans affect the environment and organisms within it?
- Why is the maintenance of a healthy balance in nature important to the survival of humans?

Scope and Sequence, page 18
Lesson Planning Material, pages 51–107

UNIT 2

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

Unit 2 Section 1

WHAT IS AN ECOSYSTEM?

UNIT 2 SECTION 1

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Parts of the Ecosystem	Holt, pp. 340–342, 365–367
3–4	2	Where Organisms Live	Holt, pp. 365, 371–375
5	3	Trophic Levels	Holt, pp. 345–349
6–7	4	Food Webs and Energy Pyramids	Holt, pp. 345–349
8		Biomagnification	Holt, p. 391

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 4: Changes in Ecosystems and Interactions of Living Organisms with their Environments

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW...

...for Standard 4

All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem. As energy flows through the ecosystem, all organisms capture a portion of that energy and transform it to a form they can use. All organisms, including humans, and their activities cause changes in their environment that affect the ecosystem. (GLE 4.1.A, 4.1.C, 4.2.A)

CONTENT EXPECTATIONS

☐ 1. Biotic and abiotic factors are important for the maintenance of a balanced ecosystem. (GLE 4.1.A *PR*)

☐ 2. Matter and energy are constantly cycling through stable ecosystems. (GLE 4.2 *PR*)

☐ 3. Organisms are interdependent with one another and their environment. (GLE 4.1)

☐ 4. Food chains and food webs demonstrate how matter and energy move through the ecosystem. Each organism in a food chain represents a trophic level. (GLE 4.2.A.a *PR*)

☐ 5. The sun is the original source of energy for all food chains. (GLE 4.2.A.a *PR*)

☐ 6. Energy pyramids depict energy conversions in an ecosystem. (GLE 4.2.A.b *PR*)

...for Standard 8

Social, political, economic, ethical, and environmental factors strongly influence, and are influenced by, the direction of progress of science and technology. (GLE 8.3.B)

CONTENT EXPECTATIONS

☐ 7. The formation of public policy should take into account considerations of science and technology. (GLE 8.3.B.b *PR*)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

UNIT 2 SECTION 1

…for Standard 4

Analyze how living things affect their environments and other living things. Analyze how matter and energy flow through an ecosystem. (GLE 4.1 *PR*, 4.2 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Explain the difference between a habitat and a niche. (GLE 4.1.A.c *PR*)

☐ 2. Explain why no two species can occupy the same niche in a community. (GLE 4.1.A.c)

☐ 3. Illustrate and describe the flow of energy within a food web. (GLE 4.2.A.a)

☐ 4. Explain why there are generally more producers than consumers in an energy pyramid. (GLE 4.2.A.b)

☐ 5. Predict how energy distribution and energy use will be altered due to changes in a food web. (GLE 4.2.A.c)

☐ 6. Describe how biomagnification can lead to the extinction of a population. (GLE 4.1.D.b *PR*)

☐ 7. Accurately define and utilize important ecological vocabulary terms.

…for Standard 8

Discuss the scientific, technological, and political aspects of major challenges to society. Describe how each of these aspects influences public policy formulation in dealing with these challenges. (Frameworks II.A.1.a)

PERFORMANCE EXPECTATIONS

☐ 8. Identify and describe major scientific and technological challenges to society and their ramifications for public policy (e.g., the use of pesticides to control pests). (GLE 8.3.B.b)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Parts of the Ecosystem Days 1–2	CE 1, 3 PE 7	Have students imagine a forest community and then list living and nonliving objects in the forest and the importance of each object to the proper functioning of the forest. In journals or learning logs, have students predict what would happen if some of these objects were removed and how the other parts of the ecosystem would be affected. Students should complete a cause-effect graphic organizer (*ER*, p. RR-13). Use the forest example to define the terms *biotic*, *abiotic*, *ecosystem*, *community*, and *population*. (Goal 4.1)
	CE 1, 3 PE 7	**Hands-On Activity/Lab:** Have students conduct a field study. They should choose a 1-square meter area and record data on abiotic factors such as soil pH, air temperature, and light intensity. Next, have students record all the biotic factors found in the area and make sketches and count or estimate the population's size. Students should collect soil samples, which could be analyzed in the lab and swabbed on Petri dishes to observe microorganisms. Have students organize and display the data collected. They should show at least three examples how the different factors in the ecosystem depend on each other. (Goals 1.3, 1.4, 1.8)
Where Organisms Live Days 3–4	CE 1, 3 PE 1	Define *niche*. Have students complete a Take-Two exercise where they write a sentence that incorporates two of the following terms: *habitat, niche,* and *competition*. Have students read about niches (Holt, p. 365) and write a Free Response (*SUTW*, p. 8-8) in their notebooks. As a class, discuss examples of different organisms and their niches. Have students create a Power Outline (*SUTW*, pp. 2-11 through 2-17) on biomes after reading Holt, pages 371–375. (Goals 1.5, 1.8)
	CE 1, 3 PE 1, 2	Display the Warbler's Foraging Zone teaching transparency (Ch. 17) and have students discuss MacArthur's investigation on warblers that occupy different niches in the same tree. Have students analyze the statement, "Two species can share the same habitat and not compete but not the same niche." Have students write a 5-Sentence Paragraph (*SUTW*, p. 10-20) using this statement as the topic sentence. (Goals 1.5, 2.1, 3.5)
Trophic Levels Day 5	CE 3, 4 PE 1, 3	**Hands-On Activity/Lab:** Have students work in groups to design a new organism, providing information on the function of its various structures, how the organism obtains and distributes energy and nutrients, and the organism's habitat and niche. Each group should provide a model or drawing of the new organism. (Goals 2.1, 2.3, 4.6)
	CE 3 PE 7	Have students work in pairs to create a concept web (*ER*, p. RR-15) using the terms *ecosystems, consumers, producers, herbivores, omnivores, carnivores, detritivores,* and *decomposers*. (Goals 1.8, 2.3)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Provide examples, from drawings or magazine photographs, of a habitat, a community, and an ecosystem.	Have students identify abiotic and biotic factors present in pictures of ecosystems. (ELL-2)	Have students investigate changes in the deer population in Missouri over time. Discuss the pros and cons of culling.
Provide a checklist of the observations and measurements that should be made for students to use during their field study.	During the field study have students record their observations in sketches. Written descriptions of sketches can be completed for homework. (ELL-8)	Have students estimate the size of a population such as a plant or insect in a particular area by counting individuals in a random selection of three different sample areas.
Explain to students that a niche is analogous to the job of the organism in the environment. Have students imagine a farm and think of the different jobs of the animals on the farm and why they are important.	Have students create Frayer Model Maps (*ER,* p. RR-25) for the important vocabulary terms in this section. Give students a list of organisms such as bee, eagle, mold, grass, and vulture. For each organism, they should identify the habitat and niche. (ELL-6)	Have students compare and contrast the soil profiles in different biomes. They should investigate and prepare diagrams of soil profiles of the temperate forest, grassland and desert. They should explain how the soil profiles affect plant growth.
Have students list all the ways they affect and are affected by their environment.	Have students identify three organisms they encounter on a regular basis (e.g., dog, squirrel, tree). They should then identify each organism's niche. (ELL-3)	Tell students that some organisms have a fundamental niche that allows them to coexist well with humans. Have them work in groups to brainstorm a list of these organisms and their niches.
Provide more structure for each group, such as an assigned habitat or niche.	Give students a food web diagram and have them color the producers green, the consumers red, and the decomposers brown. Students should then add these vocabulary words to their glossary. (ELL-5, ELL-6)	Design an organism that lives in a particular biome and needs adaptations that helps it to survive in that particular environment.
Give students a list of organisms (e.g., lion, mold, cow, corn, etc) and have them assign as many of the trophic level labels (e.g., consumer, producer, decomposer, carnivore, omnivore, herbivore, and scavenger) as they can to each.	Teach student about the derivations of the words carnivore, herbivore and omnivore. Ask students to think of other words that begin with the prefixes *omni-*, *herb-*, and *carne-*. (ELL-8)	Have students create analogies for the vocabulary words in this unit. For example producers: herbivores as consumers: _____________.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Food Webs and Energy Pyramids Days 6–7	CE 1, 2, 3, 4, 5 PE 3, 5	**Hands-On Activity/Lab:** Have students choose 10 organisms found in a forest ecosystem to create a food web. They should label each as a producer, consumer, or decomposer. Students should write the name of each on a piece of paper, arrange them on a large piece of paper, and draw arrows to represent the flow of energy through the food web. They should also indicate the original source of energy for all food webs. Then, students should choose one of the organisms to become extinct and identify three possible consequences of its extinction. (Goals 2.1, 3.1)
	CE 2, 4, 5, 6 PE 3, 4	Have students imagine that they are a packet of light energy from the sun with a value of 1000 energy units. Have them write a Quick Sketch Story (*SUTW,* pp. 6-2 through 6-16) about their travels through an ecosystem. They should trace their path through an energy pyramid and indicate their value at each level. (Goal 2.1)
	CE 2, 3, 5, 6 PE 3, 4	Have students create a food chain and then draw an energy pyramid to illustrate the transfer of energy in the food chain. They should label the trophic levels, describe relative quantities of organisms at each level, and use the 10% law to describe the amount of energy available at each level. Have students choose one of the organisms and list four ways that it uses the energy available to it. (Goals 2.1, 4.1)
Biomagnification Day 8	CE 2, 3, 4, 7 PE 6, 8	Use the Biological Magnification of DDT teaching transparency (Ch. 18) to demonstrate how DDT becomes concentrated at the top of the food chain. Explain how DDT is stored in fatty tissue instead of being excreted by the body. Distribute data that show changes in the bald eagle population over the last 40 years. Data can be obtained at www.learner.org/jnorth/tm/eagle/Population.html. Have students create graphs of this data and analyze them. Discuss *Silent Spring* by Rachel Carson and the banning of DDT in the US. *See Model Lesson*. (Goals 1.5, 1.8, 3.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Give students cut-out pictures of organisms. Have them use these pictures to construct a food web.	When introducing food chains, food webs, and energy pyramids use organisms that are familiar to students. Use the same organisms in all three examples before exposing students to examples with other organisms. This allows students to apply the knowledge from one organizing scheme to another. (ELL-3)	The extinction of the dodo bird eventually led to the extinction of a local tree. Have students research the extinction of an organism in the past, and the impact it had on the local food web and ecosystem.
As a class, discuss the amount of energy that will be available at each level of the energy pyramid before students begin to write their stories.	Have students create an illustrated poster, model, or oral explanation to accompany their stories. (ELL-7)	Have students research why eating low on the food chain (vegetarian diets) is better for the environment in terms of energy consumption and waste and pollution. They should then write a 5 X 8 Speech (*SUTW,* pp. 5-4 through 5-5) promoting or countering a vegetarian diet.
As a class, use a few initial amounts of energy (e.g., 1000, 200, 50) to work through the 10% law several times on the same energy pyramid consisting of three trophic levels.	Create a sample "pond community" in a paper bag using gummy fish, fish-shaped crackers, and sprinkles for algae. Have students create a biomass pyramid by finding the average weight of one organism from each species and multiplying by the estimated number of organisms in each population. (ELL-5)	Have students compare and contrast aquatic and terrestrial food chains and have them investigate why aquatic food chains tend to be longer than terrestrial ones.
Have students write out step-by-step what happens as DDT moves up the food chain.	Give students a case study of what happened to eagles in the US or cats in Borneo after the widespread use of DDT. Information can be obtained at www.cdra.org.za/creativity/Parachuting%20cats%20into%20Borneo.htm. (ELL-2)	Have students research ways to control pests biologically and discuss the benefits and possible drawbacks to these methods. Have students write a persuasive speech to convince the local government not to use pesticides to kill mosquitoes.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, pp. RR-13, RR-15, RR-25

   Step Up to Writing, pp. 2-11 through 2-17, 3-43 through 3-45, 5-4 through 5-5, 6-2 through 6-16, 8-8, 10-20

2. **Internet Resources for Teachers**

   Analyzing the Bald Eagle Population Activity
   www.learner.org/jnorth/tm/eagle/Population.html

3. **Internet Resources for Students**

   Parachuting Cats into Borneo
   www.cdra.org.za/creativity/Parachuting%20cats%20into%20Borneo.htm

   The Story of *Silent Spring*
   www.nrdc.org/health/pesticides/hcarson.asp

   The World's Biomes
   www.ucmp.berkeley.edu/glossary/gloss5/biome/

4. **Multicultural Resources and/or Activities**

   Study cultural patterns that promote healthy interactions between humans and the environment. For example, it is important in the Navajo culture to keep one's life in harmony with nature.

   Compare the diets of humans in various parts of the world and show how they fit into their respective food webs. Have students compare them to each other in terms of monetary and ecological costs.

5. **Additional Instructional Resources**

   Carson, Rachel. *Silent Spring*. Houghton Mifflin, 1962.

Suggested Assessments

1. Have students explain the relationship between the following word pairs:
   - *population* and *ecosystem*
   - *habitat* and *niche*
   - *biotic factor* and *community*
2. Have students choose an ecosystem to research and report on the biotic and abiotic components. They should provide examples of producers, herbivores, carnivores, and detritivores. Then they should make one food chain, one food web, and an energy pyramid.
3. Have students predict what would happen to living things if the sun's light were blocked for a period of 7 to 8 months. Have them write a Cause and Effect paragraph (*SUTW*, pp. 3-43 through 3-45) explaining how the blockage of the sun would affect food chains and food webs on Earth.
4. Have students complete the Evaluating Biodiversity Quick Lab (Holt *Biology*, p. 342).

UNIT 2 SECTION 1

Sample Constructed-Response Item

Create a food chain with 4 trophic levels, identify the producers and consumers. Why are there no food chains with 10 trophic levels found in nature?

Grass (producer) ⇒ Grasshopper (primary consumer) ⇒ Frog (secondary consumer) ⇒ Hawk (tertiary consumer)

A food chain with 10 levels would be very unlikely because there wouldn't be enough energy available to the organisms at the top of the chain to survive. Only about 10% of the available energy is passed on from one trophic level to the next.

Model Lesson (Traditional Roster): *Biomagnification*

Lesson Questions

What is biomagnification?

How do chemical pesticides like DDT affect ecosystems?

How can biomagnification lead to extinction of organisms?

Materials

Copies of excerpts from *Silent Spring*, Biological Magnification of DDT teaching transparency (Ch. 18), bald eagle population data, graph paper

Content and Performance Expectations

CE 2, 3, 4, 7; PE 6, 8

Teacher's Notes

It may be useful to discuss current controversy over the claim that DDT caused bird deaths through the thinning of eggshells.

Warm-Up

Excerpts from *Silent Spring* by Rachel Carson

- Read excerpts from "A Fable for Tomorrow" by Rachel Carson.
- Stop at predetermined places to allow students to write Free Responses (*SUTW*, p. 8-8) to what has been read.

Instruction

DDT and Biomagnification

- ▶ The Story of DDT
  - ▷ Use students' Free Responses to discuss the excerpts. Other possible discussion questions are, "How did you feel while reading?", "What is the passage about?", "Who or what is the 'grim specter'?", and "What does she mean by saying it is a 'spring without voices'?"
  - ▷ Explain to students that Rachel Carson wrote *Silent Spring* in response to the death of large numbers of birds due to the use of DDT (an insecticide) in the 1950s and 60s. In her book she described how DDT entered the food chain and accumulated in the fatty tissues of animals, including human beings, and caused cancer and genetic damage. A single application on a crop, she wrote, killed insects for weeks and months, and not only the targeted insects but countless more, and remained toxic in the environment even after it was diluted by rainwater.

- ▶ Biomagnification
  - ▷ Show students the teaching transparency Biological Magnification of DDT (Ch. 18). Define biological magnification.
  - ▷ Explain to students that DDT is a fat-soluble molecule so it is stored in the fatty tissues of organisms and not excreted.
  - ▷ Explain to students that organisms at the top of the food chain are affected the most because DDT becomes more concentrated as it moves up the food chain.

Analyzing Bald Eagle Population Data

- ▶ Graphing Exercise
  - ▷ Tell students that DDT was banned from use in the US in 1972, but that prior to that the bald eagle almost became extinct.
  - ▷ Give students data on the bald eagle population.
  - ▷ Have them make graphs of the data. They should then describe trends and provide explanations for them.

Wrap-Up

- ▶ DDT Today
  - ▷ Explain to students that DDT is still produced in the US and used by many countries throughout the world. Discuss its use in areas affected by malaria.
  - ▷ Have students discuss whether DDT should be used in other parts of the world.

Assessment

- Have students explain why doctors recommend that women who are pregnant avoid eating certain types of fish.

Homework Assignment

- Have students write a persuasive speech to convince US government officials about the dangers of DDT and to enact legislation to ban the import of food from countries that use it.

Teaching Resources

- Holt *Biology*, pp. 390–391
- The Story of Silent Spring
  www.nrdc.org/health/pesticides/hcarson.asp
- Bald Eagle Population Data
  www.learner.org/jnorth/tm/eagle/Population.html
- "DDT and Africa's War on Malaria"
  http://news.bbc.co.uk/2/hi/world/africa/1677073.stm

Unit 2 Section 2

COMMUNITY INTERACTIONS

UNIT 2 SECTION 2

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Interactions Among Species	Holt, pp. 361–364
3–4	2	Competition	Holt, pp. 365–370
5–6	3	Changes in Populations	Holt, pp. 320–325
7–8	4	Succession	Holt, pp. 343–344

BENCHMARK ASSESSMENT 1—WEEK OF OCTOBER 2 (CONTINUED NEXT SECTION)

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 4: Changes in Ecosystems and Interactions of Organisms with their Environment

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 4

Organisms are interdependent with one another and their environment. Overpopulation in an ecosystem can lead to depletion of natural resources and elimination of a species. (GLE 4.1, Frameworks VIII.B.2)

CONTENT EXPECTATIONS

☐ 1. All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem. (GLE 4.1.A)

☐ 2. Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. (GLE 4.1.B)

☐ 3. The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes. (GLE 4.1.D)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 4

Observe and identify competitive and cooperative interrelationships among species of a local ecosystem. Identify the density-dependent limiting factors of a population and discuss consequences of overpopulation. Discuss how changes in one population in an ecosystem affect the population of another species in that ecosystem. (Frameworks VIII.A.1.a, VIII.B.2.a, VIII.B.2.b)

PERFORMANCE EXPECTATIONS

- ☐ 1. Explain the nature of interactions between organisms in different symbiotic relationships (i.e., mutualism, commensalism, parasitism). (GLE 4.1.A.a)
- ☐ 2. Explain how cooperative (e.g., symbiosis) and competitive (e.g., predator/prey) relationships help maintain balance within an ecosystem. (GLE 4.1.A.b)
- ☐ 3. Identify and explain the limiting factors that may affect the carrying capacity of a population within an ecosystem. (GLE 4.1.B.a)
- ☐ 4. Predict changes in populations due to changes in biotic and/or abiotic factors. (GLE 4.1.B.b)
- ☐ 5. Predict the impact (beneficial or harmful) a natural environmental event (e.g., forest fire, flood, volcanic eruption) may have on the diversity of different species in an ecosystem and describe possible causes of extinction of a population. (GLE 4.1.D.a)

…for Standard 7

Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Frameworks I.A.3.a)

PERFORMANCE EXPECTATIONS

- ☐ 6. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., microscopes). (GLE 7.1.B.a)
- ☐ 7. Analyze experimental data to determine patterns, relationships, perspectives, and credibility of explanations (e.g., predict/extrapolate data, explain the relationship between the independent and dependent variables). (GLE 7.1.C.b)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Interactions Among Species Days 1–2	CE 1, 4 PE 1, 2	Have students compile a list of all the ways organisms of different species can interact in an ecosystem. Have them make predictions about how the ecosystem would be affected if these interactions did not exist. Have students analyze a graph showing the fluctuations in the populations of two species in a predator-prey relationship over time. (Goals 1.6, 2.4, 3.5, 4.1)
	CE 1, 4 PE 1, 6	**Hands-On Activity/Lab:** Have students explore a symbiotic relationship found between leguminous plants and nitrogen-fixing bacteria. Have students observe prepared slides of root nodules from leguminous plants that support bacteria populations and make observations. Have them research this mutualistic relationship and write a Framed Paragraph (*SUTW,* pp. 3-59 through 3-61) about it with the topic sentence, "Mutualism is a relationship between two organisms where both organisms benefit." (Goals 1.2, 1.4, 1.6, 2.1)
	CE 1, 2, 4 PE 1, 2	Show students a graph demonstrating fluctuations in the populations in a predator-prey relationship. Have them analyze the graph and explain how this type of relationship helps to maintain a balance in the ecosystem. Have students identify different examples of symbiotic relationships, such as mutualism, commensalism, or parasitism. *See Model Lesson*. (Goals 1.1, 1.5, 3.5, 4.1)
Competition Days 3–4	CE 1, 2 PE 2	Have students write Free Responses (*SUTW*, p. 8-8) about the following questions: What do organisms compete for? How do humans compete with other organisms? How do humans compete with each other? Have them create a list of examples of interspecific and intraspecific competition. Have students share their ideas in a class discussion. (Goals 1.10, 2.3, 2.4, 4.1)
	CE 1, 2 PE 2	Have students read about the competition experiments of Connell, Gause, and Paine (Holt, pp. 368–370). They should use sticky notes to write down important concepts or ideas and to mark areas of difficulty, or they should write Two-Column Notes (*SUTW*, pp. 9-4 through 9-14). After completing the section, have students work with a partner to discuss the text and clarify the content. As a class, compare and contrast the fundamental niche with the realized niche of each species. (Goals 1.6, 3.5, 4.6)
Changes in Populations Days 5–6	CE 2 PE 3, 4	Have students graph data of human population growth over time using the data table on Holt, page 394. Have them analyze the graph and make predictions about the future. Have students respond to the following writing prompt: Has the population reached carrying capacity? Use their written responses to begin a discussion of how the growth of the human population affects other species and our natural resources. (Goals 1.5, 1.8, 2.1, 2.4, 3.1, 3.6, 4.1)
	CE 1, 2, 4 PE 3, 4, 6, 7	Give students a set of data on bacteria growth in a Petri dish over time. Have them graph the data and make inferences about the growth of the population. Have students list possible limiting factors and make predictions about how changes in these factors would affect the bacteria population on a cause-effect graphic organizer (*ER*, p. RR-13). Have them identify the point when the population reached carrying capacity. (Goals 1.8, 2.1, 2.4, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Show students pictures of different species interacting in nature. Have students describe the interactions they can see.	Have students record the different interactions they have with other people over a 24-hour period. Have them identify these interactions a positive, negative, or neutral. (ELL-3)	Discuss the importance of dominant (keystone) predators, such as wolves or sea otters, in a community. Have students research how the loss of keystone predators can result in competitive exclusion.
Start out with concrete examples of symbiosis between humans and other organisms (e.g., humans/dogs and humans/mosquitoes).	Provide students with research materials to find information about pairs of organisms that practice symbiosis. Students should take notes on index cards and arrange the index cards in categories. (ELL-2)	Explain that symbiotic relationships are often the result of coevolution. Have students choose a symbiotic relationship and research the evolution of it.
Have students draw and write about two people central to their lives. One illustrated description should detail an adversary, the other an ally.	Have photographs of jumbled pairs of organisms on the wall. As a class, decide which organisms pair together, and define their relationship as either predator/prey or symbiotic. (ELL-5)	Have students design an investigation that analyzes the effect of a competitive relationship or a symbiotic relationship on a given organism.
Have students draw and write about their habitats and niches. Have students discuss how these habitats and niches would be different if they lived in another habitat (rural, urban, or suburban).	Explain to students the meanings of the prefixes *intra*- and *inter*-. Have them come up with a list of other words that begin with the prefixes and define them. (ELL-1)	Have students complete Investigating Competition Group Activity (Holt *TE,* p. 368) in small groups to investigate an example of competition.
Give students additional examples or realized and fundamental niches such as the finches in the Galapagos Islands.	Have students create a chart to compare the fundamental niche with the realized niche. (ELL-6)	Have students identify the strengths and weaknesses of each scientist's hypothesis or theory.
Have students identify the factors that contribute to the high human population growth rate.	Have students discuss about whether the human population growth rate in the United States is similar to rates in other parts of the world, including their home countries. (ELL-3)	Have students investigate and compare the effects on the environment of suburban growth and urban growth. Have them develop a conclusion about which is better for the environment.
Have students count the number of potential offspring in one green pepper. Have them explain why the world is not covered with green pepper plants.	Have students explain the difference between the following word pairs: *density-dependent factors* and *density-independent factors, predation* and *competition*. Have them provide examples for each of the terms. (ELL-6)	Have students research the meanings of the terms *r-strategists* and *K-strategists*. Have them provide examples and characteristics for each group.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Succession Days 7–8	CE 1, 3 PE 2, 5	**Hands-On Activity/Technology:** Have students study succession in a pond water culture. Place pond water in a jar with holes in the lid. Students should observe changes in the pond water culture each day, beginning with the first day of this section. Students should record changes in pH and organism growth (using a microscope). Groups of students can rotate this responsibility. Use the pond water culture to discuss succession. Have students identify the climax community. (Goals 1.1, 1.2, 1.3, 1.4, 4.1)
	CE 1, 3, 4 PE 6, 7	**Hands-On Activity/Lab:** Take students on a field trip outside to the parking lot, school grounds, or local park. In pairs, have students find examples of primary and secondary succession. Have students create a map of the area demonstrating places where primary and secondary succession occur. (Goals 1.1, 1.2, 1.3, 1.4, 2.1, 3.1, 4.5, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Give students a jumbled set of pictures that depict the different stages of community succession. Have them put the pictures in order and write descriptions for what is happening in each stage.	Have students define the term *pioneer*. Have them create a chart to compare and contrast a climax community and a pioneer community. (ELL-1)	Discuss how fires are important to the ecological health of many communities and have students hypothesize why this might be the case in relation to succession. Have students research and debate the benefits of proscribed burning.
Discuss familiar situations or events that are familiar to students and may have resulted in secondary succession. This provides a framework for students to understand more abstract concepts related to secondary succession.	In their pairs, have students take turns recording and verbally describing the examples of succession they discover. (ELL-5)	Have students compare the climax communities in different ecosystems. After analyzing the connections between the types of organisms present and the climate of the area, have students predict which organisms would be present in the climax community in a new ecosystem.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, p. RR-13

   Step Up to Writing, pp. 3-21 through 3-29, 3-43 through 3-45, 3-59 through 3-63, 5-4 through 5-5, 6-2 through 6-11, 8-8, 9-9

2. **Internet Resources for Teachers**

   PBS Newshour Lesson Plan: Stopping the Demise of the Worlds Coral Reefs
   www.pbs.org/newshour/extra/teachers/lessonplans/science/coralreefs.html

   Ecological Succession in Pond Water Sample Lesson Plan
   www.woodrow.org/teachers/bi/1998/presentations/jones/

3. **Internet Resources for Students**

   Symbiotic Relationships
   www.cals.ncsu.edu/course/ent591k/symbiosis.html

   Deer: Predation or Starvation Data
   www.biologycorner.com/worksheets/deer_predation.html

   Ecological Succession in Pond Water Cultures
   www.woodrow.org/teachers/bi/1998/presentations/jones/

4. **Multicultural Resources and/or Activities**

   Examine the history of how different groups of people interacting with their ecosystems viewed those ecosystems from theological and social perspectives. Explain how in certain parts of the world the ecosystem and the earth are seen as sacred and are expected to be treated as such.

   The demographics of different countries around the world show very different scenarios of population growth. Show students growth rate and age structure graphs of different countries such as Italy (which is experiencing negative growth) and India (which is experiencing explosive growth) and discuss the effects these trends will have on natural resources and food production.

Suggested Assessments

1. Have students write a short report, containing Compare or Contrast Paragraphs (*SUTW*, pp. 3-21 through 3-29), that contrasts competition between organisms in a natural community with competition between businesses in a human community.
2. Give students descriptions of different examples of symbiosis in nature. Have them identify each as mutualism, commensalism, or parasitism.
3. Have students design an experiment to determine how different factors such as light, fertilizer, and temperature affect the population growth of duckweed.
4. Have students complete the Interpreting Competition Among Protists Data Lab (Holt, p. 468).

Sample Constructed-Response Item

How can predators be beneficial to a prey population?

Predators can remove the weak and the sick leaving only the strong to reproduce. Predators can make sure that the prey population does not grow out of control and prevent periods of starvation for the prey species. Predators can also prevent the extinction of a species due to competitive exclusion.

Model Lesson (Block Roster):
Interactions Among Species

Lesson Questions

How do populations in a community affect each other directly and indirectly?

How do mutualism, commensalism, and parasitism differ from each other?

Materials

Transparency of the Woodpecker and Beetle Populations graph, copies of the Mosquito Population Control activity sheet, copies of the Types of Symbiotic Relationships activity sheet

Content and Performance Expectations

CE 1, 2, 4; PE 1, 2

Teacher's Notes

None

Warm-Up

Woodpecker and Beetle Population Graph

- Display a transparency of the Woodpecker and Beetle Populations graph.
- Have students record their observations about the graph, offer possible reasons for fluctuations in the graph, make comparisons between the two populations, and predict what would happen if the graph were extended.

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Instruction

Types of Interactions Among Species

▶ Predator-Prey Relationships	▷ Define *predator* and *prey*. Have students add the definitions to their vocabulary lists. Discuss how the terms apply in the beetles and woodpeckers example ▷ Discuss with students the fact that many predator-prey relationships show a cycle of population increases and decreases over time. Explain that predator-prey relations are important for the health of natural populations. Ask students to hypothesize how predators can be good for their prey populations. ▷ Discuss scenarios of what might happen to a prey population after the extinction of its predator. ▷ Have students give examples of other populations that might be present in the habitat. Discuss whether they would affect the beetles and woodpeckers directly or indirectly. ▷ Have students explain what would happen with the introduction of another species of beetle that the woodpeckers would eat. Have them identify which population(s) might be affected by changes in the beetle or woodpecker populations.
▶ Pest Control Case Study	▷ Have students complete the Mosquito Population Control activity sheet. ▷ Have each group choose the best method of mosquito population control and explain their reasoning in a paragraph. ▷ Have groups share their reasoning with the class.
▶ Symbiotic Relationships	▷ Have students describe the relationship between mosquitoes and humans. ▷ Tell students that symbiotic relationships are like partnerships in nature. Symbiosis occurs when there is a close relationship between two species that helps the survival of at least one of those species. Define *mutualism*, *commensalism*, and *parasitism*. Have students add the definitions to their vocabulary lists. ▷ Have students determine which definition applies to the relationship between mosquitoes and humans. Have the students think of other examples. ▷ Have students complete the Types of Symbiotic Relationships activity sheet. They should identify the type of symbiotic relationship present in each situation. This may be accomplished by giving one situation to each group, discussing each situation as a class, or having them work individually.

Assessment

- Have students choose a predator-prey relationship (for example, wolves and deer) and draw a graph illustrating the relationship between the two populations. Students should include written descriptions of their graphs.
- Have students answer the following questions: In what ways are predators and parasites alike? How do they differ? Why are there always more prey than predators in a stable ecosystem? What are the effects of hunting on predator/prey relationships?

Homework Assignment

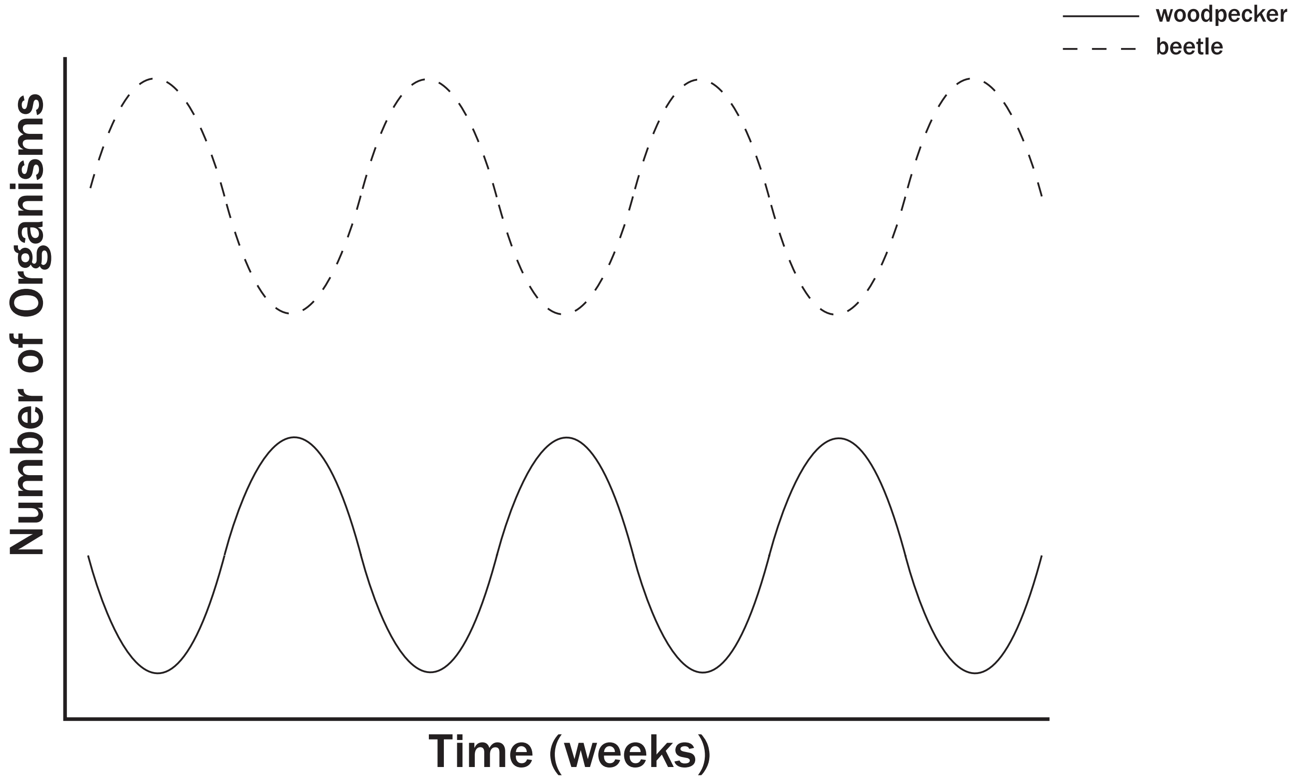
- Have students read Holt, pages 362–364.
- Have students complete the Directed Reading Skills Worksheet on page 1 of Holt *Biology CRF 17: Biological Communitie*s.

Teaching Resources

- Holt, pp. 362–364
- Holt *Biology Chapter Resource File 17: Biological Communities*
- Holt *Biology Special Needs Activities and Modified Tests with Answer Keys*
- Mosquito population control information
  www.co.leon.fl.us/mosquito/mceduc/index.asp
- Hare/Lynx Dynamics Graphing Exercise
  http://people.westminstercollege.edu/departments/science/The_Natural_World/Lesson_Schedule/Assignments/Hare_Lynx.htm

WOODPECKER AND BEETLE POPULATIONS GRAPH

Woodpeckers are birds that eat insects, fruit, and nuts. They use their long pointed beaks to obtain insects hiding beneath bark.



UNIT 2 SECTION 2

name ______________________ date ____________

Mosquito Population Control

Mosquitoes are often considered to be one of the most common pests worldwide. Female mosquitoes bite animals to feed on their blood. In doing so, they can spread diseases such as West Nile virus, yellow fever, malaria, and dengue fever. Mosquitoes lay their eggs in standing water or damp places.

There are a variety of ways to approach mosquito population control. Pesticides can be applied aerially or on the ground. Individuals can apply insect repellents and wear protective clothing. Breeding grounds for mosquito larvae can be eliminated. Physical barriers can be put in place.

Some organisms have been used as agents of biological control such as *Bacillus thuringiensis israelensis* (Bti), *Gambusia affinis* (mosquito fish), and bats. Bti is typically applied by placing disks coated with the bacteria in places where mosquitoes might breed, because Bti kills mosquito larvae. Bti has not been shown to be toxic to humans, amphibians, fish, crustaceans, adult insects, flatworms, or mollusks. Mosquito fish also control mosquito larvae by feeding upon them. Bats eat adult mosquitoes, though bats prefer other organisms as food and do not typically eat enough in one night to significantly impact a mosquito population.

List the methods of biological control.

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Choose two of the methods of biological control and compare them to each other. Include the possible impact of each on the community.

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List the other methods of mosquito population control.

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Choose one of the other methods of mosquito population control and compare it to a method of biological control. Include the possible impact of each on the community.

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name ______________________ date __________

Types of Symbiotic Relationships

Identify each situation as mutualism, commensalism, or parasitism. For each situation, give evidence for its classification.

1. Coral reefs are composed of living and nonliving structures. While corals, algae, and sponges are the predominant organisms forming the backbone of the structure, many organisms are found living in, on, and near coral reefs. For example, sea anemones attach themselves to coral reefs. Sea anemones are typically shaped like cylinders topped off with tentacles. They use their tentacles to paralyze small marine animals that they then eat. Clownfish are small, brightly colored fish that live among the tentacles of the sea anemones. They are protected from the stinging tentacles by mucus on their skin.

   Type of symbiotic relationship: ______________________

   Evidence: ______________________

   ____

2. Tapeworms range in size from a fraction of a centimeter to many meters long. Tapeworms have suckers and hooks that allow them to attach themselves inside the intestines of vertebrates such as dogs, pigs, and humans. Tapeworms get nutrients from the animal they are living inside of. Though it is difficult to detect tapeworm infections, possible symptoms are diarrhea, gastrointestinal discomfort, weakness, and unexplained weight loss.

   Type of symbiotic relationship: ______________________

   Evidence: ______________________

   ____

3. Lichens are known as pioneer species due to their ability to live in inhospitable environments such as recently exposed land or on bare rocks. Lichen resemble plants, but are actually composed of fungus and algae living together. The fungus attaches the lichen to the structure upon which it is living and absorbs nutrients from the environment. The algae produce oxygen and glucose through photosynthesis.

   Type of symbiotic relationship: ______________________

   Evidence: ______________________

   ____

4. Aphids are considered pests by most gardeners and farmers. They are small insects that feed on plant sap, which is primarily made of sugars and water. Aphids excrete excess sugars as sticky honeydew secretions. Ants are insects that live in colonies and feed on a range of sweet foods, other insects, grains, and seeds. Colonies of ants seem to adopt groups of aphids. The ants harvest these honeydew secretions, protect the aphids from predators, and even bring them into anthills during cold weather.

   Type of symbiotic relationship: ______________________

   Evidence: ______________________

   ____

name ______________________ date ____________

5. Many species of birds typically inhabit a forest. Female European cuckoos lay their eggs in the nests of other species of birds, sometimes removing the eggs originally laid in the nest. Since the eggs of the European cuckoo bird usually mimic the eggs of other species of birds, the host adults are often tricked into incubating the cuckoo eggs and raising the young. Young European cuckoos are larger than the young of many other species of birds and often outcompete them for food and space.

   Type of symbiotic relationship: ______________________________

   Evidence: ______________________________

   ____

6. The grasslands of Africa support a variety of organisms. Such grasslands, also known as savannahs, are usually covered with grasses and shrubs. Grazing animals feed on these grasses and shrubs, stirring up insects as the herds move. Cattle egrets are birds that often follow herds around, eating the insects that have been stirred up. These birds are also sometimes seen picking off ticks from cattle, horses, and rhinos.

   Type of symbiotic relationship: ______________________________

   Evidence: ______________________________

   ____

Unit 2 Section 3

NUTRIENT CYCLES

UNIT 2 SECTION 3

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	Water Cycle	Holt, pp. 350–351
2–3	1–2	Carbon Cycle	Holt, p. 352
4	2	Nitrogen and Phosphorous Cycles	Holt, pp. 353–354

BENCHMARK 1 REVIEW, REMEDIATION, AND ENRICHMENT—2 DAYS

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 4: Characteristics and Interactions of Living Organisms

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 4

Matter is recycled through an ecosystem. Organisms are interdependent with one another and their environment. (GLE 4.1, 4.2B)

CONTENT EXPECTATIONS

- ☐ 1. Oxygen, carbon, water, phosphorous, and nitrogen continuously cycle through an ecosystem. (GLE 4.2.B.a *PR*)
- ☐ 2. The cycling of matter in an ecosystem helps to maintain homeostasis. (GLE 4.2.B.b *PR*)
- ☐ 3. All organisms, including humans, and their activities cause changes in the environment that affect an ecosystem. (GLE 4.1.C)
- ☐ 4. There are consequences for interrupting the cycling of oxygen, carbon, water, nitrogen, and phosphorus, including habitat destruction, disruption of food chains, species extinction, and climate change. (GLE 4.1.C.b *PR*)

…for Standard 8

Human beings have a huge impact on other species, their environments, and technology. These impacts include: reducing the amount of habitat available, interfering with food sources, and changing the temperature and chemical composition of their habitats. (Framework II.A.2)

CONTENT EXPECTATIONS

- ☐ 5. The impact human beings have on the environment influences scientific research and public policy. (GLE 8.3.B.b *PR*)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

UNIT 2 SECTION 3

…for Standard 4

Analyze how organisms are dependent upon a stable ecosystem and each other, and how the stability of the ecosystem depends upon the recycling of nutrients. (GLE 4.1 *PR*, GLE 4.2.B *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Explain the importance of the recycling of nitrogen, oxygen, water, phosphorus, and carbon within an ecosystem. (GLE 4.2.B.b *PR*)

☐ 2. Explain the processes involved in the recycling of nitrogen, oxygen, and carbon through an ecosystem. (GLE 4.2.B.a)

☐ 3. Identify the role of organisms, including humans, in nutrient cycles. (GLE 4.2.B.b *PR*)

☐ 4. Predict and explain how natural or human caused changes (biological, chemical and/or physical) in one ecosystem may affect other ecosystems due to natural mechanisms (e.g., water cycle). (GLE 4.1.C.b)

…for Standard 8

Analyze and evaluate how specific technological solutions may impact the environment in areas such as habitat loss, disruptions in the food web, and temperature and chemical changes. (Frameworks II.A.2.a)

PERFORMANCE EXPECTATIONS

☐ 5. Identify and describe major scientific and technological challenges to society and their ramifications for public policy (e.g., global warming). (GLE 8.3.B.b)

UNIT 2 SECTION 3

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Water Cycle Day 1	CE 1, 2 PE 1, 3	As a class, define the important vocabulary terms for this section and brainstorm examples of the terms. In pairs, have students complete a Take Two exercise by forming a sentence from at least two of the following terms: *condensation*, *evaporation*, and *precipitation*. Then, have them read Holt, pages 350–351 and create a flowchart to demonstrate the movement of water through the cycle. (Goals 1.5, 1.6, 1.8, 2.1, 2.3, 4.6)
	CE 1, 2, 4 PE 3, 4	Have students write a Quick Sketch Story (*SUTW,* pp. 6-2 through 6-11) from the viewpoint of a molecule of water. They should describe their travels through each step of the water cycle, accompanied by illustrations. Have them describe what would happen if the water molecule could not complete its travels. (Goals 1.8, 2.1, 2.5)
Carbon Cycle Days 2–3	CE 1, 2, 3, 4, 5 PE 1, 2, 3, 4, 5	Guide students through the steps of the carbon cycle. Discuss how human activities have altered the natural cycle and the implications of increased amounts of CO_2 in the atmosphere. Have students write Power Outlines (*SUTW,* pp. 2-11 through 2-17) and then write letters to local legislators about global warming. *See Model Lesson*. (Goals 1.5, 2.1, 2.4, 3.1, 3.6)
	CE 1, 2, 3, 4 PE 1, 2, 3, 4	**Hands-On Activity/Lab:** Explain the greenhouse effect. Have students complete the Modeling the Greenhouse Effect Quick Lab (Holt, p. 389). Have them hypothesize how the addition of CO_2 to their model would affect their model. Have students conduct an experiment to test their hypotheses. Students should draw inferences from the model and from other resources to determine possible outcomes of increased temperatures on Earth. (Goals 1.2, 1.3, 1.8, 3.5, 3.6)
	CE 3, 4, 5 PE 1, 2, 3, 4, 5	**Technology:** Have students use a spreadsheet program to construct graphs of changes in atmospheric CO_2 levels over time. One source of data is http://cdiac.esd.ornl.gov/trends/co2/sio-mlo.htm. Have students make a list of activities that lead to rising levels of CO_2. Have them explain the graph, make predictions about the future, and propose solutions to increasing CO_2 levels. (Goals 1.6, 1.8, 3.1, 3.3, 3.7, 3.8, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Review changes in the state of water with students. Demonstrate real-world examples of condensation, precipitation, and evaporation.	Have students create vocabulary flash cards for this section's key terms. (ELL-1)	Have students design a demonstration to illustrate the water cycle at work.
Have students create a poster of the water cycle, labeling the following terms: *evaporation, condensation, precipitation, transpiration*, and *percolation* into the soil.	Have students read pages 21–23 in Holt *Biology Reading in the Content Area*. (ELL-6)	Have students include the role of energy in the water cycle and describe how the water molecule gets the energy it needs to move through the ecosystem.
In pairs, have students create annotated carbon cycle diagrams.	Have groups of students cut out pictures from magazines and newspapers, and have them use them to construct a carbon cycle. After construction, have them compare their versions to more complicated versions in biology textbooks and encyclopedias. Have them list the differences and modify their cycles if necessary. (ELL-2)	Have students investigate the importance of bacteria and fungi in the carbon cycle. Have students write about what the world would be like without bacteria or fungi.
Give students a sequencing map (*ER*, p. RR-77), to jot down the steps to the activity in order. Then, have them write a 5-Sentence Paragraph (*SUTW*, p. 10-20) describing and explaining their observations.	Have students read aloud each step of the procedure and demonstrate it at the front of the room before allowing students to do the experiment themselves. (ELL-4)	Have students use an experiment to investigate how the world's ocean currents influence the carbon cycle. An example can be found at www.wested.org/werc/earthsystems/biology/carbondioxide.html.
Have students list five ways they as individuals can reduce carbon dioxide emissions. After they present their suggestions orally in front of their classmates, add their ideas to a master list on the board.	Have students imagine that they are a carbon atom. They have to describe their carbon cycle journey in a journal entry, poetry, essay, song, cartoon, or acting. (ELL-7)	Give students articles about current proposals to curb worldwide CO_2 production. Have them write a Summary Paragraph beginning with a Burrito Summary Topic Sentence (*SUTW,* pp. 3-3 through 3-14) of what they read.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Nitrogen and Phosphorous Cycles Day 4	CE 1, 2, 3, 4 PE 1, 2, 3, 4	**Hands-On Activity/Lab:** Have students design and perform an experiment to investigate either the effect of adding nitrates to the soil in which a plant is growing or how the addition of phosphorous to a fish tank disrupts the ecosystem. An alternate experiment would be to have them conduct an experiment on the effect of phosphorous and nitrogen on algae growth. (Goals 1.1, 1.2, 1.3, 1.4, 4.1)
	CE 1, 2, 3, 4, 5 PE 1, 2, 3, 4, 5	Have students work in pairs to make a list of the steps involved in the nitrogen cycle. Have them predict how a disruption in one part of the cycle would affect other parts. Have them explain why nitrogen is rare in the soil but abundant in the atmosphere. Discuss the practice of crop rotation and the importance of nitrogen-fixing bacteria in the nitrogen cycle. (Goals 1.6, 1.8, 2.1, 2.3, 3.5, 4.1, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students create a play that tells the story of atmospheric nitrogen gas, and its metamorphosis during the nitrogen cycle. Actors need to demonstrate nitrogen's movement from soil air to nitrogen-fixing bacteria to nitrifying bacteria to plants to animals to decomposers, and nitrogen from dead organisms to decomposers to nitrifying bacteria to plants.	Have students define *cycle*. Have them list examples of cycles found in nature; the first three listed should be the water, carbon, and nitrogen cycles. (ELL-3)	Have students write a Cause and Effect Paragraph (*SUTW,* 3-43 through 3-45) on how phosphorus from fertilizers and detergents cause eutrophication and algal blooms.
Show students examples of leguminous plants.	Have students complete a cause-effect graphic organizer (*ER,* p. RR-13) of how a disruption in one part of the cycle would affect other parts of it. (ELL-7)	Have students evaluate the advantages and disadvantages of using gene technology to put a nitrogen-fixing gene in a nonleguminous plant.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, pp. RR-13, RR-77

   Step Up to Writing, 2-11 through 2-17, 3-3 through 3-14, 3-21 through 3-29, 3-43 through 3-45, 6-2 through 6-11, 10-20

2. **Internet Resources for Teachers**

   Earth's Biological Systems Lesson Plans
   www.wested.org/werc/earthsystems/biology/biology.html

   CNNfyi.com: Carbon and Nitrogen Cycles Lesson Plan
   http://cnnstudentnews.cnn.com/2001/fyi/lesson.plans/03/30/carbon.dioxide/

   Modeling the Greenhouse Effect
   www.wested.org/werc/earthsystems/energy/greenhouse.html

3. **Internet Resources for Students**

   Atmospheric Carbon Dioxide Record from Mauna Loa
   http://cdiac.esd.ornl.gov/trends/co2/sio-mlo.htm

   Eutrophication
   http://en.wikipedia.org/wiki/Eutrophication

   WWF Information on Algal Blooms
   www.wwf.org.nz/earthsaver/es_28.cfm

4. **Multicultural Resources and/or Activities**

   Examine the history of land management practices. For example, archeological research at El Pilar in Belize and Guatemala indicates that ancient Mayans understood soil chemistry, microclimates, and ecological succession. There is evidence of enrichment practices and slash-and-burn agriculture. Aboriginal tribes in Australian used a fire management program to create open spaces for travel, form shelters in mature trees, stimulate the growth of green grass and heath plants, and cause nutrients to form rich soil downslope from the burned areas.

Suggested Assessments

1. Have students select one of the cycles and explain how humans would be affected if their chosen element did not cycle.
2. Have students identify the similarities and differences between the carbon cycle and the nitrogen cycle using a Venn diagram.
3. Have students read Holt, pages 351–354 in Holt and answer #1–5 in the Section Review.
4. Have students write a Cause-Effect Paragraph (*SUTW,* 3-43 through 3-45) to explain how carbon in the atmosphere acts like the glass in a greenhouse to cause a rise in global temperatures.

Sample Constructed-Response Item

Explain the role of plants in the water cycle and carbon cycle.

Plants absorb water from the ground and release water into the atmosphere through transpiration. Plants take carbon from the air and turn it into glucose which can be passed along the food chain. Dead plants can be changed into fossil fuels after millions of years of compression and trap carbon underground.

UNIT 2 SECTION 3

Model Lesson (Traditional Roster): *Carbon Cycle*

Lesson Questions

What are the stages of the carbon cycle?

How have humans altered the natural carbon cycle?

What are the consequences of increased amounts of carbon in the atmosphere?

What are some solutions to the problems of increased carbon in the atmosphere?

Materials

Carbon Cycle teaching transparency (Ch. 16), Atmospheric Temperature and CO_2 Levels (Ch. 18), Change in Global Temperature teaching transparency (Ch. 18); copies of the carbon cycle chart

Content and Performance Expectations

CE 1, 2, 3, 4, 5; PE 1, 2, 3, 4, 5

Teacher's Notes

None

Warm-Up

Fossil Fuel K-W-L

- Ask students the following questions: What are fossil fuels? Where do they come from? How are they created? Why are they so important to us?
- Have students fill out the first two columns of a K-W-L chart (example on p. xx of *ER*).
- Discuss responses with the class.

Instruction

Carbon Cycle

- **Outlining the Carbon Cycle**
  - Use the Carbon Cycle teaching transparency (Ch. 16) to show students the movement of carbon through the ecosystem.
  - Explain that carbon moves through the environment in different forms such as CO_2 gas, CO gas, CH_4 (methane), glucose, and fossil fuels.
  - Show students the basic equations for photosynthesis and respiration. Explain that photosynthesis removes carbon from the air so that it can enter the food chain and respiration returns carbon to the atmosphere. Stress the importance of carbon to organisms.
  - Using the diagram, have students list the ways that carbon is released into the atmosphere, becomes part of organisms, and becomes buried in the earth. Emphasize the ways that human activity impacts the cycling of carbon through the environment.
  - Explain how carbon in organisms can become fossil fuel over millions of years.
  - Have students complete the carbon cycle chart.

- **Increases in Atmospheric Carbon Dioxide**
  - Tell students that the amount of carbon in the atmosphere is increasing. Have them propose explanations for this.
  - Display the Atmospheric Temperature and CO_2 Levels teaching transparency (Ch. 18) and the Change in Global Temperature teaching transparency (Ch. 18). Discuss the impact of increasing carbon dioxide levels.
  - Have students work in groups to develop strategies for reducing the amount of carbon in the atmosphere.
  - Have students write a Power Outline (*SUTW*, 2-11 through 2-17) of their strategies.
  - Have students use their Power Outlines to write a letter to their Senator or Congressman urging them to support legislation and treaties aimed at lowering carbon dioxide emissions.

Assessment

- Have students imagine themselves as a carbon atom and trace their journey through the carbon cycle until they return to their point of origin. Students may choose to write this in one of the following forms:
  - Journal entries
  - Poetry
  - Essay form
  - Choose the music from a song and fit your journey to music
  - Cartoon form

Homework Assignment

- Have students complete their letters to their chosen government official.

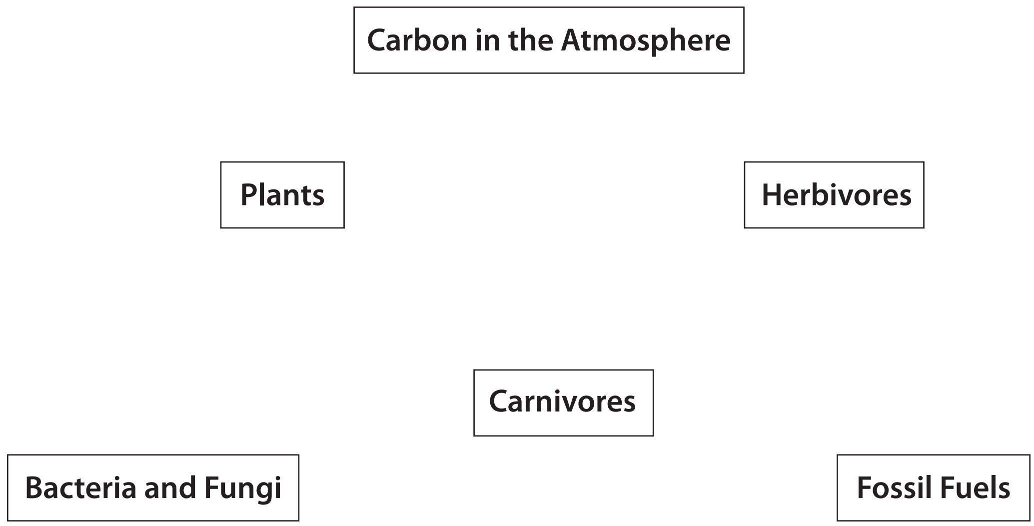
Teaching Resources

- Holt, p. 352
- Holt *Biology Chapter Resource File 16: Ecosystems*
- "Carbon Dioxide Levels Sky High"
  www.cbsnews.com/stories/2004/03/20/tech/main607629.shtml
- "Carbon Dioxide Continues Its Rise"
  http://news.bbc.co.uk/1/hi/sci/tech/4395817.stm

name ____________________ date __________

Carbon Cycle

Use arrows to show the movement of carbon in the ecosystem. Label each arrow to show the process (Photosynthesis, Respiration, Consumption, Decomposition, Combustion, or Compression) through which the carbon is cycled. For example, an arrow could be drawn from "Carbon in the Atmosphere" to "Plants" and be labeled "Photosynthesis." Draw as many arrows as you can.



Unit 2 Section 4

HUMAN IMPACT ON THE ENVIRONMENT

UNIT 2 SECTION 4

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	Global Changes	Holt, pp. 386–389
2	2	Habitat Destruction and Human Population Growth	Holt, pp. 390–395
3		The Biodiversity Crisis	Holt, pp. 392, and 406–407

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 4: Changes in Ecosystems and Interactions of Organisms with their Environments

Standard 5: Processes and Interactions of the Earth's Systems

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 4

Organisms are interdependent with one another and their environment. (GLE 4.1)

CONTENT EXPECTATIONS

☐ 1. All organisms, including humans, and their activities cause changes in their environment that affect the ecosystem. (GLE 4.1.C)

☐ 2. The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes. (GLE 4.1.D)

…for Standard 5

Human activity is dependent upon and affects Earth's resources and systems. (GLE 5.3)

CONTENT EXPECTATIONS

☐ 3. Earth's materials are limited natural resources affected by human activity. (GLE 5.3.A)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Scientific inquiry includes evaluation of explanations (hypotheses, laws, theories) in light of scientific principles (understandings). (GLE 7.1.D)

☐ 5. The nature of science relies upon communication of results and justification of explanations. (GLE 7.1.E)

…for Standard 8

The nature of technology can advance, and is advanced by, science as it seeks to apply scientific knowledge in ways that meet human needs. Science and technology affect and are affected by society. (GLE 8.1, GLE 8.3)

CONTENT EXPECTATIONS

☐ 6. Technological solutions to problems often have drawbacks as well as benefits. (GLE 8.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

UNIT 2 SECTION 4

…for Standard 4

Describe how organisms are affected by each other and by their environment. (GLE 4.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Devise a multi-step plan to restore the stability and/or biodiversity of an ecosystem when given a scenario describing the possible adverse effects of human interactions with that ecosystem (e.g., destruction caused by direct harvesting, pollution, atmospheric changes). (GLE 4.1.C.a)

☐ 2. Predict and explain how natural- or human-caused changes (biological, chemical, and/or physical) in one ecosystem may affect other ecosystems due to natural mechanisms (e.g., global wind patterns, water cycle, ocean currents). (GLE 4.1.C.b)

☐ 3. Predict the impact (beneficial or harmful) a natural environmental event (e.g., forest fire, flood, volcanic eruption, avalanche) may have on the diversity of different species in an ecosystem. (GLE 4.1.D.a)

☐ 4. Describe possible causes of extinction of a population. (GLE 4.1.D.b)

…for Standard 5

Describe the effect of human activity on Earth's resources. (GLE 5.3 *PR*)

PERFORMANCE EXPECTATIONS

☐ 5. Identify human activities that adversely affect the composition of the atmosphere, hydrosphere, or geosphere. (GLE 5.3.A.c)

…for Standard 7

Analyze experimental data to determine patterns, relationships, perspectives, and credibility. Present arguments based on scientific investigations that include detailed procedures, graphs and tables, and conclusions. (Frameworks I.A.1.a, Frameworks I.A.2.a)

PERFORMANCE EXPECTATIONS

☐ 6. Evaluate the reasonableness of an explanation (conclusion). (GLE 7.1.D.b)

☐ 7. Communicate the procedures and results of investigations and explanations through: drawings and maps, data tables, and graphs. (GLE 7.1.E.a)

…for Standard 8

Analyze and evaluate how specific technological solutions may impact the environment in areas such as habitat loss, disruption of the food web, and temperature and chemical changes. (Frameworks II.A.2.a)

PERFORMANCE EXPECTATIONS

☐ 8. Identify and evaluate the drawbacks (e.g., design constraints, unintended consequences, risks) and benefits of technological solutions to a given problem (e.g., using pesticides to eliminate mosquitoes). (GLE 8.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Global Changes Day 1	CE 1, 3, 6 PE 2, 5, 8	Display images of the hole in the ozone layer over a year's time. Samples are available at http://toms.gsfc.nasa.gov/. Have students see how the ozone layer varies month to month. Have them hypothesize to why the attenuation of the ozone layer is much greater over the polar regions than over where people live, even though those are the areas where the CFCs are released. Explain the role of CFCs in creating the hole in the ozone layer. Discuss world-wide consequences of the hole in the ozone layer and ways to address the problem. (Goals 1.5, 1.6, 3.1)
	CE 1, 4, 5, 6 PE 5, 6, 7, 8	**Hands-On Activity/Lab:** Introduce global warming and the possible connection between increased global gases and Earth's rising temperatures. Then have students complete the Modeling the Greenhouse Effect Quick Lab (Holt, p. 389). Students should graph temperatures as a function of time. Next, have students write two Persuasive or Convincing Paragraphs (*SUTW,* pp. 3-30 through 3-33). The first should support the statement, "Correlation does not prove cause and effect." The second should detail whether he or she is a believer in or a skeptic of the global warming phenomenon. (Goals 1.10, 3.6)
Habitat Destruction and Human Population Growth Day 2	CE 1, 2, 3, 4, 5, 6 PE 5, 6	**Hands-On Activity/Lab:** Have students create an aquifer and discuss how population growth affects groundwater. *See Model Lesson*. (Goals 1.6, 1.10, 3.5, 4.3, 4.7)
	CE 3, 6 PE 5	Discuss the following quote defining sustainability, "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). Then have students write a Free-Response (*SUTW*, p. 8-8) about their needs. Discuss whether any of these needs are in conflict with one another. Next, ask students how they will know when the Earth has reached carrying capacity. Have them list ten possible indicators that Earth is close to its carrying capacity and discuss whether any of these indicators, such as habitat destruction, are present today. (Goals 1.10, 3.1, 3.6, 3.7, 4.3, 4.7)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students list all the ways they release CFCs into the environment.	Have students create graphic organizers to show how the release of CFCs in the atmosphere impacts humans and other organisms. (ELL-2)	Have students research the chemistry behind how CFCs destroy the ozone layer.
Have students create pamphlets they can hand out in school explaining how every student can reduce carbon dioxide emissions.	Have students create a labeled diagram of the ways carbon dioxide is emitted into the atmosphere. (ELL-6)	Have students debate the following question, "Was the 2005 G8 summit a success in addressing the problem of climate change?"
Have students create a clay model and label the following structures: water table, saturation zone/groundwater, bedrock, well, and aquifer.	Demonstrate how much of the Earth's water is available for human needs. Fill a liter container with water and add a few drops of blue food coloring to represent all the water on Earth. Take out 95 percent (950 mL), place it in a clear container, and add salt, so as to represent the amount of salt water on Earth. Tell the students that the remaining 5 percent (50 mL) represents the freshwater on Earth. Of this amount, remove 31.4% (15.7 mL) to represent frozen water (ice caps and glaciers) and remove 68.4% (34.2 mL) to represent groundwater. The remaining 0.2% (0.1 mL) represents surface water (lakes, rivers, and ponds). Not much of Earth's water supply is available for agriculture, drinking, and washing, as well as for lakes, rivers, and freshwater ecosystems. (ELL-5)	Have students research harmful algal blooms and then build an algal bloom.
After listing on the board sources and locations of air pollution in their local neighborhood, students should create a local map and place pins on the polluters' locations (e.g., bus depot, power plant, cars and trucks).	Discuss possible topic sentences for Cause and Effect Paragraphs (*SUTW*, pp. 3-43 through 3-45) about the environmental concern they believe will have the greatest impact on their community in the next decade. (ELL-4)	Have students research the atmospheres of Mars, Venus, and Earth, in order to explain the cliché, "Venus is too hot, Mars is too cold, and Earth is just right, " and to determine whether space colonies might be successful on Venus or Mars.

UNIT 2 SECTION 4

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
The Biodiversity Crisis Day 3	CE 1, 2, 3 PE 3, 4, 5	Divide the class into two teams and prepare for a debate (*ER*, p. PTT-9) on the question "Are we doing enough to save biodiversity?" Students should use case studies where possible. Select one case study and have students predict how biodiversity would be affected by a natural environmental event. (Goals 1.10, 2.3, 3.1, 4.3)
	CE 1, 2, 3 PE 1, 4, 5, 7	Have students conduct research and create a poster that focuses on two topics: how a Missourian species became endangered, and what conservation steps must be taken to save it. (Goals 1.2, 2.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
As a class create an intricate food web, with each student playing a role in the web. Connect them to one another with yarn. Have students describe what happens if one of the organisms becomes extinct.	Review biodiversity by exploring the interactions of living organisms at a site near the school. Have students fill out a chart with the following three headings: What do I observe? What interactions are present? Is this an example of interdependence between organisms? (ELL-6)	Have each group read a recent rapid assessment program survey from the *Conservation International RAP Bulletin of Biological Assessment* available at www.biodiversityscience.org/xp/CABS/research/rap/aboutrap.xml. Then have groups share summaries with the class.
Have students look at pictures of endangered and extinct organisms (preferably from Missouri). The pictures should be accompanied by the organism's name, habitat, lifestyle, and cause for decline. After students examine the pictures, discuss the similarities and differences among the reasons for their decline.	Divide the class into five groups. Each group is responsible for creating a poster on one of the five threats to biodiversity: habitat loss, introduced species, pollution, population growth, and over-consumption. (ELL-8)	Have students research the Endangered Species Act of 1973 and write Descriptive Paragraphs (*SUTW*, pp. 3-34 through 3-36) that summarize the provisions of the law. Include examples of local species affected by the law. Information is available at www.fws.gov/endangered/esa.html.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, p. PTT-9

   Holt *Biology CRF 18: The Environment, Section 3*

   Step Up to Writing, pp. 3-30 through 3-36; 3-43 through 3-45, 3-50 through 3-52, 8-8

2. **Internet Resources**

   Environmental Protection Agency
   www.epa.gov

   Global Warming
   http://weathereye.kgan.com/expert/warming/explain.html

   Hydrogeology
   www.epa.gov/seahome/gwprimer.html

   Ozone Hole
   www.theozonehole.com

   Population Growth Rate
   www.worldbank.org/depweb/english/modules/social/pgr/

3. **Multicultural Resources and/or Activities**

   Have students research Dr. Mario Molina, who shared the 1995 Nobel Prize in Chemistry for work on the fate of chlorofluorocarbons in the atmosphere.

   Have students investigate a new pharmaceutical agent that is being developed from a tropical plant found in the rainforest.

   Have students examine the consequences of the One Child Policy that was instituted in China in 1979. Discuss current population-restriction or population-growth policies in place in various countries.

Suggested Assessments

1. Have students give real-world examples of how human activity has polluted or depleted the ground water.
2. Have students design a procedure that will lead them to correctly assess the biodiversity in a local plot of land.
3. Have students explain the population growth patterns of particular countries when given graphs of previously unstudied nations.
4. Have students find articles from magazines or newspapers that relate to human's impact on the environment. Have them write about the article using Special Writing Assignment: Current Events skills (*SUTW*, pp. 3-50 through 3-52).

Sample Constructed-Response Item

Can development continue indefinitely? Explain your answer.

Earth has a finite carrying capacity; there is a limit to food supplies, available raw materials (e.g., wood, minerals), fresh water, and open land. Resources remain abundant if one uses sustainability practices (i.e., if people don't consume resources more quickly than they are naturally replenished).

Model Lesson (Traditional Roster):

Habitat Destruction and Population Growth: Groundwater Pollution

Lesson Questions

How does soil composition affect groundwater?

How do habitat destruction and population growth affect groundwater?

What can be done to protect groundwater?

Materials

Plastic cups, long pieces of plastic tubing, disposable plastic syringes, fine-grained sand, coarse-grained sand, small-stoned gravel, large-stoned gravel, coffee filters, 1/2-inch pieces of cloth, red food coloring, spray bottles filled with water

Content and Performance Expectations

CE 1, 2, 3, 4, 5, 6; PE 5, 6

Teacher's Notes

None

Warm-Up

Water Consumption

- Have students brainstorm a list of the ways they use water from the time they wake up until the time they enter the classroom (e.g., drinking, cooking, farming, recreation, transportation, bathing).
- Make a list of their ideas on the board.

Instruction

Freshwater is a Limited Resource

▶ World Water Supply	▷ Construct a pie-chart to display the world's different types of water. Oceans (salt water) account for approximately 95.1% total water. Freshwater accounts for approximately 4.9% of total water. Of the freshwater, surface water (e.g., lakes, rivers, ponds) accounts for approximately 0.2%, snow and ice (e.g., ice caps, glaciers) account for approximately 31.4%, and groundwater accounts for approximately 68.4%. ▷ Point out that not much of the world's water is available for human use. ▷ Have students add up groundwater and surface water percentages and multiply by total freshwater percentage to determine the total amount of world's water humans can harvest for consumption. **3.36%**

UNIT 2 SECTION 4

Groundwater

▶ Groundwater Vocabulary	▷ Define the terms *groundwater, saturated zone, water table, aquifer*, *well*, and *bedrock*. ▷ Explain that groundwater comes from rain, snow, sleet, and hail that soak into the ground. Gravity forces the water between the particles of rock, soil, sand, gravel, or rock, until it reaches a point in which the ground is filled, or saturated with water. ▷ Have students discuss what happens when a hole is dug near an ocean or lake, using all of the introduced vocabulary terms. ▷ Make the analogy of groundwater as the water that is soaked up by a sponge, with the earth acting like the sponge.
▶ Groundwater Diagram	▷ Have students create a diagram labeling the following vocabulary terms: *groundwater, saturated zone, water table, well, aquifer*, and *bedrock*. Include arrows to illustrate the movement of water in the water cycle (e.g., evaporation, condensation, precipitation).

▶ Groundwater Model	▷ Have students fasten a piece of cloth over one end of a piece of plastic tubing with a rubber band. Students should then position the tubing inside the cup such that the covered end of the tubing is at the bottom of the cup and the tubing is taped to the side of the cup. ▷ Have students place large-stoned gravel in the bottom third of the cup and then cover it with filter paper. ▷ Have students fill the rest of the cup with fine-grained sand. ▷ Have students compare the aquifer model with their groundwater diagrams and identify which parts of the model represent the various parts of the diagram.
▶ Porosity and Permeability	▷ Have students use the spray bottle to simulate rain on the sand until water filters into the large-stoned gravel. ▷ Have students place a syringe in the open end of a tube and draw the plunger out. The syringe represents a well-pump. ▷ Have students repeat the above procedure with coarse-grained sand in place of the fine-grained sand. Have students observe how many sprays it takes for the water to filter down into the bottom of the cup and the ease/difficulty of drawing the water up with the syringe. ▷ Explain that the utility of aquifers depends on the porosity and permeability of soil. Water movement down through the soil depends on porosity (size of holes with which water can travel through) and water movement out of the soil by wells depends on permeability (how much water clings to the soil/rock).

Assessment

- Have students write a Descriptive Paragraph (*SUTW*, pp. 3-34 through 3-36) explaining why groundwater is a precious, limited resource.

Homework Assignment

- Have students list five ways that their families can reduce the amount of pollutants that enter ground water.

Teaching Resources

- Holt, p. 393

name ______________________ date __________

GROUNDWATER QUESTIONS

1. Why is there a limited supply of freshwater?

____

____

____

2. Why are aquifers crucial?

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____

____

3. How does soil-type affect your groundwater model? Why?

____

____

____

4. What is the relationship between population size and water pollution?

____

____

____

5. What happened with the addition of food coloring to your model aquifer? Why?

____

____

____

Unit 3 Biological Evolution

- How and why do organisms change over time?
- Are organisms currently evolving?
- Are "advanced organisms" better adapted to life on Earth than "primitive organisms"?

Scope and Sequence, page 19
Lesson Planning Material, pages 109–156

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

Unit 3 Section 1

EXAMINING THE FOSSIL RECORD

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	The Origin of Life	Holt, pp. 251–257
2		Biological Evolution of Cells	Holt, pp. 258–263
3–4	2	Multicellularity	Holt, pp. 264–269

UNIT 3 SECTION 1

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 4: Changes in Ecosystems and Interactions of Organisms with their Environments

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 4

Evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of organisms and in the fossil record. (GLE 4.3.A)

CONTENT EXPECTATIONS

☐ 1. The fossil record provides evidence of biological evolution. (GLE 4.3.A *PR*)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 2. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 3. Evidence is used to formulate explanations. (GLE 7.1.C)

☐ 4. The nature of science relies upon communication of results and justification of explanations. (GLE 7.1.E)

…for Standard 8

The nature of technology can advance, and is advanced by, science as it seeks to apply scientific knowledge in ways that meet human needs. (GLE 8.1)

CONTENT EXPECTATIONS

☐ 5. Advances in technology often result in improved data collection and an increase in scientific information. (GLE 8.1.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 4

Interpret fossil evidence to explain the relatedness of organisms using the principles of superposition and fossil correlation. (GLE 4.3.A.a)

PERFORMANCE EXPECTATIONS

- ☐ 1. Apply information about ancient life-forms obtained from the fossil record. (GLE 4.3.A.a *PR*)

…for Standard 7

Analyze experimental data to determine patterns, relationships, perspectives, and credibility. Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Frameworks I.A.1.a, Frameworks I.A.3.a)

PERFORMANCE EXPECTATIONS

- ☐ 2. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., microscopes). (GLE 7.1.B.a)
- ☐ 3. Analyze experimental data to determine patterns, relationship, perspectives, and credibility of explanations (e.g., predict/extrapolate data). (GLE 7.1.C.b)
- ☐ 4. Communicate the procedures and results of investigations and explanations through drawings, data tables, graphs, and writing. (GLE 7.1.E.a)

…for Standard 8

Describe how technology impacts data collection. (GLE 8.1.B *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 5. Identify the limitations of scientific techniques for studying ancient life-forms. (GLE 8.1.B.a *PR*)

Suggested Activities

UNIT 3 SECTION 1

TOPIC	EXPECTATIONS	ACTIVITY
The Origin of Life Day 1	CE 2, 3, 4 PE 2, 3, 4	**Hands-On Activity/Lab/Technology:** Have students complete the Modeling Coacervates Lab (Holt, p. 257) to investigate the similarities between coacervates and cells. Have prepared slides of animal and plant cells available for comparison. Students should draw a coacervate, a plant cell (Holt, p. 66), and an animal cell (Holt, p. 58), so as to compare and contrast the three. Revisit the characteristics of life discussed earlier in the course. Have students write a Persuading or Convincing Paragraph (*SUTW*, pp. 3-30 through 3-33) about whether the coacervates should be considered living. (Goals 1.8, 3.5, 4.1)
	CE 1, 2, 3, 5 PE 2, 3, 4, 5	**Hands-On Activity/Lab:** In pairs, have students model radioactive decay using pennies. Discuss how radioactive decay is used to determine the age of ancient objects. *See Model Lesson*. (Goals 1.6, 1.8)
Biological Evolution of Cells Day 2	CE 2, 3, 4 PE 2, 3, 4	Have students complete the Analyzing Signs of Endosymbiosis Data Lab (Holt, p. 259). Data sheets are available in Holt *Biology CRF 12: The History of Life on Earth,* page 41. In order to further illustrate the endosymbiotic theory, have students compile a list of the similarities and differences between prokaryotes, eukaryotes, mitochondria of eukaryotic cells, and chloroplasts of photosynthetic eukaryotes. The list should include type of DNA, manner of replication, type of ribosomes, location of the electron transport chain, size, period they appeared on Earth, and number of membranes. Have students summarize this information in a Compare and Contrast Paragraph (*SUTW,* pp. 3-21 through 3-29). (Goals 1.6, 3.5, 4.1)
	CE 2, 5 PE 2, 5	**Hands-On Activity/Lab/Technology:** Have students compare and contrast unicellular and multicellular organisms. (A sample of pond water and prepared slides of *Paramecium* and *Hydra* can be used.) Have students discuss reasons that multicellular organisms may have evolved and whether it is possible to find evidence supporting their ideas. (Goals 1.6, 3.5, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students draw a picture of what they believe Earth's first life-forms looked like. Have them compare their drawings to representations of scientists' theories.	Have students list the different forms of life they encounter in everyday life from least organized to most organized. Have them identify what they believe was the first and most simple organism. (ELL-3)	Have students conduct research to answer the following questions: Is there life on Mars? What conditions must be met for there to be life? How have scientists explored the possibility of Martian life?
Create a chart with the class that describes half-lives (for example, start with 100 and show how each number is divided by 2). Give each student pair a premade bag of beans that they have to count. They must figure out how many half-lives have passed using the chart and given the number of beans counted. Students can repeat many times, with different premade bags.	Have student pairs graph the amount of carbon-14 versus time with data tables provided by the teacher. (ELL-5)	Discuss as a class why carbon-14 is such a useful isotope for radioactive dating. Discuss its limitations. Have students complete the Determining the Age of Artifacts Using C-14 worksheet (Holt *Biology CRF 12: History of Life on Earth*, pp. 49–52).
Describe other examples of endosymbiots (e.g., nitrogen-fixing bacteria, rhizobia that live in root nodules of legumes; single-celled algae in coral; bacteria within the digestive system of termites, cows, and humans). Emphasize that the endosymbiots provide a service for the host.	Explain to students the meanings of the *endo-, cyto-,* and *symbiosis*. Have them figure out the meanings of the words *endocytosis* and *endosymbiosis*. Have them come up with and define a list of words that contain the prefixes *endo-* and *cyto-*. (ELL-1)	Have students work in small groups to create models or posters of nonphotosynthetic bacteria, photosynthetic bacteria, mitochondria, chloroplasts, and Margulis's theory of endosymbiosis. Make sure that students devise a measurement scale prior to drawing so that the cells, bacteria, and organelles are of appropriate size.
To have students understand the concept of multicellularity and the division of labor, in pairs have them come up with three real-world examples of departmentalizing. One possible example is that in a given high school, different teachers teach different subjects.	To understand the concept of the division of labor have pairs come up with examples from the human body. They should use anatomy textbooks, general biology textbooks, or the Internet for research. One possible example would be the digestive system: mouth, esophagus, stomach, etc. A more difficult example would be a neuron: axon, body, dendrite. (ELL-2)	Examine additional slides. Attempt to find slides, photographs, or electron micrograph examples of prokaryotic, eukaryotic, algal, animal, plant and fungal cells. Students should note in these cell types the similarities and differences in external and internal features. Examples that can be used include: Stromatolites (ancient rocks containing microfossils of chains of prokaryotes), S*pirogyra*, *Chlamydomonas* (unicellular flagellate), *Volvox* (a colony comprised of many flagellated cells working together; it is not a differentiated multicelled organism), *Hydra* (shows some cellular specialization and division of labor), fungal hyphae, and *Elodea*.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Multicellularity Days 3–4	CE 1, 2, 3 PE 1, 4	Create a chart with the heading, "Why have these organisms biologically evolved?" The types of organisms should be listed horizontally (e.g., vascular plants, arthropods, jawless fishes, cartilaginous fishes, bony fishes, amphibians, reptiles, birds, and mammals). Categories such as structural features, special adaptations, and examples should be listed vertically. Assign each group a different type of organism and have them obtain information on it that is relevant to the vertical categories. Information may be obtained from Holt, Ch. 23–35. Have each group fill in the row of information corresponding to its assigned type of organism. Use the information presented on the chart to address the question, "Why have these organisms biologically evolved?" (Goals 1.6, 1.8, 2.3, 4.6)
	CE 1, 4, 5 PE 1, 5	**Hands-On Activity/Lab:** In pairs, have students complete the Making a Timeline of Life on Earth Exploration Lab (Holt, pp. 272–273). Datasheets are available on Holt *Biology CRF 12: History of Life on Earth,* pages 43–46. Information can also be drawn from The History of Everything Timeline Project (www.fresno.k12.ca.us/schools/s090/_atkinsgatebio/timelineproject/tmlinefstpage.htm). Students should be sure to include the development of multicellularity, the major forms of life (e.g., plants, fungi, fish), and the mass extinctions. Discuss limitations of using the fossil record to create a timeline of life on Earth. (Goals 1.8, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Students should draw pictures of one organism from each category: arthropod, fish, amphibian, reptile, bird and mammal. Have them hypothesize and write down what advantages each category has compared to the others.	Students should create six flashcards. On the front should be the following categories: arthropod, fish, amphibian, reptile, bird, and mammal. On the back should be definitions as well as examples from their home country. (ELL-1)	Have students imagine the type of organism that will have succeeded two thousand years from now. They should describe their reasoning.
Give students a jumbled set of pictures of organisms. Have them organize the pictures in order of their succession from sea to land.	Prior to creating a timeline, students should define the following terms: *seconds, minutes, hours, days, weeks, years, thousands, millions*, and *billions*. (ELL-1)	Have students create a graph of major developments in the timeline vs. time in order to estimate the rate of change.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 12: History of Life on Earth*, pp. 41, 43-46

   Step Up to Writing, pp. 3-21 through 3-39

2. **Internet Resources for Teachers**

   The Extinction Files
   www.bbc.co.uk/education/darwin/exfiles/index.htm

   Evolution
   www.pbs.org/wgbh/evolution/

   Understanding Evolution: A Website for Teachers
   http://evolution.berkeley.edu/evosite/evohome.html

3. **Internet Resources for Students**

   Explorations Through Time
   www.ucmp.berkeley.edu/education/explotime.html

   How Did Life Begin?: An Interview With Andrew Knoll (Harvard Biology Professor)
   www.pbs.org/wgbh/nova/origins/knoll.html

   Radiometric Dating Tutorial
   http://sciencecourseware.com/VirtualDatingDemo/index.html

   A Drop Of Life (see unicellular and multicellular pond organisms)
   http://ebiomedia.com/gall/drop/dropmain.html

4. **Multicultural Resources and/or Activities**

   Explore cultural myths related to the origin of life such as Norse, Greek, Japanese, and Indian creation myths.

Suggested Assessments

1. Have students explain how radioactive decay is used to date artifacts. Have them interpret and/or construct a radioactive decay graph.
2. Using household objects, have students construct models of the theory of endosymbiosis.
3. Have students research and write a Descriptive Paragraph (*SUTW*, pp. 3-34 through 3-39) on each of the five mass extinctions. Included in their paragraphs should be a description of one organism that prospered after each extinction.
4. Have students draw an example of each of the following categories: arthropods, amphibians, reptiles, birds, and mammals. They should also describe a feature that enables these creatures to thrive on land.

Sample Constructed-Response Item

Why is multicellularity beneficial?

Multicellularity allows the organism to divide the labor among different types of cells. The cells in multicellular organisms can have specialized functions, whereas the cell in a unicellular organism must perform all of the functions.

Model Lesson (Block Roster):
The Origin of Life: Fossil Dating

Lesson Questions

What techniques are used to date fossils?

What are the limitations of these techniques?

Materials

100 pennies, container for the pennies, graph paper, miniature layered candy bars (e.g., Snickers® bars), plastic knives

Content and Performance Expectations

CE 1, 2, 3, 5; PE 2, 3, 4, 5

Teacher's Notes

None

UNIT 3 SECTION 1

Warm-Up

Superposition

- Have students write responses to the following question, "Two scientists working at the same dig site find fossils. How can they tell which fossil is older?"
- Discuss students' answers to the question.

Instruction

Methods Scientists Use

▶ Superposition	▷ Define the term *superposition.* ▷ Have students identify where the oldest fossils would be found. ▷ Explain that by correlating fossils from various parts of the world, scientists are able to give relative ages to particular strata.
▶ Relative Dating Activity	▷ Tell students that the Snickers® bar represents layers of sedimentary rock. Have them cut it in half with their knives. ▷ Have them draw the cross-section of the candy bar. ▷ Have students identify where in this rock the oldest fossil would be found and which would have the youngest fossil. **Layers from oldest to youngest: bottom chocolate, caramel-peanut mix, overlying chocolate.**

▶ Radiometric Dating	▷ Ask students what scientists in the Warm-Up scenario could do if they wanted to know the age of one of the fossils rather than which was older. Explain that scientists use radiometric dating to estimate an object's age by measuring the amount of radioactive isotopes present. ▷ Define *isotope* and *radioactive isotope.* ▷ Use the Radioactive Decay teaching transparency (Ch. 12) to explain how the ratio of the parent isotope to the more stable daughter isotope determines the age of the object. Define *half-life*. ▷ Tell students that the two most used radioactive isotopes in dating are potassium-40/argon-40 (used for rocks, half-life is 1.25 billion years) and carbon-14/nitrogen-14 (used for organic materials, half-life is 5730 years). ▷ Discuss limitations of both methods.
▶ Radiometric Dating Example	▷ Model how to solve a radiometric dating problem using the Two-Column Math Method (*SUTW,* pp. 3-53 through 3-55). Use the following problem: An imaginary radioactive isotope has a half-life of two years. The object in question originally had 8 grams of the parent isotope and now has 1 gram. How old is it? **6 years**
▶ Explanation of Carbon-14 Dating (for advanced students)	▷ Explain that cosmic rays from the sun strike nitrogen-14 atoms in the atmosphere and cause them to turn into radioactive carbon-14, which combines with oxygen to form radioactive carbon dioxide. ▷ Since radioactive carbon dioxide is absorbed and used by plants, it gets into the food chain and the carbon cycle. ▷ All living things contain a constant ratio of carbon-14 to carbon-12. (1 in a trillion). However, at death carbon-14 exchange ceases, and any carbon-14 in the tissues of the organism begins to decay to nitrogen-14, and is not replenished by new carbon-14. ▷ The change in the carbon-14 to carbon-12 ratio is the basis for dating. ▷ Point out that since the half-life is so short (5730 years) this method can only be used on materials less than 70,000 years old.

Radiometric Activity

▶ Procedure	▷ Toss the hundred pennies onto the table surface. Have students count the pennies that land head-side-up and remove all the pennies that land tail-side-up. Have a volunteer gather up the remaining pennies and toss them again. Again, have students count head-side-up pennies and remove tail-side-up. Have students repeat tossing and counting until all the pennies have been removed.
▶ Analysis	▷ Have students graph the amount of pennies head-side-up to number of tosses and then calculate the half-life. ▷ Have students explain what the head-side-up pennies and the tail-side-up pennies represent. ▷ Have students calculate how many tosses would be necessary if they started with two hundred pennies. ▷ Have them discuss what the half-life of two hundred pennies would be and why.

UNIT 3 SECTION 1

Assessment

- Have students compare and contrast radioactive dating vs. relative dating.
- Have students write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) on the advantages and disadvantages of each method.

Homework Assignment

- Have students read Holt, pages 252–253.
- Have students answer Holt, page 270, #1, 7, and 8.

Teaching Resources

- Holt *Biology*, pp. 252–253
- Holt *Biology Chapter Resource File 12: History of Life on Earth*
- Virtual Dating
  http://vcourseware.calstatela.edu/VirtualDating/

Unit 3 Section 2

DARWIN AND NATURAL SELECTION

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	Darwin's Voyage	Holt, pp. 276–278
2			
3	2	Natural Selection	Holt, pp. 279–280
4			
5	3	Patterns of Biological Evolution	Holt, pp. 281–282
6			

UNIT 3 SECTION 2

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 4: Changes in Ecosystems and Interactions of Organisms with their Environment

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 4

Organisms are interdependent with one another and their environment. Genetic variation sorted by the natural selection process explains evidence of biological evolution. (GLE 4.1, 4.3)

CONTENT EXPECTATIONS

☐ 1. The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes. (GLE 4.1.D)

☐ 2. Natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem. (GLE 4.3.C)

UNIT 3 SECTION 2

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 3. Evidence is used to formulate explanations. (GLE 7.1.C)

☐ 4. Scientific inquiry includes evaluation of explanations (hypotheses, laws, theories) in light of scientific principles (understandings). (GLE 7.1.D)

☐ 5. The nature of science relies upon communication of results and justification of explanations. (GLE 7.1.E)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 4

Explain how species diversity can be due to natural or man-made environmental changes. Describe natural selection and its effects. (GLE 4.1.D PR, 4.3.C *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Predict the impact (beneficial or harmful) a natural environmental event (e.g., destruction caused by direct harvesting, pollution, atmospheric changes) may have on the diversity of different species in an ecosystem. (GLE 4.1.D.a)

☐ 2. Describe the possible causes of extinction of a population. (GLE 4.1.D.b)

☐ 3. Describe how variation in characteristics provides populations an advantage in survival. (GLE 4.3.C.a)

☐ 4. Identify examples of adaptations that may have resulted from variations favored by natural selection (e.g., long-necked giraffes, long-eared jack rabbits). (GLE 4.3.C.b)

☐ 5. Explain how genetic homogeneity may cause a population to be more susceptible to extinction (e.g., succumbing to a disease for which there is no natural resistance). (GLE 4.3.C.c)

☐ 6. Explain how environmental factors (e.g., habitat loss, climate change, pollution, introduction of non-native species) can be agents of natural selection. (GLE 4.3.C.d)

☐ 7. Given a scenario describing environmental change, hypothesize why a given species was unable to survive. (GLE 4.3.C.e)

…for Standard 7

Analyze experimental data to determine patterns, relationships, perspectives, and credibility. Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Frameworks I.A.1.a, Frameworks I.A.3.a)

PERFORMANCE EXPECTATIONS

☐ 8. Make use of qualitative and quantitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

☐ 9. Evaluate the reasonableness of an explanation (conclusion). (GLE 7.1.D.a)

☐ 10. Communicate the procedures and results of investigations and explanations through: oral presentations, drawings, data tables, graphs, or writing. (GLE 7.1.E.a)

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 8

Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time. (GLE 8.2)

CONTENT EXPECTATIONS

☐ 6. Scientific theories are developed based on the body of knowledge that exists at any particular time and must be rigorously questioned and tested for validity. (GLE 8.2.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 8

PERFORMANCE EXPECTATIONS

☐ 11. Identify and describe how explanations (hypotheses, laws, or theories) of scientific phenomena have changed over time as a result of new evidence (e.g., theory of biological evolution). (GLE 8.2.B.a)

☐ 12. Identify and analyze current theories that are being questioned, and compare them to new theories that emerged to challenge older ones (e.g., theory of biological evolution). (GLE 8.2.B.b)

Suggested Activities

UNIT 3 SECTION 2

TOPIC	EXPECTATIONS	ACTIVITY
Darwin's Voyage Days 1–2	CE 1, 2, 3, 4, 5, 6 PE 2, 3, 4, 5, 9, 11	Have students use BDA reading strategies (*ER*, p. PTT-3) to read original excerpts from Lamarck (Zoological Philosophy) and Darwin (On the Origin of Species). Base class discussion on the following questions: How can society influence one's views? What led Lamarck and Darwin to formulate their theories? What evidence did they use to support their theories? How would Lamarck and Darwin explain adaptations such as long-necked giraffes, large-eared jackrabbits, or anteaters? How would Lamarck and Darwin explain the process of extinction? Excerpts of Lamarck's writing can be obtained at www.mala.bc.ca/~johnstoi/LAMARCK/tofc.htm. Chapter 7—"Concerning…the Influence of the Actions and Habitats of these Living Bodies as Causes Which Modify Their Organic Structure and Parts"—is most useful. Excerpts of Darwin's writing can be obtained at www.literature.org/authors/darwin-charles/the-origin-of-species/. Chapter 4—"Natural Selection"—is the most useful. Have students compare and contrast the theories of Darwin and Lamarck using a Venn diagram. (*ER*, p. RR-83) (Goals 1.9, 2.3, 2.4, 3.4)
	CE 3, 4, 5, 6 PE 6, 8, 9, 10	**Hands-On Activity/Lab:** In pairs, have students perform an activity to model Malthus' concept of expanding human populations and limited resources. Each pair should have ten small clear plastic cups and many corn kernels. The cup represents Earth's limits (e.g., land that can be cultivated for food). Place two kernels in the first cup; mark the outside of the cup with the number two. In the second cup place twice as many kernels as in the first cup (four); mark the second cup with the number four. Continue this doubling procedure in cups three through ten. Students should construct a chart and graph of population of corn kernels versus percentage of empty cup (an estimate). A table of human population growth is available on Holt, page 394. Emphasize that Malthus' essay on human population growth greatly influenced Darwin; he realized "that natural selection was the inevitable result of the rapid increase of all organic beings." (Darwin, *The Variations of Animals and Plants under Domestication)*. (Goals 1.6, 1.8, 3.4)
Natural Selection Days 3–4	CE 1, 2, 3 PE 1, 2, 3, 6, 7, 9, 10	Divide the class into four groups and assign each a different aquatic habitat (e.g., seaweed filled, dark, many predators, cold). Have each group design a fish that would thrive in its assigned habitat, focusing on its body shape, coloring, mouth, and feeding strategy, and means of reproduction. They should then describe to the class why their fish is well-suited for its environment. Last, the groups should randomly exchange habitats with each other and discuss whether their fish could thrive in that new environment. (Goals 1.5, 1.6, 2.1, 2.3, 3.3, 3.5, 4.1, 4.6)
	CE 2 PE 3, 8, 10	**Hands-On Activity/Lab:** Give each pair of students five beans of five different types (e.g., pinto beans, lentils, red beans, black beans, lima beans) for a total of 25, and a foam bowl with different-size holes in it. A pen can be used to make holes in the bowls. Have pairs shake the bowl side to side fifteen times and record the type and number of beans that stay in the bowl. The ones that fall through the hole are considered dead. The ones in the bowl should reproduce; students should represent this by adding one of the same type to the bowl. Have students repeat this procedure for ten generations and then chart and graph the results. Discuss how principles of natural selection apply to the activity. (Goals 1.6, 1.8, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Use excerpts from the textbook rather than original writing (Holt, pp. 276–280).	Have students create flashcards for the following words: *hypothesis, theory, law, fiction,* and *fact*. Then have them illustrate and write about the biological evolution of giraffes according to Lamarck's and Darwin's theories. (ELL-1, ELL-5)	To the reading, add the following excerpts: Georges Cuvier, Charles Lyell, Thomas Malthus, and Alfred Russell Wallace. These excerpts are available at www.natur.cuni.cz/~vpetr/Cuvier.htm, www.grtbooks.com/lyell.asp?idx=0&sub=0, www.ac.wwu.edu/~stephan/malthus/malthus.0.html, and www.nap.edu/readingroom/books/evolution98/evol6-j.html
Give students contrasting pictures of populated areas versus unpopulated areas (e.g., cities in China versus the plains in North Dakota). Discuss differences in populations and food supply needs.	Have students explain the difference between arithmetic progression and geometric progression. They should give real-world examples of each. (ELL-6)	Have students research ways that human exponential growth has impacted the environment (e.g., rainforest deforestation for agriculture, cattle-raising).
Have students match pictures of organisms and their habitats. They should explain all of the qualities that make that organism suitable for its environment (e.g., a bear has fur so it can keep warm, it has claws to use as a tool like opening up a beehive, it can also use its claws as a weapon).	Have students list all of the adaptations humans possess which have allowed them to thrive. (ELL-3)	Have students imagine Earth's future a million years from now. Have them describe what humans might look like. They should identify the adaptations present and explain why they are present.
Draw a dog on the board (e.g., Great Dane). Have students draw an example of a dog breed they know (e.g., Chihuahua). As they share their drawing with the class have them identify differences between their dog and the dog on the board (e.g., speed, color, size). Have them explain how the differences make their dog better at some things and worse at others.	Have students complete the Modeling Natural Selection Quick Lab (Holt, p. 280). (ELL-5)	Discuss the emergence of antibiotic-resistant bacteria. Have students discuss the following questions: Why do they exist? What antibiotics have become less useful? What powerful medicines are now used? How can further resistance be prevented?

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Patterns of Biological Evolution Days 5–6	CE 1, 2 PE 1, 4, 6, 7	**Hands-On Activity/Lab:** Have students complete the Hardy-Weinberg Equilibrium Simulation Lab. *See Model Lesson*. (Goals 1.6, 1.8, 3.5, 4.6)
	CE 1, 6 PE 10, 11, 12	Have students examine the diagram on Holt, page 282 that differentiates between gradual and punctuated equilibrium. In groups, have students figure out how best to present the two processes of biological evolution to the class (e.g., oral presentation, poster, clay models, dramatization). After presentations are complete, have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-14) describing these two models of biological evolution. (Goals 1.5, 1.6, 1.8, 2.1, 2.3, 3.4, 3.6, 4.1, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Model a few rounds of mating before having students begin the Hardy-Weinberg Principle Activity.	Have students define the terms *allele, gene, DNA,* and *equilibrium* prior to the beginning of the class period. (ELL-1)	Have groups research balanced polymorphisms (i.e., when carriers have advantages that allow a harmful allele to persist in the population). Examples include sickle-cell disease, glucose-6-phosphate dehydrogenase deficiency, Tay-Sachs disease, and cystic fibrosis.
Provide pictures of the ancestral line of one organism. Have students arrange the pictures in the sequence they would be found as fossils, if the species evolved because of gradualism. They should then arrange the pictures if the model is punctuated equilibrium.	Explain to the students the meanings of *-ism* and *equi-*. Have them define the terms *equilibrium* and *gradualism*. Have them list more words that contain *-ism* and *equi-*. (ELL-1)	Have students research and write a paper using Narrative Descriptive Paragraphs (*SUTW*, pp. 3-34 through 3-38) on Stephen Jay Gould.

Additional Resources

1. **Curriculum Resources**

    Educational Resources, pp. PTT-3, RR-83

    Step Up to Writing, pp. 3-3 through 3-14, 3-30 through 3-38

2. **Internet Resources for Teachers**

    Evolution and the Nature of Science Institutes Lesson Plans
    www.indiana.edu/%7Eensiweb/evol.fs.html

    Teach Evolution and Make It Relevant
    www.evoled.org/default.htm

    Understanding Evolution: A Web site for Teachers
    www.ucmp.berkeley.edu/history/evolution.html

3. **Internet Resources for Students**

    Evolution of Antibiotic Resistance
    www.pbs.org/wgbh/evolution/library/10/4/l_104_03.html

    Online Evolution Lab
    http://biologyinmotion.com

    Natural Selection
    http://evolution.berkeley.edu/evosite/evo101/IIIENaturalSelection.shtml

    Treasures of Evolution Island
    http://whyfiles.org/125galapagos/index.html

    Gradual and Punctuated Equilibrium
    http://acs.ucsd.edu/~idea/punceq.htm

4. **Multicultural Resources and/or Activities**

    Have students research the biodiversity present on the Galapagos Islands, how it impacted Darwin's thinking, and strategies currently being used to preserve it.

    Have students investigate whether different cultures understand the process of biological evolution differently.

    Show students actual fossils or photographs of fossils from the same era but from different countries about the world. Discuss how they were discovered and the structural similarities and differences between them.

Suggested Assessments

1. Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-14) detailing the principles of natural selection.
2. Have students design an experiment disproving Lamarck's evolutionary theory of "use/disuse."
3. Using a Persuading Paragraph (*SUTW*, pp. 3-30 through 3-33), have students argue which evolutionary theory is more reasonable: the theory of gradualism or the theory of punctuated equilibrium.
4. Have students draw an animal from an extreme climate with labels that describe their adaptive features.

Sample Constructed-Response Item

Biological evolution is dependent on genetic variation. What are the five situations that change allele frequency? Describe one of the five situations further with an example.

Allele frequency changes when there is nonrandom mating, mutations, natural selection, genetic drift, or migration. For example, if a group of squirrels was isolated from others of the same species because of a mountain range, they would not mate at random. This is an example of reproductive isolation.

UNIT 3 SECTION 2

Model Lesson (Block Roster):

Patterns of Biological Evolution: Hardy-Weinberg Equilibrium Principle

Lesson Questions

What does biological evolution have to do with genes?

What happens to the allele frequency when the five assumptions of the Hardy-Weinberg equilibrium are followed?

What happens to the allele frequency when some of the assumptions are not followed?

Materials

Decks of playing cards, calculators, coins, copies of the Hardy-Weinberg Equilibrium Principle handout

Content and Performance Expectations

CE 1, 2; PE 1, 4, 6, 7

Teacher's Notes

The following activity is designed for 25 students. The activity can be adjusted for more or less students (each student still receives four cards). Calculate the frequencies before class so they are appropriate to your class size.

Warm-Up

Inheritance Within Families

- Have students list traits that run in their families or famous families (e.g., families of famous actors, royalty).
- Discuss inherited traits and introduce basic definitions of the terms *DNA, gene,* and *allele.* Explain that people inherit traits from their parents, that genes are responsible for the expression of these traits, that genes are pieces of DNA responsible for the expression of these traits, and that each parent contributes one set of genes to its offspring.

Instruction

Hardy-Weinberg Equilibrium Principle Activity

▶ Introduction to the Activity	▷ Tell students that they will be studying an imaginary miniature frog that comes in two colors, red or black. ▷ Explain that the activity will involve studying what happens when these frogs reproduce and future generations inherit different sets of alleles (or gene variants, red and black).
▶ Allele Representation	▷ Explain that black is the dominant allele, and is expressed with an *R* and that red is the recessive allele, and is expressed with an *r*. ▷ Review the three different genotypes possible: *RR* (black), *Rr* (black), and *rr* (red). ▷ Each card represents these alleles: a black color card, spade or club, represents the allele *R* and a red color card, heart or diamond, represents the allele *r*. Each frog is represented by two cards.
▶ Initial Conditions	▷ Give each student four cards, which represents two frogs. Create thirty homozygous black frogs (*RR*) and twenty homozygous red frogs (*rr*). ▷ Have students fill out their charts with the initial number of black *RR* frogs (**30**); the number of black *Rr* frogs (**0**); the number of red *rr* frogs (**20**); the frequency of *RR* (**30**/**50**); the frequency of *Rr* (**0**/**50**); the frequency of *rr* (**20**/**50**); the frequency of the black allele (**60**/**100**); and the frequency of the red allele (**40**/**100**). ▷ Display a chart with the initial conditions on an overhead projector or on the board.
▶ Random Mating Procedure	▷ Have students walk around the room, hiding the card's identity, and keeping the cards in pairs. When they encounter another frog they should trade cards; give one card of a pair to the other person and receive a card from the other person in return. When a card of a pair has been replaced by mating, that pair should not be mated again. ▷ Have students continue to walk around until all of the frogs have mated once. ▷ Have students calculate number and frequency of genotypes (*RR, Rr,* and *rr*) and number and frequency of alleles. They should then fill in their chart. ▷ Have students share their results. As a class, discuss their results. Have students hypothesize what will happen if they mate randomly again. ▷ Have students mate randomly, using the above procedure.

▶ For Advanced Students	▷ For the first mating, calculation of genotype frequency is the product of the alleles' individual probabilities. The chance of having an *R* allele contribution from the mother is 0.6, and the chance of having an *R* allele from the father is also 0.6, thus the chance of having an *RR* offspring is 0.36 or 36%.The chance of having an *rr* is 16 or (0.4×0.4). ▷ The chance of having a heterozygote is more complicated. A heterozygote can have the combination of *Rr* or *rR*, depending on which allele the parent contributed. Thus, the chance of having a heterozygote is the sum of both probabilities $(0.6 \times 0.4 + 0.4 \times 0.6 = 0.48)$. ▷ Have students discuss whether calculated frequencies match up to data gathered in class.

Hardy-Weinberg Principle Activity with Natural Selection

▶ Natural Selection	▷ Have students explain what natural selection is. ▷ Have students determine how they could model natural selection with their frog cards.
▶ Modeling Natural Selection Example	▷ Explain that red frogs (*rr*) are more visible during the day and are thus easily seen by predators. ▷ Start with thirty homozygous black frogs and twenty homozygous red frogs. Have students record the initial conditions again in their chart. ▷ Have students have frogs mate. If a red frog appears, flip a coin to see if it survives (e.g., head yes, tails no). If a black frog appears, have it double in number. For example, if my frog mates and I now have *Rr*; I should get another *Rr* to represent it mating successfully and producing similar offspring. ▷ Have students calculate genotype and allele frequency. Discuss results.

UNIT 3 SECTION 2

Discussion of the Hardy-Weinberg Equilibrium Principle

- Equilibrium
  - Have students define *equilibrium*. They should relate it to the above activity. Point out that the population's allele frequencies do not change from generation to generation if there is completely random mating.
  - Have students discuss the following questions: What is biological evolution? Are there ever periods of equilibrium?
  - Ask students when the allele frequencies will change (i.e., equilibrium is not present)?
  - If students do not list any of the following points, include them in the discussion:
    1. Non-random mating
       For example, individuals tend to mate with those close by, not far away.
    2. Mutation
       It introduces genetic variation (i.e., different alleles) into the population.
    3. Migration
    4. Natural selection
    5. Genetic drift
       In small populations, chance events like storms, floods, or fires can change the allelic frequency. For example, if you have ninety black frogs and ten red frogs and a storm blows five of the ten red frogs and ten of the ninety black frogs to a new isolated area, the allelic frequency in the new area changes drastically.

Assessment

- Have students create a concept map for biological evolution. Terms they can use include *DNA, gene, trait, adaptation, natural selection, reproductive isolation, mutation, migration, genetic drift, evidence,* and *fossils*.
- Have students explain why the following statement is false, "As organisms evolve they are always getting better."

Homework Assignment

- Have students read Holt, page 281.
- Have students write a Descriptive Paragraph (*SUTW*, pp. 3-34 through 3-36) that describes natural selection in terms of genetic variation.

Teaching Resources

- Holt, pp. 276–282, 326–330
- Causes of Biological Evolution: www.evoled.org/Lessons/causes.htm#natural

UNIT 3 SECTION 2

activity sheet

name ______________________ date __________

Hardy-Weinberg Equilibrium Population Data Collection Sheet

First Generation (Random Mating)

Total number of frogs: __________

Total number of *R* alleles: __________

Total number of *r* alleles: __________

Before mating

	Number	Frequency
RR (red)		
Rr (red)		
Rr (black)		
R allele		
r allele		

After mating

	Number	Frequency
RR (red)		
Rr (red)		
Rr (black)		
R allele		
r allele		

UNIT 3 SECTION 2

name ____________________ date ____________

Second Generation (Random Mating)

Total number of frogs: ___________

Total number of *R* alleles: ___________

Total number of *r* alleles: ___________

Before mating (same numbers as table 2)

	Number	Frequency
RR (red)		
Rr (red)		
Rr (black)		
R allele		
r allele		

After mating

	Number	Frequency
RR (red)		
Rr (red)		
Rr (black)		
R allele		
r allele		

Third Generation (Natural Selection)

Total number of frogs: __________

Total number of *R* alleles: __________

Total number of *r* alleles: __________

Before mating

	Number	Frequency
RR (red)		
Rr (red)		
Rr (black)		
R allele		
r allele		

Total number of frogs: __________

Total number of *R* alleles: __________

Total number of *r* alleles: __________

After mating

	Number	Frequency
RR (red)		
Rr (red)		
Rr (black)		
R allele		
r allele		

Unit 3 Section 3

EVIDENCE FOR BIOLOGICAL EVOLUTION

SUGGESTED PACING

<table>
<tr><th>DAY (TRADITIONAL)</th><th>DAY (BLOCK)</th><th>TOPIC</th><th>CORE TEXT</th></tr>
<tr><td>1</td><td rowspan="2">1</td><td>Fossil Record</td><td>Holt, pp. 283–285</td></tr>
<tr><td>2–3</td><td>Comparative Anatomy and Embryology</td><td>Holt, p. 286</td></tr>
<tr><td>4</td><td>2</td><td>DNA Analysis</td><td>Holt, p. 287</td></tr>
<tr><td>5–6</td><td>3</td><td>Speciation</td><td>Holt, pp. 288–292</td></tr>
</table>

UNIT 3 SECTION 3

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 4: Changes in Ecosystems and Interactions of Organisms with their Environments

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. (GLE 3.3)

CONTENT EXPECTATIONS

☐ 1. All living organisms have genetic material (DNA) that carries hereditary information. (GLE 3.3.B)

…for Standard 4

Organisms are interdependent with one another and the environment. Genetic variation sorted by the natural selection process explains evidence of biological evolution. (GLE 4.1, 4.3)

CONTENT EXPECTATIONS

☐ 2. The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes. (GLE 4.1.D)

☐ 3. Evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of organisms and in the fossil record. (GLE 4.3.A)

☐ 4. Natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem. (GLE 4.3.C)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 6. Evidence is used to formulate explanations. (GLE 7.1.C)

…for Standard 8

Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time. (GLE 8.2)

CONTENT EXPECTATIONS

☐ 7. Scientific theories are developed based on the body of knowledge that exists at any particular time and must be rigorously questioned and tested for validity. (GLE 8.2.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Discuss how genes are responsible for the transfer of biological characteristics from one generation to the next. (GLE 3.3 *PR*)

☐ 1. Recognize that DNA codes for proteins, which are expressed as the heritable characteristics of an organism. (GLE 3.3.B.c)

…for Standard 4

Analyze how organisms are interdependent with one another and the environment. Explain how genetic variation sorted by the natural selection process explains evidence for biological evolution. (GLE 4.1, 4.3)

PERFORMANCE EXPECTATIONS

☐ 2. Interpret fossil evidence to explain the relatedness of organisms using the principles of superposition and fossil correlation. (GLE 4.3.A.a)

☐ 3. Evaluate the evidence that supports the theory of biological evolution (e.g., fossil records, similarities between DNA and protein structures, similarities between developmental stages of organisms, homologous and vestigial structures). (GLE 4.3.A.b)

☐ 4. Explain how environmental factors (e.g., habit loss, climate change, pollution, introduction of non-native species) can be agents of natural selection. (GLE 4.3.C.d)

UNIT 3 SECTION 3

…for Standard 7

Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a theory, or make predictions. (Frameworks I.A.3.a)

PERFORMANCE EXPECTATIONS

☐ 5. Analyze experimental data to determine patterns, relationship, perspectives, and credibility of explanations (e.g., explain the credibility of evolutionary theory given evidence). (GLE 7.1.C.b)

☐ 6. Analyze whether evidence (data) and scientific principles support proposed explanations (hypotheses, laws, theories). (GLE 7.1.D.a)

…for Standard 8

Identify and analyze theories that are currently being questioned, and compare them to new theories that have emerged to challenge the older ones. (Frameworks II.B.1.a)

PERFORMANCE EXPECTATIONS

☐ 7. Identify and describe how explanations (hypotheses, laws, theories) of scientific phenomena have changed over time as a result of new evidence (e.g., theory of biological evolution). (GLE 8.2.B.a)

Suggested Activities

UNIT 3 SECTION 3

TOPIC	EXPECTATIONS	ACTIVITY
Fossil Record Day 1	CE 3, 6, 7 PE 2, 3, 6	Display a diagram of a skeleton of a modern animal (e.g., horse, dog, cat, chimpanzee) and a diagram of a skeleton of an extinct animal. Have students do a think-pair-share (*ER*, p. GPT-11) on the following questions prior to a class discussion or as a class discussion: What do you know about the modern animal from the skeleton? What do you know about the extinct animal given the fossilized skeleton? What specializations or adaptations does each one appear to have? Discuss ideas that came up during the think-pair-share. Explain what conditions are necessary for fossilization to occur. Have students discuss why only the skeletons become fossilized and what information about ancient life-forms cannot be obtained from fossils. Discuss ways in which the fossil record provides evidence in support of the theory of biological evolution. (Goals 1.5, 1.6, 3.5)
	CE 3, 6, 7 PE 2, 3, 6	**Technology:** Have students examine a timeline of the history of life on Earth. Students should then make a list of the organisms they would expect to see in the fossil record and apply the principle of superposition to place them in chronological order. Have each student choose one of the organisms and conduct Internet research to complete the Favorite Fossil Activity (Holt *TE*, p. 261), placing emphasis on possible relationships between the organism and modern organisms. Discuss ways in which the fossil record provides evidence in support of the theory of biological evolution. (Goals 1.4, 1.6)
Comparative Anatomy and Embryology Days 2–3	CE 3, 5, 6, 7 PE 3, 5, 6	Use the Forelimbs of Vertebrate Comparison teaching transparency (Ch. 13) to explain homologous structures. Draw a comparison to analogous structures, using real-world examples. Have students complete the Comparing Limb Structure and Function Quick Lab (Holt *Biology CRF 13: The Theory of Evolution,* pp. 47–48). Discuss ways in which homologous structures provide evidence in support of the theory of biological evolution. (Goals 1.6, 3.5, 4.1)
	CE 3, 5, 6, 7 PE 3, 5, 6	**Hands-On Activity/Lab:** Distribute a set of cut-up pictures of developing vertebrate embryos to each pair of students. Pictures can be obtained from www.pbs.org/wgbh/evolution/educators/course/session3/resources.html. Select "Comparative Embryology: The Vertebrate Body." Have students put the pictures in chronological order. A class discussion should ensue about the difficulty they will encounter when they organize the beginning of each embryo's development. A teacher's number key is needed to tell them which developmental picture belongs to which vertebrate. Discuss ways in which comparative embryology provides evidence in support of the theory of biological evolution. (Goals 1.5, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students describe evidence they leave behind everyday. For example, in the morning they might leave an unmade bed, a wet towel and toothbrush, dirty pajamas, and a dirty breakfast plate. Discuss the connection to fossils, in that they are evidence organisms have left behind that demonstrate their existence.	Give students dried chicken bones. Have them organize them in the form of the animal and have them discuss the similarities between this activity and paleontologists' work. (ELL-5)	Have students research the La Brea Tar Pits. Information is available at www.tarpits.org/.
Limit the choices of organisms and have a list of Web sites with information on those organisms available for students to use if needed.	Allow students to label diagrams, drawings, or photographs with sentence fragments to complete the Favorite Fossil Activity. (ELL-8)	Have students make a list of the gaps in the fossil record and current research in archeology that address the gaps.
Have students draw and label examples of organisms that have homologous and analogous structures (e.g., bat and bird, human and alligator).	From a butcher's shop obtain cow leg bones and chicken wing bones. Have students organize the jumbled bones into true anatomical position, and have them compare and contrast structures. (ELL-5)	Have students complete the Comparing Hominid Skulls Exploration Lab (Holt, pp. 742–743). Data sheets are available on Holt *Biology CRF 23: Introduction to Vertebrates,* pages 49–52.
Have students color uncut pictures of developing vertebrate embryos. Similar-looking forms should have similar colors.	With the pictures of developing vertebrate embryos, have students label the developmental structures. (ELL-2)	Have students compare two different vertebrate embryos (e.g., pig and rat) and create a timeline that describes when significant structures are formed (e.g., notochord, brain, limbs).

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
DNA Analysis Day 4	CE 1, 3, 5, 6, 7 PE 1, 3, 5, 6, 7	Have students compare the amino acid sequences of similar proteins from different organisms and deduce their evolutionary history (e.g., hemoglobins or myoglobins). Amino acids sequences can be obtained at http://64.233.161.104/search?q=cache:5bq9KG0kgjQJ:biology.wsc.ma.edu/biology/experiments/bioinformatics/CompVertGlobins.pdf+species+myoglobin+amino+acid+sequences&hl=en&client=safari. Discuss ways in which amino acid sequences provide evidence in support of the theory of biological evolution and how this evidence has affected the history of the theory. (Goals 1.2, 1.6, 3.5, 4.1)
	CE 1, 3, 5, 6, 7 PE 1, 3, 5, 6	Have students read the section entitled "Biological Molecules" (Holt, p. 287). As they read, have them write a Descriptive Paragraph (*SUTW*, pp. 3-34 through 3-39) about how either proteins or DNA sequences provide evidence in support of the theory of biological evolution. Pair students such that one student has written a paragraph on proteins and the other has written one on DNA sequences. Have students exchange information. As one student explains verbally, the other should take notes to write another Descriptive Paragraph. (Goals 1.5, 2.3)
Speciation Days 5–6	CE 2, 4 PE 4	Divide the class into two teams. Each team represents an animal population. Each team must figure out as many scenarios possible that would lead their population to develop a new species. Prior to starting, tell students to focus on prezygotic and postzygotic mechanisms of isolation. The team with the most plausible scenarios wins. (Goals 2.3, 3.1, 3.5, 4.1, 4.6)
	CE 1, 2, 3, 4 PE 1, 2, 3, 4	Have students create a graphic organizer that illustrates the connection between the principles of natural selection and the process of speciation. Next, as a class, play a game to review the major concepts of biological evolution. *See Model Lesson*. (Goals 1.10, 2.3)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students use a note card to cover portions of the amino acid sequences, allowing them to focus on one set of amino acids at a time.	Have students create Frayer model maps (*ER,* p. RR-25) of relevant terms such as *fossil, embryo, adaptation, natural selection, homologous structures,* and *biological evolution*. (ELL-6)	Have students create a poster that illustrates the evolutionary relationships between three organisms (e.g., bear, opossum, and raccoon), given anatomical, embryological, and molecular evidence.
Have students write a Power Outline (*SUTW,* pp. 2-11 through 2-17) instead of a Descriptive Paragraph.	Use a think aloud to model writing one of the Descriptive Paragraphs. Have students write the other independently. (ELL-4)	Have students debate which is a better source of evidence for the theory of biological evolution in terms of accuracy and feasibility.
Prior to defining the term *speciation,* brainstorm a list of ways to separate organisms from each other.	Have students define and organize the sequence of speciation, given the following terms: *divergence, isolation, natural selection, subspecies, new species, genetic variation,* and *adaptation*. (ELL-1)	There are at least seventeen different penguin species in the Southern Hemisphere. Have students create a map of the Southern Hemisphere that shows the penguins' biogeographic distribution. Each student should be assigned a particular penguin species to research, focusing on its unique structural and behavioral adaptations.
Have students construct five questions from Holt, Ch. 13 The Theory of Evolution. Use these questions during the review game.	Give a list of vocabulary terms to study prior to the review game. (ELL-6)	Have students create difficult questions to use in the review game.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, pp. GPT-11, RR-25

   Step Up to Writing, pp. 2-11 through 2-17, 3-34 through 3-39

   Holt *Biology CRF 13: The Theory of Evolution*, pp. 47–48

   Holt *Biology CRF 23: Introduction to Vertebrates,* pp. 49–52

2. **Internet Resources for Teachers**

   All in the Family (Activity showing that homologous structures indicate descent from a common ancestor.)
   www.pbs.org/wgbh/evolution/educators/lessons/lesson3/additional.html

   Evidence for Evolution
   www.evoled.org/Lessons/evidence.htm#fossil

   Lesson: Using Amino Acid Sequences to Show Evolutionary Relationships
   www.woodrow.org/teachers/bi/1995/simulation_amino.html

   Speciation
   www.evoled.org/Lessons/speciation.htm

3. **Internet Resources for Students**

   Comparing Primate Proteins
   www.bioquest.org/bioinformatics/module/tutorials/Anthropology/

   Evolution Game
   www.bbc.co.uk/beasts/evolution/evolution_game.shtml

4. **Multicultural Resources and/or Activities**

   Have students research paleontologists and their discoveries. Possible subjects include Mary Anning (Britain), Rinchen Barsbold (Mongolia), Jose F. Bonaparte (Argentina), Phillip J. Currie (Canada), Zhiming Dong (China), Werner Janensch (Germany), E.A. Maleev (Russia), Thomas H. Rich (Australia), or Joan Wiffen (New Zealand).

   As a class create a world map. Using pins, have students mark the areas where important fossils have been discovered. Create a pin key detailing the fossils found at that site.

Suggested Assessments

1. Have students write a Descriptive Paragraph (*SUTW*, pp. 3-34 through 3-36) of the known evidence that supports the theory of biological evolution.
2. Have students define analogous and homologous structures and give an example of each.
3. Have students explain how the many finch species on the Galapagos Islands illustrate the process of speciation.
4. Present students with five different DNA segments. Have them analyze the codes and determine which two species are most evolutionary related.

Sample Constructed-Response Item

Describe how DNA sequences are used to investigate evolutionary histories.

When looking at species of animals that come from the same lineage, the more distantly they're related, the more different the DNA sequences are for similar proteins. Each time a lineage splits off, and then splits again, the sequences diverge further.

Model Lesson (Block Roster):
Speciation and Biological Evolution Review

Lesson Question

What is speciation?

Materials

Timer, three bells, photographs of a liger and a tion (optional)

Content and Performance Expectations

CE 1, 2, 3, 4; PE 1, 2, 3, 4

Teacher's Notes

Sample questions for the review game follow the lesson plan.

UNIT 3 SECTION 3

Warm-Up

- ▶ Have students write answers to the following questions, "What is a liger?" and, "What is a tion?" (If available, display photographs of the hybrids.)
- ▶ Define the term *hybrid*. Have students share other examples.

Instruction

Speciation

▶ Definition of *Speciation*	▷ Define the terms *species* and *speciation.* ▷ Explain that speciation requires genetic changes to accumulate between two groups that could previously breed with each other. ▷ Have students brainstorm a list of causes of reproductive isolation (e.g., separation by geography/habitat or behavior, temporal isolation, mechanical incompatibility, gametic isolation, hybrid inviability, hybrid sterility, hybrid breakdown). Classify them as postzygotic or prezygotic.
▶ Connection Between Natural Selection and Speciation	▷ Review the principles of natural selection. ▷ Have students create a graphic organizer illustrating the connection between the principles of natural selection and the process of speciation.

Biological Evolution Review Game

- **Procedure**
  - ▷ Write on the board the following categories: History of Evolutionary Thought, Biological Evolution, Evidence for Evolution, Speciation, and Bonus.
  - ▷ Explain to the students that they are going to play a review game. Each correct response is worth one point, with the exception of bonus questions, which are worth two points.
  - ▷ Divide the class into three groups and give each team a bell. Have students rotate among themselves so that each has an opportunity to ring the bell and has a response.
  - ▷ Prior to playing, collect the student-written questions and answers. Keep them in distinct team piles so that a team is not given a question written by one of its members.
  - ▷ Have teams take turns choosing a category. Read the answer and then the player that rings the bell first gets to respond with the correct question.
  - ▷ Use student-written questions as appropriate throughout the game.
  - ▷ Have students write down each vocabulary word that is used in the game.

UNIT 3 SECTION 3

Assessment

- Have students define and give real-world examples of three of the eight reproductive-isolating mechanisms.
- Have students hypothesize whether they believe modern-day humans can diverge into two or more species. Ask whether there are any reproductive isolating mechanisms in place in the modern-day world.

Homework Assignment

- Have students write down any unfamiliar vocabulary words that were gathered during the game and define them.

Teaching Resources

- Holt, pp. 251–294
- Teach Evolution and Make it Relevant: www.evoled.org/default.htm

activity sheet

name ______________________ date ____________

History of Evolutionary Thought

1. Answer: A French naturalist who proposed that biological evolution resulted from the inheritance of acquired characteristics

   Question: Who was Lamarck?

2. Answer: An English naturalist who formulated a theory of biological evolution by natural selection

   Question: Who was Charles Darwin?

3. Answer: A model of biological evolution that assumes slow steady rates of change

   Question: What is gradualism?

4. Answer: A model of biological evolution in which change occurs in relatively rapid bursts, followed by longer periods of little change

   Question: What is punctuated equilibrium?

5. Answer: The British economist who wrote that populations increase geometrically while food supplies increase arithmetically

   Question: Who was Thomas Malthus?

Biological Evolution

1. Answer: An anatomical, physiological, or behavioral feature that improves a population's ability to survive

   Question: What is an adaptation?

2. Answer: The process by which individuals that have favorable variations and are better adapted to the environment survive and reproduce more successfully than less well adapted individuals

   Question: What is natural selection?

3. Answer: A group of organisms of the same species that live in a specific geographical area and interbreed

   Question: What is a population?

4. Answer: Four types of evolutionary evidence

   Question: What are the fossil record, comparative anatomy, comparative embryology, and biological molecule sequences?

5. Answer: A cause of genetic variation

   Question (three possibilities): What is mutation?, What is recombination or sexual reproduction?, or What is gene flow or the movement of a set of organisms, and their alleles, into a new population?

activity sheet

name ______________________ date ____________

Evidence for Biological Evolution

1. Answer: Preserved in sedimentary rock, the remains of an organism that lived long ago

   Question: What is a fossil?

2. Answer: Structures that are similar, regardless of their function, because they were inherited from a common ancestor that also had that structure

   Question: What are homologous structures?

3. Answer: Structures in two different species that are similar but have separate evolutionary origins (e.g., bird and bat wings)

   Question: What are analogous structures?

4. Answer: A biological molecule that is considered evidence for biological evolution

   Question (three possibilities): What is DNA?, What is a protein?, What is an amino acid?

5. Answer: The layer of sedimentary rock in which the oldest fossil is found

   Question: What is the lowest?

Speciation

1. Answer: A group of individuals that can only interbreed among themselves

   Question: What is a species?

2. Answer: The process by which a new species develops, usually by the division of a single species into two or more genetically distinct ones

   Question: What is speciation?

3. Answer: Two major categories of reproductive isolation

   Question: What are prezygotic and postzygotic barriers?

4. Answer: When a species dies out completely

   Question: What is extinction?

5. Answer: Three postzygotic barriers

   Question: What are hybrid inviability, hybrid sterility, and hybrid breakdown?

activity sheet

name ______________________ date ____________

Bonus

1. Answer: A person who studies fossils

   Question: What is a paleontologist?

2. Answer: The ship Darwin used to travel to the Galapagos Islands

   Question: What is the HMS *Beagle*?

3. Answer: His proposed theory of biological evolution prompted Darwin to publish his own theory sooner than he intended

   Question: Who was Alfred Wallace?

4. Answer: The geologist who proposed that Earth's surface changed slowly over many years

   Question: Who was Charles Lyell?

5. Answer: An alternative form of a gene that produces a certain characteristic

   Question: What is an allele?

6. Answer: A method of determining the age of an object by estimating the relative percentages of radioactive parent isotope to stable daughter isotope

   Question: What is radiometric dating?

7. Answer: The time it takes for half of a sample of a radioactive substance to disintegrate by radioactive decay

   Question: What is a half-life?

8. Answer: A structure in an organism that is reduced in size and function; it may have been complete and functional in the organism's ancestors.

   Question: What is a vestigial structure?

9. Answer: Three premating prezygotic barriers

   Question: What are habitat isolation, temporal isolation, and behavioral isolation?

10. Answer: Two postmating prezygotic barriers

    Question: What are mechanical isolation and gametic isolation?

Unit 4 Chemistry of Life

- What conditions are necessary to sustain life on Earth?
- How do atoms interact to form matter?
- Which chemical compounds are important to biological processes?

Scope and Sequence, pages 19
Lesson Planning Material, pages 157–201

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

Unit 4 Section 1

ATOMS AND CHEMICAL BONDING

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Atomic Structure and the Periodic Table	Holt, p. 28
3–4	2	Chemical Bonding	Holt, pp. 29–30
5	3	Physical and Chemical Changes	Holt, pp. 38–39

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 1: Properties and Principles of Matter and Energy

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 1

Changes in properties and states of matter provide evidence of the atomic theory of matter. (GLE 1.1)

CONTENT EXPECTATIONS

☐ 1. The atomic model describes the electrically neutral atom. (GLE 1.1.E)

☐ 2. The periodic table organizes the elements according to their atomic structure and chemical reactivity. (GLE 1.1.F)

☐ 3. Properties of objects and states of matter can change chemically and/or physically. (GLE 1.1.G)

☐ 4. Chemical bonding is the combining of different pure substances (elements, compounds) to form new substances with different properties. (GLE 1.1.H)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 6. The nature of science relies upon communication of results and justification of explanations. (GLE 7.1.E)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 1

Describe atomic structure, the periodic table, physical and chemical changes in matter, and chemical bonding. (GLE 1.1.F *PR*, 1.1.G *PR*, 1.1.H *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Describe the atom as having a dense, positive nucleus surrounded by a cloud of positive electrons. (GLE 1.1.E.a)

☐ 2. Calculate the number of protons, neutrons, and electrons of an element (or isotopes) given its atomic mass (or mass number) and atomic number. (GLE 1.1.E.b)

☐ 3. Explain the structure of the periodic table in terms of the elements with common properties (groups/families) and repeating properties (periods). (GLE 1.1.F.a)

☐ 4. Distinguish between physical and chemical changes in matter. (GLE 1.1.G.a)

☐ 5. Compare and contrast the types of chemical bonds (i.e., ionic, covalent). (GLE 1.1.H.c)

☐ 6. Identify the consequences of different types of reactions (i.e., oxidation/reduction reactions such as combustion, acid/base reactions) to humans and human activities. (GLE 1.1.H.d)

…for Standard 7

Make systematic (nonexperimental) observations of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. Communicate results. (Frameworks I.A.3.a, GLE 7.1.E *PR*)

PERFORMANCE EXPECTATIONS

☐ 7. Communicate the procedures and results of investigations and explanations through diagrams and writing. (GLE 7.1.E.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Atomic Structure and the Periodic Table Days 1–2	CE 1 PE 1, 2	**Day 1:** Assign each student an element. Have students create a poster that has a Bohr diagram and states its symbol, number of protons, neutrons, and electrons, atomic number, atomic mass, chemical and physical properties, and uses. Discuss differences between the Bohr model and current beliefs about the structure of an atom. (Goals 1.6, 1.8, 2.1)
	CE 2, 5, 6 PE 3, 7	**Day 2:** Have students display their element posters and then have them attempt to arrange themselves in a logical order (e.g., using atomic mass or atomic number as the organizing principle). Next, have them arrange themselves like the periodic table. Discuss the organization of the periodic table in terms of groups and periods. (Goals 1.6, 2.3, 3.5, 4.1)
	CE 1 PE 2	**Hands-On Activity/Lab:** Assign each student a particular atom to study, and have him create an edible model that contains the appropriate number of protons, neutrons, and electrons (e.g., cookies, chocolate chips, sprinkles, candy). (Goals 1.6, 2.5)
	CE 2 PE 3, 7	**Hands-On Activity/Lab:** Give each student a periodic table. Have them color-code elements by group and period. Have them identify what distinguishes groups from each other and what distinguishes periods from each other. (Goals 1.6, 1.8, 3.5, 4.1)
Chemical Bonding Days 3–4	CE 4 PE 5	**Hands-On Activity/Lab:** Assign students various elements. Have them wear identification tags. Have them determine the number of balls needed to represent the number of electrons in their outer shell. The students are instructed to bond ionically with other students by finding one or more bonding partners to transfer their electrons to, so that each will have a complete outer shell. Have students work with their partner(s) and write a formula and name for the compound they formed. After 3 bonds with different partners, have students switch tags with another student and start bonding again. Before repeating for covalent bonding, have students discuss how to represent covalent bonding. (Goals 1.6, 2.3, 3.5, 4.1, 4.6)
	CE 4 PE 5	**Hands-On Activity/Lab:** Have students work in pairs to construct models of ionic compounds using models or candy (e.g., marshmallows and gumdrops can serve as atoms, whereas licorice can serve as bonds). They should then describe with diagrams exactly why these atoms formed these ionic bonds in compounds such as NaCl, LiF, $CaCl_2$, BaO, K_2S, $FeBr_3$, $AlCl_3$, and Cr_2O_3. Have students repeat for molecules such as H_2O, CH_4, O_2, CO_2, F_2, H_2, Cl_2, and NH_3. Have students discuss why these compounds contain covalent bonds. (Goals 1.6, 3.5, 4.1, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Give students paper circles representing protons, neutrons, and electrons. After assigning an element to each student, have them create an atom model with these paper circles.	Have students create atom models with beads and string. Use different color beads to represent protons, neutrons, and electrons. (ELL-5)	Have students figure out an atom's size and answer the following questions: How many times would they have to cut a piece of paper to reach an atom's size? How many atoms are in a cell? How many atoms are in a penny? and How many atoms are in a grain of sand?
Provide an outline of the periodic table and explain to students that it represents the organization scheme that is most commonly used.	Brainstorm a list of characteristics of atoms prior to the activity. (ELL-1)	Have students determine why carbon is the atom of life based upon its position in the periodic table.
As a class, create a flowchart of the steps to determining the number of protons, electrons, and neutrons in an atom.	Start a word wall for this chemistry section. Add terms, definitions, drawings/models, and examples. Start the word wall with the terms *elements, atoms, protons, neutrons, electrons,* and *periodic table.* (ELL-1)	Have students research one of the following investigators of subatomic particles: Ernest Rutherford, James Chadwick, or Murray Gell-Mann.
Have students work in pairs to determine patterns in the atomic numbers of a group or period.	Have students create a K-W-L chart (*ER,* p. RR-43) for the periodic table, groups, and periods. (ELL-8)	Have students investigate atomic properties and periodic table organization by constructing two graphs: atomic radius vs. atomic number and first ionization energy vs. atomic number.
Have students model ionic and covalent bonding by representing protons, neutrons, and electrons. For example, to represent lithium, have one person represent the three protons and another person represent the three neutrons in the nucleus. Have three people represent the electrons. For fluorine, have one person represent the nine protons and another person represent the nine neutrons in the nucleus. Have nine people represent the electrons. Explain what happens during ionic bonding, and have students move to represent the formation of an ionic bond.	Give students ion playing cards and a periodic table. Have them play "Go Fish" with a partner, and attempt to construct as many ionic bonds as possible. (e.g., If I have fluorine, which needs one electron to complete its outer shell, I should ask for an element that has one electron in its outer shell, like lithium.) (ELL-5)	Give students limited amount of "element" playing cards and a periodic table. They must play by themselves and attempt to construct as many covalent bonds as possible. (e.g., If I have carbon, which has four electrons to complete its outer shell, and I also have four hydrogens, which have one electron in its outer shell and needs one more, I think they can all bond together.) After completing the covalently bonded molecules in their limited packs, they should trade packs with a neighbor.
Give students already constructed molecular models. Have them explain to partners why the models exist in these conformations.	Have students sketch and label the molecular models with relevant vocabulary from this section. (ELL-6)	Give students chemical formulas of simple chemical reactions involving covalent bonding. Have them construct models or draw diagrams showing how the atoms have rearranged themselves.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Physical and Chemical Changes Day 5	CE 5 PE 6, 7	**Hands-On Activity/Lab:** Have a student hypothesize as to whether household substances (e.g., lemon juice, ammonia, soft drinks, orange juice) are acids or bases. Have students chart the pHs of these substances, using either purchased pH indicators or homemade cabbage juice as the pH indicator. Discuss acid-base reactions as a chemical change. Draw connections to the ecological issue of acid rain and whether its effects are due to physical or chemical changes. (Goals 1.6, 1.10)
	CE 3 PE 4, 6, 7	Have students complete the Physical and Chemical Changes Activity. *See Model Lesson*. (Goals 1.2, 1.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
After discussing acids and bases, have students write a message in an acid or base (e.g., vinegar or baking soda dissolved in water). Let the message dry. Spray the message with red cabbage indicator solution. If acidic and basic solutions are used to write different parts of the message, different colors will appear.	Show photographs of areas affected by acid rain. Have students then create a mural that shows how acid rain forms, what it does, and what conservation steps should be taken. (ELL-3)	Have students investigate the important role acids and bases have in the human body (e.g., the role of bicarbonate ion concentration in acid-base balance).
Use in a discussion the activities of cooking, eating, and digesting as examples of physical and chemical change (e.g., When I chew my food, what type of change is it? Why? How about when my saliva contacts my food? Why?).	Demonstrate examples of physical and chemical changes from everyday life (e.g., cutting paper, burning paper; mixing an egg, frying an egg; crushing a soda can, allowing a soda can to rust). (ELL-3)	Have students investigate why the formation of sedimentary rock is a physical change but the formation of metamorphic rock is a chemical change.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, pp. RR-25, RR-43, RR-83

   Step Up to Writing, p. 8-8

2. **Internet Resources for Teachers**

   Atoms, Matter, and Chemistry Bonding Activities and Lesson Plans
   http://educ.queensu.ca/~science/main/concept/chem/c07/c07main.htm

   Chemistry and You! Lessons
   www.saskschools.ca/curr_content/science9/chemistry/index.html

   The Science House: Countertop Chemistry
   www.science-house.org/learn/CountertopChem/index.html

3. **Internet Resources for Students**

   Atom Builder
   www.pbs.org/wgbh/aso/tryit/atom/

   Chemical Elements (Interactive Periodic Table)
   http://chemicalelements.com/

   Rader's Chem4kids
   www.chem4kids.com/

4. **Multicultural Resources and/or Activities**

   Have students investigate the origins of the names of some elements. (e.g., Actinium has an atomic number of 89 and the chemical symbol Ac. The name derives from the Greek, *aktis* or *akinis* for "beam" or "ray" because in equilibrium with its decay products, actinium is a powerful source of alpha radiation.)

   Have students research the historical development of the atomic theory, noting contributions from a variety of cultures.

Suggested Assessments

1. Have students determine element identities if given atomic numbers.
2. Have students construct models of molecules and compounds.
3. Have students determine whether an unknown substance is an acid or base by giving them a pH indicator and color key.
4. Have students complete a Venn diagram (*ER,* p. RR-83) comparing ionic and covalent bonding.

Sample Constructed-Response Item

What is one difference between ionic bonds and covalent bonds?

In a covalent bond, atoms share electrons and form molecules. In an ionic bond, atoms gain or lose one or more electrons and become ions. Ions of opposite charge are held together by ionic bonds and form ionic compounds.

UNIT 4 SECTION 1

Model Lesson (Traditional Roster):
Physical and Chemical Changes

Lesson Question

What are the differences between chemical and physical changes?

Materials

For each group: 2 plastic cups; 2 beakers; water; salt; hot plate; baking soda, vinegar; antacid tablet; plastic cup filled with fresh milk; plastic cup filled with spoiled milk; balance, safety goggles

Content and Performance Expectations

CE 3; PE 4, 6, 7

Teacher's Notes

Review safety procedures with hot plates and chemicals before allowing students to begin the activity.

Warm-Up

Physical and Chemical Changes Story

- Tell students that you are going to tell them a story about what happened to you this morning. At each pause in the story, they should write a Free Response (*SUTW*, p. 8-8) about whether the change that has been described is physical or chemical.
- Tell the following story, pausing at each of the parentheses: I like to eat cereal and drink coffee while I read the newspaper. I poured milk and sugar into my coffee (physical) and poured milk into my cereal (physical). The dog likes cereal too, so I put some on the floor beside me. All of a sudden, the lights went out. It was so dark outside, I had to light a candle (chemical). It was a fast-burning candle, and wax dripped all over the table (physical). Trying to clean up the wax I spilled milk on the newspaper (physical). The dog, eager to get some milk, ripped the paper (physical). The paper caught on fire (chemical).
- As a class, write definitions of the terms *physical change* and *chemical change*.

Instruction

Physical and Chemical Changes Activity

▶ Examples of Physical or Chemical Changes	▷ Each group will make observations of six situations. For each, they will have to determine whether they are observing physical or chemical changes. ▷ Have groups dissolve 2 g of salt in a beaker full of water. Have them record their observations. ▷ Have groups heat the water and salt until it begins to boil. Have them record their observations. ▷ Have groups add 3 g of baking soda to 15 mL of vinegar in a plastic cup. Have them record their observations. ▷ Have groups add an antacid tablet into the cup with the baking soda and vinegar. Have them record their observations. ▷ Have groups tear a piece of paper into eight pieces. Have them record their observations. ▷ Have groups compare a plastic cup with fresh milk and one with spoiled milk. Have them record their observations. ▷ Have groups categorize each situation as either a physical or a chemical change.
▶ Wrap-Up	▷ Have groups share how they grouped the situations from the Physical and Chemical Changes Activity. ▷ Review the class-generated definitions from the beginning of class. Have students evaluate the definitions and revise them as necessary. Discuss how to determine whether a change is physical or chemical. ▷ Point out the connection between chemical changes and chemical reactions. ▷ Brainstorm a list of chemical reactions that affect humans or human activities.

Assessment

- Have students list five household activities that are physical changes and five that are chemical changes.

Homework Assignment

- Have students complete Frayer model maps (*ER,* p. RR-25) for the terms *chemical change* and *physical change.*

Teaching Resources

- Holt, pp. 38–39

UNIT 4 SECTION 1

Unit 4 Section 2

BIOLOGICALLY IMPORTANT COMPOUNDS

SUGGESTED PACING

<table>
<tr><th>DAY (TRADITIONAL)</th><th>DAY (BLOCK)</th><th>TOPIC</th><th>CORE TEXT</th></tr>
<tr><td>1–2</td><td>1</td><td>Water</td><td>Holt, pp. 31–33</td></tr>
<tr><td>3–4</td><td rowspan="2">2</td><td>Biomolecules</td><td>Holt, pp. 34–37</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Nutrition</td><td rowspan="2">Holt, pp. 900–905</td></tr>
<tr><td>3</td></tr>
</table>

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 1: Properties and Principles of Matter and Energy

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

UNIT 4 SECTION 2

WHAT ALL STUDENTS SHOULD KNOW...

...for Standard 1

Energy has a source, can be transferred, and can be transformed into various forms but is conserved between and within systems. (GLE 1.2)

CONTENT EXPECTATIONS

☐ 1. Energy is stored within the chemical bonds of biomolecules. (GLE 1.2.A.b *PR*)

...for Standard 3

Living organisms carry out life processes in order to survive. (GLE 3.2)

CONTENT EXPECTATIONS

☐ 2. Energy is released during the breakdown of organic compounds in the body. (GLE 3.2.D.c *PR*)

☐ 3. Cellular activities and responses can maintain stability internally while external conditions are changing (homeostasis). (GLE 3.2.F)

...for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Scientific inquiry includes the ability to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 6. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 1

Describe various forms of energy (e.g., energy stored in chemical bonds). (GLE 1.2 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Recognize chemical energy as the energy stored in the bonds between atoms in a compound. (GLE 1.2.A.b)

…for Standard 3

Use models to demonstrate various chemical transformations carried out by cells and apply this information to different contexts of everyday life. (Frameworks VII.B.1.a)

PERFORMANCE EXPECTATIONS

☐ 2. Distinguish among organic compounds (e.g., proteins, nucleic acids, lipids, carbohydrates) in relation to their role in living systems. (GLE 3.2.D.b)

☐ 3. Explain how water is important to cells (e.g., is a buffer for body temperature, provides soluble environment for chemical reactions, serves as a reactant in chemical reactions, provides hydration that maintains cell turgidity, maintains protein shape). (GLE 3.2.F.d)

…for Standard 7

Analyze experimental data to determine patterns, relationships, perspectives, and credibility. Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Frameworks I.A.1.a, Frameworks I.A.3.a)

PERFORMANCE EXPECTATIONS

☐ 4. Design and conduct a valid experiment. (GLE 7.1.A.c)

☐ 5. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., thermometers, balances, graduated cylinders). (GLE 7.1.B.a)

☐ 6. Measure mass to the nearest gram, volume to the nearest milliliter, and temperature to the nearest degree Celsius. (GLE 7.1.B.b *PR*)

☐ 7. Use quantitative and qualitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Water Days 1–2	CE 6 PE 3, 7	**Hands-On Activity/Lab:** Set up stations around the classroom where students will investigate different properties of water. Have groups rotate through each station. At each station, have students take Two-Column Notes (*SUTW*, pp. 9-1 through 9-15) with their observations about the property of water being studied, ideas on the chemistry behind the property, and explanations of how the property of water studied affects life. At the first station, have students investigate surface tension by 1) counting the number of water drops that can be placed on a penny until it runs over 2) filling a container to the top, predicting how many pennies can be added before the water spills over, and then adding the pennies one by one until the water spills 3) floating a needle coated with petroleum jelly in a beaker full of water and then pushing the needle slightly below the surface so that it sinks 4) comparing water drop shapes when placed on wax paper and on a glass slide, and 5) examining photographs of water striders. At the second station, have students investigate capillary action by 1) comparing how far water travels up a capillary tube to how far a nonpolar substance travels up a capillary tube 2) using a magnifying glass to examine the vascular tissue that water travels through in celery that has absorbed red- or blue-tinted water, and 3) making a chromatogram from a drop of ink, chromatography paper, and water. At the third station, have students investigate polarity by 1) adding oil and then water into a beaker, and then in a separate beaker adding water and then oil and 2) adding water-soluble dye to the oil-water mixtures. Discuss students' Two-Column Notes as a class. (Goals 1.6, 3.5, 4.1)
	CE 6 PE 3, 7	**Hands-On Activity/Lab:** Using precut colored circles (e.g., red for oxygen and blue for hydrogen), have students model the three states of water: the ordered lattice structure of ice, the semi-ordered structure of liquid water, and the random structure of water vapor. Use models to explain why ice is less dense than liquid water and why this property of water is important. Have students write a Quick Sketch story (*SUTW*, pp. 6-2 through 6-15) describing an imaginary world in which ice is more dense than liquid water. (Goals 1.6, 1.8)
	CE 4, 6 PE 3, 4, 7	**Hands-On Activity/Lab:** Have students devise and carry out an experiment in which they investigate how bond type (i.e., ionic, polar, or nonpolar) affects a substance's solubility in water. After students have finished their experiments, have them discuss how solubility in water affects life on Earth. (Goals 1.2, 1.3, 1.6, 3.1)
	CE 3, 6 PE 3, 7	As a class, brainstorm a list of water's properties and its function in cells (e.g., a buffer for body temperature due to high specific heat, provides soluble environment for chemical reactions, serves as a reactant in chemical reactions, provides hydration that maintains cell turgidity, maintains protein shape). Have students create a mural as a class that illustrates both water's properties and its functions in cells. (Goals 1.2, 1.4, 1.8, 2.5, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
At the beginning of the lesson, have students list and/or draw sites where water can be found (e.g., rivers, oceans, beverages, cells, blood) and compare them.	Create a word wall with the following terms: *polar, nonpolar, soluble, insoluble, cohesion, adhesion, surface tension,* and *capillary action*. (ELL-6)	Have students respond to the following quote: "If there is magic on this planet, it is contained in water." (Loren Eiseley, *The Immense Journey*, 1957)
Have students act as water molecules in each of its three phases.	As a demonstration, heat a beaker of oil that contains one or two ice cubes. Have students observe how water density changes as ice turns to liquid water. (ELL-4)	Have students create a model that illustrates why water is densest at four degrees Celsius.
Before students design their experiments, use construction paper models of water molecules to demonstrate the principle of hydrogen bonding.	As a class, brainstorm a list of testable questions before students begin designing their experiments. (ELL-1)	Have students research whether water has been found on other planets. Have students explain what water's presence on other planets would signify.
Assign each group to one property of water or one of its functions in cells and have them create a portion of the mural about it.	Have students list and/or draw how they have used water today. (ELL-3)	Have students research what happens within their bodies when they become dehydrated.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Biomolecules Days 3–4	CE 2 PE 2	**Day 3:** Divide the class into four groups. Each group is responsible for teaching the rest of the class about one of the four types of biomolecules (i.e., carbohydrates, proteins, lipids, and nucleic acids). (Goals 1.8, 2.1, 2.3, 4.6)
	CE 1, 2 PE 1, 2	**Day 3:** Have students create a table on organic compounds. Horizontally students should list the headings "Carbohydrates," "Proteins," "Lipids," and "Nucleic Acids." Vertically, students should list the headings "Building Block (Monomer)," "Building Block Diagram," "Function," "Food Source Example," and "Human Body Example." Have students read the section entitled "Chemistry of Cells" (Holt, pp. 33–36) and fill in the table. (Goals 1.6, 1.8)
	CE 1, 2, 5, 6 PE 1, 2, 5, 7	**Day 4/Hands-On Activity/Lab:** Have students complete the Identifying Food Nutrients Lab (Holt *Biology CRF 2: Chemistry of Life*, pp. 53–56), with the exception of the Extensions. (Goals 1.2, 1.6, 3.5)
	CE 2 PE 1, 2	**Day 4:** In groups, students have to construct a construction-paper human model that best illustrates the roles biomolecules (i.e., carbohydrates, proteins, lipids, and nucleic acids) have in the body. (Goals 1.8, 2.1, 2.3, 4.6)
Nutrition Day 5	CE 1, 2, 5, 6 PE 1, 2, 5, 6, 7	**Hands-On Activity/Lab/Technology:** Have students complete the Energy Content of Foods Lab (Holt *Forensics and Applied Science Experiments,* pp. 155–161) and relate it to differences in the quantities of chemical energy stored in different types of food. The procedure is written for use with a TI CBL system and will have to be adjusted for use with other types of probeware. *See Model Lesson*. (Goals 1.6, 1.10)
	CE 2 PE 2	Display the USDA Food Pyramid teaching transparency (Ch. 39). Have students research alternatives to it, such as the USDA My Pyramid plan. Information on the USDA My Pyramid plan can be obtained at www.mypyramid.gov/. Have students write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) on comparing the USDA Food Pyramid versus the alternative. (Goals 1.6, 1.10)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Bring food samples or photographs of proteins, carbohydrates, and lipids. Have students categorize the examples.	Create a word wall for biomolecules. (ELL-1)	Give students the resources so that they can create a six-page book that contains structural diagrams and descriptions of the following biomolecules: 1) monosaccharides (e.g., glucose, fructose, galactose, ribose, deoxyribose) 2) disaccharides (e.g., sucrose, lactose, maltose, dehydration synthesis, hydrolysis) 3) polysaccharides (e.g., starch, glycogen, cellulose) 4) lipids (e.g., unsaturated fat, saturated fat, steroids, phospholipids, cholesterol) 5) protein (e.g., essential amino acids, nonessential amino acids, primary structure, secondary structure, tertiary structure, quaternary structures), and 6) nucleic acids (e.g., DNA, RNA).
After explaining the differences between saturated and unsaturated fats, have students classify five different everyday examples (e.g., olive oil, butter, margarine, lard, peanut oil). Discuss connections between fat source and fat type.	Using structural diagrams as a reference, have students construct molecular models of a monosaccharide, an unsaturated fat, a saturated fat, and a nucleic acid. (ELL-5)	Divide the class into groups. With art supplies, have each group develop a three-dimensional representative model of one of the four biomolecules.
Have students use the smear test to detect fats in food. Smear portion of food sample on to brown paper bag and lift to light. Fat-containing substances will allow light to penetrate the brown paper. Use water as a control.	Before students begin the lab, review the procedure with the class. Define unfamiliar terms and clarify any steps of the procedure that students are confused about. (ELL-1)	Have students complete the Extensions.
Have students construct a DNA molecule using models or precut labeled construction paper.	Have students create a concept web (*ER,* p. RR-15) that includes the following terms: *carbon, carbohydrate, glucose, starch, lipids, proteins, amino acids, enzymes, nucleic acids, DNA,* and *RNA*. (ELL-6)	Give each of the five groups an article to read that relates to an interesting protein just discovered (e.g., leptin, meth-1/meth-2, melanopsin, dysferlin, apelin). Have groups identify the main idea and interesting facts and present their findings to the class.
As a class, classify the food samples by macromolecule.	Model the procedure for students before they begin the lab. (ELL-4)	Have students discuss ways that the procedure could be revised in order to reduce error in this lab.
Draw the "My Pyramid" on the board, with an envelope on each of the six bands. Give two to three food photographs to each student and have him place it in the right envelope/food group.	Have students draw what they ate yesterday. With a partner, they should then help one another identify where their food items fit into the USDA "My Pyramid" schema. (ELL-3, ELL-5)	Have students compare their diet to what is recommended by the USDA "My Pyramid" schema. Have them list five ways they could better comply with the recommendations.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 2: Chemistry of Life*, pp. 53–56

   Holt *Forensics and Applied Science Experiments*, pp. 155–161

   Educational Resources, p. RR-15

   Step Up to Writing, pp. 3-21 through 3-29, 3-34 through 3-39, 6-2 through 6-15, 8-8, 9-1 through 9-15

2. **Internet Resources**

   Biochemistry
   www.biology.arizona.edu/biochemistry/biochemistry.html

   Carbon is 4 Ever
   http://library.thinkquest.org/C005377/content/intro.htm

   Water: Properties and Behavior
   www.visionlearning.com/library/module_viewer.php?c3=&mid=57&l=

   USDA Nutrient Data Laboratory
   www.nal.usda.gov/fnic/foodcomp/

3. **Multicultural Resources and/or Activities**

   Have students write a Descriptive Paragraph (*SUTW,* pp. 3-34 through 3-39) explaining how their culture or family has influenced their diet.

   Have students explore how different diets are consumed in different parts of the world at www.open2.net/everwondered_food/culture/culture_global_view.htm#

4. **Additional Instructional Resources**

   Eiseley, Loren. *The Immense Journey*. Random House, 1957.

Suggested Assessments

1. Have students classify each of the biomolecules studied as water soluble or water insoluble. Have students then explain what determines solubility in water.
2. Have students list three characteristics for each of the four classes of organic compounds.
3. Have students explain why vegetarians can be nutritionally deficient.
4. Have students compare the school lunch menu to the recommended amounts given in the "My Pyramid."

Sample Constructed-Response Item

Why does water act as a buffer for body temperature?

Water has a high specific heat, thus it requires a large amount of energy (or heat input) to increase its temperature.

UNIT 4 SECTION 2

Model Lesson (Block Roster):
Nutrition: Food and Energy

Lesson Questions

Why do humans need to eat food?

What is a Calorie?

How do proteins, carbohydrates, and fats differ in terms of providing energy?

Materials

Cans, matches, water, wooden splints, food holders, graduated cylinders, CBL probeware, stirring rods, ring stands, slit stoppers, clamps, graphing calculators, temperature probes, marshmallows, cashews, popcorn

Content and Performance Expectations

CE 1, 2, 5, 6; PE 1, 2, 5, 6, 7

Teacher's Notes

The Energy Content of Foods Lab can be done in groups or as a demonstration. The instructions are written for use with a TI CBL system and will have to be adjusted for use with other types of probeware.

Peanuts should not be used during the calorimetry activity due to the possibility of life-threatening allergies.

Warm-Up

What have you eaten today?

▶ Have students list the foods they have eaten during the last 24-hour period.

Instruction

Food as Fuel

▶ What is a Calorie?

▷ Have students write a Free Response (*SUTW,* p. 8-8) to the question "What is a Calorie?"

▷ Have students share their Free Responses. Ask them whether the Calorie requirements are the same for every person (i.e., different ages, different genders, different levels of physical activity).

▷ Define the terms *calorie* and *Calorie* (*kilocalorie*). Point out that a Calorie, used as a unit of food energy, is a thousand calories.

▷ Have students explain how food stores chemical energy. Explain that during the process of digestion chemical bonds are broken and reformed; during this process energy is released. Foods that are high in calories have chemical bonds that when broken and reformed in a new configuration release a large amount of energy. If the body does not use all of this energy released, it stores it in the chemical bonds of fat molecules.

Energy Content of Foods Lab

▶ Hypothesis about Differences Between Biomolecules

▷ Explain the function of a calorimeter.

▷ Have students hypothesize which of the three types of food (e.g., popcorn, marshmallow, cashew) has the most calories and explain their reasoning.

▶ Carrying Out the Lab

▷ Have students complete the Energy Content of Foods Lab (Holt *Forensics and Applied Science Experiments,* pp. 155–161).

Calories as Indicated by the Food Label

- **Food Labels**
  - ▷ Have students examine the food labels provided in the Energy Content of Foods Lab and have students list the amount of protein, carbohydrate, and fat in each food.
  - ▷ Point out that nutrition labels usually indicate the number of grams per serving and that servings are sometimes given in food units. Have students explain how to determine the information for a single food item (e.g., one marshmallow).
  - ▷ Explain that energy in food (measured in Calories) is provided by the following biomolecules: protein, carbohydrates, and fat. A food's Calories can be estimated by using the 4-9-4 rule. Proteins and carbohydrates each provide about 4 Calories per gram and fat provides about 9 Calories per gram.
  - ▷ Have students calculate total number of Calories per food unit as indicated by the label by using the 4-9-4 rule: calories/serving =
    $$\left(\frac{\text{g of protein}}{\text{serving}} \times \frac{4\text{ Cal}}{\text{g}}\right) + \left(\frac{\text{g of fat}}{\text{serving}} \times \frac{9\text{ Cal}}{\text{g}}\right) + \left(\frac{\text{g of carbohydrate}}{\text{serving}} \times \frac{4\text{ Cal}}{\text{gm}}\right)$$
    Have them write their calculations on data table.
  - ▷ Have students analyze how closely estimates for Calories match the calorimeter calculations.
  - ▷ Have students answer additional questions related to the Energy Content of Foods Lab that follow the lesson plan. Review the answers as a class.

Assessment

- Give students two imaginary food labels that contain the following information: grams of protein per serving, grams of fat per serving, and grams of carbohydrates per serving. Have them calculate the total number of Calories per serving and then explain which would be most beneficial for a high school student's snack.

Homework Assignment

- Have students write down the food labels of one day's worth of meals. Have them explain how the calories eaten correspond to the dietary recommended allowances for their gender and age.

Teaching Resources

- Holt Biology, pp. 34–37
- www.usda.gov/cnpp/dietary_guidelines.html

activity sheet

name ______________________ date ____________

Additional Questions for the Energy Content of Foods Lab

1. To what degree does your hypothesis agree with your conclusions?

2. What are some sources of heat loss during this experiment? How can this experiment be better designed?

3. Besides providing energy, what else does food provide?

4. Why aren't the amount of nucleic acids measured in food?

5. What are the two ways people lose weight? Include the term *Calorie* in your answer.

UNIT 4 SECTION 2

Unit 4 Section 3

ENZYMES

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Enzymes and Chemical Reactions	Holt, pp. 38–41
3–5	2–3	Factors that Affect Enzyme Activity	Holt, p. 42

BENCHMARK ASSESSMENT 2—WEEK OF DECEMBER 4 (CONTINUED IN NEXT UNIT)

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 1: Properties and Principles of Matter and Energy

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW...

...for Standard 1

Energy has a source, can be transferred, and can be transformed into various forms but is conserved between and within systems. (GLE 1.2)

CONTENT EXPECTATIONS

☐ 1. Chemical reactions involve the release or absorption of energy. (GLE 1.2.D *PR*)

...for Standard 3

Living organisms carry out cell processes in order to survive. (GLE 3.2)

CONTENT EXPECTATIONS

☐ 2. Enzymes are a class of proteins that act as catalysts in living cells. (GLE 3.2.D *PR*)

...for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 3. Scientific inquiry includes the ability to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)

☐ 4. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 5. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 1

Describe how energy is involved in chemical changes. (Frameworks III.C.1.a *PR)*

PERFORMANCE EXPECTATIONS

☐ 1. Describe evidence of energy transfer and transformations that occur during exothermic and endothermic reactions. (GLE 1.2.D.a)

…for Standard 3

Use models to demonstrate various chemical transformations carried out by cells and apply this information to different contexts of everyday life. (Frameworks VII.B.1.a)

PERFORMANCE EXPECTATIONS

☐ 2. Explain how protein enzymes affect chemical reactions (e.g., the breakdown of food molecules). (GLE 3.2.D.d)

☐ 3. Interpret a data table showing the effects of an enzyme on a biochemical reaction. (GLE 3.2.D.e)

…for Standard 7

Analyze experimental data to determine patterns, relationships, perspectives and credibility. Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Frameworks I.A.1.a, I.A.3.A)

PERFORMANCE EXPECTATIONS

☐ 4. Formulate testable questions and hypotheses. (GLE 7.1.A.a)

☐ 5. Design and conduct a valid experiment. (GLE 7.1.A.c)

☐ 6. Evaluate the design of an experiment and make suggestions for reasonable improvements. (GLE 7.1.A.g)

☐ 7. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., thermometers, metric rulers, graduated cylinders). (GLE 7.1.B.a)

☐ 8. Use quantitative and qualitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Enzymes and Chemical Reactions Days 1–2	CE 1, 2 PE 1, 2	**Day 1:** Have students list all the energy forms and their sources that they have used that day (e.g., I dried my hair with a hairdryer, which is electrical energy that was transformed into heat and sound energy). Point out food as an energy source that might not be immediately obvious. Discuss how chemical energy is stored and released. Then, use Figure 13 on Holt, page 39 to discuss the differences between endothermic and exothermic reactions. Have students list examples of each. Have students read the section entitled "Activation Energy" and the first paragraph of the section entitled "Enzymes" (Holt, pp. 39–40). Also have students examine Figure 14 on Holt, page 40. Have students write a Cause and Effect Paragraph (*SUTW,* pp. 3-43 through 3-45) about enzymes and chemical reactions. (Goals 1.6, 2.3)
	CE 1, 2 PE 1, 2	**Day 1:** Have students create two energy diagram models similar to Figure 13 on Holt, page 39. One should represent an exothermic reaction and the other should represent an endothermic reaction. After demonstrating their models to the teacher, the students should then alter these models, in order to illustrate how enzymes would change activation energies. Students should use materials such as clay balls, cardboard boxes, paper-towel rolls, and pipe-cleaners. (Goals 1.6, 1.8, 2.1)
	CE 1, 2 PE 2, 8	**Day 1:** Prior to class, prepare several sets of pairs of matching puzzle pieces. Display the Activation Energy With and Without Enzymes teaching transparency (Ch. 2) and discuss the effect of enzymes on a chemical reaction. To act out the lock-and-key enzyme model, divide the class in two. Give each student in the first group a puzzle piece that has an *R* on the front side and a *P* on the back side. Explain to them that every three minutes the reactant becomes the product and that they have to flip the puzzle piece. Have this group mill around the class acting out the chemical reaction two or three times. Next, give the second group puzzle pieces that match the first group. These puzzle pieces have an *E* on the front side. Have them mill around the class with the first group, trying to find their match. If the match happens before the three-minute interval the reactant turns to product. If no match happens at the three-minute interval, the reactant still turns to product. Have students compare these two situations. (Goals 1.6, 3.5, 4.6)
	CE 2, 4, 5 PE 2, 8	**Day 2/Hands-On Activity/Lab:** Have students determine which fruits contain proteolytic enzymes that denature the protein molecules in gelatin. Create the gelatin solution using half of the water amount recommended. Create fruit juice by pureeing fruit and filtering it through cheesecloth. Have students place 3 mL of the gelatin solution in each of ten test tubes. Students should then label the test tubes with the nine juices being tested. The 10th test tube should be the control. Have students add 3 mL of pineapple, apple, kiwi, papaya, orange, prune, grapefruit, cranberry, or grape juice to the appropriate test tube and place water as the control in the 10th test tube. Refrigerate the test tubes overnight and have students check for gelatin solidification the next day. Have them explain their observations based on the action of the proteolytic enzymes. (Goals 1.2, 1.6)
	CE 2, 4, 5 PE 2, 7, 8	**Day 2:** Have students observe the activity of catalase. Pulverize and filter green beans through cheesecloth. Place 3 mL of the green beans into a labeled test tube. Repeat this procedure three more times for liver, chicken meat, and apples; place each separately into labeled test tubes. In a separate fifth test tube, place 3 mL of water to act as the control. Add 1 mL of hydrogen peroxide to each of the five test tubes and measure the rate of enzyme activity as the amount or depth of hydrogen peroxide in mm/time in sec. Discuss with the class similarities and differences in the rates. (Goals 1.2, 1.6)
	CE 2, 4, 5 PE 2, 3, 8	Have students complete the Pretend To Be an Enzyme Activity. *See Model Lesson*. (Goals 1.6, 1.8, 2.3, 3.3, 4.1, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students create a poster illustrating endothermic and exothermic chemical reactions.	Define the prefixes *endo-* and *exo-*. Discuss other words that contain these prefixes. (ELL-2)	Have students write a Compare and Contrast Paragraph (*SUTW,* pp. 3-21 through 3-27) on endothermic and exothermic chemical reactions.
Perform the following demonstrations in class and have students classify them as exothermic or endothermic chemical reactions: wood burning, ice pack that you have to squeeze to get cold, calcium chloride (road salt) in water, sodium bicarbonate in water, picture of a plant (photosynthesis). Wear safety glasses for this demonstration. If calcium chloride contacts eyes or skin, flush immediately with water. If irritation persists obtain medical help.	Give students two different graphs in which they have to label the axes, reactants, products, and activation energies. They should also classify the reactions as exothermic or endothermic. (ELL-6)	Have students research and describe three examples of coupled reactions in which the energy released by an exothermic reaction is used to drive an endothermic reaction.
Have pairs of students create lock-and-key models of enzymes and their substrates by creating models out of paper.	Provide students with a cut-out piece of construction paper that represents the substrate. Have students construct the matching enzyme that would fit with this molecule using the lock-and-key model of enzyme activity. (ELL-5)	Have students write a Compare and Contrast Paragraph (*SUTW,* pp. 3-21 through 3-29) the lock-and-key enzyme model to the induced-fit enzyme model.
Reduce the number of juices being tested to three.	Model the procedure with one of the juices and have students repeat independently or in pairs with the other juices. (ELL-4)	Have students complete a jigsaw (*ER,* p. GPT-7) with five different articles that describe new enzymes discovered.
Have students compare different amounts of catalase from the same source rather than different sources of catalase.	After demonstrating the catalase lab, have students illustrate the reaction, using the terms *enzyme, substrate*, and *rate* in their diagrams. (ELL-4)	Have students investigate the American biochemist J.B. Sumner.
In pairs, have students draw what happens when an enzyme is involved in a chemical reaction.	Create a word wall with the following terms: *chemical reaction*, *reactants*, *products*, *activation energy*, *substrate*, and *enzyme*. (ELL-6)	Have students illustrate the mechanisms of negative feedback, positive feedback, competitive inhibition, noncompetitive inhibition, cofactors, and coenzymes.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Factors that Affect Enzyme Activity Days 3–5	CE 2, 3, 4, 5 PE 2, 4, 5	**Day 3:** In groups, have students design an experiment investigating catalase activity in relation to one of these four variables: pH, temperature, enzyme concentration, or substrate concentration. Have them complete the Prior Knowledge, Testable Question, Hypothesis, Materials, and Procedure portions of the Designing an Experiment worksheets (*ER,* pp. RR-17 through RR-21) and submit them for teacher approval prior to performing their experiments. (Goals 1.2, 1.3, 1.6, 3.1, 3.4, 3.5, 4.5, 4.6)
	CE 2, 3, 4, 5 PE 2, 3, 4, 5, 6, 7, 8	**Day 4:** Have groups perform their experiments and complete the Data, Conclusion, and Extension portions of the Designing an Experiment worksheets (*ER,* pp. RR-21 through RR-23). Students should then identify two ways to improve their experiments. (Goals 1.2, 1.3, 3.1, 3.5, 4.5, 4.6)
	CE 2, 3, 4, 5 PE 2, 3, 6, 8	**Day 5:** Have groups present to the class their experiment designs, results (including graphs), conclusions, and methods for design improvement. (Goals 1.6, 1.8, 2.1, 2.3, 3.5, 4.6)
	CE 2, 5 PE 3, 8	Divide the class into four groups. Give each group a data set that they must use to create a graph for display. The four different data sets illustrate how enzyme-catalyzed reaction rates differ due to changes in enzyme concentration, substrate concentration, temperature, or pH. After creating their graphs, the groups must explain how the variable in their data sets affected reaction rates. (Goals 1.6, 3.5, 4.1)
	CE 2, 3, 4, 5 PE 2, 7, 8	**Hands-On Activity/Lab/Technology:** Have students complete the Observing the Effect of Temperature on Enzyme Activity Lab (Holt *Biology CRF: Chemistry of Life*, pp. 57–62). (Goals 1.8, 3.5)
	CE 2, 3, 4, 5 PE 2, 3, 4, 5, 6, 7, 8	**Hands-On Activity/Lab:** Have students complete the Observing Enzyme Detergents Exploration Lab (Holt *Biology CRF 2: Chemistry of Life*, pp. 49–52). (Goals 1.3, 1.6, 1.8, 3.5, 4.1, 4.5, 4.6)
	CE 2 PE 2	Give students resources and/or Internet access to research one inherited enzyme deficiency (e.g., glucose-6-phosphate dehydrogenase deficiency, phenylketonuria, Tay-Sachs disease, porphyries, lactose intolerance). (Goal 1.2)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
As a class, review how to use a graduated cylinder, balance, thermometer, and pH paper before students write their procedure.	Before students design their experiments, brainstorm a list of questions. Categorize them as testable or nontestable. Students should then use one of the testable questions to design their experiment. (ELL-4)	Have students design an additional experiment analyzing the activity of Lactaid© on lactose, a sugar found in dairy products, given one of the following variables: pH, temperature, enzyme concentration, and substrate concentration.
As a class, brainstorm a list of sources of error and ways an experiment could be improved for students to apply to their own experiments.	Prior to the data analysis, have students brainstorm terms that apply to trends in data such as *increase* and *decrease*. (ELL-6)	Have groups who performed experiments testing the same variable compare data. Have students complete a statistical analysis comparing the two sets of data and summarize their conclusions.
Have students prepare 5 × 8 Speeches (*SUTW,* pp. 5-4 through 5-5).	Have students prepare visual aids to accompany their presentations. (ELL-7)	Have students create and use a rubric for assessing the presentations.
Create a data table as a class and then model turning it into a graph before students work with the four data sets independently.	Have students analyze the graphs using Cause/Effect Two-Column Notes (*SUTW,* p. 9-12) before explaining how the variable in the data sets affected reaction rates. (ELL-8)	Give students three additional data sets to graph. After plotting the data and deducing the relationship between substrate concentration and reaction rate, have students identify the data sets as corresponding to enzyme alone, enzyme with competitive inhibitor, or enzyme with noncompetitive inhibitor.
Review the procedure as a class before students begin the experiment.	Have students draw, act, or mime enzyme actions, and how they are affected by pH and temperature. (ELL-5)	Have students complete one of the two Extensions.
Have students create an experiment investigating how different detergent types affect a white T-shirt stained with grape juice.	After discussing how proteases work in detergents, create a class list of all the questions the students have about enzyme detergents that they would want to answer through investigation. Choose one testable question and model how to design a procedure to test it. (ELL-4)	Investigate what enzymes are used in detergents, and whether they differ according to brand. Have students discuss the following question: Does the price of the detergent correspond to quantity or quality of enzymes used?
Watch *Lorenzo's Oil*, a film about parents who struggle to find a cure for their son who has adrenoleukodystrophy; he is unable to degrade long chain fatty acids which eventually causes myelin destruction.	Have students create a pamphlet on lactose intolerance. (ELL-5)	Have students complete the Demonstrating Lactose Digestion Exploration Lab (Holt *Biology CRF 39: Digestive and Excretory Systems*, pp. 43–47).

Additional Resources

1. **Curriculum Resources**

   Educational Resources, pp. GPT-7, RR-17 through RR-23

   Holt *Biology CRF 2: Chemistry of Life*, pp. 49–52, 57–62

   Holt *Biology CRF 39: Digestive and Excretory Systems*, pp. 43–47

   Step Up to Writing, pp. 3-21 through 3-29, 3-43 through 3-45, 5-4 through 5-5, 9-12

2. **Internet Resources**

   Energy, Enzymes, and Catalysis Problem Set
   www.biology.arizona.edu/biochemistry/problem_sets/energy_enzymes_catalysis/energy_enzymes_catalysis.html

   Enzyme Activity
   www.lewport.wnyric.org/jwanamaker/animations/Enzyme%20activity.html

   Enzyme Biochemistry Chapter
   http://web.mit.edu/esgbio/www/eb/ebdir.html

3. **Multicultural Resources and/or Activities**

   Have students research patterns of lactose intolerance in ethnic populations.

Suggested Assessments

1. Have students give three real-world examples of energy transformations.
2. Give students an energy diagram and have them explain why they classify it as an endothermic or exothermic reaction.
3. Have students construct the lock-and-key model of enzyme activity out of art supply materials.
4. Have students explain why trypsin and pepsin are most functional at basic and acidic environments, respectively. Have them predict what would happen if they were placed in a different pH and explain their reasoning.

Sample Constructed-Response Item

What is an enzyme's function?

An enzyme increases the rate of the reaction. The enzyme itself is unchanged in the reaction.

UNIT 4 SECTION 3

Model Lesson (Traditional Roster):

Enzymes and Chemical Reactions: Pretend To Be an Enzyme Activity

Lesson Question

What is an enzyme's function?

Materials

For each group: a watch, 50 nickels, 50 pennies, tape, copies of the data tables and questions that follow the Model Lesson

Content and Performance Expectations

CE 2, 4, 5; PE 2, 3, 8

Teacher's Notes

None

Warm-Up

The Term *Enzyme*

- Have students brainstorm answers to the following question, "Why does *enzyme* come from the Greek word *enzumos*, which means "leavened" or "fermented"?

Instruction

Enzyme Activity

▶ Procedure Without an Enzyme

▷ Divide class into groups with at least three students per group.

▷ Explain to students that a penny and a nickel unattached represent the two reactants in the chemical reaction. Once the penny is placed face-up on top of a nickel that is also face-up, the coin pair represents the product of the reaction.

▷ Distribute copies of the data tables and the questions that follow the Model Lesson.

▷ Have students place the reactants on the floor. Have one member of the group pick up a penny and a nickel and place them joined and both face-up on the table. The student must have his five fingers taped together with tape.

▷ Have another member of the group record how many products are formed within 10 seconds on the enclosed data table.

▷ Have students repeat the procedure 10 times.

▷ Have students calculate the average rate for the 10 trials.

▶ Procedure With an Enzyme

▷ Have students complete the above procedure with fingers freed (untaped).

▶ Student-Designed Procedure

▷ Have students propose two other ways they could model enzyme activity. They must use the third student in one of their proposals (e.g., have two students with hands taped pick up and join coins while the third student times and records data; have the third student place the unjoined coins on the table prior to the activity so that the step of carrying the coins is eliminated).

▷ Perform the two student-devised procedures 10 times each. Record results on the data table.

▷ Calculate the average rates.

Review

▶ Discussion

▷ Have students complete the Pretend To Be an Enzyme Activity Questions that follow the Model Lesson and discuss the answers as a class.

Assessment

- Have student devise another activity that can be used by others to model an enzyme's functions.

Homework Assignment

- Have students create a bar graph using the data from the activity. They should include a title, labels for the axes, and key.

Teaching Resources

- Holt, pp. 38–41

activity sheet

name ____________________ date __________

Data Tables

Without Enzyme

TRIALS	NUMBER OF COIN PAIRS ("PRODUCTS")	TIME (SECONDS)	RATE (# OF PRODUCTS/SECOND)
1		10	
2		10	
3		10	
4		10	
5		10	
6		10	
7		10	
8		10	
9		10	
10		10	
Average Rate			

activity sheet

name ______________________ date ____________

With Enzyme

TRIALS	NUMBER OF COIN PAIRS ("PRODUCTS")	TIME (SECONDS)	RATE (# OF PRODUCTS/SECOND)
1		10	
2		10	
3		10	
4		10	
5		10	
6		10	
7		10	
8		10	
9		10	
10		10	
Average Rate			

name ______________________ date ____________

Student-Designed, With Enzyme

TRIALS	NUMBER OF COIN PAIRS ("PRODUCTS")	TIME (SECONDS)	RATE (# OF PRODUCTS/SECOND)
1		10	
2		10	
3		10	
4		10	
5		10	
6		10	
7		10	
8		10	
9		10	
10		10	
Average Rate			

activity sheet

name ______________________ date __________

Student-Designed, With Enzyme

TRIALS	NUMBER OF COIN PAIRS ("PRODUCTS")	TIME (SECONDS)	RATE (# OF PRODUCTS/SECOND)
1		10	
2		10	
3		10	
4		10	
5		10	
6		10	
7		10	
8		10	
9		10	
10		10	
Average Rate			

activity sheet

name ____________________ date __________

Pretend To Be an Enzyme Activity Questions

1. Why did you have to perform the procedure 10 times and average the results?

2. How does this activity demonstrate enzyme function?

3. Why did you choose those two methods to represent enzyme actions?

4. How did the rates compare for the reaction without an “enzyme” and the three reactions with an “enzyme”?

UNIT 4 SECTION 3

Unit 5 Science Project and Presentation

- How are science and scientific inquiry important to our lives?
- How can an experiment be improved?
- How does viewpoint influence science?

Scope and Sequence, page 20
Lesson Planning Material, pages 203–234

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

Unit 5 Section 1

SCIENCE PROJECT

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	Formulating a Testable Question and Hypothesis	Holt, pp. 14–16
2–3		Designing and Conducting a Valid Experiment	Holt, pp. 16–18
4	2	Gathering and Analyzing Data	Holt, pp. 18–20, 1030–1035

BENCHMARK 2 REVIEW, REMEDIATION, AND ENRICHMENT—2 DAYS

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 7

The testing of a hypothesis requires a structured and rigorous investigative process. (Framework I.B.3)

CONTENT EXPECTATIONS

☐ 1. Scientific inquiry includes the ability to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)

☐ 2. There is no fixed procedure called "the scientific method," but some investigations involve systematic observations, carefully collected and relevant evidence, logical reasoning, and some imagination in developing hypotheses and other explanations. (GLE 7.1.A.f)

☐ 3. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 4. Observation is biased by the experiences and knowledge of the observer (e.g., strong beliefs about what should happen in particular circumstances can prevent the detection of other results). (GLE 7.1.B.f)

☐ 5. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 7

Design and conduct a full scientific investigation including a comprehensive review of related literature: experimental design that is thoughtful and well-controlled, with adequate repeated trials; accurate measurement of data; some form of statistical treatment and display of data; thoughtful interpretation of data; and communication and defense of logical arguments supported by the finding. (Framework I.B.3.a)

PERFORMANCE EXPECTATIONS

- ☐ 1. Formulate testable questions and hypotheses. (GLE 7.1.A.a)
- ☐ 2. Analyzing an experiment, identify the components (i.e., independent variable, dependent variables, control of constants, multiple trials) and explain their importance to the design of a valid experiment. (GLE 7.1.A.b)
- ☐ 3. Design and conduct a valid experiment. (GLE 7.1.A.c)
- ☐ 4. Determine the appropriate tools and techniques to collect, analyze, and interpret data. (GLE 7.1.B.c)
- ☐ 5. Judge whether measurements and computation of quantities are reasonable. (GLE 7.1.B.d)
- ☐ 6. Analyze experimental data to determine patterns, relationships, perspectives, and credibility of explanations (e.g., predict/extrapolate data, explain the relationship between the independent and dependent variable). (GLE 7.1.C.b)
- ☐ 7. Identify the possible effects of errors in observations, measurements, and calculations on the validity and reliability of data and resultant explanations (conclusions). (GLE 7.1.C.c)
- ☐ 8. Use quantitative and qualitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)
- ☐ 9. Evaluate the design of an experiment and make suggestions for reasonable improvements. (GLE 7.1.A.g)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Formulating a Testable Question and Hypothesis Day 1	CE 1, 2 PE 1	Assign one challenge question to the entire class, such as "How does temperature, light, oxygen, or moisture affect the growth of bacteria or mold?"; "How does caffeine affect a person's concentration or athletic ability?"; "How do the pigments vary among photosynthetic plants?"; or "What factors affect the rate of transpiration in plants?" Other ideas for generating projects are available in Science Fair Projects (*ER*, p. PTT-55), or students may extend experiments from other units in the course. Designate students to research the topic using the textbook, the Internet, classroom resources, and the school library, while taking Two-Column Notes (*SUTW*, pp. 9-1 through 9-15). Have students share the results of their research and design a testable question as a class. As a class, discuss and describe situations where the scientific method may not apply. Hand out copies of the first page of the Designing an Experiment worksheets (*ER*, p. RR-17) and have students fill out the background knowledge, observation, and testable question sections independently. Have students choose groups, then develop a hypothesis. Use the information in Laboratory Work (*ER*, pp. PTT-16 through PTT-17) to guide student writing. (Goals 1.3, 2.3, 3.3)
	CE 1, 2 PE 1	Have students brainstorm questions that they would like to answer through experimentation, and write the questions on the board. Have students select a question and then research their question while taking Two-Column Notes (*SUTW,* pp. 9-1 through 9-15). Use the guidelines in Laboratory Work (*ER,* pp. PTT-16 through PTT-17) to guide students through filling out the background knowledge, observation, testable question, and hypothesis portions of the Designing an Experiment worksheets. (*ER,* p. RR-17). *See Model Lesson*. (Goals 1.3, 2.3, 3.3)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Introduce each step of Designing an Experiment using the guidelines in the appropriate section of Laboratory Work. Pause after each step to have several students share their responses and give suggestions for improvements and extensions.	Before the lesson, have students guess the meanings of the terms *prior, comparative, belief, identity, substance, publish, gather, separate, fuzzy, noisy, trend, improved,* and *related*. As students read Designing an Experiment, have them check or correct their guesses. (ELL-1)	Have students design a two-part lab that tests the main question the class is answering and a related question of their own interest.
Reinforce the Rule of Five for taking Two-Column Notes. Do not allow students to copy entire sentences or phrases, unless they are using a quote for historical or emotional impact. This forces students to understand and process the texts they read.	Review research strategies such as selecting words for a search engine, using the Dewey decimal system for finding related works, and using indices and glossaries to find information within books. (ELL-4)	Encourage students to work in current areas of biology research such as environmental science, microbiology, molecular genetics, immunology, or cell biology. Alternately, have students research the major unsolved problems in biology. A list is available at http://en.wikipedia.org/wiki/Unsolved_problems_in_biology.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Designing and Conducting a Valid Experiment Days 2–3	CE 1, 2, 3, 4, 5 PE 2, 3, 4	**Day 2:** If the entire class is working on the same project, discuss the importance of reproducibility, large sample size, and using consistent systems for measuring results. Work with the class to designate systems of measurement, then allow students to design procedures by writing or drawing each step on a note card and underlining the materials used in each step. Reinforce the importance of large sample size, a control group, and a the use of single independent variable with all other variables controlled. Make sure that students take into account any safety issues. Check students' note cards and have them copy their materials and procedure onto the Designing an Experiment worksheets (*ER,* pp. RR-19 through RR-21). Have students set up data tables and fill in as much information as possible. For homework, assign students to bring in necessary materials and do further research. (Goals 1.3, 2.3, 3.3)
	CE 1, 2, 3, 4, 5 PE 2, 3, 4	**Day 2:** Review the steps of the scientific method by examining the research of Gregor Mendel. Have students design their experiments by writing or drawing each step on a note card, then arranging them in order. Make sure that students take into account any safety issues. Have them copy their materials and procedure onto the appropriate pages of the Designing an Experiment worksheets (*ER*, p. RR-19 through RR-21). Have students set up data tables and fill in as much information as possible. For homework, assign student to bring in necessary materials and do further research. *See Model Lesson*. (Goals 1.3, 2.3, 3.3)
	CE 1, 2, 3, 4, 5 PE 3, 4	**Day 3/Hands-On Activity/Lab:** Have students assemble the materials they need for their experiments. Give students copies of the Laboratory Safety handout (*ER*, pp. RR-55 through RR-57) and have them highlight or underline all safety rules that apply to their experiments. Have students complete their experiments. Walk around the classroom to assess student behavior and technique. (Goal 1.3)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Give students the acronym DISC to remember the features of a good experiment. The *D* stands for difference in the results, which must be significant. The *I* stands for independent variable and there should be only one. The *S* stands for sample size, which must be sufficiently large. The *C* stands for control group.	After students draw the steps of their procedure, help them label the materials shown in their drawings. Work with students to make grammatical revisions on their cards before transferring their steps to the worksheet. (ELL-1)	Allow students to design their experiments independently and coach them as necessary. After designing their experiments, students should have time to begin experimentation or conduct further research.
Explain that scientists will sometimes overlook new ideas because they have other ideas already fixed in their explanations. Give students examples of bias in science, such as disbelief in a heliocentric solar system or the germ theory of disease. Students can read more about intentional and accidental bias at http://eo.nso.edu/MrSunspot/answerbook/bad-science.html.	Have students read the Mendel passage and underline words they are not familiar with. Have a volunteer state a word he is unfamiliar with, followed by a guess about the meanings from context. Confirm, deny, or expand upon the meaning, using diagrams as necessary. Encourage students to make notes in the margins. (ELL-8)	Have students design parallel experiments with different independent variables. For example, one experiment might vary the temperature of a plant while another varies the amount of light. After conducting the experiment, have students compare their results.
Review students' data tables before they begin experimenting. Have students write down a sentence explaining how they will get the information for each column in the data table. Remind students to record data as soon as it is measured.	Select safety rules that apply to students' experiments and have students act them out prior to conducting their experiments. (ELL-4)	If students are performing multiple or joint experiments, help them to structure time or obtain materials to continue experimentation outside of the normal class period.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Gathering and Analyzing Data Day 4	CE 1, 2, 3, 4, 5 PE 5, 6, 7, 8, 9	If their data is numerical, have students calculate the range, average/mean, percent, and/or ratios for sets of data. Discuss the uses of bar graphs (i.e., comparing amounts in different categories), line graphs (i.e., continuous change over a range), and pie charts (i.e., fractions of a whole) and have students decide which best meet their needs. Review the parts of a graph and the placement of the independent variable on the *x*-axis. Have students graph their data, then complete the Analyzing Data section of the Designing an Experiment worksheets (*ER,* p. RR-21). Then have students complete the Conclusion and Extension sections of the worksheets (*ER,* p. RR-23). If the entire class addressed the same challenge, compare data and results. Discuss the presence of bias. If any students had results that did not support their hypotheses, have them describe how they responded when they started obtaining results. (Goals 1.6, 1.8)
	CE 1, 2, 3, 4, 5 PE 5, 6, 7, 8, 9	**Technology:** If their data is numerical, have students calculate the range, average/mean, percent, and/or ratios for sets of data. Discuss the uses of bar graphs (i.e., comparing amounts in different categories), line graphs (i.e., continuous change over a range), and pie charts (i.e., fractions of a whole) and have students decide which best meet their needs. If students have not used a spreadsheet program such as Microsoft Excel before, hand out copies of the Graphing Data in Microsoft Excel instructions (*ER*, pp. PTT-21 through PTT-22). Have students graph their data. Check students' graphs, then allow them to print their graphs if they will be making presentations using hard copies. Note: To reduce ink usage, click on the gray background of a graph, and under the "Area" heading choose "None." This makes the background white. Have students complete the Analyzing Data section of the Designing an Experiment worksheets (*ER*, p. RR-21). Then have students complete the Conclusion and Extension sections of the worksheets (*ER*, p. RR-23). If time permits or students have the resources at home, encourage students to follow through with their improvements or related testable questions. Discuss the presence of bias. If any students had results that did not support their hypotheses, have them describe how they responded when they started obtaining results. (Goals 1.6, 1.8)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Review accuracy and precision using the Accuracy and Precision Exercise (*ER*, pp. RR-3 through RR-5).	Have students write drafts of their conclusions and extensions and have them revise them using Encouraging Revision (*SUTW*, pp. 7-10 through 7-13) before they copy them onto the Designing a Laboratory worksheets. (ELL-7)	If time allows or students have the resources at home, encourage students to follow through with their improvements or related testable questions.
Give students examples of statistics that might be graphed and have them determine which type of graph is appropriate.	Model the steps of making a graph while students follow along on the Graphing Data in Microsoft Excel handout. (ELL-4)	If students all conducted the same experiment, have students combine the class data into one graph and analyze the accuracy and precision of each group.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, pp. PTT-16 through PTT-17, PTT-21 through PTT-23, PTT-55, RR-3 through RR-5, RR-17 through RR-23, RR-55 through RR-57

   Step Up to Writing, pp. 7-10 through 7-13, 9-1 through 9-15

2. **Internet Resources**

   Links to Science Projects and Ideas
   www.multcolib.org/homework/physcihc.html

3. **Multicultural Resources and/or Activities**

   Have students research famous modern and ancient scientists from different cultures. Some starting points include: http://inventors.about.com/od/famousinventors/, www.factmonster.com/spot/asianbios7.html, https://webfiles.uci.edu/mcbrown/display/faces.html, www.almaz.com/nobel/women.html, www.vidyapatha.com/scientists/index.php, www.factmonster.com/spot/whmbios2.html, and http://64.171.10.183/biography/.

Suggested Assessments

1. Give students a hypothesis, list a set of materials, and have students design an experiment to address the question. Students should include the results they expect from each step.
2. Describe the procedure and results of a poor experiment that lacks a sufficient sample size, significant difference, or control group, or that has more than one independent variable. Have students detect flaws and suggest improvements.
3. Give students the scenario of an experiment and a sample data table. Have students analyze the data to look for accuracy, precision, fuzzy data, and a significant difference between the control and variable groups. Have students write the conclusions of the experiment.
4. Give students an observation and have them write several testable questions. Have students translate testable questions into hypotheses.

Sample Constructed-Response Item

Recently, many articles in the local newspaper have discussed the causes of acid rain and its effects on organisms and their environment. Other articles have discussed the increased growth of algae on the top of lakes and ponds. A student decides to design an experiment to find out if the two problems are related.

1. List one way the student can begin to investigate this problem.

Conduct library and/or Internet research about the levels of acid rain present locally over the last decade and local algae growth patterns over the last decade.

2. The student develops the testable question, "Does acid rain increase algae growth?" Write a hypothesis based upon this testable question.

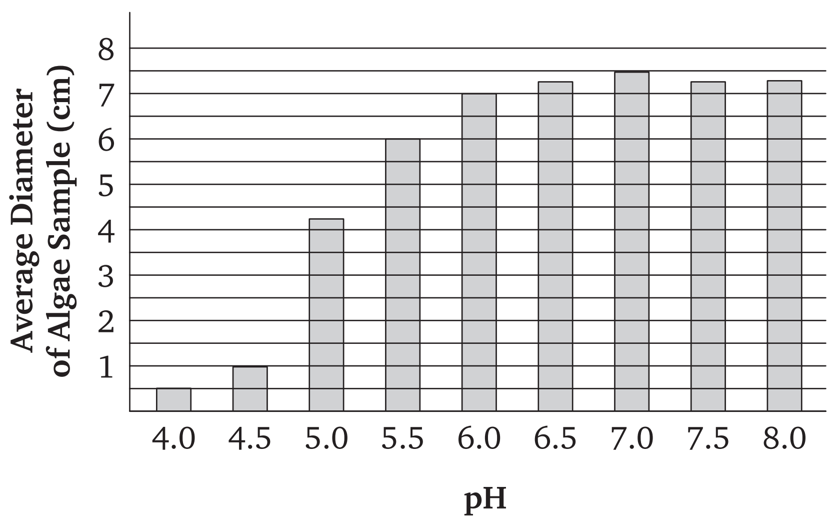
Acid rain will increase the rate of algae growth.

UNIT 5 SECTION 1

3. Algae samples of the same size are exposed to different pH levels for three weeks (10 samples for each pH), and all other variables are controlled. Precipitation of a pH below 5.5 is considered to be acid rain. At the end of the three weeks, the average diameter of the algae samples at each pH is taken. Graph the following data. Label both axes.

pH	AVERAGE DIAMETER OF ALGAE SAMPLE (cm)
4.0	0.5
4.5	1.0
5.0	4.2
5.5	6.0
6.0	7.0
6.5	7.2
7.0	7.5
7.5	7.2
8.0 (normal rain)	7.3

ALGAE GROWTH AT VARIOUS pH LEVELS



4. Identify one conclusion from the data and graph.

At pH levels below 5.5, algae growth is reduced.

5. Write one question that could be used to develop a related experiment.

How do pH levels above 8.0 affect algae growth?

Model Lesson (Block Roster):

Formulating a Testable Question and Hypothesis & Designing and Conducting a Valid Experiment

Lesson Questions

How do scientists make verifiable discoveries?

What is a valid experiment?

Materials

Copies of the Designing an Experiment worksheets (*ER*, pp. RR-17 through RR-23), copies of the Mendel's Discoveries passage, which follows the Model Lesson

Content and Performance Expectations

CE 1, 2, 3, 4, 5; PE 1, 2, 3, 4

Teacher's Notes

None

Warm-Up

Ideas for Experiments

- Explain to students that they will be conducting experiments in topics of their interest over the next week.
- Have students brainstorm questions that they would like to answer through experimentation, and write the questions on the board.
- Encourage students to flip through the pictures in their textbooks, review the extension questions in labs they have completed, peruse the Want to Know columns of any K-W-Ls they have completed, and bring in questions from outside reading, discussions, and media.

Instruction

Formulating a Question and Hypothesis

▶ Writing a Testable Question	▷ Outline the schedule for this section and explain guidelines for experimental design. ▷ Have students decide if they would like to work alone or in groups of two or three, then sit with their groups. ▷ Have each group or individual choose a question to answer and write it down. ▷ Discuss the purpose and limitations of testable questions and have students determine whether their question is testable. Use the information in Laboratory Work (*ER,* p. PTT-17). ▷ If students questions are not testable, have them revise them as a group. Note: Students may choose to revise their questions again after conducting background research.
▶ Conducting Background Research	▷ If possible, bring the class to the library. Make classroom resource books available to students. ▷ Assign each student to book or Internet research. If students are working in groups, assign each student to a different research location. ▷ Have students look for background information on their questions and take Two-Column Notes (*SUTW,* pp. 9-1 through 9-15). ▷ Have students working in groups discuss their research and extend their Two-Column Notes. Have students working individually conduct research in a different location. ▷ Hand out copies of the Designing an Experiment worksheets (*ER,* pp. RR-17 through RR-23) and have students fill out the background knowledge, observation, and testable question portions of the sheet. ▷ Use the information in Laboratory Work (*ER,* p. PTT-17) to review writing hypotheses. ▷ Have students write hypotheses for their experiments.

Designing an Experiment

▶ Modeling the Scientific Method	▷ Have students read the Mendel's Discoveries passage. ▷ Write on the board the steps of the scientific method (e.g., observation, question, procedure, etc.) and each of the requirements for an experiment (i.e., control group, sufficient sample size, only one independent variable and all other variables controlled). ▷ Have students identify each step or requirement in Gregor Mendel's discovery and explain why it is important. ▷ As a class, discuss and describe situations where the scientific method may not apply. ▷ Have students determine whether their area of interest can be addressed with controlled experiments, and if not, what the requirements are for a valid experiment.
▶ Writing a Procedure	▷ Give each group or individual about 15 note cards. ▷ Have students design their experiments by writing or drawing each step on a note card, then arranging them in order. Remind students to include safety requirements. ▷ Have students underline the materials they will need for each step on their cards, then make a new card for the first step which involves gathering all the materials. ▷ When students are finished, check their note cards and have them copy their materials and procedure onto the Designing an Experiment worksheets (*ER,* pp. RR-19 through RR-21).
▶ Preparing a Data Table	▷ Have students make a list of the data they will collect and the units (if any) they will use to measure it. ▷ Remind students that data tables must list the independent variable in the left column, and that all measurements should be repeated three times. ▷ Have students set up data tables on a separate sheet and fill in as much information as possible. ▷ Check students' data tables and make suggestions for improvement as necessary.

Assessment

- Have students write two testable questions and two nontestable questions.

Homework Assignment

- Have students bring in materials necessary for conducting their experiment.

Teaching Resources

- Holt, pp. 14–20
- *Educational Resources,* pp. PTT-17, RR-17 through RR-23
- *Step Up to Writing*, pp. 9-1 through 9-15

Mendel's Discoveries

Before Gregor Mendel's research was published in 1865, most biologists believed in the theory of blending inheritance in which parents contributed an "essence" to their offspring. The offspring would possess traits intermediate to those of both parents. For example, red and white flowers would produce only pink flower offspring. Although this theory explained how offspring could resemble both parents, it could not be used to explain how diversity was maintained. For example, how could pink flowers produce red or white offspring? All members of a population would eventually resemble one another if all traits were averaged out.

Mendel conducted his famous pea genetic experiments from 1857–1865 while he was an Austrian monk. Mendel had very clear ideas of what was needed for his studies. He chose the garden pea, *Pisum sativum*, because they had a short generation time and could be cross-pollinated. He was able to develop accurate conclusions because he was very particular in his experiments. He used only pure-breeding parent plants, considered only one trait at a time in his experiments, conducted a large number of crosses, always kept his generations separate, maintained precise records for each generation of pea plants, and used statistical and mathematical principles to arrive at his results.

Mendel developed a theory of particulate inheritance. This theory states that an organism's traits are determined by distinct units of inheritance that are passed down from one generation to the next. These units were later discovered by other scientists to be genes.

Unit 5 Section 2

PRESENTATIONS

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–3	1–2	Student Presentations	

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 1. The nature of science relies upon communication of results and justification of explanations. (GLE 7.1.E)

☐ 2. Publication and presentation of scientific work with supporting evidence are required for critique, review, and validation by the scientific community. The presentation of such work adds to the body of scientific knowledge and serves as background for subsequent investigations in similar areas. (Framework I.A.2)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 7

Present arguments based on scientific investigations that include detailed procedures, graphs, and tables and conclusions; participate in follow-up discussion by responding to alternative positions. (Framework I.A.2.a)

PERFORMANCE EXPECTATIONS

- ☐ 1. Communicate the procedures and results of investigations and explanations through oral presentations, drawings and maps, data tables (allowing for the recording and analysis of data relevant to the experiment such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities), graphs (bar, single, and multiple line), and equations and writings (GLE 7.1.E.a)
- ☐ 2. Communicate and defend a scientific argument. (GLE 7.1.E.b)
- ☐ 3. Explain the importance of the public presentation of scientific work and supporting evidence to the scientific community (e.g., work and evidence must be critiqued, reviewed, and validated by peers; needed for subsequent investigations by peers; results can influence the decisions regarding future scientific work). (GLE 7.1.E.c)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Student Presentations Days 1–3	CE 1, 2 PE 1, 2, 3	**Day 1/Technology:** Have students prepare three-minute presentations using Accordion Speeches (*SUTW*, pp. 5-1 through 5-14). Introduce Microsoft PowerPoint or similar presentation software and model how to create a presentation. Have students design their presentations on note cards and then create them in Microsoft PowerPoint or with similar presentation software. Students should include pictures of their laboratory setups if digital cameras are available. Data should be presented in graphs from Microsoft Excel or a similar software program. *See Model Lesson*. (Goals 1.8, 2.1, 2.7, 4.5)
	CE 1, 2 PE 1, 2, 3	**Day 1:** Have students make a poster board presentation according to the instructions in Posterboard Displays (*ER*, p. PTT-55). When student are finished, have them prepare three-minute presentations with Accordion Speeches (*SUTW*, pp. 5-1 through 5-14). (Goals 1.8, 2.1, 4.5)
	CE 1, 2 PE 1, 2, 3	**Day 1/Technology:** Have students create Web sites to display their methods, data, and conclusions. Students should include pictures of their laboratory setups if digital cameras are available. Data should be presented in graphs made in Microsoft Excel or a similar software program. Have students submit their HTML files and post them on a class Web page. Free Internet space is available at http://geocities.yahoo.com. Netscape Composer is a free Web development program that may already be installed on school computers, and other free Web development software is available from www.download.com. (Goals 1.8, 2.1, 2.7, 4.5)
	CE 1, 2 PE 1, 2, 3	**Day 1/Technology:** Show students several professional research journals and have students examine their components (e.g., abstract). Discuss the importance of using a consistent format for publication so that information is easy to find. Point out that information is relayed in the third person. Have students write journal articles outlining their experiments and results, and type them in a word processing program. Have students perform self and peer revisions using Encouraging Revision (*SUTW*, pp. 7-10 through 7-13), then submit the files for teacher approval. Have students include pictures of their laboratory setups if digital cameras are available, and present data in graphs made in Microsoft Excel or a similar software program. Have students submit their files and combine them into a journal to keep in the school library. (Goals 1.8, 2.1, 2.7, 4.5)
	CE 1, 2 PE 1, 2, 3	**Days 2–3:** Have students present their experiments to the class. During each presentation, have students write three things they learned and three things they still wonder about. (Goals 1.5, 1.10, 2.3)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Create a Microsoft PowerPoint template for students to use and have them fill in their own data.	Have students practice their presentations with a partner. Partners should ask each other clarifying questions so that presentations can be improved. (ELL-8)	Have students work with design templates and animation schemes in Microsoft PowerPoint. These can be found in the Format menu. Remind students that these features should not distract from their presentations.
Model each step of creating a poster board presentation, then have students complete that portion. Students who designed experiments independently may pair up to review each others' work.	Have students revise their writing using Encouraging Revisions (*SUTW*, pp. 7-10 through 7-13) before placing it on the poster board. (ELL-6)	Have students enhance their presentations with an applications section for real-world applications and related scientific disciplines.
Model HTML tags by placing several smaller bowls inside larger bowls. Explain that each bowl is an HTML tag, and everything inside of it has the characteristics of that tag.	Explain to students the origin of HTML tags using www.web-source.net/html_codes_chart.htm. Draw or explain terms such as *anchor* and *hyperlink*. (ELL-1)	Have students upload the pictures and files to the Web server and organize a home page linking each of the individual pages.
Have students create a map showing which parts of the Designing an Experiment worksheets (*ER*, pp. RR-17 through RR-23) they can use for writing their articles. For example, the introduction of the article will come from the background knowledge and observations sections of the worksheet.	Work with students to translate first person to third person. Give students sentence starters such as "The data showed that..." or "The object was placed..." (ELL-8)	Have students choose two media (e.g., speech, poster board, Internet, Microsoft PowerPoint, or journal article) for presenting their research.
Before each student comes up to present, announce the title of the presentation and have students think for 30 seconds about what it might contain.	Have students make a third column on their notes for writing new words to look up after class. (ELL-8)	Have students develop their presentations into lessons and have them teach mini-lessons to groups of students in other grades.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, pp. PTT-55, RR-17 through RR-23

   Step Up to Writing, pp. 5-1 through 5-14, 7-10 through 7-13

2. **Internet Resources**

   Microsoft PowerPoint Tutorials
   www.actden.com/pp/
   http://einstein.cs.uri.edu/tutorials/csc101/powerpoint/ppt.html

   Student Guide to Presentations
   www.mtroyal.ab.ca/studentlife/study_presentations.shtml

3. **Multicultural Resources and/or Activities**

   Find online journals published in different languages. Have students compare them to journals published in English and discuss the similarities. Give students an article written in a language they do not speak, and have them guess what each of the headings means.

Suggested Assessments

1. Assess students on their writing and presentations.
2. Have students explain the connections between their experiments and real-world experiences or other branches of science and engineering.
3. Give students a situation and have them design an experiment around it.
4. Give students data from a hypothetical experiment and have them analyze it and draw conclusions.

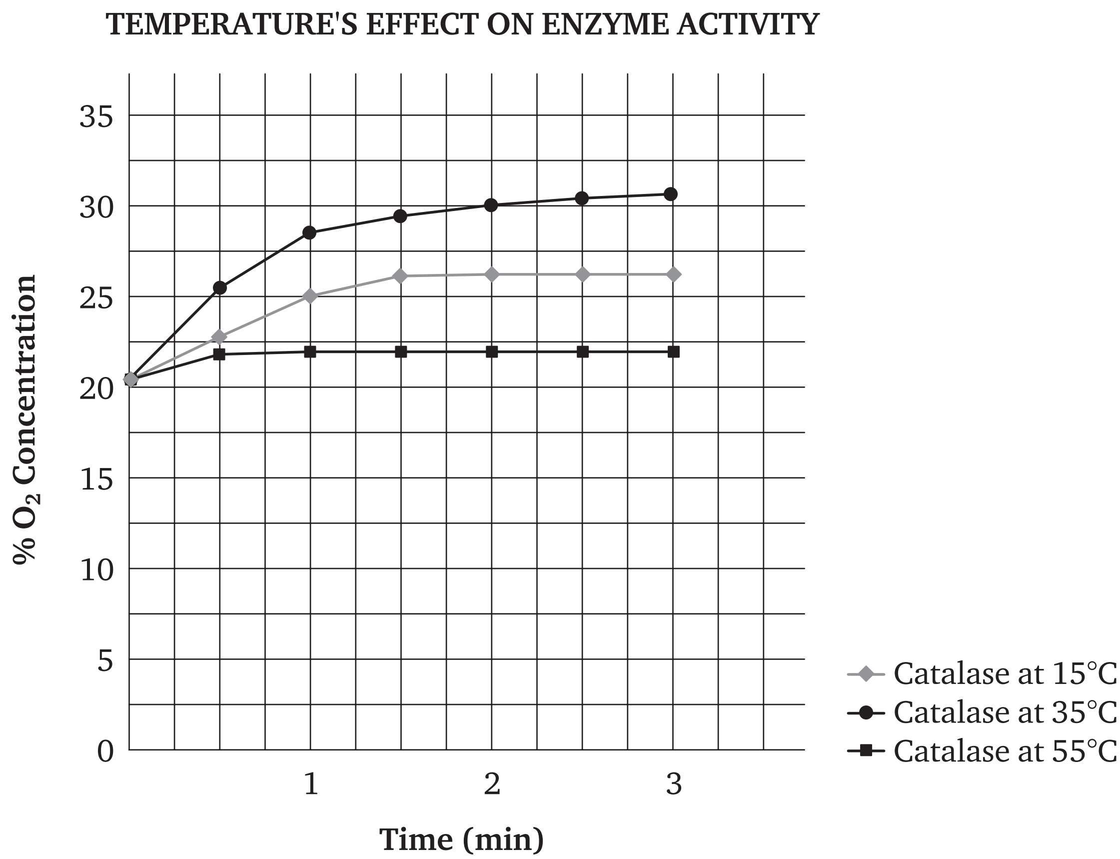
Sample Constructed-Response Item

Hydrogen peroxide (H_2O_2) is highly toxic to living cells. Although H_2O_2 can be converted to oxygen and water spontaneously (O_2 and H_2O), the enzyme catalase increases the reaction rate considerably. In cells, catalase helps to convert the H_2O_2 to O_2 and H_2O before it can do much damage.

A student wanted to investigate how temperature affects catalase activity. She measured how much O_2 gas was formed as the reaction progressed, in order to determine how fast H_2O_2 was being converted. She measured the gas with a gas sensor under three different temperature conditions, as seen in the data table below. Note that at the start of the reaction there is no product, and the O_2 concentration is the same as the atmosphere (21%).

MINUTES	0.0	0.5	1.0	1.5	2.0	2.5	3.0
% O_2 CONCENTRATION LIVER CATALASE AT 15°C	21	23	25	26	27	27	27
% O_2 CONCENTRATION LIVER CATALASE AT 35°C	21	26	28	29	30	31	31
% O_2 CONCENTRATION LIVER CATALASE AT 55°C	21	22	22	22	22	22	22

1. **Construct a multi-line graph below using the information in the data table. Be sure to provide labeled axes with number scales, as well as an appropriate title and key.**



2. **What are the independent and dependent variables?**

The independent variable is the temperature. The dependent variable is the O_2 concentration.

3. **Describe one conclusion that can be made based on the data.**

Enzyme activity is affected by temperature.

4. **According to the graph, what is the optimum temperature for catalase activity?**

The optimum temperature is 35°C. This enzyme probably came from an organism whose body temperature is close to 35°C.

UNIT 5 SECTION 2

Model Lesson (Traditional Roster):
Student Presentations, Day 1

Lesson Questions

How do scientists communicate ideas?

What makes a good presentation?

Materials

Access to computers with Microsoft PowerPoint or a similar program, prepared model PowerPoint presentation, copies of the PowerPoint Presentation handout, note cards

Content and Performance Expectations

CE 1, 2; PE 1, 2, 3

Teacher's Notes

Before class, create a model PowerPoint presentation on any topic with a title card, an outline of the presentation, a graph, a picture, a quote, and a summary. Include one additional card with a paragraph of information to model poor presentation design.

Warm-Up

Engaging an Audience

- Explain to students that they will be preparing a speech about their experiment. Remind students that one of the most important aspects of giving a speech is engaging an audience.
- Give students several minutes to brainstorm about the most interesting or exciting pieces of information related to their experiments and have them write them down.

Instruction

Preparing a Presentation

▶ Writing an Accordion Speech	▷ Review the components of Accordion Speeches (*SUTW*, pp. 5-1 through 5-14). ▷ Tell students that their presentations should include their questions, hypotheses, brief descriptions of their procedures, a brief analysis of the data including comments on noisy data, their conclusion, and information designed to engage the audience. ▷ Give students note cards and have them write one idea at the top of each card with supporting information in bullets beneath. Remind students to use the Rule of Five unless they are quoting someone. ▷ Have students arrange their cards and then write new cards with complete sentences for their introduction and conclusion.
▶ Planning a Presentation	▷ Tell students that they will be creating presentations using Microsoft PowerPoint. Explain that the purpose of the presentation software is to outline the presentation and enhance a speech visually with key pictures and graphs. The audience should not read sentences or paragraphs, unless they are key quotes. (Students may also write out their testable question or hypothesis.) ▷ Model giving a PowerPoint presentation and then model reading or paraphrasing from a PowerPoint slide with a full paragraph. ▷ Give students note cards and have them write, sketch, or describe the contents of each slide.
▶ Creating a PowerPoint Presentation	▷ As students finish planning their presentations, give them the PowerPoint Presentation handout and have them begin work at the computers. ▷ Walk around the room to assist students.

Assessment

- Assess students on organization and communication in their presentations.

Homework Assignment

- Have students finish their PowerPoint presentations if necessary.
- Have students practice giving their speeches in preparation for the next lesson.

Teaching Resources

- *Step Up to Writing*, pp. 5-1 through 5-14

Creating a PowerPoint Presentation

1. *Open Microsoft PowerPoint.*

   Option 1: Find the icon for Microsoft PowerPoint on the desktop. Double click.

   Option 2: Go to **Start**⟶**All Programs**⟶**Microsoft PowerPoint** or **Start**⟶ **Program Files**⟶**Microsoft PowerPoint**

2. *Save the file*

   A. Go to **File**⟶**Save**.

   B. Under **Save in...** go to the location instructed by your teacher.

      Location for saving file: ____

   C. Under **File name:** enter your class period followed by your initials and a word describing your experiment. Example: "3KM-planes.ppt"

3. *Creating the Title Card*

   A. Click on the square that says "Click to Add Title."

   B. Write a title for your presentation.

   C. Click on the square that says "Click to Add Subtitle."

   D. Enter your name and class period.

4. *Adding an Outline*

   A. Add a new slide.

      Option 1: Hold down the *Ctrl* key and the *M* key at the same time.

      Option 2: Go to **Insert**⟶**New Slide**.

      Option 3: Click on the icon of a rectangle with a sparkle on the corner.

   B. Format the slide.

      Option 1: The Slide Layout box may appear on the right side automatically.

      Option 2: Go to **Format**⟶**Slide Layout**.

   C. Choose the slide with one column of bullets.

   D. Click in the top box and type the word "Outline."

   E. In the lower box, write an outline to prepare your audience for your presentation. Do not add a bullet for every slide—just outline the big ideas.

5. *Adding Graphs from Microsoft Excel*

   A. Create a new slide in PowerPoint. Choose the layout that has only a title on the top. (Do not choose a content layout slide with a graph in it.)

   B. Add a title for your graph.

   C. Open the Microsoft Excel file containing your graph.

   D. If the graph has its own page, right click on the white area outside the graph, choose **Location** and select **As object in...**

   E. Click on the white area outside the graph. Small black squares should appear at the corners and on each side to show that you have selected the graph.

F. Copy the graph from Excel.

Option 1: Hold down the *Ctrl* key while holding down the *C* key.

Option 2: Go to **Edit**⟶**Copy**.

Option 3: Right click and choose **Copy**.

G. Click on the slide in PowerPoint.

H. Paste the graph into PowerPoint.

Option 1: Hold down the *Ctrl* key while holding down the *V* key.

Option 2: Go to **Edit**⟶**Paste**.

Option 3: Right click and choose **Paste**.

I. Hold the cursor over one corner of the graph until it becomes a two-headed arrow. Click and drag the mouse to resize the graph.

6. *Adding a Picture*

A. Create a new slide in PowerPoint. Choose the layout that has only a title on the top. (Do not choose a content layout slide with a graph in it.)

B. Add a title for your picture.

C. Open a web browser such as Internet Explorer or Netscape.

D. Go to http://images.google.com.

E. Type in a search term to find pictures.

F. Click on a picture.

G. Click on "See full-size image."

H. Right click on the picture and choose **Copy**.

I. Click on the PowerPoint Slide.

J. Paste the picture into PowerPoint.

Option 1: Hold down the *Ctrl* key while holding down the *V* key.

Option 2: Go to **Edit**⟶**Paste**.

Option 3: Right click and choose **Paste**.

K. Hold the cursor over one corner of the picture until it becomes a two-headed arrow. Click and drag the mouse to resize the picture.

7. *Viewing your Slide Show*

A. To organize and edit slides, find the three buttons in the bottom left corner.

Option 1: The button with a large rectangle shows one slide at a time.

Option 2: The button with four rectangles shows all of the slides at once. To change the order of the slides, click on one and drag it to a new location.

B. To present the slide show, click on the button with a movie projector.

C. Move to the next slide by clicking the mouse or using the down or right arrow keys.

Unit 6 Cells and Cellular Processes

- If all living organisms are made of cells, why aren't they all alike?
- How do cells maintain a balance between themselves and their environment?
- How can a single cell carry out all the activities of life?

Scope and Sequence, page 20
Lesson Planning Material, pages 235–278

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

Unit 6 Section 1

INTRODUCTION TO CELLS

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Using the Microscope	Holt, pp. 50–54, 1028–1029, 1032–1033
3–4	2	The Discovery of Cells	Holt, pp. 55–56
5–6	3	Prokaryotic vs. Eukaryotic Cells	Holt, pp. 57–58

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

There is a fundamental unity underlying the diversity of all living organisms. Cells are the fundamental structural and functional units of all living organisms and take highly varied forms in different plants, animals, and microorganisms. (GLE 3.1, Framework VII.A.1)

CONTENT EXPECTATIONS

☐ 1. Cells are the fundamental units of structure and function of all living things. (GLE 3.1.C)

☐ 2. Cumulative historical contributions have led to the development of the three principles comprising the cell theory: all living things are made of cells, cells are the basic units of life, and cells come from existing cells. (GLE 3.1.C *PR*)

☐ 3. Cells have distinct and separate structures that perform and monitor processes essential for the survival of the cell and/or organism. (Framework VII.A.2)

☐ 4. Cells can be classified as prokaryotes, which lack membrane-bound organelles, or eukaryotes, which have membrane-bound organelles. (GLE 3.1.E *PR*)

…for Standard 7

Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. Evidence is used to formulate explanations (GLE 7.1.B, 7.1.C)

CONTENT EXPECTATIONS

☐ 5. Microscopic observations are essential to the study of cellular organelles. (GLE 7.1.B.a *PR*)

…for Standard 8

Advances in technology often result in improved data collection and an increase in scientific information. (GLE 8.1.B)

CONTENT EXPECTATIONS

☐ 6. The improvement in the magnification and resolving power of microscopes makes the modern study of cells possible. (GLE 8.1.B *PR*)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO...

...for Standard 3

Use appropriate technology and other resources to compare and contrast ways in which special cells carry out reproduction, photosynthesis, respiration, mitosis, meiosis, etc. (Framework VII.A.1.a)

PERFORMANCE EXPECTATIONS

☐ 1. Explain the differences between eukaryotic and prokaryotic cells. (GLE 3.1.E.a *PR*)

...for Standard 7

Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., microscopes). (GLE 7.1.B.a)

PERFORMANCE EXPECTATIONS

☐ 2. Identify the parts of the compound microscope and list the function of each part. (GLE 7.1.B.a *PR*)

☐ 3. Use the microscope for experimental study, including making wet mounts. (GLE 7.1.B.c *PR*)

☐ 4. Determine approximate sizes of microscopic objects. (GLE 7.1.B.d *PR*)

☐ 5. Make accurate drawings of specimens viewed under the microscope. (GLE 7.1.B.a *PR*)

...for Standard 8

Recognize the relationship linking technology and science (e.g., how new technologies make it possible for scientists to extend research and advance science). (GLE 8.1.B.a)

PERFORMANCE EXPECTATIONS

☐ 6. Explain the relationship between improvements in technology and our knowledge about cells. (GLE 8.1.B.a *PR*)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Using the Microscope Days 1–2	CE 5, 6 PE 6	Have students read Holt, pages 52–54. They should write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) about the different types of microscopes that includes information on magnification ability, ability to view living or dead specimens, and types of images produced. (Goal 1.5)
	CE 5, 6 PE 2, 3	Review care and use of the microscope with students. Give students a picture of a microscope and have them label the parts and identify their functions. Have them write out step-by-step directions for viewing a slide and calculate the power of magnification for each lens. Have students pair up and follow each others' directions to assess accuracy. (Goal 2.1)
	CE 5, 6 PE 2, 3	**Hands-on Activity/Lab/Technology:** Make slides with a small letter *e* on them for students to view under the microscope. Have them experiment with moving the slide up and down, and left and right on the stage as they view it through the eyepiece. Have them compare the orientation of the image to the orientation of the *e* slide and the image under high and low power. In pairs, have students develop some hypotheses about how the lenses of the microscope affect what is seen through the eyepiece. (Goals 1.1, 1.2, 3.5)
	CE 5, 6 PE 3, 4	Have students determine the sizes of objects under the microscope. *See Model Lesson*. (Goals 1.2, 1.3)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Show students photomicrographs of cells from light and electron microscopes. Discuss differences in two-dimensional and three-dimensional images. Photomicrographs can be obtained at www.biochem.wisc.edu/inman/empics.	Have students make a chart that shows each type of microscope, the magnification ability, and types of images produced. (ELL-6)	Arrange a visit to a local college or university to view an electron microscope. Discuss the techniques involved in preparing specimens for electron microscopy.
Spend time with each student to review proper use of the microscope. Have them demonstrate their proficiency in locating and focusing on a specimen.	Define prefixes, suffixes, and roots used in this section such as *micro-* and *-scope*. Have students come up with other words containing them. (ELL-3)	Discuss with students how the quality of a microscope and its ability to magnify depends on its resolving power. Have students research why electron microscopes have greater resolving power than light microscopes.
Demonstrate how a lens works by having students experiment with a magnifying glass and a newspaper photo. Discuss the shape of the lens and how it creates a larger image. Have them place the glass over the image at an arms length from the eye and slowly move the glass towards the eye until the image flips upside down.	Make a water lens by covering a page of newsprint with plastic wrap and then putting a drop of water on the plastic. The words on the newsprint will appear large. Explain what happens to light as it passes through the water. (ELL-5)	Have students research how a dissection microscope differs from a compound microscope. They should explain in what situation each type would be used.
Review the SI system of measurement and the prefixes used. Have students complete the Looking at Cells Active Reading Skills Worksheet (Holt *Biology CRF 3: Cell Structure*, pp. 7–8).	Have students practice estimating how much of the field of view a specimen occupies. Give students circles of various sizes drawn on paper and have them work in pairs to estimate how many dimes or quarters could fit across the field of view. (ELL-4)	Have students select one of the types of electron microscopes listed in the lesson and research how it works and how scientists determine the size of objects viewed. Students should prepare a report that includes a picture or diagram of the microscope.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
The Discovery of Cells Days 3–4	CE 3, 5, 6 PE 3, 5, 6	**Hands-On Activity/Lab/Technology:** Demonstrate how to make wet mounts. Have students practice making wet mounts and observations of cork and onion cells. They should make detailed drawings and describe any cell structures they observe. (Goal 1.5)
	CE 1, 2, 5, 6 PE 6	Set up a timeline on the chalkboard. Start with 1600 and include 1650, 1700, 1750, 1800, 1850, 1900, 1950, and end with 2000. Divide the class into eight small groups and assign each group a time period, such as 1600 to 1650, 1650 to 1700, etc. Have the groups use information from various sources, including the Internet, to describe the invention of various magnifying devices (hand lenses to microscopes) and the discoveries about living things that resulted. After about ten minutes, have a member of each group write on the chalkboard a brief summary for their assigned time period. Have students write about the relationship between technology and the development of cell theory in a Cause and Effect Paragraph (*SUTW*, pp. 3-43 through 3-45). (Goals 1.8, 3.5)
	CE 2, 6 PE 6	**Hands-On Activity/Lab:** Have students hypothesize why cells are so small (microscopic). Set up a demonstration. Soak different size cubes of potato in an iodine solution for equal amounts of time. Have students cut open the cubes and observe the movement of the iodine. Have students determine how cube size and surface area-to-volume ratio affects the length of time required for substances to reach the center of the cell. Have students write a Free Response (*SUTW*, p. 8-8) about what they have observed. Discuss how this relates to the movement of materials into a cell, the limits upon cell size, and why many organisms are made of more than one cell. Have students complete the Calculating Surface Area and Volume Math Lab (Holt, p. 56). (Goals 1.2, 1.3, 3.5)
Prokaryotic vs. Eukaryotic Cells Days 5–6	CE 1, 3, 4 PE 1	Have students create a Venn diagram (*ER*, p. RR-83) to demonstrate the differences between prokaryotic and eukaryotic cells. They should include characteristics such as size range, nucleus present/absent, internal membrane-bound organelles, and representative organisms. (Goal 1.8)
	CE 1, 3, 4, 5, 6 PE 1, 4, 5	**Hands-on Activity/Lab/Technology:** Distribute prepared slides of prokaryotic and eukaryotic cells for students to observe. Have them estimate cell size for each and then compare them in terms of the cell sizes, shape, and structures they observe. Have students work in groups to draw some conclusions about prokaryotic and eukaryotic cells. (Goal 2.3)
	CE 3, 4 PE 1	Show students a diagram of a *Paramecium* and highlight the structures found within the cells. Discuss the function of each structure. Have hypothesize why eukaryotes are considered "advanced" compared to prokaryotes. (Goals 1.5, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Use a microprojector to show prepared slides (e.g., *Amoeba*, *Paramecium*, *Elodea*, cork cells, blood cells, muscle cells). Have students identify similarities and differences.	Show students diagrams and photos of various cells, pointing out any visible cell structures. Have students copy diagrams in their notebooks. (ELL-2)	Have students research the different stains used in the preparation of slides. Have them discuss how the stains are used to identify different structures.
Have students make a table that lists the name of each scientist and his contribution to cell theory.	Have students complete a K-W-L chart (*ER*, p. RR-43) for the topic "Cells and Microscopes" and then read Holt, pages 50–55. (ELL-8)	Have students write an essay about a scientist who made a major contribution to one principle of the cell theory. In the essay, they should identify the contribution and why it is important.
In pairs, have students practice calculating the surface area and volume of different objects, such as blocks, dice, and boxes. Have them write out the relationship between surface area and volume.	Give students sponges of various sizes, a plate, and a bottle of cola. Have students make predictions about which sponge will absorb the cola the fastest. Have them design and conduct an experiment to test their hypotheses. Relate this activity to the surface area of a cell and its ability to absorb nutrients. (ELL-5)	Have students calculate the surface area to volume ratio for a cube with a side length of 4 mm, eight cubes with a side length of 2 mm, and sixty-four cubes with a side length of 1 mm. Have students relate the results as to why the human body is made of billions of tiny cells instead of fewer larger cells.
Have students construct a T-chart to compare and contrast prokaryotic and eukaryotic cells	Define the prefixes and roots used in this section (e.g., *pro-*, *eu-*, *kary*). Give students examples of other words using these terms. (ELL-3)	Have students conduct research about the endosymbiosis theory, which explains the origin of eukaryotes. They should discuss the evidence that scientists have to support this theory.
Explain to students the benefits of compartmentalization in eukaryotes. Relate the concept to other real-world examples, such as a manufacturing plant. Discuss how, due to their small size, prokaryotes can still function effectively without compartmentalization.	Show students pictures of cells and point out differences and similarities. Students should make labeled diagrams of basic eukaryotic and prokaryotic cells. (ELL-2)	Give students yogurt containing live bacteria cultures to make wet mounts of and observe under the microscope.
In pairs, have students list the functions performed by the organs in the human body. Have them identify which functions they think an individual cell must perform in order to survive.	Have students come up with definitions for the terms *advanced* and *primitive*. Have them then provide examples of each. (ELL-3)	Have students study different protist genus such as *Amoeba* and *Euglena* and their cell structure. Have them compare and contrast these with *Paramecium* and develop some hypotheses for differences they may observe.

Additional Resources

1. **Curriculum Resources**

    Holt *Biology CRF 3: Cell Structure,* pp. 7–8

    Educational Resources, pp. RR-43, RR-83

    Step Up to Writing, pp. 3-15 through 3-29, 3-34 through 3-45, 8-8

2. **Internet Resources**

    Electron Micrograph Library
    www.biochem.wisc.edu/inman/empics

    CellsAlive: How Big Interactive
    www.cellsalive.com/howbig.htm

    Studying Cells Tutorial
    www.biology.arizona.edu/cell_bio/tutorials/cells/cells2.html

    Electron Microscopy
    www.unl.edu/CMRAcfem/em.htm

    Endosymbiotic Theory
    www.mrs.umn.edu/~goochv/CellBio/lectures/endo/endo.html

3. **Multicultural Resources and/or Activities**

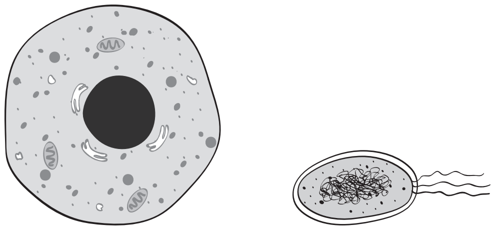
    The scientists responsible for the development of cell theory were mainly European. However, there are many other scientists from other parts of the world who have contributed to the study of cell biology and microscopy. Have students investigate some of these scientists and their contributions to the advancement of cell biology. A list of famous scientists and their achievements can be found at www.med.uiuc.edu/sa/uhp/Famous%20Blacks%20and%20Latino%20Physician%20and%20Scientists.htm.

Suggested Assessments

1. Have students write out a step-by-step procedure in a Process Paragraph (*SUTW*, pp. 3-15 through 3-20) for focusing a microscope on a specimen and calculating the magnification of the lenses in a light microscope.
2. Have students calculate the estimated size of a specimen using the diameter of the field of view and an estimate of how many of the specimen will span the diameter.
3. Have students construct three cells of different sizes and compare their surface area to volume ratios.
4. Set up a lab practical to assess student's proficiency in using the microscope, making wet mounts, and determining approximate sizes of specimens.
5. Call on volunteers to identify each part of the microscope and its function.

Sample Constructed-Response Item

Construct diagrams of a prokaryotic and eukaryotic cell for comparison. Compare and contrast each in writing.



Both types of cells can be seen in unicellular organisms; however, multicellular organisms are made of eukaryotic cells only.

Eukaryotic cells contain a nucleus and prokaryotic cells do not.

Prokaryotic cells are much smaller than eukaryotic cells.

Model Lesson (Traditional Roster):
Using the Microscope: Measuring With a Microscope

Lesson Question

How is the compound microscope used to make measurements of microscopic specimens?

Materials

Microscopes; transparent metric rulers; prepared slides of *Paramecium caudatum*, human blood cells, and various other specimens; lens paper; onion skin; slides; cover slips; Lugol's solution or Iodine; copies of the "Metric Conversions Using the Micrometer" and "Determining Size with a Microscope" worksheets that follow the Model Lesson

Content and Performance Expectations

CE 5, 6; PE 2, 3, 4

Teacher's Notes

Students should work in pairs. Be sure to review the how to convert units of measurement.

Preview with students all safety cautions associated with using a microscope. If a lamp provides light for the microscope, instruct students to be careful when using electrical equipment, and avoid touching the lamp after it has been turned on. If the microscope has a mirror, tell students not to use direct sunlight as a light source. Warn students to be careful when working with scissors and about breakage when working with glassware. Have one member of each team carry a microscope to their working area by placing one hand on the arm, and the other hand under the base.

Warm-Up

Units of Measurement

- Explain that the basic unit of length in the metric system is the meter. Ask students why this is the incorrect unit to use when measuring cells.
- Tell students that the egg of a frog is about 1 mm in diameter. Ask students how many frog eggs stacked on top of each other, would be one meter tall.
- Have students examine the metric ruler and use it to draw the actual size of a frog egg. Have students make hypotheses about the size of a human egg cell and a human red blood cell.

Instruction

Techniques with Microscopes

▶ Introducing the Micrometer	▷ Define the microscope as an important tool used by biologists to make objects look larger. ▷ Explain that microscopes also increase the resolution of an image. Define the term *resolution* as the ability to distinguish between two points that are close together. The greater the resolution, the sharper the image. ▷ Explain that together, magnification and resolution enable the microscope to show details that are too small to be seen by the unaided eye. ▷ Explain to students that limit of visibility of the human eye is about $\frac{1}{10}$ mm or 0.1 mm. Therefore, objects that are smaller than 0.1 mm require magnification to be seen by humans. Point out that most cells are smaller than 0.1 mm. Tell students that a human egg cell is approximately 0.13 mm in diameter. ▷ Tell students that the micrometer (μm) is the best unit for measuring most cells. Ask students how many micrometers are in a millimeter. **1000** ▷ Have students look at their rulers again and imagine a millimeter divided into 1000 equal parts. ▷ Review with students how to convert between millimeters and micrometers. To convert from mm to μm, multiply by 1000; to convert from μm to mm divide by 1000. ▷ Distribute copies of the Metric Conversions Using the Micrometer worksheet and have students complete it.
▶ Determining Size with a Microscope Laboratory Activity	▷ Distribute copies of the Determining Size With a Microscope worksheet. ▷ Explain to students how to determine the size of a specimen viewed with a microscope. ▷ Demonstrate how to make a wet mount of the onion skin. ▷ Guide students through all of the procedures. ▷ Have students record all of their observations and data in their notebooks as they complete the lab.

Assessment

- Have students write a Descriptive Paragraph (*SUTW*, pp. 3-34 through 3-42) about what they have learned.

Homework Assignment

- Have students complete Analysis and Application questions of the Determining Size with a Microscope worksheet.

Teaching Resources

- Holt, pp. 1028–1029, 1032–1033

activity sheet

name ____________________ date ____________

Metric Conversions Using the Micrometer

1. Bacteria are the smallest of all cells. They vary in size, but many are about 1 μm in diameter. How many bacteria would equal the thickness of 1 mm?

2. A human white blood cell measures 0.02 mm in diameter. What is its size in μm?

3. The virus that causes the flu is about 0.1 μm in diameter. What is its size in mm?

4. How many flu viruses could fit across the diameter of a human white blood cell?

5. What is the size of a human egg cell in μm?

6. A human sperm cell is about 3 μm in width. How many would fit across the diameter of a human egg cell?

activity sheet

name ______________________ date __________

Determining Size Using a Microscope

Procedure

1. Examine the markings on a transparent metric ruler. Determine which marks indicate millimeter lengths. Then place the ruler upside down on the stage so that is covers half of the stage opening.
2. View the ruler under low power. Place the center of one mark at the left side of the field of view. Make sure that the edge of the ruler is exactly across the center of the field.
3. Estimate the diameter of the low-power field of view to the nearest tenth of a millimeter. Record the measurement of the low-power field in mm and μm.
4. Calculate the high power field of view by using the following formula:

   $$\text{high-power field diameter} = \frac{\text{low power field diameter} \times \text{low power magnification}}{\text{high power magnification}}$$

   Since we know the low-power field of view diameter and the magnifying power of both objective lenses, the magnification of the objectives is inversely proportional to the field size.
5. Record the measurement of the high-power field diameter in mm and μm.
6. Make a wet mount of onion skin using Lugol's solution. Observe the cells under low power and count the number of cells that span the diameter lengthwise. Record this number.
7. You can estimate the size of objects that you view under the microscope by comparing them with the diameter of the field of view. Calculate the average length of onion skin cells, in mm and μm, using the following formula:

   $$\text{average length of an onion skin cell} = \frac{\text{diameter of the field of view}}{\text{number of cells that span the diameter}}$$

   Record the data.
8. Calculate the average width of an onion skin cell in mm and μm using the same procedure. Record this data.
9. Switch to high power. Calculate the average length and width of an onion skin cell in mm and μm under high power. Record this data.
10. Create a data table to record all of the information you have collected.
11. Obtain prepared slides of various specimens and practice estimating their lengths. Write the name of each specimen and its estimated size in mm and μm in a data table.

activity sheet

name ______________________ date __________

Analysis Questions

1. Why does the method used in this investigation give the average size of an onion skin cell rather than the actual size?

2. What happens to the field of view when you change from low power to high power?

3. How does the image of a specimen change when you switch from low power to high power?

4. Compare the measurements that you calculated for the onion skin cells under low power and the measurements under high power. Should the measurements be the same? Why? If the measurements for the same object are different, give a possible explanation.

5. How many times is the magnification increased when you change from low power to high power?

activity sheet

name ______________________ date __________

Application Questions

Show all calculations.

1. How many micrometers are in one meter?

2. Approximately 500 of a certain species of bacteria can fit across the diameter of the low power field of view. What is the approximate size of 1 bacterium?

3. If a microscope has a low power magnification of 100×, a high power magnification of 600× and a low-power field diameter of 1800 μm, what is the high-power field diameter in μm?

4. Find the diameter of the high-power field of view of a microscope with an ocular marked 10×, a low-power objective marked 10×, a high-power objective marked 40×, and a low-power field diameter of 1600 μm.

5. If a cell is 7 μm in length, how many would fit across the diameter of the low power field of view?

Unit 6 Section 2

EUKARYOTIC CELL STRUCTURE

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–4	1–2	Eukaryotic Organelles	Holt, pp. 58–66
5–6	3	Protein Production and Distribution	Holt, pp. 63–64

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

Cells are the fundamental units of structure and function of all living things and take highly varied forms in different plants, animals, and microorganisms. Living things carry out life processes to survive. (GLE 3.1.C, Framework VII.A.1, GLE 3.2)

CONTENT EXPECTATIONS

☐ 1. The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means. (GLE 3.2.A)

☐ 2. The cells of plants and animals differ in ways that are important to the specialized processes that occur within them. (GLE 3.1.C *PR*)

☐ 3. Cellular activities and responses can maintain stability internally while external conditions are changing (homeostasis). (GLE 3.2.F)

☐ 4. DNA indirectly controls what cells do and when they do it by conveying encoded information directing the cell's synthesis of protein molecules. (Framework VII.A.3)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Investigate, observe directly or indirectly, and communicate to others the basic life processes that take place at a cellular level. (Framework VII.A.2.a)

PERFORMANCE EXPECTATIONS

- ☐ 1. Describe the structure of cell parts (e.g., cell wall, cell membrane, cytoplasm, nucleus, chloroplast, mitochondrion, ribosomes, vacuole) found in different types of cells (e.g., plant, animal) and the functions they perform (e.g., structural support, transport of materials, storage of genetic information, photosynthesis and respiration, synthesis of new molecules, waste disposal) that are necessary for the survival of the cell and organism. (GLE 3.1.C.b)
- ☐ 2. Compare and contrast the structure and function of mitochondria and chloroplasts. (GLE 3.2.A.a)
- ☐ 3. Compare and contrast the structure and function of cell wall and cell membranes. (GLE 3.2.A.b)
- ☐ 4. Explain physical and chemical interactions that occur between organelles as they carry out life processes. (GLE 3.2.A.c)

...for Standard 7

Use technological tools and techniques that extend human capabilities to perform investigations in more detail and with greater accuracy and precision. (Framework I.A.4 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 5. Make qualitative and quantitative observations using the appropriate senses, tools and equipment to gather data (e.g., microscopes). (GLE 7.1.B.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Eukaryotic Organelles Days 1–4	CE 1 PE 1, 2, 3	Have students make a table to summarize information about each cell organelle being studied, including its function. Then have students read Holt, pages 60–66 and fill out the table. Working in pairs, have students quiz each other on the information in their tables. (Goals 1.5, 1.8, 2.3)
	CE 1, 2, 5 PE 1, 5	**Hands-On Activity/Lab/Technology:** Have students observe prepared slides of plant and animal cells with a microscope. They should then prepare wet mounts of onion cells and their own cheek cells, using methylene blue stain, and observe them. Methylene blue may irritate and stain skin. Guidelines concerning the collection, use, and disposal of human body tissues found in the *Missouri Secondary Science Safety Manual* on pages 61–62 should be followed. Students should make labeled diagrams of each cell they observe. Next to each label have them describe the function of each organelle. Have students use their observations to compare plant and animal cells and make a table that identifies whether the organelles are found in plant cells, animal cells, or both. (Goals 1.2, 1.4, 1.6)
	CE 1, 5 PE 1, 2, 3, 4, 5	Have students examine electron micrographs of various cell organelles and correctly identify each organelle. Have students work in groups to organize organelles based on structure and function. Students should compare and contrast various features of the organelles. Then have students sort the electron micrographs into various categories, such as plant cell structures, animal cell structures, prokaryotic cell structures, “hydrolyzes,” “synthesizes,” “has 1 membrane,” “has 2 membranes,” and “transports.” (Goals 1.5, 1.8, 2.3)
	CE 1, 2 PE 1, 2, 3, 5	In groups, have students prepare presentations about different cell organelles. Students should also create models of a plant and an animal cell and their structures for use during their presentations. *See Model Lesson*. (Goals 1.2, 1.4, 2.1, 2.3, 4.5, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students work in pairs to complete this task. Each student reads silently and writes down questions that arise. Then have pairs discuss the questions and complete the table together.	Have students draw a cell, showing all organelles. Have them then label each organelle and write a short description of its function. (ELL-7)	Have students find out about the contributions of Camillo Golgi, discoverer of the Golgi apparatus.
In pairs, have students draw a Venn diagram (*ER*, p. RR-83) comparing animal cells and plant cells. Put a student's diagram on the board and use it as the basis for discussion.	Have students respond in writing to the following questions: "Which structures are found in both plant and animal cells?" "Which structures are found in plant cells but not in animal cells?" "What is the function of each special structure of the plant cell?" "Which structures are found in the animal cells but not in the plant cells?" Discuss with students the correct responses to each question. (ELL-6)	Use a microprojector to illustrate the movement of cilia and flagella. Show students living specimens of *Paramecia* and *Euglena* in separate petri dishes. Explain that both of these organisms are unicellular eukaryotes. Have students compare the movement of cilia in *Paramecia* with that of flagella in *Euglena*.
Play a "Who Am I?" game where a picture of each organelle is presented along with a brief description of its function. Have students identify which organelle is pictured.	Have students add important terms, such as *nucleus*, *organelle*, and *cilia*, from this unit into their glossaries. Have students complete the Vocabulary Review Skills Worksheet (Holt *Biology CRF 3: Cell Structure*, pp. 13–14). (ELL-6)	Collect pictures of cell organelles that have scale bars or given magnifications and have students figure out how to calculate the sizes of the organelles. Have them compare the actual sizes of the organelles to how they are depicted in most cell structure diagrams, such as Figure 15 on Holt, page 64.
Have students work in pairs to develop three questions about cells that could be answered by using their model.	Have students prepare 5 $\times$ 8 Speeches (*SUTW*, pp. 5-4 through 5-5) and allow students some time to practice their presentations before making them to the class. Clarify any confusion about pronunciation prior to the presentations. (ELL-5)	Have students produce a travel brochure that describes a plant or animal cell as if it were a large exhibit or amusement park where the organelles are the attractions. Students should accurately describe, draw, and/or explain the organelles and their functions.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Protein Production and Distribution Days 5–6	CE 1, 3, 4 PE 1, 4	Have students discuss the departments, people, and machines that work together to keep a factory operating efficiently. Brainstorm a list of things that a factory needs to operate, such as a supply of energy, command center, production machinery, receiving and shipping, waste removal, packaging, storage, and cleanup. Have students refer to their factory list and identify the organelle that performs a similar function in a cell. Have students write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) comparing a eukaryotic cell (a "protein-producing factory") and each of its structures to the different components of an industrial factory. (Goals 1.6, 1.10)
	CE 1, 4 PE 1, 4	Perform a jigsaw (*ER*, p. GPT-7) by assigning each student in a group one of the organelles involved in protein production. Have students read the relevant portion of Holt, pages 63–64 to obtain information. Then have students share their information in their groups and answer any clarifying questions. Then have students create a flowchart that outlines the steps of protein production and distribution. Have students summarize the process of protein production and distribution in a Process Paragraph (*SUTW*, pp. 3-15 through 3-17). (Goals 1.8, 2.3, 4.6)
	CE 1, 4 PE 1, 4	Have students work in groups to role-play the organelles of a typical plant or animal cell. Students should take the roles of particular organelles and show how these cell parts work together to produce, package, and distribute proteins. (Goals 2.1, 2.5, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students make a T-chart to organize the different structures involved in protein production and their functions.	Have students complete a sequencing map (*ER*, p. RR-77) to organize the steps of protein production. (ELL-2)	Have students locate and read information about cell specialization, then research the different kinds of cells that make up tissues. They should find an illustration or electron micrograph of epithelial cells, connective tissue cells, muscle cells, bone cells, and/or nerve tissue cells. Choose three examples and on a separate piece of paper, draw and label the types of tissue chosen. Then have students write a Compare and Contrast Paragraph comparing the three tissue drawings.
Have students complete Cell Organelles Active Reading Skills Worksheet (Holt *Biology CRF 3: Cell Structure*, pp. 11–12).	Use the Processing of Proteins B13 teaching transparency (Ch. 3) to outline each step of the process of protein production and distribution. Have students copy the steps down in their notebooks. (ELL-2)	Discuss Hammerling's *Acetabularia* experiment which demonstrates that the nucleus directs the activity of the cell. Use connections between the experiment and protein production to preview concepts from Units 8 and 9.
Give students a diagram of a cell with arrows showing the steps of protein synthesis. Have them write out in words what is happening for each arrow.	Have students read Holt, page 64. Have them generate a question about each step described in the reading. Working in pairs, have students quiz each another. (ELL-6)	Have students research various lysosomal storage diseases, such as Tay-Sachs disease, and how they prevent cells from functioning properly.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 3: Cell Structure,* pp. 11–14

   Educational Resources, pp. GPT-7, RR-77, RR-83

   Step Up to Writing, pp. 3-15 through 3-17, 3-21 through 3-29, 5-4 through 5-5

   Missouri Secondary Science Safety Manual, pp. 61–62

2. **Internet Resources**

   Missouri Secondary Science Safety Manual
   http://dese.state.mo.gov/divimprove/curriculum/science/manuals/secman.pdf

   Access Excellence Graphics Gallery
   www.accessexcellence.org/RC/VL/GG/

   Hammerling's *Acetabularia* Experiment
   www.accessexcellence.org/RC/VL/GG/hammerling_s.html

   Protein Synthesis
   www.accessexcellence.org/RC/VL/GG/protein_synthesis.html

   Life and Discoveries of Camillo Golgi
   http://nobelprize.org/medicine/articles/golgi/

   Electron Micrographs
   http://bioweb.wku.edu/courses/biol22000/11Organelles/Fig.html

   Cells and Cell Organelles Electron Micrographs
   www.umanitoba.ca/faculties/science/biological_sciences/lab3/biolab3_2.html#

3. **Multicultural Resources and/or Activities**

   Discuss the work of Ernest Everett Just. He was an African-American scientist who realized that the plasma membrane and cytoplasm actively contribute to the regulation of a cell's activities and homeostasis.

Suggested Assessments

1. Ask students which type of cells would have more mitochondria: skin cells or muscle cells. Have students justify their answers.
2. Have students list identifying characteristics of bacterial, plant, and animal cells.
3. Give students unlabeled diagrams of plant and animal cells. Have them identify the cell structures and their functions.
4. Have students write a Compare and Contrast Paragraph (*SUTW,* pp. 3-21 through 3-29) comparing a eukaryotic cell and each of its structures to the different components of a school. They should explain the reasoning behind each comparison.
5. Have students write a journal entry about what they would be able to see if they were able to shrink to the size of a molecule and take a tour inside a cell.

Sample Constructed-Response Item

List five structures that can be found in a cell. Identify the function of each and whether it is found in animal, plant, or bacterial cells.

STRUCTURE	FUNCTION	TYPE OF CELL FOUND IN
nucleus	*controls the cells activities*	*animal, plant*
ribosome	*protein production*	*animal, plant, bacterial*
chloroplast	*photosynthesis*	*plant*
cell membrane	*controls the movement of materials in and out of the cell*	*animal, plant, bacterial*
mitochondria	*makes ATP, the main energy source for cells*	*animal, plant*

Model Lesson (Block Roster): *Eukaryotic Organelles: The Eukaryotic Cell Project*

Lesson Questions

Which structures are found in plant and animal cells?

What are the functions of the structures found in plant and animal cells?

Materials

Reference books, computers with Internet access, butcher paper, art supplies

Content and Performance Expectations

CE 1, 2; PE 1, 2, 3, 5

Teacher's Notes

As many resources (books and Internet) as possible should be available for students to use for research. Discuss with students how to ensure that information they obtain from the Internet is accurate.

Make sure when the students begin to make their models that they consider the size of the structure as well as the number of structures they are making. The models should be of an appropriate size and in some cases there should be many of them in each cell.

Warm-Up

Components of a Good Presentation

- Inform students that they will be teaching each other about the structures found in plant and animal cells, as well as making visual representations of the cells.
- Have students think about lessons they receive from teachers and what constitutes a good presentation and lesson. Have students generate a list of requirements for a good presentation and lesson. Discuss their lists.

Instruction

The Eukaryotic Cell

▶ Framing the Project	▷ Randomly place students into groups. Each group will be responsible for one of the following organelles: mitochondria, nucleus, cell membrane and cell wall, endoplasmic reticulum and ribosomes, Golgi apparatus and lysosomes, chloroplast, or cytoplasm and cytoskeleton. ▷ Each group will be responsible for teaching the class about one or two of these organelles. Each presentation must address the following questions: • What is your organelle's function and why is it important? • Where is your organelle found in the cell and why? • What would happen if your cell didn't have this organelle? ▷ Place butcher paper on a wall and draw a large plant cell and a large animal cell. Explain that each group is required to make models of their organelle that will attach to the giant cell on the wall.
▶ Group Work	▷ Give students time in class to research their organelle(s) in reference books or on the Internet. ▷ Provide material for students to create the models. ▷ Circulate around the room to answer questions and provide assistance.
▶ Presentations	▷ Before the presentations, the different groups should attach their models to the cells on the wall. Then have each group make its presentation to the class. ▷ While students are listening to the presentations, have them take notes about each organelle.

Assessment

- Assess student presentations for factual accuracy, organization and preparedness.

Homework Assignment

- Have students create keys for their cell models that indicate the function of each organelle and which organelles it affects or works with.

Teaching Resources

- Holt, pp. 58–66

Unit 6 Section 3

TRANSPORT ACROSS MEMBRANES

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	Structure of the Cell Membrane	Holt, pp. 60–61
2–3		Diffusion and Osmosis	Holt, pp. 74–80
4	2	Active Transport	Holt, pp. 81–86

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

Living organisms carry out life processes in order to survive. Cells have distinct and separate structures that perform and monitor processes essential for the survival of the cell and/or organism, such as chemical synthesis, energy conversion, material transport, and cell replication. (GLE 3.2, Framework VII.A.2)

CONTENT EXPECTATIONS

- ☐ 1. The cell membrane is involved in structural support and the transport of materials into and out of the cell. (GLE 3.2.A *PR*)
- ☐ 2. Cellular activities and responses can maintain stability internally while external conditions are changing (homeostasis). (GLE 3.2.F)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

- ☐ 3. Scientific inquiry includes the ability to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)
- ☐ 4. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)
- ☐ 5. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Describe the structure of cell parts (e.g., cell membrane) found in different types of cells (e.g., plant, animal) and the functions they perform (e.g., structural support, transport of materials) that are necessary to the survival of the cell and organism. (GLE 3.1.C.b, 3.2 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 1. Explain the significance of semi-permeability to the transport of molecules across cellular membranes. (GLE 3.2.F.a)
- ☐ 2. Predict the movement of molecules needed for the cell to maintain homeostasis, given concentration gradients of different sizes of molecules. (GLE 3.2.F.b)
- ☐ 3. Relate the role of diffusion, osmosis, and active transport to the movement of molecules across semi-permeable membranes. (GLE 3.2.F.c)
- ☐ 4. Compare and contrast the structure and function of cell wall and cell membranes. (GLE 3.2.A.b)
- ☐ 5. Investigate, observe directly or indirectly, and communicate to others the basic life processes that take place at a cellular level. (Framework VII.A.2.a)

...for Standard 7

Analyze how science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 6. Formulate testable questions and hypotheses. (GLE 7.1.A.a)
- ☐ 7. Design and conduct a valid experiment. (GLE 7.1.A.c)
- ☐ 8. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., microscopes). (GLE 7.1.B.a)
- ☐ 9. Use qualitative and quantitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Structure of the Cell Membrane Day 1	CE 1, 2 PE 1	Illustrate the fluid mosaic model with a tub of water, table-tennis balls with attached strings, and several tennis balls. Float a layer of table-tennis balls on top of the water and then add the tennis balls. Explain that the water represents the cytoplasm of the cell, the table-tennis balls represent the phospholipids, and the tennis balls represent proteins. Show students how the balls can move around if one is removed. Have students discuss how the movement of tennis balls through the table-tennis balls demonstrates the activity of the cell membrane. Have students list the ways that this model differs from the actual cell membrane (e.g., that is a bilayer, how polarity affects how phospholipids arrange themselves, that it is semipermeable). Have students make labeled diagrams or three-dimensional models of the cell membrane. (Goals 1.5, 2.1, 3.5)
	CE 1, 3, 4, 5 PE 1, 5, 6, 7, 8, 9	**Hands-On Activity/Lab:** In pairs, have students conduct an investigation to answer the question, "Are plastic bags selectively permeable?" Explain that if a plastic bag is selectively permeable some substances will pass through and others will not. Provide students with the following materials: starch solution, iodine solution, plastic sandwich bags, small rubber bands or masking tape, and large beakers. Remind students that when iodine combines with starch it turns bluish black. Students should make predictions and design an experiment to test their hypothesis. Check their experimental plans and then have them perform the experiment, analyze the data, and draw a conclusion. Have students write a Process Paragraph (*SUTW*, pp. 3-15 through 3-17) that explains their observations and discusses the significance of the semipermeability of the cell membrane to the functioning of the cell. (Goals 1.2, 1.3, 2.1, 4.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Demonstrate polar and nonpolar substances for students. Mix together colored water and alcohol to show what happens when you combine polar substances. Then combine oil and water and shake them together. Have students observe what happens in each situation. Explain how the same types are attracted and the opposites repel.	Define the terms *mosaic* and *fluid*, and provide examples of each. Bring in one example of any type of mosaic art. Compare the mosaic art to the fluid mosaic model of the cell membrane. (ELL-2)	Have students research the development of the fluid mosaic model by Gorter and Grendel, Danielli and Davson, and Singer and Nicolson. Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-13). A brief summary of the history of membrane models can be found at the following Web site: www1.umn.edu/ships/9-2/membrane.htm. The following articles may also be useful: Danielli, J. F. and Davson, H. 1935. A contribution to the theory of permeability of thin films. *J. Cell Comp. Physiol*. 5:495–508 Singer, S. J. & Nicolson, G. L. The fluid mosaic model of the structure of cell membranes. *Science* 175 Gorter, E. and Grendel, F. 1925. On bimolecular layers of lipoids on the chromocytes of the blood. *J. Exp. Med.* 41:439–443
Draw a diagram of the experimental setup on the board, using different colors to show water molecules, starch molecules, and iodine molecules. Have students predict where the different molecules will be after the experiment is completed. As a class, interpret what each possible outcome means in terms of the permeability of the sandwich bag.	Provide students with an analogy to better understand this topic. Have students think of security guards at an office building. Discuss the purpose of security guards and IDs. Explain how the cell membrane is like the entrance to the building, membrane proteins are like security guards, and some substances have "IDs" that allow them passage across the membrane. Have students discuss why it is important to a cell to be selectively permeable. (ELL-3)	Have students visit the Web site "Cell Biology Animations" (www.johnkyrk.com) to view detailed descriptions and animations of the component of the cell membrane and their functions within the cell membrane. Have them write a summary paragraph about what they have learned.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Diffusion and Osmosis Days 2–3	CE 1, 2, 4, 5 PE 3, 5, 8	Set up a demonstration of food coloring dropped into a beaker of water. Have students record their observations and draw what they see. They should also write a Free Response (*SUTW,* p. 8-8) about the demonstration. Explain that this is an example of diffusion and define the terms *diffusion* and *osmosis*. Have students explain why the phenomenon occurs and when equilibrium is reached. Have them draw a picture of equilibrium using different colors for water molecules and food coloring molecules. Have them list other real-world examples of diffusion and osmosis. Examples of osmosis include swollen wood doors due to high humidity and wrinkly swollen fingers after soaking in the bathtub. Use the demonstration on Holt *TE,* page 77. Have them discuss how diffusion is seen in the demonstration and list other real-world examples of hypertonic, hypotonic, and isotonic solutions. Explain that the cell membrane does not allow the diffusion of all molecules and it is selectively permeable, so that some substances are allowed to diffuse with the concentration gradient and others are not. (Goals 1.5, 1.6, 1.10)
	CE 1, 2, 3, 4, 5 PE 3, 4, 5, 6, 7, 8, 9	**Hands-On Activity/Lab:** Have students design and conduct an investigation to determine how a concentrated salt solution and distilled water will affect *Elodea* and cheek cells. Guidelines concerning the collection, use, and disposal of human body tissues found in the *Missouri Secondary Science Safety Manual* on pages 61–62 should be followed. *See Model Lesson*. (Goals 1.2, 1.3, 1.8, 2.3, 3.5, 4.5)
	CE 1, 2 PE 2, 3	In groups, have students make predictions about what will happen to a red blood cell in salt water, a saltwater fish in freshwater, and a freshwater fish in salt water. Have them identify which solutions are hypertonic and hypotonic. Then have students invent an adaptation that would assist the cell or organism to adapt to its new environment. Display the *Paramecium* F16 teaching transparency (Ch. 21). Point out the contractile vacuoles and explain their function. Then have students complete the Cell Transport Science Skills worksheet (Holt *Biology CRF 4: Cells and Their Environment,* pp. 11–12). (Goals 1.6, 2.3, 3.1, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Give students more examples of diffusion by demonstrating a tea bag in hot water or air freshener sprayed in the room. Have them brainstorm in groups other real-world examples of diffusion and osmosis.	Have students read Holt, pages 74–77 silently, using sticky notes to indicate sections where they have questions. Then place students in pairs to discuss their questions and try to answer them for each other. (ELL-5)	Human lungs and kidneys rely on diffusion and/or osmosis to function properly. Have students research and explain the importance of osmosis and/or diffusion in how the organs function. Information is available at www.pdh-odp.co.uk/diffusion.htm.
Before conducting the experiment, prepare the Demonstration on Holt *TE*, page 77. Have students classify each solution as hypertonic, hypotonic, or isotonic. Then have students predict what will happen and observe the results.	Prepare a vocabulary review by creating groups of terms from this unit. In each group, place words that have a relationship with one word that does not relate as the others. Put the list on an overhead projector and have students determine which term does not belong in each group. Then have students describe the relationship among the other terms. (ELL-6)	Explain to students how the antibiotic penicillin uses osmotic pressure to destroy bacterial cells.
Have students complete the Observing Osmosis Quick Lab (Holt, p. 76).	Define the prefixes *hypo*-, *hyper*-, and *iso*- for students. Have them look up other examples of words that begin with these prefixes and their definitions. (ELL-2)	Have students conduct research about aquatic organisms that are able to survive in both salt and fresh water such as salmon. They should answer the question, "What adaptations do they have to help their cells deal with osmosis?"

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Active Transport Day 4	CE 1, 2 PE 3	Have students examine the Sodium-Potassium Pump B21 teaching transparency (Ch. 4) that shows active transport of ions against a concentration gradient. Explain that this type of transport requires membrane-bound carrier proteins and the energy of ATP. Ask students "What happens in each of these four steps?" Emphasize that energy is required for the active transport of molecules in and out of a cell. Have students summarize each of the steps in their notebooks and then write a Process Paragraph (*SUTW*, pp. 3-15 through 3-20). Then have students study Figure 6 on Holt, page 83. In pairs, have then write out in words what happens during endocytosis and exocytosis. (Goals 1.5, 1.6, 1.8)
	CE 1, 2 PE 3, 5	Have students read Holt, pages 81–82 and use sticky notes to record comments or questions about the reading. Discuss students' questions and responses. Then have them work in groups to make comic strips illustrating active transport. Display the Exocytosis and Endocytosis B22 teaching transparency (Ch. 4) and explain the processes, define terms, and have students make sketches. Discuss the steps of each process. Then have students act out the process of endocytosis and exocytosis. Students should touch shoulders or put their hands on each other's shoulders to make a circle in the room that represents a cell membrane. Have a volunteer act as material to be engulfed by endocytosis. Have other students form a lysosome within the cell that will fuse with the vesicle that is formed. Then have a volunteer act out the exocytosis of wastes. Allow students to direct the action and identify the different structures that are being portrayed. Explain that pinocytosis (the intake of liquids) and phagocytosis (the intake of solids) are forms of endocytosis. (Goals 1.5, 1.8, 2.1, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Relate the active transport of molecules through the cell membrane to the movement of people through a revolving door or turnstile into an empty room. Just as energy is required to move the door, so is energy required to move molecules through the semipermeable cell membrane. People passing through an open door would be an example of passive transport since no energy is required to move the door.	Have students work in groups to make a model of active transport in a plasma membrane. They should then explain to the class how it works. (ELL-7)	Have students complete the Analyzing the Effect of Electrical Charge on Ion Transport Data Lab (Holt, p. 79). Datasheets are available on Holt *Biology CRF 4: Cells and Their Environment*, page 33.
Discuss the differences between osmosis and diffusion, and endocytosis and exocytosis. Have students work in pairs to draw four diagrams to show the activity that takes place during each process. The drawings should include arrows and explanatory terms.	Define the prefixes *exo-* and *endo-*, and then have students work in pairs to brainstorm other words that begin with these prefixes and their meanings. Have them use a dictionary to find more words. (ELL-2)	Have students complete the Good and Bad Cholesterol Group Activity (Holt *TE*, p. 83).

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 4: Cells and Their Environment,* pp. 11–12, 33

   Step Up to Writing, pp. 3–3 through 3–13, 3-15 through 3-17, 8-8

2. **Internet Resources**

   Missouri Secondary Science Safety Manual
   http://dese.mo.gov/divimprove/curriculum/science/manuals/secman.pdf

   Diffusion of Gases Through a Respiratory Membrane
   www.pdh-odp.co.uk/diffusion.htm

   Maintaining the Body's Chemistry: Dialysis in the Kidneys
   www.chemistry.wustl.edu/~edudev/LabTutorials/Dialysis/Kidneys.html

   Cell Biology Animations
   www.johnkyrk.com

   From the Lipid Bilayer to the Fluid Mosaic: A Brief History of Membrane Models
   www1.umn.edu/ships/9-2/membrane.htm

3. **Multicultural Resources and/or Activities**

   Discuss how people throughout the world have used desiccation, or the addition of salt or sugar, to preserve food supplies. Explain to students how the concept of osmosis relates to this topic. Have students investigate the different foods from cultures around the world that are preserved by these methods.

Suggested Assessments

1. Have students write a short description of the fluid mosaic model including the terms *plasma membrane, phospholipid, bilayer, polar, non polar,* and *proteins.*
2. Have students create a table that lists and compares the modes of passive transport with active transport (i.e., diffusion, osmosis, facilitated diffusion, endocytosis, exocytosis); they should identify the types of materials transported by each mode of transport, whether energy is required, and if a transport protein is used.
3. Create a worksheet showing cells in solutions with varying concentrations. Label percent of solute inside and out. Have students use arrows to show the movement of water and then label solutions as isotonic, hypertonic, or hypotonic.
4. Write on the board the terms *semipermeability, passive transport, energy, active transport, diffusion, osmosis, endocytosis,* and *exocytosis*. Have students use the words to prepare a flowchart showing the movement of materials through a membrane.

Sample Constructed-Response Item

Compare and contrast passive and active transport in terms of energy requirements and direction of movement in relation to concentration gradients. Provide one example of each type of transport.

Passive transport does not require energy because molecules move from an area of high concentration to low concentration. An example would be the diffusion of water (osmosis) across the cell membrane. Active transport requires energy because it moves substance against the concentration gradient, from low concentration to high concentration. An example of active transport would be the pumping of sodium and potassium across the cell membrane.

Model Lesson (Traditional Roster):

Diffusion and Osmosis: Osmosis, Plasmolysis, and Turgor Pressure Lab

Lesson Questions

How do hypertonic and hypotonic solutions affect cells?

Do plant and animal cells react the same way to osmotic pressure?

Materials

Elodea plant, microscopes, slides, cover slips, distilled water, hypertonic salt solution, pond water (isotonic to *Elodea*), methylene blue stain, toothpicks, paper towels

Content and Performance Expectations

CE 1, 2, 3, 4, 5; PE 3, 4, 5, 6, 7, 8, 9

Teacher's Notes

Guidelines concerning the collection, use, and disposal of human body tissues found in the *Missouri Secondary Science Safety Manual* on pages 61–62 should be followed. The *Missouri Secondary Science Safety Manual* can be obtained at http://dese.mo.gov/divimprove/curriculum/science/manuals/secman.pdf. Methylene blue may irritate and stain skin.

When *Elodea* is placed in a hypertonic solution, the cell membrane will shrink away from the cell wall. The cell can be returned to its original turgid state by adding a hypotonic solution such as distilled water.

Warm-Up

Osmosis and Cells

- Have students write a Free Response (*SUTW,* p. 8-8) with their ideas about how plants can maintain an upright structure without an internal skeleton.
- Discuss students' responses.
- Introduce and define the terms *plasmolysis* and *turgor pressure*.
- Explain to students that turgor pressure within plant cells helps plant tissues maintain their structure and that turgor pressure results from high osmotic pressure inside the cell. The cell wall protects the cell from bursting under turgor pressure, and when plants lose turgor pressure they will wilt. Plasmolysis results from a loss of turgor pressure within the cell.
- Explain to students that they will design their own investigation to test the effects of osmosis on plant and animal cells. Give students a list of materials that are available for use in the investigation.
- Have students identify which solution from the materials list would be hypertonic to the plant cells and which would be hypotonic to the plant cells and explain why.

Instruction

Introduction to *Elodea*

▶ Observations of *Elodea*	▷ Have students remove a young leaf from the growing tip of an *Elodea* plant and prepare a wet mount using the culture water that the plant was living in. ▷ Have students observe the slide under low power. ▷ Have students observe the slide under high power and draw a picture of a few of the cells, labeling any cell structures that are visible.
▶ *Elodea* in Different Solutions	▷ Have students hypothesize what would happen to *Elodea* cells in a distilled water solution and in a concentrated salt solution. ▷ Explain that a drop of hypertonic or hypotonic solution can be placed on one side of the slide near the cover slip and a paper towel can be placed on the other side of the cover slip to draw out the culture water and pull the new solution under the coverslip. Demonstrate this procedure.

Designing and Carrying Out the Investigation

▶ Planning the Investigation	▷ Place students in pairs. ▷ Give pairs 10 minutes to brainstorm a testable question about how osmosis affects plant and animal cells. Explain that the source of the plant cells will be *Elodea* and that animal cells can be obtained by scraping the inside of their cheek with a toothpick. ▷ Review the guidelines concerning the collection, use, and disposal of human body tissues found in the *Missouri Secondary Science Safety Manual* on pages 61–62. ▷ Have students develop a hypothesis, a procedure to test the hypothesis, an explanation of the data that will be collected, and a list of materials required. These should be approved by the teacher before students conduct their investigation
▶ Conducting the Investigation	▷ Have students conduct their investigations. ▷ Have students make drawings to record their observations. They should label the drawings to identify structures. ▷ Have students share their results with the class during a class discussion at the end of the investigation. ▷ If time permits, have students begin answering the conclusion questions.

Assessment

- Have students explain why it is dangerous for humans to drink seawater. Have students describe how plant and animal cells react differently to hypotonic and hypertonic solutions.

Homework Assignment

- Have students answer the following conclusion questions: 1) Overall, what happened in your investigation? 2) Do the results support the hypothesis? Why or why not? 3) How does the investigation demonstrate osmosis? 4) How could you improve this investigation? 5) What are three possible sources of error in this investigation? 6) Why is important to learn about the effects of osmosis on cells?
- Have students write a lab report.

Teaching Resources

- Holt, pp. 76–77
- Plasmolysis Experiment explanation
  http://crystal.uah.edu/~carter/osmosis/experime.htm

Unit 7 Biochemical Pathways

- How do cells obtain, use, and change energy?

Scope and Sequence, page 21
Lesson Planning Material, pages 279–325

UNIT 7

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

Unit 7 Section 1

ENERGY AND PLANTS

UNIT 7 SECTION 1

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	ATP: The Energy Molecule of the Cell	Holt, pp. 94–96
3–4	2	Light and Photosynthetic Pigments	Holt, pp. 97–99

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW...

...for Standard 3

Living organisms carry out life processes in order to survive. (GLE 3.2)

CONTENT EXPECTATIONS

☐ 1. Cells carry out chemical transformations that use energy for the synthesis and breakdown of organic compounds. (GLE 3.2.D)

☐ 2. The ATP molecule stores energy in its chemical bonds. (GLE 3.2.D.a *PR*)

☐ 3. Autotrophs utilize photosynthetic pigments to capture the energy of the sun. (GLE 3.2.D.a *PR*)

...for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Scientific inquiry includes the ability to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 6. Evidence is used to formulate explanations (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Analyze how cells carry out chemical transformations that allow the conversion of energy from one form to another, the breakdown of molecules into smaller units, and the building of larger molecules from smaller ones. (Framework VII.B.1 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 1. Use models to demonstrate various chemical transformations carried out by cells and apply this information to different contexts of everyday life. (Framework VII.B.1.a)
- ☐ 2. Explain the role of ATP and/or photosynthetic pigments in the breakdown and/or synthesis of organic compounds. (GLE 3.2.D.c *PR*)
- ☐ 3. Recognize energy is absorbed or released in the breakdown and/or synthesis of organic compounds. (GLE 3.2.D.c)
- ☐ 4. Summarize how energy transfer occurs during photosynthesis and respiration (i.e., the storage and release of energy in the bonds of chemical compounds). (GLE 3.2.D.a)

…for Standard 7

Demonstrate that science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 5. Formulate testable questions and hypotheses. (GLE 7.1.A.a)
- ☐ 6. Design and conduct a valid experiment. (GLE 7.1.A.c)
- ☐ 7. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., thermometers). (GLE 7.1.B.a)
- ☐ 8. Use qualitative and quantitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
ATP: The Energy Molecule of the Cell Days 1–2	CE 1, 2 PE 1, 2, 3	Display ATP Releases Energy B32 teaching transparency (Ch. 5). Explain to students how the equation ADP + P + energy ⇄ ATP illustrates the way that breaking the bond releases energy and forming ATP requires energy. Explain that ATP is used to power the activities of the cell, such as synthesizing organic compounds. Have students explain why ATP is called the energy currency of the cell. In groups, have students make cartoons that demonstrate how ATP stores and releases energy for the cell. (Goals 1.5, 1.6, 2.1, 2.3, 3.5)
	CE 1, 2, 5, 6 PE 3, 4, 7, 8	If students did not complete the Energy Content of Foods Lab in Unit 4 Section 2, set up a demonstration to investigate the amount of chemical energy found in food by converting it to heat energy. Fill a test tube with 10 mL of water and measure the temperature. Then attach the test tube to a ring stand and hold a burning walnut under it. Observe fire safety precautions. Have students record the temperature change and calculate the amount of calories (amount of water × temperature change × 1 cal/g C). Have students write responses to the following questions: "Where did the heat to raise the water temperature come from?" "How is this demonstration similar to how the human body 'burns' food?" "How is it different?" Emphasize that in cells some of the energy is converted to ATP so that it can be used by the cells instead of being lost as heat. (Goals 1.5, 1.10, 3.5, 4.1)

Suggested Adaptations

	STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
	Use the analogy that ATP is like a rechargeable battery to help students understand the concept better. ATP is reusable since new ATP molecules can be made by adding energy just as a battery can be recharged by adding more ions.	Have students read Holt, pages 94–96 silently. As they read, have them write down questions they have about the reading. Then have students work with a partner to answer those questions and write a sentence describing what is happening in Figure 2 on Holt, page 95. (ELL-2)	Have students make molecular models of the ATP molecule using different colors for the different atoms.
	Review with students how to read a thermometer. Have students identify what each mark on the thermometer represents. Explain to students how the volume of water in milliliters is equal to its mass in grams and go through the equation step by step to calculate the amount of calories.	Review the law of conservation of energy with students. Have students list the different forms that energy may exist in. Remind students that chemical energy is the energy contained in the chemical bonds between atoms and burning the walnut helps to break the chemical bonds. (ELL-3)	Have students conduct this experiment. Have them make hypotheses about the amount of calories contained in other food sources, such as a marshmallow or a potato chip, and then test their hypotheses in an experiment they design.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Light and Photosynthetic Pigments Days 3–4	CE 3, 6 PE 2, 4	Use a prism and a flashlight to demonstrate how sunlight (white light) contains the full visible spectrum. Discuss light as a form of electromagnetic radiation. Review the electromagnetic spectrum (www.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec2.html). Have students explain what happens to light when it hits an object. Explain why we see colors and then have students explain why plants are green. Display the Absorption Spectra of Photosynthetic Pigments B25 teaching transparency (Ch. 5). Have students identify which wavelengths are absorbed and which are reflected. If possible, show spectra of other pigments. Ask why plants use more than one type of pigment. Explain that photosynthetic pigments capture light energy that is used in the process of photosynthesis. Have students write Summary Paragraph with a Burrito Topic Sentence (*SUTW,* pp. 3-3 through 3-13) about light and pigments. (Goals 1.5, 1.6, 2.1, 3.5)
	CE 1, 4, 5, 6 PE 2, 5, 6, 7, 8	**Hands-On Activity/Lab:** Have students work in pairs to make a hypothesis about how different colors of light affect plant growth. Provide them with plants and different colored cellophane (as well as clear) and have them design an experiment to test their hypotheses. Have them conduct their experiment and prepare a presentation for the class to report their results. (Goals 1.2, 1.3, 1.8, 4.1, 4.5)
	CE 3, 5, 6 PE 2, 7, 8	**Hands-On Activity/Lab:** Have students conduct an experiment to isolate the pigments in a spinach leaf. *See Model Lesson.* (Goals 1.2, 1.3, 1.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Tell students that a new planet was discovered. It is very hot and dry on the planet. Most of the light that reaches the planet is red, orange, and yellow. Have students draw a picture in the color of the imaginary plants on this planet and then write a paragraph about why the plants look the way they do.	Before starting this topic, assess students' prior knowledge using a previewing strategy such as K-W-L chart (*ER*, p. RR-43) or freewriting (*ER*, p. GPT-6). (ELL-1)	Have students find out information about other types of energy besides the visible spectrum on the electromagnetic spectrum. They should find out where the energy originates from and whether it is harmful to humans. Students should prepare a written report including the sources of their information.
Review the concept of a control in an experiment with students. Have students identify the control in their experiments. Discuss with students what sort of data will be collected; encourage the collection of both qualitative and quantitative data.	Give students extra time to prepare their presentations. Have them use diagrams, charts, or posters to illustrate their results. (ELL-7)	Have students investigate how gro-lights, fluorescent lights, and incandescent lightbulbs affect plant growth. Have them conduct research to find out differences in the light produced by each type of lightbulb.
Before conducting this experiment, set up a demonstration for students. Use a strip of filter paper, a test tube filled with a small amount of water and a black nonpermanent, overhead marker. Put a dot of marker on the end of the strip of paper and place the very end of the paper in the water (below the dot). After the water has moved to the top of the paper, show students the paper and explain what has happened.	Demonstrate, step by step, how to perform this lab and explain procedures, such as preparing the experimental setup, applying the spinach extract to the filter paper, and measuring the distance between the starting point and the spots of pigment. (ELL-4)	Have students conduct research about the health benefits of antioxidants and the relationship between antioxidants and plant pigments. Have them create a bulletin board explaining the health benefits of plant pigments.

Additional Resources

1. **Curriculum Resources**

   Educational Resources, pp. GPT-6, RR-43

   Step Up to Writing, pp. 3-3 through 3-13

2. **Internet Resources**

   Electromagnetic Spectrum
   www.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec2.html
   http://imagers.gsfc.nasa.gov/ems/ems.html

   Chlorophylls and Carotenoids
   http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/C/Chlorophyll.html

   The Chemistry of Autumn Colors
   http://scifun.chem.wisc.edu/chemweek/fallcolr/fallcolr.html

3. **Multicultural Resources and/or Activities**

   Have students compare cultures when investigating plant pigments. Have them read about various cultures' use of natural pigments to create art and decorate clothing, such as North African and Indian hennas and Old English lichen dyes.

Suggested Assessments

1. Have students develop questions based on the information in this section. They should write each question on one side of an note card and the answer on the other side. Have students work in pairs to quiz each other on the information.
2. Have students write a paragraph explaining the relationship between photosynthesis, pigments, and light.
3. Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-13) to explain how ATP provides energy for cells.

Sample Constructed-Response Item

How does ATP store energy?

ATP stores energy in its chemical bonds (phosphate to phosphate). When the bonds are broken, energy is released.

Model Lesson (Block Roster):
Light and Photosynthetic Pigments: Chromatography

Lesson Questions

What photosynthetic pigments are found in plants?

How does paper chromatography separate different pigments?

Materials

Spinach extract (or a fresh spinach leaf and a penny), 18-cm strips of filter paper, capillary tubes, test tubes, cork stoppers, rulers, thumbtacks, safety goggles, disposable gloves, acetone/petroleum ether solvent, pencil, *Coleus* leaves, copies of the Chromatography of Photosynthetic Pigments worksheets that follow the Model Lesson

Content and Performance Expectations

CE 3, 5, 6; PE 2, 7, 8

Teacher's Notes

Have students make a hypothesis before conducting the experiment.

Spinach extract can be prepared using a 10-oz package of frozen spinach. Microwave it for 5–10 minutes until most of the water melts, squeeze out the water and cover with 1 liter of 95% ethanol, and boil in a fume hood for a few minutes. Filter it first through cheesecloth and then filter paper. An alternative is to have student roll a penny over a fresh spinach leaf on top of a piece of filter paper. The solvent is prepared using 9 parts petroleum ether: 1 part acetone. It is an eye and skin irritant, highly flammable, and gives off hazardous fumes. A completed chromatogram should show four bands of pigment in order, carotenes (farthest from the origin), xanthophylls, chlorophyll *a*, and chlorophyll *b* (closest to the origin).

Warm-Up

Plant Pigments

- Ask students how plants are able to absorb the energy of the sun. Have them name the different pigments plants use to absorb light.
- Discuss accessory pigments such as carotenes and xanthophylls and their ability to absorb light at different wavelengths and transfer the energy to chlorophyll *a*.
- Ask students why the leaves of many deciduous trees change colors in the fall. Explain that most plants use a combination of pigments to trap the energy of the sun and the other colors are not seen because they are hidden by chlorophyll. In autumn, the chlorophyll begins to break down and the other pigments can be seen.

Instruction

Preparing for the Investigation

- Explanation of Chromatography
  - Tell students that they will use a process called paper chromatography to separate the different pigments found in plant leaves.
  - Explain that a solution of pigments is applied to the filter paper and the paper is immersed in a solvent. As the solvent moves through the paper the pigments will move as well, though at different rates depending upon molecular size, polarity, and solubility. Each pigment has a characteristic rate of movement in relation to the distance moved by the solvent, called the R_f value.

Investigation

- Chromatography of Photosynthetic Pigments
  - Review answers to the Pre-Lab questions and discuss the procedure with students.
  - Circulate around the classroom during the activity to assist students.
  - Have students record the data, analyze the results, and answer the Analysis and Conclusion questions.

Assessment

- Have students answer the Analysis questions.

Homework Assignment

- Have students complete the Extension questions. Encourage students to research the answers with the Internet or library.

Teaching Resources

- Holt, p. 98

activity sheet

name ____________________ date ____________

Chromatography of Photosynthetic Pigments

Pre-Lab Questions

List the different types of pigments found in plants and their color.

___

___

Explain why a pigment (or any object) appears to be a certain color to the human eye.

___

___

Introduction

In this investigation, you will use a process called paper chromatography to separate the different pigments found in plant leaves. A solution of pigments is applied to the filter paper and the paper is immersed in a solvent. As the solvent moves through the paper the pigments will also move though at different rates depending upon molecular size, polarity and solubility. Each pigment has a characteristic rate of movement in relation to the distance moved by the solvent, called the R_f value.

The R_f is calculated using the following equation:

$$R_f = \frac{\text{Distance moved by the pigment}}{\text{Distance from pigment origin to solvent front}}$$

Question

Which photosynthetic pigments are present in spinach leaves? In *Coleus* leaves?

Hypothesis

___

___

Materials

Spinach extract (or a fresh spinach leaf and a penny), 18-cm strips of filter paper, capillary tubes, test tubes, cork stoppers, rulers, thumbtacks, safety goggles, disposable gloves, acetone/petroleum ether solvent, pencil, *Coleus* leaf

UNIT 7 SECTION 1

name ______________________ date __________

Procedure

1. Obtain a strip of filter paper. Handle the paper only by its edges. Make a faint pencil line across the paper about 2 cm from the bottom. Use a thumbtack to attach the filter paper to the cork stopper. Place the filter paper inside of the test tube to ensure it fits. The strip of paper should reach the bottom of the test tube and not be bent or touch the sides of the tube. Adjust as necessary. Remove the filter paper from the test tube.
2. Dip the capillary tube in the spinach extract. Touch it to the center of the pencil line on the filter paper. Repeat 20 times, allowing the spot to dry between applications. OR Place the spinach leaf over the pencil line and roll the penny over the leaf, crushing its cells. Repeat this several times so that there is a thin, dark line of pigment along the pencil line.
3. Add acetone/petroleum ether solvent into the test tube to reach 1 cm up from the bottom. Do not inhale the fumes. Try not to allow the sides of the tube to get wet.
4. Put the filter paper in the test tube making sure the pigment on the paper is not submerged in the solvent. Allow the solvent to progress up the paper and do not disturb the test tube. When the solvent line has almost reached the top of the test tube, remove the filter paper. Put the cork stopper back on the test tube.
5. Mark the position of the solvent front with a pencil and allow the strip to dry.
6. Observe the results and draw a picture of your chromatogram. Identify the pigments that are present.
7. Measure the distance from the pigment origin to the solvent front and from the origin to each pigment band. Calculate the R_f for each pigment.
8. Repeat this procedure using the red *Coleus* leaf.

Data/Results

Spinach Chromatogram

Coleus Chromatogram

name ______________________ date __________

R_f values

PIGMENT	R_f (cm)

Analysis and Conclusion Questions

1. Explain you results in relation to your hypothesis.

2. Which pigment traveled the farthest? Which traveled the least?

3. What does a small R_f value tell you about the characteristics of the moving molecules?

4. Identify at least 2 possible sources of error.

5. How does this investigation explain why some leaves turn yellow, red, and orange in autumn?

6. How did the pigments in the spinach leaf compare with the pigments in the *Coleus* leaf?

name ______________________ date __________

Extension Questions

1. Why do some pigments travel farther on the paper than others?

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2. Would you expect the R_f value of a pigment to change if we altered the composition of the solvent? Why or why not?

____

____

3. What are some other applications for paper chromatography?

____

____

4. What would be the benefit for a plant to have more than one kind of pigment?

____

____

5. Some leaves, such as those from the Japanese maple, are red all year long. How could you find out if chlorophyll is present in these leaves?

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Unit 7 Section 2

PHOTOSYNTHESIS

UNIT 7 SECTION 2

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Chloroplasts: Photosynthetic Plastids	Holt, pp. 98–99
3–5	2	The Chemical Reactions of Photosynthesis	Holt, pp. 97–103

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

Living organisms carry out life processes in order to survive. (GLE 3.2)

CONTENT EXPECTATIONS

☐ 1. Plant cells carry out chemical transformations that use energy for the synthesis of organic compounds. (GLE 3.2.D *PR*)

☐ 2. The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means. (GLE 3.2.A)

☐ 3. The process of photosynthesis is necessary to the survival of most organisms on Earth. (GLE 3.2.B *PR*)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Scientific inquiry includes the ability to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 6. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Analyze how cells carry out chemical transformations that allow the conversion of energy from one form to another, the breakdown of molecules into smaller units, and the building of larger molecules from smaller ones. (Framework VII.B.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Use models to demonstrate various chemical transformations carried out by cells and apply this information to different contexts of everyday life. (Framework VII.B.1.a)

☐ 2. Investigate, observe directly or indirectly, and communicate to others the basic life processes that take place at a cellular level. (Framework VII.A.2.a)

☐ 3. Recognize energy is absorbed in the synthesis of organic compounds. (GLE 3.2.D.c *PR*)

☐ 4. Summarize how energy transfer occurs during photosynthesis (i.e., the storage of energy in the bonds of chemical compounds). (GLE 3.2.D.a *PR*)

☐ 5. Determine what factors affect the processes of photosynthesis (i.e., light intensity, availability of reactants, temperature). (GLE 3.2.B.c *PR*)

☐ 6. Explain how the function of the chloroplast is related to its structure. (GLE 3.2.A.a *PR*)

...for Standard 7

Demonstrate that science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

PERFORMANCE EXPECTATIONS

☐ 7. Design and conduct a valid experiment. (GLE 7.1.A.c)

☐ 8. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., microscopes, CBL system). (GLE 7.1.B.a)

☐ 9. Use qualitative and quantitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Chloroplasts: Photosynthetic Plastids Days 1–2	CE 2 PE 6	Display the Chloroplast B24 teaching transparency (Ch. 5) to discuss chloroplast structures and to review their functions. Have students sketch and label chloroplast structures and make a T-chart of chloroplast structures and their function. Show students electron micrographs of chloroplasts and point out interior structures. Have students compare the illustration to microscopic photographs. In pairs, have them identify some misconceptions that might arise from viewing only the illustration. (Goals 1.5, 1.8)
	CE 2, 5, 6 PE 6, 8, 9	**Technology:** Have students examine *Elodea* cells under a microscope and make sketches. Have students answer the following questions: 1) What is the shape of the chloroplasts? 2) Where are the chloroplasts located in the cell? 3) What structures enable you to identify *Elodea* cells as plant cells? 4) Why do these cells appear green? Explain that chloroplasts are a type of plant organelle called a plastid, used for storage; provide examples of other plastids that may hold different colored pigments or extra starches. Then have students create wet mounts of thin sections of potato and stain them with iodine. Students should then write observations of the plastids that store starch. (Goals 1.2, 1.4, 1.5, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Carry out the Demonstration on Holt *TE*, page 99 using small chocolate mints to represent a column of thylakoids.	Have students add important vocabulary terms for this section such as *stroma*, *thylakoids*, *grana*, *outer membrane*, and *inner membrane* to their glossary. (ELL-2)	Have students research the difference between the chlorophyll of plants and the light-capturing pigments of photosynthetic bacteria. Have them write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) about the pigments.
Have students build three-dimensional models of chloroplasts within a cell. Have them label the important structures inside the chloroplast.	Allow students to work in pairs to answer the questions. (ELL-5)	Have students research how scientists study cell structures using cell fractionation and prepare a written report.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
The Chemical Reactions of Photosynthesis Days 3–5	CE 1, 5, 6 PE 3, 4	**Day 3:** Have students complete a K-W-L chart (*ER*, p. RR-43) on the topic of photosynthesis. Discuss the experiments of Van Helmot, Priestly, Ingenhousz, and Senebier. Have students explain how each contributed to the current understanding of the process of photosynthesis. Review the equation for photosynthesis. Have students explain where the reactants come from and what happens to the products. Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-13) about how our knowledge of photosynthesis is the result of the work of many scientists over time. (Goals 1.8, 2.1, 3.4)
	CE 1, 5, 6 PE 2, 4, 8, 9	**Day 3/Hands-On Activity/Lab/Technology:** Present the overall reaction of photosynthesis. Have students translate it into words. Then have students complete the "Identifying a Product of Photosynthesis" Quick Lab (Holt, p. 101). A datasheet is available on Holt *Biology CRF 5: Photosynthesis and Cellular Respiration*, page 39. Have students explain how the data confirms the overall reaction of photosynthesis. (Goals 1.4, 4.1)
	CE 1, 2, 3 PE 1, 3, 4	**Day 3:** Make copies of Figure 4 on Holt, page 97 and have students work in pairs to write out what happens in stage 1, stage 2, and stage 3 based on their observations. Introduce and define the following terms: *autotrophs, photosynthesis, pigments, Calvin cycle, chlorophyll, chloroplasts, heterotrophs, light-dependent reactions, electron-transport chain, food, ATP, ADP, light, water,* and *carbon dioxide*. Then have students create a concept web (*ER*, p. RR-15) or sequencing map (*ER*, p. RR-77) with the terms. (Goals 1.5, 1.8, 2.1, 2.3, 4.6)
	CE 1, 4, 5, 6 PE 2, 5, 7, 8, 9	**Days 4–5/Hands-On Activity/Lab:** Have students work in groups to brainstorm a list of factors that would affect the rate of photosynthesis. Then have groups design and carry out an investigation of the relationship between light intensity and the rate of photosynthesis. They should determine the relationship between the distance from a light source and the rate of photosynthesis, measure and interpret data obtained, and make conclusions. *See Model Lesson.* (Goals 1.2, 1.3, 3.1, 3.5)
	CE 1, 4, 5, 6 PE 2, 5, 7, 8, 9	**Days 4–5/Hands-On Activity/Lab:** Have students work in groups to brainstorm a list of factors that would affect the rate of photosynthesis. Then have groups design and conduct an experiment to determine which factors limit the rate of photosynthesis when the light intensity remains constant. (Goals 1.3, 3.1, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Remind students of the law of conservation of energy. Have students count the number of atoms on each side of the photosynthesis equation. Have them confirm that it is a balanced equation.	Define the meanings of the prefixes, roots and suffixes, such as *photo-*, *-synthesis*, *chloros-*, and *-lysis*. Provide students with other examples of words that contain these roots. (ELL-2)	Discuss the use of radioactive isotopes to trace a particular molecule through a chemical reaction, and the research of C. B. van Niel concerning the chemical reactions of photosynthesis. Information can be found at www.biojourney.org/photosynthesis.htm.
Set up the CBL systems or other probeware prior to class. Students should begin the lab with Step 2.	Demonstrate the procedure of the lab step by step. Rephrase instructions if necessary. (ELL-4)	Have students determine a best-fit line for the data and write a mathematical formula for it.
Divide the class into three groups. Have each group discuss chloroplasts, the light reactions, or the Calvin cycle. Give each group time to prepare a short report to be presented by one member of the group.	Have students create graphic organizers to explain the reactants and products of each step. (ELL-2)	Have students analyze the intermediate reactions of photosynthesis.
Before conducting the experiment, have students list three factors that would increase the rate of photosynthesis. Have them identify what stage of photosynthesis each factor would affect.	Have students complete the Active Reading Skills Worksheet (Holt *Biology CRF 5: Photosynthesis and Cellular Respiration*, pp. 9–10). (ELL-2)	Have students design and carry out an experiment examining how the concentration of sodium hydrogen carbonate solution influences the rate of photosynthesis in an aquatic plant.
Review the function of enzymes and factors affecting their function from Unit 4 Section 3.	Brainstorm a list of factors that would affect the rate of photosynthesis as a class. As a class, develop a list of testable questions based on the list of factors affecting the rate of photosynthesis. Have groups design and conduct their experiment based on one of these testable questions. (ELL-4)	Have students target one of the intermediate reactions in their experiment.

Additional Resources

1. **Curriculum Resources**
   Holt *Biology CRF 5: Photosynthesis and Cellular Respiration*, pp. 9–10, 39
   Educational Resources, pp. RR-15, RR-43, RR-77
   Step Up to Writing, pp. 3-3 through 3-13, 3-21 through 3-29

2. **Internet Resources**
   Electron Micrograph of a Chloroplast
   www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=stryer.figgrp.2835
   Introduction to Photosynthesis
   http://web.mit.edu/esgbio/www/ps/intro.html
   Photosynthesis
   www.biojourney.org/photosynthesis.htm
   van Helmont's Mass
   www2.nsta.org/energy/find/lessons/934/934tb3.html
   Photosynthesis: Discovery Milestones
   www.juliantrubin.com/bigten/photosynthesisexperiments.html

3. **Multicultural Resources and/or Activities**
   Different cultures rely upon different plant sources as the staple of their diets. For example, corn was the staple of many Native American cultures. Have students conduct research and prepare presentations on a specific culture from various regions of the world and its staple plant. Have students describe all the different ways the plant was used (e.g., food, shelter, clothing, religious ceremonies).

Suggested Assessments

1. Have students write a brief essay on the importance of light in the photosynthetic process. Instruct students to name the substances and structures involved in photosynthesis and compare the steps in photosynthesis that require light with those that do not.
2. Have students describe the events of photosynthesis from the perspective of one of the carbon atoms in a carbon dioxide molecule.
3. Have students identify two environmental factors that affect the rate of photosynthesis and explain why they affect it.

Sample Constructed-Response Item

Make a table that identifies the role of each of the following in photosynthesis: light, water, ATP, and carbon dioxide.

REACTANT	ROLE
Light	*Excites electrons*
Water	*Provides hydrogen ions and electrons*
ATP	*Stores chemical energy*
Carbon dioxide	*Used to make organic compounds like glucose*

Model Lesson (Block Roster):

The Chemical Reactions of Photosynthesis: Investigation into Light Intensity

Lesson Question

What is the relationship between the intensity of light and photosynthesis?

Materials

Elodea, water, graduated cylinders, large test tubes, ring stands, clamps, lamps, foil, rulers, safety goggles, disposable gloves, copies of the Photosynthesis Investigation worksheets that follow the Model Lesson

Content and Performance Expectations

CE 1, 4, 5, 6; PE 2, 5, 7, 8, 9

Teacher's Notes

This investigation should be completed after students conduct the "Identifying a Product of Photosynthesis" Quick Lab (Holt, p. 101).

Warm-Up

Factors Affecting Photosynthesis

- In groups, have students brainstorm a list of factors that might affect the rate of photosynthesis. Have them identify which stage of photosynthesis each factor would affect.
- Have groups share their ideas with the class. Explain that they will conduct an experiment to test the affect of light intensity on photosynthesis.

Instruction

Photosynthesis Investigation

▶ Pre-Lab Questions	▷ Have students answer the Pre-Lab questions and then discuss their answers with their groups. ▷ Review answers to the Pre-Lab questions.
▶ Conducting the Investigation	▷ Discuss the introduction and procedure with students. ▷ During the investigation, circulate around the classroom to assist students.
▶ Wrap-Up	▷ Have each group announce their results to make a class histogram. Have students design a class data chart on the back of one of the lab pages. ▷ Have students record the data, make graphs on graph paper, analyze the results, and answer the Results questions.

Assessment

- Have students write a paragraph that explains how the rate of photosynthesis is affected by light intensity and why the rate of photosynthesis increases with light intensity only to a certain point.

Homework Assignment

- Have students answer the Extension questions.

Teaching Resources

- Holt, p. 103

name ______________________ date ____________

PHOTOSYNTHESIS INVESTIGATION:
How does distance from a light source affect the rate of photosynthesis?

Pre-Lab Questions

Write the overall reaction of photosynthesis.

____

Translate the reaction to words.

____

____

Where does the oxygen that is released as a result of photosynthesis come from?

____

Why do we use a control when conducting an experiment?

____

____

Introduction

In this investigation, we will examine the effect of light intensity on photosynthesis. Oxygen is one of the end products of photosynthesis and visible bubbles of oxygen are produced by aquatic plants as they perform photosynthesis. We will determine the rate of photosynthesis performed by *Elodea* by measuring the rate of oxygen bubbles produced. The question of the investigation is, "What is the relationship between the intensity of light and photosynthesis?"

Hypothesis:

____

Materials Needed

4 equal sprigs of *Elodea*, water, graduated cylinder, 4 large test tubes, ring stand, clamp, lamp, foil, ruler, safety goggles, disposable gloves, distilled water, sodium bicarbonate

name ______________________ date ____________

Procedure

1. Use the graduated cylinder to fill each test tube with distilled water to approximately 4 cm from the top. Label one tube with each of the following: Dark, 5 cm, 10 cm, and 15 cm.
2. Draw a chart for recording the data below. Observations will be recorded as bubbles per minute.
3. Place a 0.5 cm-sprig of *Elodea* in the Dark test tube. Record observations and wrap in foil.
4. Using the clamp and ring stand, position the 5-cm test tube 5 cm away from the lamp. Add a sprig of *Elodea* and record observations. Repeat for the other two test tubes, placing them 10 cm and 15 cm away from the lamp.
5. Count the number of bubbles given of by each plant for five minutes. Calculate the average per minute.
6. Using the data create a graph (distance from light should be on the *x*-axis).

Data

Results

Summarize the relationship between the intensity of light and photosynthesis. Include two supporting examples in your summary.

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____

Explain how the number of bubbles relates to the rate of photosynthesis.

____

____

name ______________________ date __________

List other factors that may affect the rate of photosynthesis.

Explain why the Dark test tube was used.

List one extension question.

Identify one possible source of error.

Extensions

Choose another factor that might affect the rate of photosynthesis, formulate a testable question, and design another experiment to test the question.

Explain how a gardener or farmer might apply the information obtained from this investigation.

Some plants grow well in dim light while others prefer full sun. Suggest a possible reason for this.

Unit 7 Section 3

CELLULAR RESPIRATION

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	The Chemical Reactions of Cellular Respiration	Holt, pp. 104–107
3–4	2	Anaerobic Respiration	Holt, pp. 108–110
5–6	3	Rates of Respiration and Photosynthesis	Holt, p. 103

BENCHMARK ASSESSMENT 3—WEEK OF FEBRUARY 12

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

Living organisms carry out life processes in order to survive. (GLE 3.2)

CONTENT EXPECTATIONS

☐ 1. The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means. (GLE 3.2.A)

☐ 2. Photosynthesis and cellular respiration are complementary processes necessary to the survival of most organisms on Earth. (GLE 3.2.B)

☐ 3. Cells carry out chemical transformations that use energy for the synthesis or breakdown of organic compounds. (GLE 3.2.D)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Scientific inquiry includes the ability to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 6. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO...

...for Standard 3

Investigate, observe directly or indirectly, and communicate to others the basic life processes that take place at a cellular level. (Framework VII.A.2.a)

PERFORMANCE EXPECTATIONS

☐ 1. Compare and contrast the structure and function of mitochondria and chloroplasts. (GLE 3.2.A.a)

☐ 2. Compare and contrast photosynthesis and respiration reactions. (GLE 3.2.B.a)

☐ 3. Explain the interrelationship between the processes of respiration and photosynthesis. (GLE 3.2.B.b)

☐ 4. Determine what factors affect the processes of photosynthesis and cellular respiration (i.e., light intensity, availability of reactants, temperature). (GLE 3.2.B.c)

☐ 5. Summarize how energy transfer occurs during photosynthesis and respiration (i.e., the storage and release of energy in the bonds of chemical compounds). (GLE 3.2.D.a)

...for Standard 7

Demonstrate that science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 6. Formulate testable questions and hypotheses. (GLE 7.1.A.a)

☐ 7. Design and conduct a valid experiment. (GLE 7.1.A.c)

☐ 8. Make qualitative and quantitative observations using the appropriate senses, tools and equipment to gather data (e.g., microscopes, CBL system). (GLE 7.1.B.a)

☐ 9. Use qualitative and quantitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

☐ 10. Evaluate the design of an experiment and make suggestions for reasonable improvements. (GLE 7.1.A.g)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
The Chemical Reactions of Cellular Respiration Days 1–2	CE 1, 2, 3 PE 1, 2, 3, 5	Burn a cube of sugar, observing fire safety precautions. The demonstration may require burning some paper before it will begin. A sugar packet can be used. Explain that the reaction releases CO_2, H_2O, and a lot of energy. Discuss similarities and differences between the demonstration and the process of aerobic cellular respiration. Have students provide the chemical equation for photosynthesis and explain that the process of aerobic cellular respiration is summarized in the reverse reaction. Have students translate the chemical equations to word equations. Display the Mitochondrion B12 teaching transparency (Ch. 3) and identify the structures inside it. Have students complete the Folding of the Inner Membrane activity. In pairs, students should then compare and contrast mitochondrion and chloroplast structure and function. *See Model Lesson*. (Goals 1.6, 2.3, 3.5)
	CE 3 PE 5	Have students read Holt, page 104. Have them create flowcharts to outline what happens during Stages 1 and 2 of cellular respiration in their notebooks. Use the Cellular Respiration B53 teaching transparency (Ch. 5) to walk students through cellular respiration. In groups, have students create a chart to summarize each stage of respiration that includes where it occurs, relative levels of ATP production, whether it requires oxygen, and a sentence that explains what happens overall. (Goals 1.8, 2.1)
	CE 1, 2, 3, 5, 6 PE 1, 2, 3, 5, 8, 9	**Days 1–2/Hands-On Activity/Lab/Technology:** Have students provide the chemical equation for photosynthesis and explain that the process of aerobic cellular respiration is summarized in the reverse reaction. Have students translate the chemical equations to word equations and identify where in the the cell each process takes place. Have students complete the Day 1 Procedure and Day 2 Procedure of the Plants and Animals Interrelationships Lab (Holt *Biology CRF 5: Photosynthesis and Cellular Respiration,* pp. 45–50). The lab is designed for use with a TI CBL system and will have to be adjusted for use with other types of probeware. (Goals 1.4, 1.8)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students color code the equations for photosynthesis and aerobic cellular respiration, using a different color for each substance (e.g., blue for water, red for carbon dioxide).	Have students make labeled diagrams of the mitochondrion and its internal structures and then use their diagrams of a chloroplast from the previous section to compare and contrast their structures. (ELL-2)	Have students design and carry out a demonstration that shows that respiration occurs in germinating peas or beans. Have students make presentations to the class explaining their results and conclusions.
Provide students with unlabeled diagrams of the two stages of respiration. Have them fill in the labels as you go over the process.	List different pairs of terms, such as *glucose* and *pyruvate*, *aerobic* and *anaerobic*, and *glycolysis* and *cellular respiration*. Have students explain how the paired terms are related to each other. (ELL-5)	Have students read Holt, pages 104–106 instead of only page 104.
Set up the CBL systems prior to class. Students should begin the lab with Step 7.	Demonstrate the procedure of the lab step by step. Rephrase instructions if necessary. (ELL-4)	Have students complete Extensions #1 simultaneously.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Anaerobic Respiration Days 3–4	CE 3, 5, 6 PE 5, 8, 9	Have students work in groups to brainstorm a list of foods and beverages that use fermentation. Set up the Demonstration on Holt *TE*, page 109 of yeast, water, and bromothymol blue. Then for a separate demonstration, combine a separate yeast culture with fruit juice in one beaker and put plain fruit juice in another beaker. Have students record observations of appearance and smell for both demonstrations at ten-minute intervals. Based upon the demonstrations, have students identify the products of fermentation. As a class, examine Figure 16 on Holt *TE*, page 110. Have students summarize the steps in their notebooks and then write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) about aerobic and anaerobic cellular respiration. (Goals 1.5, 1.6, 2.1)
	CE 3, 5, 6 PE 5, 8, 9	**Hands-On Activity/Lab/Technology:** Explain the steps of alcoholic and lactic acid fermentation using Figure 15 on Holt, page 108. Obtain a drop of yeast culture and prepare wet mounts. Have students observe it under low and high power. Have students look for budding yeast and sketch what they see. Have them explain the relationship between the process of fermentation and yeast reproduction. (Goals 1.4, 3.5)
	CE 3, 4, 5, 6 PE 4, 6, 7, 8, 9, 10	**Hands-On Activity/Lab:** Have students complete the Conditions that Favor Cellular Respiration Inquiry Lab (Holt *Biology CRF 5: Photosynthesis and Cellular Respiration*, pp. 51–56). (Goals 1.2, 1.3, 1.6, 1.8)
Rates of Respiration and Photosynthesis Days 5–6	CE 3, 4, 5, 6 PE 4, 6, 7, 8, 9	**Hands-On Activity/Lab:** Have students investigate the question, “How does exercise affect cellular respiration?” Provide students with test tubes, bromothymol blue (BTB), straws, and a watch. Have them work in pairs to make a prediction about how exercise will affect the body’s production of CO_2. Then have them fill 2 test tubes with 10 mL of water and a few drops of BTB. One student will blow consistently through the straw into the bottom of one test tube while the other times how long it takes to change color to yellow. Then they should decide what kind of exercise will be performed and determine the amount of time it takes to blow into the other test tube and see a color change after exercise. Have them experiment with different amounts of time and/or different types of exercise. Have students analyze results, make conclusions, and share the results with the class. (Goals 1.2, 1.3, 1.6, 4.5)
	CE 2, 4, 5, 6 PE 3, 4, 6, 7, 8, 9	**Hands-On Activity/Lab:** Provide students with *Elodea*, pond snails, beakers, pond water, bromothymol blue (BTB), and plastic wrap. Have them design and carry out a lab to demonstrate the complementary relationship between photosynthesis and respiration. Have them brainstorm a list of factors that may affect the rates of respiration and/or photosynthesis. Then have them design an experiment to determine how one of these factors will affect the results. (Goals 1.3, 2.3, 3.1, 3.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Provide students with unlabeled diagrams of glycolysis, alcoholic fermentation, and lactic acid pathways. Have them fill in products and reactants of the processes.	Perform the Reteaching on Holt *TE*, page 110. (ELL-8)	Have students design and carry out an experiment about the effects of sweeteners on carbon dioxide production by yeast. Have available various sweeteners, such as table sugar, corn syrup, molasses, honey, saccharine, and aspartame. Remind students to set up a control. Have students analyze the data and draw conclusions. Discuss the outcome and results.
Have students complete a Venn diagram (*ER*, p. RR-83) comparing alcoholic and lactic acid fermentation.	Perform the Identifying Preconceptions activity on Holt *TE*, page 104. (ELL-3)	Have students research the intermediate reactions of alcoholic and lactic acid fermentation.
In groups or as a whole-class discussion, students should discuss possible hypotheses and procedures for carrying out this experiment.	When introducing the lab, have samples of all the materials available and demonstrate some possible experimental setups. (ELL-4)	Have students use the Internet to look up songs about respiration and fermentation, such as "Come on Down (the Electron Transport Chain)" at http://faculty.washington.edu/crowther/Misc/Songs/comeon.shtml or "Glucose, Glucose" at http://faculty.washington.edu/crowther/Misc/Songs/glucose.shtml. Have them work in groups *to* create their own songs or poems about aerobic and anaerobic respiration.
Review the importance of conducting a controlled experiment. Have students identify all the variables that will be controlled in their experiment to confirm that only one variable will be allowed to vary.	Provide students with alternate assessment activities such as making diagrams or writing in a journal. (ELL-7)	Tell students that CO_2 reacts with water to form carbonic acid and water will become more acidic if more CO_2 is added. Explain to students that an acidic solution can be neutralized by a base, such as sodium hydroxide. Phenolphthalein is an indicator that is pink in a basic solution and colorless in an acidic solution. Have students design an experiment using these materials to measure the amount of CO_2 produced before and after different types of exercise.
Have students make a table to summarize the similarities and differences between photosynthesis and respiration.	Have students complete the Energy and Living Things Active Reading Skills Worksheet (Holt *Biology CRF 5: Photosynthesis and Cellular Respiration*, pp. 7–8). (ELL-2)	Have students write fictional stories using the Quick Sketch Method (*SUTW*, pp. 6-2 through 6-16) about a future when all photosynthesis ceases to occur. Have students develop a scenario where photosynthesis is unable to occur and then they should explain how all life on Earth, including humans, would be affected.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 5: Photosynthesis and Cellular Respiration*, pp. 1–2, 7–8, 45–56

   Educational Resources, p. RR-83

   Step Up to Writing, pp. 3-21 through 3-29, 6-2 through 6-16

2. **Internet Resources**

   Analysis for Carbon Dioxide using a Titration with a Phenolphthalein Indicator and a Standard Sodium Hydroxide Solution
   http://services.juniata.edu/ScienceInMotion/chem/labs/hach/co2.doc

   Yeast Fermentation Labs
   www.zoo.utoronto.ca/able/volumes/vol-19/8-pigage.pdf

3. **Multicultural Resources and/or Activities**

   Fermentation is used to make many familiar food products, such as cheese, kimchi, soy sauce, and sauerkraut. These foods are a part of American culture contributed by diverse ethnic groups. Discuss which groups contributed these foods to American cuisine.

Suggested Assessments

1. Have students write a Compare and Contrast paragraph (*SUTW*, pp. 3-21 through 3-29) about anaerobic and aerobic respiration in terms of reactants used, energy production, products formed, where reactions occur, and efficiency.
2. Provide students with a list of the following terms: *alcoholic fermentation, ATP cycle, Calvin cycle, electron transport, glycolysis, Krebs cycle, lactic acid fermentation,* and *light-dependent reactions*. Have students identify which of these processes takes place during photosynthesis, aerobic respiration, and anaerobic respiration.
3. Have students explain how autotrophs and heterotrophs depend on each other for materials to survive.
4. Have students use a diagram of a mitochondrion to create a flowchart that indicates where each stage of cellular respiration (glycolysis, Krebs cycle, and electron transport chain) occurs. Have them explain why each stage occurs in different locations.

UNIT 7 SECTION 3

Sample Constructed-Response Item

Explain why cellular respiration is considered a more effective use of glucose than anaerobic respiration.

Cellular respiration can produce up to 36 ATP molecules for each glucose molecule, while glycolysis can only produce 2 ATP for each glucose molecule.

Model Lesson (Traditional Roster): *The Chemical Reactions of Cellular Respiration*

Lesson Questions

What happens during the process of cellular respiration?

What is the relationship between respiration and photosynthesis?

How is the mitochondrion adapted to carry out cellular respiration?

Materials

Mitochondrion B12 teaching transparency (Ch. 3), copies of the Folding of the Inner Membrane activity sheet

Content and Performance Expectations

CE 1, 2, 3; PE 1, 2, 3, 5

Teacher's Notes

Since students often confuse respiration with breathing, be sure to explain that we breathe in order to get oxygen so that our cells can perform respiration. The demonstration may require burning some paper before it will begin. A sugar packet can be used.

Warm-Up

Demonstration

- Burn a cube of sugar, observing fire safety measures, and have students explain what is happening.
- Explain that the reaction releases CO_2, H_2O, and a lot of energy.
- Have students explain how this demonstration is similar to and different from how the body burns glucose during cellular respiration. Point out that in aerobic respiration, the same overall process occurs more slowly and under controlled conditions and the energy released is used to make ATP molecules.

Instruction

Introduction to Cellular Respiration

▶ Aerobic vs. Anaerobic Cellular Respiration	▷ Ask students why we need oxygen to live. Explain that we are aerobes because we require oxygen to release the energy in food (aerobic cellular respiration). ▷ Explain that not all organisms require oxygen. Some organisms can perform anaerobic cellular respiration in the absence of oxygen. Have students list examples of anaerobes and where they might live. ▷ Clear up two important misconceptions about respiration: Remind students that plants must perform cellular respiration as well. Have students explain why. Then ask students if respiring is the same thing as breathing. Explain how they are different.
▶ The Relationship between Photosynthesis and Aerobic Cellular Respiration	▷ Have students provide the equation for photosynthesis and explain that the process of aerobic cellular respiration is summarized in the reverse reaction. Have them describe what happens in the reaction and translate it to a word equation. ▷ Ask students where the energy in the product side of the respiration reaction came from. Have them determine the original source of energy. ▷ Explain that respiration and photosynthesis are considered complementary processes. Have students explain why, and how this illustrates that autotrophs and heterotrophs depend on each other for survival. ▷ Elicit from students where respiration occurs in a eukaryotic cell.

- **The Structure of the Mitochondrion**
  - Display the Mitochondrion B12 teaching transparency (Ch. 3) and identify the structures inside it.
  - Have students sketch a mitochondrion and label its parts.
  - Explain that mitochondria can be shaped like spheres, rods, sausages, or threads. Point out that the folds (cristae) of the inner layer project into the interior of the mitochondrion. Tell students that enzymes needed for cellular respiration are organized along these folds. Ask students why the inner membrane is folded.
  - Distribute the Folding of the Inner Folding activity sheet. Instruct students to cut out the three strips of paper representing the inner membrane.
  - Have them arrange the first strip inside the mitochondrion, sketch the arrangement, make observations, and calculate the surface area of the inner membrane. They should fill in the chart.
  - Have students repeat these steps with the two other strips before answering the questions.
  - Discuss observations and answers to the questions. Emphasize the advantages of increased surface area. Have students relate this idea to the fact the smaller cells have greater surface area than larger ones.

Assessment

- Have students write a Compare and Contrast paragraph (*SUTW*, pp. 3-21 through 3-29) about the reactions of photosynthesis and respiration and where they occur in cells.

Homework Assignment

- Have students complete the Energy and Living Things Directed Reading Skills Worksheet (Holt *Biology CRF 5: Photosynthesis and Cellular Respiration*, pp. 1–2).

Teaching Resources

- Holt, pp. 94–95

activity sheet

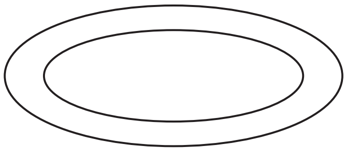
name ____________________ date __________

Folding of the Inner Membrane

	CASE 1	CASE 2	CASE 3
Sketch			
Observations			
Surface Area of the Inner Membrane			

UNIT 7 SECTION 3

name ______________________ date ____________



Mitochondrion

Case 1 Inner Membrane

Case 2 Inner Membrane

Case 3 Inner Membrane

Which case yielded the greatest surface area?

____

Which case resembles the real structure of a mitochondrion?

____

What are some advantages of a large surface area?

____

____

What is the connection between the structure and function of the inner membrane of a mitochondrion?

____

____

Unit 8 Genetic Processes

- Why do some organisms reproduce sexually and others reproduce asexually?
- How are characteristics passed from parents to offspring?
- Why are children both similar to and different from their parents and siblings?

Scope and Sequence, page 21
Lesson Planning Material, pages 327–375

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

UNIT 8

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

Unit 8 Section 1

CELL REPRODUCTION

UNIT 8 SECTION 1

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Chromosomes	Holt, pp. 118–124
3	2	The Cell Cycle	Holt, p. 125
4–5		The Stages of Mitosis	Holt, pp. 128–132
6	3	Cancer and Control of the Cell Cycle	Holt, pp. 126–127

BENCHMARK 3 REVIEW, REMEDIATION, AND ENRICHMENT—3 DAYS

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. (GLE 3.3)

CONTENT EXPECTATIONS

☐ 1. Chromosomes are the components of cells that occur in pairs and carry hereditary information from one cell to daughter cells and from parent to offspring during reproduction. (GLE 3.3.C)

☐ 2. Mitosis occurs in four distinct phases: prophase, metaphase, anaphase, and telophase. (GLE 3.3.C.a *PR*)

☐ 3. Changes in chromosome number or structure can affect the development of an organism. (Framework VII.D.3 *PR*)

☐ 4. The cell cycle is a controlled sequence of growth and division of a cell. (GLE 3.3.B PR)

UNIT 8 SECTION 1

...for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 6. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Explain that cells have distinct and separate structures that perform and monitor processes essential for the survival of the cell and/or organism, such as cell replication. (Framework VII.A.2)

PERFORMANCE EXPECTATIONS

- ☐ 1. Recognize the chromosomes of daughter cells, formed through the processes of asexual reproduction and mitosis, the formation of somatic (body) cells in multicellular organisms, are identical to the chromosomes in daughter cells. (GLE 3.3.C.a)
- ☐ 2. Investigate, observe directly or indirectly, and communicate to others the basic life processes that take place at the cellular level. (Frameworks VII.A.2.a)
- ☐ 3. Identify the implications of human sex chromosomes for sex determination. (GLE 3.3.C.d)
- ☐ 4. Summarize the events of the four stages of mitosis. (GLE 3.3.C.a *PR*)
- ☐ 5. Identify the major events that characterize the cell cycle. (GLE 3.3.C.a *PR*)

...for Standard 7

Demonstrate that science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 6. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., microscopes). (GLE 7.1.B.a)
- ☐ 7. Use qualitative and quantitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Chromosomes Days 1–2	CE 1 PE 1	**Day 1:** Have students brainstorm a list of reasons why cell division is necessary. Draw a concept web (*ER*, p. RR-15) on the board with the term *cell division* in the center. Have students read information about cell division on Holt, pp. 118–119, and have them complete the concept map with terms and phrases such as *reproduction*, *growth*, *gamete*, *DNA*, *binary fission*, *genes*, and *chromosomes*. Define the terms *chromosome*, *gene*, *chromatids*, and *centromere*. Working in groups, students should use different colored pipe cleaners to demonstrate the concepts of chromosome, gene, DNA, chromatid and centromere. In their notebooks, they should define each term and sketch a picture of their model. *See Model Lesson*. (Goals 1.5, 1.8, 2.1, 4.6)
	CE 3 PE 3	**Day 2:** Draw a large diagram of a homologous pair of chromosomes. Use different colored dots to indicate the locations of the same genes (alleles) such as eye color or hair color on each chromosome. Explain that most body (somatic) cells contain both chromosomes in the pair, but that cells used in reproduction (gametes) contain only one copy. Display male and female karyotypes. Have students describe how the two karyotypes are different. Discuss the role of the sex chromosomes in humans in sex determination. Have students explain how a karyotype can be used to determine sex before birth. Have students read the section entitled "Prenatal Testing" (Holt, p. 123). Discuss chromosomal disorders such as Klinefelter syndrome (XXY) or a female with three X chromosomes. Have students hypothesize about what might have occurred during the cell cycle to produce these chromosomal disorders. Have students discuss the advantages and disadvantages of prenatal testing for chromosomal disorders. (Goals 1.10, 2.3)
	CE 3 PE 3	**Day 2/Hands-On Activity/Lab:** Display the Karyotype B45 teaching transparency (Ch. 8). Discuss what a typical karyotype is and how it is prepared. Display male and female karyotypes. Have students describe how the two karyotypes are different. Discuss the role of the sex chromosomes in humans in sex determination. Have students complete the Karyotypes Activity (Holt *TE,* p. 121). Provide students with additional examples of karyotypes with chromosomal aberrations. Have them identify the chromosomal aberrations. Discuss chromosomal disorders such as trisomy and monosomy. Human karyotypes for teaching can be found at http://worms.zoology.wisc.edu/zooweb/Phelps/karyotype.html. Discuss how changes in chromosome structure can lead to changes in DNA. Have students complete the "Modeling Chromosomal Mutations" Quick Lab (Holt, p. 124). (Goals 1.5, 1.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students take Two-Column Notes (*SUTW*, pp. 9-1 through 9-15) as they read Holt, pp. 118–119.	Give students different pairs of terms, such as *gene and DNA*, *chromosome and chromatid*, and *gene and chromosome*, and have them explain how the paired terms are related to each other. (ELL-6)	Have students research to find information on plant hormones that stimulate cell division, such as cytokinins and gibberellins, especially in roots.
Display the Chromosome Number of Various Organisms B44 teaching transparency (Ch. 8). Have students determine the haploid number for each organism.	Explain that the prefix *hapl-* means "single" and *dipl-* means "double." Have students relate the prefixes to the algebraic terms n and $2n$. (ELL-3)	Have students research Barr bodies and ideas about their function.
Have students create questions on note cards about the different types of chromosomal aberrations and mutations. Have them write the answers to the questions on the back of the cards and then pair up and quiz each other.	Have students make labeled drawings of each type of chromosomal mutation. Have them draw and label a picture of how nondisjunction occurs. (ELL-7)	Have students conduct a debate (*ER*, p. PTT-9) about the pros and cons of genetic testing.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
The Cell Cycle Day 3	CE 1, 4 PE 2, 5	Tell students that the cell cycle of an actively dividing human skin cell is approximately 20–24 hours. Have students calculate how many cells there would be in one week from a skin cell with a 20-hour cell cycle. Have students discuss why some cells would proceed through the cell cycle faster or slower than others. Have students read Holt, p. 125. In pairs, have students create a T-chart to explain what happens in each phase of the cell cycle. Then have students write a Quick Sketch Story (*SUTW*, pp. 6-2 through 6-16) about the life of a cell as it passes through the stages of the cell cycle, highlighting the checkpoints that precede major life changes. (Goals 1.8, 1.10, 3.5)
	CE 1, 4 PE 2, 5	**Technology:** Have students copy Figure 6 on Holt, p. 125, into their notebooks. Have students watch an animation of the cell cycle, such as the one at www.cellsalive.com/cell_cycle.htm, and take notes on their diagram about what happens during each stage. Have students discuss what characterizes each stage of the cell cycle. Have students complete the Cell Cycle Active Reading skills worksheet (Holt *Biology CRF 6: Chromosomes and Cell Reproduction*, pp. 9–10). (Goals 1.5, 2.3)
The Stages of Mitosis Days 4–5	CE 1, 2, 4, 5, 6 PE 1, 2, 4, 6, 7	**Hands-On Activity/Lab/Technology:** Have students complete the Mitosis Exploration Lab (Holt *Biology CRF 6: Chromosomes and Cell Reproduction*, pp. 49–52). After completing the lab have students write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) about plant and animal cell mitosis. Display the Stages of Mitosis B47 teaching transparency (Ch. 6) with the descriptions at the top of the transparency covered. Have students summarize the important features of each of the stages. Uncover the descriptions on the transparency and have students compare their responses to its descriptions. (Goals 1.3, 1.4, 2.1)
	CE 1, 2, 4, 5, 6 PE 1, 2, 4, 6, 7	**Hands-On Activity/Lab/Technology:** Have students complete the Observing Mitosis and Cytokinesis Quick Lab (Holt, p. 132). Datasheets are available on Holt *Biology CRF 6: Chromosomes and Cell Reproduction*, pp. 43–44. Students should also determine the relative duration of each phase of mitosis by first counting the total number of cells in the field of view and then counting the number of cells in interphase and each phase of mitosis. The average percentage of time spent in each phase can be determined by dividing the number of cells in each phase by the total number of cells in the field of view and multiplying by 100. Have students create pie graphs to illustrate the percentage of time spent in each phase. (Goals 1.3, 1.6, 1.8)
	CE 1, 3 PE 1, 2	**Hands-On Activity/Lab:** Have students read Holt, pp. 130–132, and take Two-Column Notes to Read Textbooks (*SUTW*, pp. 9-32 through 9-36). Make copies of unlabeled photomicrographs of cells in the different stages of mitosis. Have students work in groups to identify the stages, arrange them in the correct order, and write explanations of what occurs in each phase. Have students then complete the Modeling Mitosis Exploration Lab (Holt, pp. 136–137). Datasheets are available on Holt *Biology CRF 6: Chromosomes and Cell Reproduction*, pp. 45–48. After the models have been constructed, have groups test the accuracy of their models by asking other classmates to identify the stages represented by the model. If any stages prove hard to identify from the models, have students revise the models to make them clearer. (Goals 1.8, 1.10, 2.5, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Prepare a worksheet of the cell cycle with the stages scrambled. Have students number the stages in proper sequence and label each.	Have students complete the Cell Cycle Directed Reading worksheet (Holt *Biology CRF 6: Chromosomes and Cell Reproduction*, p. 3). (ELL-6)	Have students conduct research about kinases and cyclins, which are enzymes that regulate the passage of cells through cell cycle checkpoints.
Have students complete Cell Cycle Phases Group Activity (Holt *TE*, p. 126).	Have students make a graphic organizer that summarizes the events of the cell cycle. (ELL-6)	Have students research how long each stage of the cell cycle lasts for different species and report their findings to the class.
Have students make a T-chart of the phases of mitosis and what occurs in each. Have students complete the Sequencing Science Skills Worksheet on Holt *Biology CRF 6: Chromosomes and Cell Reproduction*, pp. 15–16.	Give groups of students cut out diagrams of a cell in different stages of mitosis. Have students place them in order and explain what is happening in each diagram. (ELL-5)	Have students *compare* and *contrast* spindle formation during mitosis in plant and animal cells.
Review with students how to construct pie graphs and to determine the size of each "slice" using a protractor or computer program.	Before doing the lab, show students photomicrographs of cells in the different phases of mitosis. Have students identify each stage and explain what is occurring. (ELL-1)	Have students complete the Preparing a Root Tip Squash Skills Practice Lab instead (Holt *Biology CRF 6: Chromosomes and Cell Reproduction*, pp. 53–58).
Have students make flashcards with a stage of mitosis on one side and a drawing of the stage on the other side.	Show students animations of mitosis, such as the one found at www.cellsalive.com/mitosis.htm, to explain what occurs during each stage of the process. (ELL-2)	Have students compare the process of mitosis to other processes of cell division (e.g., binary fission).

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Cancer and Control of the Cell Cycle Day 6	CE 4 PE 5, 7	In pairs, have students fill in the first two columns of a K-W-L chart (*ER,* p. RR-43) about cancer. Have students read Holt, p. 127 and add to the L column of the chart. Have students read Holt, p. 126 and use sticky notes to ask questions about the reading. Have students explain how cancer might affect the checkpoints of the cell cycle. Read aloud the second paragraph on Holt, p. 127. Define the term *mutagen* and have students brainstorm a list of known and possible mutagens. Have students research one known or possible cause of cancer. The "Cancer and the Environment" booklet published by the National Cancer Institute (NCI) and the National Institute of Environmental Health Sciences available at www.cancer.gov/images/Documents/5d17e03e-b39f-4b40-a214-e9e9099c4220/Cancer%20and%20the%20Environment.pdf may be helpful. Have students discuss behaviors and strategies that may be helpful in avoiding cancer and then complete the L column of their K-W-L chart. (Goals 1.5, 3.5, 4.7)
	CE 4, 6 PE 2, 5, 7	**Technology:** Ask students why cancer is called a disease of the cell cycle and write a Free Response (*SUTW,* p. 8-8). Then have students watch animations on the cell cycle and cancer, such as those found at http://science.education.nih.gov/supplements/nih1/cancer/activities/activity2_animations.htm, and take notes. Have students revise their Free Response and share their original and revised versions. Display a transparency of Figure 7 on Holt, p. 126. Have students explain how cancer might affect the checkpoints shown. Have them create public service announcements to teach the public about cancer, including the role of mutagens. (Goals 1.5, 1.8, 2.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students complete the Reteaching activity on Holt *TE*, p. 127 and then explain how cancer would affect their graphic.	Have students examine a list of terms related to *mutagen*, such as *mutation* and *mutant*. Explain how the terms are similar and how they are different. (ELL-2)	Have students independently read Holt, p. 127 in its entirety.
Replay animations that students are having difficulty understanding.	Have students take Two-Column Notes (*SUTW*, pp. 9-1 through 9-15) while watching the animations. Encourage the use of drawings as well as terms in the Two-Column Notes. (ELL-7)	Have students investigate the role of telomeres in regulating the number of times a cell can pass through the cell cycle and the programmed death of the cell.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 6: Chromosomes and Cell Reproduction,* pp. 3, 15–16, 43–58

   Educational Resources, pp. PTT-9, RR-15, RR-43

   Step Up to Writing, pp. 3-3 through 3-13, 3-21 through 3-29, 6-2 through 6-16, 8-8, 9-1 through 9-15, 9-32 through 9-36

2. **Internet Resources**

   Access Excellence Graphics Gallery: Chromosomes and Cell Division
   www.accessexcellence.org/RC/VL/GG/index.html#Anchor-Chromosomes-23240

   Plant Hormones and Growth Regulators
   http://extension.oregonstate.edu/mg/botany/hormones.html

   Mitosis Animations
   www.johnkyrk.com/mitosis.html
   www.cellsalive.com/mitosis.htm

   The Cell Cycle Proteins
   www.ndsu.nodak.edu/instruct/mcclean/plsc431/cellcycle/cellcycl1.htm

   National Cancer Institute
   www.cancer.gov

   NIH Curriculum Supplement Series: Cell Biology and Cancer
   http://science.education.nih.gov/supplements/nih1/cancer/default.htm

   Ask a Scientist (Centriole function in mitosis)
   www.hhmi.org/cgi-bin/askascientist/highlight.pl?kw=&file=
   answers%2Fgeneral%2Fans_051.html

3. **Multicultural Resources and/or Activities**

   Point out that in 1891 Katsusaburo Yamagiwa, a Japanese scientist, was the first scientist to demonstrate that a specific substance can cause cancer. He intentionally produced cancer cells by applying coal tar extract to the skin of rabbits.

Suggested Assessments

1. Have students compare a cell before mitosis to the daughter cells created after mitosis. Have students answer the following questions: What is the same? What is different?
2. Have students write a story about the life of a chromosome as it travels through the phases of its life (the cell cycle).
3. Have students review the sequence of events that regulate the cell cycle and describe how these events change in a cancer cell.

Sample Constructed-Response Item

List the stages of mitosis in order and describe one event that happens in each stage.

Stage of Mitosis	Event
Prophase	*Chromosomes become visible, nuclear envelope disappears*
Metaphase	*Chromosomes line up along the equator of the cell*
Anaphase	*Sister chromatids move towards opposite poles as spindle fibers shorten*
Telophase	*Nuclear envelope forms at each pole, cytokinesis begins*

Model Lesson (Traditional Roster):
Chromosomes: Cell Division

Lesson Questions

Why do cells divide?
How is genetic continuity maintained during and after cell division?

Materials

Different colored pipe cleaners (or yarn), Chromosome B43 teaching transparency (Ch. 8)

Content and Performance Expectations

CE 1; PE 1

Teacher's Notes

The Chromosome graphic at www.accessexcellence.org/RC/VL/GG/chromosome.html and Genes & Chromosomes graphic at www.accessexcellence.org/RC/VL/GG/genes.html can be used instead of the Chromosome B43 teaching transparency (Ch. 8).

Warm-Up

Brainstorming

- In groups, have students brainstorm a list of reasons why cell division is necessary.

Instruction

Cell Division

▶ Why do cells divide?

- ▷ Have students share their ideas about cell division.
- ▷ Review with students a list of reasons why the human body must produce new cells that are exact copies of the original cells.
- ▷ Review with students the constraints upon cell size due to diffusion.
- ▷ Draw a concept web (*ER,* p. RR-15) on the board with the term *cell division* in the center.
- ▷ Have students read information about cell division on Holt, pp. 118–119, and have them complete the concept web with terms and phrases such as *bacteria cells, eukaryotic cells, reproduction, growth, gamete, DNA, binary fission, genes,* and *chromosomes*.

▶ Chromosomes and Genes

- ▷ Introduce and define the terms *chromatin* and *centromere.*
- ▷ Explain to students that most of the time the chromosomes (molecules of DNA) are in chromatin form (tell students to think of a bowl of spaghetti) so that it can be directing cell activities. In this form, DNA is invisible under the microscope.
- ▷ Explain that before a cell gets ready to divide, the DNA is copied. Right before cell division, the DNA becomes tightly coiled into visible chromosomes (like a coiled telephone cord or wire).
- ▷ Explain that these chromosomes are made of two halves called sister chromatids (which are identical copies of each other) that are held together by a centromere.
- ▷ Have students hypothesize why it is necessary for the DNA to become tightly coiled and condensed before dividing.
- ▷ Use the Chromosomes B43 teaching transparency (Ch. 8) to describe the structure of chromosomes.
- ▷ Divide students into groups and distribute different colored pipe cleaners. Students should use the pipe cleaners to illustrate *chromatin*, *chromosome*, *gene*, *DNA*, *chromatid*, and *centromere*. Have students define each term.
- ▷ Have students sketch a picture of their model and label it using the terms that they defined.

UNIT 8 SECTION 1

- **Homologous Chromosomes**
  - ▷ Define the terms *diploid, haploid,* and *homologous pair.*
  - ▷ Explain that all animals have a characteristic number of chromosomes in their body (somatic) cells called the diploid (or $2n$) number. These chromosomes occur as homologous pairs, one member of each pair having come from each parent.
  - ▷ Explain that the gametes are special cells that contain the haploid number (n) of chromosomes. Male and female gametes join together to form a new individual with the diploid number of chromosomes ($n + n = 2n$). Perform the Missing Homologue Teaching Tip (Holt *TE,* p. 120).
  - ▷ Have students examine Table 1 on Holt, p. 121 and point out the differing chromosome numbers of various organisms. Have students discuss whether chromosome number is related to complexity.
  - ▷ Have students explain how chromosome number for each species is kept constant from generation to generation.

Assessment

- Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-13) about cell division and chromosomes.
- Have students explain the difference between a gene, a DNA molecule, chromosomes, and a chromatid.

Homework Assignment

- Have students read Holt, pp. 120–124 and complete Holt, p. 124, #1–5.

Teaching Resources

- Holt, pp. 118–124
- Access Excellence Graphics Gallery: www.accessexcellence.org/RC/VL/GG/

Unit 8 Section 2

MEIOSIS

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Stages of Meiosis	Holt, pp. 144–145
3–4	2	Genetic Recombination During Meiosis	Holt, pp. 146–149
5–6	3	Comparing Mitosis and Meiosis	Holt, pp. 128–132; 144–145

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. (GLE 3.3)

CONTENT EXPECTATIONS

☐ 1. Chromosomes are components of cells that occur in pairs and carry hereditary information from one cell to daughter cells and from parent to offspring during reproduction. (GLE 3.3.C)

☐ 2. There is heritable variation within every species of organism. Meiosis contributes to genetic variation within a species. (GLE 3.3.D)

☐ 3. Meiosis maintains a constant number of chromosomes in the body cells of all the members of a species. (GLE 3.3.C.b *PR*)

...for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 5. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Analyze the reproductive processes that serve as the genetic basis for the transfer of biological characteristics from one generation to the next. (GLE 3.3 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 1. Recognize that during meiosis, the formation of sex cells, chromosomes are reduced to half the number present in the parent cell. (GLE 3.3.C.b)
- ☐ 2. Explain how fertilization restores the diploid number of chromosomes. (GLE 3.3.C.c)
- ☐ 3. Describe how genes can be altered and combined to create genetic variation within a species (i.e., recombination of genes). (GLE 3.3.D.b)
- ☐ 4. Compare and contrast the processes of meiosis and mitosis. (GLE 3.3.C *P*R)

UNIT 8 SECTION 2

...for Standard 7

Demonstrate that science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 5. Use qualitative and quantitative data as support for reasonable explanations (conclusions). (GLE 7.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Stages of Meiosis Days 1–2	CE 1, 3 PE 1	**Day 1:** Have students trace five generations of a mouse family. Tell students that in the first generation, each mouse sperm and each mouse egg has 20 chromosomes. Write the numbers 1–5 on the board and then have students fill in the number of chromosomes in the cells of the offspring in each generation if only mitosis occurs. Have students discuss why an increasing number of chromosomes could be a problem. Use the Stages of Meiosis B49 teaching transparency (Ch. 7) to walk students through the steps of meiosis. Have students develop a flowchart showing the process of meiosis I and meiosis II and explain the activity of each phase. Have students complete the Meiosis Directed Reading worksheet (Holt *Biology CRF 7: Meiosis and Sexual Reproduction*, pp. 1–2) using Holt, pp. 144–145 for reference as necessary. (Goals 1.6, 1.8, 3.5)
	CE 1, 3, 4, 5 PE 1, 5	**Day 1/Hands-On Activity/Lab:** Ask students why gametes must be produced by meiosis and not mitosis. Perform the Demonstration on Holt *TE*, p. 144 and have students explain why the chromosome number must be halved in the gametes. Display the Stages of Meiosis B49 teaching transparency (Ch. 7). Have students determine the chromosome number at the beginning of interphase I, prophase I, interphase II, and at the end of telophase II. Then have students complete the Modeling Meiosis Group Activity (Holt *TE*, p. 145). (Goals 2.1, 3.5, 4.6)
	CE 1, 2, 3 PE 1, 2	**Day 2:** Display the Meiosis in Male and Female Animals B51 teaching transparency (Ch. 7) and explain the difference between spermatogenesis and oogenesis. Explain how the union of an egg and sperm restores the diploid number of chromosomes. Have students make gametogenesis flip books, which provide a moving picture of gamete formation. Provide a template containing small rectangles and instruct students to use a cell containing three pairs of homologous chromosomes and to color the maternal and paternal chromosomes a different color. Have students explain how a crossing-over would change the gametes produced at the end. (Goals 2.1, 2.5, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students use their shoes to represent homologous chromosomes and to act out the stages of meiosis. Ask students how pairs of shoes are similar to homologous chromosomes. (Students have different pairs of shoes, which represent the different sets of homologous chromosomes in a cell, each carrying different genes.) Point out that in each pair, the shoes are not identical and have students explain why.	Review with students the meanings of the prefixes *inter-*, *pro-*, *meta-*, *ana-* and *telos-*. Have them make a list of additional terms that begin with these prefixes. (ELL-6)	Have students research and report on a genetic disorder that is a result of mistake in the meiotic process such as aneuploidy or monosomy.
Make strips of varying lengths of blue paper and a matching set of pink strips. Have the strips represent chromosomes, blue from father and pink from mother. Have students determine the diploid number. Have students use the strips to illustrate all the possible chromosome combinations in the gametes. Have them determine the correct haploid number of chromosomes.	Provide students with a prepared sheet of unlabeled diagrams. The diagrams should represent a cell in each stage of meiosis and should be presented in random order. Students should cut out the diagrams and arrange them in order, label the stage, and describe what is happening in each diagram. (ELL-5)	Have students research the physical and chromosomal differences between the sexes and the evolution of the sex chromosomes.
As a class, make a list of the important characteristics of each step in the process of meiosis to review the process of meiosis prior to the lesson.	Have students explain the relationship between the following word pairs: *meiosis* and *gametes*, *oogenesis* and *egg cells*, *meiosis* and *haploid cells*, *fertilization* and *diploid cells*. (ELL-6)	Conduct the Discussion on Holt *TE*, p. 149.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Genetic Recombination During Meiosis Days 3–4	CE 1, 2, 5 PE 1, 3, 5	**Hands-On Activity/Lab:** Open a class discussion with the following questions: "What is the evolutionary value of mixing genetic information (recombination)?" "Why don't siblings look exactly alike?" "Why don't children look more like their parents?" Have students use colored clay and a blank template to demonstrate meiosis in a cell with two pairs of homologous chromosomes. Have them demonstrate what the possible combinations of chromosomes look like during metaphase I, and determine the possible gamete combinations produced after meiosis is completed. Have students simulate crossing-over between chromosomes and determine the gametes that would be produced. Then have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-13) explaining how independent assortment during meiosis and crossing-over contributes to genetic variation and relating this to why siblings sometimes resemble each other and/or their parents and sometimes do not. *See Model Lesson*. (Goals 1.6, 1.10, 2.1, 4.6)
	CE 1, 2, 4, 5 PE 1, 3, 5	**Hands On Activity/Lab:** Have students work in groups to complete the Modeling Meiosis Lab (Holt, pp. 158–159). Datasheets are available on Holt *Biology CRF 7: Meiosis and Sexual Reproduction,* pp. 41–44. Have students record their hypothesis for each question in Part B and write a description of their results. (Goals 1.2, 1.3, 2.3, 3.5)
	CE 1, 2, 5 PE 1, 3, 5	**Hands-On Activity/Lab:** Have students read Holt, pp. 146–147. As they read, students should write a question for each section on an index card. Discuss students' questions. Then have students complete the "Modeling Crossing-Over" Quick Lab (Holt, p. 147). A datasheet is available on Holt *Biology CRF 7: Meiosis and Sexual Reproduction*, p. 37. Have students work in groups to describe the major events in meiosis such as meiosis I, synapsis, tetrad formation of non-sister chromatids, crossing-over, independent assortment, and meiosis II. Then have them create role-plays for the events and act them out for the other members of the class. Have the observers try to guess which events are being depicted in the role-plays. (Goals 2.5, 3.5, 4.1, 4.6)
Comparing Mitosis and Meiosis Days 5–6	CE 1, 2, 3 PE 1, 3, 4	Display a transparency of a diagram that compares mitosis and meiosis, such as the one at www.accessexcellence.org/RC/VL/GG/comparison.html, to review the two processes. Have students create a Venn diagram (*ER,* p. RR-83) to illustrate similarities and differences between mitosis and meiosis. Have students work in groups to make large chromosome models and role-play the movement of chromosomes during mitosis and meiosis. Each student should develop a set of questions about the processes of mitosis and meiosis on note cards (question on front, answer on back). Have students pair up and quiz each other. (Goals 1.8, 2.1, 2.5, 4.6)
	CE 1, 2, 3 PE 1, 2, 3, 4	**Technology:** Have students view computer animations of mitosis and meiosis such as the Meiosis tutorial and animation at www.biology.arizona.edu/cell_bio/tutorials/meiosis/page3.html and the Mitosis tutorial and animation at www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/cells3.html. Then have students make a chart comparing the types of cells, the number of cell divisions, number of daughter cells formed, and the chromosome number of daughter cells (haploid or diploid) in mitosis and meiosis. Have students write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) about the processes of mitosis and meiosis. (Goals 1.4, 1.5, 1.6, 2.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Model how to demonstrate meiosis using the colored clay and a blank template.	Have students create an illustrated dictionary (*ER*, p. GPT-6) for key terms such as *meiosis*, *genetic recombination*, *crossing-over*, and *independent assortment*. (ELL-8)	Have students explain why crossing-over between nonsister chromatids of homologous chromsomes cannot occur during mitosis.
If students completed the Modeling Mitosis Lab (Holt, pp. 136–137) in Unit 8 Section 1, have students discuss the models they used for it. Have students extend those ideas to how to design their new model.	Go over the instructions with students, rephrasing any difficult language or instructions. (ELL-4)	Have students complete the "Do You Know?" section on Holt, p. 159.
Have students write a sentence for each group of terms that explains the connection between the terms in the group: 1) g*ametes, egg cell, sperm cell*; 2) *diploid, haploid, mitosis, meiosis*; 3) *gametes, zygote, fertilization*; 4) *tetrad formation, crossing-over, genetic recombination*.	Have students conduct a jigsaw (*ER*, p. GPT-7) in groups of three. Each member of the group is responsible for reading and explaining a section of the reading to the other two. (ELL-5)	Have students determine how to calculate how frequently two traits are passed on together. Explain how this information is used to create linkage maps of chromosomes.
Have students work in groups to list as many similarities and differences between mitosis and meiosis as possible and then construct the Venn diagram on the board with the assistance of students.	Have students complete the Distinguishing Between Mitosis and Meiosis Teaching Tip (Holt *TE*, p. 147). (ELL-6)	Using the Internet and/or printed material, have students conduct research about Dolly the cloned sheep. Have them write an article about how the cloning was accomplished, and relate it to mitosis and meiosis.
Have students complete the Alternative Assessment on Holt *TE*, p. 155.	Set up the chart before students view the animations. Have students complete the chart as they watch the animations. (ELL-4)	Have students research the timeframe for meiosis (in males and females) and mitosis in humans to further compare the processes.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 7: Meiosis and Sexual Reproduction,* pp. 1–2, 37, 41–44

   Educational Resources, pp. GPT-6, GPT-7, RR-83

   Step Up to Writing, pp. 3-3 through 3-13, 3-21 through 3-29, 8-8

2. **Internet Resources**

   Information about Linkage and Gene Mapping
   http://cropandsoil.oregonstate.edu/classes/css430/CIHEAM04/unit2/Lec204.htm

   Comparison of Mitosis and Meiosis
   www.accessexcellence.org/RC/VL/GG/comparison.html

   Meiosis Tutorial and Animation
   www.biology.arizona.edu/cell_bio/tutorials/meiosis/page3.html

   Mitosis Tutorial and Animation
   www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/cells3.html

3. **Multicultural Resources and/or Activities**

   Nettie Stevens was one of the first female scientists in the United States to receive recognition for her research. She and Edmund Wilson independently described sex determination based on X and Y chromosomes in 1905.

Suggested Assessments

1. Have students write a story from the viewpoint of a chromosome going through the stages of meiosis.
2. Have students write a journal entry to compare and contrast mitosis and meiosis in terms of number of cell divisions, number of daughter cells formed, and chromosome number of daughter cells.
3. Have students work in groups to create a cartoon or story to explain why an egg and sperm must have half the number of chromosomes found in the body cells of an organism.
4. Have students complete Holt, p. 149, #1–6.

Sample Constructed-Response Item

In mitosis, replication of chromosomes precedes each cell division. In meiosis, two cell divisions take place without a replication of chromosomes between them. Why is this difference significant?

Mitosis creates daughter cells that contain the same number of chromosomes as the parent cell. However, in meiosis the second cell division creates haploid daughter cells (gametes) with half the number of chromosomes as the parent cell.

Model Lesson (Traditional Roster):
Genetic Recombination During Meiosis

Lesson Questions

How do chromosomes independently assort during meiosis?
How is genetic variation created by crossing-over of chromosomes during meiosis?

Materials

Four different colors of clay, blank paper, colored pencils, copies of the How Chromosomes Independently Assort and Exchange Genetic Information activity sheets

Content and Performance Expectations

CE 1, 2, 5; PE 1, 3, 5

Teacher's Notes

Have students work in pairs or groups for the activity.

Warm-Up

A Family Resemblance?

- Have students write a Free Response (*SUTW,* p. 8-8) to the following questions: "Why don't siblings look exactly alike?" "What causes members of the same family to look alike in some ways but different in other ways?"
- Discuss students' responses. Extend the discussion with the question, "Why don't children look more like their parents?"
- Ask students, "What's the evolutionary value of mixing genetic information (recombination)?" Discuss students' responses.

Instruction

How Chromosomes Independently Assort and Exchange Genetic Information Activity

▶ Modeling Crossing-Over	▷ Explain to students that they will conduct an activity to simulate crossing-over and independent assortment during meiosis. Explain that they will be working with a mythical organism that has a diploid chromosome number of four. ▷ Provide pairs of students with four different colored balls of clay, colored pencils, and large pieces of white paper on which they will draw the outline of a cell. ▷ Have students follow the directions on the How Chromosomes Independently Assort and Exchange Genetic Information activity sheet. Circulate through the room, providing assistance when necessary.
▶ Wrap-Up	▷ Have students explain what they have learned from this activity. ▷ Review when crossing-over occurs during meiosis. Explain that this genetic swapping results in recombinant chromosomes. When this occurs, alleles that were linked are no longer linked and are not necessarily inherited together. ▷ Have students discuss the consequences of this change. Point out that it contributes to genetic variation in eggs and sperm cells, and that genetic variation leads to variation in offspring. Revisit the questions from the Warm-Up. ▷ Have students relate the importance of genetic variation to the theory of natural selection. Have students discuss why, from the viewpoint of natural selection, it is more beneficial for a set of parents to have genetically varied offspring instead of exact copies (clones).

Assessment

- Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-13) about how independent assortment during meiosis and crossing-over contributes to genetic variation and relate this to why siblings sometimes resemble each other and/or their parents and sometimes do not.

Homework Assignment

- Have students draw a cell with three pairs of homologous chromosomes. Then have them draw prophase I after crossing-over has occurred, metaphase I, telophase I, metaphase II, and the four gametes produced after telophase II and cytokinesis. Have students explain how the alignment of chromosomes during metaphase I affects the gamete combinations that are produced.

Teaching Resources

- Holt, pp. 144–146

activity sheet

name ______________________ date ____________

How Chromosomes Independently Assort and Exchange Genetic Information

1. In this activity, you will demonstrate the processes of meiosis using chromosome models from a mythical organism. First name your mythical organism and then use the clay provided by the teacher (divide each colored ball in half and use one half) to make two pairs of homologous chromosomes. Each homologue should be the same size but a different color. Make sure that the two pairs are different sizes (e.g., one pair is 4 cm long and the other is 6 cm long). Use your colored pencils to draw a picture of your chromosomes and identify which ones are maternal and paternal below.

2. Remember that a chromosome is tightly coiled strand of DNA. Within each chromosome there are many, many genes. The chromosomes within each pair are said to be homologous, meaning that they carry information for the same characteristics but are not necessarily identical. For instance, two homologous chromosomes might contain the gene that codes for eye color, but the allele form might be different, with the blue eye allele on one chromosome and brown eye allele on the other.

   Give another example of how homologous chromosomes may differ. ______________________

   ____

   ____

name ______________________ date ____________

3. Imagine your chromosomes in interphase. Simulate replication by creating a matching chromosome (same shape and color) using the remaining bits of clay for each of the four chromosomes in your genome. Create a centromere to hold sister chromatids together. Draw a picture of your chromosomes.

3a. Record how many chromosomes are present in the cell. ______________________

4. Simulate prophase I by pairing each newly replicated chromosome with its homologous chromosome. Draw a picture of the tetrads.

name ______________________ date ____________

5. Arrange your chromosomes to simulate metaphase I. Draw a picture of metaphase I. Move the chromosomes through anaphase I to telophase I and sketch the two cells that are created at the end of telophase I.

Metaphase I | Telophase I

6. Continue to move the chromosomes through meiosis II. Draw the cells in metaphase II and then the four gametes created after telophase II and cytokinesis.

Metaphase II | Gametes

Explain whether the two gametes are identical. ______________________________

____

Explain whether the gametes are haploid or diploid. ______________________________

____

____

name ______________________ date ____________

7. Move your chromosomes back to prophase I. Now that homologous chromosomes are near each other, crossing-over can occur. In each tetrad, trade one section of DNA between two nonsister (nonidentical) chromatids by first overlapping chromosome arms to form an area of crossing-over and then break the clay and join the exchanged parts to their new chromosomes. Sketch your chromosomes crossing-over during prophase I.

8. Move the chromosomes through the stages of meiosis. Draw a picture of metaphase I, metaphase II, and the four gametes produced at the end. Compare these gametes with those from Step #6.

Metaphase I	Metaphase II	Gametes

activity sheet

name ______________________ **date** ____________

Describe how the gametes produced compare with those from Step 6 (without crossing-over).

____

____

Explain how crossing-over increases genetic variation in offspring. ______________________

____

____

9. Next you will create an X and a Y sex chromosome. Change one homologous chromosome pair into a nonhomologous pair of sex chromosomes (X and Y). Select one chromosome to be the Y chromosome and let the other chromosome be the X chromosome. In order to make the model resemble a Y chromosome, remove 2/3 of the clay (genes) from the chromosome. Line the Y chromosome up with the X chromosome and observe the size differences between the two sex chromosomes. Draw a picture of the chromosomes.

X Chromosome	Y Chromosome

Give a possible explanation for the difference in their sizes. ______________________

____

____

Explain the inability of these two nonhomologous chromosomes to exchange segments. __________

____

____

UNIT 8 SECTION 2

Unit 8 Section 3

TYPES OF REPRODUCTION

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Sexual vs. Asexual Reproduction	Holt, pp. 150–151
3–4	2	Sexual Life Cycles	Holt, pp. 152–154, 538
5–6	3	Cell Differentiation	Holt, pp. 419, 596–597

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW...

...for Standard 3

There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. (GLE 3.3)

CONTENT EXPECTATIONS

☐ 1. Reproduction can occur sexually or asexually. (GLE 3.3.A)

☐ 2. Organisms can reproduce asexually through various methods including budding, binary fission, and fragmentation. (GLE 3.3.A.a *PR*)

☐ 3. In organisms that undergo sexual reproduction, meiosis occurs to create male and female gametes (haploid cells). The diploid number of chromosomes is then restored during fertilization. (GLE 3.3.C *PR*)

☐ 4. The life cycle of sexually reproducing organisms follows an alternation between the haploid and diploid life cycles. (GLE 3.1.B *PR*)

☐ 5. Embryological development in plants and animals involves a series of orderly changes in cell division and differentiation. (Framework VII.D.5)

...for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 6. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

☐ 7. Evidence is used to formulate explanations. (GLE 7.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Analyze the different types of reproductive processes in which genetic information is passed from one generation to the next and the processes by which different types of cells within an organism arise. (GLE 3.1.B *PR,* 3.3 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Distinguish between asexual (i.e., binary fission, budding, cloning) and sexual reproduction. (GLE 3.3.A.a)

☐ 2. Describe the advantages and disadvantages of asexual and sexual reproduction with regard to variation within a population. (GLE 3.3.D.a)

☐ 3. Recognize the chromosomes of daughter cells, formed through the processes of asexual reproduction and mitosis, the formation of somatic (body) cells in multicellular organisms, are identical to the chromosomes of the parent cell. (GLE 3.3.C.a)

☐ 4. Recognize that during meiosis, the formation of sex cells, chromosomes are reduced to half the number present in the parent cell. (GLE 3.3.C.b)

☐ 5. Explain how fertilization restores the diploid number of chromosomes. (GLE 3.3.C.c)

☐ 6. Recognize that cells both increase in number and differentiate, becoming specialized in structure and function, during and after embryonic development. (GLE 3.1.B.a)

☐ 7. Identify factors (e.g., biochemical, temperature) that may affect the differentiation of cells and the development of an organism. (GLE 3.1.B.b)

...for Standard 7

Use science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking to develop scientific understanding. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 8. Make qualitative and quantitative observations using the appropriate senses, tools, and equipment to gather data (e.g., microscopes). (GLE 7.1.B.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Sexual vs. Asexual Reproduction Days 1–2	CE 1, 2, 6, 7 PE 1, 2, 3, 8	**Day 1/Technology:** Review the process of meiosis and its contribution to genetic variation. In pairs, have students complete the first two columns of a K-W-L chart (*ER*, p. RR-43) about sexual and asexual reproduction. Have students share their responses. Extend the conversation to a discussion of cloning. Have students read Holt, pp. 150–151. Explain different types of asexual reproduction (e.g., budding, binary fission, and fragmentation). Have students make observations of a movie of dividing bacteria (binary fission) such as the one found at www.cellsalive.com/ecoli.htm. Discuss students' observations. Emphasize that the outcome of each of the processes is offspring with chromosomes identical to the parent. Then have pairs complete the last column of their K-W-L chart. Have two pairs join to form a group of four, then have groups compare their K-W-L charts. Have groups list the advantages and disadvantages of asexual reproduction. Groups should then share their results with the class. Have students write Compare and Contrast Paragraphs (*SUTW*, pp. 3-21 through 3-29) that address the benefits and drawbacks of asexual and sexual reproduction, citing specific examples to illustrate points. (Goals 1.2, 1.3, 1.4, 1.6, 1.8, 2.1)
	CE 1, 2 PE 1, 2, 3	**Day 1/Hands-On Activity/Lab/Technology:** Complete the Identifying Preconceptions on Holt *TE*, p. 150. Have students complete the Sexual Reproduction Active Reading Skills worksheet (Holt *Biology CRF 7: Meiosis and Sexual Reproduction*, pp. 9–10). Provide students with examples of offspring produced by sexual and asexual reproduction. If students did not already observe budding yeast in Unit 7 Section 3, have students complete the "Observing Reproduction in Yeast" Quick Lab (Holt, p. 151). A datasheet is available on Holt *Biology CRF 7: Meiosis and Sexual Reproduction,* p. 39. Alternatively, have students make observations of dividing paramecia and a prepared slide of a budding hydra. Take a leaf cutting from a plant to start a new one as a demonstration of vegetative propagation. Emphasize that the outcome of each of the processes is offspring with chromosomes identical to the parent. Contrast this with an illustration of a sexually reproducing organism, such as a picture of cat with a litter of kittens. Have students write Compare and Contrast Paragraphs (*SUTW*, pp. 3-21 through 3-29) that address the benefits and drawbacks of asexual and sexual reproduction, citing specific examples to illustrate points. (Goals 2.1, 3.8, 4.1)
	CE 1, 2 PE 1, 2, 3	**Day 2:** Have students complete the Asexual Reproduction in Bacteria Activity (Holt *TE,* p. 151). Have students make a graph of the data for analysis. Have students share their observations about asexual reproduction in bacteria and then discuss whether their observations can be generalized to all forms of asexual reproduction. Have students revisit their Compare and Contrast Paragraphs from Day 1 and revise them as necessary based on what the activity demonstrated about asexual reproduction. Have students complete Holt, p. 156, #14. (Goals 2.2, 2.3, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students complete the first page of the Sexual Reproduction, Directed Reading skills worksheet (Holt *Biology CRF 7: Meiosis and Sexual Reproduction* p. 5) after reading the text.	Have students create an illustrated dictionary (*ER*, p. GPT-6) for the key terms in this section, such as *clone*, *budding*, *fission*, *fragmentation*, and *propagation*. (ELL-2)	Have a class discussion about the Cloning by Parthenogenesis article on Holt, p. 153. Use the Discussion questions on Holt *TE*, p. 153 to lead the discussion. Discuss examples of protogyny in some organisms, such as anenome fishes.
Have students write a set of Power Outlines (*SUTW*, pp. 2-11 through 2-17) before beginning their paragraphs.	After distributing copies of the Sexual Reproduction Active Reading skills worksheet (Holt *Biology CRF 7: Meiosis and Sexual Reproduction*, pp. 9–10), have students identify the terms in bold and their definitions. Define other key terms in the passage before students begin reading it. (ELL-2)	Have students research the methods used to propagate fruit trees, such as grafting, to find out how the propagation is done and to identify whether it is a form of sexual or asexual reproduction.
Have students limit the Asexual Reproduction in Bacteria Activity (Holt *TE*, p. 151) to 3 hours.	Review ecological concepts from Unit 2. Have students list the abiotic and biotic factors they would consider when determining whether an ecosystem is stable. (ELL-6)	Have students use their answer to Holt, p. 156, #14 to conduct a debate (*ER*, p. PTT-9).

UNIT 8 SECTION 3

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Sexual Life Cycles Days 3–4	CE 3, 4 PE 4, 5	Explain to students that the life cycles of all sexually reproducing organisms follow a pattern of alternation between haploid (*n*) and diploid (2*n*) stages, and between the processes of meiosis and fertilization. In some life cycles the diploid stage is dominant, in others the haploid stage is dominant. Have students make a diagram to show the relationship between diploid cells, haploid cells, meiosis, fertilization, and gametes. Display the Haploid Life Cycle F13 teaching transparency (Ch. 7) and Diploid Life Cycle B48 teaching transparency (Ch. 7) to explain these two types of life cycles. Have students revise their diagrams and correct misconceptions as necessary. Have students write a Quick Sketch Story (*SUTW*, pp. 6-2 through 6-14) of a sexually reproducing cell as it passes through its life cycle. Have students share their stories with a partner and have the partner determine whether the haploid or diploid stage was dominant. (Goals 1.5, 1.8, 2.1)
	CE 3, 4 PE 4, 5, 8	**Hands-On Lab/Activity/Technology:** Have students read Holt, p. 538. Distribute flowers (such as a lily or gladiolus, make sure stamens are intact) and have students draw and label a diagram of a flower, indicating male and female parts. Have them gather some pollen, make a wet mount of it, and make observations of it under a microscope. Use the Life Cycle of an Angiosperm G39 teaching transparency (Ch. 23) to explain how pollination and fertilization occur in the flower to create seeds. Have students draw a diagram that explains sexual reproduction in flowering plants and identifies where meiosis and fertilization occur. Have students work in pairs to list the advantages of sexual reproduction for flowering plants. (Goals 1.3, 1.5, 2.1, 2.3)
	CE 3, 4 PE 4, 5, 8	**Hands-On Activity/Lab/Technology:** Have students read Holt, p. 154 about alternation of generations. Use the Life Cycle of a Fern G34 teaching transparency (Ch. 24) to discuss the life cycle of a fern. Have students complete the “Observing a Fern Gametophyte” Quick Lab (Holt, p. 532). Have students explain how the gametophyte is able to produce a diploid adult fern plant. Have students work in groups to compare the haploid and diploid stages in humans and ferns. Have students develop a concept map about sexual life cycles similar to Holt *TE*, p. 155. (Goals 1.2, 1.3, 1.4, 1.5, 1.8, 2.1, 2.3)
	CE 3, 4 PE 4, 5, 8	**Hands-On Activity/Lab/Technology:** Show students a fern plant (the sporophyte) and the sporangia on the leaves. Have students prepare wet mounts of spores (from a fern frond with sporangia) and pollen grains (male pine cone). Have students work in pairs to observe them under the microscope, draw diagrams, and create a chart to compare and contrast them by identifying whether they are formed by mitosis or meiosis, whether they are haploid or diploid, and how they would form a multicellular organism. (Goals 1.2, 1.3, 1.8, 2.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students plan their story using the Planning a Short Story graphic organizer (*SUTW*, p. 10-46).	Complete the Using the Figure activity on Holt *TE*, p. 152 to explain the different life cycles. (ELL-4)	Have students describe the alternation of generations in a wide variety of organisms and identify any patterns seen in which stage is dominant.
Have students create a flowchart describing the processes of pollination and fertilization in flowering plants.	Prior to the explanation of pollination and fertilization, have students make a chart of each flower part, its description, and its function. They should then fill it in during the explanation of pollination and fertilization. (ELL-2)	Have students write a report or prepare a presentation about the different methods plants utilize to foster or deter pollination, or about the symbiotic relationships between flowering plants and their pollinators.
Give students a partially completed concept map and have them fill in the missing terms.	Preview the meanings of terms *gametophyte*, *sporophyte*, and *spore* before the reading. Have students complete a take-two exercise by writing a sentence using two of them. (ELL-1)	Have students work in groups to make posters that depict the alternation of generations in the life cycles of mosses, indicating haploid and diploid stages. Then have them contrast the life cycles of ferns and mosses.
Show students electron micrographs of pollen grains and fern spores to compare with their own diagrams.	Discuss the different definitions of the term *spore* in relation to bacteria, fungi, and plants. (ELL-1)	Have students research fossilized pollen or spores and explain what conclusions scientists have drawn about past environments from them.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Cell Differentiation Days 5–6	CE 5, 6, 7 PE 6, 7, 8	**Hands-On Activity/Lab/Technology:** Have students read the sections entitled "Blastula Formation" (Holt, p. 596) and "From Zygote to Gastrula" (Holt, p. 597). Than have students complete the Observing Embryonic Development Lab (Holt, pp. 1014–1015) and answer the Analyze and Conclude questions at the end of the lab. Datasheets are available on Holt *Biology CRF 43: Reproduction and Development*, pp. 47–50. Have students make a list of factors that may affect the differentiation of cells and the development of sea urchins. (Goals 1.2, 1.3, 1.6, 3.5, 4.1)
	CE 5 PE 6	**Technology:** Have students watch movies or animations of fish and amphibian embryos, such as those found at www.luc.edu/depts/biology/dev/devm.htm. They should observe how cells divide, their appearance, and how they move to form the embryo. Provide students with diagrams of embryonic development of the same organisms and then have them make labeled clay models of fertilization and the different stages of early fish development. Have students write a Process Paragraph (*SUTW,* pp. 3-15 through 3-17) of how one cell becomes many cells and how cell differentiation creates the different types of body cells. (Goals 1.4, 1.5, 2.1, 2.5)
	CE 3, 5, 6, 7 PE 4, 5, 6, 7, 8	**Hands-On Activity/Lab/Technology:** Have students observe and analyze sea urchin fertilization and early development. Have students make a list of factors that may affect the differentiation of cells and the development of sea urchins. *See Model Lesson*. (Goals 1.2, 1.3, 1.4, 2.1, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students work on the questions in groups, record their ideas on chart paper, and then discuss their answers with the class.	Explain the meanings of *derm-*, *ecto-*, *endo-*, and *meso-*. Have students identify other terms containing these roots or prefixes. (ELL-2)	Have students research and report on differences in development of protostomes and deuterostomes.
Provide examples of completed models of embryonic development.	Have students create an illustrated dictionary (*ER*, p. GPT-6) of terms from this topic such as *zygote*, *blastula*, and *gastrula*. (ELL-2)	Discuss the topic of undifferentiated stem cells, their role in scientific research, and the possibility of their use in curing some diseases.
Before conducting the experiment, have students watch animations of sea urchin development and embryonic cleavage and development.	Have students draw labeled diagrams of the different stages of embryonic development. (ELL-2)	Have students design an investigation into one factor that might affect the differentiation of cells and the development of sea urchins. Students do not have to carry out the investigation.

Additional Resources

1. **Curriculum Resources**

    Holt *Biology CRF 7: Meiosis and Sexual Reproduction*, pp. 5, 9–10, 39

    Holt *Biology CRF 43: Reproduction and Development,* pp. 47–50

    Educational Resources, pp. GPT-6, PTT-9, RR-43

    Step Up to Writing, pp. 2-11 through 2-17, 3-13 through 3-17, 3-21 through 3-29, 6-2 through 6-14, 8-8, 10-46

2. **Internet Resources**

    Protogyny in Anenome Fishes (scroll down)
    www.marinebiology.org/fish.htm#FISH%20SEX-%20how%20fish%20reproduce

    Movie of Dividing Cells
    www.cellsalive.com/ecoli.htm

    Grafting and Budding Fruit Trees
    www.extension.umn.edu/distribution/horticulture/DG0532.html

    Chlamydomonas Life Cycle Animation

    http://academic.kellogg.edu/herbrandsonc/bio111/animations/0117.swf

    Pine Pollen
    www.geo.arizona.edu/palynology/pid00005.html

    Sea Urchin Development from 1 Cell to Blastula
    www.luc.edu/depts/biology/dev/urchindv.htm

    Movies of Embryonic Cleavage and Development
    www.luc.edu/depts/biology/dev/devm.htm

    Sea Urchin Animations
    www.stanford.edu/group/Urchin/ani-plus.htm

3. **Multicultural Resources and/or Activities**

    Have students research and discuss the work of Latino and/or Native-American biologists. Information is available at http://64.171.10.183/biography/listsscientist.asp.

Suggested Assessments

1. Have students complete Holt, p. 154, #1–6.
2. Have students create a graphic organizer using the following terms: *sexual reproduction, asexual reproduction, alternation of generations, meiosis, mitosis, haploid cells, diploid cells, gametes, fertilization,* and *life cycle.*
3. Have students complete the Alternative Assessment on Holt *TE*, p. 154.
4. Have students make a graphic organizer about asexual and sexual reproduction, including the terms *clone, gametes, fertilization, genetic variation, parent, zygote, budding* and *binary fission*.

Sample Constructed-Response Item

Describe two ways in which sexual reproduction differs from asexual reproduction.

Sexual reproduction results in offspring that are genetically different from the parents, while asexual reproduction produces clones of the parent. Sexual reproduction involves the creation of gametes by meiosis. In asexual reproduction, new individuals are created from a single parent that copies its genetic information exactly and then divides. The life cycle of sexually reproducing organisms alternates between the diploid and haploid chromosome numbers, while asexually reproducing organisms maintain a constant chromosome number.

Model Lesson (Block Roster):

Cell Differentiation: Fertilization and Development of Sea Urchins Lab

Lesson Question

What happens during the processes of fertilization and development in sea urchins?

Materials

Female sea urchins, male sea urchins, hypodermic needles, potassium chloride (KCl) solution, 4% salt (NaCl) solution, slides, cups, petri dishes, pipettes, ice, prepared slides of sea urchin egg development

Content and Performance Expectations

CE 3, 5, 6, 7; PE 4, 5, 6, 7, 8

Teacher's Notes

All safety guidelines regarding the use of live animal specimens and hypodermic needles found in the *Missouri Secondary Science Safety Manual* available at http://dese.mo.gov/divimprove/curriculum/science/manuals/secman.pdf should be followed. Hypodermic needles should be used and disposed of in such a way that students do not have access to them.

Prior to the lesson, sea urchin eggs will need to be obtained and the zygote incubation mixtures made. If possible, make several different zygote incubation mixtures at different times so that students can observe the different developmental stages (e.g., cleavage at various stages, the blastula at 24 hours). Cultures of embryos could be started $1\frac{1}{2}$, 3, 6, and 24 hours before the class period. Sea urchin embryology kits can be purchased from biological supply companies and contain all the necessary materials. If you buy materials separately, sea urchins can be forced to shed gametes by the following procedure:

1) Place live sea urchin specimens over a sterile cup filled half way with salt water solution.
2) Fill hypodermic syringe with 0.5 to 1.5 cc of the KCl salt solution. Insert the needle into the oral region of the urchins, and inject the solution.
3) Hold urchin over the cup upside down, allowing the gametes to drip into the cup.
4) Observe gametes. If they are white, the urchin is a male; if they are orange, the urchin is a female.

5) Female gametes can be kept in the NaCl solution, male gametes are best stored in a test tube on ice.

Information about how to induce sea urchins to shed gametes can be found at Sea Urchin Embryology Lab: www.stanford.edu/group/Urchin/. Additional information on how to prepare the 4% NaCl solution and other solutions that may be necessary can be found in a lab on sea urchin fertilization and early development on the Internet or in laboratory manuals.

Students will view the sperm and eggs separately and then mix the gametes and observe the moment of fertilization. Development of the fertilized urchin egg is rapid and dramatic, with the first division occurring within two hours of fertilization. The blastula stage should be reached within 24 hours.

Warm-Up

Review of Fertilization and Development

- Have students write a Free Response (*SUTW,* p. 8-8) to the question, "How is the number of chromosomes in a species maintained in the offspring?"
- Discuss students' responses. Reinforce that during meiosis, homologous pairs are separated and each haploid gamete receives just one set of chromosomes. At fertilization, each gamete contributes its one set of chromosomes, restoring the diploid chromosome number of the species.
- Review the process of meiosis to create gametes.

Instruction

Embryonic Development

- Single-Celled Zygote to Gastrula
  - Explain that after fertilization, a single-celled zygote is formed. Then cleavage occurs, a rapid series of cell divisions that turn a zygote into a ball of cells called a blastula. Following cleavage is gastrulation, where the cells move inward, forming a rudimentary digestive cavity (blastopore). The result is a gastrula containing three layers—the ectoderm, endoderm, and mesoderm—which give rise to the specific organ systems.
  - Have students make a chart of the three tissue layers and the tissues and organs that they give rise to.
  - Remind students that humans follow a similar pattern of development to sea urchins that will be observed in this investigation.

Fertilization and Development of Sea Urchins Lab

▶ Lab Procedure

- ▷ Instruct pairs of students to place a clean, flat microscope slide on the stage of a compound microscope.
- ▷ Have them place one drop of sea urchin eggs in 4% NaCl solution on the microscope slide.
- ▷ Have students focus on the eggs using the low-power objective. If they are using a light source, they should turn it off because the heat of the light damages the eggs.
- ▷ Have one student in each pair add a drop of dilute sperm to the eggs on the slide while the other student looks through the microscope. Students should watch carefully for what happens to the eggs. Have students record their observations.
- ▷ Have students take a sample from one of the zygote incubation mixtures and use a pipette to place a drop of the incubating mixture on a clean microscope slide. Students should observe the zygotes with the low-power objective and record their observations.
- ▷ Have students take other samples from the different zygote incubation mixtures to observe. Students should observe the zygotes with the low-power objective and record their observations.
- ▷ Have students observe the developmental stages as seen on a permanent microscope slide of sea urchin development and compare these stages with the slides they made.

▶ Analysis Questions

- ▷ Have students answer the following questions:

  1. What processes were you able to observe during this investigation?
  2. How do organisms develop from the size of a sperm and egg to an adult?
  3. Why is there such a difference in the size of the egg and the sperm?
  4. Why do sea urchins have external fertilization? What are the advantages of external fertilization? What are the advantages of internal fertilization?
  5. What would happen if one cell was removed or damaged at the 2-cell, 4-cell, 8-cell stage?

- ▷ Identify at least two factors that might affect the embryological development of a sea urchin.
- ▷ Lead a class discussion about the analysis questions.

Assessment

- Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-13) about how one cell becomes many specialized cells, specifically outlining the processes of fertilization and early development in sea urchins.

Homework Assignment

- Have students answer the following questions: 1) What is the importance of meiosis to sexual reproduction? 2) Explain the difference between a haploid cell and a diploid cell. 3) Write a summary about the stages of cell differentiation starting with a fertilized egg and ending with gastrulation. 4) How are gametes specialized to match their function?

Teaching Resources

- Sea Urchin Embryology Lab: www.stanford.edu/group/Urchin/

Unit 9 DNA and Patterns of Heredity

- How does DNA determine physical characteristics?
- How has the discovery and study of DNA changed our lives?
- Does heredity contribute to continuity or change?

Scope and Sequence, page 22
Lesson Planning Material, pages 377–458

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

UNIT 9

Unit 9 Section 1

LAWS OF HEREDITY

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–3	1	Mendel's Laws	Holt, pp. 162–169
4–5	2	Monohybrid and Dihybrid Crosses	Holt, pp. 170–176

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. (GLE 3.3)

CONTENT EXPECTATIONS

☐ 1. The pattern of inheritance for many traits can be predicted by using the principles of Mendelian genetics. (GLE 3.3.E)

☐ 2. Punnett squares can be used to make predictions as to probabilities and patterns of inheritance for resulting inherited traits in organisms. (Framework VII.D.2.a *PR*)

☐ 3. Gregor Mendel, through his experiments with pea plants, discovered the laws, or principles (law of dominance, law of segregation, and the law of independent assortment), that can be used to explain the inheritance of traits. (GLE 3.3.E *PR*)

☐ 4. Differing genotypes contribute phenotypic variation within a species. (GLE 3.3.E.a *PR*)

…for Standard 7

Publication and presentation of scientific work with supporting evidence are required for critique, review and validation by the scientific community. The presentation of such work adds to the body of scientific knowledge and serves as background for subsequent investigations in similar areas. (Framework I.A.2)

CONTENT EXPECTATIONS

☐ 5. The nature of science relies upon communication of results and justification of explanations. (GLE 7.1.E)

…for Standard 8

Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time. (GLE 8.2)

CONTENT EXPECTATIONS

☐ 6. Scientific theories are developed based on the body of knowledge that exists at any particular time and must be rigorously questioned and tested for validity. (GLE 8.2.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Using existing models that demonstrate patterns of inheritance (e.g., Punnett squares), make predictions as to probabilities and patterns of inheritance for resulting inherited traits in organisms. (Framework VII.D.2.a)

PERFORMANCE EXPECTATIONS

☐ 1. Explain how genotypes (heterozygous and homozygous) contribute to phenotypic variation within a species. (GLE 3.3.E.a)

☐ 2. Predict the probability of the occurrence of specific traits in an offspring by using a monohybrid cross. (GLE 3.3.E.b *PR*)

☐ 3. Predict the results of monohybrid and dihybrid crosses using Punnett squares to determine probabilities and patterns of inheritance. (GLE 3.3.E.b *PR*)

☐ 4. Explain the experimental design and results of Gregor Mendel and describe his laws of heredity. (GLE 3.3.E *PR*)

☐ 5. Use a test cross to determine the genotype of an individual with a dominant phenotype. (GLE 3.3.E *PR*)

...for Standard 7

Recognize that publication and presentation of scientific work with supporting evidence are required for critique, review, and validation by the scientific community. The presentation of such work adds to the body of scientific knowledge and serves as background for subsequent investigations in similar areas. (Framework I.A.2)

PERFORMANCE EXPECTATIONS

☐ 6. Communicate and defend a scientific argument. (GLE 7.1.E.b)

☐ 7. Make systematic observations (non-experimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Framework I.A.3.a)

...for Standard 8

Explain how historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time. (GLE 8.2 *PR*)

PERFORMANCE EXPECTATIONS

☐ 8. Identify and describe how explanations (hypotheses, laws, theories) of scientific phenomena have changed over time as a result of new evidence (e.g., theories of inheritance). (GLE 8.2.B.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Mendel's Laws Days 1–3	CE 1, 3 PE 4, 6, 7	**Day 1/Hands-On Lab/Activity:** Have students work in groups to create a list of characteristics that are inherited from their parents. Then have them indicate with an asterisk which characteristics on the list can be influenced by the environment and share their results with the class. Have students read Holt, pp. 162–165. As they read, they should take Two-Column Notes (*SUTW*, pp. 9-1 through 9-15). Display the Three Steps of Mendel's Experiments C1 teaching transparency (Ch. 8) and explain Mendel's experiments. Provide pairs of students with flowers (e.g., lilies, gladioli) to simulate how Mendel crossed his pea plants and then have them diagram and label the steps. After modeling Mendel's experiments, have students explain why pea plants are well suited for genetic studies. Have them hypothesize what other species might be useful for genetic studies and why. (Goals 1.3, 1.6, 2.3, 3.5, 4.1)
	CE 1, 3, 4 PE 4, 7	**Day 1/Hands-On Lab/Activity:** Have students observe some inherited traits in themselves and each other such as widow's peak, tongue rolling, detached earlobes, cleft chin, hitchhiker's thumb, dimples, mid-digital hair, and the ability to taste PTC strips. (Information on these characteristics can be found online; some of the traits are discussed in the "Identifying Dominant or Recessive Traits" Quick Lab on Holt, p. 168.) Explain the concept of dominant and recessive traits. Have students discuss whether a dominant trait is always better. Then extend the discussion to the benefits of genetic variation in a population and some problems that it can cause. Discuss the seven traits Mendel studied in pea plants. Provide students with examples of crosses between two true-breeding plants (e.g., smooth seeds × wrinkled seeds) that Mendel performed to demonstrate the 3:1 ratio seen in the F_2 offspring. Have students complete the Origin of Genetics Active Reading skills worksheet (Holt *Biology CRF 8: Mendel and Heredity*, pp. 9–10). Have each student toss a coin 20 times to determine the ratio of heads to tails observed. Tally individual results on the board to determine the average ratio of heads to tails for the class. Discuss why a large sample size and meticulous records were vital to Mendel's success. Have students complete the Calculating Mendel's Ratios Math Lab (Holt, p. 165). A datasheet is available on Holt *Biology CRF 8: Mendel and Heredity,* p. 45. (Goals 1.2, 1.3, 2.3)
	CE 1, 3, 4 PE 1, 4	**Day 2:** Have students read Holt, pp. 166–169 and then complete the Mendel's Theory Directed Reading Skills worksheet (Holt *Biology CRF 8: Mendel and Heredity*, p. 3). Have students work in pairs to create an illustrated dictionary (*ER,* p. GPT-6) for the key terms in this section, such as *allele, dominant, recessive, homozygous, heterozygous, genotype, and phenotype*. They should then write sentences to describe the relationship between terms such as *genotype* and *phenotype*, *allele* and *gene*, *homozygous* and *heterozygous*, and *dominant* and *recessive*. Have students create a graphic organizer that depicts the relationships between the terms. Then have students make flashcards using the key terms and use them to quiz each other. (Goals 1.5, 1.8, 4.6)

UNIT 9 SECTION 1

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Review with students the anatomy of the flower using a diagram or model, such as the Floral Structure G36 teaching transparency (Ch. 24). Have students identify the male and female structures and their functions in reproduction	Have students create a flowchart to describe the steps of Mendel's experiments. (ELL-2)	Have students begin a long term research project like the Analyzing Corn Genetics Inquiry Lab (Holt *Biology CRF 8: Mendel and Heredity*, pp. 61–65). The lab requires four weeks to complete. Students would need to regularly water the plants and collect the data at the end. This could be timed to coincide with this section or a subsequent section.
Relate the concepts of the P, F_1, and F_2 generations to the generations of the students, their parents, and their grandparents. Have them identify which label belongs with each generation.	Review with students how to set up the ratios. Provide examples and model how students should perform the calculations. (ELL-4)	Explain to students that Mendel choose to study traits that follow a simple pattern of dominant and recessive inheritance. However, most of the time, inheritance of traits is not so simple. Have students hypothesize why this is true based on what they studied about DNA and genetic processes in Unit 8.
Have students use a main-idea organizer (*ER*, p. RR-59) for each of the assigned sections to take notes as they read this section.	Explain to students that *pheno*- means "to show," *homo*- means "same," *hetero*- means "different." (ELL-1)	Have students investigate the genes that control eye color in humans to determine whether any one color is dominant over another.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Mendel's Laws Days 1–3	CE 1, 4 PE 1, 4, 6, 7	**Day 2/Technology:** Have students visit the Virtual Fly Lab at http://bioweb.wku.edu/courses/Biol114/Vfly1.asp. Have them complete three original crosses, record their crosses and the offspring produced, and answer the questions provided after each mating. After completing the Virtual Fly Lab, have them write Descriptive Paragraphs (*SUTW*, pp. 3-34 through 3-39) to describe the ratios observed in the F_1 and F_2 generations and how the results of the Fly Lab support the ratios that Mendel observed in his pea plant crosses. (Goals 1.6, 3.5, 4.1)
	CE 1, 3, 4, 5, 6 PE 1, 4, 6, 8	**Day 3/Hands-On Activity/Lab:** Introduce Mendel's laws of segregation and independent assortment and have students use pipe cleaners to model and relate them to what occurs during meiosis. Have students explain how Mendel's experiments support his laws of heredity. Have students complete the Law of Independent Assortment activity sheet, which is included at the end of the Model Lesson. Discuss the exceptions to his law of independent assortment including genes located on the same chromosome (linked genes). Have students imagine that they are Gregor Mendel and have them write a short article describing their findings. *See Model Lesson.* (Goals 1.6, 1.7, 3.2, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Define and explain *apterous*, *vestigial*, and *wild type* phenotypes before students conduct the lab.	Before conducting the lab, preview the directions for students, and model one cross. (ELL-4)	Have students research and report on other traits that are studied in fruit flies such as eye color (sex-linked) or bristles.
When discussing Mendel's laws, provide students with diagrams of meiosis to demonstrate how the two alleles for a trait segregate when gametes are formed, and how alleles for genes located on different chromosomes are inherited independently.	Have students complete the Graphic Organizer Activity on Holt *TE*, p. 168. (ELL-2)	Have students research a scientist other than Mendel who was or is involved in genetic research. They should include aspects of his or her life and a detailed description of the research.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Monohybrid and Dihybrid Crosses Days 4–5	CE 1, 2, 4 PE 1, 2, 3	**Day 4:** Demonstrate how to construct and analyze Punnett squares. Use the Monohybrid Crosses of Homozygous Plants C5 teaching transparency (Ch. 8) and the Monohybrid Crosses of Heterozygous Plants C6 teaching transparency (Ch. 8) to compare two monohybrid crosses. Have students work in pairs to practice constructing Punnett squares and predicting the outcomes of various monohybrid crosses. Then have students read the "Crosses That Involve Two Traits" Exploring Further (Holt, p. 171) and then work in pairs to complete the Punnett square and answer the questions. Have students write Process Paragraphs (*SUTW*, pp. 3-15 through 3-17) to explain how to construct and analyze a Punnett square. (Goals 1.8, 3.4, 4.1)
	CE 1, 2, 4 PE 1, 5, 6	**Day 5:** Ask students whether they can always predict a genotype by looking at an organism. Have them explain why or why not. Explain to students that in pea plants there are two alleles that control height (*T* for tall and *t* for dwarf). A homozygous recessive individual will be a dwarf plant. Have them imagine that they want to buy pea plants to breed them, but they do not want any who carry the *t* (dwarf) allele. A friend wants to sell them a tall pea plant. Have students work in groups to think about how they could determine its genotype. Give them the following hint: the friend will let them mate the plant a few times before buying it. Have groups draw Punnett squares to show how the plant's genotype could be revealed. Have groups share their methods. Explain which methods were successful and why. Have students complete the Analyzing a Test Cross Data Lab (Holt, p. 172). A datasheet is available on Holt *Biology CRF 8: Mendel and Heredity,* p. 49. Discuss situations in which test crosses would be useful and those in which they would be impractical. (Goals 1.8, 3.4, 4.1)
	CE 1, 2, 4 PE 2, 3, 7	**Day 5/Hands On Activity/Lab:** Use the Probability with Two Coins C4 teaching transparency (Ch. 8) to discuss probability. Have students put tape on both sides of a penny, labeling them *R* on one side and *R* on the other (to represent gametes from a homozygous dominant parent) and then label another penny *r*, *r*. Have students toss them together 20 times and record the combination of gametes. Tally class data. Discuss the importance of a large sample size. Have students determine possible genotypes in this case and the probability of offspring with each genotype. Then, have them use another penny labeled *R*, *r* to toss with the *R*, *R* penny; predict which genotype combination would be the most common in the offspring; and then follow the same procedure as before. Have students complete the Predicting the Results of Crosses Using Probabilities Math Lab (Holt, p. 174). A datasheet is available on Holt *Biology CRF 8: Mendel and Heredity*, p. 51. (Goals 1.3, 1.10, 3.2)
	CE 1, 2 PE 1, 2, 3	**Day 5/Hands On Activity/Lab:** Have students complete the Modeling Monohybrid Crosses Lab (Holt, pp. 186–187). Datasheets are available on Holt *Biology CRF 8: Mendel and Heredity,* pp. 55–58. (Goals 1.3, 2.1, 3.5, 4.1, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Perform the Using the Figure on Holt *TE*, p. 171 during the explanation of the teaching transparencies.	Have students complete the Studying Heredity Active Reading skills worksheet (Holt *Biology CRF 8: Mendel and Heredity*, p. 13) to reinforce concepts. (ELL-2)	Have students visit the Pea Experiment Web site (http://www.sonic.net/~nbs/projects/anthro201/exper/) to perform virtual dihybrid crosses. Have them create a Punnett square for each cross.
Perform the Test Cross Teaching Tip (Holt *TE*, p. 172).	Define the term *test cross* by examining each portion of the term. Have students identify what is being tested. (ELL-1)	Have students discuss whether it is possible to perform a test cross for two traits and why or why not.
Ask students whether two coins are more likely to be the same (both heads or both tails) or different when flipped. Have them determine the probability of tossing two heads, then a head and a tail. Have them actually toss the coins. Explain why results of a few tosses do not always match the predicted results.	Use a graphic organizer to review the process of constructing a Punnett square. Discuss the meaning of the term *probability* and the idea of whether something is probable or likely. (ELL-6)	Introduce students to the chi-square test to analyze the validity of statistical results.
Assist students in determining genotypic and phenotypic ratios by providing examples of how to perform the calculations.	Read through the procedure with students and provide a demonstration for each step of Part A. (ELL-4)	Have students complete research to answer the questions in the “Do You Know?” on Holt, p. 187.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 8: Mendel and Heredity*, pp. 3, 9–10, 51, 53, 55–58, 61–65

   Educational Resources, pp. GPT-6, RR-59

   Step Up to Writing, pp. 3-3 through 3-13, 3-15 through 3-17, 3-34 through 3-39, 9-1 through 9-15

2. **Internet Resources**

   Descriptions and Pictures of Inherited Traits in Humans
   http://sps.k12.ar.us/massengale/genetic_traits_activity.htm

   MendelWeb
   www.mendelweb.org

   Mendelian Genetics Problem Sets and Tutorials
   www.biology.arizona.edu/mendelian_genetics/mendelian_genetics.html

   Virtual Fly Lab
   http://bioweb.wku.edu/courses/Biol114/Vfly1.asp

   Pea Experiment
   www.sonic.net/~nbs/projects/anthro201/exper/

   Basic Principles of Genetics
   http://anthro.palomar.edu/mendel/Default.htm

3. **Multicultural Resources and/or Activities**

   Sickle-cell anemia is a hereditary disease that affects mostly people of African ancestry, but also occurs in other ethnic groups. Sickle-cell anemia occurs when an individual inherits two copies of the trait (on homologous chromosomes) which causes blood cells to be formed in the shape of a sickle. Many people are carriers of the sickle cell trait because they carry one copy of the gene. Have students research sickle-cell anemia further at http://kidshealth.org/teen/diseases_conditions/blood/sickle_cell_anemia.html.

Suggested Assessments

1. Have students complete Holt, p. 176, #1–5.
2. Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW,* pp. 3-3 through 3-13) to relate Mendel's four hypotheses to his experimental results.
3. Have students construct a Punnett square to cross two heterozygous individuals and then explain how probability relates to heredity, or have them construct a Punnett square to demonstrate how two parents with a dominant phenotype for a particular trait can have a child with the recessive phenotype for that trait.
4. Have students imagine that they have discovered a new species of insect in the rainforest. Have students provide examples of five traits, and, using a diagram and written statement, describe the possible genotypes and phenotypes for those five traits.

Sample Constructed-Response Item

Why is not always possible to determine the genotype of an organism through observation alone? How could the genotype be confirmed?

An organism with the dominant phenotype could be homozygous or heterozygous for that trait. A test cross could be performed by mating the organism with an organism with the homozygous recessive phenotype to observe offspring. If any of the offspring display the recessive phenotype, the genotype of the parent in question is known to be heterozygous.

Model Lesson (Traditional Roster):
Mendel's Laws

Lesson Questions

What is the law of segregation?
What is the law of independent assortment?
What is a sex-linked trait?

Materials

Pipe cleaners, coins, transparency of the Genotype-Phenotype Key, copies of the Law of Independent Assortment activity sheet, copies of Some Highlights in Genetic Research sheet, Stages of Meiosis B49 teaching transparency (Ch. 7)

Content and Performance Expectations

CE 1, 3, 4, 5, 6; PE 1, 4, 6, 8

Teacher's Notes

None

Warm-Up

Review of Meiosis

- Display the Stages of Meiosis B49 teaching transparency (Ch. 7).
- Have students write an outline of what happens to the sister chromatids of homologous chromosomes during meiosis.

Instruction

Mendel's Laws

▶ Law of Segregation

▷ Have students share their outline with the class.

▷ Have students explain why the separation of the sister chromatids of homologous chromosomes is important for sexually reproducing organisms.

▷ Review the concept that different alleles exist for the same gene. Have students provide examples of different alleles for the same trait (e.g., different eye colors or blood types).

▷ Explain to students that Mendel did not know about chromosomes or meiosis when he conducted his experiments, but he realized that when gametes are formed, they receive only one allele for each inherited trait. This is called the law of segregation.

▷ Provide groups of students with pipe cleaners and have them demonstrate and defend Mendel's law of segregation during meiosis.

▷ Provide students with the following example to demonstrate the law of segregation: True-breeding green pod pea plants × True-breeding yellow pod pea plants; the F_1 generation all have green pods. When two individuals from the F_1 generation are crossed, the F_2 offspring are 75% green pods and 25% yellow (3 green: 1 yellow).

▷ Have students answer the following questions about the example: 1) How many traits are segregating? 2) Which trait is dominant? Explain how this was determined. 3) What are the genotypes in the cross? 4) How does this cross illustrate the law of segregation?

▶ Law of Independent Assortment

▷ Explain that for the traits that Mendel studied, the alleles for different traits separated independently of each other. This is called the law of independent assortment.

▷ Display a transparency of the Genotype-Phenotype Key. Distribute copies of the Law of Independent Assortment activity.

▷ Have students complete the Law of Independent Assortment activity sheet.

▷ Discuss how this activity demonstrates the law of independent assortment.

▶ Exceptions to Mendel's Laws	▷ Explain to students that the modern study of genetics includes new insight related to Mendel's experiments. We now know that alleles for genes located on the same chromosomes are often inherited together. Mendel chose traits to study that were not located on the same genes. ▷ Have students read the handout, "Some Highlights in Genetic Research." Have students identify why it is important to scientists to publish their results. Discuss why the observations of one scientist must be confirmed by other scientists before they can be accepted by the scientific community as a whole. ▷ Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-13) to identify and describe how explanations of how characteristics are passed from parents to offspring have changed over time as a result of new evidence.

Assessment

- Have students imagine that they are Gregor Mendel and have them write a short article describing their experimental findings and the formulation of the laws of segregation and independent assortment.

Homework Assignment

- Have students complete Holt, p. 169, #1–6.

Teaching Resources

- Mendel Web: www.Mendelweb.org (contains Mendel's 1865 paper and resources)

activity sheet

name ______________________ **date** ____________

Law of Independent Assortment

You will be studying the patterns of inheritance in the newly discovered species, *Funnius geneticus*. For each trait, you will flip a coin to determine the allele contributed by the biological father. Heads indicates that the first allele is inherited while tails indicates that the second allele is inherited. Record the information on the table below and repeat for the biological mother. Determine the phenotype of the offspring from its genotype using the Genotype-Phenotype Key displayed on the overhead projector.

Trait	Biological Father	Biological Mother	Genotype	Phenotype
Face Shape	*Aa*	*Aa*		
Eye Shape	*Bb*	*Bb*		
Number of Eyes	*Cc*	*Cc*		
Nose Shape	*Dd*	*Dd*		
Location of Hair	*Ee*	*Ee*		
Ear Shape	*Ff*	*Ff*		
Mouth Shape	*Gg*	*Gg*		
Location of Mouth	*Hh*	*Hh*		

Portrait of the *Funnius Geneticus* Offspring

UNIT 9 SECTION 1

Describe the *Funnius geneticus* offspring. Use genetic terminology to explain the reasons for the offspring's phenotype.

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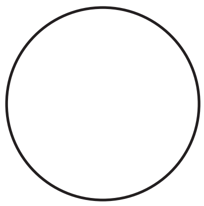
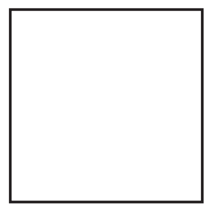
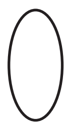
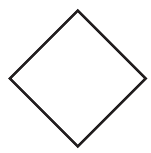
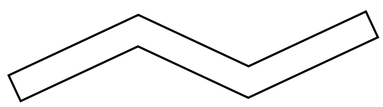
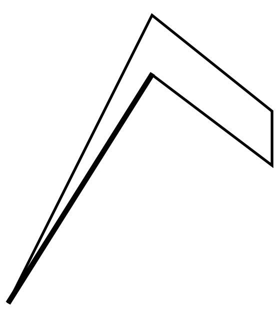
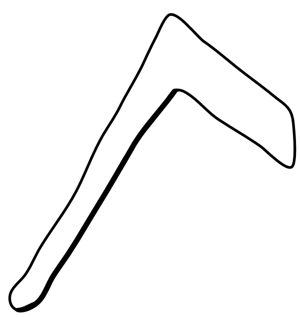
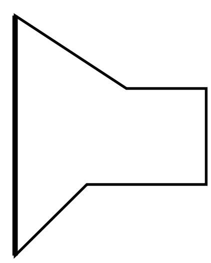
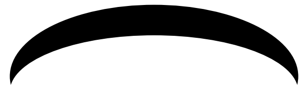
name ______________________ date ____________

Genotype-Phenotype Key

Trait	Genotype/Phenotype	Genotype/Phenotype	Genotype/Phenotype
Face Shape	*AA, Aa* 	*aa* 	
Eye Shape	*BB, Bb* 	*bb* 	
Number of Eyes	*CC* 4 eyes	*Cc* 3 eyes	*cc* 2 eyes
Nose Shape	*DD* 	*Dd* 	*dd* 
Location of Hair	*EE, Ee* Top of the head	*ee* Bottom of the head	
Ear Shape	*FF* 	*Ff* 	*ff* 
Mouth Shape	*GG, Gg* 	*gg* 	
Location of Mouth	*HH* Left side of the chin	*Hh* Middle of the chin	*hh* Right side of the chin

name ________________ date ________

Some Highlights in Genetic Research

In 1865, Mendel wrote a paper, "Experiments in Plant Hybridization," to explain the results of his pea plant breeding experiments. His experiments were mostly ignored at the time. In the year 1900, three botanists, all working independently and unaware of Mendel's work, arrived at the same principles of segregation and independent assortment from their own experiments.

Structures (chromosomes) in the nuclei of cells were first observed through a microscope by Nageli in 1842. This observation was confirmed years later by other scientists, and the structures were later named chromosomes.

In 1902, a scientist named Sutton observed spermatogenesis in the testes of grasshoppers and the reduction of the chromosome number to half the diploid number found in the adult. In 1903, he published a paper proposing that the behavior of chromosomes during meiosis could explain the segregation and recombination of genes observed by Mendel. Thus, Mendel's results could be explained by the fact that genes were parts of chromosomes. Other observations of meiosis by other scientists confirmed Sutton's results, which led to the development of the chromosome theory of inheritance.

Boveri, in 1902, demonstrated that a complete set of chromosomes is necessary for normal development in sea urchins. He observed that embryos with more or fewer chromosomes than the normally observed number did not develop properly. Through his experiments, he established the relationship between chromosomes and inheritance that was observed in other organisms by other scientists.

In 1908, two scientists, Bateson and Punnett, observed that purple flowers and long pollen were inherited together in the sweet pea more often (more than 75% of the time) than predicted by Mendel's law of independent assortment (50%). These experiments demonstrated linkage, an exception to Mendel's law of independent assortment. The two genes are close together on the same chromosome and are not always separated by crossing-over during meiosis.

Unit 9 Section 2

DNA: THE MOLECULE OF LIFE

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1	1	History of the Discovery of DNA	Holt, pp. 190–193
2–3		DNA Structure	Holt, pp. 194–197
4	2	DNA Replication	Holt, pp. 198–200

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

All living organisms have genetic material (DNA) that carries hereditary information. (GLE 3.3.B)

CONTENT EXPECTATIONS

☐ 1. DNA is a large polymer formed from linked subunits of four kinds of nitrogen bases; genetic information is encoded in genes based on the sequence of subunits. (GLE 3.3.B.a *PR*)

☐ 2. Identifying DNA as the molecule of heredity required the work of many scientists (e.g., Griffith, Avery, Hershey, Chase, Chargaff, Franklin, Wilkins, Watson, and Crick). (GLE 3.3.B *PR*)

☐ 3. Complementary base pairing is necessary to the process of DNA replication. (GLE 3.3.B *PR*)

…for Standard 7

Publication and presentation of scientific work with supporting evidence are required for critique, review, and validation by the scientific community. The presentation of such work adds to the body of scientific knowledge and serves as background for subsequent investigations in similar areas. (Framework I.A.2)

CONTENT EXPECTATIONS

☐ 4. The nature of science relies upon communication of results and justification of explanations. (GLE 7.1.E)

...for Standard 8

Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time. (GLE 8.2)

CONTENT EXPECTATIONS

☐ 5. Scientific theories are developed based on the body of knowledge that exists at any particular time and must be rigorously questioned and tested for validity. (GLE 8.2.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Explain the function and structure of DNA in living organisms. (GLE 3.3.B *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Describe the chemical and structural properties of DNA (e.g., DNA is a large polymer formed from linked subunits of four kinds of nitrogen bases; genetic information is encoded in genes based on the sequence of subunits; each DNA molecule in a cell forms a single chromosome). (GLE 3.3.B.a)

☐ 2. Develop a model to demonstrate the structure of DNA. (GLE 3.3.B.a *PR*)

☐ 3. Summarize the process of DNA replication. (GLE 3.3.B *PR*)

☐ 4. Explain how an error in the DNA molecule (mutation) can be transferred during replication. (GLE 3.3.B.d)

…for Standard 7

Apply science process skills, scientific knowledge, reasoning, and critical thinking to formulate scientific explanations and arguments. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 5. Communicate and defend a scientific argument. (GLE 7.1.E.b)

☐ 6. Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Framework I.A.3.a)

...for Standard 8

Explain how historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time. (GLE 8.2 *PR*)

PERFORMANCE EXPECTATIONS

☐ 7. Identify and describe how explanations (hypotheses, laws, theories) of scientific phenomena have changed over time as a result of new evidence (e.g., nature of heredity). (GLE 8.2.B.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
History of the Discovery of DNA Day 1	CE 2, 4 PE 1	Have students make a K-W-L chart (*ER*, p. RR-43) about DNA. Explain to students that the combined efforts of many scientists have led to our current understanding of the structure and function of DNA. Have students read Holt, pp. 190–193. As they read, have students complete the Paired Reading Skillbuilder on Holt *TE*, p. 191. Then have them complete the Identifying the Genetic Material Directed Reading skills worksheet (Holt *Biology CRF 9: DNA: The Genetic Material*, pp. 1–2). Use the Griffith's Discovery of Transformation C9 teaching transparency (Ch. 9) and Hershey-Chase Experiment C10 teaching transparency (Ch. 9) to discuss the experiments. Then have students create flowcharts or graphic organizers to organize the experiments of Griffith, Avery, and Hershey and Chase. (Goals 1.5, 1.8, 2.1)
	CE 2, 4, 5 PE 5, 7	**Technology**: Have students conduct a Web quest, where they visit Web sites and answer a set of questions as they view the animations and read the articles. After completing the Web quest, have students identify the important discovery related to each of these scientists' experiments and describe the evidence for the discovery. Then have students complete the Alternative Assessment on Holt *TE,* p. 193. *See Model Lesson*. (Goals 1.2, 1.4, 2.1)
DNA Structure Days 2–3	CE 1, 4 PE 1, 2, 6	**Days 2–3/Hands-On Activity/Lab:** As an opening exercise, have students complete the "Observing Properties of DNA" Quick Lab (Holt, p. 195). Change Analysis question 2 to a prediction of the characteristics of DNA and omit Analysis question 3. Display a commercial model (or one you have constructed) of DNA for students to observe and have them describe patterns in its structure. Identify its structure as a double helix. Display the DNA Double Helix C11 teaching transparency (Ch. 9) to further explain the structure of DNA, including the complementary base pairing. Discuss the importance of DNA in an organism and why it is important for the chemical instructions in an organism to be correct. Have them hypothesize how base pairing helps to maintain continuity in the DNA molecule. Have students read Holt, pp. 196–197 and then complete the Structure of DNA Directed Reading worksheet (Holt *Biology CRF 9: DNA: The Genetic Material*, pp. 3–4). Discuss Watson and Crick and their discovery of the DNA structure in the early 1950s. Explain that this model was based on data from other scientists' experiments and highlight the importance of the pictures of DNA generated by Wilkins and Franklin through x-ray diffraction. Have students complete a chart listing the scientists (i.e., Watson and Crick, Wilkins and Franklin, Chargaff), how they conducted their experiments, and their discovery related to DNA. Then have students complete Part A of the Modeling DNA Structure Lab (Holt, pp. 204–205). Datasheets are available on Holt *Biology CRF 9: DNA: The Genetic Material,* pp. 43–44. (Goals 1.5, 1.8, 3.5, 4.1)
	CE 1 PE 1, 5, 6	**Days 2–3/Hands On Activity/Lab:** Complete the Demonstration on Holt *TE*, p. 194 to construct a model of DNA for use in describing its structure. Have students examine data on nucleotide percentages present in different organisms and list any patterns they observe. Discuss the rules of base pairing with students. Have students examine Figure 6 on Holt, p. 196 and discuss their observations. Explain that x-rays of the DNA molecule led Watson and Crick to deduce that the structure of DNA was a double helix. Have students complete the Structure of DNA Active Reading skills worksheet (Holt *Biology CRF 9: DNA: The Genetic Material*, pp. 9–10). Display various pictures and diagrams of DNA for students to observe and discuss whether they accurately depict the structure of DNA. Have students complete the Extracting DNA Lab (Holt *Biology CRF 9: DNA: The Genetic Material,* pp. 47–51). (Goals 1.3, 1.5, 3.5, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students focus on creating a flowchart for one of the experiments, such as the Hershey-Chase experiment, rather than for all three.	Have students use note cards on which they diagram each step of one of the experiments discussed. Students should then shuffle the cards so that they are out of order and exchange cards with a partner to be arranged in the correct sequence. (ELL-5)	Have students perform a transformation exercise. Kits can be purchased from biological supply houses.
Have students organize their ideas before writing the article with a Power Outline (*SUTW*, pp. 2-11 through 2-17).	Allow students to write a journal entry about the scientists' work rather than the Alternative Assessment. (ELL-7)	Have students present their reports and then answer questions on them as part of a mock expert panel on the discovery of DNA.
Provide students with sample questions they may want to explore in the Modeling DNA Structure Lab. Have a class discussion about the possible ways the materials could be used to create the model.	Have students prepare an illustrated dictionary (*ER*, p. GPT-6) for the terms that are important in this section such as *double helix*, *nucleotide*, *complementary*, and *replication*. (ELL-6)	Have students complete research to answer the "Do You Know?" question 2 on Holt, p. 205.
Have students write a journal entry about what they learned during the lesson, such as what DNA looks like and how detergents, heat, and alcohol are used in the extraction of DNA. They should also include a list of concepts they still have questions about.	Read through the procedure with students and provide a demonstration for each step. (ELL-4)	Have students complete Extensions 1 on Holt *Biology CRF 9: DNA: The Genetic Material*, p. 51.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
DNA Replication Day 4	CE 3 PE 2, 3, 4	Have students read Holt, pp. 198–200. As they read, have them complete the Replication of DNA Directed Reading skills worksheet (Holt *Biology CRF 9: DNA: The Genetic Material*, pp. 5–6). Display the DNA Replication C12 teaching transparency (Ch. 9) to further explain the process. Discuss the proofreading of the DNA by DNA polymerases. Ask students why this is important. Have students explain what would happen if the DNA polymerase misses a copying mistake. Have students create 4 different nucleotides (to represent A, G, C, and T) using toothpicks and gumdrops. Then have them create a DNA molecule and use extra nucleotides to demonstrate the replication process. Give students a sequence of bases from a sample DNA strand and have them determine the base sequence of the complementary strand. Then have students complete the Analyzing the Rate of DNA Replication Math Lab (Holt, p. 199). A datasheet is available on Holt *Biology CRF 9: DNA: The Genetic Material*, p. 41. Have students write a Process Paragraph (*SUTW*, pp. 3-15 through 3-17) explaining the process of DNA replication. (Goals 1.5, 2.1)
	CE 3 PE 3, 4	Have students complete the Replication of DNA Active Reading skills worksheet (Holt *Biology CRF 9: DNA: The Genetic Material*, pp. 11–12). Have students explain how the base pairing rules in DNA facilitate the replication process. Introduce the concept of a mutation, and have students discuss how a mutation might be passed on during replication. Discuss the role of DNA polymerase in preventing the spread of mutations. Provide the nucleotides of a short sequence of DNA and indicate which is the coding strand. Work with the class to create diagrams of the steps this DNA would go through during replication. Have students work in groups to create and perform a role-play of DNA replication. (Goals 1.8, 2.5, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Prior to the lesson, have students complete the Interpreting Diagrams science skills worksheet (Holt *Biology CRF 9: DNA: The Genetic Material*, p. 15) to review the structure of DNA.	Have students examine animations from the Internet of the replication process (see Internet Resources). (ELL-2)	Discuss the Meselson-Stahl experiment and how it proved that the process of DNA replication was semiconservative as proposed by Watson and Crick.
Instead of creating a flowchart, display the DNA Replication C12 teaching transparency (Ch. 9) with the summaries of each step covered up. Have students provide a summary of each step.	Have students add important terms such as *DNA replication*, *DNA helicase*, *replication fork*, and *DNA polymerase* to their illustrated dictionaries (*ER*, p. GPT-7). (ELL-1)	Have students research and describe the role of Okazaki fragments in DNA replication.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 9: DNA: The Genetic Material*, pp. 1–12, 15, 41, 43–44, 47–51

   Educational Resources, pp. GPT-6, GPT-7, RR-43

   Step Up to Writing, pp. 2-11 through 2-17, 3-15 through 3-20, 8-8

2. **Internet Resources**

   DNA Replication Animation
   www.johnkyrk.com/DNAreplication.html

   DNA and Proteins Animations, History, and Problems
   www.dnaftb.org/dnaftb/15/concept/

   DNA Transformation Animation
   www.dnalc.org/ddnalc/resources/transformation1.html

   Animation of Avery's Experiment
   www.dnaftb.org/dnaftb/17/animation/animation.html

   The Hershey Chase Experiment
   www.accessexcellence.org/RC/AB/BC/Experiments_that_Inspire.html

   Video clips from the PBS DNA series
   www.pbs.org/wnet/dna/episode1/index.html

   Meselson-Stahl DNA Replication Experiment
   www.biology.arizona.edu/molecular_bio/problem_sets/nucleic_acids/06t.html

   Chargaff's Rule of Base-Paring
   http://fig.cox.miami.edu/~cmallery/150/gene/chargaff.htm

3. **Multicultural Resources and/or Activities**

   Discuss Baldomero Olivera, a Filipino scientist who has worked extensively to study the process of DNA replication. He is the codiscoverer of DNA ligase, an important enzyme in the replication process. He has also studied neurotoxins produced by marine snails, and his research has been used to create a pain medication more effective than morphine.

Suggested Assessments

1. Have students summarize in a List Paragraph (*SUTW*, pp. 3-18 through 3-20) the research of the different scientists studied in this section and their role in uncovering the secrets of DNA.
2. Have students complete the Alternative Assessment on Holt *TE*, p. 200.
3. Have students plan and build a model of DNA using candy (e.g., gum drops, toothpicks) and label the components.
4. Have students complete Holt, p. 197, #1–6.

Sample Constructed-Response Item

Explain the importance of complementary base pairing in the DNA molecule.

The sequence of bases on one strand of DNA determines the sequence on the other strand. When DNA is replicated, new nucleotides are added following the base-pairing rules so that two exact copies are made.

UNIT 9 SECTION 2

Model Lesson (Traditional Roster):

History of the Discovery of DNA: DNA Web Quest

Lesson Question

How did scientists discover that DNA is the molecule of heredity?

Materials

Computers with Internet access, copies of Web quest student activity sheet

Content and Performance Expectations

CE 2, 4, 5; PE 5, 7

Teacher's Notes

Students can work in pairs on this project if there are not enough computers available. Circulate around the room to ensure students are on task.

Warm-Up

Scientific Discovery

- Display a picture representing a DNA molecule. Have students identify it.
- Have students write a Free Response (*SUTW,* p. 8-8) about what they know about DNA. Ask students if they know who discovered DNA.
- Explain that our current knowledge of the function and structure of DNA is based upon the cumulative research of many scientists over time.
- Explain to students that they will conduct a Web quest to learn about the history of DNA research.

Instruction

DNA is the Hereditary Material

- DNA Web Quest Activity
  - Distribute copies of the Web quest activity sheet. Have students work independently or in pairs to answer the questions using the Internet.
  - Circulate throughout the room to answer questions and provide assistance.

▶ Discussion of the Web Quest	▷ After students complete the Web quest, have a discussion about what they have learned. ▷ Discuss how Griffith conducted a process known as transformation in his experiments. Explain that today scientists use transformation on a regular basis and that it is relatively simple to introduce new DNA (usually in the form of a plasmid) into a bacterium, by subjecting it to a heat shock that then causes the bacterium to pick up the new DNA. Thus, transformation can introduce new traits and alter the genotype of a cell. ▷ Discuss the fact that it took many experiments and much convincing to persuade many scientists that DNA was the hereditary material. Proteins seemed to be more complex and they had been studied more than DNA. People had previously thought DNA was too simple to have such an important job. ▷ Explain that the discoveries described in this lesson paved the way for other scientists, such as Wilkins, Franklin, Watson and Crick, to determine the structure of DNA and how it encodes hereditary information.
▶ Writing a Report	▷ Have students work in groups (or individually if there is not enough time) to complete the Alternative Assessment on Holt *TE,* p. 193.

Assessment

- ▶ Have students identify the important discovery related to each of these scientists' experiments.
- ▶ Have students complete the Holt, p. 193, #1–6.

Homework Assignment

- ▶ Have students complete the Identifying the Genetic Material Active Reading skill worksheet (Holt *Biology CRF 9: DNA: The Genetic Material*, pp. 7–8).

Teaching Resources

- ▶ DNA and Proteins Animations, History, and Problems: www.dnaftb.org/dnaftb/15/concept/
- ▶ DNA Transformation Animation: www.dnalc.org/ddnalc/resources/transformation1.html
- ▶ Animation of Avery's Experiment: www.dnaftb.org/dnaftb/17/animation/animation.html
- ▶ The Hershey Chase Experiment: www.accessexcellence.org/RC/AB/BC/Experiments_that_Inspire.html

name ______________________ date ____________

WEB QUEST

1. Go to www.dnaftb.org/dnaftb/15/concept/ and answer the following question:

In the early 1900s, many scientists thought proteins, not DNA, were the molecules of heredity. Why?

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2. Click the animation box at the bottom of the screen to view the animation and answer the questions. You can move to the next frame by clicking the arrow at the bottom right on the screen.

Where did Miescher collect the white blood cells that he studied? How did he extract the substance he called nuclein? What is nuclein?

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Why did Levene think that proteins were the molecules of heredity?

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List the three elements of a nucleotide. Describe the function of phosphodiester bonds in the DNA molecule.

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name ______________________ date __________

3. **Go to www.dnaftb.org/dnaftb/17/animation/animation.html to learn about Griffith's and Avery's experiments. Click through the animation to answer the questions**.

What is the cause of the different appearance between smooth and rough strains of *Pneumococcus*?

Describe the experimental set-up and results of Griffith's 1928 experiment.

Describe the set-up of Avery's experiments.

Why did he use the enzyme SIII to destroy the sugar coats of the bacteria?

How was he able to demonstrate that the transforming "principle" was not a protein?

09_StLouis_CR_10Sci_LPM6.indd 409 8/10/06 5:17:20 PM

activity sheet

name ____________________ date __________

What was Avery's conclusion?

4. Visit www.accessexcellence.org/RC/AB/BC/Experiments_that_Inspire.html and read about the Hershey-Chase experiment.

What types of diseases are viruses responsible for?

What did Hershey and Chase want to find out?

What is a bacteriophage? Why did Hershey and Chase choose the study viruses to uncover the molecule of heredity?

What did they use a blender for in this experiment?

How did they prove that the DNA, not the protein, from the bacteriophage enters the bacteria cell?

UNIT 9 SECTION 2

Unit 9 Section 3

HOW DNA TRANSLATES TO PHYSICAL CHARACTERISTICS: DNA—RNA—PROTEIN

SUGGESTED PACING

<table>
<tr><th>DAY (TRADITIONAL)</th><th>DAY (BLOCK)</th><th>TOPIC</th><th>CORE TEXT</th></tr>
<tr><td>1</td><td rowspan="2">1</td><td>Transcription</td><td>Holt, pp. 208–211</td></tr>
<tr><td rowspan="2">2–4</td><td rowspan="2">Translation</td><td rowspan="2">Holt, pp. 212–214</td></tr>
<tr><td>2</td></tr>
<tr><td>5</td><td>3</td><td>Regulation of Protein Synthesis</td><td>Holt, pp. 215–218</td></tr>
<tr><td>6–7</td><td>4</td><td>Mutations</td><td>Holt, pp. 219–220</td></tr>
</table>

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

DNA indirectly controls what cells do and when they do it by conveying encoded information directing the cell's synthesis of protein molecules. (Framework VII.A.3)

CONTENT EXPECTATIONS

☐ 1. Protein structure and function are coded by the DNA (deoxyribonucleic acid) molecule. (GLE 3.2.E)

☐ 2. Transcription is the process by which DNA information is encoded in RNA and translation is the process by which protein molecules are constructed according to the sequence of codons in the RNA molecule. (GLE 3.2.E *PR*)

☐ 3. Like DNA, RNA is a nucleic acid, a molecule made of nucleotides linked together. However, RNA differs from DNA in structure and function. (GLE 3.2.E *PR*)

☐ 4. Mutations in the DNA molecule could alter the amino acid sequence in the protein that is encoded for. (GLE 3.3.B.e *PR*)

☐ 5. New heritable characteristics can only result from new combinations of existing genes or from mutations of genes in an organism's sex cells. (GLE 3.3.D.c)

UNIT 9 SECTION 3

…for Standard 7

Science investigation is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 6. Scientific inquiry includes the ability to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. (GLE 7.1.A)

☐ 7. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO...

...for Standard 3

Explain the genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes, including the role of DNA in protein synthesis. (GLE 3.3 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Explain how the DNA code determines the sequence of amino acids necessary for protein synthesis. (GLE 3.2.E.a)

☐ 2. Recognize the function of protein in cell structure and function (i.e., enzyme action, growth and repair of body parts, regulation of cell division and differentiation). (GLE 3.2.E.b)

☐ 3. Recognize that DNA codes for proteins, which are expressed as the heritable characteristics of an organism. (GLE 3.3.B.b)

☐ 4. Identify possible external causes (e.g., heat, radiation, certain chemicals) and effects of DNA mutations (e.g., protein defects which affect chemical reactions, structural deformities). (GLE 3.3.B.e)

☐ 5. Describe how genes can be altered and combined to create genetic variation within a species (e.g., mutation, recombination of genes). (GLE 3.3.D.b)

☐ 6. Summarize the process of transcription. (GLE 3.2.E.a *PR*)

☐ 7. Outline the major steps of translation. (GLE 3.2.E.a *PR*)

☐ 8. Describe the role of regulatory proteins in the synthesis of proteins. (GLE 3.3.B.b *PR*)

...for Standard 7

Perform investigations to formulate explanations and develop science understanding. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 9. Formulate questions for scientific investigations that indicate conceptual insights and a depth of understanding of the historical development of the idea or issue to be investigated. (Framework I.B.1.a)

☐ 10. Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Framework I.A.3.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Transcription Day 1	CE 1, 2, 3 PE 2, 3, 6	Have students make a K-W-L chart (*ER*, p. RR-43) about proteins. Discuss the relationship between traits and proteins. Explain that proteins are responsible for the structural characteristics of organisms and provide examples such as hair color and texture, skin color, eye color, and bone structure. Remind students that enzymes are proteins and play an important role in the chemical reactions that occur inside an organism. Write "DNA⟶RNA⟶Protein" on the board. Explain that the instructions in the DNA molecule (determined by the nucleotide sequence) are used to make RNA, which is then used to produce proteins (the first arrow represents transcription, the second represents translation). Have students read Holt, pp. 208–211 and take Two-Column Notes (*SUTW*, pp. 9-1 through 9-15) as they read. In groups, have students construct Venn diagram (*ER*, p. RR-83) to compare and contrast DNA and RNA. (Goals 1.5, 1.8, 2.1, 2.3)
	CE 1, 2, 3, 7 PE 6, 10	**Hands-On Activity/Lab:** Display the Transcription C15 teaching transparency (Ch. 10) and use it to explain the steps of transcription. Explain that the instructions in DNA are written in the sequence of nucleotides, like a secret code, and this code is transcribed into the RNA molecule using the same nucleotides except T is replaced by U. Have students make a list of each substance involved in transcription and its function (e.g., uracil, RNA polymerase, promoter, codon). Have students complete the "Modeling Transcription" Quick Lab (Holt, p. 210). Datasheets are available on Holt *Biology CRF 10: How Proteins Are Made,* pp. 33–34. Have students write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) about transcription and replication. (Goals 1.3, 1.8, 2.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Display a diagram of a DNA nucleotide sequence and an RNA nucleotide sequence and have students compare their structure before beginning work on the Venn diagram.	Have students use Brainstorming Skillbuilder on Holt *TE*, p. 210 as they read Holt, pp. 208–211. (ELL-5)	Have students conduct research to find out how the nucleotide bases were identified. Then have them write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-14) about their findings.
Have students complete the Comparing Transcription and Replication Teaching Tip (Holt *TE*, p. 210) before writing the Compare and Contrast Paragraph.	Have students make a glossary for the key terms in this section including *RNA*, *transcription*, *translation*, *gene expression*, *RNA polymerase*, and *codon*. (ELL-2)	Discuss the scientific research of Marshall Nirenberg and Heinrich Matthaei who demonstrated the role of mRNA in how DNA is translated into protein.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Translation Days 2–4	CE 1, 2, 3 PE 1, 3, 7	**Days 2–3/Hands-On Activity/Lab:** Display the Codons in mRNA C16 teaching transparency (Ch. 10) and explain how to "crack the code" to determine the amino acid sequence. Point out synonyms, or different codes that translate into the same amino acid. Give students a sample DNA sequence, such as TACAGTGTGCGTCCCCGATTTACT, and then have them determine the corresponding RNA strand and amino acid sequence. Have students complete the Decoding the Genetic Code Data Lab (Holt, p. 214). Datasheets are available on Holt *Biology CRF 10: How Proteins Are Made*, pp. 35–36. Have students read Holt, pp. 212–214. Use the Translation: Assembling Proteins C17 teaching transparency (Ch. 10) to review the process of translation. Discuss the relationship between proteins and traits. Have students complete the From Genes to Proteins Directed Reading skills worksheet (Holt *Biology CRF 10: How Proteins Are Made*, pp. 1–2). Give students a sample coding DNA strand. Have students construct a paper model of the corresponding mRNA strand and paper models of different tRNA molecules with the anticodon on one end and the corresponding amino acid on the other end. Students should imagine that they are the ribosome and simulate translation. As the mRNA moves by, they should line it up with the corresponding tRNA molecule, tape together the amino acids to construct the protein, and cut off the protein from the tRNA molecules when the sequence is complete. Have students work in groups to complete the Alternative Assessment on Holt *TE*, p. 214. Then have students write a Process Paragraph (*SUTW*, pp. 3-15 through 3-17) to explain the process of translation. (Goals 1.8, 2.1, 2.5, 4.6)
	CE 1, 2 PE 1, 7	**Day 4/Technology:** After reviewing the steps of translation, have students visit http://gslc.genetics.utah.edu/units/basics/transcribe/ to transcribe and translate a gene. Have students record the DNA strand, the corresponding mRNA, and the amino acid sequence in the resulting protein. Have students make a diagram of cell and its organelles. Have them add in DNA, mRNA, tRNA, and amino acid molecules. Then have them demonstrate the process of protein synthesis and protein packaging and shipping, using arrows and numbers. Have students make a key for the diagram, indicating what each arrow and number represents. Then students should write a description of the interactions between cell organelles and the nucleic acids during transcription and translation. Provide students with an analogy of protein synthesis (see www.pbs.org/wgbh/nova/teachers/viewing/3210_02_nsn.html for an example). Have students work in groups to create their own analogies. (Goals 1.4, 1.6, 2.1)
	CE 1, 2, 7 PE 1, 6, 7, 10	**Day 4**: Explain to students that almost every organism on Earth uses the same genetic code system so that all of the different proteins that exist are made from different combinations of the same 20 amino acids. Have students discuss how this is possible and explain why the sequence must be important. Use a comparison with the words being made from the letters of an alphabet. Point out that there are only four nucleotide bases in DNA and RNA and have students discuss how a four-letter code might be able to specify 20 amino acids. Explain that the code is written in groups of three nucleotides (codons). Have students determine how many three-letter combinations can be made from four letters. Have students discuss the need for transcription and develop a hypothesis to explain why only one strand of the DNA molecule is used during transcription. Have students use their models from the previous suggested activity (Days 2–3) to test their explanations. Have students work in pairs, ask them to individually construct an amino acid sequence, then determine the mRNA codon sequence and the corresponding DNA molecule. Have them write down the DNA code and switch with their partner to crack each other's code and determine the correct amino acid sequence. (Goals 1.6, 2.3, 3.5)
	CE 2, 3, 4, 6, 7 PE 1, 6, 7, 9, 10	**Day 4/Hands-On Activity/Lab:** Have students brainstorm a list of all the terms associated with protein synthesis and write them on the board. In groups, students should use the terms to create a graphic organizer about protein synthesis. Have students conduct the Modeling Protein Synthesis Lab (Holt, pp. 224–225). Omit portions that deal with mutations. Datasheets are available on Holt *Biology CRF 10: How Proteins Are Made*, pp. 39–42. (Goals 1.1, 1.2, 1.3, 1.8)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students use a note taking strategy, such as making a main idea organizer (*ER*, p. RR-59) for each paragraph as they read.	Provide several examples of translation using diagrams, videos, and/or animations, to reinforce the concept. (ELL-2)	Have students complete the Retroviruses Group Activity (Holt *TE*, p. 213).
Have students practice transcribing DNA to mRNA and translating RNA into the correct amino acid sequence, by providing a worksheet with sample DNA sequences.	Have students work in groups to make the cell diagram of translation. (ELL-5)	Have students watch the NOVA program RNAi segment available on the Web at www.pbs.org/wgbh/nova/teachers/viewing/3210_02_nsn.html. Have a class discussion about the discovery of RNAi, and its role in protecting cells from viral RNA and preventing the translation of viral proteins.
Have students first determine the number of combinations of any two bases of the four found in DNA.	Have students complete the Triplet Spelling Activity (Holt *TE*, p. 211) as an introduction to this lesson. (ELL-2)	Have students view a detailed animation of transcription (see Internet Resources) and discuss the modifications to the RNA molecule before it moves out of the nucleus.
Have students complete the Concept Mapping skills worksheet on Holt *Biology CRF 10: How Proteins Are Made*, p. 13 instead.	Have the class brainstorm a list of possible questions to explore in this Lab. Have a class discussion about how to use the materials to build the model. (ELL-4)	Discuss rRNA, the main constituent of ribosomes, and its role in protein synthesis.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Regulation of Protein Synthesis Day 5	CE 1 PE 8	Explain to students that all genes are not constantly being expressed and thus not all genes are being translated all the time. A typical human cell only expresses a tiny percentage of its genes at a particular time. Have students hypothesize why. Point out that the cell must regulate what is occurring, what proteins are being made, and genes can be turned off and on. Have students read Holt, pp. 215–218. As they read, have them use sticky notes to record important information and write down questions that they have. Use the Demonstration on Holt *TE,* p. 216 to demonstrate the regulation of the *lac* operon. Have students complete a labeled diagram in their notebooks of the *lac* operon and explain how it is turned off and on. Display a diagram of RNA synthesis and processing, such as the one at www.accessexcellence.org/RC/VL/GG/rna_synth.html, to explain how RNA is processed. Have students complete the "Modeling Introns and Exons" Quick Lab (Holt, p. 218). Datasheets are available on Holt *Biology CRF 10: How Proteins Are Made,* pp. 37–38. (Goals 1.5, 2.1, 3.5)
	CE 1 PE 8	Discuss the function of regulatory proteins in gene expression in prokaryotes and eukaryotes. Have students evaluate the adaptive value of regulating gene expression by turning genes off and on. Then have students work in groups to create a role-play or a model of how the *lac* operon is turned off and on, or how transcription is regulated in eukaryotes. After the groups present their role-plays or models, have students complete the Organizing Information Study Tip on Holt *TE*, p. 217 comparing the types of gene regulation. Have students write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) about gene regulation in prokaryotic and eukaryotic cells. (Goals 1.8, 2.1, 2.5, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students make two flowcharts to explain the *lac* operon, one for when there is no lactose present and another for when lactose is present.	Have students work in pairs to complete the reading. After reading each section, have students discuss the main ideas and try to answer each other's questions. (ELL-5)	Have students research and report on theories about the existence of introns.
Have students draw diagrams to explain how regulatory proteins control gene expression.	Have students add key terms to their glossary, such as *operator*, *operon*, and *repressor*. Discuss other usage for the terms *operator* and *repressor*. (ELL-2)	Have students investigate the *trp* operon and compare and contrast with the *lac* operon.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Mutations Days 6–7	CE 4, 5 PE 4, 5	**Day 6:** Review with students the concept of a mutation. Refer to the Modeling Protein Synthesis Lab (Holt, pp. 224–225) if students completed it. Discuss similarities and differences between chromosomal mutations and gene mutations. Display the Major Types of Mutations C26 teaching transparency (Ch. 10) and compare gene rearrangements, point mutations (insertion and deletion), and frame shift mutations. Have students explain how a mutation in a DNA sequence might affect the protein that it codes for. Discuss the role of mutations in creating genetic variation. Have students complete the Interpreting Tables skills worksheet on Holt *Biology CRF 10: How Proteins Are Made*, pp. 11–12. Have groups of students research mutagenic agents (e.g., x-rays, UV light, radioactivity) and how they cause mutations, and then prepare a short presentation for the class. (Goals 2.1, 4.6)
	CE 4, 5, 7 PE 4, 5, 10	**Day 6:** Have students read Holt, pp. 219–220. Have them identify the main idea for each paragraph using the main-idea organizer (*ER*, p. RR-59). Have students make connections to the Modeling Protein Synthesis Lab (Holt, pp. 224–225) if they completed it. To demonstrate how gene mutations affect the protein, give students a sequence such as TACGCCAGTGGTTGAACT, have them transcribe it to mRNA, then translate it to determine the amino acid sequence. Then introduce a point mutation by changing the fourth base from a G to a C and have students demonstrate how this would affect the protein produced. Using the provided DNA stand, have students provide an example of frame shift mutation. Compare how the different types of mutations affect the protein produced. Have students identify a mutation that would not affect the amino acid sequence. Point out that not all mutations are bad. Have students work in groups to complete the Alternative Assessment on Holt *TE*, p. 221. Discuss the role of mutations in creating genetic variation. Have a class discussion about how mutations would be involved in the evolution of a species. (Goals 2.3, 3.5, 4.1)
	CE 4 PE 4	**Day 7:** Have students create an informational pamphlet about a genetic disease (e.g., hemophilia, sickle cell anemia, PKU, Tay-Sachs, cystic fibrosis, Huntington's, ALS). They should choose a disorder, and research the genetic mutation that causes it, symptoms, incidence, ways to test, treatment, and current research on the disease. *See Model Lesson.* (Goals 1.2, 1.4, 1.8, 2.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students make flash cards with the type of mutation on one side and an explanation on the other. Then have them quiz each other.	Have students add important terms from this section, such as *gene rearrangements*, *point mutations*, and *frame shift mutations,* to their glossaries. (ELL-1)	Discuss temperature-sensitive mutations with students and their use in genetic research. Researchers can turn a gene off and on depending on the temperature that an organism is exposed to.
Show students unlabeled diagrams of different types of mutations and have them describe in their own words what is taking place. Then label each of the mutations with the correct vocabulary.	Have students work in pairs to transcribe and translate the DNA sequence and determine the effect of a mutation. (ELL-5)	Have students read the section entitled "Jumping Genes" (Holt, p. 216) and discuss how they can cause mutations in a DNA sequence.
Provide students with some sample pamphlets from a doctor's office or health clinic so they know how to design the project.	Provide students with the opportunity for self-assessment on this project by writing a journal or defending their project orally. (ELL-7)	Have students interview a genetic counselor to gather information for the pamphlet.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 10: How Proteins Are Made*, pp. 1–2, 11–13, 33–42

   Educational Resources, pp. RR-43, RR-59, RR-83, PTT-51

   Step Up to Writing, pp. 3-3 through 3-14, 3-21 through 3-29, 9-1 through 9-15

2. **Internet Resources**

   The Life and Scientific Work of Marshall Nirenberg
   www.calstatela.edu/faculty/nthomas/nirenber.htm

   Transcription Animation
   www.johnkyrk.com/DNAtranscription.html

   Transcribe and Translate a Gene
   http://gslc.genetics.utah.edu/units/basics/transcribe/

3. **Multicultural Resources and/or Activities**

   Discuss the research of Har Gobind Khorana, an Indian-American biochemist. In the 1960s, he created artificial genes in a laboratory that were capable of coding for the synthesis of proteins, as genes do in living cells. Khorana received the Nobel Prize for Physiology or Medicine in 1968.

Suggested Assessments

1. Have students write a short essay summarizing how DNA directs the production of proteins in the cell.
2. Have students create a role-play to demonstrate the process of protein synthesis.
3. Have students create a coding DNA sequence, transcribe the base sequence of the complementary molecule of mRNA and identify the corresponding tRNA molecules, and then write out the animo acid sequence of the resulting protein. (Give them the hint that it would best to choose the amino acid sequence first.)
4. Have students complete Holt, p. 220, #1–5.
5. Have students make a graphic organizer that shows the role of RNA in gene expression, including terms such as *transcription, translation, mRNA, tRNA, rRNA, codons, anticodons, ribosome, protein,* and *amino acids*.

Sample Constructed-Response Item

Describe two possible results of changing one nucleotide in a DNA sequence.

It may result in the placement of the wrong amino acid during protein synthesis or the termination of the synthesis process.

Model Lesson (Block Roster):

Mutations: Genetic Disease Pamphlets

Lesson Question

What types of mutations are associated with specific genetic disorders?

Materials

Library access and/or computers with Internet access, samples of pamphlets from a doctor's office or clinic, *CNN Presents Science in the News: Biology Connections* videotape, copies of the Segment 8: Alzheimer's Mutations worksheet from *CNN Presents Science in the News: Biology Connections Critical-Thinking Worksheets*

Content and Performance Expectations

CE 4; PE 4

Teacher's Notes

Students can work in pairs on this project if there are not enough computers available. Students will need to complete their pamphlets outside of class. Provide a due date and after they are collected, display completed pamphlets.

Warm-Up

Mutations

- Have students work in groups to create three lists: 1) Causes of Mutations, 2) Types of Mutations, and 3) Effects of Mutations.
- Have groups share lists with the class.
- Discuss how protein function can be inhibited due to a change in amino acid sequence. Have students discuss whether gene mutations can be avoided.
- Have students discuss what it means to be a carrier of a genetic disease and whether they would want to know if they were a carrier.

Instruction

Genetic Disease Pamphlet

- **Research**
  - ▷ Explain to students that they will research a genetic disease and create an educational pamphlet about the disease. Allow them to choose from a list of genetic diseases (e.g., PKU, cystic fibrosis, hemophilia, sickle cell anemia, Tay-Sachs, Huntington's disease, ALS).
  - ▷ Explain that the pamphlet will include the following information: how the disease is caused and/or inherited, what specific protein function is affected, how it is identified, its incidence, symptoms of the disease, treatment and/or prevention of the disease, screening for the disease, and current research on treatment and/or prevention.
  - ▷ Allow students to research their disease using the Internet and/or library. Information may also be available in the textbook. Have students use an organizer to gather information such as the research paper quote-to-paraphrase transformation chart (*ER*, p. PTT-51).
  - ▷ Have students plan the layout and design of their pamphlet.
  - ▷ Circulate throughout the room to answer questions and provide assistance.
  - ▷ Pair students and have them examine the layout and design of each other's pamphlets, as well as their notes. Have students provide feedback for each other and ask questions.
  - ▷ Have students complete their pamphlets outside of class and provide a due date. If possible, have them contact a genetic counselor to gather more information.

Follow-Up Class Discussion

- **Genetics and Society**
  - ▷ Distribute copies of the Segment 8: Alzheimer's Mutations worksheet from *CNN Presents Science in the News: Biology Connections Critical Thinking Worksheets.* Play Segment 8: Alzheimer's Mutation from *CNN Presents Science in the News: Biology Connections*.
  - ▷ Discuss students' responses to the video clip.
  - ▷ Have a class discussion about the pros and cons of genetic testing and testing individuals to see if they are carriers of a disease.

Assessment

- Have students prepare a short oral report on the genetic disease they researched.

Homework Assignment

- Have students complete a journal entry about what they learned while completing this project.

Teaching Resources

- Prenatal Genetic Testing: www.dnafiles.org/about/pgm3/topic.html
- Understanding Gene Testing: www.accessexcellence.org/AE/AEPC/NIH/gene05.html
- Medline Plus (database of medical information): http://medlineplus.gov/
- Children's PKU Network: www.pkunetwork.org/
- Sickle-Cell Anemia: http://kidshealth.org/teen/diseases_conditions/blood/sickle_cell_anemia.html

Unit 9 Section 4

GENE TECHNOLOGY

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–2	1	Recombinant DNA	Holt, pp. 228–232
3–4	2	Genetically Modified Organisms (GMOs)	Holt, pp. 238–242
5–6	3	Applications of Genetic Engineering in Humans	Holt, pp. 233–237

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. (GLE 3.3)

CONTENT EXPECTATIONS

☐ 1. Genes can be altered and combined to create genetic variation within a species (e.g., recombination of genes). (GLE 3.3.D.b *PR*)

☐ 2. Recombinant DNA, DNA made from two or more organisms, has important scientific and medical applications (e.g., manufacturing new drugs and vaccines, genetically modified plants and animals). (GLE 3.3.D.b *PR*)

☐ 3. Restriction enzymes, gene cloning, and gel electrophoresis are important tools and techniques used in genetic engineering. (GLE 3.3.D.b *PR*)

☐ 4. DNA fingerprinting is an important tool in forensics and medicine. (GLE 3.3.D.b *PR*)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 5. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

…for Standard 8

The nature of technology can advance, and is advanced by, science as it seeks to apply scientific knowledge in ways that meet human needs. Science and technology affect, and are affected by, society. (GLE 8.1, 8.2 *PR*, 8.3)

CONTENT EXPECTATIONS

☐ 6. Advances in technology often result in improved data collection and an increase in scientific information. (GLE 8.1.B)

☐ 7. Technological solutions to problems often have drawbacks as well as benefits. (GLE 8.1.C)

☐ 8. Social, political, economic, ethical, and environmental factors strongly influence, and are influenced by, the direction of progress of science and technology. (GLE 8.3.B)

☐ 9. Gender and ethnicity may influence the questions asked, methods used in scientific research, and/or the applications of scientific research. (GLE 8.2.A.b *PR*)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Analyze the genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. (GLE 3.3 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Describe how genes can be altered and combined to create genetic variation within a species (e.g., recombination of genes). (GLE 3.3.D.b)

☐ 2. Explain the process of genetic engineering. (GLE 3.3.D.b *PR*)

☐ 3. Explain how DNA fingerprints are made and what they are used for. (GLE 3.3.D.b *PR*)

...for Standard 7

Perform investigations to develop science understanding. (GLE 7.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 4. Analyze experimental data to determine patterns, relationships, perspectives, and credibility. (Framework I.A.1.a)

…for Standard 8

Explain how science and technology affect, and are affected by, society. (GLE 8.1 *PR,* 8.3 *PR*)

PERFORMANCE EXPECTATIONS

☐ 5. Recognize the relationships linking technology and science (e.g., how new technologies make it possible for scientists to extend research and advance science). (GLE 8.1.B.a)

☐ 6. Identify and evaluate the drawbacks (e.g., unintended consequences, risks) and benefits of technological solutions to a given problem (e.g., genetic engineering of cells). (GLE 8.1.C.a)

☐ 7. Identify and describe major scientific and technological challenges to society and their ramifications for public policy (e.g., genetic engineering of plants). (GLE 8.3.B.b)

☐ 8. Identify the ethical issues involved in experimentation (i.e., risks to organisms or the environment). (GLE 8.3.C.b)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Recombinant DNA Days 1–2	CE 1, 2, 3, 6 PE 1, 2, 5	**Day 1/Hands-On Activity/Lab:** Discuss examples of applications of recombinant DNA technology, such as manufacturing insulin. Explain to students how recombinant DNA is produced and isolated. Include the Molecular Scissors Attention Grabber (Holt *TE*, p. 230). Have students complete the Recombinant DNA Activity (Holt *TE*, p. 229). Then have students create a labeled paper model of recombinant DNA with a diagram of how it was constructed. *See Model Lesson*. (Goal 2.1)
	CE 1, 3 PE 1, 2	**Day 2/Hands-On Activity/Lab:** Display the Gel Electrophoresis C33 teaching transparency (Ch. 11). Discuss how gel electrophoresis is used to confirm the presence of the desired DNA sequence. Have students conduct the "Modeling Gel Electrophoresis" Quick Lab (Holt, p. 232). A datasheet is available on Holt *Biology CRF 11: Gene Technology,* p. 39. Have students write a Process Paragraph (*SUTW*, pp. 3-15 through 3-17) to explain how recombinant DNA is made and then confirmed. *See Model Lesson*. (Goals 1.6, 2.1)
	CE 1, 3 PE 1, 2	**Day 2/Hands-On Activity/Lab**: Have students complete the Exploration Lab: Modeling Recombinant DNA (Holt, pp. 246–247). Datasheets are available on Holt *Biology CRF 11: Gene Technology*, pp. 41–44. (Goals 1.3, 2.1, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Prior to the lesson, have students predict the definition of the term *recombinant DNA*, based on similar-sounding words. At the end of the lesson, have students explain whether their predictions were correct and how this was determined.	Have students add the key terms for this lesson, such as *restriction enzyme*, *vector*, and *plasmid*, to their glossaries. (ELL-1)	Have students research and report on recombinant bacteria, such as the ones created to degrade oil from oil spills.
Use the Using the Figure on Holt *TE*, p. 231 when discussing the Gel Electrophoresis C33 teaching transparency (Ch. 11).	Instead of a Process Paragraph, have students complete a flowchart of the steps to create recombinant DNA and confirm its presence. (ELL-7)	Discuss the information in the Integrating Physics and Chemistry on Holt *TE*, p. 231.
Have students complete the Interpreting Diagrams science skills worksheet on Holt *Biology CRF 11: Gene Technology*, pp. 15–16.	Prior to the lab, provide students with several examples of the complementary sticky ends produced after DNA molecules are cut with restriction enzymes. (ELL-2)	Have students carry out a lab transforming bacteria with a plasmid containing antibiotic resistance or fluorescence instead (such as the Transforming Bacteria with a Firefly Gene on Holt *Biology CRF 11: Gene Technology*, pp. 53–58). Alternatively, laboratory kits can be purchased from biological supply houses.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Genetically Modified Organisms (GMOs) Days 3–4	CE 2, 6, 7, 8 PE 1, 5, 6, 7, 8	**Days 3–4:** Have students complete the first two columns of a K-W-L chart (*ER*, p. RR-43) about genetically engineered plants and animals. Have students read Holt, pp. 238–242 and complete a Q&A note-taking chart (*ER*, p. RR-73). Discuss the possible advantages (e.g., improved nutritional value of crops) and risks (e.g., experimentation on plants leading to the unintentional spread of recombinant DNA). Then have students complete the Genetic Engineering in Agriculture Directed Reading worksheet (Holt B*iology CRF 11: Gene Technology*, p. 5). Have students complete the Genetically Engineered Crop Plants Group Activity (Holt *TE*, p. 239) and then complete the last column of their K-W-L chart. (Goals 1.4, 1.5, 2.1, 4.6)
	CE 2, 7, 8 PE 6, 7, 8	Have a class discussion to compare and contrast organisms produced by selective breeding and those produced by genetic engineering. Have students prepare for and conduct a debate (*ER,* p. PTT-9) about whether genetically modified organisms are beneficial for humans and the environment. Divide the class into two groups, one that supports GMOs and one that is against the production of GMOs. Have students research the benefits and risks associated with GMOs, prepare a written statement, and then conduct a debate with the teacher as the moderator. At the conclusion of the debate, have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW,* pp. 3-3 through 3-14) that concludes with their own opinions about whether GMOs are good for society and the environment. (Goals 1.4, 2.1, 2.3, 3.1, 4.1)
	CE 2, 7, 8 PE 6, 7, 8	Discuss what students know about Dolly, the cloned sheep. Have students complete the Genetic Engineering in Agriculture Active Reading worksheet (Holt *Biology CRF 11: Gene Technology*, pp. 11–12). Have students make a flowchart outlining the steps used to make Dolly. Have students read an article about Dolly the sheep, such as "Dolly, the sheep clone, dies young" at http://news.bbc.co.uk/2/hi/science/nature/2764039.stm, and note the pros and cons discussed in the article. Discuss the ethics involved. Have students work in groups to make a list of pros and cons associated with transgenic and cloned animals. Have students write a Stand Up and Sound Off Speech (*SUTW*, p. 5-17) to present to legislators to either ban or support cloning. (Goals 2.4, 3.8, 4.1, 4.6)

Suggested Adaptations

	STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
	Have students use the research paper quote-to-paraphrase transformation chart (*ER*, p. PTT-51) to collect the information for the Engineered Crop Plants Group Activity (Holt *TE*, p. 239).	Have students read the text in pairs. After each section have them summarize the material and any questions they might have. (ELL-5)	Discuss with students the creation of "knockout mice" and their use in scientific research (see Internet Resources).
	Provide students with specific articles to read or Web sites to visit to ensure they are getting reliable information.	Instead of a debate, have students create questions related to GMOs, conduct an opinion poll, and report on their results. (ELL-7)	Have students research and then prepare a short oral report about global controversy or local public policy in relation to genetically modified crops.
	Have a class discussion to explore what makes a speech effective and the appropriate tone to use in the speech.	Have students read the article in pairs. After each paragraph they should discuss the main points and any questions they may have. (ELL-5)	Have students research and report on current legislation that is being proposed to deal with the issues of cloning.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Applications of Genetic Engineering in Humans Days 5–6	CE 4, 5, 6, 7, 8, 9 PE 3, 4, 5, 6, 7	**Days 5–6/Technology:** Cut out bar codes from different boxes and create a fictional name for each one (each student should have a unique bar code). Make an enlarged copy of one of them for an overhead projector. As students enter the class, distribute one to each student and explain that this is a DNA fingerprint of a crime suspect and that they are a team of detectives working on the case. The bar codes represent DNA samples that were collected from the scene of the crime. Explain that the samples were sent in for analysis (DNA fingerprinting) and display the "results" on the overhead. Have students determine who committed the crime. Have students complete a jigsaw (*ER,* p. GPT-7) to read Holt, pp. 233–237. Break the class up into groups and assign each member of a group one of the following sections: "The Human Genome Project," "Genetically Engineered Drugs and Vaccines," and "DNA Fingerprinting" that they will then explain to their group. Use the Genetically Engineered Medicine C35 teaching transparency (Ch. 11) and Making a Genetically Engineered Vaccine C38 teaching transparency (Ch. 11) to explain how they are made and used. Then have them complete the Human Applications of Genetic Engineering Directed Reading worksheet (Holt *Biology CRF 11: Gene Technology*, pp. 3–4). Have students visit the Web site for the Human Genome Project (www.genome.gov/12011238) to read an overview of the project. Have students discuss questions such as, "How many genes have been identified in the human genome?" "How is the genome like a book with multiple purposes?" and "What are the benefits of sequencing the entire human genome?" Also discuss any related issues of gender and/or ethnicity. Display a sample DNA fingerprint and explain how it is made and how scientists use it. Have students complete the Genetic Privacy Group Activity (Holt *TE,* p. 234). Have students work in groups to complete the Ads for Gene Products Group Activity (Holt *TE,* p. 240). (Goals 1.4, 1.5, 3.5, 3.6, 3.8)
	CE 3, 4, 5, 6, 9 PE 3, 4, 5	**Days 5–6/Hands-On Activity/Lab:** Review the process of genetic engineering and its applications in creating genetically modified plants and animals. Have students discuss possible applications of genetic engineering in humans. Have students complete the Human Applications of Genetic Engineering Active Reading skills worksheet (Holt *Biology CRF 11: Gene Technology*, pp. 9–10). Discuss the Human Genome Project and have students work in groups to create list of possible applications of the Human Genome Project. Have students complete the DNA Whodunit Exploration Lab (Holt *Biology CRF 10: How Proteins Are Made*, pp. 43–48) or the Murder and the Blood Sample Lab (Holt *Forensics and Applied Science Experiments*, pp. 77–82). Review the applications of genetic engineering in humans, including potential differences by gender and/or ethnicity. Have students write a Persuading or Convincing Paragraph (*SUTW*, pp. 3-30 through 3-33) for or against the use of genetic engineering in humans. (Goals 1.3, 3.2, 3.5)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students make a graphic organizer like the one on Holt *TE*, p. 238 to outline how genetically engineered drugs are made.	Use the Demonstration in Holt *TE*, p. 233 to introduce DNA fingerprints. (ELL-2)	Have students read the Polymerase Chain Reaction (PCR) BioWatch article about PCR (Holt, p. 236) and then complete a sequencing map (*ER*, p. RR-77) to explain the steps of PCR.
Before conducting this lab, have a class discussion about forensics and the different types of evidence used to solve crimes.	Have students write a journal entry on their personal feelings about the use of DNA fingerprinting. Have them explain why they feel the way they do. (ELL-7)	Have students complete Extensions 1 and/or 2.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 11: Gene Technology,* pp. 3–5, 9–12, 15–16, 39, 41–44, 53–58

   Holt *Biology CRF 10: How Proteins Are Made,* pp. 43–48

   Holt *Forensics and Applied Science Experiments*, pp. 77–82

   Educational Resources, pp. GPT-7, PTT-9, PTT-51, RR-43, RR-59, RR-73, RR-77

   Step Up to Writing, pp. 3-3 through 3-17, 3-30 through 3-39, 5-17

2. **Internet Resources***

   * *Teachers should discuss the influence of bias and point of view on content before having students visit Web sites about controversial issues, such as GMOs.*

   Knockout Mice
   http://genome.wellcome.ac.uk/doc%5Fwtd021038.html

   Say No to GMOs
   www.saynotogmos.org/

   Greenpeace: Say NO to GMOs
   www.greenpeace.org/international/campaigns/genetic-engineering

   GMOs: Looking at Both Sides of the Controversy
   www.aces.uiuc.edu/~asap/expanded/gmo/gmo.html

   The Science Behind GMOs
   www.nature.ca/genome/03/d/30/03d_33_e.cfm

   Regulating GMOs in Developing and Transition Countries
   www.fao.org/biotech/C9doc.htm

3. **Multicultural Resources and/or Activities**

   Point out that Howard University has started a research center called the National Human Genome Center which "is a comprehensive resource for genomic research on African Americans and other African Diaspora populations, distinguished by a diverse social context for framing biology as well as the ethical, legal, and social implications of knowledge gained from the human genome project and research on genome variation." The center conducts research on African Americans and West Africans, and cancers that disproportionately affect those of African descent. The center's goal is also to train more African-American researchers and attract them to the field of molecular biology.

   Discuss the Genographic Project, which hopes to collect DNA samples from people all over the world to determine the migratory routes of early humans, and the international Human Genome Diversity Project, which was designed to trace the evolutionary history of the human race. Point out that these projects are controversial and have been met with resistance from some Native-American organizations.

   Have students complete the Genetic Diseases of Different Ethnicities Group Activity (Holt *TE,* p. 235).

Suggested Assessments

1. Have students create a model recombinant DNA molecule. Have them create a sequence of DNA that includes two restriction sites for the restriction enzyme, Hind III (Hind III recognizes the sequence AAGCTT and cuts between the two A's). Have students demonstrate the sticky ends created by Hind III, and then create a plasmid vector for the DNA to be spliced into.
2. Have students write Descriptive Paragraphs (*SUTW*, pp. 3-34 through 3-39) about how DNA technology affects medicine and agriculture.
3. Have students complete Holt, p. 232, #1–6.
4. Have students create posters to teach the public about the Human Genome Project and its applications.
5. Have students write a Persuading or Convincing Paragraph (*SUTW*, pp. 3-30 through 3-33) to explain why they support or are against cloning of animals and humans.

Sample Constructed-Response Item

Explain why DNA fingerprinting can be used as evidence to solve a crime.

Every individual (except identical twins) has a unique DNA fingerprint. A DNA sample from a crime scene can be compared with a DNA sample collected from a suspect to determine if there is a match.

UNIT 9 SECTION 4

Model Lesson (Block Roster):
Recombinant DNA

Lesson Question

How is recombinant DNA created?

Materials

Restriction Enzymes Cut DNA C32 teaching transparency (Ch. 11), Gel Electrophoresis C33 teaching transparency (Ch. 11), Genetic Engineering C34 teaching transparency (Ch. 11), yellow and orange construction paper, tape, scissors, 500-mL beakers, large jars, 3 sets of beads (each set a different size and color)

Content and Performance Expectations

CE 1, 2, 3, 6; PE 1, 2, 5

Teacher's Notes

None

Warm-Up

- Carry out the Discussion on Holt *TE*, p. 228. Have students list the characteristics they would change in their favorite fruits or vegetables if they could.
- Discuss examples of how scientists are able to manipulate the characteristics of organisms using genetic engineering techniques.

Instruction

Gene Technology

▶ Genetic Engineering of Insulin	▷ Discuss how *E. coli* are used to produce insulin for diabetics. Explain that scientists use recombinant DNA technology to create insulin in a laboratory instead of obtaining it from pigs or sheep as had been done in the past. Scientists are able to introduce human DNA that codes for the synthesis of insulin into the bacteria. ▷ Discuss with students the following questions: Why is the use of human insulin better than using insulin from other organisms? Why do scientists use bacteria to produce the insulin? How are bacteria able to "read" the human DNA code and produce a human hormone such as insulin?
▶ Plasmids and Transformation	▷ Explain that bacteria have circular DNA molecules called *plasmids* in addition to their normal circular chromosomal DNA. Bacteria are capable of picking up plasmids from their environment and then they have the ability to express the new genes. ▷ Remind students of the transformation experiments of Griffith. Explain that today scientists use transformation on a regular basis and that it is relatively simple to introduce new DNA (usually in the form of a plasmid) into a bacterium, by subjecting it to a heat shock that then causes the bacterium to pick up the new DNA. Thus, transformation can introduce new traits and alter the genotype of a cell. ▷ Have students hypothesize how human DNA could be inserted into a plasmid.
▶ Restriction Enzymes	▷ Explain that special enzymes called *restriction enzymes* can cut a plasmid at a specific site. ▷ Display the Restriction Enzymes Cut DNA C32 teaching transparency (Ch. 11) and discuss how restriction enzymes work. Point out the sticky ends and have students explain how they can be used to join human DNA and the plasmid DNA. ▷ Discuss the fact that restriction enzymes are naturally found in bacteria and can be used to kill viruses. Explain that restriction enzymes are like molecular scissors that cut a DNA molecule. Include the Molecular Scissors Attention Grabber (Holt *TE,* p. 230). ▷ Explain that the desired sequence of human DNA and the plasmid are joined together using DNA ligase, which catalyzes the formation of DNA, and then human DNA is incorporated into the plasmid.

▶ Transformation and Gene Cloning	▷ Display the Genetic Engineering C34 teaching transparency (Ch. 11) and discuss the basic steps of the process of genetic engineering. ▷ Have students complete the Recombinant DNA Activity (Holt *TE*, p. 229). Have students create a labeled paper model of recombinant DNA with a diagram of how it was constructed. ▷ Explain that after the recombinant DNA is created, a transformation is then carried out so that bacteria cells take up the recombinant DNA. These bacteria cells can now express the plasmid's phenotype and are allowed to reproduce by binary fission, creating many copies of the desired gene (cloning). ▷ Explain that scientists often use plasmids that have metabolic markers on them, such as a gene for antibiotic resistance, so that bacteria which incorporate the plasmid can be differentiated from those that do not. For example, during screening, only bacteria with a gene for antibiotic resistance will survive in a culture medium containing the antibiotic. ▷ Explain that the bacteria cells with the desired gene will be isolated and the cells will transcribe and translate the gene and produce the desired protein. Scientists can then isolate the protein, purify it, and use for other purposes.
▶ Gel Electrophoresis	▷ Explain that scientists use a Southern blot to confirm that the desired gene is present in the bacteria. ▷ Display the Gel Electrophoresis C33 teaching transparency (Ch. 11). Point out that each line on the gel represents a DNA fragment. ▷ Explain that the agarose gel contains pores through which DNA molecules can move. DNA is a negatively charged particle and when it is loaded on a gel and subjected to an electric current, it will move through the gel. ▷ Point out that before the DNA is loaded on the gel it is cut into different-sized fragments using restriction enzymes. The smaller pieces of DNA will move faster through the gel than the larger ones. Scientists are able to identify the desired gene by looking for a piece of DNA that is the correct size, based on the expected sequence. ▷ Have students complete the "Modeling Gel Electrophoresis" Quick Lab (Holt, p. 232). A datasheet is available on Holt *Biology CRF 11: Gene Technology,* p. 39.

▶ Modeling Recombinant DNA

▷ Working in groups, have students cut yellow paper into one long strip. The strip should be long enough to contain the following DNA code: ATTCATACAGGATCCAAGCGATTCGACTATCGCCATGGATCCAAACCGTTACGA.

▷ Have students determine the complementary DNA strand and write it on the strip. This will represent the desired human DNA that will be inserted into the plasmid.

▷ Then have the class cut pieces of orange construction paper into one-inch strips lengthwise and tape them together in a continuous strip. They should copy the following DNA code and its complementary strand onto the orange strip, adding more paper if necessary. Orange DNA code: GCGCCCTGAGGATCCATATCCGCATCTACT. They should tape the ends of the orange strip together to form a loop, representing the plasmid DNA.

▷ Tell students that they will cut their DNA using the restriction enzyme *Bam*HI. *Bam*HI recognizes the following base sequence in DNA and makes a cut designated by the asterisks.

G*GATC C
C CTAG*G

▷ Have students physically cut both the plasmid DNA and the human DNA with scissors at the restriction site. They should search through the codes to find the restriction sequence for *Bam*HI.

▷ Have students identify the sticky ends on their DNA molecules. Have them match the sticky ends on the plasmid to the sticky ends on the human DNA and use tape to join them together. Explain that the tape represents the DNA ligase and that they now have the recombinant DNA molecule.

▷ Have students attach the paper model of recombinant DNA to a large piece of construction paper. Have them diagram how the recombinant DNA was created, and label the sticky ends, plasmid, restriction enzyme, and recombinant DNA.

▷ Have students share their model and diagram, then explain how the recombinant DNA is confirmed.

Assessment

- Have students write a Process Paragraph (*SUTW*, pp. 3-15 through 3-17) to explain how the recombinant DNA plasmid is made and then confirmed, including the role of restriction enzymes, DNA ligase, and the donor DNA and the host DNA (plasmid).

Homework Assignment

- Have students read Holt, pp. 228–232 and complete p. 232, #1–6.

Teaching Resources

- Holt, pp. 228–238

Unit 9 Section 5

PATTERNS OF HEREDITY

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–4	1–2	Non-Mendelian Inheritance	Holt, pp. 175–179
5–6	3	Applied Genetics	Holt, pp. 180–182

BENCHMARK ASSESSMENT 4—WEEK OF MAY 7 (CONTINUED IN NEXT UNIT)

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. (GLE 3.3)

CONTENT EXPECTATIONS

☐ 1. New heritable characteristics can only result from new combinations of existing genes or from mutations of genes in an organism's sex cells. (GLE 3.3.D.c)

☐ 2. Punnett squares and pedigrees can be used to make predictions as to probabilities and patterns of inheritance for resulting inherited traits in organisms. (Framework VII.D.2.a *PR*)

☐ 3. Traits are often inherited by more complex patterns of heredity than the simple dominant-recessive patterns described by Mendel, such as those influenced by several genes, those controlled by multiple alleles, or those that are influenced by the environment. (GLE 3.3.E *PR*)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Evidence is used to formulate explanations. (GLE 7.1.C)

...for Standard 8

Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time. The nature of technology can advance, and is advanced by, science as it seeks to apply scientific knowledge in ways that meet human needs. (GLE 8.1, 8.2)

CONTENT EXPECTATIONS

☐ 5. Scientific theories are developed based on the body of knowledge that exists at any particular time and must be rigorously questioned and tested for validity. (GLE 8.2.B)

☐ 6. Technological solutions to problems often have drawbacks as well as benefits. (GLE 8.1.C)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Using existing models that demonstrate patterns of inheritance (e.g., Punnett squares), make predictions as to probabilities and patterns of inheritance for resulting inherited traits in organisms. (Framework VII.D.2.a)

PERFORMANCE EXPECTATIONS

- ☐ 1. Predict the probability of the occurrence of specific traits, including sex-linked traits, in an offspring by using a monohybrid cross. (GLE 3.3.E.b)
- ☐ 2. Predict the results of monohybrid crosses using Punnett squares to determine probabilities and patterns of inheritance. (GLE 3.3.E.b *PR*)
- ☐ 3. Analyze and interpret a pedigree. (GLE 3.3.E *PR*)
- ☐ 4. Explain how sex-linked traits may or may not result in the expression of a genetic disorder (e.g., hemophilia, muscular dystrophy, color blindness) depending on gender. (GLE 3.3.E.c)

…for Standard 7

Make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (Framework I.A.3.a)

PERFORMANCE EXPECTATIONS

- ☐ 5. Analyze experimental data to determine patterns, relationship, perspectives, and credibility of explanations (e.g., predict/extrapolate data). (GLE 7.1.C.b)

...for Standard 8

Explain the interaction between technology and science as society seeks to apply scientific knowledge in ways that address societal needs, how historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science, and how science knowledge and technology evolve over time. (GLE 8.1 *PR*, 8.2 *PR*)

PERFORMANCE EXPECTATIONS

- ☐ 6. Identify and describe how explanations (hypotheses, laws, theories) of scientific phenomena have changed over time as a result of new evidence (e.g., Mendel's laws of heredity). (GLE 8.2.B.a)
- ☐ 7. Identify and evaluate the drawbacks (e.g., unintended consequences, risks) and benefits of technological solutions to a given problem (e.g., genetic engineering of cells). (GLE 8.1.C.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Non-Mendelian Inheritance Days 1–4	CE 2, 3, 4 PE 1, 2, 3, 4, 5	**Day 1/Hands-On Activity/Lab:** Ask students why it is important to know their family's genetic history. Have students take Two-Column Notes (*SUTW*, pp. 9-1 through 9-15) on Holt, pp. 175–176. Perform the Using the Figure on Holt *TE*, p. 175. Have students complete the Evaluating a Pedigree Data Lab (Holt, p. 176). A datasheet is available on Holt *Biology CRF 8: Mendel and Heredity*, p. 53. Discuss how the pedigree would have differed if it were a sex-linked trait. Display a pedigree that demonstrates sex-linkage for a trait. Use a Punnett square to demonstrate the inheritance of color blindness. Have students revisit the pedigree and answer questions about it such as, "If a woman is a carrier of the recessive allele, what are the chances that her son will develop the disease? Is the same for her daughter?" Have students draw a Punnett square to answer the questions. Discuss how Queen Victoria, a carrier of hemophilia, transmitted the disease to other European royal families. Have students read a family history and then construct a pedigree. Discuss how pedigrees are used to demonstrate how traits are inherited in a family. Have students collect family data for a single trait such as detached vs. attached earlobes, and then construct a pedigree. Students should include an explanation of the patterns of heredity illustrated by the pedigree. Provide students with the option of inventing family data. Emphasize that they will be assessed on whether the pedigree matches their family data and their explanation of the patterns of heredity illustrated by the pedigree. (Goals 1.6, 1.8, 2.1)
	CE 2, 3, 4, 5 PE 1, 2, 3, 4, 5, 6	**Day 1/Hands-On Activity/Lab:** Explain to students how Thomas Hunt Morgan discovered that the gene for eye color is located on the X chromosome in fruit flies. Explain that he knew that red (*R*) was dominant over white (*r*) and he thought that the white-eyed male was homozygous recessive. Have students complete a theoretical Punnett square for a cross between the white-eyed homozygous male and a true-breeding red-eyed female to predict the phenotypes of the offspring. Then have them determine the F_2 generation from this cross. Explain that when Morgan performed these crosses he found that only males in the F_2 generation had white eyes, while no males in the F_1 generation had this trait. Explain why a female can be heterozygous for a sex-linked trait but a male cannot. Have students complete a Punnett square of a cross between a white-eyed male (X^rY) and a red-eyed (wild type) female (X^RX^R) to demonstrate sex-linkage and predict the genotypes of the offspring. Then have them determine the F_2 generation from this cross. Have students explain how this demonstrates sex-linkage by comparing the resulting ratios with those predicted by Mendelian genetics. Perform the Using the Figure on Holt *TE,* p. 175. Have students complete the Evaluating a Pedigree Data Lab (Holt, p. 176). A datasheet is available on Holt *Biology CRF 8: Mendel and Heredity*, p. 53. Then have students create a three-generation pedigree to demonstrate how a sex-linked trait such as eye color in fruit flies, hemophilia, color blindness, or muscular dystrophy is inherited. Have students write a Descriptive Paragraph (*SUTW*, pp. 3-34 through 3-39) to explain why sex-linked genes do not follow Mendelian rules of inheritance, citing examples to support their ideas. (Goals 1.6, 1.8, 2.1, 4.1)
	CE 3 PE 1	**Day 2:** Explain that some traits are often inherited together because they are linked, or located close together on the same chromosome, such as red hair and freckles. Have students create paper chromosome models with genes labeled on the chromosomes, and then demonstrate how linked genes stay together during meiosis. Then have students model how crossing-over could change the inheritance pattern of linked genes. Differentiate between gene linkage and sex-linked traits. Explain that crossing-over does not occur between X and Y chromosomes. Have students explain in a Problem and Solution Paragraph (*SUTW*, pp. 3-46 through 3-48) why Mendelian logic cannot be applied to situations of sex-linked traits or gene linkage. Have students use Punnett squares to illustrate their logic. (Goals 2.1, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Instead of having students construct the royal family pedigree, show them a completed one to discuss.	Walk students through the process of constructing a pedigree step by step, providing examples for them to see. (ELL-4)	Have students complete the Writing Skills skillbuilder on Holt *TE*, p. 174.
Set up the Punnett squares for students to complete and review the expected ratios for these crosses.	Allow students the opportunity to complete the writing assignment as a journal entry. (ELL-7)	Have students research how other eye colors (e.g., orange) in fruit flies are inherited.
Provide paper chromosome models with the genes labeled on the chromosomes. Display the Stages of Meiosis B49 teaching transparency (Ch. 7) and have students use it as a reference when they demonstrate how linked genes stay together during meiosis.	Instead of writing the Problem and Solution Paragraph, provide students with the description of a dihybrid cross and have students construct a Punnett square that indicates probabilities in the offspring, assuming independent assortment. Have students explain how the probabilities would differ if the traits were linked. (ELL-7)	Have students research how chromosome mapping takes place.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Non-Mendelian Inheritance Days 1–4	CE 2, 3, 5 PE 1, 2, 6	**Days 3–4:** Discuss non-Mendelian patterns of heredity. Have students brainstorm a list of examples of traits in humans (and other organisms) that may not follow Mendel's laws. Have students read Holt, pp. 177–179 and record the key terms in the reading. Have students complete the Patterns of Heredity Group Activity (Holt *TE*, p. 181). Have students create a Punnett square of a cross between a red and a white snapdragon and a cross between two F_1 individuals. In the discussion of the Punnett squares, use the Incomplete Dominance Teaching Tip (Holt *TE*, p. 178). Discuss codominance and provide some examples for students, such as blood type in humans. Carry out the Demonstration on Holt *TE*, p. 178 to demonstrate blood type compatibility. Have students explain how a child with type O blood could have a mother with type A blood and a father with type B blood. Provide students with sample matings of various crosses involving incomplete dominance, codominance, and multiple alleles, and have them complete Punnett squares to determine the genotypes and phenotypes of the offspring. Have students write a letter to Mendel to inform him of modern genetic theory and how it differs from his work. *See Model Lesson*. (Goals 1.5, 1.6, 2.1, 3.5)
	CE 3, 4 PE 5	To demonstrate polygenic inheritance of a trait, have students collect height data (in cm) and create bar graphs of height (in 5-cm intervals) vs. number of students. This will result in a bell curve. Have students list environmental factors that may affect height. Then have a discussion of how age or gender may affect the expression of some traits. Have students write a Summary Paragraph with a Burrito Topic Sentence (*SUTW*, pp. 3-3 through 3-14) to explain the complex nature of the inheritance of height in humans, using the collected data to support their ideas. (Goals 1.3, 1.8, 2.1)
	CE 3, 4 PE 5	**Hands-On Activity/Lab:** Have students use red cabbage extract as an acid-base indicator. (To obtain the extract, boil cabbage in tap water to extract the red color.) Have students observe changes to the colored water when vinegar (an acid) or baking soda (a base) is added to it. Explain that the same type of chemical that gives red cabbage its color (anthocyanins) gives hydrangea flowers their color. Point out that not all anthocyanins have the same color/pH profiles. Explain that acidic soils produce blue flowers and basic soils result in pink flowers in hydrangeas. Discuss Figure 15 on Holt, p. 179. Have students design an experiment with hydrangeas to determine how pH affects the expression of a trait. Then have them write an explanation of how the expected outcome of this experiment demonstrates that the environment can influence gene expression. (Goals 1.3, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Explain to students that in the case of incomplete dominance, such as flower color in snapdragons, the genotypes can always be determined by the phenotype. Have them explain why this is not true for a trait that is controlled by a completely dominant allele.	To explain the difference between incomplete dominance and codominance, discuss the meanings of the term *incomplete* and the prefix *co*-. (ELL-2)	Have students research and report on current theories on the inheritance of complex human traits such as height or eye color.
Review the guidelines for making graphs with students and construct a labeled set of axes on the board for students to use.	Explain that the prefix *poly*- means "many" and the root *genos* means "gene," thus a polygenic trait is controlled by many genes. (ELL-2)	Have students research and report on how blood pressure can be influenced by many genes and as well as by the environment.
Provide students with sample data from an experiment on how pH affects flower color in hydrangeas, and discuss the results as a class.	Allow students to make a poster or give an oral explanation of the results of the experiment, rather than a written explanation. (ELL-7)	Have students research other examples of the environmental effect on gene expression, such as sex determination in many fish and reptiles.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Applied Genetics Days 5–6	CE 1, 3, 6 PE 4, 7	**Days 5–6/Technology**: Have students hypothesize how a child with a genetic disorder could be born from two parents who do not have that disorder. Have students work in groups to brainstorm a list of disorders or diseases that are caused by genetic mutations. Have students share their lists with the class and discuss possible causes of genetic mutations, what it means to be carrier of a disease, and whether they would want to know if they had a mutation that might someday cause disease. Have students read Holt, pp. 180–182 and complete a cause-effect graphic organizer (*ER*, p. RR-13) for each disorder. Have students work in pairs to compare and contrast autosomal and sex-linked disorders and dominant and recessive disorders. Explain that the genetic contribution of other diseases is unclear. Point out that in some cases of recessive diseases, such as sickle-cell anemia, being heterozygous for a trait is beneficial and the harmful allele remains persistent in the population. Have students watch Segment 2: Cystic Fibrosis from *CNN Presents Science in the News: Biology Connections* and then create a flowchart outlining the steps of gene therapy to treat cystic fibrosis. Have students explain why gene therapy could cure an individual, but still allow them to pass the disease to their offspring. Then have students work in pairs to develop a possible protocol for treating Hemophilia A (a deficiency of the protein factor VIII, which is required for normal blood clotting) through gene therapy. (Goals 1.8, 2.1, 3.2, 3.5, 4.6)
	CE 6 PE 7	**Days 5–6:** Have students work in groups to make a list of benefits and drawbacks of screening for genetic diseases. Divide the class into four groups: the insurance company, company with many employees, employee organization, and government health department. Have the students conduct a debate (*ER*, p. PTT-9) about genetic screening. Have students address the different types of screening: prenatal testing, preconception screening, and employee testing for susceptibility and/or later development of a disorder. Discuss the possibility of genetic discrimination due to screening. Have students discuss whether parents should be required to undergo genetic screening tests. Have students write a Persuading or Convincing Paragraph (*SUTW*, pp. 3-30 through 3-33) either for or against mandatory prenatal testing or genetic screening by employers. (Goals 1.10, 4.1, 4.3, 4.6)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students take Two-Column Notes (*SUTW*, pp. 9-1 through 9-15) as they read Holt, pp. 180–182.	At the beginning of the lesson, have students include genetic disorders or diseases that are prevalent in their home country. Have students develop a protocol for treating one of those disorders or diseases rather than Hemophilia A. (ELL-3)	Have students read an article about gene therapy from www.hemophilia.org/bdi/bdi_gene3.htm and write a summary about it.
Discuss with students the differences between ethical issues, legal issues, and social issues. Remind students that they need to pretend to have the viewpoints of the group they are placed in for the purposes of the debate.	Discuss the definitions of the terms *ethical*, *legal*, *social*, and *policy* with students when introducing the activity. (ELL-2)	Introduce students to the concept of germ-line gene therapy (which is done in sperm and egg cells) and discuss the ethics of the procedure.

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 8: Mendel and Heredity*, p. 53

   Educational Resources, pp. PTT-9, RR-13

   Step Up to Writing, pp. 3-3 through 3-14, 3-30 through 3-39, 3-43 through 3-48, 9-1 through 9-15

2. **Internet Resources**

   History of Hemophilia (Royal History)
   www.hemophilia.org/NHFWeb/MainPgs/MainNHF.aspx?menuid=178&contentid=6&rptname=bleeding

   Color Blindness Problem Set
   www.biology.arizona.edu/human_bio/problem_sets/color_blindness/intro.html

   A History of Hemophilia
   www.medicine.ox.ac.uk/ohc/history.htm

   Genetics of High Blood Pressure
   www.abc.net.au/rn/talks/8.30/helthrpt/stories/s322.htm

   Gene Therapy: Molecular Bandage?
   http://gslc.genetics.utah.edu/units/genetherapy/

   What is Gene Therapy?
   http://gslc.genetics.utah.edu/units/genetherapy/whatisgt/

   Space Doctor (Gene Therapy Simulation)
   http://gslc.genetics.utah.edu/units/genetherapy/spacedoctor/

3. **Multicultural Resources and/or Activities**

   Point out that there are regional and ethnic differences in the distribution of human ABO blood type groups. For example, B is more common in many Asian cultures than in European or Native American cultures. However, as people throughout the world continue to intermingle and intermarry, blood type distribution should become more uniform.

Suggested Assessments

1. Have students provide an example of each of the types of inheritance in this section, such as incomplete dominance, codominance, multiple alleles, sex-linked trait inheritance, and inheritance of a trait that is influenced by the environment, and then draw Punnett squares to explain how they are inherited differently from the traits that Mendel studied.
2. Have students create a fictional family pedigree using one inherited trait, such as dimples or freckles.
3. Have students complete Holt, p. 182, #1–6.
4. Have students create posters to teach the public about the promising new technology of gene therapy to treat genetic disorders.
5. Have students write a Cause and Effect Paragraph (*SUTW*, pp. 3-43 through 3-45) to explain why sex-linked traits usually have a higher incidence among males than females.

Sample Constructed-Response Item

A cross between a chicken with all black feathers and a chicken with all white feathers results in 10 offspring, all of which have both black and white feathers. What type of inheritance would explain this pattern? What would the offspring of the F_2 generation look like?

Since both forms of the trait are expressed, this is an example of codominance. The F_2 generation would probably be 25% black, 50% black and white, and 25% white.

Model Lesson (Block Roster):
Non-Mendelian Inheritance

Lesson Questions

Why is Mendelian genetics unable to explain the inheritance of many human traits?

What are some examples of the complex patterns of inheritance that exist in living organisms?

How are height, eye color, and blood type inherited in humans?

Materials

Copies of the Genetics Problems student activity sheet, flasks, water, red and blue food coloring, pictures of eyes (close-ups, from fashion magazines) for students to observe

Content and Performance Expectations

CE 2, 3, 5; PE 1, 2, 6

Teacher's Notes

None

Warm-Up

Human Height

- Have students explain how we know that human height is not controlled by two alleles, tall and short, for a single gene.
- Explain to students that most of the time, traits do not follow simple, single-gene dominant/recessive patterns of inheritance. Some traits are controlled by many genes and/or multiple alleles, and sometimes alleles are equally dominant. In addition, phenotypes can also be influenced by the environment.
- Have students work in groups to brainstorm a list of examples of traits in humans (and other organisms) that may not follow Mendel's laws. Have students share their lists with the class.

Instruction

Complex Heredity of Traits

▶ Different Patterns of Inheritance	▷ Have students read Holt, pp. 177–179 and record the key terms in the reading. ▷ Have students complete the Patterns of Heredity Group Activity (Holt *TE*, p. 181).
▶ Incomplete Dominance	▷ Explain that in the case of incomplete dominance, the phenotype of the heterozygous individual is an intermediate between the homozygous dominant and homozygous recessive. ▷ Have students complete a Punnett square to determine the offspring that result from a cross between a white and a red snapdragon. Have them use *W* for white and *W'* for red. Then have students use a Punnett square to determine the F_2 offspring from a cross between two F_1 individuals. ▷ Have students share their Punnett squares. Use the Incomplete Dominance Teaching Tip (Holt *TE*, p. 178) during the discussion of their Punnett squares. Have them complete a new Punnett square to support their answers.
▶ Codominance and Multiple Alleles	▷ Explain the concept of codominance and that codominant alleles cause the phenotypes of both homozygotes to be seen in a heterozygous individual. ▷ Explain to students that there are three alleles for blood type: I^A, I^B, and *i*. I^A and I^B are codominant, and are both dominant over *i*. Have students determine how many different genotypes and phenotypes are possible. ▷ Carry out the Demonstration on Holt *TE,* p. 178 to explain why O is considered the universal donor and AB is the universal acceptor. ▷ Discuss how blood type can be used in cases of unknown paternity. For example, if a mother has type A blood and her child has type AB, then a man with type O cannot be the father. Have students complete Punnett squares to determine the possible offspring from a mother with type A blood and a father with type O blood. Point out that blood tests cannot prove that a man is definitely the father of a child, only whether it is possible that he is. ▷ Have students determine whether a mother with type B blood and a father with type A blood can have a child with type O blood. Have them determine the genotypes of the mother and father and use a Punnett square to support their answer.

▶ Practice Genetics Problems	▷ Distribute the Genetics Problems activity sheet and have students complete it. ▷ Circulate around the room to provide assistance as students work on the problems. ▷ After students complete the activity sheet, have volunteers put their answers on the board. ▷ Discuss the answers to each problem as a class.

Assessment

- Modern genetic theory takes into account Gregor Mendel's work on simple dominant/recessive inheritance, and knowledge we have today about the complex inheritance of traits. Have students write a letter to Mendel explaining what we know today about the inheritance of traits.

Homework Assignment

- Have students create their own genetics problems and provide the solutions to the problems.

Teaching Resources

- Holt, pp. 177–179

name ________________ date ________

Genetics Problems

Solve the problems below using Punnett squares to support your answers.

1. A cross between a homozygous black horse and a homozygous white horse produces offspring that all have brown hair. How would you explain this? What would be the genotypes and phenotypes of the offspring from a cross between two of the brown horses? (Use *B* for the black allele and *B′* for the white allele.)

2. A woman has type AB blood and her baby has type A blood. One man has type O blood and another has type B. Can you determine which man is the father? Why or why not?

name ______________________ date __________

3. In cows, red hair is codominant with white hair (*R* = red, *W* = white). A farmer has a herd of all red-haired (*RR*) cows and then he decides to buy 10 red and white-haired (*RW*) cows. What are the chances of some white-haired cows being born after the new cows breed with the original herd?

4. If one parent has type O blood and another has type AB, what is the chance that their child will have type O blood? Type A? Type B? Type AB?

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Unit 10 Diversity and Unity Among Organisms

- What is the best way to organize the diversity found among organisms?
- How are the different types of organisms on Earth similar to and different from each other?

Scope and Sequence, page 22
Lesson Planning Material, pages 459–484

UNIT QUESTIONS
How can I clarify these questions for students? What are they really asking?

How can I keep students focused on these questions throughout the unit?

BIG IDEAS
What important concepts do I want students to understand during this unit?

What skills and knowledge will students need as they work towards understanding?

EVIDENCE OF LEARNING
How can I assess student understanding of the Big Ideas?

UNIT 10

Unit 10 Section 1

TAXONOMY AND CLASSIFYING ORGANISMS

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–3	1	The Classification System	Holt, pp. 300–304
4–6	2–3	How Organisms are Classified	Holt, pp. 305–310

BENCHMARK 4 REVIEW, REMEDIATION, ENRICHMENT—3 DAYS

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 4: Changes in Ecosystems and Interactions of Organisms with Their Environments

Standard 8: Impact of Science, Technology, and Human Activity

WHAT ALL STUDENTS SHOULD KNOW...

...for Standard 3

Organisms are classified into a hierarchy of groups and subgroups, based on their structural similarities and reflecting as much as possible their evolutionary relationships. (Framework VII.A.4)

CONTENT EXPECTATIONS

☐ 1. Biological classifications are based on how organisms are related. (GLE 3.1.E)

☐ 2. Taxonomy, the science of naming and classifying organisms, is based on studying specific traits of organisms and is important for organizing the diversity of life and understanding the evolutionary relationships between organisms. (GLE 3.1.E *PR*)

☐ 3. Similarities in DNA and protein structure can be used to classify and determine degrees of kinship among organisms. (Framework VII.C.1)

...for Standard 4

Reproduction is essential to the continuation of every species. (GLE 4.3.B)

CONTENT EXPECTATIONS

☐ 4. The biological species concept defines a biological species as a group of natural populations that are interbreeding or could interbreed, and that are reproductively isolated from other groups. However, the biological species concept fails to describe organisms that reproduce asexually and organisms are that able to form fertile hybrids with closely related species. (GLE 4.3.B.a *PR*)

...for Standard 8

The nature of technology can advance, and is advanced by, science as it seeks to apply scientific knowledge in ways that meet human needs. (GLE 8.1)

CONTENT EXPECTATIONS

☐ 5. Advances in technology often result in improved data collection and an increase in scientific information. (GLE 8.1.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Analyze biological classifications in terms of how they are determined and what they indicate about how organisms are related. (GLE 3.1.E *PR,* 3.3.B *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Explain how similarities used to group taxa might reflect evolutionary relationships (e.g., similarities in DNA and protein structures, internal anatomical features, patterns of development). (GLE 3.1.E.a)

☐ 2. Explain how and why the classification of any taxon might change as more is learned about the organisms assigned to that taxon. (GLE 3.1.E.b)

☐ 3. Describe how degree of relatedness can be determined by comparing DNA sequences. (GLE 3.3.B.c)

☐ 4. Construct a cladogram to explain the relationships between organisms based upon derived characters. (GLE 3.1.E.a *PR)*

☐ 5. Use a dichotomous key to identify organisms. (GLE 3.1.E.a *PR*)

...for Standard 4

Explain how a species is defined. (GLE 4.3.b *PR*)

PERFORMANCE EXPECTATIONS

☐ 6. Define a species in terms of the ability to breed and produce fertile offspring. (GLE 4.3.B.a)

☐ 7. Explain the importance of reproduction to the survival of a species (i.e., the failure of a species to reproduce will lead to extinction of that species). (GLE 4.3.B.b)

…for Standard 8

Explain how technology can advance, and is advanced by, science as it seeks to apply scientific knowledge in ways that meet human needs. (GLE 8.1 *PR*)

PERFORMANCE EXPECTATIONS

☐ 8. Recognize the relationships linking technology and science (e.g., how new technologies make it possible for scientists to extend research and advance science). (GLE 8.1.B.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
The Classification System Days 1–3	CE 1, 2 PE 1	**Day 1/Hands-On Activity/Lab:** Display pictures of a set of closely related animals (e.g., lion, tiger, domestic cat, cheetah, jaguar). Have students name them and hypothesize how they are related. Identify each by its scientific name and point out that it consists of two names. Have students identify which are more closely related. Discuss problems associated with common names. Discuss the Attention Grabber on Holt *TE*, p. 303. Have students read Holt, pp. 300–304. Have them complete the Categories of Classification Directed Reading skills worksheet (Holt *Biology CRF 14: Classification of Organisms*, pp. 1–2) as they read the section. Display the Biological Hierarchy of Classification D29 and Classification of a Bee D30 teaching transparencies (Ch. 14) to discuss the levels of classification and provide an example. Discuss what taxonomy may indicate about evolutionary relationships. Have students work in groups to create a mnemonic to help them remember the levels of classification. Then have students complete the Comparing Classifications Activity (Holt *TE*, p. 303) and the "Using a Field Guide" Quick Lab (Holt, p. 304). Datasheets for the "Using a Field Guide" Quick Lab are available on Holt *Biology CRF 14: Classification of Organisms*, pp. 37–38. (Goals 1.5, 1.6, 2.1, 4.6)
	CE 1, 2 PE 5	**Days 2–3/Hands-On Activity/Lab/Technology:** Have students work in groups to create a classification system for pasta shapes. Then introduce new pasta shapes and have students classify them according to their system. Have students compare their system to the system of binomial nomenclature currently in use. Discuss why classification systems are important in biology, particularly when new organisms are discovered. Have students watch Segment 11: Something Worth Saving from *CNN Presents Science in the News: Biology Connections* and complete the Something Worth Saving Critical Thinking worksheet (*CNN Presents Science in the News: Biology Connections Critical-Thinking Worksheets,* p. 11). *See Model Lesson.* (Goals 1.8, 2.3)
	CE 1, 2 PE 5	**Days 2–3/Hands-On Activity/Lab:** Explain that once a classification system has been implemented, a dichotomous key can be created to identify unknown organisms based on their characteristics. Have students complete the Making a Dichotomous Key Lab (Holt, pp. 314–315). (Goals 1.1, 1.3, 1.6, 3.2)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
To help explain a hierarchical classification system use the analogy of a house location identified by classification in a country, state, county, city, street, and house number.	Have students share the common names in their home language of the animals displayed. (ELL-3)	Have students complete the These Are the Names of My Favorite Things Group Activity (Holt *TE*, p. 303).
Have students complete the 4-1 Why Do We Classify? worksheet (Holt *Biology Reading in the Content Area*, pp. 52–53) before conducting the lab.	Provide examples for students of things that are classified in everyday life (e.g., classified ads in newspapers). Have students work in groups to complete the activity. Have them create a chart using pictures to explain their classification system. (ELL-3)	Have students research recent discoveries of new species.
Have students complete the 4-3 Levels of Generality worksheet (Holt *Biology Reading in the Content Area*, pp. 58–61) before conducting the lab.	Explain the terms *teeth*, *lobes*, *waves*, and *bristles* using pictures for students to observe. (ELL-2)	Have students conduct research to answer the questions in the "Do You Know?" on Holt, p. 315.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
How Organisms Are Classified Days 4–6	CE 1, 2, 3, 4, 5 PE 1, 2, 3, 6, 7, 8	Introduce the biological species concept. Have students discuss why reproduction is vital to the survival of a species. Have them hypothesize what would happen if a species failed to reproduce. Ask students: "How many species of dogs exist? Humans? Birds?" Have students read Holt, pp. 305–310 and take Two-Column Notes (*SUTW*, pp. 9-1 through 9-15) as they read. Then have them complete the How Biologists Classify Organisms Directed Reading skills worksheet (Holt *Biology CRF 14: Classification of Organisms*, pp. 3–6). Have students brainstorm examples of analogous characters. Then have students brainstorm a list of the different methods for classifying organisms. Carry out the Cladograms Exploring Further, Teaching Strategies (Holt *TE,* p. 308). Have students read "Coral Family Tree Reorganized, Result of DNA Analyses" at www.accessexcellence.org/WN/SU/coralgenemar1604.htm. Have a discussion of how modern DNA analysis has changed classification. (Goals 1.5, 1.8, 2.3)
	CE 1, 2 PE 1, 4	**Hands-On Activity/Lab:** Have students read the Exploring Further section entitled, "Cladograms" (Holt, p. 308). Discuss how a cladogram is constructed. Use the Dolphin Evolution Teaching Tip (Holt *TE,* p. 309) to explain the differences between ancestral and derived characters. Then have students complete the Making a Cladogram Data Lab (Holt, p. 309). A datasheet is available on Holt *Biology CRF 14: Classification of Organisms,* p. 41. Have students work with a partner to complete the Reteaching on Holt *TE,* p. 310. Then have them write Process Paragraphs (*SUTW*, pp. 3-15 through 3-17) to explain how they constructed their cladograms. (Goals 1.8, 2.1, 3.2, 4.6)
	CE 1, 3, 5 PE 1, 3, 4, 8	**Hands-On Activity/Lab:** Discuss the techniques used to determine evolutionary relationships between organisms in order to classify them, such as embryology, behavior, morphology, amino acid sequencing and DNA analysis. Point out the usefulness and limitations of each. Explain how nucleotide sequence comparisons in DNA are used to determine relatedness and to construct cladograms or evolutionary trees. Have students complete the Analyzing Amino Acid Sequences Lab (Holt *Biology CRF 14: Classification of Organisms*, pp. 55–60), including Extensions 1. (Goals 1.3, 1.6, 3.5, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Show students pictures to explain convergent evolution, such as the internal structure of the wings of butterflies, birds, and bats. The wings of each serve a similar function but are very different structurally and do not indicate a close relationship.	Have students make flashcards to quiz each other with important terms on one side, such as *cladistics*, *phylogeny*, *analogous characters*, *biological species*, and *convergent evolution,* and definitions on the other side. (ELL-6)	Have students read "The Panda is a Panda" at www.press.uchicago.edu/Misc/Chicago/736296.html instead of the coral article.
Have students examine how a cladogram is constructed by visiting a Web site on cladistics, such as www.brooklyn.cuny.edu/bc/ahp/CLAS/CLAS.Clad.html.	Have students complete the Organizing Information Science Skills worksheet (Holt *Biology CRF 14: Classification of Organisms*, pp. 13–14) and assist students in identifying the traits used to separate the organisms. (ELL-5)	Have students compare and contrast phylogenic models and cladograms.
Have students use highlighters to mark the differences in the amino acids in the lab.	Discuss the introduction to the lab with students, rephrasing difficult terms and instructions, before they conduct the activity. (ELL-4)	Discuss the method of DNA-DNA hybridization to determine relatedness among organisms for classification purposes (see Internet Resources).

Additional Resources

1. **Curriculum Resources**

   Holt *Biology CRF 14: Classification of Organisms*, pp. 1–6, 13–14, 37–38, 41, 55–60

   Holt *Biology Reading in the Content Area*, pp. 52–53, 58–61

   Educational Resources, p. GPT-4

   *CNN Presents Science in the News: Biology Connection*s

   CNN Presents Science in the News: Biology Connections Critical-Thinking Worksheets, p. 11

   Step Up to Writing, pp. 3-15 through 3-17, 9-1 through 9-15

2. **Internet Resources**

   Classification (the Web page on cladistics may be particularly useful)
   www.brooklyn.cuny.edu/bc/ahp/CLAS/CLAS.HP.html

   Classifying Life
   www.pbs.org/wgbh/nova/orchid/classifying.html

   Classification (info on DNA-DNA hybridization)
   http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/T/Taxonomy.html#DNA_DNAHybridization

   DNA Analysis Revolutionizes Taxonomy
   http://clasnews.clas.ufl.edu/news/clasnotes/0003/judd.html

   Coral Family Tree Reorganized, Result of DNA Analyses
   www.accessexcellence.org/WN/SU/coralgenemar1604.htm

3. **Multicultural Resources and/or Activities**

   Discuss Adelmar Coimbra-Filho, a Brazilian biologist who is responsible for the classification of tamarins, including recently discovered species. He has also worked to create a reserve for tamarins in their natural habitat, and a reintroduction program for captive tamarins to return them the wild in an effort to save them from extinction.

Suggested Assessments

1. Give students a group of hardware (e.g., bolts, screws, nails) as representative organisms. Then have students make a list of traits they will study and construct a table of traits (characters) for the organisms. From this, have students devise a cladogram to organize them.
2. Have students complete Holt, p. 310, #1–6.
3. Have students research the classifications of the fox, wolf, coyote, and dog and explain which ones are more closely related.
4. Give students a bag of mixed beans. Have them make dichotomous keys for the beans and then switch with a partner to see if their key works.
5. Have students create a concept map (*ER*, p. GPT-4) using the terms *binomial nomenclature, genus, species, derived characters, cladogram, taxonomy, kingdom,* and *biological species concept.*

Sample Constructed-Response Item

What kinds of information can be used to identifying relationships among species?

Organisms can be classified based on structural, biochemical, or genetic similarities.

Model Lesson (Traditional Roster):
The Classification System

Lesson Question

How are objects organized into a classification system?

Materials

Various types of pasta, transparency of an organism (e.g., grasshopper), *CNN Science in the News: Biology Connections* videotape, copies of the Segment 11: Something Worth Saving Worksheet from *CNN Presents Science in the News: Biology Connections Critical-Thinking Worksheets*

Content and Performance Expectations

CE 1, 2; PE 5

Teacher's Notes

Before conducting the activity, prepare bags of pasta in many sizes, shapes and colors, including long strands, tubes, shells, and curly ones (e.g., linguini, fettuccini, spaghetti, angel hair, linguini fini, ditalini, elbows, ziti, penne, rigatoni, fusilli). Prepare a second bag for each group, containing the two newly discovered pasta species that are different from those included in the original bags. Different groups will develop different classification systems. Point out that the same organism may be classified differently by different biologists depending upon how the organism is viewed. There will not be one correct system, but stress to students that their system should be useful for classifying new, previously unknown, species.

Warm-Up

Identifying Characteristics

- Have students observe a picture of an organism such as a grasshopper. Have them make a list of characteristics that the organism has that scientists might use for classification.
- Have students share their ideas with the class, discussing why some characteristics might be better for classification than others. For example, the number of antenna or wings would be more useful in terms of classification than color.
- Ask students what other organisms might be closely related to the grasshopper. Have them explain their reasons why.

Instruction

Classifying Organisms and Its Importance

▶ The Classification System	▷ Review with students the levels of classification by listing the classification of one type of grasshopper. For example, the American grasshopper: Kingdom Animalia, Phylum Arthropoda, Subphylum Uniramia, Class Insecta, Order Orthoptera, Family Acrididae, Genus *Schistocerca*, Species *americana.* ▷ Review the concept of binomial nomenclature. Have students identify the components of a scientific name.
▶ Classifying Pasta Activity	▷ Explain to students they are going to organize a classification system for the kingdom Pasta. The pasta shapes should be organized based upon similar characteristics. ▷ Have students empty their bags and divide their pasta into groups. Each group will be labeled as a phylum. Have students name each phylum. Next, have students separate each phylm into groups. Each of these groups will represent a genus. Students should name each genus. Then students should divide each genus into species, so that there is one type of pasta in each species. They should give each species a name. ▷ Have students make a branching chart to show how the objects were divided. They should identify the character used to divide each group on the lines in the chart. ▷ Have students develop a dichotomous key that can be used to classify the pasta shapes. Have them trade their keys with another group to test them and make sure that they work. ▷ Provide each group with the bag containing the new pasta species. Have them identify which phylum and genus they would belong to and why. ▷ Have students share their classification systems.
▶ Wrap-Up of the Classifying Pasta Activity	▷ Have students answer the following questions: 1. How is this investigation similar to how biologists classify organisms? 2. Were all the classification systems in the class the same? Why or why not? 3. What are the benefits of organizing things into a classification system? 4. Why do biologists classify organisms? What happens when a new organism is discovered?

- The Importance of a Classification System
  - Discuss why classification systems are important in biology, particularly when new organisms are discovered.
  - Have students watch Segment 11: Something Worth Saving from *CNN Science in the News: Biology Connections* and complete the Segment 11: Something Worth Saving worksheet (*CNN Presents Science in the News: Biology Connections Critical-Thinking Worksheets,* p. 11).
  - Discuss students' responses to the questions on the worksheet and any other issues raised by the video segment.

Assessment

- Have students complete the Alternative Assessment on Holt *TE,* p. 310.

Homework Assignment

- Have students research the classification of two organisms they believe to be closely related, such as a humpback whale and a sperm whale, and compare them.
- Have students complete Holt, p. 304, #1–4

Teaching Resources

- Holt, pp. 300–304

Unit 10 Section 2

AN INTRODUCTION TO THE SIX KINGDOMS AND VIRUSES

SUGGESTED PACING

DAY (TRADITIONAL)	DAY (BLOCK)	TOPIC	CORE TEXT
1–4	1–2	The Six Kingdoms	Holt, pp. 412–426
5–6	3	Viruses	Holt, pp. 434–441

ALIGNMENT TO SHOW-ME STANDARDS FOR SCIENCE

Standard 3: Characteristics and Interactions of Living Organisms

Standard 7: Scientific Inquiry

WHAT ALL STUDENTS SHOULD KNOW…

…for Standard 3

Organisms are classified into a hierarchy of groups and subgroups, based on their structural similarities and reflecting as much as possible their evolutionary relationships. (Framework VII.A.4)

CONTENT EXPECTATIONS

☐ 1. Biological classifications are based on how organisms are related. (GLE 3.1.E)

☐ 2. All organisms are classified into one of six kingdoms depending on cell type, cell structure, mode of nutrition, and body type. (GLE 3.1.E *PR*)

☐ 3. Viruses, composed of a DNA molecule encased within a protein coat, are not considered to be living organisms. (GLE 3.1.E *PR*)

…for Standard 7

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

CONTENT EXPECTATIONS

☐ 4. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations. (GLE 7.1.B)

WHAT ALL STUDENTS SHOULD BE ABLE TO DO…

…for Standard 3

Recognize that the diversity of life on Earth is organized into a six kingdoms based upon structural characteristics, biochemistry, and behavior. (GLE 3.1.E *PR,* 3.3 *PR*)

PERFORMANCE EXPECTATIONS

☐ 1. Explain how similarities used to group taxa might reflect evolutionary relationships (e.g., cell structure, mode of nutrition). (GLE 3.1.E.a)

☐ 2. Explain how and why the classification of any taxon might change as more is learned about the organisms assigned to that taxon. (GLE 3.1.E.b)

☐ 3. Classify organisms into kingdoms based upon structural similarities. (Framework VII.A.4.a *PR*)

☐ 4. Summarize virus structure and the steps of viral replication. (GLE 3.1.E *PR,* 3.3.A *PR*)

...for Standard 7

Recognize that science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking. (GLE 7.1)

PERFORMANCE EXPECTATIONS

☐ 5. Make qualitative and quantitative observations using the appropriate senses, tools and equipment to gather data (e.g., microscopes, metric rulers). (GLE 7.1.B.a)

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
The Six Kingdoms Days 1–4	CE 1, 2 PE 1, 2, 3	**Day 1:** Review the definitions of the following terms with the class: *prokaryote*, *eukaryote*, *unicellular*, *multicellular*, *autotroph,* and *heterotroph*. Have students read Holt, pp. 412–413. As they read, have them use sticky notes to mark main ideas and write down questions they have. Have students complete the Organizing Information/Interpreting Tables Science Skills worksheet (Holt *Biology CRF 19: Introduction to the Six Kingdoms*, pp. 15–16). Revisit the discussion from the previous section about what taxonomy may indicate about evolutionary relationships. Discuss how DNA analysis has led to the division of the kingdom Monera. Display pictures of familiar organisms and have students identify which kingdom they belong in. Then show students pictures of unfamiliar organisms. Have students explain where they would place each organism. Have students write a Compare and Contrast paragraph (*SUTW*, pp. 3-21 through 3-29) about the six kingdoms. *See Model Lesson*. (Goals 1.5, 1.6, 2.1, 3.5)
	CE 1, 2 PE 1, 2, 3	**Day 1**: Have students complete the Introduction to Kingdoms and Domains Active Reading Worksheet (Holt *Biology CRF 19: Introduction to the Six Kingdoms*, pp. 7–8). Display the Kingdom and Domain Characteristics D28 teaching transparency (Ch. 19). Perform the Using the Table on Holt *TE,* p. 416. Discuss how DNA analysis has led to the division of the kingdom Monera. Have students work in groups to make word study organizers (*ER*, p. RR-85) for the terms *unicellular, multicellular, heterotroph, autotroph, eukaryote,* and *prokaryote*. Show students pictures of representative cells from each kingdom. Have them identify any visible structures. Sketch a phylogenetic diagram of the six kingdoms and have students explain how the kingdom classifications reflect evolution. Review with students the theory of endosymbiosis. Have students work in groups to make a Venn diagram (*ER,* p. RR-83) of the six kingdoms of classification. (Goals 1.8, 2.1, 4.6)
	CE 1, 2 PE 3	**Days 2–3:** Divide the class into six groups. Each group will learn about one kingdom, write a summary of the information obtained, plan a brief presentation for the class, and create a visual aid to be used during the presentation. Students should include information on defining characteristics of the kingdom, representative groups, and important vocabulary terms. Information can be obtained from the relevant sections of Holt, pp. 414–415 and 420–426. Have students take notes as they listen to the presentations and use their notes to make a chart comparing the six kingdoms. (Goals 1.8, 2.1, 4.6)
	CE 1, 2, 4 PE 3, 5	**Day 4/Hands-On Activity/Lab:** Have students examine Figure 6 on Holt, p. 418. Explain how *Volvox* is an example of a colonial organism. Use the Figure 8 on Holt, p. 419 to describe how cells are organized into tissues, organs, and organ systems in multicellular organisms. Have students complete the Surveying Kingdom Diversity Lab (Holt, pp. 430–431). (Goals 1.1, 1.3, 1.4, 3.5)
	CE 1, 2, 4 PE 3, 5	**Day 4/Hands-On Activity/Lab:** Have students complete the Identifying Unknown Organisms Inquiry Lab (Holt *Biology CRF 19: Introduction to the Six Kingdoms*, pp. 49–52). (Goals 1.3, 1.4, 1.6, 3.5, 4.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students read about comparison tables and complete the Writing Comparisons from a Comparison Table exercise (Holt *Skills Workshop Reading in the Content Area*, pp. 101–102).	Have students complete the Concept Mapping Worksheet on Holt *Biology CRF 19: Introduction to the Six Kingdoms*, p. 15. (ELL-6)	Discuss how the process of Gram staining is used to identify bacteria. Have students complete the Gram Staining of Bacteria Lab (Holt *Biology CRF 20: Viruses and Bacteria*, pp. 39–44).
Construct the Venn diagram as a class. Draw an outline on the board and then have students help to complete it. Students can copy the completed diagram in their notebooks.	Have students work in pairs on the Introduction to Kingdoms and Domains Active Reading Worksheet (Holt *Biology CRF 19: Introduction to the Six Kingdoms*, pp. 7–8). (ELL-5)	Discuss the bacteria kingdoms in more depth. Have students research and report on the division of the Kingdom Monera to Eubacteria and Archaebacteria.
Have students create flashcards for the defining characteristics of each kingdom. Have them work in pairs to quiz each other.	Have students practice their presentations to identify any pronunciation questions they may have and identify portions that are unclear and need revision. (ELL-6)	Have students discuss the history of classification of the kingdom.
Use the Reading Organizer Reading Skillbuilder on Holt *TE*, p. 419 to explain the levels of organization within an organism.	Have students draw pictures to illustrate their observations during the Surveying Kingdom Diversity Lab. (ELL-7)	Have students design an investigation around Analyze and Conclude question #5.
Have a class discussion with students about their observations before they begin work on the procedure. Encourage students to use size to identify the classification of organisms in a particular group.	Prior to the lab, show students electron micrographs of eubacteria, archaebacteria, protists, and fungi, pointing out internal structures. (ELL-2)	Have students complete the Extension on Holt *Biology CRF 19: Introduction to the Six Kingdoms*, p. 52.

Suggested Activities

TOPIC	EXPECTATIONS	ACTIVITY
Viruses Days 5–6	CE 3 PE 4	Have students make K-W-L charts (*ER*, p. RR-43) about viruses. Have them read Holt, pp. 434–437 and take notes using the One Idea Note Card strategy (*SUTW*, pp. 9-17 through 9-18). Have students create a chart to compare and contrast viruses and cells, including what traits they share and how they differ. Display Important Viral Diseases F10 teaching transparency (Ch. 20). Explain why antibiotics are effective on bacteria, not viruses. Have students create short public service announcements to teach the public about viruses and explain why antibiotics are not effective on viruses. (Goals 1.5, 1.8, 4.6)
	CE 3 PE 4	Display the Structures of Adenoviruses and Bacteriophage F7 and Structures of TMV and Influenza Virus F8 teaching transparencies (Ch. 20) and have students examine Figure 5 on Holt, p. 437. Perform the Using the Figure on Holt *TE,* p. 435 to discuss some common viruses. Have students compare them and describe the different shapes. Then have students complete the Viruses Active Reading skills worksheet (Holt *Biology CRF 20: Viruses and Bacteria*, pp. 5–6). Provide students with unlabeled pictures of the lytic and lysogenic cycles with the steps jumbled, then have them identify which cycle is which, and organize the steps in order. Have students complete the Design a Virus Teaching Tip (Holt *TE,* p. 435). (Goals 1.5, 1.6, 2.1)

Suggested Adaptations

STUDENTS WITH DISABILITIES	ENGLISH LANGUAGE LEARNERS	ADVANCED STUDENTS
Have students complete the Vocabulary Review Worksheet on Holt *Biology CRF 20: Viruses and Bacteria*, p. 9 only.	Have students complete the note-taking activity in pairs. (ELL-5)	Discuss the use of viruses as vectors for delivering new genes for people suffering from genetic disorders.
Have students work in pairs to complete the Design a Virus activity.	Have students work in groups to label the steps of the lytic and lysogenic cycles. (ELL-5)	Have students complete the Graphing Skillbuilder on Holt *TE*, p. 436.

Additional Resources

1. **Curriculum Resources**
   Holt *Biology CRF 19: Introduction to the Six Kingdoms*, pp. 7–8, 15, 17, 49–52
   Holt *Biology CRF 20: Viruses and Bacteria*, pp. 5–6, 39–44
   Holt *Skills Workshop Reading in the Content Area*, pp. 101–102
   Educational Resources, pp. RR-43, RR-83, RR-85
   Step Up to Writing, pp. 3-21 through 3-29, 9-17 through 9-18

2. **Internet Resources**
   The Six Kingdoms
   www.ric.edu/ptiskus/Six_Kingdoms/Index.htm
   PCR Enzymes from Thermophiles
   www.accessexcellence.org/BF/bf05/girard/bf05c3.html

3. **Multicultural Resources and/or Activities**
   Discuss the Accidental Spread of Viral Diseases Cultural Awareness (Holt *TE,* p. 440).

Suggested Assessments

1. Provide students with a list of organisms such as mushrooms, humans, fish, roses, clam, seaweed, pine trees, horses, jellyfish, mosquitoes, molds, and carrots, and have them identify which kingdom they belong in.
2. Have students create posters to teach about one of the kingdoms studied, including a description of the kingdom, defining characteristics, and at least five representative species identified by their common and scientific names.
3. Describe a mystery organism for students, including identifying characteristics, and have students determine in which kingdom it belongs.
4. Have students complete the Alternative Assessment on Holt *TE,* p. 417.

Sample Constructed-Response Item

A new microorganism has recently been discovered. How would you determine its classification?

Students might observe the organism under the microscope to determine if it was a prokaryote or a eukaryote. If a nucleus is observed, then the organism can be classified as a protist. If there is no visible nucleus, the cell could be tested for peptidoglycan to determine if it belongs in Eubacteria, which have peptidoglycan, or Archaebacteria, which do not have peptidoglycan.

Model Lesson (Traditional Roster):
The Six Kingdoms

Lesson Question

How are organisms classified into the six kingdom system?

Materials

Mushrooms, copies of the Organizing Information/Interpreting Tables Science Skills worksheet (Holt *Biology CRF 19: Introduction to the Six Kingdoms*, pp. 15–16), pictures of organisms (e.g., various animals, plants, lichens, mushrooms, slime molds, sponges, corals, molds, *Volvox*, various bacteria and protists, algae, rotifer, hydra, seaweed)

Content and Performance Expectations

CE 1, 2; PE 1, 2, 3

Teacher's Notes

Remind students not to eat the mushrooms used in class.

Warm-Up

Mushroom Observation

- Give pairs of students mushrooms to examine. Have them separate the stalk from the cap and then break the cap into two parts to examine. As they do this, they should write down all their observations.
- Ask students whether mushrooms should be placed in the same kingdom as plants and explain why or why not. Have students describe how they are similar to and different from plants.

Instruction

The Six Kingdoms

▶ Historical Background

▷ Explain to students that until fairly recently mushrooms were classified in the plant kingdom. From Aristotle's time until the mid-20th century, all organisms were classified as either plants or animals. Even the 1700s Linneaus classification system still grouped organisms into the two kingdoms of plant and animal. The shift to more kingdoms did not occur until Whittaker's five-kingdom system was introduced in 1969.

▷ Explain that until recently a five-kingdom system was used, and then the current six-kingdom system. Have students hypothesize why these changes occurred.

▷ Write the following terms on the board: *autotroph* and *heterotroph*. Have students define the terms and provide examples of each. Have them copy the information in their notebooks.

▷ Follow the same procedure for the terms *unicellular* and *multicellular* and then for *eukaryote* and *prokaryote*.

▷ Have students read Holt, pp. 412–413. As they read, have them use sticky notes to mark main ideas and write down questions they have. Then have them work with a partner to compare and discuss their notes.

▶ How Organisms are Organized into the Six Kingdoms

▷ Distribute copies of the Organizing Information/Interpreting Tables Science Skills worksheet (Holt *Biology CRF 19: Introduction to the Six Kingdoms*, pp. 15–16). Have students complete it.

▷ Circulate throughout the room to provide assistance and answer questions.

▷ Explain that eubacteria and archaebacteria had been previously grouped into the kingdom Monera, which contained all bacteria. Discuss how DNA analysis has led to the division of the kingdom Monera.

▷ Explain that archaea are a small group of prokaryotes that have unique molecular structure and physiology. They tend to live in extreme environments and are considered by some to be very different from the true bacteria (eubacteria).

▷ Point out that not all scientists are in agreement with the six kingdom system and that other proposals have been made.

▷ Display pictures of familiar organisms and have students write down which kingdom they belong think it belongs in. Then show students pictures of unfamiliar organisms. Ask students to determine where they would place each organism.

▷ Have students discuss each pictured organism. Then identify it and its kingdom.

Assessment

- Have students write a Compare and Contrast Paragraph (*SUTW*, pp. 3-21 through 3-29) about the six kingdoms.

Homework Assignment

- Have students complete Holt, p. 417, #1–3 and 5.

Teaching Resources

- Holt, pp. 412–417

Data Analysis Worksheets

core curriculum

CURRICULUM RESOURCES

SAINT LOUIS PUBLIC SCHOOLS

Benchmark Assessment Analysis: The Big Picture

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Based on the patterns you are seeing, what additional assistance in strategies and/or resources will you need?

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PERFORMANCE

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What topics were assessed by this test?
(For a clearer picture, you may wish to review the test items themselves.)

ANALYZE:
To what extent do these topics align to the curriculum that you recently taught?

INSTRUCT:
What decisions should you make concerning completion of the curriculum schedule?

Comparison of Sections (Groups)

ASSESS:
If you teach multiple sections of the same course, are there differences in performance between sections?

ANALYZE:
How do differences in section results mirror differences in your instructional approach?

INSTRUCT:
What adjustments will you make in your approach to help the lower-scoring sections improve?

CLASS RESULTS

ASSESS:
Which students scored:
- particularly low?
- particularly high?
- differently than in classroom assessments?

ANALYZE:
What accounts for the results of each student you identified above?

Are there students with *similar* challenges or needs?

Are the strongest or weakest students strongly affecting the overall average?

INSTRUCT:
To help a student with specific needs, will you:
- adjust whole-class instruction to embed attention to the needs?
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- meet with a student individually?
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TEST ANALYSIS

Item-by-Item Analysis

ASSESS:
Identify popular wrong answers.

ANALYZE:
Look at the original test item for each incorrect answer choice you found above. What mistake or misconception might have led a student to choose this wrong answer?

INSTRUCT:
What can you do to address the student's errors?

Intra-Topic Analysis

ASSESS:
Are there groups of questions that address the same curriculum topic?

ANALYZE:
Within each topic, are students getting one question right and another not? Why?

INSTRUCT:
What aspects of the topic do you need to re-address?

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(For a clearer picture, you may wish to review the test items themselves.)

ANALYZE:
To what extent do these topics align to the curriculum that you recently taught?

INSTRUCT:
What decisions should you make concerning completion of the curriculum schedule?

Comparison of Sections (Groups)

ASSESS:
If you teach multiple sections of the same course, are there differences in performance between sections?

ANALYZE:
How do differences in section results mirror differences in your instructional approach?

INSTRUCT:
What adjustments will you make in your approach to help the lower-scoring sections improve?

CLASS RESULTS

ASSESS:
Which students scored:
- particularly low?
- particularly high?
- differently than in classroom assessments?

ANALYZE:
What accounts for the results of each student you identified above?

Are there students with *similar* challenges or needs?

Are the strongest or weakest students strongly affecting the overall average?

INSTRUCT:
To help a student with specific needs, will you:
- adjust whole-class instruction to embed attention to the needs?
- sponsor small-group instruction?
- meet with a student individually?
- strategically pair up students?

TEST ANALYSIS

Item-by-Item Analysis

ASSESS:
Identify popular wrong answers.

ANALYZE:
Look at the original test item for each incorrect answer choice you found above. What mistake or misconception might have led a student to choose this wrong answer?

INSTRUCT:
What can you do to address the student's errors?

Intra-Topic Analysis

ASSESS:
Are there groups of questions that address the same curriculum topic?

ANALYZE:
Within each topic, are students getting one question right and another not? Why?

INSTRUCT:
What aspects of the topic do you need to re-address?

Benchmark Assessment Analysis: The Big Picture

Teacher ____________________________ ***Course*** ____________________________

Assessment date ______________________ ***Section*** ____________________________

Access your Kaplan Achievement Planner data reports. Which topics and skills posed the greatest challenge for your students during this assessment period? What accounts for the challenges?

What changes in teaching strategies might be called for?

What additional resources will you use to remediate these skills and knowledge gaps?

How will you differentiate instruction to target the areas and students of greatest need?

Based on the patterns you are seeing, what additional assistance in strategies and/or resources will you need?

Benchmark Assessment Analysis: The Details

PERFORMANCE

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