

Biology I Teacher's Edition (TE)

CK-12 Foundation

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CK-12 Foundation is a non-profit organization with a mission to reduce the cost of textbook materials for the K-12 market both in the U.S. and worldwide. Using an open-content, web-based collaborative model termed the “FlexBook,” CK-12 intends to pioneer the generation and distribution of high quality educational content that will serve both as core text as well as provide an adaptive environment for learning.

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Chapter 1

Introduction to Biology Teacher's Edition (TE)

1.1 Biology I: Teacher's Edition (TE)

Introduction

As a teacher, have you ever felt that your textbook was not thorough or up-to-date? Do you have to use other resources, such as on-line resources, to teach your lessons? Do your students believe they can get current information from sources such as the internet rather than their textbook? The answer to these questions is usually a resounding yes. So what do school districts do? They spend millions of dollars every year to buy “current, up-to-date” textbooks.

CK-12 believes we can do better. CK-12, a nonprofit organization launched in 2006, aims to reduce the cost of textbook materials for the K-12 market, both in the US and worldwide. CK-12 is developing a series of web-based middle school and high school adaptive textbooks - each termed a “FlexBook.” These web-based FlexBooks will have unlimited flexibility and variability, allowing the user to focus on the materials appropriate for his or her class. Content can be customized and individualized. CK-12 intends to pioneer the generation and distribution of these high quality educational web texts.

The content generated by CK-12 will serve as both source material for a student's learning and provide an adaptive environment that scaffolds the learner's educational experience as he or she masters a standards-based body of knowledge.

The Biology I FlexBook is one of the introductory books from CK-12. It contains 25 chapters covering cell biology, genetics, ecology, evolution and human biology (chapters 1-18 and 35-41). Each chapter has 2 - 4 lessons. Biology II is a companion to Biology I, and

covers microorganisms and fungi, plants, invertebrates, and vertebrates (chapters 19-34). Together, the two books provide a complete educational tool for the high school student. CK-12's Biology I and II have 41 chapters and over 120 lessons. These lessons, written by renowned experts in high school biological science education, are designed to address both state and national standards.

Please note, the answers to the Review Questions, Points to Consider, Assessments, Quizzes, and Worksheets have not been included in the Teacher's Edition. However, we will supply educators with the answer keys to all of the sections upon request. Please email teachers-requests@ck12.org to request a PDF of the complete Bio I Teacher's Edition with answers.

The Biology FlexBooks are an unprecedented and unique educational tool. It is the first time a comprehensive on-line searchable resource for the high school student has been developed. When utilized properly, this tool should completely revolutionize the methods of teaching. It is the goal of CK-12 that these on-line resources, Flexbooks, are constantly updated, with new and relevant information added to the resource. As more classrooms become equipped with computers and internet access, and as more students have this availability in their homes, a web-based resource, such as those made available by CK-12, will become an invaluable resource.

As a teacher, you know how time-consuming it can be to have to search for on-line resources. Having a resource such as CK-12's Biology I and Biology II will make teaching easier and more relevant for both you and your students. Many times, textbooks are developed by individuals who have never taught at the high school level; this is not the case for these books. CK-12 has used a team of highly experienced and talented individuals to compile this resource. The time to take advantage of all the information available to the students is now, and with CK-12's Biology, you can be at the forefront of 21st Century education.

Contents: Biology I and II

Unit 1: Introduction to Life Science

- Chapter 1: Foundations of Life Science
- Chapter 2: Chemical Basis of Life

Unit 2: Cells

- Chapter 3: Cell Structure and Function
- Chapter 4: Photosynthesis
- Chapter 5: Cellular Respiration
- Chapter 6: Cell Division and Reproduction

Unit 3: Genetics

Chapter 7: Mendelian Genetics
Chapter 8: Molecular Genetics
Chapter 9: Human Genetics
Chapter 10: Biotechnology

Unit 4: Evolution

Chapter 11: History of Life
Chapter 12: Evolutionary Theory
Chapter 13: Evolution in Populations
Chapter 14: Classification

Unit 5: Ecology

Chapter 15: Principles of Ecology
Chapter 16: Biomes, Ecosystems and Communities
Chapter 17: Populations
Chapter 18: Ecology and Human Actions

Unit 6: Microorganisms and Fungi

Chapter 19: Prokaryotes and Viruses
Chapter 20: Protists
Chapter 21: Fungi

Unit 7: Plants

Chapter 22: Evolution and Classification of Plants
Chapter 23: Structure and Function in Plants
Chapter 24: Reproduction of Plants
Chapter 25: Plant Adaptations and Responses

Unit 8: Invertebrates

Chapter 26: Introduction to Animals and Invertebrates
Chapter 27: Simple Invertebrates: Sponges, Cnidarians, and Worms
Chapter 28: Mollusks and Annelids
Chapter 29: Arthropods and Insects
Chapter 30: Echinoderms and Nonvertebrate Chordates

Unit 9: Vertebrates

Chapter 31: Fishes and Amphibians

Chapter 32: Reptiles and Birds

Chapter 33: Mammals

Chapter 34: Animal Behavior

Unit 10: Human Biology

Chapter 35: The Human Body

Chapter 36: Nervous and Endocrine Systems

Chapter 37: Skeletal, Muscular, and Integumentary Systems

Chapter 38: Circulatory and Respiratory Systems

Chapter 39: Digestive and Excretory Systems

Chapter 40: Immune System and Disease

Chapter 41: Reproductive System and Human Development

The Teacher's Edition (TE)

Each unit and chapter will have a general overview. Each chapter section will also include an introduction and teaching strategies. The majority of content will be presented by individual lesson.

This Teacher's Edition will focus on ten subtopics for each lesson:

1. Key Concept
2. Lesson Objectives
3. Lesson Vocabulary
4. Check Your Understanding
5. Teaching Strategies

General

Differentiated Instruction

Enrichment

6. Laboratory Activities

7. Science Inquiry

8. Reinforce and Review

Review Questions

- (Review Questions with Sample Answers provided upon request.)

9. Points to Consider

- (Sample answers provided upon request.)

10. Lesson Assessment

- (Sample answers provided upon request.)

Answer Keys

- Please note, the answers to the Review Questions, Points to Consider, Assessments and Worksheets have not been included in the Teacher's Edition. However, we will supply educators with the answer keys to all of the sections upon request. **Please email teachers-requests@ck12.org to request a PDF of the complete Biology Teacher's Edition with sample answers.**

Science Notebook

For a year's study of Biology, we recommend a **science and/or lab notebook** in which students may:

- answer the *Check Your Understanding* questions
- answer/reflect on the *Points to Consider* questions
- write additional questions about an upcoming lesson/chapter/unit of study
- draw pictures of living organisms and diagrams of life processes
- take notes and define academic vocabulary
- keep a record of pertinent web sites to access relevant information
- write up lab activities
- write up ideas for possible longer term projects
- keep reflections on what they have learned

Students should date each entry and refer back to their ideas earlier in the year, reflecting on their deepening understanding.

Teaching Strategies

Throughout the TE, we will provide numerous examples of strategies that can be used to make the content accessible to students. This will include general teaching strategies, as

well as differentiated instruction, enrichment, science inquiry, and reinforcement strategies. Laboratory activities have also been included. Many strategies and activities have been included as web site links, and we recommend that this be previewed before assigning to the students.

Teaching Strategies: General

1. Appreciate what's difficult for students, helping them develop scientific ways of thinking.
2. Vary class activities, using a wide variety of resources to aid students in deepening their understanding of scientific issues.
3. Give students opportunities to participate in scientific investigations to understand "doing science."

Using Visuals

Use of an illustration in the student edition as a tool for teaching content, exploring ideas, probing students' misunderstandings.

Building Science Skills Have students apply higher-level thinking or other relevant skills as they relate to lesson content (e.g., predicting, forming hypotheses, drawing conclusions, interpreting data, observing, classifying, making inferences, comparing and contrasting, identifying cause and effect, analyzing). Through a simple activity, answering questions, class discussion, partner work.

Discussion

Stimulate class discussion of a topic. Could include scripted questions to ask the class, with expected or sample answers. The discussion tips should be specific and focused. For example, don't write "Discuss Darwin's theory of evolution." Instead write "Guide students in discussing why Darwin's theory was not widely accepted in his own lifetime. Ask: How did Darwin's theory of evolution conflict with prevailing views of living things?"

Demonstration

Do (and fully describe) an in-class demonstration to illustrate or explain a process, concept, etc. Keep in mind constraints on classroom time and resources. Include a concluding sentence or scripted question that relates the demonstration to the process or concept.

Activity

Have students do a simple hands-on activity that will help them better understand a topic, process. Explain fully how the activity is to be done. This could be a pencil-and-paper activity or other activity that does not involve materials, although readily available classroom materials could be used. Again, conclude with a sentence or question that ties the activity with the topic or process.

Teaching Strategies: Differentiated Instruction

These strategies can be used for all three types of student populations that are typically addressed by DI (i.e., ELL, LPR, SN), but a particular population has been specified each time a strategy is used. The strategy can be tailored somewhat to that population, even if it's only by referring to the population type in the strategy (e.g., "Pair English language learners with native speakers of English").

KWL

Have students make a KWL chart, where K = Know, W = Want to Know, and L = Learned. Students should fill in the K and W columns before reading and the L column after reading a particular passage or lesson.

Cloze Prompts

Give students cloze sentences (basically, fill-in-the blank sentences) about important lesson concepts. Students are instructed to fill in the missing words as they read the lesson.

Gallery Walk

Divide the class into groups and have the groups walk around the room to read and discuss posted questions or topics (each on a large sheet of paper). Each group (using a different color pen) answers the questions or writes comments about the topics. They also read and respond to answers/comments written by other groups. This is followed by discussing the answers/comments with the class, or reviewing misunderstandings they reveal, or by groups summarizing what they know about one or more questions/topics.

Think-Pair-Share

Assign questions or topics to individual students to think about. Pair ELL students with native speakers, LPR students with more proficient readers, to work together on answering the questions or discussing the topics.

Framer Model

Assign this vocabulary strategy, which involves students drawing a large box and dividing it into four parts labeled **Definition**, **Drawing**, **Example**, **Non-example**. Assign students a vocabulary word and tell them to fill in the parts of the box for that word.

Cluster Diagram

Have individual students, pairs, groups, or the class as a whole make a cluster diagram organizing lesson concepts.

Concept Map

Have individual students, pairs, groups, or the class as a whole make a concept map organizing lesson concepts.

Venn Diagram

Have individual students, pairs, groups, or the class as a whole make a Venn diagram organizing lesson concepts.

Compare/Contrast Table

Have individual students, pairs, groups, or the class as a whole make a compare/contrast table for specific lesson concepts, processes, etc. (e.g., photosynthesis and cellular respiration; mitosis and meiosis). You may need to provide the column and row headings for the table.

Cycle Diagram

Have individual students, pairs, groups, or the class as a whole make a cycle diagram to show the steps in a cyclical process (e.g., life cycle of amphibians).

Flow chart

Have individual students, pairs, groups, or the class as a whole make a flow chart to show the steps in a process (e.g., photosynthesis).

Main Ideas/Details Chart

Have students divide a sheet of paper in half, on the left side write the main ideas from a passage or lesson (skipping several lines between the main ideas). On the right side, students are instructed to fill in important details about each main idea as they read.

Word Wall

Post lesson vocabulary words and their definitions, examples, etc., on a bulletin board or wall. Refer students to the word wall as they study lesson content.

Teaching Strategies: Enrichment

Although online and/or library research is always an option for enrichment, it tends to be overused. Avoid it unless it is really relevant and likely to be helpful for the other students in the class. Whatever students are assigned to do, they should be given a chance to share their work with the class through an informal oral presentation, a written report, etc. In some cases (e.g., making a board game or crossword puzzle), the product can be used by the class to reinforce or review lesson content.

Table 1.1:

Research a Topic	Present a Role-Play	Teach a Topic
Create a Video	Create a Poster	Debate an Issue
Interview an Expert	Create a Model	Demonstrate a Process
Take a Survey	Write an Essay	Make a Board Game

Table 1.1: (continued)

Research a Topic	Present a Role-Play	Teach a Topic
Make a Crossword Puzzle	Create a Web site	Make a Diagram
Make a Diorama	Make a Display	Write a Research Proposal
Make a Video	Write a Rap (Song)	Present a PowerPoint Show
Lead a Discussion		

Science Inquiry

These strategies should get students involved in thinking or acting like a scientist. They should help the students learn lesson content by encouraging them to be actively engaged in scientific thinking and/or using scientific methods.

- Ask a Research Question: e.g., based on hypothetical observations.
- Formulate a Hypothesis: e.g., based on a research question. Must be specific and testable; could also ask students to describe data that would support or disprove the hypothesis.
- Develop a Research Plan: e.g., to test a specific hypothesis. Could focus on types of variables, controls, etc.
- Analyze Data: Data could be in a graph or table that is provided in the SE or TE or students could find the data online.
- Solve a Problem: requiring application of lesson concepts, procedures, etc.

Reinforcement Activity

In addition to online quizzes, this could be a quick teacher-directed activity or something students do alone or in pairs to make sure they understand lesson content. It should probably be aimed at the average to below-average students in the class. Some suggestions are listed below. The goal is to reveal to the teacher or to the students themselves what they know and what they still don't understand. The activity should include a sentence suggesting a way for students to learn what they don't know (e.g., "Find definitions in the FlexBook of any vocabulary words you did not know.").

Take an Online Quiz Make Flashcards This activity could be used for boldface vocabulary words or important concepts; have students use the flashcards to quiz a partner.

Label a Drawing

The drawing could be art from the SE with the labels deleted.

Outline the Lesson

This could be done with a partner or as a class using an overhead projector.

Ask Questions

Each student turns in a question on an index card. Then, the teacher answers or reviews material relevant to those questions that are asked most frequently.

List and Discuss

Students make a list of something (e.g., reproductive isolating mechanisms), and then partners compare and discuss their lists.

Use Vocabulary

Students use the lesson vocabulary words in sentences or a brief paragraph.

Make a Quiz

Students write a few fill-in, matching, or true/false questions and then use them to quiz a partner.

Make a Drawing

Students create a simple sketch to demonstrate comprehension of a process (e.g., cell division).

Complete a Chart

Students complete missing parts of a diagram or fill in cells of a table that have missing information.

Check Your Understanding

This section includes questions related to previously presented information that the authors consider important for **the student** to have access to the information in the current lesson.

Points to Consider

Questions in this section serve as a segue into the next lesson (or chapter). Ask students to read the Points to Consider at the end of the lesson in their FlexBook. They can be answered individually or as an opening to lead a class discussion. Use these questions to assess student understanding and misconceptions before beginning the next unit of study. Sample answers are available upon request.

Contributors

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Chapter 2

Biology Standards

2.1 California Science Standards

Biology/Life Science Standards 9-12

Cell Biology

SCI.CA.9-12.LS.1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept:

Table 2.1:

Standard Number	Standard	Chapters and Lessons
1a	Students know cells are enclosed within semi permeable membranes that regulate their interaction with their surroundings.	Chapter 3: Cell Structure and Function <ul style="list-style-type: none">Lesson 3.3: Cell Transport and Homeostasis

Table 2.1: (continued)

Standard Number	Standard	Chapters and Lessons
1b	Students know enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings.	Chapter 2: Chemical Basis of Life <ul style="list-style-type: none"> • Lesson 2.3: Chemical Reactions Chapter: Digestive and Excretory Systems <ul style="list-style-type: none"> • Lesson 2: Digestive System
1c	Students know how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.	Chapter 3: Cell Structure and Function <ul style="list-style-type: none"> • Lesson 3.1: Introduction to Cells Chapter 11: History of Life <ul style="list-style-type: none"> • Lesson 11.2: Early Life
1d	Students know the central dogma of molecular biology outlines the flow of information from transcription of ribonucleic acid (RNA) in the nucleus to translation of proteins on ribosomes in the cytoplasm.	Chapter 8: Molecular Genetics <ul style="list-style-type: none"> • Lesson 8.2: Protein Synthesis
1e	Students know the role of the endoplasmic reticulum and Golgi apparatus in the secretion of proteins.	Chapter 3: Cell Structure and Function <ul style="list-style-type: none"> • Lesson 3.2: Cell Structures

Table 2.1: (continued)

Standard Number	Standard	Chapters and Lessons
1f	Students know usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.	<p>Chapter 4: Photosynthesis</p> <ul style="list-style-type: none"> • Lesson 4.1: Energy for Life: An Overview of Photosynthesis • Lesson 4.2: Into the Chloroplast: How Photosynthesis Works <p>Chapter 11: History of Life</p> <ul style="list-style-type: none"> • Lesson 11.2: Early Life
1g	Students know the role of the mitochondria in making stored chemical-bond energy available to cells by completing the breakdown of glucose to carbon dioxide.	<p>Chapter 5: Cellular Respiration</p> <ul style="list-style-type: none"> • Lesson 5.1: Powering the Cell: Cellular Respiration and Glycolysis • Lesson 5.2: Into the Mitochondrion: Making ATP with Oxygen • Lesson 5.3: Anaerobic Respiration: ATP, new fuels, and yogurt without oxygen <p>Chapter 11: History of Life</p> <ul style="list-style-type: none"> • Lesson 11.2: Early Life

Table 2.1: (continued)

Standard Number	Standard	Chapters and Lessons
1h	Students know most macromolecules (polysaccharides, nucleic acids, proteins, lipids) in cells and organisms are synthesized from a small collection of simple precursors.	Chapter 2: Chemical Basis of Life <ul style="list-style-type: none"> • Lesson 2.2: Organic Compounds Chapter 11: History of Life <ul style="list-style-type: none"> • Lesson 11.2: Early Life
1i	Students know how chemiosmotic gradients in the mitochondria and chloroplast store energy for ATP production.	Chapter 4: Photosynthesis <ul style="list-style-type: none"> • Lesson 4.1: Energy for Life: An Overview of Photosynthesis Chapter 5: Cellular Respiration <ul style="list-style-type: none"> • Lesson 5.3: Anaerobic Respiration: ATP, new fuels, and yogurt without oxygen
1j	Students know how eukaryotic cells are given shape and internal organization by a cytoskeleton or cell wall or both.	Chapter 3: Cell Structure and Function <ul style="list-style-type: none"> • Lesson 3.2: Cell Structures

Genetics

SCI.CA.9-12.LS.2. Mutation and sexual reproduction lead to genetic variation in a population. As a basis for understanding this concept:

Table 2.2:

Standard Number	Standard	Chapters and Lessons
2a	Students know meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type.	Chapter 6: Cell Division and Reproduction <ul style="list-style-type: none"> • Lesson 6.2: Meiosis
2b	Students know only certain cells in a multi cellular organism undergo meiosis.	Chapter 6: Cell Division and Reproduction <ul style="list-style-type: none"> • Lesson 6.2: Meiosis
2c	Students know how random chromosome segregation explains the probability that a particular allele will be in a gamete.	Chapter 7: Mendelian Genetics <ul style="list-style-type: none"> • Lesson 7.1: Mendel's Investigations
2d	Students know new combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization). Students know new combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization).	Chapter 6: Cell Division and Reproduction <ul style="list-style-type: none"> • Lesson 6.2: Meiosis
2e	Students know why approximately half of an individual's DNA sequence comes from each parent.	Chapter 7: Mendelian Genetics <ul style="list-style-type: none"> • Lesson 7.1: Mendel's Investigations • Lesson 7.2: Mendelian Inheritance

Table 2.2: (continued)

Standard Number	Standard	Chapters and Lessons
2f	Students know the role of chromosomes in determining an individual's sex.	Chapter 9: Human Genetics <ul style="list-style-type: none"> Lesson 9.1: Human Chromosomes and Genes Lesson 9.2: Human Inheritance
2g	Students know how to predict possible combinations of alleles in a zygote from the genetic makeup of the parents.	Chapter 7: Mendelian Genetics <ul style="list-style-type: none"> Lesson 7.1: Mendel's Investigations Lesson 7.2: Mendelian Inheritance

SCI.CA.9-12.LS.3. A multi cellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization. As a basis for understanding this concept:

Table 2.3:

Standard Number	Standard	Chapters and Lessons
3a	Students know how to predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance (autosomal or X-linked, dominant or recessive).	Chapter 7: Mendelian Genetics <ul style="list-style-type: none"> Lesson 7.1: Mendel's Investigations Lesson 7.2: Mendelian Inheritance
3b	Students know the genetic basis for Mendel's laws of segregation and independent assortment.	Chapter 7: Mendelian Genetics <ul style="list-style-type: none"> Lesson 7.1: Mendel's Investigations

Table 2.3: (continued)

Standard Number	Standard	Chapters and Lessons
3c	Students know how to predict the probable mode of inheritance from a pedigree diagram showing phenotypes.	Chapter 7: Mendelian Genetics <ul style="list-style-type: none"> Lesson 7.2: Mendelian Inheritance
3d	Students know how to use data on frequency of recombination at meiosis to estimate genetic distances between loci and to interpret genetic maps of chromosomes.	Chapter 7: Mendelian Genetics <ul style="list-style-type: none"> Lesson 7.2: Mendelian Inheritance

SCI.CA.9-12.LS.4. Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism. As a basis for understanding this concept:

Table 2.4:

Standard Number	Standard	Chapters and Lessons
4a	Students know the general pathway by which ribosomes synthesize proteins, using tRNAs to translate genetic information in mRNA.	Chapter 8: Molecular Genetics <ul style="list-style-type: none"> Lesson 8.2: Protein Synthesis
4b	Students know how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA.	Chapter 8: Molecular Genetics <ul style="list-style-type: none"> Lesson 8.2: Protein Synthesis
4c	Students know how mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in an encoded protein.	Chapter 8: Molecular Genetics <ul style="list-style-type: none"> Lesson 8.3: Mutation

Table 2.4: (continued)

Standard Number	Standard	Chapters and Lessons
4d	Students know specialization of cells in multi cellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves.	Chapter 8: Molecular Genetics <ul style="list-style-type: none"> Lesson 8.4: Regulation of Gene Expression
4e	Students know proteins can differ from one another in the number and sequence of amino acids.	Chapter 2: Chemical Basis of Life <ul style="list-style-type: none"> Lesson 2.2: Organic Compounds Chapter 8: Molecular Genetics <ul style="list-style-type: none"> Lesson 8.2: Protein Synthesis
4f	Students know why proteins having different amino acid sequences typically have different shapes and chemical properties.	Chapter 2: Chemical Basis of Life <ul style="list-style-type: none"> Lesson 2.2: Organic Compounds

SCI.CA.9-12.LS.5. The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells. As a basis for understanding this concept:

Table 2.5:

Standard Number	Standard	Chapters and Lessons
5a	Students know the general structures and functions of DNA, RNA, and protein.	<p>Chapter 2: Chemical Basis of Life</p> <ul style="list-style-type: none"> • Lesson 2.2: Organic Compounds <p>Chapter 6: Cell Division and Reproduction</p> <ul style="list-style-type: none"> • Lesson 6.1: Chromosomes and the Cell Cycle <p>Chapter 8: Molecular Genetics</p> <ul style="list-style-type: none"> • Lesson 8.1: DNA and RNA
5b	Students know how to apply base-pairing rules to explain precise copying of DNA during semi conservative replication and transcription of information from DNA into mRNA.	<p>Chapter 8: Molecular Genetics</p> <ul style="list-style-type: none"> • Lesson 8.1: DNA and RNA • Lesson 8.2: Protein Synthesis
5c	Students know how genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products.	<p>Chapter 10: Biotechnology</p> <ul style="list-style-type: none"> • Lesson 10.2: Biotechnology
5d	Students know how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation) is used to construct recombinant DNA molecules.	<p>Chapter 10: Biotechnology</p> <ul style="list-style-type: none"> • Lesson 10.1: DNA Technology

Table 2.5: (continued)

Standard Number	Standard	Chapters and Lessons
5e	Students know how exogenous DNA can be inserted into bacterial cells to alter their genetic makeup and support expression of new protein products.	Chapter 10: Biotechnology <ul style="list-style-type: none"> Lesson 10.1: DNA Technology

Ecology

SCI.CA.9-12.LS.6 Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:

Table 2.6:

Standard Number	Standard	Chapters and Lessons
6a	Students know bio diversity is the sum total of different kinds of organisms and is affected by alterations of habitats.	Chapter : Ecology and Human Actions <ul style="list-style-type: none"> Lesson 1: The Biodiversity Crisis

Table 2.6: (continued)

Standard Number	Standard	Chapters and Lessons
6b	Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.	<p>Chapter: Ecology and Human Actions</p> <ul style="list-style-type: none"> • Lesson 1: The Biodiversity Crisis • Lesson 2: Natural Resources • Lesson 3: Natural Resources II: The Atmosphere • Lesson 4: Climate Change <p>Chapter: Principles of Ecology</p> <ul style="list-style-type: none"> • Lesson 1: The Science of Ecology <p>Chapter: Populations</p> <ul style="list-style-type: none"> • Lesson 3: Human Population Growth: Doomsday, Cornucopia, or somewhere in between? <p>Chapter: Ecology and Human Actions</p> <ul style="list-style-type: none"> • Lesson 1: The Biodiversity Crisis • Lesson 2: Natural Resources • Lesson 3: Natural Resources II: The Atmosphere • Lesson 4: Climate Change

Table 2.6: (continued)

Standard Number	Standard	Chapters and Lessons
6c	Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.	Chapter: Populations <ul style="list-style-type: none"> • Lesson 1: Characteristics of Populations • Lesson 2: Population Dynamics
6d	Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.	Chapter 4: Photosynthesis <ul style="list-style-type: none"> • Lesson 4.1: Energy for Life: An Overview of Photosynthesis Chapter 5: Cellular Respiration <ul style="list-style-type: none"> • Lesson 5.1: Powering the Cell: Cellular Respiration and Glycolysis Chapter: Principles of Ecology <ul style="list-style-type: none"> • Lesson 3: Recycling Matter
6e	Students know a vital part of an ecosystem is the stability of its producers and decomposers.	Chapter: Principles of Ecology <ul style="list-style-type: none"> • Lesson 2: Flow of Energy
6f	Students know at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.	Chapter: Principles of Ecology <ul style="list-style-type: none"> • Lesson 2: Flow of Energy

Table 2.6: (continued)

Standard Number	Standard	Chapters and Lessons
6g	Students know how to distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change.	Chapter 12: Evolutionary Theory <ul style="list-style-type: none"> Lesson 12.1: Darwin and the Theory of Evolution Lesson 12.3: Evolution continues today - can we control it? Chapter: Evolution in Populations <ul style="list-style-type: none"> Lesson 2: Genetic Change in Populations

Evolution

SCI.CA.9-12.LS.7 The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. As a basis for understanding this concept:

Table 2.7:

Standard Number	Standard	Chapters and Lessons
7a	Students know why natural selection acts on the phenotype rather than the genotype of an organism.	Chapter: Evolution in Populations <ul style="list-style-type: none"> Lesson 2: Genetic Change in Populations
7b	Students know why alleles that are lethal in a homozygous individual may be carried in a heterozygote and thus maintained in a gene pool.	Chapter: Evolution in Populations <ul style="list-style-type: none"> Lesson 2: Genetic Change in Populations

Table 2.7: (continued)

Standard Number	Standard	Chapters and Lessons
7c	Students know new mutations are constantly being generated in a gene pool.	Chapter: Evolution in Populations <ul style="list-style-type: none"> • Lesson 1: Genetics of Populations • Lesson 2: Genetic Change in Populations
7d	Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.	Chapter: Evolutionary Theory <ul style="list-style-type: none"> • Lesson 1: Darwin and the Theory of Evolution Chapter: Evolution in Populations <ul style="list-style-type: none"> • Lesson 2: Genetic Change in Populations
7e	Students know the conditions for Hardy-Weinberg equilibrium in a population and why these conditions are not likely to appear in nature.	Chapter: Evolution in Populations <ul style="list-style-type: none"> • Lesson 2: Genetic Change in Populations
7f	Students know how to solve the Hardy-Weinberg equation to predict the frequency of genotypes in a population, given the frequency of phenotypes.	Chapter: Evolution in Populations <ul style="list-style-type: none"> • Lesson 2: Genetic Change in Populations

SCI.CA.9-12.LS.8 Evolution is the result of genetic changes that occur in constantly changing environments. As a basis for understanding this concept:

Table 2.8:

Standard Number	Standard	Chapters and Lessons
8a	Students know how natural selection determines the differential survival of groups of organisms.	<p>Chapter: Evolutionary Theory</p> <ul style="list-style-type: none"> • Lesson 1: Darwin and the Theory of Evolution • Lesson 3: Evolution continues today - can we control it? <p>Chapter: Evolution in Populations</p> <ul style="list-style-type: none"> • Lesson 2: Genetic Change in Populations
8b	Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.	<p>Chapter: History of Life</p> <ul style="list-style-type: none"> • Lesson 3: Multicellular Life <p>Chapter: Evolution in Populations</p> <ul style="list-style-type: none"> • Lesson 2: Genetic Change in Populations <p>Chapter: Ecology and Human Actions</p> <ul style="list-style-type: none"> • Lesson 1: The Biodiversity Crisis
8c	Students know the effects of genetic drift on the diversity of organisms in a population.	<p>Chapter: Evolution in Populations</p> <ul style="list-style-type: none"> • Lesson 2: Genetic Change in Populations

Table 2.8: (continued)

Standard Number	Standard	Chapters and Lessons
8d	Students know reproductive or geographic isolation affects speciation.	Chapter: Evolution in Populations <ul style="list-style-type: none"> • Lesson 2: Genetic Change in Populations
8e	Students know how to analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction.	Chapter: History of Life <ul style="list-style-type: none"> • Lesson 1: Studying the History of Life • Lesson 3: Multicellular Life Chapter: Evolutionary Theory <ul style="list-style-type: none"> • Lesson 2: Evidence for Evolution
8f	Students know how to use comparative embryology, DNA or protein sequence comparisons, and other independent sources of data to create a branching diagram (cladogram) that shows probable evolutionary relationships.	Chapter: Evolutionary Theory <ul style="list-style-type: none"> • Lesson 2: Evidence for Evolution
8g	Students know how several independent molecular clocks, calibrated against each other and combined with evidence from the fossil record, can help to estimate how long ago various groups of organisms diverged evolutionarily from one another.	Chapter: History of Life <ul style="list-style-type: none"> • Lesson 1: Studying the History of Life Chapter: Evolution in Populations <ul style="list-style-type: none"> • Lesson 2: Genetic Change in Populations

Physiology

SCI.CA.9-12.LS.9 As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment. As a basis for understanding this concept:

Table 2.9:

Standard Number	Standard	Chapters and Lessons
9a	Students know how the complementary activity of major body systems provides cells with oxygen and nutrients and removes toxic waste products such as carbon dioxide.	Chapter: The Human Body <ul style="list-style-type: none">• Lesson 1: Organization of the Human Body• Lesson 2: Homeostasis and Regulation Chapter: Circulatory and Respiratory Systems <ul style="list-style-type: none">• Lesson 1: Circulatory System• Lesson 3: Respiratory System
9b	Students know how the nervous system mediates communication between different parts of the body and the body's interactions with the environment.	Chapter: Nervous and Endocrine Systems <ul style="list-style-type: none">• Lesson 1: Nervous System
9c	Students know how feedback loops in the nervous and endocrine systems regulate conditions in the body.	Chapter: Nervous and Endocrine Systems <ul style="list-style-type: none">• Lesson 2: Endocrine System
9d	Students know the functions of the nervous system and the role of neurons in transmitting electrochemical impulses.	Chapter: Nervous and Endocrine Systems <ul style="list-style-type: none">• Lesson 1: Nervous System

Table 2.9: (continued)

Standard Number	Standard	Chapters and Lessons
9e	Students know the roles of sensory neurons, interneurons, and motor neurons in sensation, thought, and response.	Chapter: Nervous and Endocrine Systems <ul style="list-style-type: none"> • Lesson 1: Nervous System
9f	Students know the individual functions and sites of secretion of digestive enzymes (amylases, proteases, nucleases, lipases), stomach acid, and bile salts.	Chapter: Digestive and Excretory Systems <ul style="list-style-type: none"> • Lesson 2: Digestive System
9g	Students know the homeostatic role of the kidneys in the removal of nitrogenous wastes and the role of the liver in blood detoxification and glucose balance.	Chapter: Digestive and Excretory Systems <ul style="list-style-type: none"> • Lesson 3: Excretory System
9h	Students know the cellular and molecular basis of muscle contraction, including the roles of actin, myosin, Ca^{+2} , and ATP.	Chapter: Skeletal, Muscular, and Integumentary Systems <ul style="list-style-type: none"> • Lesson 2: The Muscular System
9i	Students know how hormones (including digestive, reproductive, osmoregulatory) provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms.	Chapter: The Human Body <ul style="list-style-type: none"> • Lesson 2: Homeostasis and Regulation Chapter: Nervous and Endocrine Systems <ul style="list-style-type: none"> • Lesson 2: Endocrine System Chapter: Digestive and Excretory Systems <ul style="list-style-type: none"> • Lesson 2: Digestive System

Table 2.9: (continued)

Standard Number	Standard	Chapters and Lessons
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SCI.CA.9-12.LS.10 Organisms have a variety of mechanisms to combat disease. As a basis for understanding the human immune response:

Table 2.10:

Standard Number	Standard	Chapters and Lessons
10a	Students know the role of the skin in providing non-specific defenses against infection.	Chapter: Skeletal, Muscular, and Integumentary Systems <ul style="list-style-type: none"> • Lesson 3: Integumentary System Chapter: Immune System and Disease <ul style="list-style-type: none"> • Lesson 1: Nonspecific Defenses
10b	Students know the role of antibodies in the body's response to infection.	Chapter: Immune System and Disease <ul style="list-style-type: none"> • Lesson 2: Immune Response
10c	Students know how vaccination protects an individual from infectious diseases.	Chapter: Immune System and Disease <ul style="list-style-type: none"> • Lesson 2: Immune Response

Table 2.10: (continued)

Standard Number	Standard	Chapters and Lessons
10d	Students know there are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections.	Chapter: Immune System and Disease <ul style="list-style-type: none"> Lesson 1: Nonspecific Defenses
10e	Students know why an individual with a compromised immune system (for example, a person with AIDS) may be unable to fight off and survive infections by microorganisms that are usually benign.	Chapter: Immune System and Disease <ul style="list-style-type: none"> Lesson 3: Immune System Diseases
10f	Students know the roles of phagocytes, B-lymphocytes, and T-lymphocytes in the immune system.	Chapter: Immune System and Disease <ul style="list-style-type: none"> Lesson 1: Nonspecific Defenses Lesson 2: Immune Response

Investigation and Experimentation

SCI.CA.9-12.IE.1 Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

Table 2.11:

Standard Number	Standard	Chapters and Lessons
1a	Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.4: Principles of Biology Chapter 15: Principles of Ecology <ul style="list-style-type: none"> • Lesson 15.1: The Science of Ecology
1b	Identify and communicate sources of unavoidable experimental error.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.2: Communicating Ideas
1c	Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.2: Communicating Ideas
1d	Formulate explanations by using logic and evidence.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.1: Nature of Science • Lesson 1.2: Communicating Ideas
1e	Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.2: Communicating Ideas • Lesson 1.4: Principles of Biology

Table 2.11: (continued)

Standard Number	Standard	Chapters and Lessons
1f	Distinguish between hypothesis and theory as scientific terms.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.1: Nature of Science • Lesson 1.2: Communicating Ideas
1g	Recognize the usefulness and limitations of models and theories as scientific representations of reality.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.2: Communicating Ideas
1h	Read and interpret topographic and geologic maps.	-
1i	Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).	Chapter 11: History of Life <ul style="list-style-type: none"> • Lesson 11.1: Studying the History of Life Chapter 13: Evolution in Populations <ul style="list-style-type: none"> • Lesson 13.2: Genetic Change in Populations
1j	Recognize the issues of statistical variability and the need for controlled tests.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.2: Communicating Ideas
1k	Recognize the cumulative nature of scientific evidence.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> • Lesson 1.2: Communicating Ideas

Table 2.11: (continued)

Standard Number	Standard	Chapters and Lessons
1l	Analyze situations and solve problems that require combining and applying concepts from more than one area of science.	Chapter 15: Principles of Ecology <ul style="list-style-type: none"> Lesson 15.1: The Science of Ecology
1m	Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> Lesson 1.1: Nature of Science Lesson 1.2: Communicating Ideas Chapter 10: Biotechnology <ul style="list-style-type: none"> Lesson 10.2: Biotechnology
1n	Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e.g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).	Chapter 1: Foundations of Life Science <ul style="list-style-type: none"> Lesson 1.2: Communicating Ideas

2.2 NSES Standards

Chapter 3

TE Biology Unit 1: Introduction to Life Science

3.1 Overview

Foundations of Life Science introduces the student to biology. The first chapter serves as a general introduction to science and ends with a general introduction of biology.

Chemical Basis of Life discusses the chemistry behind the study of biology. This chapter includes an introduction to the atom, elements and compounds, as well as: carbohydrates, lipids, proteins (including enzymes and chemical reactions), and nucleic acids. This chapter also includes an introduction to the significance of water. An understanding of chemistry is critical to an understanding of biology, especially cell biology, the focus of the next unit.

3.2 Outline

This unit, *Introduction to Life Science*, includes two chapters to introduce high school students to the study of life science (biology):

Chapter 1. Foundations of Life Science

Chapter 2. Chemical Basis of Life

Chapter 1. Foundations of Life Science

- Lesson 1.1: Nature of Science
- Lesson 1.2: Communicating Ideas
- Lesson 1.3: Tools and Techniques

- Lesson 1.4: Principles of Biology

Chapter 2. Chemical Basis of Life

- Lesson 2.1: Matter
- Lesson 2.2: Organic Compounds
- Lesson 2.3: Chemical Reactions
- Lesson 2.4: Water

Chapter 4

TE Foundations of Life Science

4.1 Chapter 1: Foundations of Life Science

Outline

The chapter *Foundations of Life Science* consists of four lessons that introduce students to the idea of science, the study of science, and biology, the study of life:

- 1.1: Nature of Science
- 1.2: Communicating Ideas
- 1.3: Tools and Techniques
- 1.4: Principles of Biology

Overview

- The goal of science is to learn how nature works through observation, formation and testing of hypotheses, gathering and analyzing data, and reporting and evaluating results. Scientists tell each other and the public about their research and the results of their research in a variety of ways. Standard laboratory procedures and equipment are used by scientists around the world. Mathematics also plays an important role in science, in models, and in statistics to assess experimental results. Biology is the study of the characteristics of living things and operates under four unifying principles: the Cell Theory, the Gene Theory, homeostasis, and evolution.
- The concept map below provides a visual representation of how the chapter concepts are related.

Teaching Strategies

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 4.1:

Lesson	Number of Class Periods*
1.1 Nature of Science	2.0
1.2 Communicating Ideas	1.5
1.3 Tools and Techniques	1.5
1.4 Principles of Biology	2.0

- Class periods are assumed to be 60 minutes long.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 4.2:

Lesson	Strategy or Activity	Materials Needed
1.1	1. Building Science Skills	1. Graduated cylinder, measuring spoons or cups, containers.
1.3	1. Enrichment: Role-Play	1. Try to have as many props as possible: lab coat, goggles, gloves, etc.
1.4	1. Activity 2. Enrichment: Teaching a Topic: Demonstration	1. Slides (Carolina Biological (www.carolina.com)) of different cell types; microscopes. 2. Materials for demonstration of volcanic eruption based on research; sample of volcanic rock (Carolina Biological).

Lab Links

The following labs are suitable for *Foundations of Life Science* and are available online:

Scientific Method

- http://www.troy.k12.ny.us/thsbiology/labs_online/school_labs/scimethod1_lab_school.html
- http://www.biology4teachers.com/scientific_method.htm

Common Misconceptions

Science Can Offer Answers to All Questions

As explained in Lesson 1.1, science cannot answer questions about the supernatural, the meaning of life, or much about moral questions. People in other fields, such as religion or philosophy, may attempt to answer these types of questions from very different perspectives.

Evolution

These misconceptions are listed in Lesson 1.4, and include (1) that the term evolution does not address the origin of life, (2) that humans did not evolve from modern apes, (3) that the process of evolution is not necessarily slow, and (4) that evolution is not a progression from “lower” to “higher” forms of life.

Additional Web-Based Resources

You may find this additional Web-based resources helpful when teaching *Foundations of Life Science*:

Use of statistics to determine the effects of a fictitious drug http://www.cdc.gov/excite/ScienceAmbassador/ambassador_pgm/lessonplans_stats.htm

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include *Foundations of Life Science*, or specific lessons in this chapter, in your students’ FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- Students should read *Foundations of Life Science* before reading the remaining chapters of the FlexBook. Lesson 1.4 is especially valuable as an introduction to the course.
- It is recommended that you include all the lessons of this chapter in the FlexBook.

4.2 Lesson 1.1: Nature of Science

Key Concept

The goal of science is to learn how nature works by observing the physical world, and to understand it through research and experimentation. Science is a distinctive way of learning about the natural world through observation, inquiry, formulating and testing hypotheses, gathering and analyzing data, and reporting and evaluating findings.

Lesson Objectives

- List the principles that should guide scientific research.
- Examine a scientist’s view of the world.
- Outline a set of steps that might be used in the scientific method of investigating a problem.
- Explain why a control group is used in an experiment.
- Outline the role that reasoning plays in examining hypotheses.
- Examine the function of the independent variable in an experiment.
- Define what is meant by a theory and compare this to the meaning of hypothesis.

Lesson Vocabulary

Table 4.3:

Lesson 1.1 Vocabulary		
science	scientific skepticism	phenomenon
scientific methods	hypothesis	observation
deduction	induction	experiment
controls	variable	independent variables
dependent variables	controlled variables	Occam’s razor
controlled experiment	placebo	double blind
natural experiments	astronomy	paleontology
meteorology	planetary nebulae	field experiments
prediction	accuracy	precision
error	scientific theory	string theory

Table 4.3: (continued)

Lesson 1.1 Vocabulary		
a theory of everything physical law	superseded	scientific laws

Check Your Understanding

Drawing on Student Experiences

Ask the students how they have used the scientific method in making everyday choices. For example, in purchasing groceries, would you need to examine the cost of individual items, the ingredient list, or the packaging of the items?. Does this involve making observations, developing a hypothesis, maybe a little experimentation and collection of data, and drawing conclusions?

- You can turn this into a class discussion that leads into the Using Visuals activity.

Teaching Strategies

Using Visuals: Figure 1

Have the students examine **Figure 1** and discuss how shopping decisions involves the use of asking questions, making observations, relying on evidence to form conclusions, and being skeptical about ideas or results.



Shopping sometimes involves a little scientific experimentation. You are interested in inventing a new type of salad that you can pack for lunch. You might buy a vegetable or salad

dressings that you have not eaten before, to discover if you like it. If you like it, you will probably buy it again. That is a type of experiment.

Building Science Skills: Interpreting Data, Measuring

Have students build skills in interpreting data and measuring through a simple activity. Have them measure a certain volume of water into a number of cups, such as 4 - 10 cups. Then have them first look online for what the threshold amount is for detecting sugar in water (see:<http://www.skidmore.edu/~hfoley/Perc2.htm#ch2demo1>).

Have them have one cup with water only (the control), and then have them add increasing amounts of sugar to each of the remaining cups. Have a person record for each student the threshold when that student detects the sugar (by taste) in the solution. The results are then tabulated and a graph made showing the number of students detecting the sugar solution at each concentration.

Differentiated Instruction: Flow Chart

Have pairs of students fill in a flow chart to demonstrate the general process of a scientific investigation, as in **Figure 4**. Pair English language learners with native speakers of English and less proficient readers with more proficient readers. (**ELL LPR**)

Enrichment: Research Proposal

Have students come up with a research proposal for something they wish to investigate. One possible proposal may include the effects of substrate and amount of light on germination and plant growth (can use dried lima beans planted in different types of substrate, such as sand, ground cat litter, and potting soil; for light, pots can be placed on windowsill in direct light or in closet or similar area with low light. Look for effects of different conditions on such things as duration of time until germination, percent germination, and in a two week period, how fast the plants grow).

Have them present the proposal to the class, going through the steps as presented in **Figure 4**, The general process of a scientific investigation.

Science Inquiry

Formulating a Hypothesis

Have students who go to school in a city make observations of pigeons, as to feeding behavior, interactions between birds, etc. Based on the observations, have them come up

with a testable research hypothesis. Ask them to describe data that would support or disprove the hypothesis. For students in a rural area, have them do something similar with ants (observable behavior here might be the ants' tracks).<http://www.birds.cornell.edu/pigeonwatch>

Reinforce and Review

Quizzing a Partner

Have students write a few fill-in, matching, or true/false questions and then use them to quiz a partner.

Lesson Worksheets

Copy and distribute the four Lesson 1.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 1.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 1.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Science is a particular way in which people examine and ask questions about the world. Can you think of other ways in which people examine and ask questions about the world?
- Consider the importance of replication in an experiment and how replication of an experiment can affect results.

- Scientists often disagree among themselves about scientific findings, and communicate such disagreement at science conferences, through science articles in magazines, or science papers and in scientific journals. Can you think of other ways in which scientists could communicate so that the public can get a better idea of what the “hot topics” in science are?

Lesson Assessment

- Have students complete the Lesson 1.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

4.3 Lesson 1.2: Communicating Ideas

Key Concepts

Scientists need to be able to tell each other and the public about their research and the results of their research. Bioethicists are concerned with the ethical questions that arise in the relationships among biology, biotechnology, medicine, politics, law, and philosophy. Biotechnology is the application of biological knowledge to develop tools and products that allow us to control and adapt to our environment.

Lesson Objectives

- Outline the need for scientists to be able to share their ideas and findings with each other.
- Identify the role of graphics in presenting results of an investigation.
- Identify the role of peer review in the communication of ideas.
- Examine how ethics are applied to communicating ideas and research.
- Compare scientist to scientist communication to scientist to public communication.
- Identify the benefits of studying science, even if you do not intend on becoming a scientist.
- List three things that can influence scientific research.
- Identify two ways that biotechnology has affected our lives.

Lesson Vocabulary

Table 4.4:

Lesson 1.2 Vocabulary		
scientific journals	academic conference	scientific article
abstract	introduction	materials and methods
reproducibility	results	discussion
conclusion	references	literature cited
primary sources	secondary sources	peer review
bias	conflict of interest	scientific misconduct
scientific consensus	science magazine	research scientists
patent	ethics	biotechnology
bioremediation		

Check Your Understanding

Drawing on Student Experiences

Ask students what scientific topics they are aware of in the news. For example, students may be aware of the discussions about health care reform; stem cell research; and global warming. Also, have a discussion about where they come across scientific topics, whether it is on the internet, television or radio, magazines or newspapers, or other sources.

Teaching Strategies

Using Visuals: Figure 6

Have the students look at **Figure 6** and discuss how knowledge about biology could help them in making decisions about health products they see advertised in various media. Have them give specific examples of products they, their friends, or their families may have bought or are thinking of buying and what other facts they might want to know to make a more informed decision. How can scientific knowledge also help them in asking informed questions at their doctors' offices, or even at their pharmacies?



Nutritional supplements. Understanding how your body works and how nutrients work will help you decide whether you need to take a nutritional supplement. It will also help you make sense of the large amount of information available about regular medicines, if and when you need to take them.

Building Science Skills: Comparing and Contrasting

Have the students review the section Science in the Media, especially the example of the 1999 West Nile Virus, and what aspects the media coverage focused on vs. the reality of the situation. Compare how this relates to the current situation (2009) with the swine flu virus, H1N1. Have a discussion about what the students' perceptions are about the virus, based on media coverage, and how this might differ from what the facts are (for example, numbers infected, number deaths, etc.). Also, have students research what their school is doing to prevent the spread of the virus. For updates concerning the swine flu, see the CDC web site: <http://www.cdc.gov/h1n1flu/>

Differentiated Instruction

Have students make a KWL chart, where K=Know, W=Want to Know, and L=Learned, for the section Applications of Biotechnology. Have English language learners pair up with native speakers of English, Less proficient readers with more proficient readers, and special needs students with students without special needs. (**ELL LPR SN**)

Enrichment

Have the students, if possible, invite someone from the local health department, or perhaps, the school nurse to come in and answer a few questions in front of the class about the H1N1 virus and Swine Flu. Have it tie in with the Building Science Skills Teaching Strategy above. For example, questions of interest might be how a new strain of virus comes about, how this outbreak is very different from the 1918 flu pandemic, vaccinations for both seasonal flu and

H1N1, and precautions to take. If there is time, open the discussion up for questions from the rest of the class. A follow-up discussion or homework assignment could ask the students to describe one new thing they learned or found interesting.

Science Inquiry

Analyzing Data

Have students pick a science topic that is currently getting lots of media coverage. For example, health care reform and swine flu are currently popular topics. Other topics such as stem cell research and AIDS in developing countries are consistently generating lots of media attention. Have each student select a media source that is convenient for him or her (for example, if a student has no access to a computer, perhaps it could be radio or television coverage). Try to get as many different media sources as possible (internet, television, radio, newspaper, magazine), and within each media source, as many different specific sources as possible (news organizations, television stations). Assign a time period, perhaps a week, for each student to track that particular source on the specific topic, and keep a written record of coverage on the topic as to frequency, how prominently it appeared, and what aspects of the topic were covered. After the time period is up, summarize the results on the board, and see what differences there were between media sources, and even between similar sources (for example, different newspapers, different television stations, different online news sources).

Reinforce and Review

Asking Questions

Have each student turn in a question he or she has about lesson content, on an index card or scrap of paper. Answer, or review material relevant to, those questions that are asked most frequently. If time permits, answer other questions as well.

Lesson Worksheets

Copy and distribute the four Lesson 1.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 1.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 1.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Bias can also be introduced into an investigation by uncalibrated or broken equipment. Consider ways to avoid this type of bias in your investigations.
- If you had to explain to a younger student the importance of learning biology, how would you go about it?
- Rules for correct behavior in the lab include not eating or drinking, dressing correctly, and no horseplay. These rules are for general safety in the lab, but could they also be considered lab ethics?

Lesson Assessment

- Have students complete the Lesson 1.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

4.4 Lesson 1.3: Tools and Techniques

Key Concept

The SI system of measurement and standard laboratory procedures and equipment are used by scientists around the world. This allows all scientists to understand what was done to get to a particular result, and also so they can replicate experiments, if they wish to. Mathematics plays important roles in science, both in scientific models and as statistics, to assess the reliability and range of differences in experimental results. In laboratories where conditions might be dangerous, safety precautions are advised.

Lesson Objectives

- Identify the units of measurement that scientists use.
- Contrast light microscopes and electron microscopes.
- Identify three items that are common to science labs.
- Outline the importance of mathematics to scientific research.
- Outline what students and researchers can do to stay safe while working in the lab.

Lesson Vocabulary

Table 4.5:

Lesson 1.3 Vocabulary			
International System of Units (SI)	SI prefix		resolution
magnification	transmission electron microscopy (TEM)	electron	scanning electron microscope (SEM)
aseptic technique	scientific modeling		abstract model
simulation	lab coat		

Check Your Understanding

Recalling Prior Knowledge

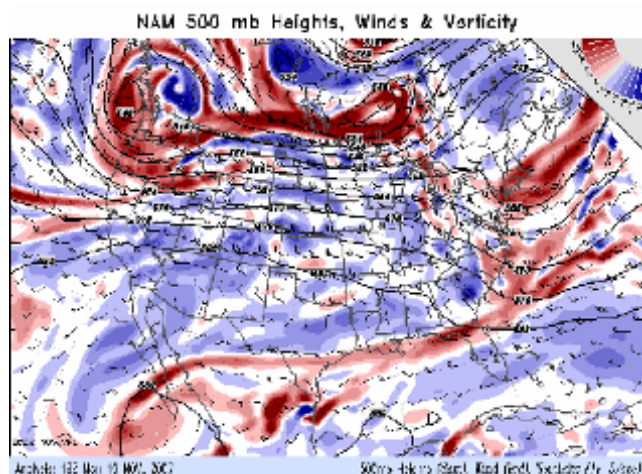
Introduce lesson concepts by asking students to recall what they learned during Lesson 1.1 (Nature of Science). Make a list on the board and have the students copy it into their notebooks. As they go through Lesson 1.3, ask the students to keep in mind how the tools and techniques covered in this lesson help scientists to carry out what was covered in Lesson 1.1.

Teaching Strategies

Using Visuals: Figure 11

Have the students look at **Figure 11** and discuss: 1. What kind of model this is (computer). 2. What this model is used for (to forecast wind speeds and directions). 3. How this model might be useful (for example, weather forecasts; airline routes). 4. What is the main advantage of this visual model to the public (much easier to understand than a large table of numbers)? 5. Also ask the students how this model (and models in general) are of use to

scientists (for example, reflecting reality, predicting future observations, ease of use and how it looks [for example, the colors used]).



A computer model of wind patterns across the continental United States for 19 November, 2007. This model is used to forecast wind speeds and directions. Data on wind speed, direction, and related data are entered into a computer which then produces this simulation. This visual model is much easier for a person to understand than a large table of numbers.

- Another model that might be worth researching and discussing is one for water flow in the Everglades (Florida). Some scientists are investigating how an increase in freshwater flow will affect patterns of organic matter as it is carried by the water and deposited downstream. If water flow is increased, this organic matter will be deposited in greater amounts in the estuarine ecotone and could lead to even higher rates of productivity in these areas. http://evergladesplan.org/images/water_flow_to_everglades.jpg

Discussion

Have the students refer back to the activity they did in Lesson 1.1 (Check Your Understanding: Building Science Skills). Have them review the equipment and units of measurement they used for the water and sugar. Also, what aseptic techniques did they use and what safety precautions did they follow? If they were doing the activity again, is there anything they would change in any of the equipment, techniques, or safety precautions they used?

Differentiated Instruction: Main Ideas/Details Chart

Have pairs of students divide a sheet of paper in half and on the left side write the main ideas from the passage on Lab Safety (skipping several lines between the main ideas). On the right side, have students fill in important details about each main idea as it is read. Pair

English Language Learners with native speakers of English and Less Proficient Readers with more proficient readers. (**ELL LPR**)

Enrichment: Role-Play

Have the students role-play different situations illustrating lab safety. Have them demonstrate both safe and unsafe conditions concerning different materials and lab practices. Follow each demonstration with a class discussion.

Science Inquiry

Analyzing Data

Examine the data collected in the activity in Lesson 1.1 (see Discussion above). In order to analyze the data further, see if there is a difference between males and females of when they detect sugar in the sugar-water solutions. Graphs showing the number of people tasting sugar at each concentration of sugar can be made for each group. A simple statistical test, called chi square analysis, can be looked up on the internet and applied to show if there is a statistical difference between the two groups.

For additional information on the chi square test:

- General Information - especially see the example listed: http://en.wikipedia.org/wiki/Pearson's_chi-square_test
- The Chi Square Test used in this hs biology lab exercise: <http://www.monarchlab.umn.edu/Lab/Research/Stats/ChiSquare.aspx>

Reinforce and Review

Completing a Chart

Have students complete missing parts of a diagram of the compound light microscope, similar to **Figure 4**. Many unlabeled examples of light microscopes are available on the internet.

Lesson Worksheets

Copy and distribute the four Lesson 1.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 1.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 1.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Consider how much more difficult it would be to carry out investigations without the use of computers, and the types of models that have developed due to the development of computers.
- Consider reasons why eating and drinking are not allowed in the lab.
- What additional ethical considerations would there be if you were working with living organisms in the lab, such as mice, rats, or other mammals?

Lesson Assessment

- Have students complete the Lesson 1.3 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

4.5 Lesson 1.4: Principles of Biology

Key Concept

All living things respond to their environments, grow and change, reproduce, perform chemical reactions, maintain homeostasis, are composed of cells, and pass on their traits to their offspring. The four unifying principles of biology are the Cell Theory, the Gene Theory, homeostasis, and evolution. Living things interact with each other and their environments.

Lesson Objectives

- List some of the different areas of study in biology.
- Identify the seven characteristics of living things.
- Identify the four unifying principles of modern biology.
- List two different types of interactions that organisms can have with each other.
- Outline the formation of modern evolutionary theory.

Lesson Vocabulary

Table 4.6:

Lesson 1.4 Vocabulary		
adaptation	biochemistry	biological interactions
biology	biosphere	botany
cell	cell biology	community
competition	ecology	ecosystem
evolution	evolutionary biology	genetics
homeostasis	immunology	metabolism
microbiology	natural selection	organism
physiology	symbiosis	zoology

Check Your Understanding

Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know from Lesson 1.1 (Nature of Science). Make a list on the board, challenging the class to have at least five concepts they believe can be applied to the Principles of Biology. These may include goals of science, scientific ideas can change, experiments, theories, etc.

Teaching Strategies

Using Visuals

Discuss **Figure 8** with the class. Use this to lead a discussion on the diversity of life. Mention that life means from bacteria to us. Ask the class to form a list of living organisms. Make sure they include some plants and fungi.



Animal diversity. This figure shows just a fraction of the diversity of life. The diversity of organisms found in the five kingdoms of life, dwarf the number of organisms found in the animal kingdom. The other kingdoms of life are Eubacteria, Archaeobacteria, Protista, Fungi, and Plantae.

(Source: http://en.wikipedia.org/wiki/Image:Animal_diversity_October_2007.jpg, Image created by: en:User:Justin, License: CC-BY-SA)

Activity

If slides can be purchased (Carolina Biological Supply or other sources), have students examine slides showing different cell types (i.e. plant cells vs. animal cells). Have the students draw what they see and then have a discussion about the differences they see, perhaps constructing a table on the board. This activity helps review the characteristic of living things (composed of cells; have students look over **Figure 2** on the plant cell) and the Cell Theory, as well as review how to use a microscope, discussed in Lesson 3 (Tools and Techniques) of this chapter.

Differentiated Instruction: Flow Chart

Have pairs of students work together on reviewing the levels of organization in a tree, presented in **Figure 2**. In addition to replicating this flow chart, see if they can do other flow charts with other types of organisms (e.g. human, worm). They could also compare and contrast the differences they find. If there is time at the end of the activity, list on the board the different organisms that students came up with. Pair English Language Learners with native speakers of English and Less Proficient Readers with more proficient readers. (**ELL LPR**)

Enrichment: Teaching a Topic, Demonstration

As part of teaching about the topic Evolution of Life, specifically to illustrate the question posed (How do scientists know the earth is so old?), have students research how to do a demonstration of a volcanic eruption (as shown in **Figure 10**), then demonstrate this, and perhaps also show the class an example of a volcanic rock (Carolina Biological Supply). Before and after the demonstration, have students explain how volcanic rocks differ from sedimentary and metamorphic rocks, and also how the study of rocks can inform us of the age of the earth (the atomic clock).

Science Inquiry

Analyzing Data

Have students come up with data online or do their own activity to generate data. Have the activity illustrate the area of biological study known as physiology. Have students work in pairs. Have the students take turns taking their pulses after sitting (pulse at resting), and then after jumping up and down after a time period, perhaps one to two minutes. Take pulses at varying times after the activity; immediately after, one minute after, two minutes after, etc. Data could be examined in a number of ways; how resting pulse compares to pulse right after the activity, at varying times after the activity, how long it might take to get back to a resting pulse, the differences in pulses between boys and girls, how pulse rate increases with how much time a person jumps (one minute vs. two minutes, etc.) Data could be presented in either graph or table form, or both. Follow with a discussion of the results.

Reinforce and Review

Outlining the Lesson

Have students work in pairs and outline the lesson using the heading structure of the SE lesson.

Lesson Worksheets

Copy and distribute the four Lesson 1.4 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 1.4 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 1.4 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- All modern scientific disciplines support the theory of evolution. Consider what type of hypothesis could be made that might challenge evolutionary theory. Likewise, consider what type of hypothesis could challenge the cell theory.
- As you read through other chapters in this book, it might help to remember that studying biology does not just mean learning facts by memory or repetition. By studying biology you are developing a knowledge and understanding of the world around you. And, combined with your study of other subjects such as literature, social studies, art, music, mathematics, and physical sciences, you will develop a fuller, deeper understanding of what it is to be a human being who interacts with and lives an interdependent life with other organisms (including other humans!) in your environment.

Lesson Assessment

- Have students complete the Lesson 1.4 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

4.6 Worksheet Answer Keys

- Worksheet Answer Keys available upon request. **Please send an email to teachers-requests@ck12.org to request answers.**

Chapter 5

TE Chemical Basis of Life

5.1 Chapter 2: Chemical Basis of Life

Outline

The chapter *Chemical Basis of Life* consists of four lessons that introduce students to the chemistry concepts they must master in order to understand life processes.

- Lesson 2.1: Matter
- Lesson 2.2: Organic Compounds
- Lesson 2.3: Chemical Reactions
- Lesson 2.4: Water

Overview

- Living organisms are made of organic compounds. Life processes involve chemical reactions and require energy. Water is a unique substance needed by all organisms.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert figure 1]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 5.1:

Lesson	Number of Class Periods*
2.1 Matter	1.0
2.2 Organic Compounds	1.5
2.3 Chemical Reactions	1.5
2.4 Water	1.0

- Class periods are assumed to be 60 minutes long.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 5.2:

Lesson	Strategy or Activity	Materials Needed
2.1	<ol style="list-style-type: none"> 1. Discussion 2. Enrichment: Poster Presentation 	<ol style="list-style-type: none"> 1. Bowl of plain bran flakes, bowl of raisin bran 2. Posterboard, markers, scissors, glue
2.2	<ol style="list-style-type: none"> 1. Discussion 	<ol style="list-style-type: none"> 1. Ads, articles, and books about low-carb products and diets
2.3	<ol style="list-style-type: none"> 1. Demonstration 	<ol style="list-style-type: none"> 1. Vinegar, baking soda, large clear container
2.4	<ol style="list-style-type: none"> 1. Activity 2. Demonstration 3. Enrichment: Demonstration 	<ol style="list-style-type: none"> 1. Apple cider vinegar, vegetable oil, beakers or test tubes 2. Samples of common acids and bases (e.g., vinegar, orange juice, coffee, baking soda solution, ammonia, bleach), red and blue litmus paper 3. Food coloring, paper towel or celery stalk

Lab Links

The following labs are suitable for Chapter 2 and are available online:

- Organic Compounds: Students test common foods for carbohydrates, lipids, and proteins. (Lesson 2.2) <http://www.accessexcellence.org/AE/ATG/data/released/0335-HeidiHaug/index.php>
- Enzyme Activity: Students monitor the catalysis of hydrogen peroxide by catalase (Lesson 2.3). http://mdk12.org/instruction/curriculum/hsa/biology/enzyme_activity/teachers_guide_exploration2.htm

Common Misconceptions

Chemical Change vs. Change of State

Students commonly confuse chemical changes, with changes of state. When you discuss these processes, compare and contrast a familiar example of each, such as an iron nail rusting for a chemical change, and icicles forming for a change of state. Discuss how the two processes differ (e.g., iron rusting involves iron and oxygen, becomes rust, and cannot return to iron and oxygen; the formation of icicles involves just water, remains water, and can return to liquid water). If students have not done so already, suggest that they start a list of common misconceptions in their science notebook, in which they also list the correct concept for each misconception.

Enzymes as Reactants

Students often think that enzymes are reactants that are used up in the reactions they catalyze. Use an analogy to help them understand the correct role of enzymes in chemical reactions. Tell the class that an enzyme is like a wrench. It helps get a job done, is not changed by doing the job, and can be used over and over again. Direct students to the animation below to see the enzyme-wrench analogy in detail. <http://www.biologyinmotion.com/minilec/wrench.html>

Other Web Resources

You may find these additional Web-based resources helpful when teaching *The Chemical Basis of Life* chapter:

- Atoms and Molecules: This chapter in an online biology book provides an excellent and well illustrated introduction to basic chemistry concepts. <http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookCHEM1.html>

- Chemicals of Life: This colorful PowerPoint presentation summarizes the information in 'The Chemical Basis of Life' chapter. http://www.biology4all.com/resources_library/source/158.ppt#

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to choose the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter or certain lessons in this chapter in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook.

- To understand the content of this chapter, students should have read the *Introduction to Life Science* chapter.
- Students should read this entire chapter before reading the remaining chapters of the FlexBook.
- It is recommended that you include all the lessons of this chapter in the FlexBook.

5.2 Lesson 2.1: Matter

Key Concepts

All living things are made of matter. Matter may be an element, which is a pure substance, or a compound, which is a combination of elements in fixed proportions. Compounds form in chemical reactions. Energy is a property of matter, and needed by all living organisms to grow and reproduce. Matter can exist in different states depending on how much energy its molecules have.

Lesson Objectives

- Describe elements and compounds, and explain how mixtures differ from compounds.
- Define energy, and describe how energy can be changed from one form to another.
- Identify three states of matter, and explain how they differ.

Lesson Vocabulary

Table 5.3:

Lesson 2.1 Vocabulary		
element	chemical compound	organic compound
mixture	energy	kinetic energy
potential energy	state of matter	gas
liquid	solid	

Check Your Understanding

Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know about water and the water cycle. Guide them in focusing their prior knowledge.

- Ask: What type of substance is water? (chemical compound)
- What elements make up water? (hydrogen and oxygen)
- Call on volunteers to describe the water cycle and identify the states of matter that water passes through in the cycle.
- Ask: What causes water to change state? (heating or cooling)

Teaching Strategies

Use Visuals: Figures 1–3

Have students compare **Figures 1–3** in their FlexBook. Ask them to explain what each figure represents. Make sure they understand that **Figure 1** represents an atom, which is the smallest particle of an element, whereas **Figures 2** and **3** represent molecules, which are the smallest particles of compounds. Call on students to distinguish between elements and compounds and give an example of each. Also, point out that all three figures are just models, or simplified ways of representing particles. Explain, for example, that electrons do not really orbit the nucleus of an atom like planets around the sun, as the model in **Figure 1** suggests. Real atoms and molecules are actually much more complex.

Demonstration

Use this simple demonstration to illustrate some of the differences between compounds and mixtures. Show students a bowl of plain bran flakes and a bowl of raisin bran. Ask students which type of cereal is a compound (*plain bran flakes*) and which is a mixture (*raisin bran*). Call on a volunteer to use the cereal to demonstrate that a mixture, unlike a compound, does

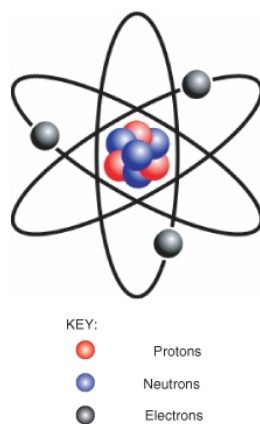


Figure 5.1: . The protons and neutrons of this atom make up its nucleus. Electrons surround the nucleus. KEY: Red = protons, Blue = neutrons, Black = electrons.



Figure 5.2: Model of a water molecule, showing the arrangement of hydrogen and oxygen atoms.

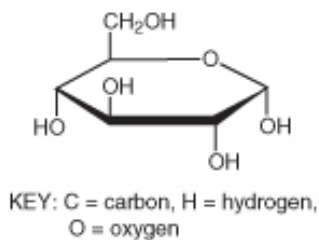


Figure 5.3: Glucose Molecule. This model represents a molecule of glucose, an organic compound composed of carbon, hydrogen, and oxygen. The chemical formula for glucose is $C_6H_{12}O_6$. This means that each molecule of glucose contains six carbon atoms, twelve hydrogen atoms, and six oxygen atoms. NOTE: Each unlabeled point where lines intersect represents another carbon atom. Some of these carbons and the oxygen atom are bonded to another hydrogen atom, not shown here.

not have a fixed chemical composition and can be separated into its component substances without a chemical reaction (*by removing some of the raisins from the raisin bran*). Challenge students to brainstorm other common examples of compounds and mixtures.

Differentiated Instruction: Main Ideas/Details Chart

Have less proficient readers make a main ideas/details chart as they read the lesson. Instruct them to divide a sheet of paper down the middle and record the main ideas on the left side and the details for each main idea on the right side. Advise them to write one main idea for each of the main headings in the lesson (Chemical Substances, Matter and Energy, and States of Matter). Suggest that students save their tables for reviewing lesson content. (LPR)

Enrichment: Poster Presentation

Ask students who need extra challenges to find additional ways that organisms change energy from one form to another. Suggest that students make a table, similar to the *How Organisms Change Energy* table below, to organize what they learn. Then have them create an illustrated poster to display the information. Give students a chance to present their poster to the class.

Table 5.4: **How Organisms Change Energy**

How Energy Changes	Organisms that Change Energy This Way	Life Process or Activity in Which Energy Is Changed
From light energy to chemical energy:	plants	photosynthesis
From chemical energy to heat energy:	all organisms	metabolism
From chemical energy to mechanical energy:	animals	movement
From chemical energy to electrical energy:	animals	carrying messages
From chemical energy to sound energy:	animals	communicating

Science Inquiry

Formulating a Hypothesis

Share the table **Boiling Points of Organic Compounds** with the class. Explain that boiling changes the state of a compound from liquid to gas. Add that the boiling point of a compound reflects the energy needed to overcome the forces of attraction between its molecules.

Table 5.5:

Name of Compound	Chemical Formula	Boiling Point ($^{\circ}\text{C}$)
Methane	CH_4	-164
Ethane	C_2H_6	-88
Butane	C_4H_{10}	-42
Pentane	C_5H_{12}	36
Hexane	C_6H_{14}	?

After students have a chance to examine the table, ask them to predict the boiling point of hexane (69°C). Then challenge students to formulate a hypothesis based on the data in the table. (*Sample hypothesis: The larger an organic molecule is, the greater the attractive forces are between its molecules.*)

Reinforce and Review

Flashcards

Have students make flashcards for the boldface vocabulary terms in the lesson. They should write each word on one side of an index card and a definition and an example on the other side. Tell students to choose partners and use their flashcards to quiz each other on the terms. Have them review relevant material in the FlexBook for any terms they miss.

Lesson Worksheets

Copy and distribute the four Lesson 2.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 2.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 2.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What are some other organic compounds in your body?
- What roles do you think other organic compounds might play?
- Why are organic compounds able to carry out these roles?
- How do organic compounds differ from inorganic compounds?

Lesson Assessment

- Have students complete the Lesson 2.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

5.3 Lesson 2.2: Organic Compounds

Key Concepts

Carbon is the major element in organic compounds. Organic compounds make up living organisms and carry out life processes. Types of organic compounds include carbohydrates, lipids, proteins, and nucleic acids.

Lesson Objectives

- Explain why carbon is essential to life on Earth.
- Describe the structure and function of carbohydrates.
- Describe the structure and function of lipids.
- Describe the structure and function of proteins.
- Describe the structure and function of nucleic acids.

Lesson Vocabulary

Table 5.6:

Lesson 2.2 Vocabulary		
functional group	carbohydrate	monosaccharide
disaccharide	simple sugar	polysaccharide
complex carbohydrate	lipid	fatty acid
saturated fatty acid	unsaturated fatty acid	trans fatty acid
triglyceride	phospholipid	steroid
cholesterol	essential fatty acids	protein
amino acid	peptide	polypeptide
essential amino acids	nucleic acid	nucleotide
deoxyribonucleic acid (DNA)	ribonucleic acid (RNA)	complementary bases
double helix		

Check Your Understanding

Drawing on Student Experiences

Students are likely to have heard about organic compounds in advertising and popular media (e.g., low-fat foods, high-protein diets). Call on volunteers to share with the class anything they already know about organic compounds. Point out correct responses and clear up any misconceptions. Tell students they will learn more about organic compounds in this lesson.

Teaching Strategies

Discussion

Introduce carbohydrates by showing students ads, articles, and books about low-carbohydrate products and diets. Ask students why carbohydrates are portrayed as “bad.” Explain that carbohydrates are actually essential for life. Discuss the important roles of carbohydrates in organisms. For example, tell students that the simple sugar glucose is the only source of energy used by the brain.

Activity

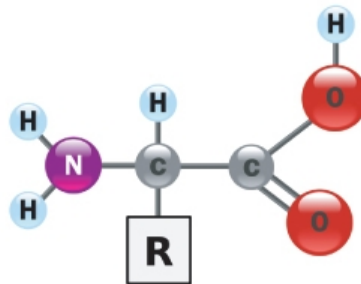
Have students do the interactive animation *Biomolecules: The Lipids* at the Web site below. The animation will give them a more detailed understanding of the structure and functions of lipids, including their role in cell membranes.

http://www.wisc-online.com/objects/index_tj.asp?objID=AP13204

Use Visuals: Figures 4–6

Call on students to explain how **Figures 4** and **5** are related to one another. Make sure they understand that amino acids like the one in **Figure 4** are represented by small circles in **Figure 5**. Compare the chain of amino acids in **Figure 5** to a chain of beads. Then move on to **Figure 6**.

- Ask: How is **Figure 5** related to **Figure 6**? (The chain of amino acids in **Figure 5** is the primary structure of the protein in **Figure 6**.)
- Call on students to describe in words how protein structure becomes more complex from the primary to quaternary levels.
- Stress that protein structure is important because a protein’s structure determines its function.



KEY: H = hydrogen , N = nitrogen , C = carbon , R = variable side chain

Figure 5.4: General structure of amino acids. This model shows the general structure of all amino acids. Only the side chain, R, varies from one amino acid to another. For example, in the amino acid glycine, the side chain is simply hydrogen (H). In glutamic acid, in contrast, the side chain is CH₂CH₂COOH. Variable side chains give amino acids different properties.

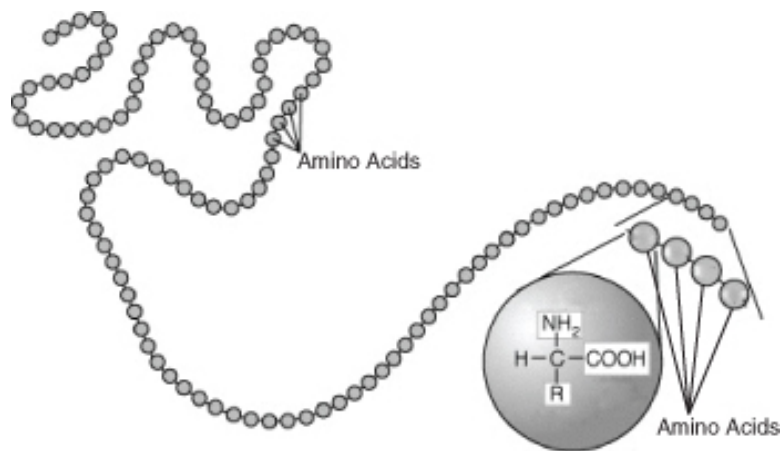


Figure 5.5: Polypeptide. This polypeptide is a chain made up of many linked amino acids

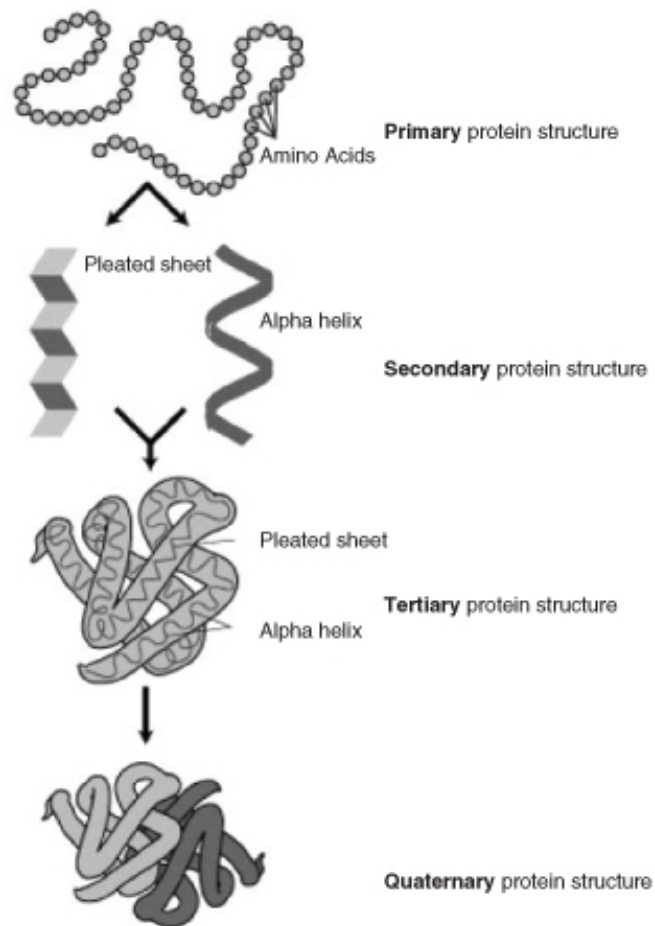


Figure 5.6: Protein structure. Primary protein structure is the sequence of amino acids in a single polypeptide. Secondary protein structure refers to internal shapes, such as alpha helices and beta sheets, that a single polypeptide takes on due to bonds between atoms in different parts of the polypeptide. Tertiary protein structure is the overall three-dimensional shape of a protein consisting of one polypeptide. Quaternary protein structure is the shape of a protein consisting of two or more polypeptides.

Activity

Suggest that students use the online animation Central Dogma of Biochemistry at the Web site below to learn more about the structure and functions of nucleic acids. The animation will help them appreciate the fundamental importance of nucleic acids in the storage and transmission of genetic information in organisms.

<http://www.wiley.com/legacy/college/boyer/0470003790/animations/animations.htm>

Differentiated Instruction: Concept Map

Pair English language learners with native speakers of English. Have partners make a simple, nontechnical concept map of organic compounds, like the sample map below. You may want to give students copies of the sample map with some boxes left blank for students to fill in. Suggest that students keep their concept map in their science notebook. (ELL)

[Insert Concept Map]

Enrichment: Research

Hemoglobin is often used as an example of the relationship between structure and function in proteins. Ask interested students to investigate the structure of hemoglobin and how it relates to the oxygen-carrying function of the molecule. Have students explain the relationship to the class. Suggest that they create sketches to illustrate their explanation.

Science Inquiry

Analyzing Data

Share the table below with students. Explain that it shows amino acids (represented by letters) in the beta chain of hemoglobin for six different species of primates. The beta chain of hemoglobin has a total of 146 amino acids. The table shows amino acids that vary among the six species, as well as some that are consistent. The other amino acids (that are not shown) are the same in all six species. The one letter code for amino acids can be found at:

<http://www.vaughns-1-pagers.com/food/amino-acids-summary.htm>

Table 5.7: (continued)

Amino Acid Position	Human	Chimpanzee	Gorilla	Gibbon	Rhesus Monkey	Lemur
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Table 5.7:

Amino Acid Position	Human	Chimpanzee	Gorilla	Gibbon	Rhesus Monkey	Lemur
1	V	V	V	V	V	T
2	H	H	H	H	H	F
4	T	T	T	T	T	T
5	P	P	P	P	P	P
6	E	E	E	E	E	E
8	K	K	K	K	K	N
9	S	S	S	S	N	G
10	A	A	A	A	A	H
12	T	T	T	T	T	T
13	A	A	A	A	A/T	S
16	G	G	G	G	G	G
20	V	V	V	V	V	V
21	D	D	D	D	D	E
22	E	E	E	E	E	K
33	V	V	V	V	L	V
43	E	E	E	E	E	E
50	T	T	T	T	S	S
52	D	D	D	D	D	D
54	V	V	V	V	V	I
56	G	G	G	G	G	G
69	G	G	G	G	G	S
70	A	A	A	A	A	A
72	S	S	S	S	S	S
73	D	D	D	D	D	E
75	L	L	L	L	L	L
76	A	A	A	A	N	H
87	T	T	T	Q	Q	Q
94	D	D	D	D	D	V
95	K	K	K	K	K	A
104	R	R	K	R	K	K
112	C	C	C	C	C	I

Table 5.7: (continued)

Amino Acid Position	Human	Chimpanzee	Gorilla	Gibbon	Rhesus Monkey	Lemur
116	H	H	H	H	H	H
120	K	K	K	K	K	N
121	E	E	E	E	E	D
123	T	T	T	T	T	S
125	P	P	P	Q	Q	Q
126	V	V	V	V	V	T
129	A	A	A	A	A	A
130	Y	Y	Y	Y	Y	F
135	A	A	A	A	A	T

Have students compare the amino acids of humans with those of the other species in the table. Explain that similarities in amino acid sequences indicate how species are related.

- **Ask:** Which species do you think is most closely related to humans? Why? (Chimpanzee; it has the same amino acid sequence as humans.)
- **Ask:** Which species do you think is least closely related to humans? Why? (Lemur; it has the greatest number of amino acids that are different from humans.)

Reinforce and Review

Asking Questions

Ask students to write a question about organic molecules. Collect the questions, and then have teams of students play a quiz game, in which they compete to answer the questions.

Lesson Worksheets

Copy and distribute the four Lesson 2.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 2.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 2.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- How do organic molecules form?
- How do smaller molecules join together to form larger molecules?
- What chemical processes are involved?

Lesson Assessment

- Have students complete the Lesson 2.2 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

5.4 Lesson 2.3: Chemical Reactions

Key Concepts

A chemical reaction changes reactants into products. There are several different types of chemical reactions, such as combustion reactions and synthesis reactions. Some chemical reactions consume energy while others release energy, but all chemical reactions require activation energy to get started. In organisms, enzymes speed up chemical reactions by reducing the amount of activation energy needed.

Lesson Objectives

- Describe what happens in a chemical reaction, and identify types of chemical reactions.
- Explain the role of energy in chemical reactions, and define activation energy.
- State factors that affect the rate of chemical reactions.
- Explain the importance of enzymes in organisms, and describe how enzymes work.

Lesson Vocabulary

Table 5.8:

Lesson 2.3 Vocabulary		
chemical reaction	reactant	product
combustion reaction	synthesis reaction	decomposition reaction
substitution reaction	exothermic reaction	catabolic reaction
endothermic reaction	anabolic reaction	activation energy
enzyme		

Check Your Understanding

Drawing on Student Experiences

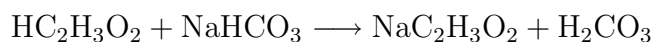
Ask the class to think about fireworks they have seen on the Fourth of July. Call on volunteers to describe the sights and sounds of the fireworks. Tell students that fireworks are caused by chemical reactions, which they will learn about in this lesson.

Teaching Strategies

Demonstration

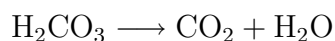
Demonstrate two types of chemical reactions that are described in the FlexBook: a substitution reaction and a decomposition reaction. Mix vinegar and baking soda in a large clear container while students watch. On the board, write the following chemical equation for the reaction:

vinegar + baking soda \longrightarrow sodium acetate + carbonic acid



- **Ask:** What type of reaction is this? (Substitution reaction.)
- Explain that carbonic acid is unstable and immediately breaks down to carbon dioxide and water. Write the formula for this second reaction on the board:

carbonic acid \longrightarrow carbon dioxide + water



- **Ask:** What type of reaction is this? (Decomposition reaction.)

- **Ask:** What causes the foaming and bubbling when vinegar and baking soda react? (The release of CO₂ gas.)

Use Visuals: Figure 2

Review **Figure 2** to make sure students understand the concept of activation energy. Explain that the energy above the horizontal line in the graph is the activation energy, which is needed to start the reaction. Compare activation energy to the push that starts a sled moving down a hill.

- **Ask:** What happens after the reaction in **Figure 2** gets started? (Energy is released.)
- **Ask:** What type of chemical reaction is this? (Exothermic reaction.)

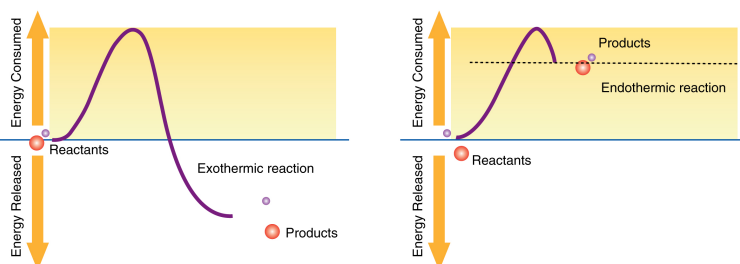


Figure 5.7: To start this reaction requires a certain amount of energy, called the activation energy. How much activation energy is required depends on the nature of the reaction and the conditions under which the reaction takes place.

Activity

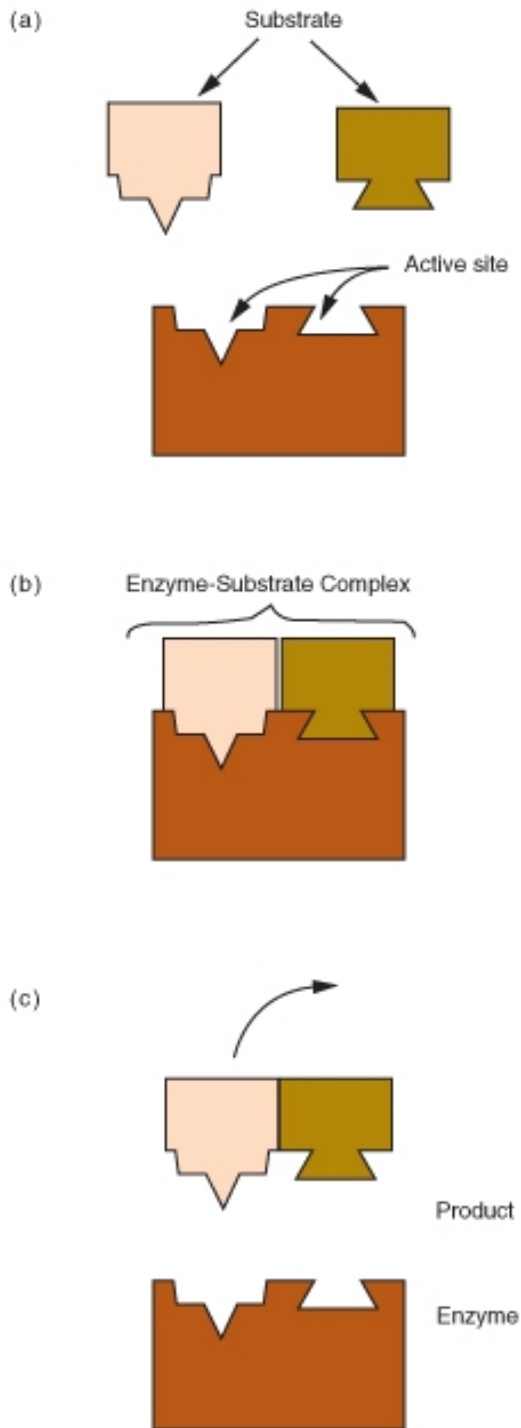
Have students do the interactive animation called *Catalysis* at the Web site below. They can use animated models and analogies to explore the role of enzymes in biochemical reactions.

<http://www.wiley.com/legacy/college/boyer/0470003790/animations/animations.htm>

Differentiated Instruction: Frayer Model

Ask students to draw a large box and divide it into four parts. Tell them to label the parts Definition, Drawing, Example, and Non Example. Then have them fill in each part of the box for the word enzyme, using information in the FlexBook. Suggest that they use **Figure 4** in their FlexBook as a model for their drawing. A completed sample is shown below. See The drawing in the sample is **Figure 4** (Source: CK-12 Foundation, License: CC-BY-SA). (**ELL**).

An enzyme is a chemical that speeds up chemical reactions in organisms.



Enrichment: Crossword Puzzle

Ask volunteers to make crossword puzzles, using the types of chemical reactions described in the lesson as words. They can make the puzzles by hand or use an online puzzle maker program (see URL below). Provide copies of the puzzles to other students, who can use them to check their knowledge of chemical reactions.

<http://puzzlemaker.discoveryeducation.com>

Science Inquiry

Building a Model

Challenge groups of students to make a model of an enzyme-substrate complex. This could be a three-dimensional model (using, for example, interlocking toy building bricks), or a series of labeled sketches. The model should show how enzymes bring reactants together so a reaction can take place. Ask each group to present its model to the class.

Reinforce and Review

Labeling a drawing

Make copies of **Figure 3** without the labels identifying the different energy levels. Use only the labels Energy Supplied, Energy Released, reactants, and products. Ask students to label the graphs to show the difference in activation energy needed to start the reaction with and without the enzyme.

Lesson Worksheets

Copy and distribute the four Lesson 2.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 2.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

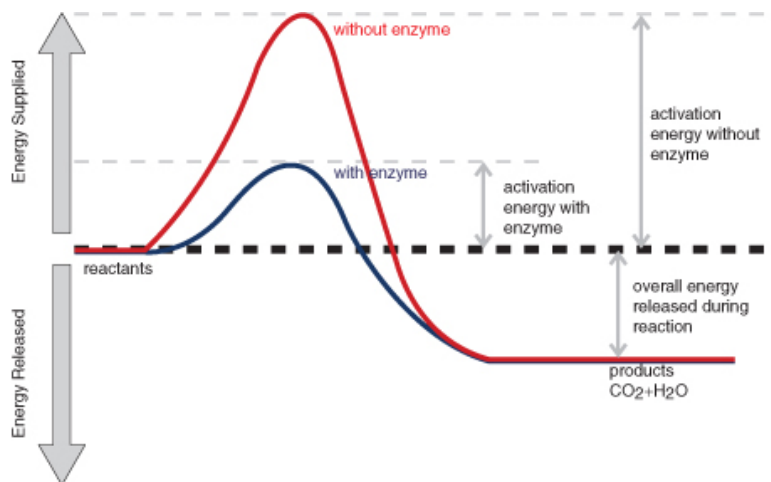


Figure 5.8: The reaction represented by this graph is a combustion reaction involving the reactants glucose and oxygen . The products of the reaction are carbon dioxide and water . Energy is also released during the reaction. The enzyme speeds up the reaction by lowering the activation energy needed for the reaction to start. Compare the activation energy with and without the enzyme.

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 2.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What do you know about water?
- Are you aware that water has unique properties?
- Do you know how water behaves differently from most other substances on Earth?
- Do you know why water is necessary for life?

Lesson Assessment

- Have students complete the Lesson 2.3 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

5.5 Lesson 2.4: Water

Key Concepts

Water is essential to all known forms of life. The polarity of water gives it unique properties that explain why it is vital for organisms. Water is a common solvent in solutions of acids and bases. It is also a solvent inside organisms and cells. It is involved in most life processes, including photosynthesis and cellular respiration.

Lesson Objectives

- Describe the distribution of Earth's water, and outline the water cycle.
- Identify the chemical structure of water, and explain how it relates to water's unique properties.
- Define solution, and describe water's role as a solvent.
- State how water is used to define acids and bases, and identify the pH ranges of acids and bases.
- Explain why water is essential for life processes.

Lesson Vocabulary

Table 5.9:

Lesson 2.4 Vocabulary		
evaporation	sublimation	transpiration
condensation	precipitation	polarity
hydrogen bond	solution	solute
solvent	solubility	ion
acidity	pH	acid
base	neutralization	metabolism

Check Your Understanding

Drawing on Student Experiences

Ask students to recall experiences in which water froze and expanded out of its container (e.g., ice cubes in a freezer tray, a can of pop left in a freezer, water freezing and cracking water pipes). Tell students that most other substances shrink when they freeze but water behaves differently because of its structure.

Teaching Strategies

Build Science Skills: Identifying Cause and Effect

Discuss the polarity of water molecules and why it causes hydrogen bonds to form between adjacent water molecules. Then work with the class to make a cause-and-effect diagram, like the one below, to show that polarity and hydrogen bonding cause water's unique properties. Call on students to explain how water's structure causes each of the properties in the diagram.

[insert diagram]

Activity

Have groups of students make two mixtures in beakers or test tubes: a 1:1 mixture of (brown) apple cider vinegar and water; and a 1:1 mixture of vegetable oil and water. Students should thoroughly mix the substances and then set the mixtures aside. Wait about 15 minutes and then have students:

- **Ask:** How do the two mixtures look? (The vinegar and water mixture has the same brown color throughout. In the other mixture, the oil is floating in a separate layer on top of the water.)
- **Ask:** Which substance is polar like water and which substance is nonpolar? How can you tell? (The vinegar is polar. You can tell because it remained mixed with the water. The oil is nonpolar. You can tell because it separated from the water.)

Demonstration

Use litmus paper to show students how to test for acids and bases. Use small samples of several of the common substances listed in the pH chart in **Figure 5** (see below). For example, you might test vinegar, orange juice, coffee, baking soda solution, ammonia, and bleach. For each substance, use both red and blue litmus paper and ask students to observe how the paper changes color.

- **Ask:** Which substances are acids? (Vinegar, orange juice, and coffee.)
- **Ask:** Which substances are bases? (Baking soda solution, ammonia, and bleach.)

Discussion

State that the pH scale in **Figure 5** is a negative logarithmic scale. Call on any students familiar with logarithms to help you explain what this means. As an example, discuss the

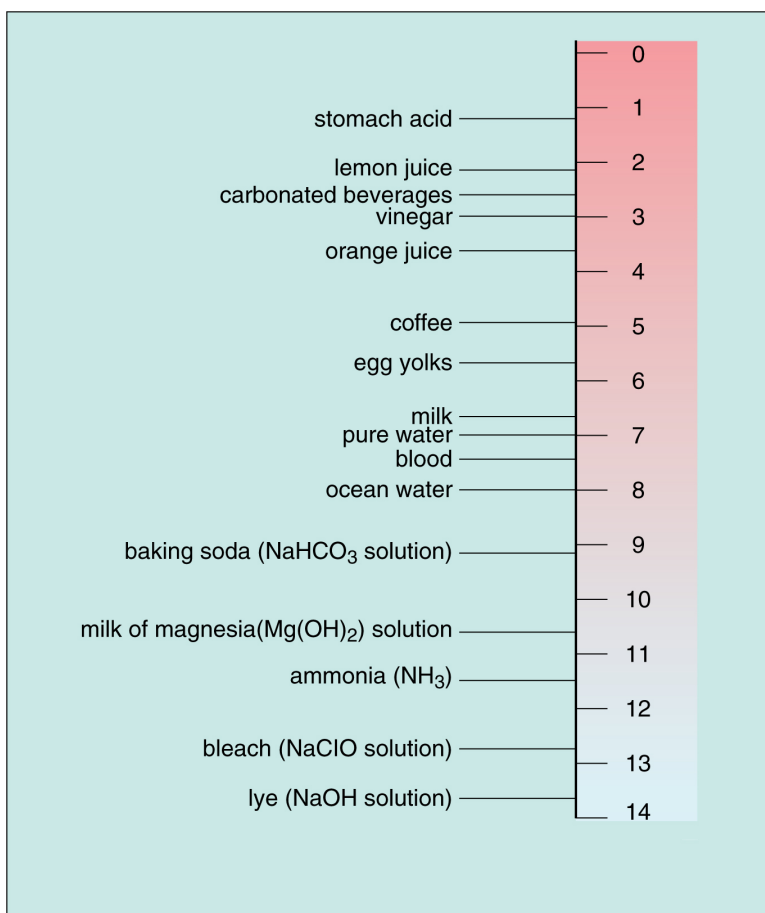


Figure 5.9: Acidity and the pH scale. Water has a pH of 7, so this is the point of neutrality on the pH scale. Acids have a pH less than 7, and bases have a pH greater than 7.

difference in acidity between pure water and vinegar. (Vinegar is 10,000 times more acidic than pure water.)

Differentiated Instruction: Compare/Contrast Table

Help students organize the information on acids and bases by having them make a compare/contrast table. A sample completed table is given below. You may want to give students a copy of the sample table with several cells left blank for them to fill in. Review completed tables with students, and ask them to point out the similarities and differences between acids and bases. Suggest that they keep their table in their science notebook. (LPR)

Table 5.10:

Acids	Bases
Hydrogen ion donors	Hydrogen ion acceptors
Higher H_3O^+ ion concentration than pure water	Lower H_3O^+ ion concentration than pure water
May be harmful to organisms and materials	May be harmful to organisms and materials
Taste sour	Taste bitter
May sting and burn skin	May feel slimy and burn skin
Turns blue litmus paper red	Turns red litmus paper blue
Examples include vinegar and lemon juice	Examples include ammonia and bleach

Enrichment: Demonstration

Challenge students to learn about the capillary action of water and why water has this property (hydrogen bonding). Then ask them to demonstrate and explain it to the class. In their demonstration, students might use a glass of water colored with a few drops of food coloring and either a paper towel or a celery stalk.

Science Inquiry

Developing a Research Plan

Have groups of students develop a research plan to determine which of two antacid tablets works better to neutralize acid. For materials, suggest that they use lemon juice, red and blue litmus paper, and two different brands of over-the-counter antacid tablets. Ask each group to present its plan to the rest of the class.

Reinforce and Review

Online Quiz

To reinforce students' knowledge of water's properties, have them complete the online quiz at the URL below. Alternatively, you might want to print and distribute the quiz for students to complete in class. Discuss any questions that they answer incorrectly.

http://www2.chccs.k12.nc.us/education/sctemp/12345/1247415807/Properties_of_Water_Warm-up.doc

Lesson Worksheets

Copy and distribute the four Lesson 2.4 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 2.4 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 2.4 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What do you think you would see if you could look inside a cell?
- What structures might you see?
- What processes might you observe?

Lesson Assessment

Copy and distribute the Lesson 2.4 quiz. Provide class time for students to complete the quiz.

5.6 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

- (1) *[CK-12 Foundation]*. CC-BY-SA.
- (2) http://en.wikipedia.org/wiki/Image:Water_molecule.svg. Creative Commons.
- (3) http://commons.wikimedia.org/wiki/Image:Stylised_Lithium_Atom.png.
Creative Commons.
- (4) <http://en.wikipedia.org/wiki/Image:Protein-primary-structure.png>. Public Domain.
- (5) http://upload.wikimedia.org/wikipedia/commons/4/46/PH_scale.png. GNU FDL.
- (6) <http://en.wikipedia.org/wiki/Image:Protein-structure.png>. Public Domain.
- (7) <http://commons.wikimedia.org/wiki/Image:Glucose.png>. Creative Commons.
- (8) <http://en.wikipedia.org/wiki/Image:AminoAcidball.svg>. Creative Commons.
- (9) http://en.wikipedia.org/wiki/Image:Activation2_updated.svg. GNU-FDL.

Chapter 6

TE Cell Structure and Function

6.1 Chapter 3: Cell Structure and Function

Outline

The chapter *Cell Structure and Function* consists of three lessons that describe fundamental cell structures and their functions.

- Lesson 3.1: Introduction to Cells
- Lesson 3.2: Cell Structures
- Lesson 3.3: Cell Transport and Homeostasis

Overview

- All living organisms are composed of cells. All cells contain a plasma membrane, cytoplasm, ribosomes, and a nucleus. These cell structures and others enable cells to reproduce and to interact with and respond to their environment.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 6.1:

Lesson	Number of Class Periods*
3.1 Introduction to Cells	1.0
3.2 Cell Structures	1.5
3.3 Cell Transport and Homeostasis	1.5

- Class periods are assumed to be 60 minutes long.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 6.2:

Lesson	Strategy or Activity	Materials Needed
3.1 Introduction to Cells	Enrichment	graph paper
3.2 Cell Structures	Enrichment	Index cards, drawing easel, whiteboard or blackboard and corresponding writing implements, timer
3.3 Cell Transport and Homeostasis	Demonstration	one small white potato, two 250 ml beakers, balance, paper towel, water-resistant marking pen, 75 ml distilled water, 75 ml of a 15% sodium chloride solution, knife or razor blade for cutting the potato

Lab Links

The following labs are suitable for this chapter and are available online:

- Microscope Mystery: In this hands-on laboratory unit, students will work both independently and cooperatively to learn how to use a light microscope and to analyze evidence from a forensic mystery. (Lesson 3.1) http://www.accessexcellence.org/AE/AEC/AEF/1994/haugen_microscope.php
- Osmosis: In this laboratory unit, students will prepare wet-mount slides of the aquatic

plant *Elodea* and view them under the light microscope. They also investigate the effects of solutions of different concentrations on the shape and size of the plant cell. The website includes teaching tips and evaluation keys. Living *Elodea* can be purchased from Carolina Biological (<http://www.carolina.com/>). (Lesson 3.3) <http://biology.arizona.edu/sciconn/lessons/mccandless/elodea.html>

Common Misconceptions

Diffusion and Osmosis

Students often hold misconceptions about diffusion and osmosis. (Cell Biol Educ 4(3): 235-248 2005 DOI: 10.1187/cbe.04-09-0049; web access is at <http://www.lifescied.org/cgi/content/full/4/3/235>).

The following two points clarify some commonly misunderstood characteristics of diffusion and osmosis. 1) At the molecular level, movement of individual molecules is random. It is not directed even when a concentration gradient exists. 2) Individual molecules still move even when there is no concentration gradient. As shown in Figure 3, Lesson 3.3, equilibrium is dynamic. Oxygen molecules cross the membrane even when the concentration of oxygen on both sides of the membrane is equal. There is no net movement and the net concentration stays the same across the membrane at equilibrium.

Passive Transport

Students may think that all protein-mediated transport must be active transport. This is not true. Emphasize to your students that passive transport is transport “down” a concentration gradient and may occur directly through the lipid bilayer (as for gases such as O₂ and CO₂), or with the aid of a protein (such as for glucose). Transport is not active unless energy is required (either in the form of ATP or an ion gradient).

Other Web Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- Searchable Cell Biology textbook: This college-level textbook, by Geoffrey Cooper of Boston University, is searchable according to topic. If the teacher or an advanced student wants to pursue further study of a topic, they can search the book for subjects. All of the book sections that address the search term will appear on the results page as hyperlinks. Moreover, teachers and students can widen the search to all books, and to PubMed. <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowTOC#38;rid=cooper.TOC#38;depth=10>

- Cell Biology Animations: This animation brings motion to diffusion, a frequently misunderstood concept. There are many other animations on John Kyrk's site. <http://www.johnkyrk.com/diffusion.html>
- Cell Organelles and Microscopy: This web page, on the National Institute of General Medical Sciences website, provides a detailed narrative and ample illustrations of cell organelles. There is also up-to-date information on cutting-edge microscopy techniques and some stunning micrographs. <http://publications.nigms.nih.gov/insidethecell/chapter1.html#a15>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include *Cell Structure and Function*, or specific lessons in *Cell Structure and Function*, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of *Cell Structure and Function*, students should have read the *Foundations of Life Science* chapter.
- Students should read *Cell Structure and Function* before reading the remaining chapters of the FlexBook.
- It is recommended that you include all the lessons of *Cell Structure and Function* in the FlexBook.

6.2 Lesson 3.1: Introduction to Cells

Key Concepts

The cell is the basic unit of structure and function of all living things. Many cells can be seen only with the aid of a microscope. Cells are small because they need a large surface area to volume ratio, to facilitate rapid transport of gases, nutrients, and wastes across the cell membrane. Biologists commonly classify cells into two groups: those that have a nucleus (eukaryotes) and those that lack a nucleus (prokaryotes).

Lesson Objectives

- Identify the scientists that first observed cells.
- Outline the importance of microscopes in the discovery of cells.
- Summarize what the cell theory proposes.

- Identify the limitations on cell size.
- Identify the three parts common to all cells.
- Compare prokaryotic and eukaryotic cells.

Lesson Vocabulary

Table 6.3:

Lesson 3.1 Vocabulary		
resolution	cell membrane	cytoplasm
organelle	ribosome	prokaryote
eukaryote	nucleus	

Check Your Understanding

Recalling Prior Knowledge

The Dutch microscopist, Anton van Leeuwenhoek, not only made careful observations about what he saw with his light microscopes, but he wrote about what he saw in report form. Ask your students to recall a time when they not only observed an object or event, but also wrote about it. Ask them, “How did writing about what you saw enhance your understanding and/or recall of the object or event?”

Teaching Strategies

Use Visuals: Figure 3

The left panel of **Figure 3** shows a microscopic rotifer, which is a pseudocoelomate animal (for more information on pseudocoelomates, see **Figure 3**, Lesson 3 in the *Simple Invertebrates: Sponges, Cnidarians, and Worms* chapter). Note the scale bar of 100 μm . Discuss with the students how scale bars are needed in order to determine the actual size of an organism or organelle in a micrograph, since photos can be taken at a variety of different magnifications. (Refer back to **Table 2**, SI prefixes, Lesson 1.3, *Foundations of Life Science* chapter.)

Building Science Skills: Classifying

Discuss with your students how they could decide if a mystery cell was a prokaryote or a eukaryote. Have students list what cellular structures they would search for in the mystery



Figure 6.1: Rotifers, similar to the type that Leeuwenhoek saw under his microscope.

cell, and have them explain how the presence or absence of such structures would enable them to determine if the mystery cell was a prokaryote or a eukaryote.

Differentiated Instruction: Measurements

Pair ELL with native speakers. Give each pair a ruler. Measure the width of: a human hair, the tip of a sharpened pencil. Compare both to the diameter of a large cell of $100\mu\text{m}$ (0.1 mm) in diameter. Students may need to estimate the measurements using the metric scale of the ruler. **ELL**

Enrichment: Crossword Puzzle

Students can work in pairs or individually for this activity. Instruct your students to create a crossword puzzle with the theme “Structures of Cells.” The clues will be descriptions of a cellular structure or organelle, and the answers will be the described cellular structure or organelle. Each group will give their crossword puzzle to the class, which will complete it. Conclude this activity with a brief class discussion. Ask the students if they feel more prepared for a quiz on cellular structures now that they have made one crossword puzzle and completed others.

Science Inquiry

Problem Solving

Students can solve the following problem by working individually or in groups.

Consider a plant cell that is roughly cylindrical and has a height of $20\mu\text{m}$ and a diameter of

$10\mu\text{m}$. Calculate the volume of the plant cell.

After you present this problem, ask the students what tools they need to solve it and where to get these tools. (They need the formula for a cylinder, which they can get from a geometry textbook, or online, or from their teacher.)

Answer: The formula for the area of a cylinder is $\pi r^2 h$. Use $\frac{22}{7}$ (or 3.14) as an approximation for π . The radius is $5\mu\text{m}$ ($\frac{1}{2}$ of the diameter) and the height is $20\mu\text{m}$. Thus, the volume of the plant cell is $\pi \times (5\mu\text{m})^2 \times 20\mu\text{m}$, which equals $1570\mu\text{m}^3$.

Reinforce and Review

Labeling a Drawing

Hand out unlabeled versions of **Figure 9**: A eukaryotic cell. Have each student label the cell structures marked by lines. Each student can correct his or her drawing labels from a labeled version of **Figure 9** (either provided by the teacher or by the students accessing the FlexBook).

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Lesson Worksheets

Copy and distribute the four Lesson 3.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 3.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 3.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What do you think is the most important structure in a cell? Why?
- How do you think cells stay intact? What keeps the insides of a cell separate from the outside of the cell?

Lesson Assessment

- Copy and distribute the Lesson 3.1 quiz. Provide class time for students to complete the quiz.
- An Answer Key will be provided upon request.

6.3 Lesson 3.2: Cell Structures

Key Concepts

All cells share a few common functions: obtaining energy from their environment for metabolic activities, monitoring and responding appropriately to their environment and environmental changes, and growing and dividing. All cells share some common structures that enable them to perform these functions: a plasma membrane, cytoplasm, and genetic material (DNA). The selectively permeable (or semipermeable) plasma membrane, which is composed chiefly of a phospholipid bilayer with embedded proteins, separates the cell from its environment. The cytoplasm contains the aqueous cytosol, in which are the cell's organelles. Each organelle has a specific structure that has evolved to optimize its function. Cells also contain a filamentous protein cytoskeleton, which has several functions, such as maintaining cell shape, transport within the cell, and cell movement. Plant cells contain three additional structures lacking in animal cells: the cell wall, the central vacuole, and plastids. The organization of cells differs in different organisms and can be single-celled, colonial, or multicellular.

Lesson Objectives

- Outline the structure of the plasma membrane.
- Distinguish cytoplasm from cytosol.

- Name three types of protein fibers that make up the cytoskeleton.
- Distinguish between cilia and flagella.
- Identify three structures that plant cells have but animal cells do not.
- List three major organelles found only in eukaryotic cells and identify their roles.
- Distinguish between a colonial organism and a multicellular organism.
- Outline the relationship between cells, tissues, organs, and organ systems.

Lesson Vocabulary

Table 6.4:

Lesson 3.2 Vocabulary		
selective permeability	semipermeability	lipid bilayer
phospholipid bilayer	membrane protein	integral membrane proteins
peripheral membrane proteins	cytoplasm	cytosol
cytoskeleton	microtubules	microfilaments
intermediate filaments	flagella	cilia
gene	chromosomes	gene expression
nuclear envelope	nucleolus	ribosomes
centrioles	mitochondrion	endoplasmic reticulum (ER)
rough endoplasmic reticulum	smooth endoplasmic reticulum	Golgi apparatus
vesicles	transport vesicles	lysosomes
peroxisomes	vacuoles	cell wall
central vacuole	chloroplasts	chromoplasts
leucoplasts	stroma	thylakoids
grana	biofilm	Colonial Theory
multicellular organisms	tissue	organ
organ system		

Check Your Understanding

Recalling Prior Knowledge

Ask students to volunteer what they already know about cellular structures from the previous lesson or from other classes or enrichment activities they might have had. Turn this into a class discussion and compile a list on the board.

Teaching Strategies

Activity

Have students test their knowledge of animal and plant cell structures by completing the interactive animation at the Cells Alive website: (http://www.cellsalive.com/cells/cell_model.htm).

Have students work with a partner and name the organelle before checking their answers through the animation.

Use Visuals: Figure 4

Figure 4, Lesson 3.2 shows three examples of where the cytoskeleton is located in three different cells. This figure is a great example of how scientists use fluorescent probes to detect specific molecules. **Ask** your students: “In **Figure 4c**, why does the fluorescent probe bind only to microtubules?” The answer is that the fluorescent probe (often itself bound to an anti-immunoglobulin antibody) detects and binds to an antibody that binds specifically to microtubules. So the picture is truly showing actual microtubules. (You may need to explain this further, as this is only a beginning chapter.) Additional information on immunofluorescence microscopy is at <http://www.antibodystation.com/immunofluorescence-microscopy/>

Additional information on antibodies is in the *Immune System and Disease* chapter.

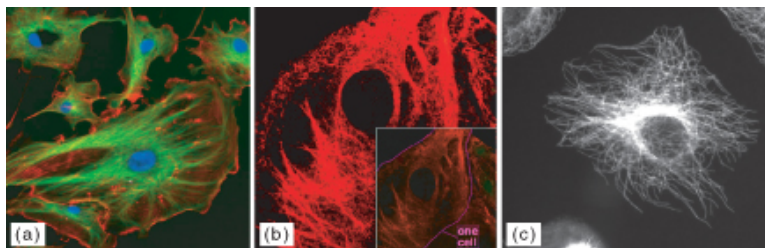


Figure 6.2: The eukaryotic cytoskeleton. Microfilaments are shown in red, microtubules in green, and the nuclei are in blue. By linking regions of the cell together, the cytoskeleton helps support the shape of the cell. Microscopy of keratin filaments (intermediate filaments) inside cells. Microtubules in a methanol-fixated cell, visualized with anti-beta-tubuline antibodies.

Discussion: The Secretory Pathway

Students may have trouble visualizing the purpose of the secretory pathway. A specific example (insulin synthesis and secretion) highlights the functioning of this pathway.

Insulin is a polypeptide hormone that is produced by pancreatic β cells. Insulin regulates the uptake of glucose from the blood into cells such as muscle and adipose cells. People who cannot make insulin have Type I Diabetes and must get their insulin from medicine.

Insulin mRNA is transcribed from the insulin gene in the nucleus and is transported through the nuclear pores into the cytoplasm. There the insulin mRNA is translated into protein by ribosomes that attach to the rough endoplasmic reticulum (RER). (Explain that this process, protein synthesis, will be discussed in a future chapter (Lesson 2 of the *Molecular Genetics* chapter.)) This is the beginning of the secretory pathway. The resulting insulin polypeptide undergoes certain chemical modifications in the RER and then is transported to the Golgi apparatus in transport vesicles. In the Golgi apparatus, the insulin is sorted and packaged into a specific class of secretory vesicles called secretory granules. These secretory granules chemically process insulin to its final form and store the insulin until it is needed.

When the pancreatic β cells receive an extracellular signal, the secretory granules fuse with the plasma membrane and insulin is released into the bloodstream and circulates throughout the body. (This process, exocytosis, will be discussed in the next lesson.) Insulin binds to a receptor protein on target cells, such as muscle and adipose cells. Insulin binding stimulates uptake of glucose from the blood into the target cells. In these cells, the glucose can then be used as an energy source for cellular respiration. (Cellular respiration is a conserved pathway for the production of ATP and requires oxygen; see *Cellular Respiration* chapter.) In summary, the secretory pathway transports macromolecules, such as proteins, from their sites of synthesis to their final destinations.

- References

Becker, W. Kleinsmith, L. Hardin, J. and Bertoni, G. 2009. *The World of the Cell*. Seventh Edition. San Francisco: Pearson Benjamin Cummings. <http://www.ncbi.nlm.nih.gov/pubmed/8792089>

Differentiated Instruction: Frayer Model

Students can work in groups of two for this exercise. Pair LPR readers with more proficient readers. This vocabulary strategy involves students drawing a large box and dividing it into four parts labeled Definition, Drawing, Example, and Non-example. Next, assign students a vocabulary word and tell them to fill in the parts of the box for that word. Choose a set of vocabulary words from the list above titled *Lesson Vocabulary*. **LPR**

Definition

Definition a membrane-bound organelle that is key to maintaining turgor pressure in plants

drawing

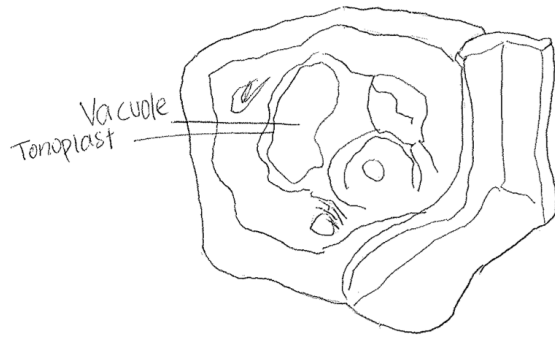


Figure 6.3

Example the central vacuole in plants

Nonexample lysosome

Enrichment: Cell Structures: Charades with Drawing

This game will help students review and recall cell structures and cell organization. It is reminiscent of the game Pictionary.

Prepare a stack of index cards, each of which should list one of the vocabulary terms from Lesson 2. Place the cards in a pile, with the terms facing down. Divide the class into two teams. One team goes first. One student from Team #1 randomly draws an index card and looks at the term. The student then has to draw pictures that give clues about what is the term on the card. The student may point and gesture as well. Other members of that student's team guess what is the term. They have sixty seconds to play (use a kitchen timer to keep track). If the team guesses correctly, they earn a point. At the end of the minute, the first team's turn is over and it is the second team's turn. The game is over when one team accumulates ten points. No textbooks allowed.

Science Inquiry

Developing a Research Plan

Figure 5 is a table of the characteristics of the three types of eukaryotic cytoskeleton. One row shows the main functions of microtubules, intermediate filaments, and microfilaments

(actin filaments). Have students develop a simple research plan to test the hypothesis that microfilaments organize cell shape. Focus on which variables should be controlled and how to control them. List what the expected results would be if the hypothesis were 1) supported or 2) refuted. Discuss as a class how scientists might have figured out what were the functions of each cytoskeletal type.

Teachers Note: This exercise also provides the opportunity to revisit and reinforce concepts in the *Foundations of Life Science* chapter, Lesson 1.

(One idea: Inhibit microfilaments with a drug. Label microfilaments (as in **Figure 4**) and view cells with a microscope. Look for differences in cell shape in the control (no drug added) and the experimental treatment (drug added). A change in shape in the plus drug cells compared to the control cells would support the hypothesis; no change would not support the hypothesis. Name of the drug is not necessary.)

Reinforce and Review

Label a Drawing

Provide students with an unlabeled drawing of a typical plant cell (see below). Individual students or pairs of students add the labels. When done, they trade their labeled drawing with another group and look for any inconsistencies in labeling.

[Insert figures here]

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Lesson Worksheets

Copy and distribute the four Lesson 3.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 3.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 3.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- How do you think small molecules, or even water, get through the cell membrane?
- Is it possible that proteins help in this transport process?
- What type of proteins would help with transport?

Lesson Assessment

- Copy and distribute the Lesson 3.2 quiz. Provide class time for students to complete the quiz.
- An Answer Key will be provided upon request.

6.4 Lesson 3.3: Cell Transport and Homeostasis

Key Concepts

At the molecular level, both diffusion and osmosis are random processes that result in a net increase in entropy. (Entropy measures disorder in a system such as a group of molecules.) In a solution, diffusion results in a net redistribution of molecules from an area of higher concentration into an area of lower concentration. At dynamic equilibrium, the molecules will be equally distributed throughout the solution. Osmosis is the diffusion of water through a semipermeable membrane. Molecules that cannot diffuse directly across a cell membrane can cross the membrane with the aid of either channel proteins or transport proteins. Active transport requires energy, whereas passive transport does not. Vesicle-mediated transport, such as endocytosis and exocytosis, is another mode of transport and is active. Cells have receptors that receive extracellular signals. Cells have evolved intracellular pathways to respond appropriately to those signals.

Lesson Objectives

- Identify two ways that molecules and ions cross the plasma membrane.
- Distinguish between diffusion and osmosis.
- Identify the role of ion channels in facilitated diffusion.
- Compare passive and active transport.
- Identify the connection between vesicles and active transport.
- Compare endocytosis and exocytosis.
- Outline the process of cell communication.

Lesson Vocabulary

Table 6.5:

Lesson 3.3 Vocabulary		
selectively permeable	semipermeable	passive transport
diffusion	concentration gradient	equilibrium
hypertonic	hypotonic	isotonic
osmosis	contractile vacuole	facilitated diffusion
transport protein	channel protein	gated channel protein
carrier protein	active transport	sodium potassium pump
endocytosis	exocytosis	phagocytosis
homeostasis	ligand	G-protein linked receptor
second messenger	signal pathway	transduction

Check Your Understanding

Recalling Prior Knowledge

Ask students what they already have learned about membranes. **Ask:** “What characteristics do membranes have? How could these structural characteristics effect the functioning of membranes?” These questions will serve as a bridge between Lesson 3.2 and Lesson 3.3. Give students about five minutes to write answers into the science notebooks. Ask for answers.

Teaching Strategies

Demonstration

The following demonstration is designed to illustrate the concepts of osmosis and tonicity. Cut two slices of approximately the same shape and size from a potato. (Cut the slices so that they will easily fit into the bottom of a 250ml beaker.) Record their initial masses on a scale. Place one slice into a labeled 250ml beaker that contains 75ml distilled water. Place the other slice into a labeled 250ml beaker containing 75ml of a 15% sodium chloride solution. Let the potatoes sit for 20 minutes. During this time, ask the students questions such as those listed below:

1. What is osmosis?
2. What is a hypotonic solution? Isotonic? Hypertonic?
3. Which beaker contains the control for the experiment?
4. After 20 minutes in their respective solutions, do you think that the mass of either potato slice will change? If so, how?

At the end of 20 minutes, remove the slices from the beakers. Blot very gently and briefly on the paper towel to remove external water. Record the masses of both slices. Discuss the actual and predicted results.

[The potato slice incubated in 15% salt solution will lose water by osmosis and will weigh less at the end of 20 minutes]

This demonstration could be expanded into a hands-on student laboratory. Refer to the reference below. http://t4.jordan.k12.ut.us/teacher_resources/Science/modelclassroomroot/biologycalendars/0203.html

Using Visuals: Figure 9

Figure 9 shows exocytosis at a synaptic junction. Reviewing this figure with your students will reinforce their understanding of the concepts of vesicles, regulated secretion, ligands (remind students that the word ligand is one of the vocabulary words in this lesson), receptor proteins and cell-cell communication.

Make photocopies of the figure for groups of 2-4 students. Ask the students to label as many of the structures in the figure as they can. When the groups are done, discuss as a class the function of nerve cells [cell-cell communication, specifically transmission of nervous impulses, refer to *Nervous and Endocrine Systems* chapter] and how specific molecules/structures of nerve cells (neurotransmitters and receptors) enable the nerve cells to accomplish their function.

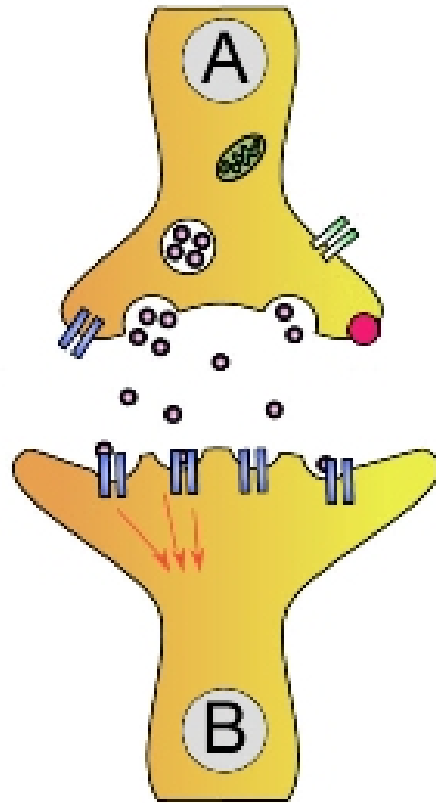


Figure 6.4: Mode of exocytosis at a synaptic junction, where two nerve cells meet. Chemical signal molecules are released from nerve cell A by exocytosis, and move toward receptors in nerve cell B. Exocytosis is an important part in cell signaling.

Differentiated Instruction: Compare/Contrast Table

Instruct the students to make a table that compares and contrasts active transport and passive transport across biological membranes. For this activity, students can work in pairs. Teachers can pair SN, ELL, and LPR students with appropriate partners; one partner should write down the group's results in a table, and the other can present the results to the class. Choose several pairs of students to present their results to the class. **ELL LPR SN**

A sample table is below:

Table 6.6:

Type of Transport	Energy Required?	Protein required?	Re-	Result
Passive	No	Sometimes; depends upon the size and charge of the molecule being transported.	de-	Movement of molecules down their concentration gradients.
Active	Yes	Yes		Movement of molecules up their concentration gradients.

Enrichment: Research

Many topics in cell biology come to life when students can relate them to personal experiences or to human health. The cell biology and medical aspects of cystic fibrosis (mentioned in the *Sodium-Potassium Pump* section of Lesson 3) are quite interesting to students because they directly link a cell biology topic (chloride channels) to a human disease (cystic fibrosis). The website of the Cystic Fibrosis Foundation (<http://www.cff.org/AboutCF/Faqs/>) provides an appropriate and global introduction of cystic fibrosis to high school students.

For this enrichment activity, students who need additional challenges can pick one of the bulleted questions (and its answer) to read, such as “How does CF affect the lungs?” They then can prepare and deliver a mini-oral presentation that addresses the question. In doing this project, students will get a jump ahead on the topics of Mendelian and Molecular Genetics, since cystic fibrosis is an autosomal recessive disease.

Science Inquiry

Asking a Question

Teachers can do this activity as a demonstration or as part of a student laboratory lesson.

- The Question: Does dissolving a solute (sugar) have an effect on the final volume of a solute in which it is dissolved?
- Control: Place 80ml water in a 100 ml graduated cylinder. Record the volume. (80ml)
- Treatment A: Dissolve 5g sugar in 80ml water in a 250ml beaker. Use a stirring rod to speed up the process. When the sugar is dissolved, transfer the solution to a 100 ml graduated cylinder and record the volume.

_____ ml

- Treatment B: Dissolve 20g sugar in 80ml water in a 250ml beaker; use a stirring rod to speed up the process. When the sugar is dissolved, transfer the solution to a 100ml graduated cylinder and record the volume.

_____ ml

The dissolved sugar will increase the volume to over 80ml in both the solutions; discuss with your class why this might be.

Reinforce and Review

Asking Questions

Request that each student turn in a question they have about lesson content on an index card or scrap of paper. Read the question and then answer the most frequently asked questions, or questions you believe will benefit the class.

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Lesson Worksheets

Copy and distribute the four Lesson 3.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 3.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 3.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What is photosynthesis?
- Where do plants get the “food” they need?
- Where does most of the energy come from?

Lesson Assessment

- Copy and distribute the Lesson 3.3 quiz. Provide class time for students to complete the quiz.
- An Answer Key will be provided upon request.

6.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

- (1) .
- (2) .
- (3) . CC-BY-SA.
- (4) .

Chapter 7

TE Photosynthesis

7.1 Chapter 4: Photosynthesis

Outline

The chapter *Photosynthesis* consists of two lessons. The first describes how autotrophs and heterotrophs obtain energy from their environment, and then summarizes the overall reaction of photosynthesis. The second outlines the two sets of reactions that make up the process of photosynthesis, the Light reactions and the Calvin Cycle.

- Lesson 4.1: Energy for Life: An Overview of Photosynthesis
- Lesson 4.2: Into the Chloroplast: How Photosynthesis Works

Overview

- Living organisms obtain chemical energy in one of two ways. Autotrophs build their own carbon-containing molecules, whereas heterotrophs must ingest fixed carbon-containing molecules from their environment. Photosynthesis, the process by which carbon dioxide from the air is fixed into organic molecules, produces over 99% of food for living organisms. Two series of reactions, the Light-Dependent reactions and the Calvin Cycle (also known as the Light-Independent reactions) comprise photosynthesis.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 7.1:

Lesson	Number of Class Periods*
4.1 Energy for Life: An Overview of Photosynthesis	1.0
4.2 Into the Chloroplast: How Photosynthesis Works	2.0

- Class periods are assumed to be 60 minutes long.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 7.2:

Lesson	Strategy or Activity	Materials Needed
4.2	<ol style="list-style-type: none">1. Demonstration: Pigment Chromatography2. Analyzing Data	<ol style="list-style-type: none">1. Green leaves, 25-cent coin, chromatography paper (Whatman 3 MM paper from http://www.whatman.com/BlottingPapers.aspx), solvent: 9 parts petroleum ether/1 part acetone (vol./vol.)(5 mls/sample). Lighter fluid is petroleum ether. 50 ml beaker, glass Petri dish to cover beaker, petroleum jelly to seal cover to beaker2. graph paper

Table 7.2: (continued)

Lesson	Strategy or Activity	Materials Needed
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Lab Links

The following labs are suitable for Photosynthesis and are available online:

- This laboratory unit, hosted on the Access Excellence website, is an inquiry-driven laboratory. It focuses on the effects that an autotroph (Elodea) and a heterotroph (Snail) have, independently and together, on the amount of CO₂ in a closed system. Students can test one of several hypotheses. This activity requires time over 2-3 days, but observations potentially can be extended through the entire school year. (Lesson 1) http://www.accessexcellence.com/AE/AEC/AEF/1996/linhares_lab.php
- This web page contains instructions for a simple protocol to separate plant pigments by chromatography. It is the second experiment on the web page, so you will need to scroll down to see it. (Lesson 2) <http://www.science-projects.com/PhotosynthPigments.htm>

Common Misconceptions

Misconceptions about ATP

ATP is often referred to as a high energy molecule with high energy phosphate bonds. In fact, both glucose and fatty acids are higher energy molecules than is ATP. Instead of thinking about ATP as having high energy phosphate bonds, it is more accurate to refer to ATP as a phosphate donor—one that donates a phosphate molecule to an acceptor molecule. The terminal phosphate of ATP is covalently attached to the acceptor molecule (one example is the sodium-potassium pump) is which then changes conformation and often activity. References: Richard D. Storey, Textbook Errors & Misconceptions in Biology: Cell Energetics, The American Biology Teacher, Vol. 54, No. 3 (Mar., 1992), pp. 161-166. Scott Freeman, Biological Science, 3rd edition, pp. 114-115.

Misconceptions about Photosynthesis

The following two websites should be required reading for all biology teachers. They list common misconceptions about photosynthesis and then provide the correct information.

<http://www.actionbioscience.org/education/hershey.html>

http://en.wikibooks.org/wiki/Transwiki:Photosynthesis_misconceptions

Other Web Resources

You may find these additional Web-based resources helpful when teaching photosynthesis:

- Interactive animations and a good review of plant cell structure and function distinguish this website. The focus is on the Light Reactions of photosynthesis. Descriptive audio accompanies the visuals. <http://www.cnr.vt.edu/DENDRO/forestbiology/photosynthesis.swf>
- Simple animations illustrate the major reactions and main components of the Calvin Cycle. A running tally of ATP and NADPH is kept. <http://www.science.smith.edu/departments/Biology/Bio231/calvin.html>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include *Photosynthesis*, or specific lessons in *Photosynthesis*, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of *Photosynthesis*, students should have read *Chemical Basis of Life* and *Cell Structure and Function* chapters.
- It is recommended that you include all the lessons of *Photosynthesis* in the FlexBook.

7.2 Lesson 4.1: Energy for Life: An Overview of Photosynthesis

Key Concepts

Chemical energy powers life. In living organisms, important energy-carrying molecules include ATP, NADPH, glucose, and fat. Some organisms can make their own food (autotrophs), while others must ingest or absorb food made by the autotrophs (heterotrophs). Photosynthesis, the process by which light energy is converted to chemical energy, is important to all living organisms, including humans.

Lesson Objectives

- Identify the kind of energy that powers life.

- Contrast the behavior of energy to that of materials in living systems.
- Analyze the way in which autotrophs obtain energy and evaluate the importance of autotrophs to energy for all life.
- Explain the relationship between autotrophs and heterotrophs.
- Discuss the importance of glucose to all life on earth.
- Compare the energy-carrying role of ATP to that of glucose.
- Explain the roles of chlorophyll and NADPH as sources of energy for life.
- Summarize the process of photosynthesis and write out the overall chemical equation for photosynthesis.
- Identify reactants, necessary conditions, and products in the chemical equation for photosynthesis.
- Describe the roles of chlorophyll and chloroplasts in photosynthesis.
- Identify the groups of organisms that are capable of photosynthesis.
- Discuss the many reasons photosynthesis is important to humans.

Lesson Vocabulary

Table 7.3:

Lesson 4.1 Vocabulary		
energy	chemical energy	autotrophs
food	photosynthesis	producers
food chain	heterotrophs	consumers
organic molecules	inorganic molecules	chemosynthesis
chlorophyll	glucose	ATP
enzymes	chloroplasts	

Check Your Understanding

Recalling Prior Knowledge

Teachers, **ask** your students the following questions: “What did you learn about chloroplasts from the *Cell Structure and Function* chapter”?

(Students may offer that chloroplasts are large organelles in photosynthetic eukaryotes, chloroplasts are the site of photosynthesis, or chloroplasts are green.)

Ask: “What unanswered questions do you have about photosynthesis?”

(Students may ask “How do plants actually use light? Can plants get too much light? Can they get sunburned?”)

Teaching Strategies

Building Science Skills: Classifying

Remind students of the diversity of life. Next, have the class brainstorm a list of all kinds of living things. The list could include names of specific species (e.g. *Homo sapiens*), or more general names (mushrooms). After making the list, students can classify all organisms in the list as autotrophs or heterotrophs and state why each organism belongs in a particular group. Students can check their answers using the FlexBook.

Using Visuals: Figure 1

Figure 1: Photosynthetic Autotrophs shows three examples of autotrophs: a) a redwood tree, b) algae, and c) bacteria. When given the definition of autotrophs, many students will think of plants and not much else. Use the examples in panels b) and c) to reinforce the concept of an autotroph, which is an organism that uses either light energy or chemical energy to transform inorganic nutrients into organic compounds.

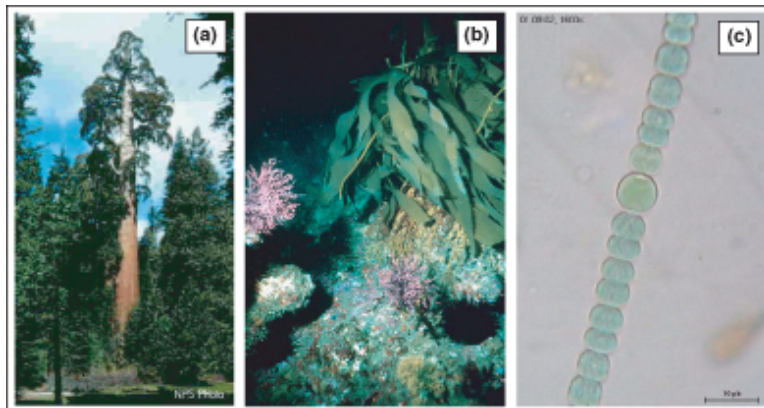


Figure 7.1: Photosynthetic autotrophs, which make food for more than 99% of the organisms on earth, include only three groups of organisms: plants such as the redwood tree (a), algae such as kelp (b), and certain bacteria like this (c).

Differentiated Instruction: KWL

Students can create a KWL chart. The chart has three columns: K= Know, W = Want to Know, and L = Learned. Before reading this lesson, students complete the K and W columns. After reading the lesson, they complete the L column. **ELL LPR SN**

Enrichment: Research

Chemoautotrophs are a fascinating group of organisms, yet under-studied at the high school level. Direct your students to use available resources (the school library, local library, or the Internet) to learn about a chemosynthetic organism. The chemosynthetic bacteria that live in hydrothermal vents (briefly described in this lesson) are one interesting example. Students can present their findings as a PowerPoint presentation, or as a written report. Students can get started with their research by visiting the website <http://www.astro.wisc.edu/~townsend/static.php?ref=diploma-6>

Science Inquiry

Formulating A Hypothesis

This exercise gives students the chance to think of hypothetical experiments designed to test a hypothesis. Teachers should first review experimental design and the importance of controls (see the *Foundations of Life Science* chapter, Lesson 1).

An example hypothesis is: Chlorophyll is a required pigment for photosynthesis. Ask the students to describe data that would 1) support the hypothesis or 2) disprove the hypothesis.

(The hypothesis is true. Data that supports the hypothesis include the absence of chlorophyll-less photosynthetic organisms. Data that would refute the hypothesis would be the discovery of an organism that could carry out photosynthesis but had no chlorophyll.)

Reinforce and Review

Outlining the Lesson

You or a student(s) can outline the main concepts of the lesson on the blackboard or whiteboard. Use the headings in the SE as a guide, adding additional information that is beneficial to the class.

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Lesson Worksheets

Copy and distribute the four Lesson 4.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 4.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 4.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Why do some people describe photosynthesis by plants as “making food from thin air?”
- Before we conclude this analysis of “the most important chemical reaction for life on Earth,” solidify your understanding of its importance by returning to the pizza, campfires, dolphins, automobiles, and glaciers. Can you connect them all to the chemical equation for photosynthesis?
- You’ll be able to make more connections after studying the next chapter on cellular respiration. Can you already connect carbon dioxide and oxygen to automobiles?

Lesson Assessment: Lesson 4.1 Quiz

- Have students complete the Lesson 4.1 Quiz. The Answer Key is available upon request.

7.3 Lesson 4.2: Into the Chloroplast: How Photosynthesis Works

Key Concepts

Lesson Objectives

- Understand that hundreds of years of scientific exploration have contributed to our understanding of photosynthesis.
- Explain the contributions of Van Helmont, Priestley, and Melvin Calvin to our understanding of photosynthesis.
- Describe the structure and function of chloroplasts, thylakoids, and pigments.
- Explain how electron carrier molecules form electron transport chains.
- Trace the flow of energy and materials through the Light Reactions, including chemiosmosis.
- Trace the flow of energy and materials through The Calvin Cycle.
- Compare and contrast C-3, C-4, and CAM pathways for carbon fixation.

Lesson Vocabulary

Table 7.4:

Lesson 4.2 Vocabulary		
chloroplasts	Endosymbiotic theory	grana
thylakoids	pigments	electron carriers
photosystems	accessory pigments	electron transport chains
photolysis	electrochemical gradient	ATP Synthase
light-dependent reactions	inorganic molecule	organic molecule
carbon fixation	RuBisCo	stomata

Check Your Understanding

Drawing on Student Experiences

Many students see plants, but do not notice them. As a means of activating student interest in the topic of photosynthesis, ask your students to notice all of the plants they see the rest of that day. Students can contribute their findings the next class period. Did the students

see plants outdoors? Indoors? Did all of the plants have green leaves? The latter is an interesting question to ask students in the winter in colder climates where deciduous plants dominate; it can lead to a brief discussion of how plants can live throughout the winter without leaves. (Plants can live without leaves in the winter because they have stored food molecules made by photosynthesis as starch.) This discussion could also foster a connection between the FlexBook material and the students' environment outside the class.

Teaching Strategies

Using Visuals: Figure 6

Using graphs allows you to present a large amount of data to students in summary form. In **Figure 6** there are two graphs: the top panel plots wavelength of light vs. absorption by photosynthetic pigments and the second, the rate of photosynthesis at a given wavelength. Discuss these graphs one at a time with students. **Ask** them:

“What does the x-axis measure?” (wavelength of light)

“What does the y-axis measure?” ((absorption of a pigment at one wavelength \div additive absorption of that pigment at all measured wavelengths) \times 100)

“In which range of wavelengths is there the greatest absorption? The least?”

You may need to spend some extra time explaining to your students what the y-axis values represent and how they are calculated. Many students have trouble primarily understanding % values in the y-axis, and what those % actually mean.

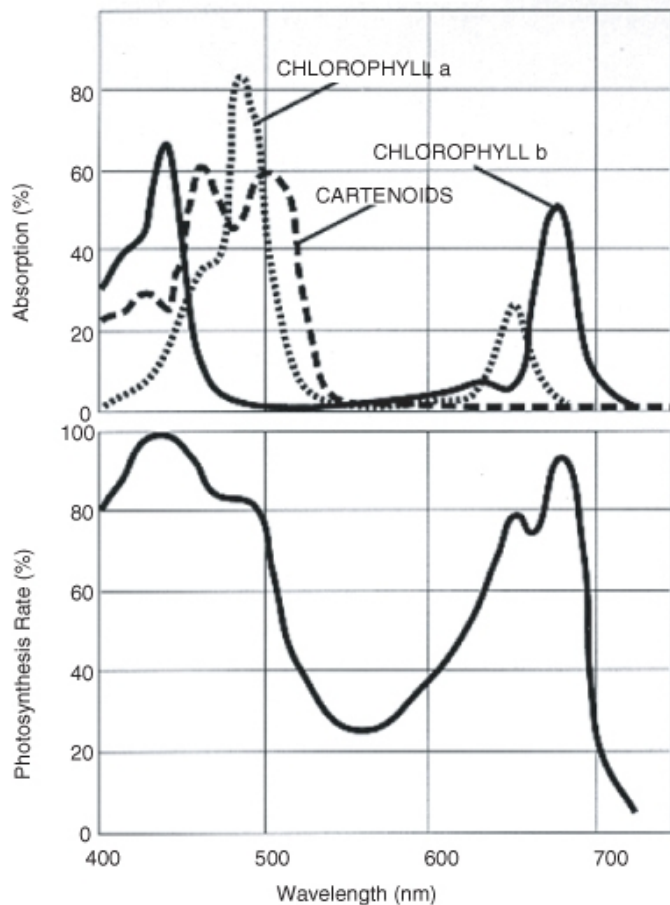


Figure 6: Each kind of pigment absorbs specific wavelengths (colors) of light. Sunlight contains many different wavelengths, which you see when they separate into a rainbow. Not all colors of light are used to make food for life. Most plants, algae, and photosynthetic bacteria appear green because they reflect green wavelengths. Their pigments have absorbed the violet-blue and red wavelengths. The amount of photosynthesis depends on the wavelength of light available.

Demonstration: Pigment Chromatography

If time does not permit the students to complete the lab described in the Lab Links section of the Photosynthesis TE, you can do a simple in-class demonstration of paper chromatography to separate plant pigments that are soluble in organic solvents. For required materials, refer to the Photosynthesis Materials List at the beginning of the chapter.

Lab link: <http://www.science-projects.com/PhotosynthPigments.htm>

Differentiated Instruction: Think-Pair-Share

For this exercise, make an overhead or give a handout of: 1) **Figure 6** without the legend and 2) the figure below

(from http://wpcontent.answers.com/wikipedia/commons/thumb/f/f1/EM_spectrum.svg/490px-EM_spectrum.svg.png)

Pair your ELL students with native English speakers and your LPR students with compatible partners. Ask them the following question: “Why do plants have more than one photosynthetic pigment?” Students in each pair work together to review the two figures, discuss the data in the figures, and create a tenable explanation. With the teacher’s guidance, each group shares its explanations with the class. Taking into account the other students’ answers, pairs then revisit their answers and come to a final conclusion. **ELL, SN**

Enrichment: Teaching a Topic

The Light-Dependent reactions of photosynthesis illustrate a number of fundamental biological concepts including excitation of electrons, electron carriers, ion gradients, and photophosphorylation (use of light energy to create a proton gradient across the thylakoid membrane which is then harnessed to synthesize ATP from ADP and P_i). Advanced students can teach this topic to the class. A group can brainstorm how to present this complex topic. Ideas include a poster presentation or a PowerPoint show.

Science Inquiry

Analyzing Data

Scientists can extract photosynthetic pigments from leaves by grinding the leaves in an organic solvent and filtering the extract. Using a spectrophotometer, they can then measure the absorption spectrum of the extract. The absorption spectrum shows the wavelengths of visible light absorbed by the extract’s pigments and gives an approximation of the wavelengths used by the plant during photosynthesis. Students can analyze and graph the hypothetical data in the table below. The table shows the absorption of an extract of spinach pigments at different wavelengths of visible light.

Table 7.5:

Wavelength (nm)	Absorption (no units)
400	1.2

Table 7.5: (continued)

Wavelength (nm)	Absorption (no units)
425	1.5
450	1.3
475	0.6
500	0.19
525	0.18
550	0.18
575	0.19
600	0.2
625	0.3
650	0.7
675	0.2

Reinforce and Review

Using Vocabulary

Instruct your students to use ten lesson vocabulary words (which ten is each student's choice) in a paragraph.

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Lesson Worksheets

Copy and distribute the four Lesson 4.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 4.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 4.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Recall Priestley’s early observation that plants, “restore the air.” Name some ways that plants and algae affect the atmosphere.
- Which of your own activities affect photosynthesis? Think “globally” in addition to “locally” and add large-scale human activities to your list. Are there any changes you could make in your life that could promote photosynthesis and a healthy atmosphere?
- You learned in this chapter that plants make “food” which life needs for energy. But is it usable energy? Or does it need to be converted into some other type of energy? What do you think and why?

Lesson Assessment

- Have students complete the Lesson 4.2 Quiz. The Answer Key is available upon request.

7.4 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

(1) .

Chapter 8

TE Cellular Respiration

8.1 Chapter 5: Cellular Respiration

Outline

The chapter *Cellular Respiration* consists of 3 lessons that: explain the relationship between breathing and cellular respiration; compare and contrast photosynthesis and cellular respiration; describe the pathways and products of glycolysis, the Krebs cycle, the electron transport chain, and anaerobic respiration.

- Lesson 5.1: Powering the Cell: Cellular Respiration and Glycolysis
- Lesson 5.2: Into the Mitochondrion: Making ATP with Oxygen
- Lesson 5.3: Anaerobic Respiration: ATP, New Fuels, and Yogurt without Oxygen

Overview

- Cells transform chemical energy from food into forms of energy that they can use to build new cellular components, grow, divide, move, and respond to their environment. In the absence of oxygen, cells use anaerobic respiration to release energy from glucose and make ATP. In the presence of oxygen, cells use aerobic respiration to release energy from glucose and make ATP. More ATP per glucose can be captured via aerobic respiration compared to anaerobic respiration. Therefore, aerobic respiration is more efficient; however, anaerobic respiration predominates in cells that live in low oxygen environments.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert figure]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 8.1:

Lesson	Number of Class Periods*
5.1 Powering the Cell: Cellular Respiration and Glycolysis	1.0
5.2 Into the Mitochondrion: Making ATP with Oxygen	1.0
5.3 Anaerobic Respiration: ATP, New Fuels, and Yogurt without Oxygen	1.0

- Class periods are assumed to be 60 minutes long.

Managing Materials

No materials are needed for the activities associated with this chapter.

Lab Links

The following lab is suitable for *Cellular Respiration* and is available online:

- This laboratory focuses on experiments testing factors that affect the rate of anaerobic respiration in yeast. Both student handouts and teacher preparation notes are available. See “Cellular Respiration in Yeast” at http://serendip.brynmawr.edu/sci_edu/waldron/#cellrespiration

Common Misconceptions

Mass and Energy: Where does matter go during weight loss in respiring organisms?

Many students, even college undergraduates, learn the pathways of cellular respiration by rote without understanding the dynamics of matter in the pathway. Educators at Michigan State University tested students’ understanding of what happens to fat (mass) in people who lose weight. Initially, many of the students thought that “mass was converted to energy.”

(Mass and energy do not interconvert; the mass is released as carbon dioxide and water, and the energy in the chemical bonds of the fat is transferred (in the process of cellular respiration) to ATP, which is used to do work.) After some instructional changes that emphasized the tracing of matter in dynamic systems, the students' misconceptions were reduced.

Reference: Christopher D. Wilson, Charles W. Anderson, Merle Heidemann, John E. Merrill, Brett W. Merritt, Gail Richmond, Duncan F. Sibley, and Joyce M. Parker. "Assessing Students' Ability to Trace Matter in Dynamic Systems" in *Cell Biology CBE Life Sci Educ*, 5(4): 323-331 2006 <http://www.lifescied.org/cgi/content/full/5/4/323>

Other Web Resources

You may find these additional Web-based resources helpful when teaching Cellular Respiration:

Glycolysis

- This animation shows each chemical reaction in the glycolytic pathway. A sidebar shows all the reaction intermediates such that students can keep track of what part of the pathway they are learning. There is also an ATP equivalence meter. <http://www.johnkyrk.com/glycolysis.html>

Krebs cycle

- This video shows the Ohio State University Marching Band acting out the Krebs Cycle. While students will not be able to learn the pathway merely by viewing this video, teachers may find that it stimulates interest in learning the pathway. <http://www.youtube.com/watch?v=FgXnH087Jik>
- This animation leads students through the Krebs Cycle. At each step, the chemical structure and a space-filling model of a cycle intermediate are shown. The right-hand side of the page shows structures of all of the Cycle's components so that students can keep track of what step they are learning. <http://www.johnkyrk.com/krebs.html>
- This website categorizes the reactions of the Krebs Cycle into three groups: formation of Acetyl CoA, production of citrate, and reduction of electron carriers. The animation shows the reactions occurring in the mitochondrial matrix, and in this way, students get visual reinforcement of the Krebs Cycle's location. <http://www.science.smith.edu/departments/Biology/Bio231/krebs.html>

Electron Transport Chain

- This animation shows the major events and products of the electron transport chain. Especially helpful is the animation that shows proton gradient formation. <http://www.science.smith.edu/departments/Biology/Bio231/etc.html>

- John Kyrk's site gives viewers both a birds-eye view and the molecular details of the electron transport chain. <http://www.johnkyrk.com/mitochondrion.html>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include *Cellular Respiration*, or specific lessons in *Cellular Respiration*, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of *Cellular Respiration*, students should have read the *Cell Structure and Function*, the *Chemical Basis of Life*, and the *Photosynthesis* chapters.
- Students should read Cellular Respiration before reading any of the chapters on the Human Body in the FlexBook.
- If time is short, you may want to omit Lesson 5.3.

8.2 Lesson 5.1: Powering the Cell: Cellular Respiration and Glycolysis

Key Concepts

Aerobic organisms need oxygen to convert the chemical energy in food molecules (such as glucose) to energy (ATP) that the cell can use for its metabolic activities. The reaction pathways that accomplish this are called cellular respiration. Without oxygen, obligate aerobes will die within minutes. The first part of cellular respiration, glycolysis, occurs in the cytosol, while the other two pathways, the Krebs Cycle and the electron transport chain, occur in mitochondria. Photosynthesis and cellular respiration are interdependent. Oxygen and glucose produced by photosynthesis are used in cellular respiration, and carbon dioxide and water produced in cellular respiration are used in photosynthesis. Producers and consumers cycle carbon, hydrogen, and oxygen between living organisms and the environment.

Lesson Objectives

- Clarify the relationship between breathing and cellular respiration.
- Trace the flow of energy from food molecules through ATP to its use in cellular work.
- Compare cellular respiration to burning.
- Analyze the chemical equation for cellular respiration.

- Briefly describe the role of mitochondria in producing ATP.
- Compare cellular respiration to photosynthesis.
- Show how carbon and oxygen atoms cycle through producers, consumers, and the environment.
- Recognize that glycolysis is the first and most universal of three stages in cellular respiration.
- Explain why biologists consider glycolysis to be one of the oldest energy production pathways.
- Describe how some of the energy in glucose is transferred to ATP in the cytoplasm, without oxygen.

Lesson Vocabulary

Table 8.2:

Lesson 5.1 Vocabulary		
cellular respiration	glucose	ATP
mitochondrion	Endosymbiotic theory	symbiont
cytosol	glycogen	NADH
anaerobic	aerobic	

Check Your Understanding

Facts and Figures

Present these statistics and facts to your students as a means of generating interest in the topic of cellular respiration. Tell your students that:

Mitochondria exist in almost all eukaryotic cells. Both heterotrophic and autotrophic eukaryotes contain mitochondria. (Review or visit the *Photosynthesis* chapter, Lesson 1, to review these terms.) Mitochondria are present in both plants and animals. Moreover, plants, as well as animals, carry out cellular respiration. Thus, plants use oxygen in cellular respiration and generate oxygen as a byproduct of photosynthesis.

An average 40-year-old male consumes between 35-40 ml kg min of oxygen, whereas, elite runners can consume double that (80 ml kg min)!

Given these values, how much oxygen do you think you consume per minute?

Why do you think trained runners can consume more?

To learn more on oxygen consumption, VO_{2max} , and its relationship to fitness level, see http://www.nismat.org/physcor/max_o2.html

Teaching Strategies

Building Science Skills: Compare and Contrast

Mitochondria and Chloroplast Structure and Function

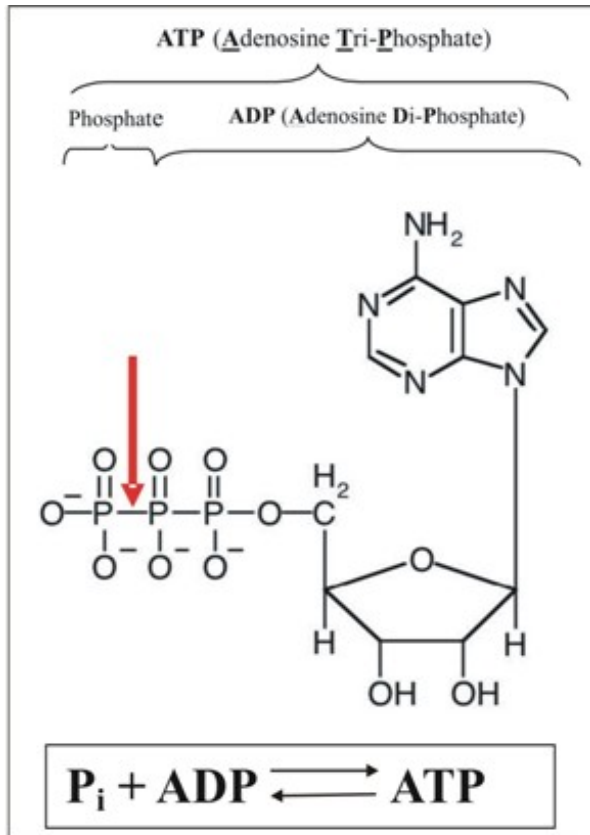
Using a blackboard, overhead, or similar device, make a table that compares and contrasts mitochondria and chloroplasts. Leave cells empty and solicit ideas from your students. The table below shows a few examples of what could go into such a table (there are many more). At this time, introduce the concept of photosynthesis and cellular respiration being a cycle.

Table 8.3:

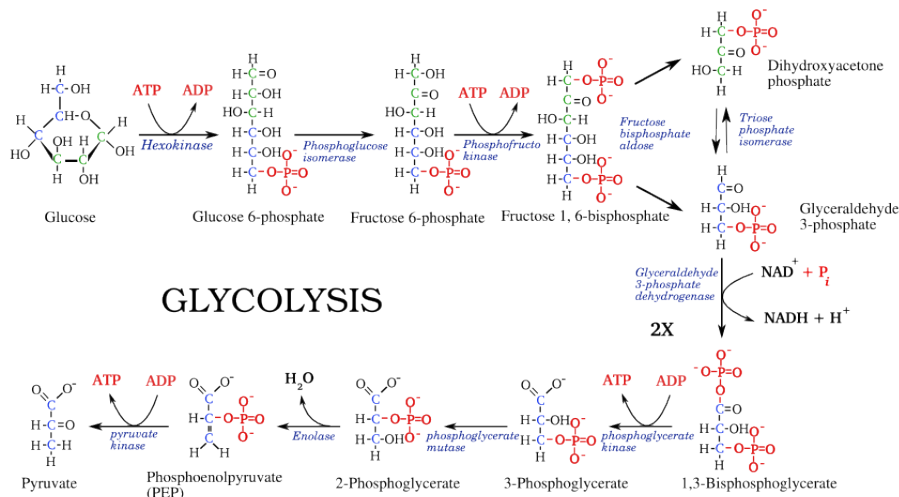
Organelle	Location	Number	per cell	Function	Comparison
Mitochondrion	Cytoplasm of most eukaryotic cells	Many		Produce ATP	CO ₂ and H ₂ O produced can be used in photosynthesis
Chloroplast	Cytoplasm of some eukaryotic cells	Many		Fix CO ₂ to produce organic compounds	O ₂ and glucose produced can be used in cellular respiration

Using Visuals: ATP

Show students the chemical structure of ATP. Point out the main parts: the nitrogen-containing adenosine, the ribose (5-carbon) sugar, and the three phosphodiester bonds.



Instead of thinking about ATP as having high-energy phosphate bonds, it is more accurate to refer to ATP as a phosphate donor—one that donates a phosphate molecule to an acceptor molecule. As shown in the figure below, in glycolysis, the acceptor molecules are glucose and fructose-6-phosphate.

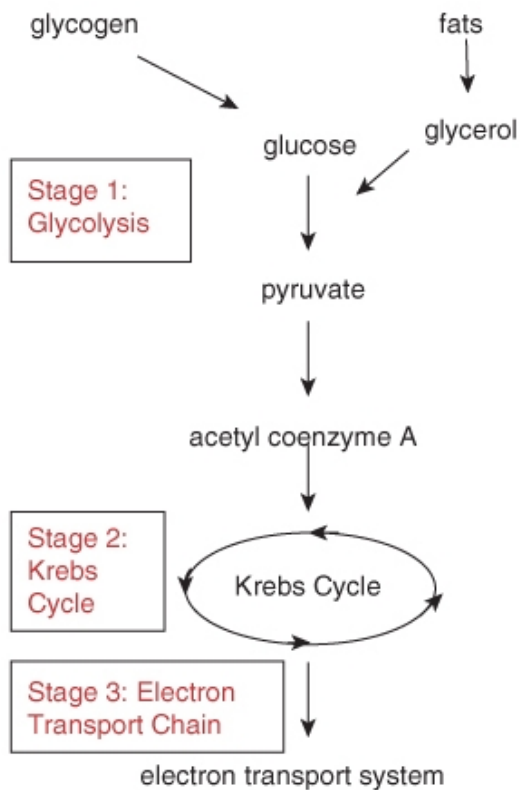


You can present the diagram below to explain how the reaction $\text{ATP} \rightarrow \text{ADP} + \text{P}_i$ can also change protein conformation, and thus activity. An example of this is how ATP donates a phosphate to the sodium-potassium pump, changes its shape to expose a high affinity binding site for potassium on the extracellular side (see *Cell Structure and Function* chapter, Lesson 3).

Download photo from: [Reversible_phosphorylation.PNG http://wpcontent.answers.com/wikipedia/en/thumb/e/ea/Reversible_phosphorylation.PNG/260px-Reversible_phosphorylation.PNG](http://wpcontent.answers.com/wikipedia/en/thumb/e/ea/Reversible_phosphorylation.PNG/260px-Reversible_phosphorylation.PNG)

Differentiated Instruction: Flow Chart

Create groups of 2-4 students to construct a flow chart of aerobic cellular respiration. A flow chart could be similar to **Figure 19** in the SE. **ELL, LPR, SN**



Enrichment: Write a Poem/Rap

Challenge students to write a poem or rap, explaining the details of glycolysis or another segment of cellular respiration. Have the students present their writing to the class.

Science Inquiry

Developing a Research Plan

The legend to **Figure 17** states that “*Clostridium tetani* bacteria are obligate anaerobes.” Tell your students to devise a set of experiments to test this hypothesis. Ask them to identify the independent variable (presence or absence of oxygen) and the dependent variable (survival of the bacteria). Ask them what is the predicted result (they cannot grow or survive in the presence of oxygen).

Reinforce and Review

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Using Vocabulary

Instruct students to use each of the words in the Lesson Vocabulary List in a sentence. Alternatively, they may write a paragraph or two that includes all of the words.

Lesson Worksheets

Copy and distribute the four Lesson 5.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 5.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 5.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- In this lesson, you've learned that scientists consider glycolysis to be the oldest, or at least one of the oldest, pathways for making ATP. What might this say about earth's ancient atmosphere? Can you imagine steps or events that might have been involved in the later evolution of aerobic cellular respiration, which includes glycolysis?

- Prokaryotes can use either photosynthesis or cellular respiration – or both - to make ATP. Why do you think both processes evolved? Why not just photosynthesis? Which do you think came first in evolution? Why?
- This lesson compares cellular respiration to burning. What activities in your daily life use burning? What are some consequences of those activities, in terms of materials produced and energy used?

Lesson Assessment

- Have students complete the Lesson 5.1 Quiz. The Answer Key is available upon request.

8.3 Lesson 5.2: Into the Mitochondrion: Making ATP with Oxygen

Key Concepts

Living cells existed before oxygen was present in the atmosphere. When photosynthetic blue-green bacteria evolved, they produced oxygen as a byproduct of photosynthesis, and thus oxygen accumulated in the air. Many types of anaerobic cells were harmed and did not survive, but those that did survive evolved to use oxygen to make ATP in a process called cellular respiration. There are three pathways in cellular respiration: glycolysis, the Krebs cycle, and the electron transport chain (ETC). The metabolism of a single glucose molecule yields up to 38 ATP: 2 from glycolysis, 2 from the Krebs cycle, and 36 from the electron transport chain. While glycolysis occurs in the cytosol, the Krebs cycle and ETC happen in the mitochondria.

Lesson Objectives

- Relate the history of oxygen in the atmosphere to the evolution of photosynthesis, aerobic respiration, mitochondria, and life on earth.
- Describe the fate in eukaryotic cells of the pyruvate molecules produced by glycolysis if oxygen is present.
- Recognize that for most organisms, if oxygen is present, the products of glycolysis enter the mitochondria for stage 2 of cellular respiration - the Krebs Cycle.
- Trace carbon and hydrogen atoms through the Krebs Cycle.
- Analyze the importance of the Krebs Cycle to cellular respiration by following the pathway taken by chemical energy.

- Describe the structure of the mitochondrion, and identify the site of Krebs Cycle reactions.
- Recognize that electron transport chain is the third and final stage of aerobic cellular respiration.
- Describe how chemiosmotic gradients in mitochondria store energy to produce ATP.
- Identify the role of oxygen in making stored chemical-bond energy available to cells.
- Relate the structure of mitochondria to electron transport chain function and the production of ATP.

Lesson Vocabulary

Table 8.4:

Lesson 5.2 Vocabulary		
glycolysis	Endosymbiotic theory	ATP
NADH	Krebs Cycle	mitochondria
matrix	chemiosmosis	cristae
intermembrane space	FADH ₂	electrochemical gradient
electron transport chain	ATP synthase	

Check Your Understanding

Recalling Prior Knowledge

Ask your students what they know about what happens to the air they inhale and exhale when breathing in and out. Some students may know, others not.

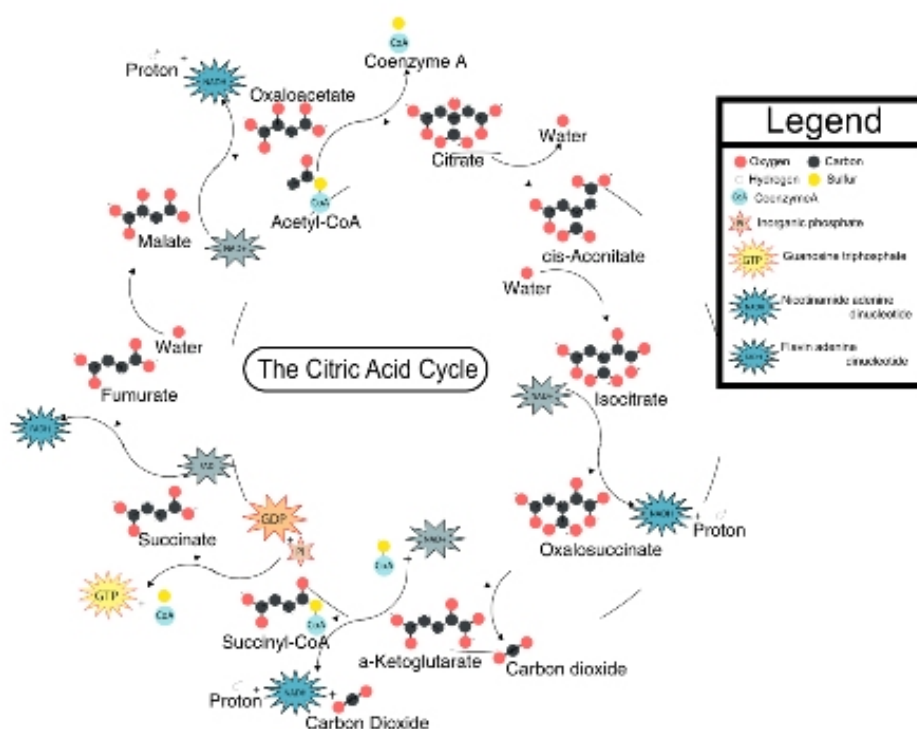
(Sample answer: oxygen is absorbed by lung cells and then diffuses into the bloodstream and carbon dioxide waste is delivered from the blood to the lungs and breathed out.)

Teaching Strategies

Using Visuals: The Krebs Cycle

1. Students will understand the Krebs Cycle better if you first provide them with a broad overview.

(The Krebs cycle completes the glucose dismantling started in glycolysis and harvests high energy electrons which will be used in the ETC to generate ATP.) 2. Then, using the diagram, systematically explain each step. Use the level of complexity you feel is appropriate for your class.

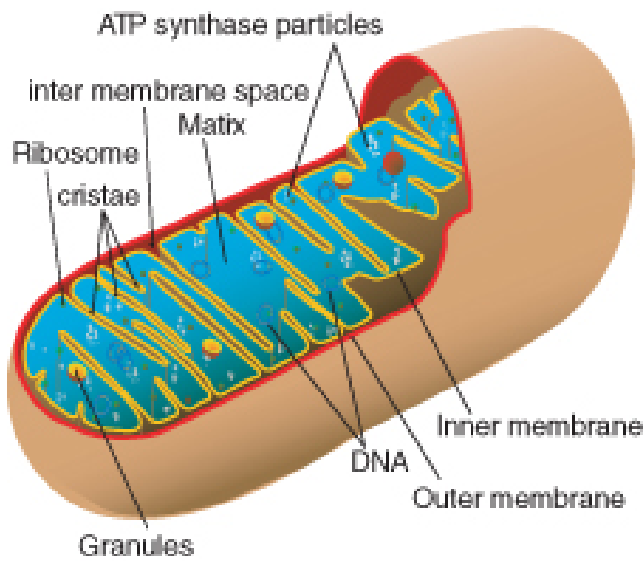
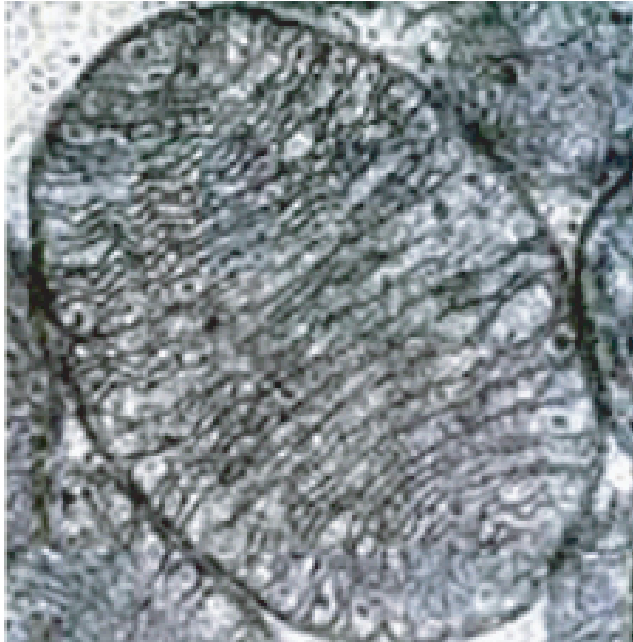


3. Finally, summarize the number of kinds of products of each “turn” of the Krebs Cycle. Use the diagram to confirm that each turn of the cycle (two turns are needed to break down each glucose) stores energy in three NADH, one FADH₂, and one ATP (from GTP), and releases two CO₂.

4. When you have done this, instruct your students (either immediately or the next class period) to explain to a partner, either orally or by a diagram, the purpose and products of the Krebs Cycle. You can circulate around the class during this activity. By listening to your students, you can determine if there are any misconceptions or points of misunderstanding that need to be addressed.

Using Visuals: Mitochondrion

In order to really understand living organisms, students need to be able to see the relationship between the structure of a cell/organelle/macromolecule and its function. Use the diagram and electron micrograph of the mitochondrion to explain this relationship to your students. Some examples follow. Outer membrane: separates the mitochondrion from the cytosol; Inner membrane: invaginations (cristae) greatly increase the surface area of the membrane; in turn, large numbers of ETC components can fit into a small area; Intermembrane space: permits the formation of a proton gradient that is used for ATP synthesis; Matrix: enzymes of the Krebs Cycle located together.



Differentiated Instruction: Flow chart

Flow chart: Electron Transport Chain

Instruct your students to make a flow chart to show the steps in the electron transport chain. Students can work in pairs so that less proficient readers are paired with more proficient ones.

LPR

Enrichment: Teaching a Topic

Students who request or would benefit from enrichment activities can research the topic of Human Mitochondrial Disorders and give a short oral presentation (with or without A/V aids). This topic aptly links basic mitochondrial biology with medicine, human health, and genetics.

Students can get started learning about this topic on these websites:

- <http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=gene&part=mt-overview>
- <http://www.nature.com/scitable/topicpage/mtDNA-and-Mitochondrial-Diseases-903>

Science Inquiry

Formulating a Hypothesis

Scientists deduced the mitochondrion's functions from interpreting the results of many, many experiments. They commonly used chemicals called inhibitors to test their hypotheses about mitochondrial function. For example, some inhibitors dissipate the H^+ gradient across the inner mitochondrial membrane (two examples are 2, 4-dinitrophenol and FCCP). Give your students this information, and ask how they think such a drug would affect cellular respiration.

(Inhibitors that eliminate ion gradients across membranes are called ionophores. Such agents will halt ATP synthesis by ATP synthase because it needs a H^+ gradient as a source of energy to make ATP.)

Reinforce and Review

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Asking Questions

The topic of cellular respiration encompasses many concepts. Request that each of your students hand in a question they have about lesson content. Answer the FAQs and review material relevant to the FAQs.

Lesson Worksheets

Copy and distribute the four Lesson 5.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 5.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 5.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- According to the endosymbiotic theory, although some prokaryotes evolved aerobic respiration, eukaryotes took the short-cut of engulfing these prokaryotes rather than “re-inventing the wheel.” The benefits to the “host” cells are obvious. What might have been some of the benefits to the prokaryote?
- Cycles, electron transport chains, and chemiosmosis are common to both photosynthesis and cellular respiration. Why do you think they’re found in both energy pathways?

Lesson Assessment

- Have students complete the Lesson 5.2 Quiz. The Answer Key is available upon request.

8.4 Lesson 5.3: Anaerobic Respiration: ATP, New Fuels, and Yogurt without Oxygen

Key Concepts

In the absence of oxygen, anaerobic respiration (fermentation) occurs. The purpose of fermentation is to regenerate NAD^+ for use in glycolysis. (Glycolysis cannot proceed without

a steady supply of NAD⁺.) There are two types of fermentation: lactic acid fermentation and alcoholic fermentation. Both human muscle and certain bacteria use lactic acid fermentation. Yeast can use alcoholic fermentation. In fact, humans use such yeast to make bread, beer, and wine.

Lesson Objectives

- Distinguish between obligate aerobes, obligate anaerobes, and facultative anaerobes.
- Explain that, in the absence of oxygen fermentation reactions must regenerate NAD⁺ in order for glycolysis to continue making ATP.
- Discuss how your muscles continue to work for you even when your respiratory and cardiovascular system can no longer keep up a continuous supply of oxygen.
- Identify yourself as “sprinter” or “endurance runner” and predict the type of muscle fiber (red or white) that predominates in your body.
- Describe how bacteria, including those we employ to make yogurt, make ATP in the absence of oxygen.
- Compare and contrast alcoholic and lactic acid fermentation pathways.
- Outline the process used to produce fuel from corn.
- Explain how we employ anaerobic organisms to make bread, beer, and wine.
- Compare the energy efficiency of aerobic cellular respiration to that of fermentation.
- List the advantages of anaerobic over aerobic respiration.
- Explain why vertebrate muscles use both aerobic and anaerobic pathways to make ATP.

Lesson Vocabulary

Table 8.5:

Lesson 5.3 Vocabulary		
aerobic	obligate aerobes	obligate anaerobes
facultative anaerobes	fermentation	lactic acid fermentation
alcoholic fermentation		

Check Your Understanding

Drawing on Student Experiences

Take a poll of your students. This poll is not meant to be scientific, but is meant to stimulate thinking about the lesson content.

- The first question for your students is: “Do you think more high school students are better at sprinting or at distance running?” Tally the opinions and write on the blackboard. Next, ask them if they are better at sprinting or at running longer distances. (Obviously, if there are physically impaired students in your class, you will modify this poll.) Tally the results. As a class, calculate the percent of students in each category. Were the actual results the same as the predicted ones?

After your students have completed this activity, tell them that you will be teaching them about aerobic and anaerobic respiration, and that different types of muscles fibers are specialized for one or the other. Some people have more “sprinting fibers,” which are specialized for anaerobic metabolisms and others, more “endurance” fibers, which are specialized for aerobic respiration. Specific training can alter the distribution between the two types. For example, there will be an increase in endurance fibers (also known as slow-twitch) in a person training for a marathon.

Reference: Ingalls, Christopher. 2004. Nature vs. nurture: can exercise really alter fiber type composition in human skeletal muscle? *J. Appl Physiol* 97: 1591-1592. <http://jap.physiology.org/cgi/content/full/97/5/1591>

Teaching Strategies

Activity

Students should engage in this activity after they have read the lesson. Ask them to work in groups of 2-3 and to make a comparative table of aerobic versus anaerobic metabolism. Such a table may include some of the following elements (many more comparisons are possible):

Table 8.6:

	Anaerobic	Aerobic
ATP yield/glucose	2	up to 38
Oxygen needed	no	yes
Mitochondria needed	no	yes
Evolved	first	next

Discussion

Discussion of a hypothetical “what if” situation can foster student interest in anaerobic respiration. Explore this quote from the FlexBook: “Imagine what would happen as you ran a race if muscle cells conducted alcoholic rather than lactic acid fermentation!”

(Ethanol is toxic in large quantities, so the results would be quite disastrous.)

Differentiated Instruction: Venn Diagram

Direct your students to construct a Venn Diagram that illustrates the similarities and differences between aerobic and anaerobic respiration. A sample diagram is below. **ELL, SN**

[insert diagram]

Enrichment: Teaching a Topic

Students like to connect what they learn in class with real life. An excellent research project for your students who need additional enrichment is the topic of “Probiotics and their effect on human health.” Instruct these students to research the topic. They can increase their library skills by making use of the school library or their local public library, or by using search engines and web resources. You can also use this activity to teach students how to vet web resources. One excellent, yet accessible website is <http://www.ific.org/publications/factsheets/preprobioticsfs.cfm>

Science Inquiry

Problem Solving

The common baker’s yeast, *Saccharomyces cerevisiae*, can carry out either aerobic respiration or anaerobic respiration, depending upon conditions. Ask your students to predict which type of respiration yeast would be utilized under: 1) an environment containing oxygen (aerobic) and 2) an anoxic environment (anaerobic). Ask them to devise some simple laboratory tests that could determine which type of respiration the yeast was actually using.

(Aerobic respiration will release carbon dioxide into the air and anaerobic will produce ethanol.)

Reinforce and Review

Quizzing a Partner

Students can review the lesson concepts by quizzing a partner. Ask students to write a few fill-in, matching, or true/false questions and then use them to quiz a partner.

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Lesson Worksheets

Copy and distribute the four Lesson 5.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 5.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 5.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Humans seem to harness anaerobic respiration much more than aerobic respiration to create useful products, such as foods or fuels. Use your understanding of the two processes to explain why this makes sense.
- Some controversy exists over whether or not ethanol produced by fermentation of corn is an efficient and wise way to produce fuel. Can you think of some reasons, pro and/or con?
- How might the wing muscles of birds which migrate long distances compare to those of birds which do not migrate? Why do you suppose human muscles are mixtures of red and white fibers, rather than specialized, as in many birds?

Lesson Assessment

- Have students complete the Lesson 5.3 Quiz. The Answer Key is available upon request.

8.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

Chapter 9

TE Cell Division and Reproduction

9.1 Chapter 6: Cell Division and Reproduction

Outline

The chapter *Cell Division and Reproduction* consists of two lessons that describe mitosis, meiosis, the cell cycle, asexual reproduction and sexual reproduction.

- Lesson 6.1: Chromosomes and the Cell Cycle
- Lesson 6.2: Meiosis

Overview

- In both prokaryotes and eukaryotes, the duplication of the chromosomes and the division of the cytoplasm are the key components of cell division. When cell growth and division becomes unregulated in a multicellular organism, cancer can result. Meiosis is a type of cell division used by many organisms to create gametes.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of *Cell Division and Reproduction*.

Table 9.1:

Lesson	Number of Class Periods*
6.1 Chromosomes and the Cell Cycle	2.0
6.2 Meiosis	2.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for *Cell Division and Reproduction* and are available online:

- This website contains three laboratories with accompanying introductory material and study questions. Students use socks (called “sockosomes” by the authors) to make models of chromosomes so that they can act out the processes of mitosis, meiosis, and fertilization. The website also includes student handouts and teacher preparation notes in both MS Word and PDF formats. <http://serendip.brynmawr.edu/exchange/waldron/mitosis>
- In this laboratory, students observe prepared slides of onion root tips, a model system for viewing the stages of mitosis. Students are asked to tally the number and percent of mitotic cells in each stage of mitosis. <http://www.geocities.com/CapeCanaveral/Hall/1410/lab-B-21.html>

Common Misconceptions

Misconceptions about Reproduction

The following list shows some common student misconceptions about sexual and asexual reproduction.

1. Students believe sexual reproduction always involves mating. They do not understand other mechanisms of sexual reproduction besides mammalian reproduction.

(Reality: Sexual reproduction also occurs in other ways such as conjugation (bacteria) and pollination (plants).)

2. Students believe plants cannot sexually reproduce.

(Reality: Plants do reproduce sexually; in flowering plants pollen is a male gamete and the egg is the female gamete.)

3. Students believe asexual reproduction is restricted to microorganisms only.

(Reality: Plants and fungi can also reproduce asexually.)

Reference: <http://departments.weber.edu/sciencecenter/biology%20misconceptions.htm> Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). Making sense of secondary science: Research into children's ideas. New York: Routledge.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for *Cell Division and Reproduction*.

Table 9.2:

Lesson	Strategy or Activity	Materials Needed
6.1	1. Demonstration	1. Whiteboard or extra-large poster paper and easel, markers of 4-6 different colors
6.2	1. Activity: Meiotic Chromosome Segregation	1. Colored pencils, erasers, and paper

Additional Web Based Resources

You may find these additional web based resources helpful when teaching Cell Division and Reproduction:

The NIH Curriculum Supplement Series has a unit for high school students on Cell Biology and Cancer. There are five modules in this unit, including Cancer and the Cell Cycle. In the Cancer and the Cell Cycle module, there are 5 animations of the cell cycle and 5 news-alert videos. In addition to reviewing the stages of the cell cycle, the animations introduce and explain terms such as proto-oncogene, oncogene, and tumor suppressor. The news-alert videos talk about the relationships between cancer and UV light, radiation, chemical poisons, and family history. An added bonus is that state-specific standards alignment is provided for each supplement.

- <http://science.education.nih.gov/Customers.nsf/HSCancer?OpenForm>
- Amitosis animation is at <http://biology.about.com/library/blmitosisanim.htm>
- Two animations on meiosis are at [/library/blmeiosisanim.htm](http://biology.about.com/library/blmeiosisanim.htm) and <http://biology.about.com/library/blmeiosisanim2.htm>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to choose the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter or certain lessons in this chapter in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook.

- To understand the content of *Cell Division and Reproduction*, students should have read the *Foundations of Life Science*, *Chemical Basis of Life*, and *Cell Structure and Function* chapters.
- Students should read *Cell Division and Reproduction* before reading *Mendelian Genetics* and *Molecular Genetics*.
- It is recommended that you include all the lessons of this chapter in the FlexBook.

9.2 Lesson 6.1: Chromosomes and the Cell Cycle

Key Concepts

Before most cell divisions, cells first grow in size and duplicate their chromosome(s). During cell division, the chromosomes are equally distributed, and the cytoplasm is divided between the two resulting cells. Cancer can result when a cell loses control of cell growth and division.

Lesson Objectives

- Describe the properties of cell division in prokaryotes.
- Describe cell division in eukaryotes. Explain the main differences between cell division in prokaryotic and eukaryotic cells.
- Describe the basic properties of chromosomes.
- Describe the key steps in the cell cycle.
- Identify and describe the main processes in mitosis.
- Describe how the cell cycle is controlled and define cancer.

Lesson Vocabulary

Table 9.3:

Lesson 6.1 Vocabulary		
binary fission	gametes	genes

Table 9.3: (continued)

Lesson 6.1 Vocabulary			
chromosome		sister chromatids	centromere
homologous chromosomes	chromosomes	homologues	zygote
diploid		haploid	autosomes
cell cycle		interphase	cytokinesis

Check Your Understanding

Facts and Figures

Did you know that:

- The bacterium *E. coli* has one chromosome, a human has 46 chromosomes, and a species of field horsetail (a plant) has 216 chromosomes!
- If all of the nucleotide bases in all your chromosomes were spaced about 1 mm apart, they would spread from Memphis, Tennessee to Los Angeles, California, (a distance of over 1600 miles)! http://www.ornl.gov/sci/techresources/Human_Genome/posters/chromosome/faqs.shtml



Figure 9.1

Teaching Strategies

Building Science Skills: Drawing Conclusions

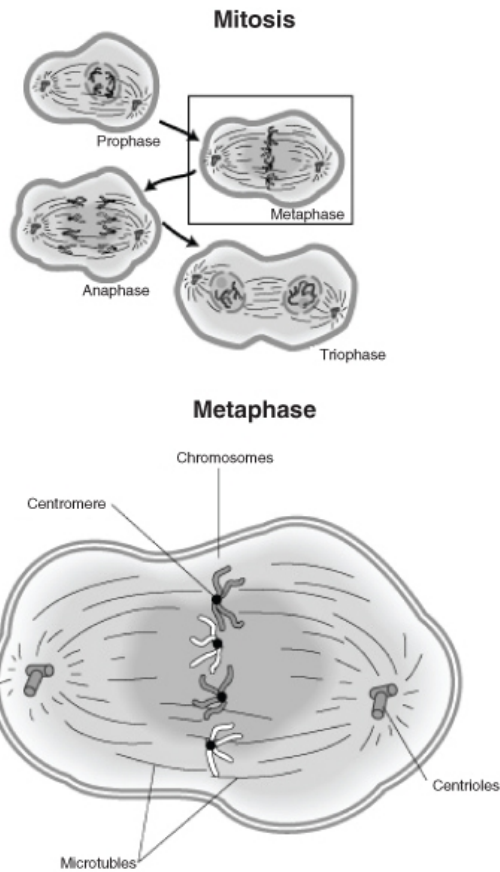
One strain of the bacterium *E. coli* has a single circular chromosome containing 4.6 million (4.6×10^6) base pairs. Humans have 46 chromosomes and a total of 3 billion (3×10^9) base pairs.

Ask your students: “Why do you think that humans have 46 chromosomes and not just one, as does *E. coli*?”

(Some possible student answers: the human genome is too large for it to be in one chromosome, humans are diploid so they must have more than one chromosome.)

Demonstration: Mitotic Chromosome Segregation

It may be challenging for some students to visualize how the duplicated chromosomes are distributed during mitosis. Drawing duplicated chromosomes at a metaphase plate and showing how the sister chromatids migrate towards opposite poles will make this concept clearer.



Use **Figure 6** in the SE as a guide to prepare for your demonstration. This figure shows a cell with 2 pairs of homologous chromosomes. In genetics terminology, this is stated as $2N = 4$ (see the *Mendelian Genetics* chapter for further information).

Describe: The two grey chromosomes (each of which has duplicated and consists of a pair of sister chromatids joined at their centromeres) are one homologous pair and the two duplicated white chromosomes are the other homologous pair. Note how the chromosomes are lined up at the metaphase plate. When the centromeres split, the sister chromatids will migrate to opposite spindle poles.

For your demonstration, use a hypothetical cell produced by sexual reproduction (the cell is diploid). Assume that this cell has four pairs of chromosomes. Use four different marker colors, both in solid and striped configurations, to represent each chromosome (examples are shown here):

Table 9.4:

Chromosome #	Color	Maternal	Paternal
1	purple	solid color	striped color

Table 9.4: (continued)

Chromosome #	Color	Maternal	Paternal
2	orange	solid color	striped color
3	green	solid color	striped color
4	yellow	solid color	striped color

Draw the chromosome configurations at mitotic metaphase and anaphase stages.

Differentiated Instruction: Cycle Diagram

Instruct your students to draw a diagram of the cell cycle. Students can work in pairs: ELL students with native English speakers and SN students with students without special challenges. Any textbooks should be put away. After completing their drawings, each pair can explain their drawings to another pair of students. **(ELL LPR SN)**

Enrichment: Game: Mitosis and the Cell Cycle Jeopardy

Students who want an additional activity can create jeopardy questions about mitosis and the cell cycle. The questions should follow standard jeopardy format; for example, the question, “What is the phase of mitosis during which sister chromatids migrate toward opposite poles?” Is answered by “anaphase.” The entire class can be divided into small groups and play the game.

Science Inquiry

Problem Solving

As stated in the SE, human chromosomes vary greatly in length, ranging from fewer than 50 million nucleotide pairs to about 250 million. Pose the following problem to your students: “If human chromosomes vary in length, then what is a way to distinguish one human chromosome from another?” (*Sample answer: each chromosome has a typical length, shape, and centromere position.*)

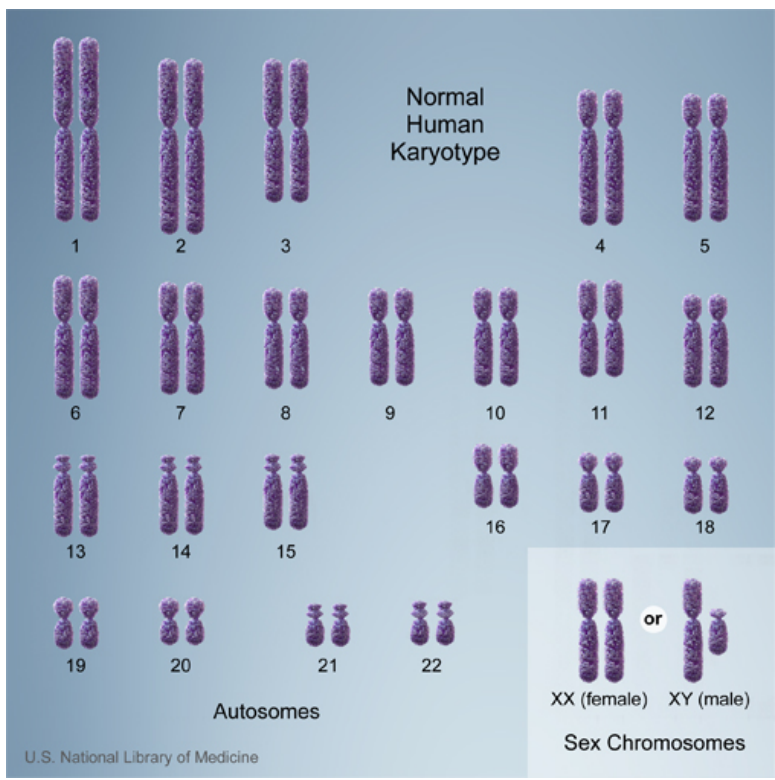


Figure 9.2

Reinforce and Review

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Online Quiz

Students can test their understanding of mitosis and the cell cycle by taking an online quiz. After they take the quiz, students get a score. You may want to assign the quiz as preparation for an in-class quiz or exam. This quiz is located at: http://www.biologycorner.com/bio4/mitosis_qz.html

Lesson Worksheets

Copy and distribute the four Lesson 6.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 6.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 6.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- A human cell has 46 chromosomes, while a bacterial cell has only one chromosome. Would you think that the number of chromosomes relates to the complexity of the cell or organism?

- Mitosis and cytokinesis produce two genetically identical daughter cells. Think about how a cell with half as much DNA, such as a sex cell, may form.
- As not every species has members of the opposite sex, such as bacteria, yet all organisms must reproduce to stay alive, think about how these sexless organisms may reproduce.

Lesson Assessment

- Have students complete the Lesson 6.1 Quiz. The Answer Key is available upon request.

9.3 Lesson 6.2: Meiosis

Key Concepts

Asexual reproduction results in offspring that are genetically identical to the parent. When an organism reproduces sexually, its offspring are similar but not identical to the parent. Meiosis is the process by which haploid gametes are created from diploid cells.

Lesson Objectives

- Describe asexual reproduction; explain the genetic relationship between parent and offspring.
- Describe sexual reproduction; explain the genetic relationship between parent and offspring.
- Identify and describe the main steps of meiosis, distinguishing between the quantity of genetic material in the parent and resulting cells.
- Describe gametogenesis and identify the key differences between oogenesis and spermatogenesis.
- Distinguish between the three types of sexual life cycles.

Lesson Vocabulary

Table 9.5:

Lesson 6.2 Vocabulary		
clone	tetrad	recombination
gametogenesis	spermatogenesis	oogenesis
polar body	life cycle	spores

Table 9.5: (continued)

Lesson 6.2 Vocabulary		
alternation of generations	asexual reproduction	budding
crossing-over	diploid	fertilization
fission	fragmentation	gametes
gametophyte	haploid	meiosis
sexual reproduction		

Check Your Understanding

Recalling Prior Knowledge

In Lesson 6.1, students were taught about mitosis. Before launching into the material in Lesson 6.2, have a classroom discussion about mitosis. Ask students to recall what they learned about mitosis, and if there are any steps of the process that are unclear to them.

Teaching Strategies

Paper and Pencil Activity: Meiotic Chromosome Segregation

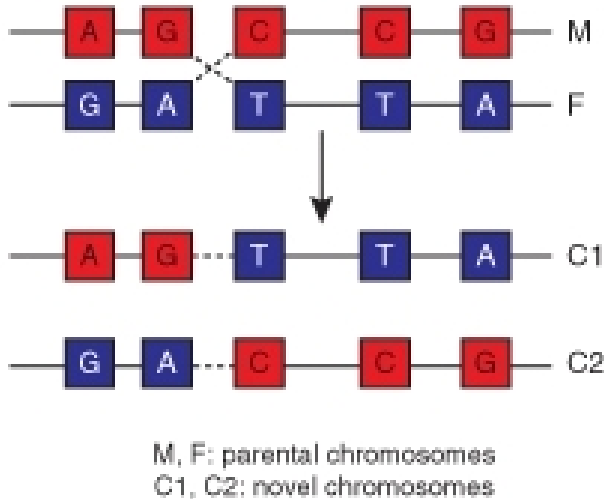
Starting with a diploid progenitor cell ($2N = 6$) that has not yet duplicated its DNA, students draw all the stages of meiosis I and II. Have the students use different colored pencils for each chromosome. To distinguish maternal and paternal homologs, they can draw one copy of each homolog in a solid color, and the other copy in stripes of the same color. Before beginning this activity, the teacher should review the independent assortment of chromosomes during metaphase of meiosis I. This review is also a great way to preview the Mendelian Genetics chapter.

Using Visuals: Figure 13, Crossing Over

Using **Figure 13** (Crossing-Over) as a visual guide, explain the step-by-step details of meiotic crossing over, namely, that:

- 1. It occurs during prophase of meiosis I, when the duplicated homologous chromosomes pair up (synapse).
- 2. Crossing-over produces two new chromosomes that have different nucleotide sequences (allele combinations) than the starting chromosomes.

- 3. The two chromosomes that did not cross over contain the same nucleotide sequences with which they started.



Crossing-over. A maternal strand of DNA is shown in red. Paternal strand of DNA is shown in blue. Crossing over produces two chromosomes that have not previously existed. The process of recombination involves the breakage and rejoining of parental chromosomes (M, F). This results in the generation of novel chromosomes (C1, C2) that share DNA from both parents.

Differentiated Instruction: Compare/Contrast Table

Students can work in groups of 2-4 for this activity. Pair ELL with native English speakers. Each pair will make a table comparing and contrasting Mitosis and Meiosis. Have them include at least 5 similarities/differences in their table. (ELL)

Enrichment: Writing a Poem

Students needing additional enrichment can compose a poem about Meiosis. They can choose the type (a few ideas: ballad, couplet, quatrain, haiku, limerick).

Science Inquiry

Asking a Question

Present the following scenario to students:

- During metaphase II of meiosis, when each chromosome is attaching to a spindle fiber, all of the chromosomes attach with the exception of one duplicated pair, which fails to attach. Nevertheless, meiosis and cytokinesis progress and 2 daughter cells result.

Ask your students “What will be the chromosomal complement of each of the 2 daughter cells?”

(Sample answer: One of the daughter cells will have an extra identical copy of the chromosome that failed to attach to the spindle; the other will have no copy of that chromosome.)

Reinforce and Review

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Online Quiz

This website has a great online quiz; several questions require students to identify the stage of meiosis in micrographs of lily anther cells. In addition, a study guide is available at the site. The web site is at: <http://biology.about.com/library/weekly/blmeios1q.htm>

Lesson Worksheets

Copy and distribute the four Lesson 6.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 6.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 6.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- The next unit, Genetics, discusses the branch of biology that studies heredity. What is heredity?
- What role do you think meiosis plays in heredity?
- Describe what would happen if gametes were formed by mitosis.
- Human Genetics is an ever increasingly important field of medicine. Explain why this field of medicine is so important.

Lesson Assessment

- Have students complete the Lesson 6.2 Quiz. The Answer Key is available upon request.

9.4 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

- (1) http://zh-min-nan.wikipedia.org/wiki/File:United_States-CIA_WFB_Map.png.
- (2) <http://ghr.nlm.nih.gov/handbook/illustrations/normalkaryotype>.

Chapter 10

TE Mendelian Genetics

10.1 Chapter 7: Mendelian Genetics

Outline

The chapter *Mendelian Genetics* consists of two lessons that cover the history of genetics starting with Mendel's experiments, simple Mendelian genetics, and more complex methods of inheritance.

- Lesson 7.1: Mendel's Investigations
- Lesson 7.2: Mendelian Inheritance

Overview

- Mendel's investigations into heredity created the foundation for the modern field of genetics. His experiments with pea plants identified several important laws including the Law of Segregation and the Law of Independent Assortment. Probability can be used to predict outcomes of genetic crosses. However, certain traits do not follow simple Mendelian inheritance patterns. Pedigrees can be used to track genetic conditions in families. The environment can also play a role in determining phenotype.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 10.1:

Lesson	Number of Class Periods*
7.1 Mendel's Investigations	2.0
7.2 Mendelian Inheritance	2.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for the Mendelian Genetics chapter and are available online:

- Dragon Genetics: http://74.125.47.132/search?q=cache:LvQ26Kok08wJ:serendip.brynmawr.edu/sci_edu/waldron/pdf/DragonGenetics1Protocol.doc+law+of+independent+assortment+activity&cd=17&hl=en&ct=clnk&gl=us
- The following online lab allows students to plant pea plants, design crosses, make predictions about the genotype and phenotype of offspring, analyze pedigrees, and determine patterns of inheritance. <http://www2.edc.org/weblabs/Mendel/MendelMenu.html>
- A large collection of hands-on labs and computer simulations can be found at <http://www.fastplants.org> These labs and activities teach students patterns of Mendelian inheritance.

Common Misconceptions

Dominant and Recessive Alleles Do Not Blend

Students often misunderstand the terms dominant and recessive when discussing variations of genes (alleles). Help students to recognize that dominant and recessive alleles do not blend together with the dominant allele “winning” over the “weaker” recessive allele. Both alleles are present on their particular chromosome and will be transcribed or translated during gene expression. Often due to a faulty protein being transcribed, the recessive allele leads to no phenotype. Only the dominant allele produces a phenotype.

For example, in Mendel's pea plants, dwarf plants are homozygous for the recessive allele which codes for a faulty enzyme that impairs proper stem growth. Therefore, these plants

do not grow to normal height. Pea plants that are heterozygous possess one recessive allele which produces a faulty enzyme, but also possess a normal functioning allele that produces enough protein for the plant to grow to normal height. In this case, the dominant allele did not beat out the recessive allele, it was just the only allele that produced the enzyme that led to a phenotype.

Dominant and Recessive Alleles are Gender Neutral

Students may incorrectly assume that males get their genes from their father and females get their genes from their mother. Stress that children get a copy of all of their father and mother's genes, regardless of gender. Students may also incorrectly believe that male genes are stronger or more dominant than female genes. Stress to students that the gender of the individual who possesses the genes has nothing to do with whether or not those genes are dominant or recessive.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 10.2:

Lesson	Strategy or Activity	Materials Needed
7.1	1. Modeling Mendel's Pea Experiments"	1. Package of garden peas from local garden/feed store.

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching Mendelian Genetics:

- This web resource provides a large number of interesting links including activity suggestions, "Ask a Geneticist", Mendel's original papers, and genetics-related movies: <http://www.kumc.edu/gec/>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to choose the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter or certain lessons

in this chapter in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook.

- To understand the content of *Mendelian Genetics*, students should have the lesson on meiosis from the *Cell Division and Reproduction* chapter.
- Students should read *Mendelian Genetics* before reading *Evolution in Populations*.
- It is recommended that you include all the lessons of *Mendelian Genetics* in the Flex-Book.

10.2 Lesson 7.1: Mendel's Investigations

Key Concepts

Mendel's investigations into heredity created the foundation for the modern field of genetics. His experiments with pea plants identified several important laws including the Law of Segregation and the Law of Independent Assortment.

Lesson Objectives

- Identify how Mendel's study of science and math was important to his success in research.
- Distinguish between characteristics and traits.
- Explain how Mendel was able to control pollination of the pea plants.
- Identify the terms used to describe the three generations in Mendel's studies.
- State one reason for carrying out a monohybrid cross.
- Identify the traits that appeared in Mendel's F₂ generation.
- Identify the actions of dominant alleles and recessive alleles for a trait.
- Outline the Law of Segregation.
- Outline the Law of Independent Assortment.
- Explain Mendel's results in relation to genes and chromosomes.
- Distinguish between genotype and phenotype.

Lesson Vocabulary

Table 10.3:

Lesson 7.1 Vocabulary		
heredity	genetics	artificial fertilization
blending inheritance	characteristic	trait

Table 10.3: (continued)

Lesson 7.1 Vocabulary		
self-pollinating	cross pollination	true-breeding
P generation	F1 generation	monohybrid cross
monohybrids	alleles	dominant
recessive	Law of Segregation	dihybrid cross
dihybrids	Law of Independent Assortment	linked genes
homozygous	heterozygous	genotype
phenotype		

Check Your Understanding

Recalling Prior Knowledge

Ask students to compare Mendel’s Law of Segregation and Law of Independent Assortment to their understanding of the process of meiosis in gamete formation. You may want to do a quick review of meiosis from the Cell Division and Reproduction chapter. Ask students to identify the stages of meiosis that Mendel’s two laws describe (metaphase I and anaphase I).

Teaching Strategies

Activity

The following website contains two interactives, “Dragon Genetics” and “Mendel’s Peas”, that can be completed by the students individually if enough computers are available, or together as a class. Dragon Genetics allows the students to change the genotype of dragons and see the resulting changes in phenotype. Part 1 of the Mendel’s Peas activity helps students to understand the relationship of meiosis to Mendel’s Law of Segregation and Law of Independent Assortment. Part 2 and 3 of this activity should be completed after students have read lesson 2 of this chapter. http://biologica.concord.org/webtest1/web_labs.htm http://biologica.concord.org/webtest1/web_labs.htm]

Activity

The following hands-on activity, “Modeling Mendel’s Pea Experiments”, replicates Mendel’s experiments using real garden peas you can purchase at a local garden/feed store. The students will be given the F1 generation from the cross of a true-breeding round pea plant, and true-breeding wrinkled pea plant wrapped in aluminum foil. The students will form

a hypothesis as to what the peas will look like, and then open the foil and record their observations. Then, they will be given F2 generation peas in aluminum foil, asked to form a hypothesis, and then open the foil and record their observations. A data sheet in which the students will record their results is provided. http://www.accessexcellence.org/AE/AEC/AEF/1996/nolin_pea.php

If more time is available and you would like to do an activity with students where they actually grow plants, and make observations over several weeks, the following fast-growing plants are recommended: <http://www.fastplants.org> Suitable activities for this lesson that use these plants include the monohybrid genetics kit and the dihybrid genetics kit.

Differentiated Instruction: Word Wall

There is a tremendous amount of vocabulary needed in order to understand genetics, and students need constant practice in order to master all of the vocabulary words. Post the lesson vocabulary on a bulletin board or wall and refer to the word wall frequently as students learn the lesson content.

In order to make learning the terms more fun, you can play a quick Bingo game at the end of each class. Print off the following blank Bingo card and give one to each student: http://www.bingocardscreator.com/bingo_blank.php

Have the students randomly place the vocabulary words from the word wall onto their Bingo sheet. Give the students scraps of construction paper to use to cover the words as they are called out. Call out the definition of one of the terms on the Word Wall. First student to get Bingo wins. **ELL**

Enrichment: Enrichment Strategy Type

Ask students to create a crossword puzzle using the lesson vocabulary. After the students have created the puzzle, make copies to give to everyone in the class.

Science Inquiry

Analyzing Data

Show students the following illustration that demonstrates Mendel's Law of Independent Assortment using a dihybrid cross. Then, have students answer the questions that follow. The traits in the picture are:

Short tail = S

Long tail =s

Brown fur = B

White fur = b

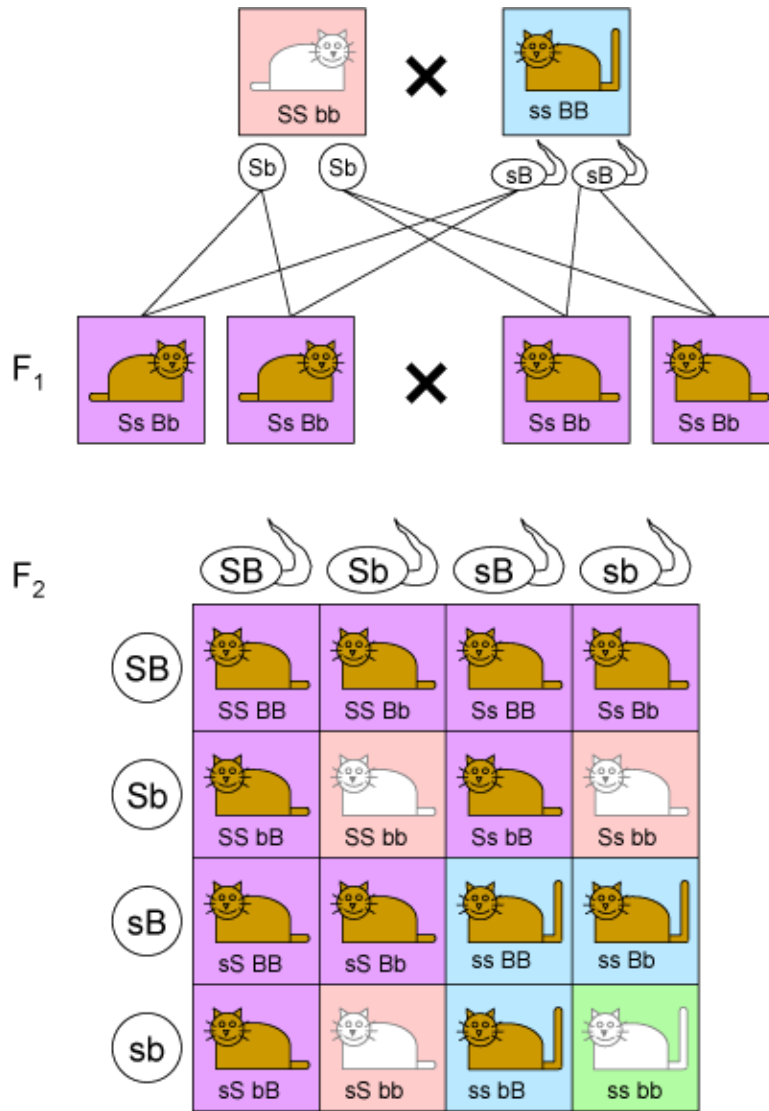


Figure 10.1: A dihybrid cross using a Punnett square.

- 1. What is the genotype and phenotype of the F1 generation?
- 2. What are the possible genotypes and phenotypes of the F2 generation?
- 3. What is the ratio of the genotypes of the F2 generation?
- 4. Do short-tailed cats always have brown fur?
- 5. How does this data prove Mendel's Law of Independent Assortment?

Reinforce and Review

Online Quiz

Have students take this online quiz to reinforce lesson content: <http://anthro.palomar.edu/mendel/quizzes/mendqui1.htm>

Lesson Worksheets

Copy and distribute the four lesson 7.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 7.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 7.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Do you think all inheritance is as straightforward as the inheritance in pea plants?
- Is there a relationship between inheritance and probability? What might that relationship be?

Lesson Assessment

- Have students complete the Lesson 7.1 Quiz. The Answer Key is available upon request.

10.3 Lesson 7.2: Mendelian Inheritance

Key Concepts

Probability can be used to predict outcomes of genetic crosses. Certain traits do not follow simple Mendelian inheritance patterns. Pedigrees can be used to track genetic conditions in families. The environment can also play a role in determining phenotype.

Lesson Objectives

- Identify how probability is used to predict outcomes of genetic crosses.
- Outline how a Punnett Square helps predict outcomes of genetic crosses.
- Identify how probability can help determine the alleles in a gamete.
- Identify how a testcross is used to determine the genotype of an organism.
- Describe how monohybrid and dihybrid crosses differ.
- Identify the ratio of phenotypes that appeared in Mendel's dihybrid crosses.
- Examine how a pedigree is used in the study of human inheritance.
- Describe how codominance does not follow Mendelian Inheritance.
- Describe how incomplete dominance does not follow Mendelian Inheritance.
- Identify examples of polygenic traits in humans.
- Outline how heredity and environment can interact to affect phenotype

Lesson Vocabulary

Table 10.4:

Lesson 7.2 Vocabulary		
Mendelian trait	probability	Punnett square
testcross	pedigree	sex chromosome
autosome	sex-linked trait	carrier
codominance	incomplete dominance	polygenic traits
multiple alleles		

Check Your Understanding

Recalling Prior Knowledge

The following practice problems integrate concepts learned from the previous lesson with concepts from this lesson. It includes problems covering Mendel's Laws, the use of a testcross,

and complex genetic inheritance patterns such as incomplete dominance and codominance:
http://www.biology.arizona.edu/mendelian_genetics/problem_sets/monohybrid_cross/monohybrid_cross.html

Teaching Strategies

Using Visuals

Students often confuse incomplete dominance and codominance. Show students the following two images and ask them to write on a piece of paper what differences they note about the two images. Then ask them to identify which image is an example of codominance, and which image is an example of incomplete dominance, and explain their reasoning.



Figure 10.2

Answer:

The rhododendron (first figure) is an example of codominance because homozygous phenotypes appear simultaneously. The snapdragon is an example of incomplete dominance because the heterozygote phenotype is a blend of the two homozygote phenotypes. Note that the alleles are not blending. Only the phenotypic expression blends.



Figure 10.3

Activity

“Those Old Kentucky Blues” is a fun case study to use with students that will help them better understand the use of pedigree analysis to evaluate genetic disorders. In this case, students will form a hypothesis as to why a group of individuals have blue skin. Then, the students will read the family background of these individuals and construct a pedigree to try and determine the genetic pattern of inheritance of this disorder. The case study is best completed as a class directed by the teacher, however, it can be completed by students in small groups, or individually if enough computers are available. http://www.sciencecases.org/blue_people/blue_people.asp

Teaching notes for this case study can be found here: http://www.sciencecases.org/blue_people/blue_people_notes.asp

Differentiated Instruction: DI Strategy Type

Have students make a KWL chart, where K = know, W = want to know, and L = learned. Students should fill in the K and W columns before reading and the L column after reading a particular passage or lesson. **SN**

Enrichment: Survey

Have students create their own family pedigree showing their family’s inheritance patterns of certain traits that follow simple Mendelian patterns. Students should select from the following traits and survey their family members in order to create their pedigree. (Please be aware of students who may be adopted or have limited information about their family before considering this activity.)

Table 10.5:

Trait	Inheritance Pattern
Blood type	A & B Codominant, i Recessive
Cheek dimples	Dominant
Free earlobes	Dominant
Attached earlobes	Recessive
Face freckles	Dominant
Hitchhiker’s thumb	Recessive
Widow’s peak	Dominant

Science Inquiry

Problem Solving

“The Death of Baby Pierre” is an exciting mystery case study where students use pedigree analysis to understand what happened to baby Pierre. Note that questions 6 and 7 in the case cannot be completed by students until they have learned about evolution and the Hardy-Weinberg equation. <http://ublib.buffalo.edu/libraries/projects/cases/pierre.htm> This activity can be done in small groups.

Reinforce and Review

Online Problem Sets

- Pedigree Practice Problems: http://www.yhc.edu/external/jasonb/previous_semesters/Bio103_Su2004/Links_of_Interest/links_to_practice_pedigree_probs.htm
- Dihybrid Crosses: http://www.biology.arizona.edu/mendelian_genetics/problem_sets/dihybrid_cross/dihybrid_cross.html
- Sex-linked Inheritance: http://www.biology.arizona.edu/mendelian_genetics/problem_sets/sex_linked_inheritance/sex_linked_inheritance.html
- Sex-linked Inheritance: http://www.biology.arizona.edu/mendelian_genetics/problem_sets/sex_linked_inheritance_2/sex_linked_inheritance_2.html

Lesson Worksheets

Copy and distribute the four lesson worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 7.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 7.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What do you think Molecular Genetics refers to?
- How can DNA contain all the genetic information?
- If DNA is in the nucleus, and proteins are made on ribosomes in the cytoplasm, how do you think this happens?

Lesson Assessment

- Have students complete the Lesson 7.2 Quiz. The Answer Key is available upon request

10.4 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

- (1) Just chaos. <http://www.flickr.com/photos/7326810@N08/1454861641>. Creative Commons License.
- (2) Darwin Cruz.
http://commons.wikimedia.org/wiki/File:Co-dominance_Rhododendron.jpg.
Creative Commons License.
- (3) Tocharianne. http://en.wikipedia.org/wiki/File:Dihybrid_cross.png.

Chapter 11

TE Molecular Genetics

11.1 Chapter 8: Molecular Genetics

Outline

The chapter *Molecular Genetics* consists of four lessons that detail the structure and function of genetic molecules.

- Lesson 8.1: DNA and RNA
- Lesson 8.2: Protein Synthesis
- Lesson 8.3: Mutation
- Lesson 8.4: Regulation of Gene Expression

Overview

- Genetic information is stored in DNA. It transfers from DNA to RNA during transcription and from RNA to protein during translation. Mutation is a change in the sequence of RNA or DNA. It is necessary for evolution to occur. Gene expression is regulated by complex mechanisms in all organisms.
- The concept map below provides a visual representation of how the chapter concepts are related.

{insert concept map}

Pacing the Lessons

Use the table below as a guide for the time required to teach the lessons of this chapter.

Table 11.1:

Lesson	Number of Class Periods*
8.1 DNA and RNA	2.0
8.2 Protein Synthesis	2.0
8.3 Mutation	1.5
8.4 Regulation of Gene Expression	1.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

- DNA: Students extract their own DNA (from cheek cells) and learn about DNA structure and replication. (Lesson 8.1) http://serendip.brynmawr.edu/sci_edu/waldron/#dna
- From Gene to Protein—Transcription and Translation: Students use simple paper models to simulate DNA transcription and translation. (Lesson 8.2) http://serendip.brynmawr.edu/sci_edu/waldron/#dna
- Deadly Letters: Groups of students investigate a hypothetical anthrax case by modeling DNA sequencing. In their investigation, they focus on the role of mutations in the identification of DNA samples. The lab uses online videos and animations. (Lessons 8.1 and 8.3) http://www.pbs.org/wgbh/nova/teachers/activities/0401_02_nsn.html
- Connecting DNA to Disease Using BLAST: Students transcribe and translate a DNA sequence containing a mutation. Then they perform a BLAST search to determine the protein that is encoded in their sequence. They also infer which disease is caused by the protein. (Lessons 8.1–8.3) <http://teacherknowledge.wikispaces.com/Quist+-+Connecting+DNA+to+Disease+Using+BLAST>
- Same Genes, Different Fates: In this wet lab, students investigate how genes are regulated during development by observing differential gene expression in genetically modified plants. The Web site provides extensive pre- and post-lab materials, worksheets, links, and other resources. The lab is suitable for AP biology students. (Lesson 8.4) http://www.moreheadplanetarium.org/files/Same_Genes_Notebook.pdf

Common Misconceptions

The Same but Different

Students may not understand how the same DNA can be found in all organisms, given how different they may appear phenotypically. Explain that the diversity of life is the result of differences in the base sequences of DNA, not in the type of molecule that carries the genetic information. You might refer students to the short online activity Genes in Common (see URL below); they can learn how much DNA they share in common with other organisms. <http://www.thetech.org/genetics/common.php#>

Essay Errors

Analysis of student essays about molecular genetics reveals the following common student misconceptions:

- DNA, genes, and chromosomes are interchangeable concepts.
- DNA is the only genetic material in the genome.
- Simple organisms such as bacteria do not have DNA.
- All DNA sequences code for proteins.

Discuss why each of these misconceptions is false. Then call on students to restate each misconception as a true fact about molecular genetics.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 11.2:

Lesson	Strategy or Activity	Materials Needed
8.1	1. Activity	1. Student handouts (from Web site), licorice sticks, colored marshmallows, toothpicks, paperclips, masking tape
8.4	1. Activity	1. craft sticks, colored markers, dried beans or pasta, modeling clay

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- DNA and RNA: This Web page provides many relevant links for activities, articles, online animations, quizzes, and other useful materials on molecular genetics. http://www.nclark.net/DNA_RNA
- DNA from the Beginning: This Web site from the Cold Spring Harbor Laboratory provides animations, photographs, biographical sketches, problems, and links for students to learn about and explore the molecules of genetics. <http://www.dnaftb.org/dnaftb/>
- Morgan, a Genetics Tutorial: This online genetics tutorial uses multimedia to present principles of molecular genetics at a level that is suitable for advanced high school biology students. http://morgan.rutgers.edu/MorganWebFrames/How_to_use/HTU_Frameset.html
- Online Biology Book: See Chapter 16 (DNA and Molecular Genetics), Chapter 17 (Protein Synthesis), and Chapter 19 (Control of Gene Expression) for a well illustrated discussion of the major topics in molecular genetics. <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to choose the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter or certain lessons in this chapter in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook.

- To understand the content of the chapter *Molecular Genetics*, students should have read the chapters *Chemical Basis of Life* and *Mendelian Genetics*.
- If you incorporate the chapter *Molecular Genetics* in your FlexBook but do not want to include all four lessons, it is recommended that you include Lessons 8.1–8.3.

11.2 Lesson 8.1: DNA and RNA

Key Concepts

The central dogma of molecular biology is that biological information is transferred from DNA to RNA to protein. The work of many scientists (from Griffith in the 1920s to Watson and Crick in the 1950s) led to the identification of DNA as the genetic material and to an

understanding of its base pairing rules and double helical structure. DNA replication occurs during cell division in eukaryotic cells. It is a semi-conservative process that requires several enzymes, including DNA polymerase. There are three types of RNA, the single-stranded nucleic acid: mRNA, tRNA, and rRNA. Each plays a role in protein synthesis.

Lesson Objectives

- Discuss how the work of Griffith, Avery, Hershey, and Chase demonstrated that DNA is the genetic material.
- Define transformation and explain that transformation is the change in genotype and phenotype due to the assimilation of the external DNA by a cell.
- Discuss the findings of Chargaff; describe the importance of the finding that in DNA, the amount of adenine and thymine are about the same and the amount of guanine and cytosine are about the same, and how this led to the base pairing rules.
- Explain Watson and Crick’s double helix model of DNA.
- Describe how DNA is replicated.
- Explain the importance of the fact that during DNA replication, each strand serves as a template to make a complementary DNA strand.
- Describe the structure and function of RNA.
- Discuss the role of the three types of RNA: mRNA, rRNA, and tRNA.

Lesson Vocabulary

Table 11.3:

Lesson 8.1 Vocabulary		
amino acid	anticodon	anti-parallel
bacteriophage	codon	deoxyribonuclease
DNA	DNA polymerase	DNA helicase
DNA ligase	DNA replication	double helix
gene	lagging strand	leading strand
mRNA	nucleotide	Okazaki fragments
primase	purines	pyrimidines
ribosome	RNA	rRNA
sugar-phosphate backbone	transcription	translation
transformation	tRNA	

Check Your Understanding

Recalling Prior Knowledge

Guide students in recalling what they already know about DNA from earlier chapters or other science classes.

- **Ask:** What is DNA? (Sample answer: DNA is the material that makes up chromosomes.)
- **Ask:** What is the function of DNA? (It controls inherited traits.)
- **Ask:** What is the structure of DNA? (It is a double helix, like a spiral staircase.)

Tell students they will learn more about DNA in this lesson.

Teaching Strategies

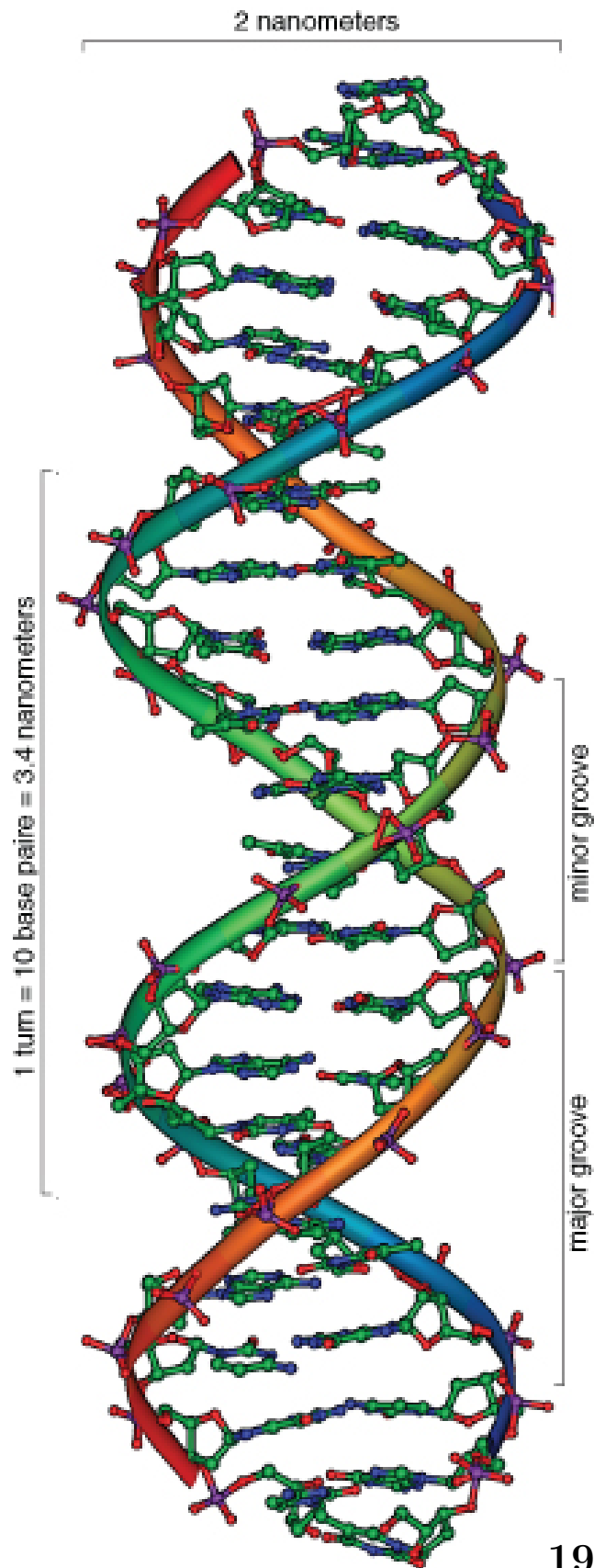
Activity

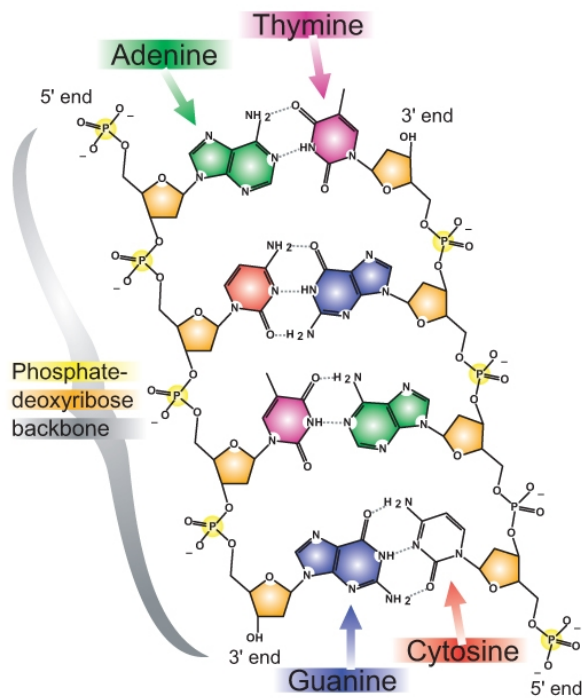
By taking the *Tour of the Basics* at the University of Utah's Genetics Learning Center (see URL below), students can review genes, chromosomes, and traits, which were introduced in other chapters, and also get an introduction to the structure of DNA.

- <http://learn.genetics.utah.edu/content/begin/tour/>

Use Visuals: Figure 6 and 7

Ask students to compare **Figure 6** and **Figure 7** (see below). Call on a volunteer to explain how the two figures are related to one another. (**Figure 7** shows a larger, more detailed version of a short section of the DNA molecule that is shown in **Figure 6**.) Make sure students can identify the sugar-phosphate backbones and bases in each figure. Review the rules for base pairing (adenine always bonds with thymine; guanine always bonds with cytosine). Then, in **Figure 7**, point out the hydrogen bonds that hold together complementary base pairs in the two DNA strands so students will understand why adenine always bonds with thymine and guanine always bonds with cytosine.





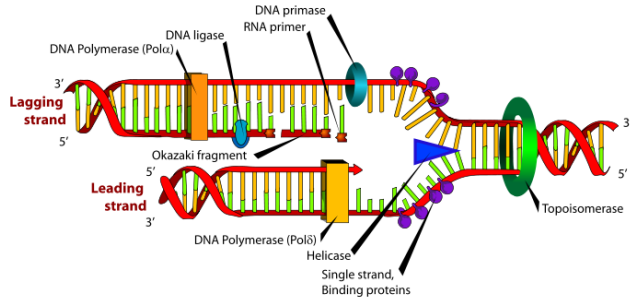
Activity

Have students build an edible model of DNA. This will help them learn the structure of DNA and how DNA bases pair. The URL below provides you with everything you and your students need for the activity.

- http://www.nclark.net/Have_Your_DNA_and_Eat_It_Too.pdf

Use Visuals: Figure 8

Use **Figure 8** (below) to explain how DNA replication occurs. Have students find each enzyme or other structure in the figure as you describe its role in replication. Focus especially on how the lagging strand is built, because this is the more complex part of the process. After you describe all the steps of replication, call on volunteers to summarize the entire process in their own words. Make sure students understand that the end result of replication is a pair of identical DNA molecules, each of which incorporates one strand of the original DNA molecule.

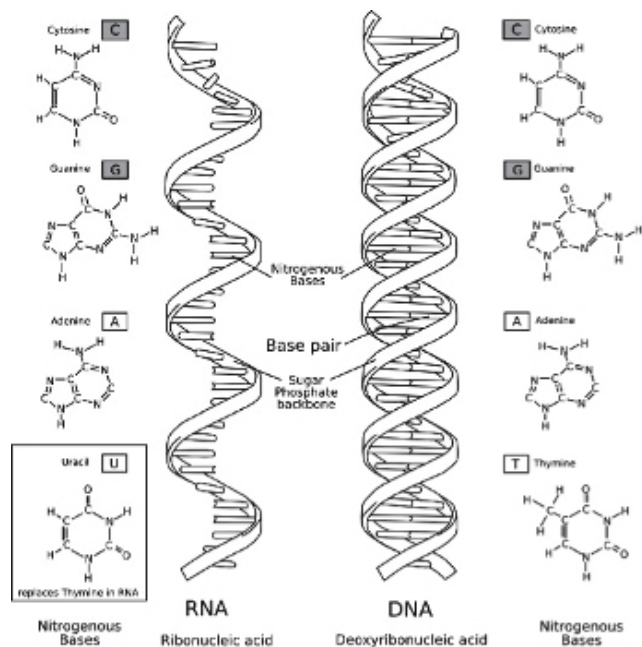


Differentiated Instruction: Venn Diagram

Pair less proficient readers with more proficient readers, and ask pairs to make a Venn diagram comparing and contrasting the structure and function of DNA and RNA. Suggest that they use **Table 1** and **Figure 9** (see below) as a guide. **LPR**

Table 11.4:

	RNA	DNA
Specific Base	single stranded contains uracil	double stranded contains thymine
Sugar	ribose	deoxyribose
Size	relatively small	big (chromosomes)
Location	moves to cytoplasm	stays in nucleus
Types	3 types: mRNA, tRNA, rRNA	generally 1 type



Enrichment: Web Site

Ask students who need extra challenges to create a Web site devoted to the discovery of DNA as the hereditary material, including the discovery of base-pairing rules and DNA's structure. The Web site should provide an overview of the topics and summarize the work of the scientists discussed in this lesson. It should also provide links with other sites that offer additional information about specific scientists and their discoveries. Encourage the entire class to visit the Web site as a way to review or learn more about the discovery of DNA and its role in inheritance.

Science Inquiry

Building a Model

Have small groups of students do the activity *Where Do Genes Begin?* (see URL below). In the activity, students will build a simple model of DNA, using colored construction paper. Then they will use their model to apply Chargaff's rules and investigate DNA sequencing.

- http://www.nclark.net/Watson_Crick_Model.pdf

Reinforce and Review

Crossword Puzzle

Assign the interactive crossword puzzle DNA at the URL below. The puzzle features hints and also the solution so students can check their own work.

- <http://www.waynesword.net/dnaxword.html>

Lesson Worksheets

Copy and distribute the four Lesson 8.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 8.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 8.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- “DNA → RNA” Can you think of a method in which the information in DNA is transferred to an RNA molecule?
- Can you hypothesize how the bases (A, C, G, and U) of RNA can code for the 20 amino acids of proteins?
- Can you develop a model in which the three types of RNA interact to make a protein.

Lesson Assessment

- Have students complete the Lesson 8.1 Quiz. An Answer Key is available upon request.

11.3 Lesson 8.2: Protein Synthesis

Key Concepts

Protein synthesis occurs in two main steps: transcription and translation. Transcription is the transfer of genetic “instructions” from DNA to RNA. It results in a complementary copy of mRNA, which is further processed before it leaves the nucleus. Translation is the transfer of the instructions in mRNA to a protein made of amino acids. This occurs at a ribosome (in the cytoplasm) and also involves rRNA and tRNA. The genetic code is the universal three-letter code in which the language of nucleotides is transcribed and translated into the language of amino acids.

Lesson Objectives

- Discuss the meaning of DNA \rightarrow RNA \rightarrow Protein.
- Describe how transcription makes RNA from a DNA template.
- Explain the various types of modification mRNA undergoes before translation.
- Discuss mRNA splicing and define introns and exons.
- Explain how the genetic code is a three-letter code, and describe its role in translating nucleotides into amino acids.
- Explain that a reading frame is the group of three bases in which the mRNA is read, and describe how interrupting the reading frame may have severe consequences on the protein.
- Discuss what is meant by the universal genetic code.
- Describe translation; explain that translation is the process of ordering the amino acids in a polypeptide; translation involves changing the language of nucleotides into the language of amino acids.
- Illustrate the process of translation, describing how mRNA, rRNA, and tRNA all work together to complete the process.
- Discuss what happens to the polypeptide after translation.

Lesson Vocabulary

Table 11.5:

Lesson 8.2 Vocabulary		
5 cap	A site	alternative splicing
E site	editing	elongation
exon	frameshift mutation	gene
genetic code	initiation	intron
P site	pre-mRNA	polyadenylation
reading frame	Rho-dependent termina- tion	ribosome
RNA polymerase termination	splicing transcription	spliceosome translation

Check Your Understanding

Recalling Prior Knowledge

Help students recall what they already know about the words transcription and translation.

- **Ask:** What do the terms transcription and translation mean as they are commonly used.

(Sample answer: Transcription means copying words; translation means changing words from one language to another.)

Tell the class that transcription and translation have similar meanings in the context of protein synthesis, which they will read about in this lesson.

Teaching Strategies

Activity

Divide the class into small groups and have each group do the activities *RNA Transcription* and *RNA Translation*, which can be accessed at the URL below. In the activities, students develop a model that shows how the sequence of bases in DNA determines the order of bases in mRNA. Then they determine the amino acid sequence encoded in the mRNA.

- http://serendip.brynmawr.edu/sci_edu/waldron/pdf/DNATeachPrep.doc

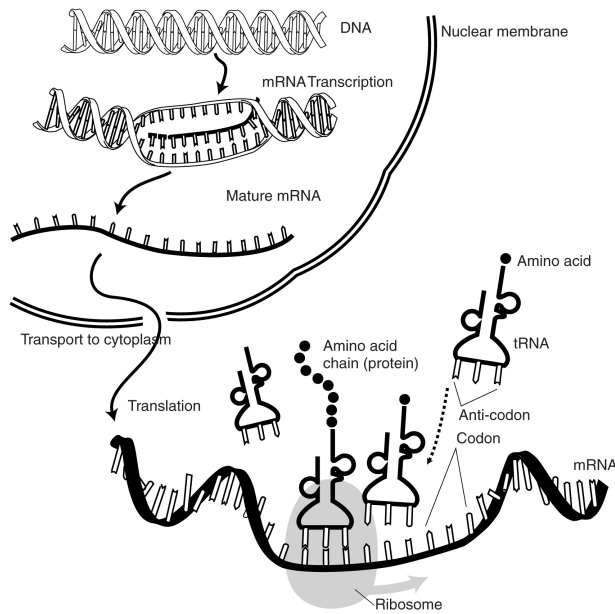
Demonstration

Have students watch the online animation *What Makes a Firefly Glow?* (see URL below). The animation demonstrates protein synthesis using as an example the enzyme that makes fireflies glow.

- <http://learn.genetics.utah.edu/content/begin/dna/firefly/>

Use Visuals: Figure 5

Call students' attention to **Figure 5** (shown below) when you discuss the process of translation with the class. Students can follow the process in the figure. This will be especially helpful for visual learners.



Activity

Have students do the activity *Say It with DNA: Protein Synthesis Tutorial* (see URL below). In the activity, students decode a secret message in a simulation of protein synthesis. They practice base-pair matching and follow the protein-synthesis sequence as it actually takes place inside cells.

- <http://www.indiana.edu/~ensiweb/connections/genetics/dna.les.html>

Activity

Engage the class in a role-playing activity in which students act out the steps of protein synthesis. Give each student an index card upon which is written a DNA codon, a messenger RNA codon, a transfer RNA anticodon, or the name of an amino acid. Assign one student to play the role of a ribosome, and designate different parts of the classroom as the nucleus and cytoplasm of the cell. Then, direct students to act out the processes of transcription and translation to make a protein. This is a good activity for kinesthetic learners.

Differentiated Instruction: Flowchart

Pair English language learners with native English speakers, and ask pairs to create a flow chart of protein synthesis, including both transcription and translation. Tell partners to sketch simple diagrams to illustrate the steps of the flow chart. Give them a chance to share their flow charts with the class. **ELL**

Enrichment: Demonstration

Provide students with materials such as white yarn or string, colored markers, scissors, and clear tape. Then challenge the students to devise a way to use the materials to demonstrate RNA splicing. Set aside time for the students to present their demonstration to the class.

Science Inquiry

Analyzing Data

Assign the activity *How Does DNA Determine the Traits of an Organism* (see URL below). Students will analyze DNA data for a fictitious organism named a snork and then, based on the DNA base sequence, determine the organism's traits. This fun activity can be done as a homework assignment.

- <http://www.biologycorner.com/worksheets/snorks.html>

Reinforce and Review

Quizzing a Partner

Ask each student to write five objective questions (multiple choice, true/false, and/or fill in) about the boldface vocabulary terms in the lesson. Then have students choose partners and use their questions to quiz each other on the terms.

Lesson Worksheets

Copy and distribute the four Lesson 8.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 8.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 8.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

We know what happens when everything goes right. The result is a correctly made protein that functions properly and maintains homeostasis.

- However, what happens when things do not go right? What can lead to a protein not being made correctly or not functioning correctly?
- Can you think of possible mechanisms that may interfere with protein synthesis?
- How can a change in the DNA sequence lead to a different protein?

Lesson Assessment

- Have students complete the Lesson 8.2 Quiz. An Answer Key is available upon request.

11.4 Lesson 8.3: Mutation

Key Concepts

Mutation is a change in the base sequence of RNA or DNA. It may be caused by such factors as chemicals in cigarette smoke, ultraviolet light, or nuclear radiation. Types of mutations include chromosomal aberrations (such as deletions and insertions) and point mutations. Germline mutations occur in gametes and can be inherited. Somatic mutations occur in body cells and cannot be inherited. Most mutations are not harmful and have no effect on fitness. Although few mutations are beneficial, evolution could not occur without them.

Lesson Objectives

- Define mutation.
- Describe common causes of mutation.
- Describe common types of mutation.
- Illustrate common chromosomal alterations.
- Discuss potential outcomes of point mutations.
- List and describe three common types of point mutations.
- Discuss consequences of effect-on-function mutations.
- Discuss the significance of germline and somatic mutations.
- Explain why some mutations are harmful and some are beneficial
- Discuss the saying, “Without beneficial mutations, evolution cannot occur.”

Lesson Vocabulary

Table 11.6:

Lesson 8.3 Vocabulary		
allele	beneficial mutation	cancer
carcinogen	chromosomal alterations	deamination
deletion	depurination	DNA ligase
dominant negative mutation	duplication	frameshift mutation
gain-of-function mutation	gene pool	genetic disorder
germline mutation	insertion	inversion
loss-of-function mutation	missense mutations	mutagen
mutation	nonsense mutation	oncogene

Table 11.6: (continued)

Lesson 8.3 Vocabulary		
point mutations	proto-oncogenes	silent mutations
somatic mutation	splice site mutation	tautomerism
transition	translocation	transversion
tumor suppressor gene		

Check Your Understanding

Drawing on Student Experiences

Call on volunteers to describe drastic mutations they have read about or seen in science fiction stories or movies, or describe examples yourself. Explain that the stories and movies are fictional and most mutations do not have such drastic effects, but mutations are nonetheless very important. In fact, they are essential for evolution to occur. Tell students they will learn more about mutations in this lesson.

Teaching Strategies

Activity

Assign the activity *Gene Mutations* at the Web site below. Students can see how gene mutations affect the production of proteins. The activity also demonstrates the difference between frameshift and point mutations.

- http://serendip.brynmawr.edu/sci_edu/waldron/pdf/DNATeachPrep.doc

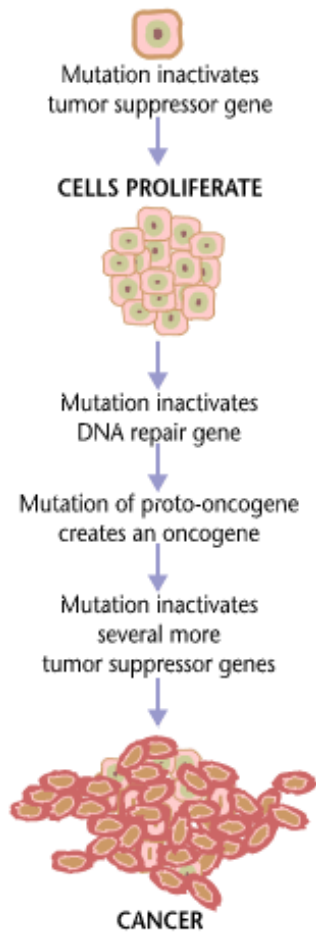
Activity

Assign the online activity *Mutations: Changing the Genetic Code*. In this activity students can simulate the influence of different mutations on proteins.

- <http://molo.concord.org/database/activities/102.html>

Use Visuals: Figure 3

Use **Figure 3** to help students understand the complex issue of mutations and cancer. Work through the figure so students understand why a series of mutations typically must occur before cancer develops.



Differentiated Instruction: Compare/Contrast Table

Pair less proficient readers with more proficient readers, and ask partners to make a table comparing and contrasting the following types of mutations: deletions, insertions, duplications, inversions, translocations, and point mutations. **LPR**

Enrichment: Public Service Announcement

Ask a group of students to research and produce a public service announcement identifying common mutagens that may cause cancer and ways that people can reduce their exposure to them. If possible, have the students put their public service announcement online.

Science Inquiry

Making Observations

Have students do the online activity *Test Neurofibromin Activity in a Cell* (see URL below). After reading about the protein neurofibromin and its role in normal cell division, students predict how mutations in the gene for this protein might affect cell division. Then they use an interactive animation to test their prediction by observing the simulated effects of different mutations on cells as though seen through a microscope.

- <http://learn.genetics.utah.edu/content/begin/dna/neurofibromin/>

Reinforce and Review

Outlining the Lesson

Ask students to outline the lesson. This will help them organize and review lesson content. Suggest that they include the lesson headings and subheadings in their outline.

Lesson Worksheets

Copy and distribute the four Lesson 8.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 8.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 8.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Now that we have discussed DNA, protein synthesis, and mutations, can you think of a mechanism that allows different cell types to have different proteins?
- What about during development? Why does a developing embryo need different proteins at different times of development?
- We have discussed oncogenes and tumor suppressor genes. Can you think of a specific cellular mechanism in which defects in these genes lead to cancer?

Lesson Assessment

- Have students complete the Lesson 8.3 Quiz. An Answer Key is available upon request.

11.5 Lesson 8.4: Regulation of Gene Expression

Key Concepts

Gene regulation accounts for cells with different proteins and functions. The classic example of gene regulation during transcription is the lac operon in *E. coli*. More sophisticated organisms have more complex mechanisms of gene regulation. In eukaryotes, gene expression during development is regulated by homeobox and gap genes, which allow specific genes to be expressed in certain cells at the proper stage of development. In cancer, both oncogenes and tumor suppressor genes play an important role in gene regulation and cell proliferation.

Lesson Objectives

- Describe general mechanisms of gene expression.
- Differentiate between a cis-regulatory element and a trans-acting factor.
- Define a transcription factor.
- Define an operon.
- Describe how the lac operon regulates transcription.
- Describe the role of the TATA box.
- Express the importance of gene regulation during development.
- Describe the role of homeobox genes and gap genes.
- Discuss gene regulation in terms of the development of cancer.

Lesson Vocabulary

Table 11.7:

Lesson 8.4 Vocabulary		
activator	basal factor	cis-regulatory element
enhancer	G protein	gap gene
homeobox	homeobox genes	hox genes
initiation complex	lac operon	operator
operon	promoter	repressor
RNA polymerase	specificity factor	TATA box
transcription factor	zinc finger	

Check Your Understanding

Recalling Prior Knowledge

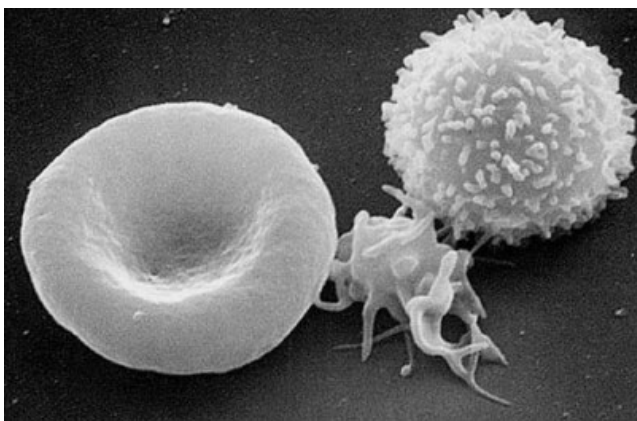
Build on the information about gene regulation from Lesson 8.3. First, remind the class that genes control the activities of cells and that all cells in an organism contain the same genes. Then, show students images of different types of human cells, such as blood cells and nerve cells (see below). Contrast the functions of the different cells.

- **Ask:** How can cells look and behave so differently if they have the same genes?

(Different genes are expressed in the different types of cells; get students to start thinking that different genes are “used” or “turned on” (expressed) in different cell types.)

Tell students they will learn in this lesson how the expression of genes is regulated.

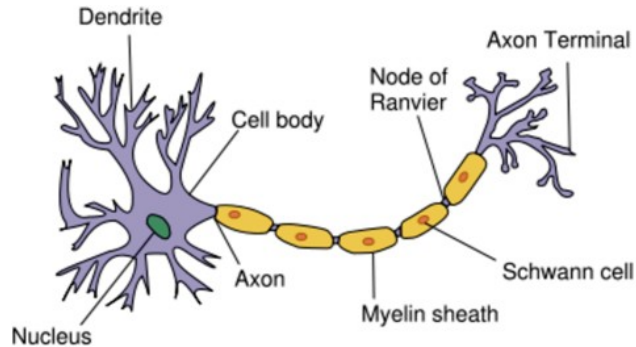
Cells of the Blood



From left to right: Red blood cell, platelet, white blood cell. The concave side of red blood cells can be seen. Both sides of red blood cells are concave. The biconcave shape gives the

red blood cells a smaller surface to volume ratio, which allows them to pick up large amounts of oxygen. From the *Circulatory and Respiratory Systems* Chapter.

Nerve Cell



The general structure of a neuron. Neurons come in many different shapes and sizes, but they all have a cell body, dendrites, and an axon. The cell body contains a nucleus and other organelles. However, not all neurons have a myelin sheath. From the *Nervous and Endocrine Systems* chapter.

Teaching Strategies

Demonstration

Suggest that students watch the online animation below. It demonstrates the lac operon mechanism for gene regulation.

- <http://www.dnatube.com/video/22/Lac-operon-mechanism>

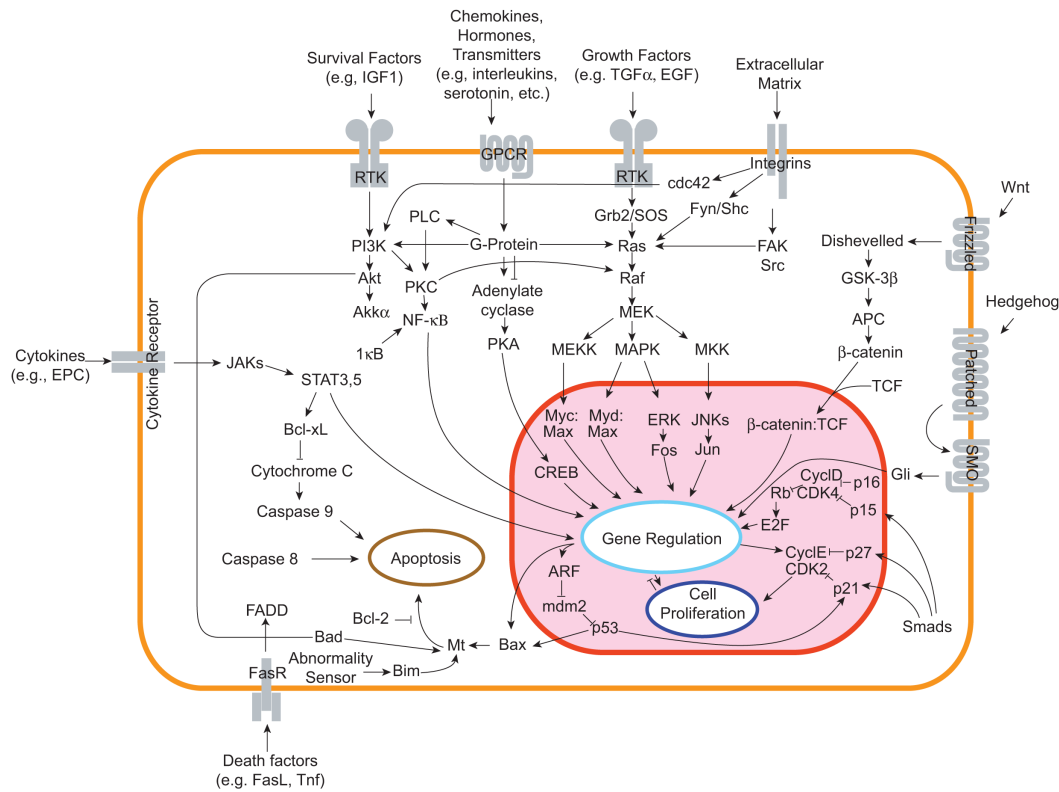
Activity

Ask small groups of students create models of gene regulation, using the lac operon mechanism as an example. Provide them with materials such as craft sticks, colored markers, dried beans or pasta, and modeling clay to construct their models. Give groups a chance to use their models to demonstrate gene regulation to the rest of the class.

Use Visuals: Figure 4

Have students look closely at **Figure 4** so they will have a better sense of the complexity of gene regulation. Work through a couple of the pathways as students follow along in the figure. For example, explain how Ras activates mitogen-activated protein kinases (MAPK),

which transmit signals downstream to other protein kinases and gene regulatory proteins. Discuss the outcomes of these pathways in terms of gene regulation and cell proliferation.



Signal transduction pathways. Ras (upper middle section) activates a number of pathways but an especially important one seems to be the mitogen-activated protein kinases (MAPK). MAPK transmit signals downstream to other protein kinases and gene regulatory proteins. Note that many of these pathways are initiated when a signal binds to its receptor outside the cell. Most pathways end with altered gene regulation and cell proliferation. The p53 tumor suppressor protein is shown at the lower section of the figure stimulating p21. The complexity of the pathways demonstrate the significant role these play in the cell.

Differentiated Instruction: Main Ideas/Details Chart

Pair less proficient readers with more proficient readers, and ask pairs to work together to make a main ideas/details chart for the lesson. Suggest that they try to write a main idea for each heading and subheading in the lesson and include at least one detail per main idea.

LPR

Enrichment: Research

This lesson focuses on transcriptional regulation of gene expression. Have interested students research translational regulation. Ask them to summarize at least one of the translational regulation mechanism, such as microRNA-mediated regulation, and present their summary to the class. Encourage them to make a diagram to help explain the mechanism.

Science Inquiry

Formulating a Hypothesis

Challenge groups of students to formulate a hypothesis for how the lac operon evolved. They should consider why it might be advantageous for an organism to be able to control the production of proteins that it needs only in certain situations, rather than produce the proteins all the time. Give groups a chance to share and discuss their hypotheses.

Reinforce and Review

Asking Questions

Have students write one question they have about lesson content. Collect their questions, and discuss the most significant or frequently asked questions with the class.

Lesson Worksheets

Copy and distribute the four Lesson 8.4 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 8.4 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 8.4 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- The next chapter is *Human Genetics*. Discuss why an understanding of human genetics is an important medical issue for our society.
- We have extensively discussed mutations and cancer. There are many other phenotypes due to mutations in the human genome. Why is understanding mutations in humans important?
- What do you think the Human Genome Project is? What could some implications of the Human Genome Project be?

Lesson Assessment

- Have students complete the Lesson 8.4 Quiz. An Answer Key is available upon request.

11.6 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 12

TE Human Genetics

12.1 Chapter 9: Human Genetics

Outline

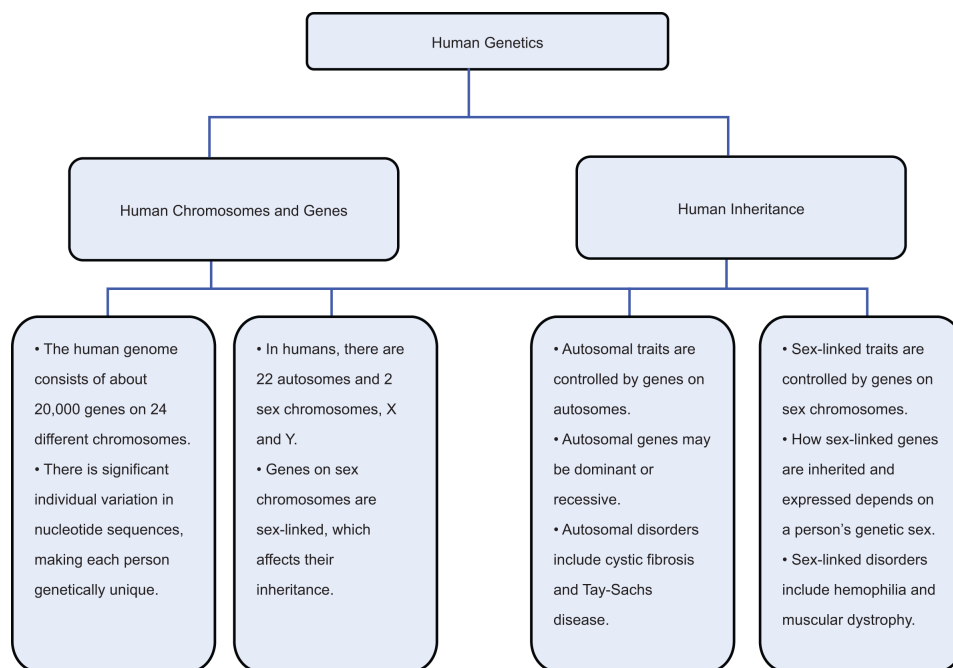
The chapter *Human Genetics* consists of two lessons that describe human genes, chromosomes, and patterns of inheritance.

- Lesson 9.1: Human Chromosomes and Genes
- Lesson 9.2: Human Inheritance

Overview

- The human genome consists of thousands of genes on 22 autosomes and 2 sex chromosomes. All humans have the same genes, but variation in nucleotide sequences makes each of us genetically unique and explains most human variation. Sex-linked inheritance is just one way that human inheritance patterns may be more complex than simple Mendelian inheritance.
- The concept map below provides a visual representation of how the chapter concepts are related.

Human Genetics concept map. (Source: CK-12 Foundation. CC-BY-SA)



Pacing the Lessons

Use the table below as a guide for the time required to teach the lessons of this chapter.

Table 12.1:

Lesson	Number of Class Periods*
9.1 Human Chromosomes and Genes	1.5
9.2 Human Inheritance	2.5

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

- Human Inheritance Lab: Students determine their own phenotypes and genotypes for several readily observable traits, ranging from tongue rolling to PTC tasting. Students calculate the percentage of the class that have each trait. The lab requires PTC test strips but no other special materials. (Lesson 9.2)

<https://www.delsearegional.us/Academic/Classes/highschool/science/mnicastro/Labs%20Academic%20B>

- Human Inheritance and Pedigree Analysis: This lab is similar to the Human Inheritance Lab described above but also includes a component in which students work with pedigrees. (Lesson 9.2)

<http://www.mrulichslandofbiology.com/Labs/Lab-HumanInheritanceandPedigreeAnalysis.pdf>

- Using Blood Tests to Identify Babies and Criminals: Students learn the genetics of the ABO blood type system, and use simple chemicals and logic to solve problems of identification based on blood type. (Lesson 9.2)

http://serendip.brynmawr.edu/sci_edu/waldron/#blood

Common Misconceptions

One Gene-One Trait

Students commonly hold the misconception that single genes are the cause of most genetic traits and inherited disorders. Be sure to spend time discussing polygenic traits, and give students several examples of human traits and disorders that are polygenic, such as height, skin color, and certain cancers.

Genetic vs. Hereditary Disorders

Students commonly confuse genetic disorders with hereditary disorders. While many disorders have a genetic component, they are not necessarily hereditary. Explain that a disorder is genetic if people with a certain genotype are more likely to develop the disorder. Whether they actually develop the disorder will depend on other genes they inherit, their environment, and other factors. A disorder is hereditary only if people who inherit a certain genotype always develop the disorder. Many types of cancer are genetic diseases. If you inherit certain genes, you are more likely to develop these types of cancer. However, few cancers are hereditary. It is rare for a specific gene to always cause cancer when it is present.

Managing Materials

The following items are needed to teach the strategies and activities described in the Teachers Edition(TE) of the FlexBook for this chapter.

Table 12.2:

Lesson	Strategy or Activity	Materials Needed
9.2	Activity	Materials for displays, such as poster board, markers, scissors, and rubber cement

Other Web Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- Human Genetics: This online chapter contains useful links and images relating to many of the same topics as this chapter of the FlexBook.

<http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookhumgen.html#TableofContents>

- National Human Genome Research Institute: This Web site links you and your students to the history, achievements, and current undertakings of the Human Genome Research Project.

<http://www.genome.gov/>

- Human Genetic Variation: This curriculum supplement for high school biology covers the basics of human genetics and its relationship to disease. It includes several student activities.

http://science-education.nih.gov/Customers.nsf/HSGenetic?OpenForm&CS_11=

- Human Genetics: This Web site provides teaching ideas and classroom activities for several human genetic disorders.

<http://www.usoe.k12.ut.us/CURR/Science/core/bio/genetics/home%20page.htm>

- Genetic Disease Information: This Web site provides a great deal of information on specific human genetic disorders.

http://www.ornl.gov/sci/techresources/Human_Genome/medicine/assist.shtml

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons of this chapter, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the *Human Genetics* chapter, students should have read the *Mendelian Genetics* and *Molecular Genetics* chapters.
- It is recommended that you include both lessons of *Human Genetics* in the FlexBook.

12.2 Lesson 9.1: Human Chromosomes and Genes

Key Concepts

Scientists have produced a reference sequence of the entire human genome. The human genome consists of 22 pairs of autosomes and one pair of sex chromosomes. Sex-linked genes are located on sex chromosomes.

Lesson Objectives

- What is a genetic disease?
- What is the human genome?
- Discuss the importance of characterizing the human genome.
- Define autosome and sex chromosome.
- Discuss the importance of SNPs.
- What is a karyotype?
- Define sex-linked and X-inactivation.

Lesson Vocabulary

Table 12.3:

genetics	genetic disease	geneticist
genetic counselor	genome	chromosome
proteome	linkage	SNPs
repetitive sequences	microsatellite	minisatellite
VNTR	sex chromosomes	autosome

Table 12.3: (continued)

genetics	genetic disease	geneticist
karyotype	sex-linked disease	SRY
X-inactivation	Barr body	

Check Your Understanding

Drawing on Student Experiences

Help students recall what they know from popular media about DNA testing. Discuss the role that DNA testing plays in solving criminal cases.

- Ask: What does DNA testing show?

(Sample answer: An individual's genetic makeup.)

- Ask: Why does DNA evidence usually provide definitive evidence of identity?

(Sample answer: No one else has exactly the same DNA as you.)

Teaching Strategies

Use Visuals: Figure 2

Students often confuse the concepts of genes, chromosomes, and DNA. Have them study **Figure 2**, which shows how the concepts are different but related. Call on volunteers to describe the visual in words and point out how they would indicate a gene in the diagram. Call on other students to revise any incorrect or confusing statements. Make copies of the Exons and Introns diagram below, and distribute them to students. Remind students of the definitions of introns and exons. Use this diagram to explain how the exons and introns of genes are related to the DNA molecule in **Figure 2**.

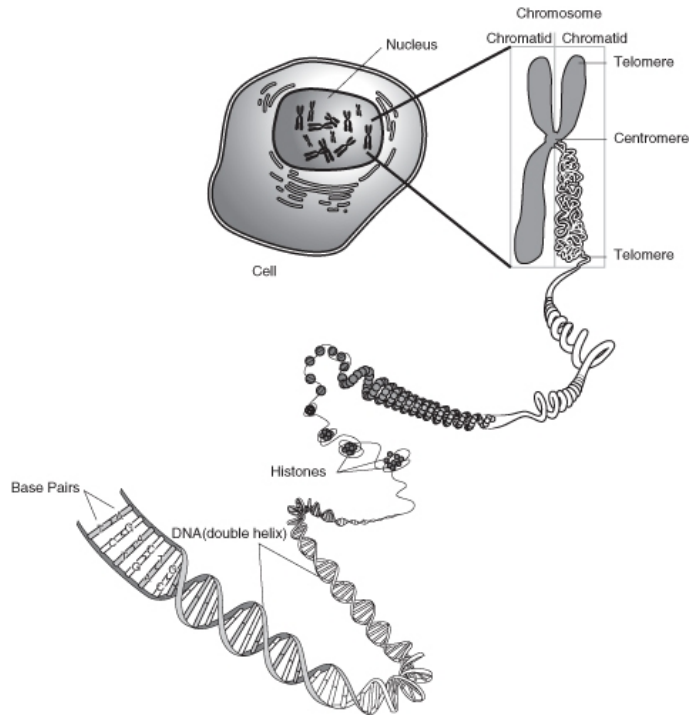


Figure 2 The human genome has 23 pairs of chromosomes located in the nucleus of somatic cells. Each chromosome is composed of genes and other DNA wound around histones (proteins) into a tightly coiled molecule.

[Insert Exons and Introns diagram, shown in a slightly modified form below, from <http://en.wikipedia.org/w>]

Discussion

The Human Genome Project provides an opportunity to discuss the collaborative nature of scientific endeavor and the incredible feats that scientific collaboration can achieve. Have students learn more about the Human Genome Project at the Web sites below. Then discuss the project with the class as an example of the role of collaboration in the advancement of scientific knowledge. Also discuss the importance of this landmark achievement.

http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml

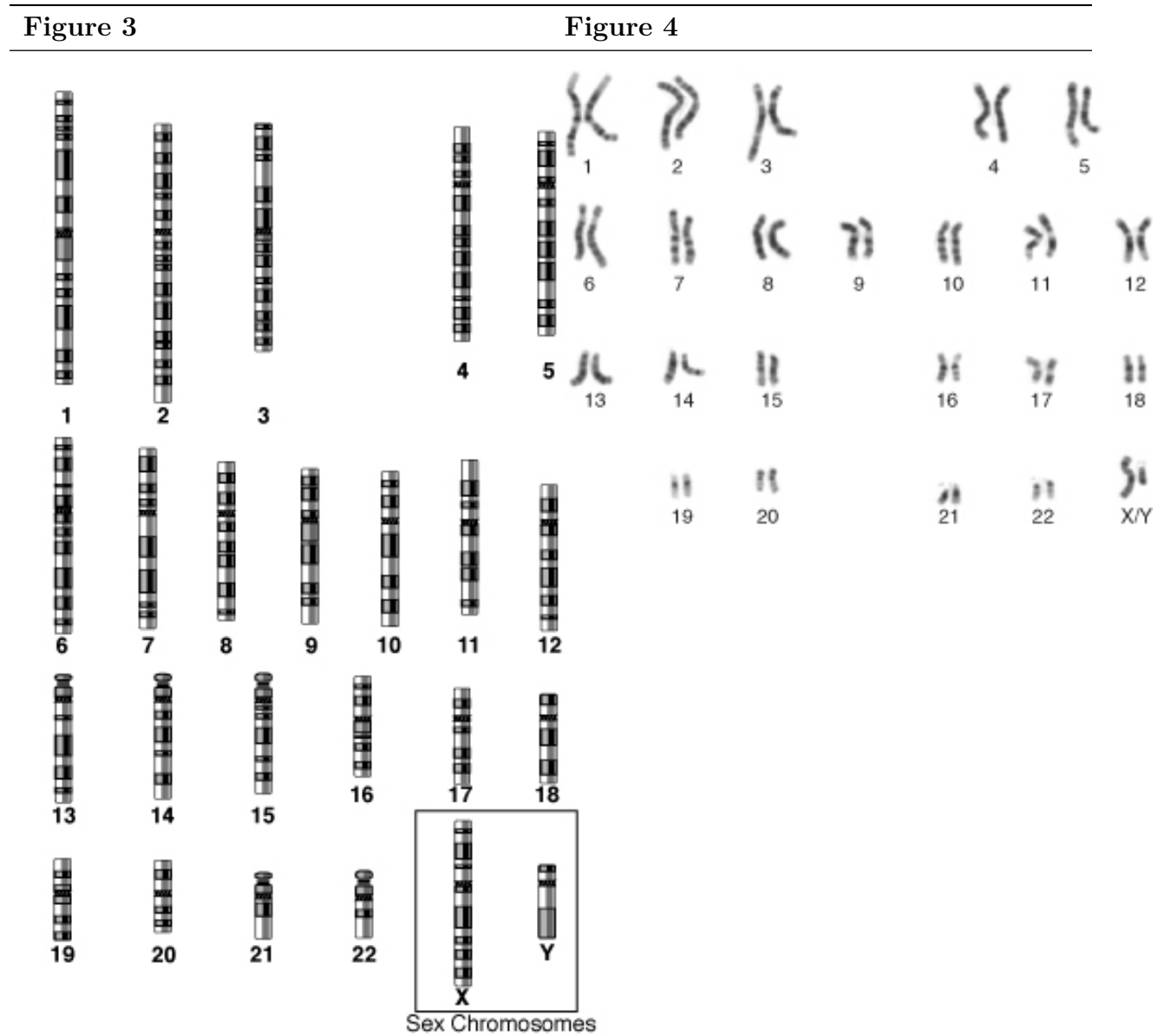
<http://www.genome.gov/10001772>

Use Visuals: Figures 3 and 4

Explain how **Figures 3** and **4** (below) are related. Make sure students understand that **Figure 3** shows one copy of each chromosome, while **Figure 4** shows two copies of each

chromosome. Describe how each type of chromosome image was made and why they look different. Have students answer the **Figure 4** caption question. (It is from a male - has both an X and Y chromosome.)

Table 12.4:



The 24 human chromosomes. The autosomes are numbered 1 - 22, based on size, with chromosome 1 being the largest. The X and Y sex chromosomes are shown in the box.

A karyotype of the human genome. Is this from a male or female?

Differentiated Instruction: Main Ideas/Details Chart

Pair less proficient with more proficient readers, and ask pairs to create a main ideas/details chart of lesson concepts. They should first skim each passage to identify main idea sentences. Then they should carefully read the passage to find important details. **LPR**

Enrichment: Teaching a Topic

Have interested students learn about spectral karyotyping and then teach the topic to the class. The Web site below is a good place for them to start. Ask the students to share colored images of spectral karyotypes with the class and explain this method of karyotyping. They should also discuss advantages of spectral karyotyping over traditional methods.

http://www.biology.arizona.edu/human_bio/current/new_karyotyping/new_karyotyping.html

Science Inquiry

Problem Solving

Science often runs into ethical, social, and legal issues. Our ability to extract an individual's DNA is no exception. For example, who owns a person's DNA? How can people keep their own DNA private? Students can address these problems by doing the activity **See Your DNA** (see URL below). In the activity, they extract DNA from their own cheek cells, using readily available materials and simple lab equipment. After they obtain their own DNA, they draft a policy statement about DNA ownership and privacy.

http://www.pbs.org/wgbh/nova/teachers/activities/2809_genome.html

Reinforce and Review

Quizzing a Partner

Ask students to write at least three true/false questions on lesson content. Then have them use their questions to quiz a partner. Students should consult their FlexBook to resolve any points of disagreement.

Lesson Worksheets

Copy and distribute the four Lesson 9.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions and Answers

Have students answer the Lesson 9.1 Review Questions that are listed at the end of the lesson in their FlexBook. Sample answers to these questions will be provided upon request at teacher-requests@ck12.org.

1. What is a genetic disease? (**Beginning**)
2. Discuss the main difference between autosomal and sex-linked traits. (**Beginning**)
3. Why is variation within the human genome important? (**Challenging**)
4. Why is it more common for males to have X-linked disorders? (**Intermediate**)
5. Describe how a mutation can lead to a genetic disease. (**Intermediate**)
6. Discuss how a new mutation can become a new dominant allele. (**Challenging**)
7. How are autosomal traits usually inherited? Give examples of autosomal traits. (**Intermediate**)
8. How are genetic diseases usually inherited? Are there exceptions? Research examples. (**Challenging**)

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 9.1 in their FlexBook. Then, discuss the questions with the class.

- How are traits inherited? How about the inheritance of genetic disorders? Are inheritance patterns of traits and disorders similar?
- Could simple Mendelian inheritance account for such complex traits with vast phenotypic variation such as height or skin color? What do you think?

Lesson Assessment

- Have students complete the Lesson 9.1 Quiz. An Answer Key is available upon request.

Human Genetics: Lesson 9.1 Quiz

Name _____ Class _____ Date __-_____

Multiple Choice

Circle the letter of the correct choice.

1. All the hereditary information encoded in human DNA makes up
 - D. a single DNA molecule
 - C. a karyotype
 - B. one chromosome
 - A. the genome

2. The human genome consists of
 - D. none of the above
 - C. 46 pairs of chromosomes
 - B. 23 pairs of chromosomes
 - A. 23 chromosomes

3. A threadlike molecule of genes and other DNA wound around proteins makes up
 - D. a phenotype
 - C. a genome
 - B. a chromosome
 - A. a base pair

4. All animals have the same
 - D. genetic code
 - C. sequence of DNA bases
 - B. genes on their chromosomes
 - A. number of chromosomes

5. Only genetic males know for certain that their
 - B. Y chromosome has been inactivated
 - D. X chromosome has been inactivated
 - C. Y chromosome comes from their mother
 - A. X chromosome comes from their mother

6. Which sentence is true about sex chromosomes?
 - D. They are found in most sexually reproducing species.

- C. They are found only in humans.
- B. They are found only in females.
- A. They are found only in sex cells.

7. Which parts of a chromosome code for proteins?

- D. regulatory sequences
- C. intergenic regions
- B. introns
- A. exons

8. About how many protein-coding genes do humans have?

- D. 20,000
- C. 2,000
- B. 200
- A. 20

9. Multiple proteins can be made from the same gene by the process of

- D. genes mutating
- C. cells dividing
- B. alternative splicing
- A. exon excising

10. Proteins are important organic molecules consisting of many amino acids. Proteins and genes are closely related. Which statement about proteins and genes is false?

- D. Mutated genes may produce proteins that do not work.
- C. Each gene codes for one amino acid of a protein.
- B. Humans have many more proteins than genes.
- A. Most genes code for proteins.

11. Genes that are close together on the same chromosome are

- D. all of the above
- C. likely to segregate together during meiosis
- B. usually inherited together
- A. called linked genes

12. Assume that you are trying to identify an unknown individual. All you know is that the individual has an X chromosome. What does this piece of information tell you?

- D. The individual also has a Y chromosome.
- C. The individual has sex-linked genes.
- B. The individual is male.
- A. The individual is female.

13. By examining a karyotype, you would be able to identify

- D. large chromosomal abnormalities
- C. individual gene mutations
- B. dinucleotide repeat polymorphisms
- A. single nucleotide polymorphisms

14. Which chromosome contains the fewest genes?

- D. Y chromosome
- C. X chromosome
- B. chromosome 2
- A. chromosome 1

15. The process called X-inactivation occurs

- D. early in life
- C. only in boys
- B. in all children
- A. at puberty

True or False

Write true if the statement is true and false if the statement is false.

- _____ 16. Homo sapiens normally have 23 pairs of autosomes.
- _____ 17. Only males inherit an X chromosome from their mother.
- _____ 18. The human genome is much larger than the genomes of other species.
- _____ 19. The X chromosome has fewer genes than the Y chromosome.
- _____ 20. A karyotype shows an individual's chromosome complement.

Fill in the Blanks

Fill in the blank with the term that best completes the sentence.

21. The human genome consists of 24 distinct _____.
22. Any chromosome other than a sex chromosome is a(n) _____.
23. A person who inherits two X chromosomes is genetically _____.
24. The complete set of proteins expressed by a genome is known as a(n) _____.
25. Substitution in just one DNA base results in a _____ polymorphism.
26. Short tandem repeats are a type of _____ polymorphism.
27. In a karyotype, autosomes are arranged on the basis of their _____.
28. Your genetic sex is determined by the sex chromosome you inherit from your _____ - _____.
29. The Y chromosome gene that determines sex is known as _____.
30. X-inactivation creates a _____ in every cell.

Short Answer

Answer each question in the space provided.

31. Explain how the human proteome can be much larger than the human genome.

-
-
-
-

32. How does linkage influence inheritance?

-
-
-
-

33. Compare and contrast autosomes and sex chromosomes.

-
-
-
-

34. Explain how you could use a karyotype to determine an individual's genetic sex.

-
-
-
-

35. If females inherit two X chromosomes, why do most of their cells have just one functional X chromosome?

-
-
-
-

12.3 Lesson 9.2: Human Inheritance

Key Concepts

Pedigrees can be used to analyze how human traits are inherited. Inherited traits can be either autosomal or sex-linked. They can also be: dominant, codominant, incompletely dominant, or recessive. Traits can be controlled by a single gene or by many genes. Multiple alleles, pleiotropy, and epistasis add more complexity to human inheritance. Genetic disorders may be caused by mutations in genes or chromosomes. Genetic diseases can be diagnosed, and treatments are being developed. Some day, gene therapy may be able to cure many genetic disorders.

Lesson Objectives

- Describe the difference between a genetic trait and a genetic disease/disorder.
- Define the various modes of inheritance, focusing on the differences between autosomal and sex-linked.
- Give examples of dominant and recessive genetic disorders.
- Discuss the inheritance of sex-linked traits.
- Discuss complex inheritance patterns.
- Define codominant alleles and give examples.
- Define incomplete dominance.
- Give examples of multiple allele traits.
- Discuss how a trisomy condition may be detected.
- What is Down syndrome?

- List some examples of phenotypes due to abnormal numbers of sex chromosomes.
- Discuss the importance of gene therapy.
- Describe the most common method of gene therapy.

Lesson Vocabulary

Table 12.5:

sex chromosomes	autosome	sex-linked traits
mutation	autosomal dominant disorder	autosomal recessive disorder
X-linked disorder	Y-linked disorder	pedigree
cystic fibrosis (CF)	Tay-Sachs disease	phenylketonuria (PKU)
achondroplasia	hemophilia	muscular dystrophy
Duchenne muscular dystrophy (DMD)	codominance	incomplete dominance
multiple allele traits	pleiotropy	epistasis
polygenic traits	nondisjunction	trisomy
trisomy 21	Klinefelter's syndrome	trisomy X
genetic counselor	genetic counseling	prenatal diagnosis
amniocentesis	chorionic villus sampling (CVS)	gene therapy
severe combined immunodeficiency (SCID)		

Check Your Understanding

Drawing on Student Experiences

Call on a volunteer to demonstrate tongue rolling. (From past experience, students with this trait are likely to be aware of it.) Explain that the inheritance of tongue rolling is an example of autosomal dominant inheritance. Tell students they will learn about this and other types of inheritance when they read this lesson.

Teaching Strategies

Activity

Ask students to do a quick class survey of at least two visible dominant traits, such as widow's peak and freely hanging earlobes, which are shown in **Figures 1** and **2** (see below). Have

students make a table showing all the possible genotypes and corresponding phenotypes for the traits. Then have them calculate the class frequency of each form of the traits and add the frequencies to the table. As an alternative to this activity, you can assign one of the two human inheritance labs described in the TE chapter opener (see URLs below).

<https://www.delsearegional.us/Academic/Classes/highschool/science/mnicastro/Labs%20Academic%20B>

<http://www.mrulichslandofbiology.com/Labs/Lab-HumanInheritanceandPedigreeAnalysis.pdf>

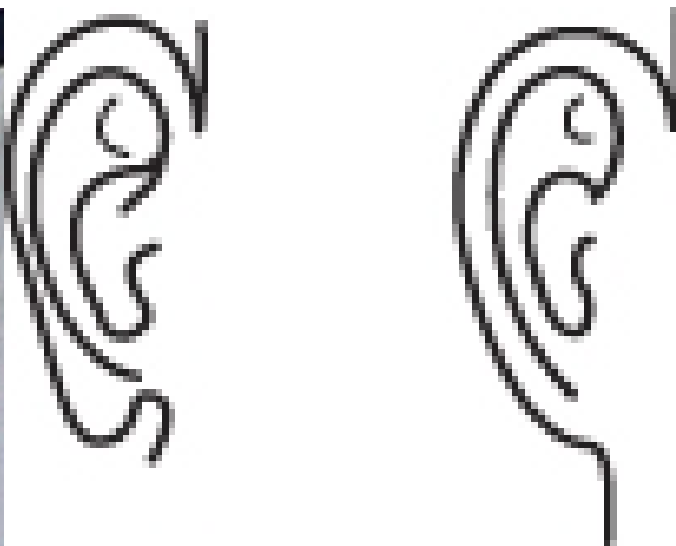
Table 12.6:

Figure 1



A young woman with a widow's peak, due to a dominant allele.

Figure 2



A diagram showing free (left) and attached (right) earlobes. Attached earlobes is a recessive trait.

Build Science Skills: Making a Model

Explain that a pedigree is a model of inheritance. (Refer to *Mendelian Genetics* chapter.) Then ask groups of students to make a hypothetical pedigree for a particular inheritance pattern. Have groups examine each other's pedigrees and try to identify the inheritance pattern they represent (dominant, recessive, autosomal, sex-linked).

Build Science Skills: Comparing and Contrasting

Ask students to collaborate on a classroom display that compares and contrasts autosomal and sex-linked inheritance. The display should use diagrams (such as pedigrees and Punnett squares) and images (such as pictures of people with the traits) to show the similarities and differences between the two types of inheritance. You can use the displays as visual aids when you teach the lesson.

Activity

Ask students to do an online simulation of human karyotyping, using digital images of chromosomes from actual human genetics studies (see URL below). The activity requires students to complete karyotypes by matching chromosomes and then use the karyotypes to identify genetic disorders.

http://www.biology.arizona.edu/human_bio/activities/karyotyping/karyotyping.html

Differentiated Instruction: Venn Diagram

Pair beginning ELL students with more advanced ELL students, and have partners make a Venn diagram comparing and contrasting autosomal and sex-linked inheritance. A sample Venn diagram is shown below. **ELL**

[inset figure of sample Venn diagram]

Enrichment: Interview

Ask a few students to interview members of their community who are professionally involved in preventing, diagnosing, and/or treating genetic disorders. Interviewees to consider might include genetic counselors, geneticists (physicians or professors), or representatives of foundations such as the March of Dimes or Cystic Fibrosis Foundation. Students should prepare for the interview by brainstorming a list of questions about genetic disorders. Tell them to take notes during the interview and report back to the class on the main points.

Science Inquiry

Problem Solving

Challenge students with one or more activities at the Web sites below. In the activities, students apply basic principles of sex-linked inheritance to solve genetics problems.

www.ck12.org

http://www.biology.arizona.edu/mendelian_genetics/problem_sets/Sex_linked_Inheritance/sex_linked_inheritance.html

http://www.biology.arizona.edu/human_bio/problem_sets/color_blindness/color_blindness.html

Reinforce and Review

Completing a Chart

Make untitled copies of the pedigree at the URL below, or copy the pedigree onto the board. Ask students to identify the mode of inheritance represented by the pedigree and add the correct title to the chart. (X-linked recessive inheritance.)

<http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=gene&part=glossary&rendertype=box&illus-226>

Lesson Worksheets

Copy and distribute the four Lesson 9.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions and Answers

Have students answer the Lesson 9.2 Review Questions that are listed at the end of the lesson in their FlexBook. Sample answers to these questions are provided below.

1. What is a genetic disease? (**Beginning**)
2. Discuss the main difference between autosomal and sex-linked traits. (**Beginning**)
3. Why is variation within the human genome important? (**Challenging**)
4. Why is it more common for males to have X-linked disorders? (**Intermediate**)
5. Describe how a mutation can lead to a genetic disease. (**Intermediate**)
6. Discuss how a new mutation can become a new dominant allele. (**Challenging**)
7. How are autosomal traits usually inherited? Give examples of autosomal traits. (**Beginning**)
8. How are genetic diseases usually inherited? Are there exceptions? Give examples. (**Beginning**)
9. Discuss the difference between codominance and incomplete dominance. Give examples.

(Intermediate)

10. What is meant by trisomy? How can trisomy phenotypes be detected? **(Beginning)**
11. What is the most common viable trisomy disorder? **(Beginning)**
12. List conditions involving an abnormal number of sex chromosomes. **(Beginning)**
13. Why is genetic counseling important? **(Challenging)**
14. What is gene therapy? **(Beginning)**
15. Describe the most common approach to gene therapy. **(Challenging)**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 2 in their FlexBook. Then, discuss the questions with the class.

In this chapter, we discussed human genetics as it is involved in human health. In the next chapter, we will discuss biotechnology. With gene therapy, we can see how biotechnology will play a significant role in society's future.

- Can you speculate on the role of biotechnology in our future?
- What other roles for biotechnology do you envision?
- Why is biotechnology important?

Lesson Assessment

- Have students complete the Lesson 9.2 Quiz. An Answer Key is available upon request.

Human Genetics: Lesson 9.2 Quiz

Name _____ Class _____ Date __-____-____

Multiple Choice

Circle the letter of the correct choice.

1. Which of the following is a recessive autosomal trait?

D. cleft chin

- C. almond-shaped eyes
 - B. attached earlobes
 - A. widow's peak
2. If a child with two healthy parents inherits an autosomal genetic disorder from the parents, what type of disorder is it likely to be?
- D. trisomic
 - C. codominant
 - B. recessive
 - A. dominant
3. An example of an autosomal dominant disorder is
- D. achondroplasia
 - C. phenylketonuria
 - B. Tay-Sachs disease
 - A. cystic fibrosis
4. All of the following are recessive X-linked conditions except
- D. hemophilia A
 - C. red-green color blindness
 - B. sickle cell anemia
 - A. Duchenne muscular dystrophy
5. Cystic fibrosis is a genetic disease that mainly affects the
- D. liver and muscular system
 - C. kidneys and immune system
 - B. lungs and digestive system
 - A. heart and reproductive system
6. Which sentence about Tay-Sachs disease is true?
- D. Tay-Sachs disease is very mild.
 - C. Tay-Sachs disease is X-linked.
 - B. Tay-Sachs disease is not inherited.
 - A. Tay-Sachs disease is very rare.

7. Why must people with PKU eat a low-phenylalanine diet?
- D. All of the above.
 - C. People with PKU develop mental retardation if they eat phenylalanine.
 - B. People with PKU cannot metabolize phenylalanine in the diet.
 - A. People with PKU lack the enzyme phenylalanine hydroxylase.
8. People with hemophilia have a problem with
- D. fat metabolism
 - C. mucus production
 - B. blood coagulation
 - A. muscle wasting
9. Why do more males than females have red-green color blindness?
- D. It is fatal in females.
 - C. It is an X-linked trait.
 - B. It is a dominant trait.
 - A. It is a Y-linked trait.
10. Stem length in pea plants is controlled by alleles with incomplete dominance. If you crossed a long-stemmed pea plant with a short-stemmed pea plant, what stem length(s) would you expect in the offspring?
- D. All of the offspring would have short stems.
 - C. All of the offspring would have medium length stems.
 - B. Three quarters of the offspring would have long stems.
 - A. All of the offspring would have long stems.
11. Which sentence about multiple allele traits is true?
- D. Multiple allele traits are also called polygenic traits.
 - C. It is rare for human traits to be controlled by multiple alleles.
 - B. An example of a multiple allele trait is ABO blood type.
 - A. An individual can have more than two alleles for this type of trait.
12. Which of the following is not a polygenic trait in humans?
- D. hemophilia

- C. skin color
- B. eye color
- A. height

13. Trisomy occurs as a result of

- D. pleiotropy
- C. immunodeficiency
- B. nondisjunction
- A. epistasis

14. Which of these abnormal genotypes produces a biological male?

- D. None of the above.
- C. XXY
- B. XXX
- A. XO

15. Which technique is used to detect genetic problems in a developing fetus?

- D. Genetic counseling.
- C. Selective reverse mutation.
- B. Homologous recombination.
- A. Chorionic villus sampling.

True or False

Write true if the statement is true and false if the statement is false.

- _____ 16. All mutations have significant phenotype effects.
- _____ 17. A pedigree can help determine the inheritance pattern of a trait.
- _____ 18. All the sons of a man with a Y-linked disorder will also have the disorder.
- _____ 19. There is no known way to screen for phenylketonuria.
- _____ 20. Most human genes have just one allele.

Fill in the Blanks

Fill in the blank with the term that best completes the sentence.

- 21. _____ is a method of detecting DNA abnormalities using amniotic fluid.

22. The ABO blood group genotype AB produces an AB phenotype because the A and B alleles are _____.
23. Heterozygotes have intermediate phenotypes when there is _____ dominance of alleles for a gene.
24. A trait controlled by a gene with more than one possible allele is called a(n) _____-_____ trait.
25. _____ refers to one gene having multiple effects on the phenotype.
26. When one gene affects the expression of another gene, this is called _____.
27. A trait controlled by more than one gene is known as a(n) _____ trait.
28. The failure of replicated chromosomes to separate properly during meiosis is called _____.
29. _____ refers to the presence of an extra chromosome in a person's cells.
30. A(n) _____ is a chart that represents genetic inheritance in a family.

Short Answer

Answer each question in the space provided.

31. X-linked traits seem to skip generations. For example, children of a man with an X-linked recessive disorder are unlikely to have the disorder, but the disorder is likely to show up in the man's grandsons. Explain why.

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-

32. Contrast dominance, codominance, and incomplete dominance.

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33. Describe and give an example of a multiple allele trait and a polygenic trait.

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34. Explain how nondisjunction could result in an embryo with three sex chromosomes, XXY.

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-
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35. How has gene therapy been used successfully to treat children with severe combined immunodeficiency?

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-
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Chapter 13

TE Biotechnology

13.1 Chapter 10: Biotechnology

Outline

The chapter *Biotechnology* consists of two lessons that introduce standard techniques of biotechnology and their practical application.

- Lesson 10.1: DNA Technology
- Lesson 10.2: Biotechnology

Overview

- This chapter introduces the concepts of gene cloning and genetic engineering and their application to solving medical and agricultural problems. The Human Genome and the Human Genome Project are also discussed.
- The concept map below provides a visual representation of how the chapter concepts are related.

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 13.1:

Lesson	Number of Class Periods*
10.1: DNA Technology	2.0
10.2: Biotechnology	2.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for Biotechnology and are available online:

- Bacterial Transformation: This laboratory, which is located on the Dolan DNA Learning Center's website, leads students through gene cloning techniques. This versatile unit can be done as a wet lab or as a virtual lab. In this lab, two genes are transformed into bacteria: Green Fluorescent Protein (GFP) and an antibiotic resistance gene. A set of tabletop icons directs site visitors to sections on background, student protocols, results, resources, applications, further exploration, and printable documents. An additional set of seven topics is available by clicking on icons on the whiteboard. http://www.dnalc.org/labcenter/transformation/transformation_h.html
- PCR Virtual Lab: This virtual laboratory, created by the Genetic Science Learning Center at the University of Utah, is amazingly fun and interactive. Students can virtually manipulate a micropipettor to pipet the reaction components into microcentrifuge tubes in ice buckets. Once they set up the reaction, they drag the tube into the thermocycler. Then animations detail each step of numerous PCR cycles. The virtual lab comes complete with sound effects. <http://learn.genetics.utah.edu/content/labs/pcr/>

Common Misconceptions

Opinions on the Safety of Transgenic Plants

Currently, 85% of the corn, 88% of the cotton, and 91% of the soy grown in the United States is transgenic (2009 data from the USDA; files available at <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1000>). Any one who eats any processed food at all has almost certainly ingested transgenic plants. The safety of transgenic plants is a highly debated topic; however, transgenic crops have been grown safely for over a decade in the United States and are regulated by the United States Department of Agriculture (USDA), Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). For a current summary of the pertinent issues, see the USDA's website at [http:](http://)

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 13.2:

Lesson	Strategy or Activity	Materials Needed
10.1	1. Differentiated Instruction: Gallery Walk 2. Enrichment: Making a Video	1. Large paper for questions and answers; bright wide-tipped markers 2. Video camera; cables for transferring video to computer
10.2	1. Differentiated Instruction: Think-Pair-Share	1. Flashcards for writing answers

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching *Biotechnology*:

The Howard Hughes Medical Institute (HHMI) website contains over two-dozen DNA animations. The following animations are especially apt for students studying biotechnology.

- Genetic engineering: This 72-second clip animates a three-dimensional representation of restriction enzyme digestion of plasmid DNA and subsequent ligation of the sticky ends; however, transformation of the plasmid DNA into bacteria is glossed over and not thoroughly explained.<http://www.hhmi.org/biointeractive/dna/animations.html>
- Human Genome Sequencing: This movie, which is less than 2 minutes long, explains the strategy used by scientists to sequence the human genome. There is a clever analogy in the clip that will help students grasp the vastness of the human genome.<http://www.hhmi.org/biointeractive/dna/animations.html>
- The Polymerase Chain Reaction: In this 87-second animation, 3D models of the template DNA, primers, nucleotides, and Taq polymerase demonstrate the denaturation, annealing, and extension steps that comprise the Polymerase Chain reaction (PCR).<http://www.hhmi.org/biointeractive/dna/animations.html>

- How to Make a Transgenic Plant: An outline of how transgenic plants are created is part of Colorado State University's website on transgenic plants. An animation accompanies the description. <http://cls.casa.colostate.edu/TransgenicCrops/how.html>
- The Human Genome: The Blueprint of Humanity: Offers many interactive sites, quizzes, and information related to the human genome. <http://library.thinkquest.org/C0125833/english/introduction.php>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to choose the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter or certain lessons in this chapter in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook.

- To understand the content of *Biotechnology*, students should have read the chapters *Mendelian Genetics*, *Molecular Genetics*, and *Human Genetics*.
- It is recommended that you include all the lessons of *Biotechnology* in the FlexBook.

13.2 Lesson 10.1: DNA Technology

Key Concepts

Biotechnology is technology based on biological applications. Biotechnology combines many features of biology, including genetics, molecular biology, biochemistry, embryology, and cell biology, and many aspects of biotechnology center around DNA and its applications, otherwise known as DNA technology. These applications - taking basic scientific discoveries and turning them into helpful products, include gene cloning and the sequencing of the human genome. Many of these applications use a revolutionary, Nobel prize winning technique, PCR.

Lesson Objectives

- What is meant by DNA technology?
- What is the Human Genome Project?
- Describe the goals of the Human Genome Project.
- Describe gene cloning and the processes involved.
- What is PCR?
- Describe the processes involved in PCR.

Lesson Vocabulary

Table 13.3:

Lesson 10.1 Vocabulary		
biotechnology	Human Genome Project (HGP)	Genbank
single nucleotide polymorphisms (SNPs)	gene cloning	recombinant DNA
restriction enzyme	restriction endonuclease	plasmid
DNA ligase	transfection	gel electrophoresis
polymerase chain reaction (PCR)	<i>Taq</i> polymerase	

Check Your Understanding

Drawing on Student Experiences

Ask your students if they know anyone, or of anyone, who has diabetes and who takes insulin to manage their blood glucose levels. (*Remind your students that there is no need for them to indicate exactly whom it is they know with diabetes.*) Explain that the insulin is a product of biotechnology and that they will be learning about the techniques used to produce insulin in this lesson.

Teaching Strategies

Activity: Restriction Enzymes

Explain to your students that over 900 restriction enzymes have been discovered thus far (<http://www.accessexcellence.org/AE/AEC/CC/restriction.php>). Most have been isolated from bacteria. They protect the bacteria from viral infections by cleaving the viral DNA, thus rendering the virus incapable of reproducing. Each enzyme cleaves a specific nucleotide sequence called the recognition sequence. For more background on restriction enzymes, see New England Biolabs website http://www.neb.com/nebecomm/tech_reference/restriction_enzymes/overview.asp

The following activity will help your students better understand restriction enzymes, and will reinforce the concept of complementary base pairing introduced in the *Molecular Genetics* chapter.

Here is a list of 3 restriction enzymes and their recognition sequences:

Table 13.4:

<i>EcoRI</i>	5' G A A T T C 3'
<i>HindIII</i>	5' A A G C T T 3'
<i>BamHI</i>	5' G G A T C C 3'

- For each enzyme, ask your students to write the sequence of the complementary strand in the recognition sequence. Label the 3' and 5' ends.

Answers:

Table 13.5:

<i>EcoRI</i>	3' C T T A A G 5'
<i>HindIII</i>	3' T T C G A A 5'
<i>BamHI</i>	3' C C T A G G 5'

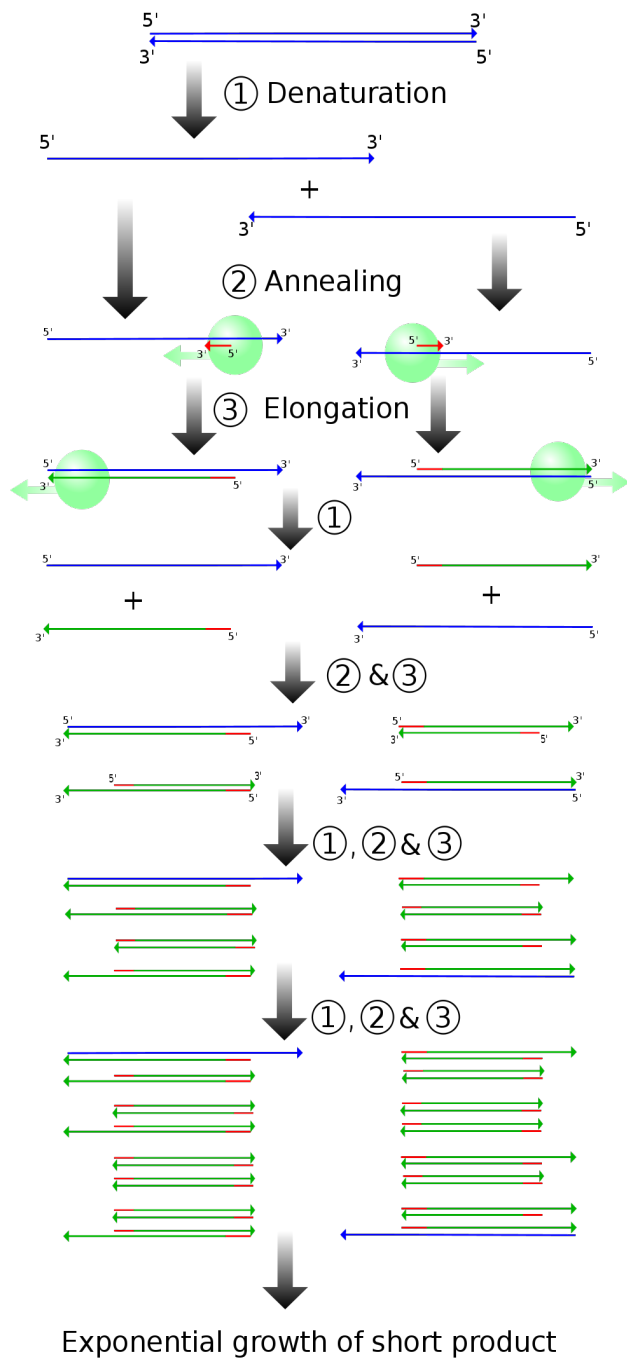
- Ask your students to write the sequence complementary to the strand below. Next, ask them to match the restriction enzyme from the above list with the DNA sequence below that contains it.

Table 13.6:

5' CCTAGATAACCTAGGATCCTCGGC- GATAG 3'	(<i>BamHI</i>)
5' AAATGAATTCCCTTGCTCGCT- TAAGGTCAA 3'	(<i>EcoRI</i>)
5' ATCCCGGTGCAATGCGCGT- TAAAGCTTAGA 3'	(<i>HindIII</i>)

Using Visuals: Figure 6 (PCR)

Use **Figure 6** (PCR) to review some of the basic concepts of molecular biology and chemistry: the antiparallel structure of double stranded DNA, complementary base pairing, hydrogen bonding versus covalent bonding and enzyme activity. Explain each step (denaturation, annealing, and extension) of each of the three stages of a PCR cycle.



PCR: A repeating cycle of denaturation (1), annealing (2), and extension (3). Notice that initially there is a double strand of DNA, and after denaturation, the DNA is single stranded. In the annealing step (2), single stranded primers bind. These primers are extended by Taq Polymerase, represented by the green ball (3).

Differentiated Instruction: Gallery Walk

For this activity, divide your class into groups of 2-4 students. Pair advanced readers with less proficient readers, and pair special needs students with complementary group members. All groups then walk around the room to read and discuss posted questions (each on a large sheet of paper). These could include some of the lesson review questions, such as “What is PCR?,” or questions such as, “What is the Human Genome Project?” Each group (using a different color pen) answers the questions as best as they can. They also read and respond to answers written by other groups. This is followed by your discussing the answers with the class and reviewing any misunderstandings they reveal. **LPR, SN**

Enrichment: Creating a Video

Advanced students seeking enrichment activities can work either individually or in groups to create a PowerPoint presentation/video that explains one of the lesson topics. Sample topics are The Human Genome Project, DNA sequencing, Gene cloning, or The Polymerase Chain Reaction.

Science Inquiry

Formulating a Hypothesis

Restriction enzymes serve as a form of immunity for bacteria. Specifically, when a virus infects a bacterium, the bacterium’s restriction enzyme(s) can prevent viral replication by cleaving the viral DNA. Ask your students to formulate a hypothesis as to why the bacterial restriction enzymes do not cleave the bacterium’s DNA. Ask them to brainstorm possible ways to test their hypotheses. (There are many possible hypotheses, but in fact, restriction enzymes do not cut bacterial DNA because it is methylated at certain sites. See the section on DNA methylation at http://www.neb.com/nebecomm/tech_reference/restriction_enzymes/dam_dcm_cpg_methylation.asp for more information.

Reinforce and Review

Review the Lesson

Either you or a student leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Flashcards

In this lesson, there are many biotechnology concepts and vocabulary words. Instruct your students to make flashcards for this lesson's boldface vocabulary words. On index cards, students can write the word on one side and the definition on the other side. Then instruct your students to quiz a partner using the flashcards they have just made.

Lesson Worksheets

Copy and distribute the four Lesson 10.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 10.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 10.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- The Human Genome Project, gene cloning, and PCR are some of the most remarkable scientific achievements of the recent past. But how can these milestones make our lives better?
- Medicine and food science are just two of the categories that benefit from biotechnology. Speculate on how our lives are made better by these achievements.

Lesson Assessment

- Have students complete the Lesson 10.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

13.3 Lesson 10.2: Biotechnology

Key Concepts

Biotechnology will have a tremendous impact on our future. Applications of biotechnology in medicine, agriculture, and forensic science are just a few of the fields which will benefit from biotechnology.

Lesson Objectives

- Describe various applications of biotechnology as related to medicine, agriculture and forensic science.
- How is DNA technology related to genetic testing and prenatal diagnosis?
- Why is biotechnology so important in agriculture?
- Why is DNA analysis the most important tool of the forensic scientist?
- Describe forensic STR analysis.
- Discuss some of the ELSI associated with biotechnology.

Lesson Vocabulary

Table 13.7:

Lesson 10.2 Vocabulary		
pharmacogenomics	prenatal screening	prenatal diagnosis
preimplantation genetic diagnosis	transgenic crops	Bt toxin
transgenic animals	genetic fingerprinting	DNA fingerprinting
microsatellites	short tandem repeats (STRs)	STR profile
CODIS	restriction fragment length polymorphisms	Southern blot
ESLI		

Check Your Understanding

Drawing on Student Experiences

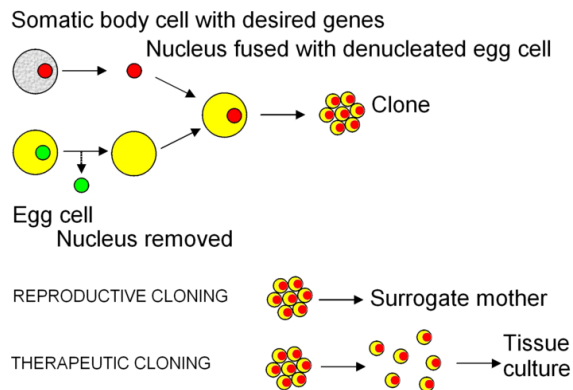
In Lesson 10.1, your students learned about the Polymerase Chain Reaction (PCR), which is a fundamental technique in the biotechnology laboratory. Lesson 10.2 focuses on biotechnol-

ogy applications. Ask your television-watching students who are CSI fans if they can recall any episodes in which PCR was used to identify a suspect or clinch a case. Ask volunteers to comment on the use of PCR in these episodes. Inform your students that in Lesson 10.2, they will learn about biotechnological applications in medicine, agriculture, and forensic science.

Teaching Strategies

Using Visuals: Figure 11

Use **Figure 11** as a tool to explain reproductive cloning to your students. It is also an apt time to review the definition of a genome (all of the genetic information (DNA) in a cell or organism). Remind your students that in humans a gamete such as an egg has a haploid genome (N or one chromosome of each type). Review the fact that a somatic cell, which is any non-gametic cell, has a diploid genome ($2N$ or two chromosomes of each type, one maternal and one paternal). Once you have reviewed these genetic concepts, the students will be better equipped to understand how the replacement of a haploid egg nucleus (green in the figure), with a diploid somatic nucleus (red in the figure), can lead to a diploid clone.



Reproductive cloning: The nucleus is removed from a somatic cell and fused with a denucleated egg cell. The resulting cell may develop into a colony of cloned cells, which is placed into a surrogate mother. In therapeutic cloning, the resulting cells are grown in tissue culture; an animal is not produced, but genetically identical cells are produced.

Viewing a Video

It is likely that not all of your students know about PCR through media such as television or the Internet. This video, which is narrated by Dr. Richard Saferstein, former Chief Forensic Scientist at the New Jersey State Police Laboratory, explains the utility of DNA and PCR in forensic science. <http://www.videojug.com/interview/csi-and-dna-2>

Building Science Skills: Predicting

An individual's DNA can be compared to an unknown sample DNA by STR analysis. Since the number of STRs at 13 loci or more can be compared, this analysis calculates the probability that 2 DNA samples are a match. This is a good activity in which to review STRs, forensic DNA analysis, and meiosis, if necessary.

- Ask your students to predict (and defend their predictions) the probabilities of an STR match in the following cases:

1. Identical twins.

(There is a near 100%, but not 100% chance that identical twins will match at all of the loci analyzed. The reason is that there can be mutations in one or more STRs during development of each individual. Students may say 100%, and that is acceptable.)

2. Same-sex siblings.

(Because of the independent assortment of the 23 pairs of human chromosomes during meiosis, there is almost no chance that two siblings will match at all of the STR loci, if sufficient loci are analyzed. On average, same sex siblings are 50% genetically identical.)

(For additional information see: Forensic science: an introduction to scientific and investigative techniques. Edited by Stuart H. James, Jon J. Nordby. 2005, 2nd ed. Boca Raton: CRC Press: p 297).

Differentiated Instruction: Think-Pair-Share

Genetically engineered plants or transgenic plants are widely grown in the United States. Ask each of your students to think about the following question: How are traditionally bred crops the same as genetically engineered crops? How are they different? After each student individually ponders this question, you can group the students in pairs: ELL students with native speakers, LPR students with more proficient readers, and SN students with typically developing students. Pairs can work together on answering the questions. (**ELL, LPR, SN**)

(Some sample answers: They are alike in that humans choose which plants to cross (breed) with one another, and select plants with specific traits. They also differ. In traditional breeding, the breeders often do not know the molecular sequence of the traits for which they are selecting. In contrast, in genetic engineering, the scientists know the exact gene sequence they are putting into the plant.)

Enrichment: Interview

Students seeking additional enrichment can learn more about biotechnology by interviewing a scientist. The interview can be by phone, web-videoconferencing, or in person. Students can work in pairs. They will need to 1) choose a specific biotechnology topic of interest, 2) decide from whom to request an interview, 3) contact the person to set up the interview, 4) If the person agrees, set up a time and date for the interview (if the person declines or is traveling, students will need to repeat step 2), 5) brainstorm a list of questions; open-ended questions are better than yes or no questions, 6) devise a way to record (or video, if possible) the interview 7) conduct the interview 8) present a transcript or highlights of the interview to the class.

Science Inquiry

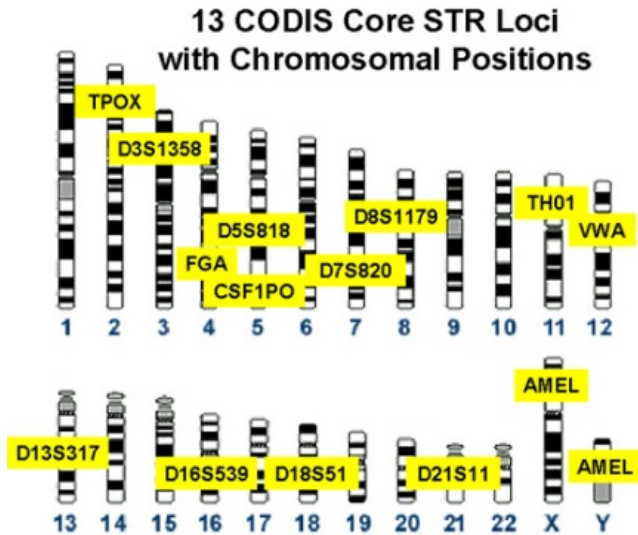
Asking a Question

Many species of animals have been cloned, including sheep and cows. Ask your students if they think that there are any advantages to cloning animals compared to simply breeding animals. (Knowledge that all genes and traits should be identical to the original animal.) Also ask them if they predict any disadvantages. (A large number of cloned animals will all have the same susceptibility to disease. Thus a particular pathogen could infect and kill the entire group, whereas in a genetically heterogeneous group, some animals would likely be resistant to that pathogen and survive.)

Reinforce and Review

Making a Drawing

Ask your students to create a sketch to demonstrate their understanding of the STRs. The students should first put away any FlexBook materials. Once they make the diagram, they can check it against **Figure 12** in the FlexBook. Of course, there are a number of different ways to describe STRs in a drawing. The names and locations of the CODIS STRs are not as important as the understanding of what an STR is and how it is used.



The CODIS loci analyzed by STR analysis. Notice they are spread over 14 chromosomes, and that two are on the X and Y chromosomes.

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Lesson Worksheets

Copy and distribute the four Lesson 10.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 10.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 10.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Can you hypothesize on the relationship between genetics and evolution?
- Why is an understanding of the principals of DNA and inheritance essential to understand evolution?

Lesson Assessment

- Have students complete the Lesson 10.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

13.4 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 14

TE History of Life

14.1 Chapter: History of Life

Outline

The chapter *History of Life* consists of three lessons that introduce students to the history of life on Earth and how it is studied.

- Lesson 11.1 Studying the History of life
- Lesson 11.2 Early Life
- Lesson 11.3 Multicellular Life

Overview

- The fossil record provides evidence for the evolution of life on Earth, beginning almost four billion years ago. The earliest living things were simple single-celled organisms. Over time, complex multicellular life forms gradually evolved.
- The concept map below provides a visual representation of how the chapter concepts are related.

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 14.1:

Lesson	Number of Class Periods*
11.1 Studying the History of Life	2.0
11.2 Early Life	1.0
11.3 Multicellular Life	3.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

Shells on the Mountain Top?

In this lab, students remove fossils from sediments, classify them by major groups of organisms (e.g., mammals, fish), and draw conclusions about the relative ages of the organisms. (Lesson 11.1)

- <http://www.accessexcellence.org/AE/AEPC/WWC/1995/shells.php>

Using Amino Acid Sequences to Show Evolutionary Relationships

Students compare amino acid sequences in five different globin molecules and then construct a phylogenetic tree to represent evolutionary relationships based on the sequences. (Lesson 11.1)

- http://www.accessexcellence.org/AE/AEPC/WWC/1995/simulation_amino.php

Eukaryotic and Prokaryotic Feast

Students observe prepared slides of prokaryotes and eukaryotes to identify organelles in the evolution of prokaryotes to eukaryotes (endosymbiotic theory). (Lesson 11.2)

- <http://www.accessexcellence.org/AE/AEPC/WWC/1995/prokfeast.php>

Where Should We Place Archaeopteryx?

In this interactive computer lab, students examine features of various groups of animals to decide where an extinct animal (Archaeopteryx) should be placed phylogenetically. (Lesson 11.3)

- <http://www.accessexcellence.org/AE/AEPC/WWC/1995/wheresould.php>

Time Machine

This role-playing lab simulates time travel to the beginning of planet Earth. On the trip, students “witness” the origin of life and key events in the evolution of life on Earth. (Lesson 11.3)

- <http://www.indiana.edu/~ensiweb/lessons/time.mac.html>

Common Misconceptions

Evolution and the Origin of Life

Some students may have the misconception that evolution is a theory about the origin of life. Make sure they understand that evolution is a theory about how life changed once it began. Although evolutionary biologists are interested in how life began, it is not the main focus of biological evolution. Similarly, not knowing how life began does not throw into doubt the fact that evolution has occurred and is still taking place.

Evolution Means Striving and Progress

The idea that evolution is a conscious striving for perfection is a common misconception. Explain to the class that organisms do not try to evolve new traits. Also explain that evolution helps organisms adapt to changing environments—not become perfect—and that so-called “lower” organisms may be better adapted to their environments than so-called “higher” organisms. Point out that some groups of organisms, including cockroaches and sharks, have changed very little for millions of years because their traits are adequate for them to survive and reproduce.

Evolution Happens by Chance

Students may believe that all processes of evolution occur by chance. Explain that some chance events are important in evolution (e.g., mutations) but that natural selection, which is the major driver of evolutionary change, does not occur by chance. It selects organisms that have traits that make them better suited for their particular environment. For example, the streamlined body shape of aquatic mammals such as dolphins evolved because it made these animals better able to survive and reproduce in their aquatic environment.

Managing Materials

The materials listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 14.2:

Lesson	Strategy or Activity	Materials Needed
11.1	<ol style="list-style-type: none">1. Demonstration2. Activity3. Science Inquiry: Building a Model	<ol style="list-style-type: none">1. About 5 meters of nylon cording2. Handouts, graphs, and fossil shell cutouts (from web site); scissors; colored pencils or water-based markers (five different colors).3. Handouts (from web site), paper clips or clothes pins, five colors of ribbon each at least 5 feet long, masking tape, calculator.
11.3	<ol style="list-style-type: none">1. Differential Instruction: Gallery Walk2. Science Inquiry: Building a Model	<ol style="list-style-type: none">1. Several large sheets of paper, tape.2. Three flowers (real or artificial), three test tubes or small plastic bottles in different lengths, straws or coffee stirrers (3 per student), scissors, juice or water, large block of Styrofoam (optional).

Additional Web-Based Resources

You may find these additional web-based resources helpful when teaching this chapter:

- Chronology of Evolution: The highly respected Access Excellence Web site provides a useful chronology of evolutionary science at the URL below. The chronology ranges from Plato to the Human Genome Project. http://www.accessexcellence.org/AE/AEPC/WWC/1995/cron_evol.php

- Issues in Evolution: This web site provides original articles, scientist interviews, links, and other materials that may benefit both teachers and students who want more in-depth information about many of the issues presented in the chapter. <http://www.actionbioscience.org/evolution/>
- Evolution: At the URL below, you can access a wide variety of useful activities, labs, and links relating to biological evolution. <http://www.nclark.net/Evolution>
- The History of Life: You can locate classroom activities, labs, and links relating to the history of life by visiting the web site below. <http://www.nclark.net/HistoryLife>
- Understanding Evolution for Teachers: This is an excellent Web site for anyone who teaches evolution. It includes lesson plans, a history of evolutionary thought, common misconceptions, and other useful resources. <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html> <http://evolution.berkeley.edu/evosite/evohome.html> <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html>
- For more information on particular topics, visit the web site below. It is a multi-authored encyclopedia on the history of life on Earth. http://www.palaeos.org/Main_Page
- Origins of Life Animation Trailer

http://animation.mirage3d.nl/index.php?option=com_content&task=view&id=33&Itemid=52

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons of this chapter, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the chapter *History of Life*, students should have read the chapter *Foundations of Life Science*.
- Students should read the *History of Life* chapter before they read the remaining chapters on evolution.
- If you incorporate the chapter *History of Life* in your FlexBook, it is recommended that you include all three lessons of the chapter.

14.2 Lesson 11.1: Studying the History of Life

Key Concepts

Paleontologists use the fossil record and molecular clocks to understand evolutionary relationships and reconstruct the tree of life. The geologic time scale marks major events in Earth's history. The history of life is characterized by repeated mass extinctions and episodes of rapid speciation. Major theories of evolutionary change include gradualism, punctuated equilibrium, and quantum evolution, each of which may apply to different events in Earth's evolutionary past. Patterns of evolution include divergent evolution, convergent evolution, coevolution, and coextinction.

Lesson Objectives

- Use the conditions required for fossilization to explain why fossils are rare.
- List and give examples of different types of fossils.
- Discuss the way in which index fossils contribute to our understanding of the history of life.
- Compare relative dating of fossils and rock layers to absolute dating.
- Explain why “carbon dating” is an inadequate description of the aging of rocks and fossils.
- Describe how molecular clocks clarify evolutionary relationships.
- Compare and contrast geologic time with absolute time. Include limits of each.
- Sequence the levels of organization of the geologic time scale from largest to smallest.
- Arrange the four major eons and one supereon from youngest to oldest.
- Describe and interpret the differences in fossil abundance throughout the geologic time scale.
- Distinguish macroevolution from microevolution and explain their relationship.
- Describe the general pattern of the fossil record to support Darwin's idea that all life descended from a common ancestor.
- Evaluate the role of mass extinctions and episodic speciation in evolution.
- Identify types of major environmental change in Earth's history and relate them to patterns in the fossil record.
- Analyze ways in which the geologic time scale may give false impressions of the history of life.
- Discuss rates of macroevolution and speciation, comparing and contrasting the ideas of gradualism, punctuated equilibrium, and quantum evolution.
- Compare and contrast adaptive radiation (divergent evolution) and convergent evolution.
- Indicate some changes in geography that influenced evolution.
- Use patterns of evolution and environmental change to account for worldwide differ-

- ences in the distribution of mammals (placentals vs. marsupials).
- Define and give examples of coevolution.

Lesson Vocabulary

Table 14.3:

Lesson 11.1 Vocabulary		
absolute aging	adaptive radiation	coevolution
coextinction	convergent evolution	divergent evolution
eons	episodic speciation	extinction
fossils	geologic time scale	gradualism
index fossils	macroevolution	microevolution
molecular clocks	paleontologists	punctuated equilibrium
quantum evolution	trace fossils	

Check Your Understanding

Recalling Prior Knowledge

Encourage students to recall basic facts they may already know about Earth's history.

- **Ask:** How old is Earth? (About 4.5 billion years.)
- **Ask:** How long has there been life on Earth? (About 4 billion years.)

Tell students they will read in this lesson how scientists study Earth's history, including the history of life on Earth.

Teaching Strategies

Discussion

Make sure students understand the concept of evolution before they read this chapter. Provide a definition of evolution (e.g., biological change in organisms over time), and suggest that students record the definition in their science notebook. Stress the significance of evolution as a major theme underlying all of biology.

Activity

A good way to introduce fossils is to have students view the interactive animation Stories from the Fossil Record (see URL below). It is an interesting way for students to learn how fossils can be used to interpret the past.

- <http://www.ucmp.berkeley.edu/education/explorations/tours/stories/guide/index.html>

Activity

Assign the animated activity Virtual Age Dating at the web site below. Students will learn more about radioactive decay and radiometric dating of fossils and then simulate the collection and analysis of radiometric data. The activity includes questions for students to check their understanding as they proceed.

- <http://www.indiana.edu/~ensiweb/virt.age.html>

Demonstration

Construct a geologic timestring (see URL below) that students can refer to as they read about evolution in this and subsequent lessons. The timestring is a physical representation of the geologic time scale. It is a simple tool that will help students comprehend the immensity of Earth's history and how recently life evolved.

- http://www.accessexcellence.org/AE/AEPC/WWC/1995/geo_time.php

Activity

After you discuss gradualism and punctuated equilibrium, ask students to complete the activity **Macroevolution: Patterns, Trends, and Rates of Change** (see URL below). In the activity, students will examine and graph patterns of fossil sequences and will decide whether the patterns support a gradualism or punctuated equilibrium model of evolution.

- <http://www.indiana.edu/~ensiweb/lessons/macroev.html>

Differentiated Instruction: Word Wall

Have students start an evolution word wall. They should include the following vocabulary terms from this lesson: **adaptive radiation, coevolution, convergent evolution, divergent evolution, extinction, fossil, geologic time scale, gradualism, punctuated**

equilibrium, macroevolution, and microevolution. Students can add more words to the word wall as they read additional lessons and chapters on evolution. **LPR**

Enrichment: Research

Suggest that interested students research additional examples of divergent and convergent evolution that are not described in the lesson. Ask the students to share what they learn with the rest of the class.

Science Inquiry

Building a Model

For a better appreciation of the time scale of Earth's life history, have students do the activity Earth History: Time Flies, No Matter What the Scale (see URL below). In the activity, students place cartoon drawings of significant events in the history of life at the appropriate place on a ribbon timeline that models the geologic time scale. Then they relate the geologic time scale to an annual calendar and reassess the placement of events on the timeline. The link below provides background information, cartoons, student handouts, and an answer key.

- http://www.asm.org/index.php?option=com_content&view=article&id=90592&Itemid=520

Reinforce and Review

Outlining the Lesson

Suggest that students outline the lesson as a way to reinforce and review lesson content.

Lesson Worksheets

Copy and distribute the four Lesson 11.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 11.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 11.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Consider the range of tools used to study a history which no human could witness. These range from fossils—the actual remnants of living organisms—to comparisons of molecules within organisms still living today. Which tools do you consider most reliable? Does the fact that the information from one set of tools often confirms evidence collected using a different set of tools strengthen your acceptance of the data?
- Review the various patterns of macroevolution, from mass extinction to coevolution and coextinction. Which of these best support the depiction of evolution as a bush, rather than an arrow?
- Which support the idea that evolution builds on what already exists, so the more variety there is, the more there can be in the future?

Lesson Assessment

- Have students complete the Lesson 11.1 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

14.3 Lesson 11.2: Early Life

Key Concepts

Earth formed about 4.6 billion years ago. The first organic molecules may have formed around 4 billion years ago in the seas of early Earth, as demonstrated by Miller and Urey's famous experiment. The first cells were prokaryotes and probably emerged by 3.5 billion years ago. After photosynthesis evolved around 3 billion years ago, oxygen was added to

Earth's atmosphere, allowing oxygen-tolerant organisms to evolve and colonize the ocean surface and terrestrial habitats. The widely accepted endosymbiotic theory proposes that eukaryotes evolved when larger prokaryotes engulfed or were invaded by smaller, specialized prokaryotes. These then became the organelles of eukaryotic cells.

Lesson Objectives

- Relate the nature of science to our current understanding of the origin of life.
- Describe the formation of the atoms which build Earth and its life.
- Explain the formation of the moon, and its effects on Earth's conditions for life.
- Compare and contrast Earth's early atmosphere with today's atmosphere.
- Discuss the formation of Earth's early atmosphere and oceans.
- Indicate the age of Earth and identify supporting evidence.
- Interpret the importance of Miller and Urey's experiment.
- Relate the properties of phospholipids to the formation of the first membranes.
- Compare and contrast the genes-first model of the origin of life and the metabolism-first model.
- Explain why some scientists believe that RNA was the basis of early life.
- Evaluate the hypothesis that exogenesis explains the origin of life on Earth.
- Describe the theoretical characteristics of the first cell.
- Discuss the concept of LUCA, or Last Universal Common Ancestor.
- Indicate the origin of photosynthesis and its consequences for Earth's life and atmosphere.
- Analyze the effects of the development of atmospheric oxygen on life.
- Explain the importance of the emergence of cellular respiration.
- Explain the endosymbiotic theory of the origin of eukaryotic cells.
- Evaluate the evidence for the endosymbiotic theory.
- Identify the origins of the three major domains of life.
- Analyze the evolutionary potential of the eukaryotic cell.
- Discuss the pros and cons of the evolutionary tree as a way of depicting the evolutionary process.

Lesson Vocabulary

Table 14.4:

Lesson 11.2 Vocabulary		
endosymbiotic theory	genes-first model	LUCA
metabolism-first model	organic molecules	oxygen catastrophe
primeval soup	protocells	RNA world hypothesis

Check Your Understanding

Recalling Prior Knowledge

Tell the class that the atmosphere of early Earth was different from the present atmosphere. The early atmosphere was lacking a gas that is vital to almost all life on Earth today.

- Ask: What gas was missing from early Earth's atmosphere? (oxygen)

Tell students they will read in this lesson about this and other ways that early Earth differed from the present we know today, as well as how life originated.

Teaching Strategies

Activity

A good introduction to the history of life is provided by the short video Explore Life on Earth (see URL below). It traces the tree of life from the earliest existence to the present. An interactive option allows students to explore different parts of the tree of life in more detail.

- <http://www.wellcometreeoflife.org/>

Activity

Suggest to advanced students that they take the online tutorial From Soup to Cells: The Origin of Life. It provides AP-level coverage of the topic of life's origins.

- http://evolution.berkeley.edu/evolibrary/article/0_0_0/origsoflife_01

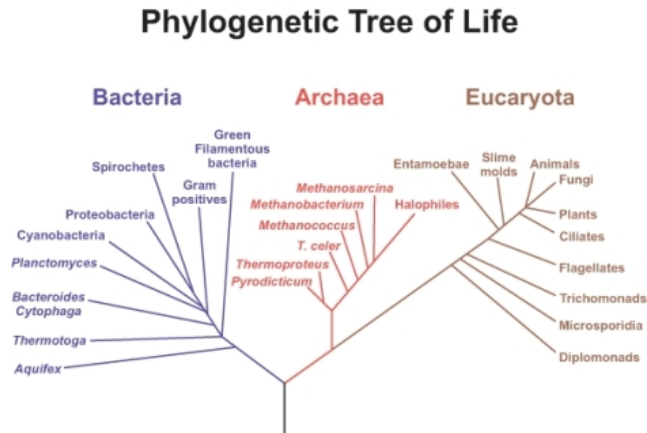
Discussion

When you discuss the endosymbiotic theory, stress how significant endosymbiosis was in the overall evolution of life on Earth. Have students read the online article It Takes Teamwork: How Endosymbiosis Changed Life on Earth (see URL below). It explains how endosymbiosis led to the evolution of eukaryotes—including themselves. Follow with a class discussion.

- http://evolution.berkeley.edu/evolibrary/article/0_0_0/endosymbiosis_01

Use Visuals: Figure 7

The phylogenetic tree of life in **Figure 7** (see below) was first introduced in Lesson 11.1. Call on volunteers to state what they know about the tree now that they have read Lesson 11.2. For example, ask them to describe the three domains of life and explain how they are related. Create a list on the board.



Differentiated Instruction: Main Ideas/Details Chart

Pair English language learners with native English speakers, and ask partners to work together to make a main ideas/details chart for the lesson. Suggest that students keep their chart to use as a study guide for the Lesson 11.2 assessment. **ELL**

Enrichment: Teaching a Topic

Challenge a small group of students to learn more about the last universal common ancestor by reading the article *My Name is LUCA—the Last Universal Common Ancestor* (see URL below). Then ask them to teach the topic to the class.

- <http://www.actionbioscience.org/newfrontiers/poolepaper.html>

Science Inquiry

Analyzing Data

Provide students with copies of the table *Prokaryotes, Eukaryotes, and Organelles* (shown below). Challenge students to explain how data in the table supports the endosymbiotic theory.

Table 14.5:

	Prokaryotes	Eukaryotes	Mitochondria of Eukaryotic Cells	Chloroplasts of Eukaryotic Cells
DNA	One circular chromosome without a nucleus.	Multiple linear chromosomes within a nucleus.	One circular chromosome without a nucleus.	One circular chromosome without a nucleus.
Replication	Binary fission (one cell splits into two cells)	Mitosis	Binary fission	Binary fission
Ribosomes	70S	80S	70S	70S
Size	1–10 microns	50–500 microns	1–10 microns	1–10 microns
Appearance on Earth (billions of years ago)	3.5	1.8	1.8	1.8

Reinforce and Review

Asking Questions

Have each student write, and turn in, one question they have about lesson content. Read the questions aloud, and call on volunteers to answer them. If any questions are asked by multiple students, review the relevant topics with the class.

Lesson Worksheets

Copy and distribute the four Lesson 11.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 11.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 11.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Which theory of life's origins do you consider most plausible: genes-first, metabolism-first, or exogenesis? What kinds of evidence would be required to support each theory?
- The standard form for an evolutionary tree is a series of branching lines which show common ancestors. Can you imagine a format which could show endosymbiosis as well as common ancestry?

Lesson Assessment

- Have students complete the Lesson 11.2 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

14.4 Lesson 11.3: Multicellular Life

Key Concepts

Multicellular life first evolved about one billion years ago. Beginning with the Cambrian explosion, millions of species came and went as: continents crashed together and broke apart, the atmosphere and climate changed, glaciers advanced and retreated, and meteors struck. Major evolutionary events during the last one billion years include the development of multicellular organisms and sexual reproduction, the move from water to land, the emergence of seed-bearing and later flowering plants, and the appearance of modern families of organisms. About 99 percent of all species that have ever lived on Earth are now extinct, most having disappeared during one of several mass extinctions. Today, there are an estimated 80 million living species, many of which may be at risk of extinction because of human actions.

Lesson Objectives

- Assess the impact of global environmental changes on the evolution of life.

- Describe the diversity of unicellular organisms which arose over two billion years of evolution.
- Evaluate the importance of major evolutionary developments which preceded the Cambrian explosion: colony formation, cell specialization, and sexual reproduction.
- Evaluate the importance of some factors which contributed to the “Cambrian explosion” of biodiversity.
- Connect Cambrian plant and animal phyla to modern species.
- Trace the evolution of plants and animals, from aquatic to terrestrial habitats.
- Connect changes in atmospheric O₂ and CO₂, temperature, geography, and sea level to extinctions and radiations of various groups throughout the Paleozoic.
- Identify recurrent extinctions as losses of diversity, but also opportunities for the evolution of new species.
- Describe the conditions under which the dinosaurs emerged to dominate life on Earth.
- Identify the diversity of habitats and niches occupied by the dinosaurs during their “golden age.”
- Discuss the relationships between reptiles, birds, and mammals during the age of the dinosaurs.
- Explain the coevolution of flowering plants and insects during the Cretaceous.
- Evaluate the evidence for an “impact event” as the primary cause of the K-T extinction, which ended the reign of the dinosaurs.
- Analyze the emergence of mammals and birds as the dominant land animals during the early years of the Cenozoic.
- Relate the climate of the early Cenozoic to the emergence of grassland and tundra habitats and their megafauna.
- Connect sea level, land bridges, and climate to their effects on evolution.
- Explain the connection between CO₂ levels, temperature, and glaciation.
- Discuss the factors that contribute to the “sixth” major extinction.
- Analyze your own response to the idea of a sixth extinction.

Lesson Vocabulary

Table 14.6:

Lesson 11.3 Vocabulary		
Archaeopteryx	Cambrian explosion	liverworts
Jurassic Period	Lucy	marsupials
monotremes	Pangaea	placentals
trilobites		

Check Your Understanding

Recalling Prior Knowledge

Most students will have prior knowledge of dinosaurs, so use dinosaurs as an example to introduce the evolution of multicellular life. Call on several students to state anything they know about dinosaurs. Make a list on the board. Tell students they will read about the evolution of dinosaurs and other multicellular organisms in this lesson.

Teaching Strategies

Demonstration

As you discuss the evolution of multicellular life, display online illustrations of important events and organisms that characterized the different geological periods since the beginning of the Cambrian. This will help make the information in the lesson come to life. The web sites below are recommended for their excellent images of the history of life, including extant organisms.

- <http://www.ucmp.berkeley.edu/alllife/eukaryota.html>
- <http://tolweb.org/tree/>
- <http://www.dlib.org/dlib/october05/10featured-collection.html>
- <http://www.uoregon.edu/~bsl/astronomy/>

Discussion

Discuss why the emergence of sexual reproduction about one billion years ago was such an important evolutionary innovation. Call on students to state ways that sexual reproduction produces variation in offspring (e.g., independent assortment, crossing over and recombination). Explain that genetic variation allows more rapid evolutionary change because it gives natural selection more “raw material” to work with. Relate this to the ability of organisms to adapt to changing environments.

Use Visuals: Pangaea, Laurasia and Gondwana

Have students compare the figures of Pangaea and Laurasia and Gondwana. Ask them to find the outlines of today’s continents in both figures. Explain enough about plate tectonics for students to understand how continents can drift (or have students with Earth science background explain it). Tie these geological changes to changes in climate and evolution. Specifically:

- Relate the drifting of continents to climate change (e.g., cooling caused by continents drifting toward the poles).
- Relate the drifting of continents to evolution (e.g., greater speciation due to new niches opening up as continents drift apart).
- Describe specific examples (e.g., adaptive radiation of Australian marsupials after Australia drifted apart from other continents).

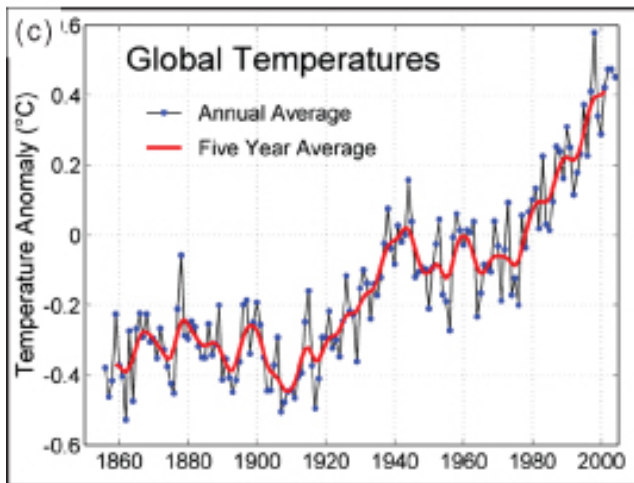
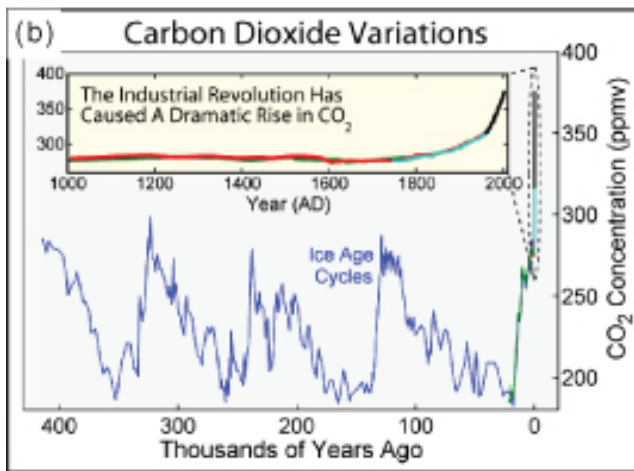
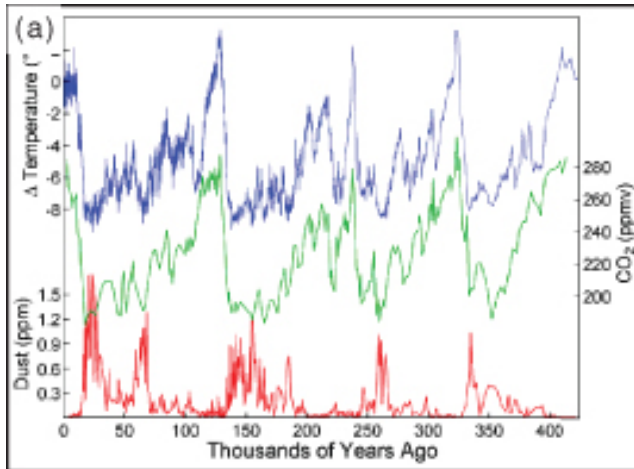


Use Visuals: Carbon Dioxide Levels

Have students analyze the data presented in the graphs below.

- **Ask:** What does the data show about the cause of global warming? Have them write a response in their notebooks.

(An increase in carbon dioxide associated with humans burning fossils fuels may account for much of the increase in global temperature.)



Build Science Skills: Predicting

Challenge students to predict how global warming might influence biological evolution in the future. Call on volunteers to share their predictions with the class and explain the basis for them. Relate global warming to the purported sixth mass extinction.

- **Ask:** How might global warming contribute to a sixth mass extinction?

(Sample answer: Global warming changes all of Earth's ecosystems, so it may be a major factor in the extinction of many organisms.)

Differentiated Instruction: Gallery Walk

Prepare a gallery walk by posting the names of geologic periods on large sheets of paper in different parts of the room. Divide the class into groups, being cognizant of the limitations of any special needs students. Ask groups of students to move from period to period and write on the posted papers any information they can recall about the periods. After the gallery walk, discuss the information they recorded. Point out any errors and underscore important points. **SN**

Enrichment: Diorama

Ask a small group of students to create a diorama representing one of the geological periods discussed in the lesson. The diorama should illustrate the climate and important organisms of the period. Display their completed diorama in the classroom, and challenge other students to identify the period it represents.

Science Inquiry

Building a Model

Expand on the coevolution example described in the lesson by having students do the activity *Coevolution: A Simulation* at the following web site. They will use various materials to create a model that simulates interactions between flowering plants and their insect pollinators. This will help them understand how the two organisms evolved together.

- <http://www.accessexcellence.org/AE/AEPC/WWC/1995/coevolution.php>

Reinforce and Review

Making a Drawing

Have pairs of students draw a timeline of the major evolutionary events described in this lesson.

Lesson Worksheets

Copy and distribute the four Lesson 11.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 11.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 11.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- The study of the history of life attempts to answer the age-old question: where did humans come from? What are some of the answers our current knowledge gives us? What points are still missing?
- To what extent has life itself influenced the history of life on earth? Consider some specific effects that certain kinds of life have had on climate, the atmosphere, and certain species.
- At least some mammoth DNA has been preserved in permafrost. What do you think about the idea of re-creating animals, such as the mammoth, from the past—as fictionalized in Jurassic Park?

- Do you think extinction plays an essential role in evolution? Is it a negative or positive role?
- Do you judge the sixth extinction to be an important problem? Do you think it is significantly different from earlier extinctions?

Lesson Assessment

- Have students complete the Lesson 11.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

14.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 15

TE Evolutionary Theory

15.1 Chapter 12: Evolutionary Theory

Outline

The chapter *Evolutionary Theory* consists of three lessons that explain the history of evolutionary theory, evidence for evolution, and modern applications of evolutionary theory.

- Lesson 12.1: Darwin and the Theory of Evolution
- Lesson 12.2: Evidence for Evolution
- Lesson 12.3: Evolution Continues Today

Overview

- The theory of evolution explains how life has changed over time and is the result of the work of many scientists. Many types of evidence support evolutionary theory. These include the fossil record, comparative anatomy, embryology, molecular data, and biogeography. Humans continue to try and control and manipulate nature using artificial selection and methods of genetic engineering. This leads to a number of benefits as well as some unintended consequences. Modern-day scientists have directly observed natural selection at work.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 15.1:

Lesson	Number of Class Periods*
12.1 Darwin and the Theory of Evolution	1.5
12.2 Evidence for Evolution	2.0
12.3 Evolution Continues Today	1.5

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for Chapter 12 and are available online:

- Natural Selection Lab: <http://www.biologycorner.com/worksheets/naturalselection.html>

This lab is a fun way for students to see the process of natural selection in action using a number of simple household items. If certain items are unavailable, different types of plastic utensils such as knives and forks can be substituted. The students will pretend to be animals called “woolyboogers”. These animals come in a variety of different mouth shapes. Spoon-mouth woolyboogers will most likely be the type that will be selected for survival and the students will see a change in the population over time. A video of some students performing a similar lab can be found here: <http://www.youtube.com/watch?v=ulrw32vkRYA&eurl=http%3A%2F%2F>

- Online Cladogram Lab: <http://www.ucmp.berkeley.edu/education/explorations/reslab/flight/main.htm>

This online activity teaches students how cladograms are used to understand evolutionary relationships while exploring the evolution of birds. The tutorial should take students approximately one hour to complete.

- Why Evolution Matters lab activities: <http://www.pbs.org/wgbh/evolution/library/10/index.html>

At this website you will find a large collection of labs and activities you can perform with your students on the topic of evolution.

- Evolution Lab:

Examines the evolution of adaptations through a natural selection simulation. <http://www.biologyinmotion.com/evol/index.html>

Common Misconceptions

It Wasn't Just Darwin

Many students believe Darwin is solely responsible for evolutionary theory. Be sure to stress the work other scientists such as Lyell and Wallace contributed to our understanding of evolution. In addition, stress that evolutionary biology is a modern field and that many scientists today add to our understanding of evolution (see Lesson 12.3 *Evolution Continues Today* for more details).

Evolution Isn't Goal-Oriented

Stress to students that evolution and natural selection are not goal-oriented. Too many students have seen the incorrect portrayal of evolution as a progressing “ladder” that goes from least to most successful organisms. In order to help students understand this is not true, emphasize the point that organisms are selected that best fit the current environment. If the environment changes, that organism may no longer be able to survive. When looking at examples of evolution, such as the horse example used in the text, students incorrectly believe that the horse is becoming more perfect as time goes on. Remind students that evolution isn't goal-oriented. The modern-day horse is not better than other horses, it is just best fit to the current environment. If you were to take the modern-day horse and place it in a past environment, it probably would not be able to survive.

It's Not “Just a Theory”

Students misunderstand the meaning of the word theory in science because the way the word theory is used in everyday language differs from how it is used in science. In everyday language, a theory is thought of as a guess (hypothesis). However, in science, the word theory is incredibly powerful - no evidence has been yet identified to disprove a scientific theory. Theories are powerful because they have broad explanatory power and can explain many natural phenomena. Emphasize to students that theories are as powerful (if not more powerful) than laws.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 15.2:

Lesson	Strategy or Activity	Materials Needed
12.1	1. Natural Selection Activity	1. Teddy Graham crackers or similar
12.2	1. Cladogram Activity	1. 5-15 items with homologous features (e.g. kitchen utensils)

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching Chapter 12:

- Interactive Tree of Life: Cladogram Maker: <http://itol.embl.de/>
- UC Berkeley Evolution Resources: <http://evolution.berkeley.edu/>
- PBS Evolution Resources: <http://www.pbs.org/wgbh/evolution/educators/index.html>
- About Darwin <http://www.aboutdarwin.com>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include Chapter 12, or specific lessons in Chapter 12, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of Chapter 12, students should have read the *Molecular Genetics* and *History of Life* chapters.
- Students should read this chapter before reading the *Evolution in Populations* chapter.
- It is recommended that you include all the lessons of this chapter in the FlexBook.

15.2 Lesson 12.1: Darwin and the Theory of Evolution

Key Concepts

The theory of evolution explains how life has changed (evolved) over time, and is the result of the work of many scientists.

Lesson Objectives

- Identify five important ideas Darwin developed during the voyage of the Beagle, and give examples of his observations that supported those ideas.
- Recognize that scientific theories and discoveries are seldom the work of just one individual.
- Describe prevailing beliefs before Darwin about the origin of species and the age of the earth.
- Evaluate Lamarck's hypothesis about how species changed.
- Analyze the impact of Lyell's Principles of Geology on Darwin's work.
- Explore the influence of Malthus' ideas about human population on Darwin's thinking.
- Clarify the importance of animal breeding to Darwin's ideas about natural selection.
- Explain the significance to Darwin of Babbage and Herschel's views of creation and life.
- Discuss the relationship between Alfred Russel Wallace and Charles Darwin.
- Describe the two general ideas of Darwin's Theory of Evolution.
- Use Darwin's reasoning to explain natural selection as the mechanism of evolution.
- Explain how natural selection results in adaptation to environment.
- Recognize the importance of variation to species survival.
- Relate the idea of differential survival to the concept of natural selection.
- Apply the concept of natural selection to explain how giraffes developed long necks.
- Interpret the expression "descent with modification."
- Discuss the concept of "common ancestry."
- Show how Darwin's theory provides a scientific explanation for the fossil record, and the similarities and differences among present-day species.
- Interpret Darwin's theory as an example of the general principle that the present arises from the materials and forms of the past.

Lesson Vocabulary

Table 15.3:

Lesson 12.1 Vocabulary		
theory	Theory of Evolution	natural selection
inheritance of acquired characteristics	artificial selection	law
adaptation		

Check Your Understanding

Drawing on Student Experiences

Ask: Have you ever seen a peacock? What are some things you know about peacocks? What is special about a peacock's tail? What do you think would happen if a peacock had a larger tail making it more attractive to females (peahens), but more likely to be eaten? How would natural selection act in this situation? Would nature select the peacock with a longer tail or a shorter tail?

[insert figure]

Students will probably be able to identify peacocks as birds with large, colorful tails. Make sure they understand that it is the males that have the large tails and that the females (peahens) do not. Peahens are attracted to males with large, healthy tails. If a peacock is able to reproduce before it gets eaten by a predator, it will pass its genes (including the genes for a long tail) on to the next generation. A short-tailed peacock that can escape its predators, but cannot reproduce will not pass its genes on to the next generation. Therefore, nature will most likely select for long-tailed peacocks. This is how peacocks evolved over time. However, you may also want to point out that the peacock tail cannot just keep getting bigger. Eventually, extremely long-tailed peacocks aren't able to successfully reproduce and so the peacock tail no longer gets larger.

- Show your students the four minute video explaining this concept at the following website: http://www.pbs.org/wgbh/evolution/library/01/6/1_016_09.html
- Please preview the video first to determine if the content is not too mature for your students.

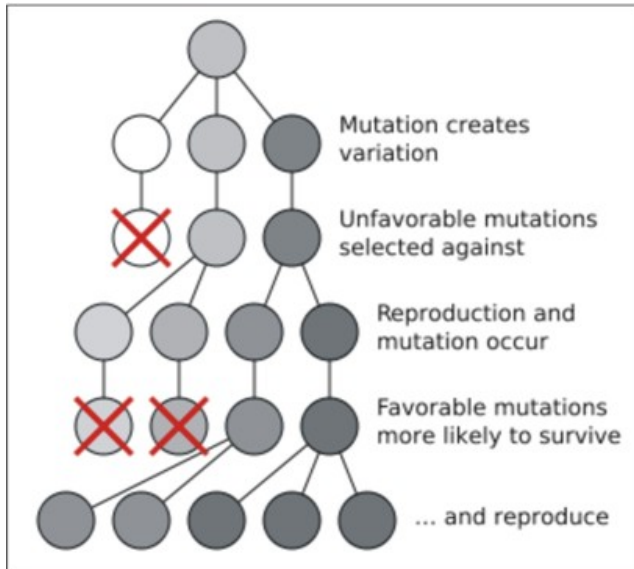
Teaching Strategies

Using Visuals: Figure 11

Direct students to look at **Figure 11** in their FlexBook. Students may be able to better understand this figure if you apply a scenario to the figure instead of just explaining the

generic concept. For example, you could use the giraffe example in the textbook, and tell the students that the light circle represents short-necked offspring, the medium-colored circle represents offspring with medium-length necks, and the dark shaded circle represents offspring with long necks. Long-necked offspring survive and reproduce more than short-necked offspring, so that overtime the population consists of fewer short-necked giraffes and more long-necked giraffes.

Ask your students to come up with their own scenarios that match the figure. Call on all students to share their examples with the class.



Natural Selection Activity

This simple and quick activity can help students better understand the process of natural selection. The activity involves the use of Teddy Graham (Dizzly Grizzly) crackers. However, the activity can be modified to use any type of food that comes in two varieties if Teddy Grahams are not available. For example, two different colors of gummy bears could be used. The activity can be found at the following website: http://www.accessexcellence.org/AE/AEC/AEF/1995/wartski_natural.php

In the activity, students act as predators that prey upon “unhappy” Teddy Grahams. Because Teddy Grahams come in two types, either smiling or frowning, over time students will notice that the population begins to entirely consist of happy Teddy Grahams as the unhappy ones are eaten. The website includes a “story”, an example hypothesis, examples of results tables for the students to complete, and concluding questions for the students to answer.

Differentiated Instruction: Main Ideas/Detail Chart

Have less proficient readers make a main ideas/details chart as they read the lesson. Instruct them to divide a sheet of paper down the middle and record the main ideas on the left side and the details for each main idea on the right side. Advise them to write one main idea for each of the main headings in the lesson. Have students save their chart in their science notebook for reviewing lesson content. (LPR)

Enrichment: Critical Reading

Students should read a selection of Darwin's book, *On the Origin of Species by Means of Natural Selection*. Chapter 3 is titled, "The Struggle for Existence", and it contains a great overview of Darwin's main concepts. A free, online version of the book can be located at <http://www.literature.org/authors/darwin-charles/the-origin-of-species/> This assignment can be done as homework.

After students read the chapter, have them discuss what they learned with a classmate or the class as a whole, and have them write a brief summary of the reading in their notebook.

Connect with Other Subjects: History

Darwin's feelings about slavery - he was vastly opposed to slavery - may have inspired some of his ideas regarding the common ancestry of all life. Discuss with students what they have learned about slavery in other classes, and why they think Darwin made the connections that he did regarding human ancestry and the ancestry of all life.

- For more details see: <http://www.newscientist.com/article/dn16503-hatred-of-slavery-drown.html>

Science Inquiry

Problem Solving

An interesting new application of the theory of evolution is to apply it to our understanding of diseases and why they occur. Considering how natural selection operates, propose a hypothesis for the existence of human diseases. Why doesn't natural selection remove diseases from the human population?

Sample answers:

- Natural selection has not had enough time to remove the particular disease from the population.

- The disease may not develop until post-reproductive age, therefore, making it impossible for natural selection to remove it from the population.
- The disease may provide some benefit to the individual at an earlier developmental stage.

Reinforce and Review

Asking Questions

Have each student turn in a question they have about lesson content on an index card or scrap of paper. Read selected questions aloud and help answer the questions for the students.

Lesson Worksheets

Copy and distribute the four lesson worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 12.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 12.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- How might the Theory of Evolution help us to understand and fight disease?
- What other aspects of medicine could benefit from an understanding of evolution?
- How can evolution and natural selection improve conservation of species and their environments?

- How would you put into words the ways in which evolution has changed the way we look at ourselves?
- How do you think it has altered the way we relate to other species? To the Earth?
- Consider the human brain. If Lamarck's hypothesis about inheritance of acquired characteristics were true, how would your knowledge compare to your parents?

Lesson Assessment

- Have students complete the Lesson 12.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

15.3 Lesson 12.2: Evidence for Evolution

Key Concepts

Many types of evidence support evolutionary theory. These include the fossil record, comparative anatomy, embryology, molecular data, and biogeography.

Lesson Objectives

- Clarify the significance of a scientific theory.
- Recognize that Darwin supported his theory with a great deal of evidence, and that many kinds of evidence since his time have further strengthened the theory of evolution.
- Compare the fossil record as we know it today with the record as it was understood in Darwin's time.
- Describe how Darwin used the fossil record to support descent from common ancestors.
- Explain how the fossil record supports natural selection in changing environments.
- Correlate the changes in ancestors of the horse to changes in their environments.
- Use the theory of evolution to explain both the similarities and the differences observed by comparative anatomists.
- Compare and contrast homologous structures and analogous structures as evidence for evolution.
- Give examples of evidence from embryology which supports common ancestry.
- Explain how vestigial structures support evolution by natural selection.
- Discuss the molecular similarities found in all species of organisms.

- Describe how evolution explains the remarkable molecular similarities among diverse species.
- Explain how differences in DNA sequences support descent with modification.
- Demonstrate how comparisons of DNA sequences can be used to construct a cladogram which shows probable evolutionary relationships.
- Analyze the relationship between Darwin’s Theory of Evolution and more recent discoveries such as Mendel’s work in genetics and the molecular biology of DNA and protein.
- Relate the distribution of plants and animals to changes in geography and climate.
- Explain how biogeography supports the theory of evolution by natural selection.
- Describe how plate tectonics explains the distant locations of closely related species.
- Summarize the explanation given by both Darwin and Wallace for the distribution of few, closely related species across island chains.
- Apply the ideas of island biogeography to the distribution of Galapagos finches and Hawaiian honeycreepers.

Lesson Vocabulary

Table 15.4:

Lesson 12.2 Vocabulary		
hypothesis	theory	paleontologists
relative dating	absolute (radioisotope) dating	comparative anatomy
homologous	anaologous	embryology
vestigial structures	cladogram	biogeography
continental drift	plate tectonics	island biogeography

Check Your Understanding

Drawing on Student Experiences

Discuss everyday uses of the term theory. Ask students for examples of the word theory used in a sentence. Highlight incidences where students use the term theory in a way that actually means a hypothesis. For example, a student might say, “I have a theory that it rains more on the weekend.” Discuss the scientific definition of the word theory and how it differs from the everyday use of the term. If students are still having difficulty, show them the video “Isn’t Evolution Just a Theory?” found at the following website: <http://www.pbs.org/wgbh/evolution/educators/teachstuds/svideos.html>

Teaching Strategies

Cladogram Activity

Prior to beginning this activity, discuss with students how to construct a cladogram by using the following website: <http://www.brooklyn.cuny.edu/bc/ahp/CLAS/CLAS.Clad.html>

While it isn't possible for the average high school biology student to examine real fossils, with a little imagination you can design a really fun cladogram activity for your students. Gather some simple household items - kitchen utensils work really well - or instruct your students to bring an item in from home. Break the class into groups of 3 or 4 students and give each group some of the items to examine.

- Note that the more items you give each group, the more difficult the activity becomes. Advanced students can work with between 7-10 items, while less advanced students should be given fewer.

Tell the students to pretend that the items are fossils, and that their assignment is to make observations of each of the "fossils" and use their data to construct a cladogram. Instruct students to look for homologous structures that the fossils share. The structures could be the presence or absence of "teeth", "appendages", symmetry, etc.

For example, a salt shaker may have been a filter-feeder with radial symmetry.

[insert figure]

You can watch a video of some students performing this activity and get a better idea of how it can be performed by going to the following website:<http://www.youtube.com/watch?v=9wXsPI9n4HE>

Once the students have collected all of their data, they should create a cladogram. Students may feel frustrated initially because it will be difficult to place all of the organisms on the cladogram. Emphasize to students that for this exercise there may not be an exact answer and there are a lot of possible placements for the organisms on the cladogram.

You will want to grade the students on the logic behind their reasoning for placing the fossils on the cladogram in the order in which they did. Have the students present their findings to the class and explain their logic behind how they constructed it. If each group examined the same set of items, there is bound to be some differences in how they decided to construct their cladograms. But, this is exciting! Now, the students can debate their conclusions exactly like real scientists do at academic conferences. Again, grade the students on the clarity in which they present their findings and the logic behind their conclusions.

Discussion

Discuss with students the meaning of evidence in science. Many students think that fossils are the only evidence of evolutionary theory. Ask students if learning about the amount of different types of evidence that support evolutionary theory in addition to fossil evidence has had any impact on their confidence in the theory.

Demonstration

Ask students what is the purpose of thumbs. Pick a student, or several, and tape their thumbs to their palms. Ask the student(s) to try and complete several tasks: pick up a book, open the door, write, etc. The student(s) should have a lot of difficulty. Discuss with the class the difficulty of performing these tasks without the use of a thumb. Point out that organisms that belong to the Primate family such as humans, chimpanzees, and gorillas are the only organisms with opposable thumbs. These opposable thumbs are able to bend and touch the fingers enabling primates to use tools. Discuss how opposable thumbs are examples of homologous structures within the primate family, and are evidence of our close evolutionary relationship with all primates.

Differentiated Instruction: Frayer Model

Assign each student a vocabulary word from the lesson. Each student should draw a large box and divide it into four parts labeled Definition, Drawing, Example, Non-example. Tell students to fill in the parts of the box for that word. (LPR)

For example, a student could create the following Frayer Model for the vocabulary word homologous structures:

Definition: similarities shared by closely related species

Example: A human and a cat are both mammals and the bones in their arms are similar in structure due to their common ancestry.

Drawing: drawing of the student's arm and a cat's arm

Non-example: A human's arm and an insect's wing are not homologous structures.

Enrichment: Reading

Have advanced students read "How the Cavefish Lost its Eyes" by PZ Myers found at http://seedmagazine.com/content/article/pz_myers_on_how_the_cavefish_lost_its_eyes/ They may choose to read this article as homework.

This article is excellent because it helps students understand that evolution is not goal-

oriented, but often a trade-off where one trait is selected over another. In Mexican blind cavefish, eyesight was gradually reduced to the point of blindness because in doing so, the cavefish gained an expanded jaw and better tastebuds. This article also does a good job of including an evaluation of Lamarck's theory of acquired characteristics discussed in the previous lesson, and it includes the genetic concept of pleiotropy found in the *Human Genetics* chapter.

Science Inquiry

Problem Solving

Show students the following table that identifies the percent similarity in DNA sequences among four species.

Table 15.5:

Species	A	B	C	D
A	-	65	90	15
B	65	-	70	40
C	90	70	-	20
D	15	40	20	-

For example, according to the table Species A and Species C have 90% similarity in the structure of their DNA. Ask students to draw a cladogram that represents the evolutionary relationships among these species.

Reinforce and Review

Flashcards

Instruct students to make flashcards for boldface vocabulary words (word on one side, definition or example on other side). After students have created the flashcards, ask them to use the flashcards to quiz a partner.

Lesson Worksheets

Copy and distribute the four lesson worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 12.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 12.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Which type of evidence for evolution is most convincing to you?
- Evidence confirms that evolution is a powerful theory. What other examples of theories have you encountered in your study of science? How would you compare their importance to the importance of the evolution?
- In this lesson, we have used the terms hypothesis, law, and theory. How would you explain the differences between these scientific ideas?

Lesson Assessment

- Have students complete the Lesson 12.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

15.4 Lesson 12.3: Evolution Continues Today - Can We Control It?

Key Concepts

Humans continue to try and control and manipulate nature using artificial selection and methods of genetic engineering. This leads to a number of benefits as well as some unintended consequences. Modern-day scientists have directly observed natural selection at work.

Lesson Objectives

- Recognize that the process of evolution by natural selection continues to change our world and ourselves, both despite and because of our best efforts to control it.
- Understand that we have added direct observation of natural selection to the evidence for evolution.
- Evaluate the importance of artificial selection to human life.
- Discuss our use of hybridization to improve yield and adapt crops to many climates.
- Identify the problems associated with hybridized crops, including the concept of genetic pollution.
- Explain how cloning contradicts the principles of natural selection.
- Compare genetic engineering to traditional methods of breeding and domestication.
- Give examples of useful products of genetic engineering.
- Identify potential problems with genetic engineering.
- Evaluate Michael Pollan's ideas that we are coevolving with our domesticated crops, animals, and pets, rather than producing them.
- Use the concept of natural selection to explain the resistance of bacteria to antibiotics and insects to pesticides.
- Explain why an individual bacterium cannot on its own change from sensitive to resistant to antibiotics.
- Assess the severity of the problem of antibiotic resistance and list some actions you can take to slow this phenomenon.
- Recognize that viral epidemics occur when chance viral mutations adapt the virus to new hosts.
- Relate the changes observed in peppered moth populations to changes in their environment.
- Describe the evidence for natural selection among Darwin's finches documented by the Grants.

Lesson Vocabulary

Table 15.6:

Lesson 12.3 Vocabulary		
artificial selection	coevolution	hybridization
genetic pollution	cloned	genetic engineering
transgenic	pandemic	

Check Your Understanding

Recalling Prior Knowledge

Ask students if they are familiar with any of the epidemics mentioned in this lesson (bird flu, tuberculosis, swine flu, HIV, etc.) and make a list on the board of the student's prior knowledge. Be sure to correct any misconceptions students already have about these epidemics before discussing their relevance to this lesson. Ask the students what information they learned in this lesson about these epidemics that they didn't already know. Add those points to the list on the board.

Teaching Strategies

Activity

Play Video 6: “Why Does Evolution Matter Now?” found at the following website: <http://www.pbs.org/wgbh/evolution/educators/teachstuds/svideos.html> The video is about multi-drug resistant tuberculosis. At the end of the video ask the students why it is so important that people understand evolution in order to know how to treat diseases such as multi-drug resistant TB. Have students write a brief paragraph in their notebooks.

Activity

Have the students complete one of the first three tutorials (Relevance of Evolution: Agriculture, Conservation, or Medicine) found at this website: http://evolution.berkeley.edu/evolibrary/search/topicbrowse2.php?topic_id=47 Assign students into groups, and assign each group one of the three tutorials so that the whole class will be able to discuss all three. Instruct the students to make notes of what they learn during the tutorial. Reconvene as a class and discuss what the students learned.

Differentiated Instruction: Word Wall

Post lesson vocabulary words and their definitions, examples, etc. on a bulletin board or wall. Have students refer to the word wall as they study lesson content. (ELL)

Enrichment: Information Pamphlet

Have students create information pamphlets to hand out to their school community that explain the dangers of antibiotic resistance and the steps the average person can take to

combat it. The pamphlet could include a definition of antibiotic resistance, reasons why people should be aware of the problem, and actions the average person can take.

Science Inquiry

Analyzing Data

Show students the graph at the following website: <http://www.pharmac.govt.nz/2005/05/26/260505b.pdf?page1> Tell students that the antibiotics are listed in the key in different colors and that the bacteria in which they attack are listed in parentheses. Ask students to write a paragraph explaining what is occurring in the graph and also ask students to provide a hypothesis as to why it is occurring. Then have the students share their paragraphs with the class.

Reinforce and Review

Quizzing a Partner

Tell students to write five fill-in, matching, or true/false questions and then use them to quiz a partner.

Lesson Worksheets

Copy and distribute the four lesson worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 12.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 12.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- To what extent do you think that humans have removed ourselves from natural selection?
- In what ways do you still feel subject to “natural” selective pressures?
- How effective do you think the measures to limit evolution of antibiotic resistance will be? Are you willing to support them?
- Do you think the benefits of genetic engineering outweigh the risks? Are there certain products you support, and others you oppose? Which ones, and why?

Lesson Assessment

- Have students complete the Lesson 12.3 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

15.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

Chapter 16

TE Evolution in Populations

16.1 Chapter 13: Evolution in Populations

Outline

The chapter *Evolution in Populations* consists of three lessons that introduce the students to the genetic changes, within populations, that result in evolution:

- Lesson 13.1 Genetics of Populations
- Lesson 13.2 Genetic Change in Populations
- Lesson 13.3 The Origin of Species

Overview

- Population genetics measures the change of allele frequencies in a population over time. A change in allele frequency (evolution) can be caused by gene flow, genetic drift, mutation, or natural selection. If a population is not experiencing any changes in allele frequencies, it is in Hardy-Weinberg equilibrium. There are several different conceptual frameworks in place to define a species. Reproductive isolation and genetic divergence lead to speciation. There are two models, gradualism and punctuated equilibrium, that attempt to explain the rate at which evolution occurs.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 16.1:

Lesson	Number of Class Periods*
13.1 Genetics of Populations	1.0
13.2 Genetic Change in Populations	2.0
13.3 The Origin of Species	1.5

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for *Evolution in Populations* and are available online:

This website contains a large collection of population genetics labs using simple materials such as M&M's, crackers, and pop beads. <http://www.woodrow.org/teachers/bi/1994/hwintro.html>

Common Misconceptions

Evolution is Random

While mutations and genetic drift are caused by random chance, natural selection by its very nature of being a selection process, is not random. New species originate because of a mix of random chance and selection.

Evolution is Still Being Debated

Students sometimes view the debate over the rate of evolution (gradualism vs. punctuated equilibrium) as reason to doubt the theory of evolution. Stress to students that evolutionary theory has an incredible amount of evidence supporting it (see the *Evolutionary Theory* chapter), and that arguments over the rate at which it occurs do not weaken the overall theory of evolution.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 16.2:

Lesson	Strategy or Activity	Materials Needed
13.1	1. Peep Genetics 2. “Toothpick Fish”	1. Packages of Peeps (2/group) or other animal-shaped food 2. Toothpicks (per group: 8 green, 8 red, 8 yellow)
13.2	1. Peep Genetics	1. Packages of Peeps (2/group) or other animal-shaped food

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching Evolution in Populations:

- There is a large list of resources for this chapter found at the following website: <http://www.pbs.org/wgbh/evolution/educators/course/session4/resources.html> For example, the “Isolating Mechanisms” resource found under Other Library Resources provides an interactive on reproductive isolation.

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to choose the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter or certain lessons in this chapter in your students’ FlexBook. You should also consult the standards correlation table that follows when selecting chapters and lessons to include in the FlexBook.

- To understand the content of Population Genetics, students should have read the *Mendelian Genetics* and *Evolution* chapters.
- Students should read this entire chapter before reading the remaining chapters of the FlexBook.
- It is recommended that you include all the lessons of this chapter in the FlexBook.

16.2 Lesson 13.1: Genetics of Populations

Key Concept

Population genetics measures the change of allele frequencies in a population over time. It is this change in allele frequencies that results, genetically, in evolution.

Lesson Objectives

- Analyze the relationship between Darwin’s work and Mendel’s discoveries.
- Explain the goal of population genetics.
- Describe the relationship between genes and traits.
- Differentiate between genes and alleles.
- Connect alleles to variations in traits.
- Distinguish environmental effects on gene expression from allelic variations in genes.
- Describe the relationship between mutations and alleles.
- Explain the causes and random nature of mutation.
- Compare rates of mutation in microorganisms to those in multicellular organisms.
- Analyze the ways in which sexual reproduction increases variation.
- Relate mutation and sexual reproduction to natural selection.
- Explain why populations, but not individuals, can evolve.
- Define a population’s gene pool.
- Distinguish between a population’s gene pool and a gene pool for a single gene.
- Analyze the usefulness of the gene pool concept.
- Explain how to determine allele frequencies.
- Define evolution in terms of allele frequencies.
- Discuss what is meant by a population which is fixed for a certain gene.
- Show how allele frequencies measure diversity.
- Evaluate the significance of a change in allele frequency.

Lesson Vocabulary

Table 16.3:

Lesson 13.1 Vocabulary		
gene	alleles	genotype
phenotype	heterozygous	homozygous
expression	mutations	fitness
sexual reproduction	population	population genetics
gene pool	allele frequency	evolution

Check Your Understanding

Recalling Prior Knowledge

Students will benefit from a review of Mendelian Genetics and Meiosis before beginning this chapter. Ask the students what they recall about how genes are inherited. Remind students that sexually reproducing populations receive two copies of each gene (one maternal copy from the egg and one paternal copy from the sperm). From there, lead into a discussion on how these two copies of the same gene may either be identical (homozygous) or different (heterozygous).

Depending on how long it has been since you have covered Mendelian Genetics with your students, you may wish to complete a few practice problems with them. The following website contains some simple practice problems: http://sciencespot.net/Media/gen_spbobgenetics.pdf

Teaching Strategies

Activity: “Peeps”

Peeps (<http://www.marshmallowpeeps.com/>), animal-shaped marshmallow candy, can be used in a fun activity to help students learn population genetics. While they are easy to find in stores around certain holidays (Easter, Halloween, Valentine’s Day), they are available year-round. If Peeps are not available, you can substitute them for a different type of animal-shaped food, or have the students create their own imaginary organism.

[insert figure]

Students should be divided into groups of 2-3 and each group given a “population” of Peeps (two packages of different color) and asked to describe the population genetics of their Peeps. They should carefully observe their Peep population and record observations about what they see. At first glance, Peeps look almost identical, however, ask the students to look carefully for differences. Then have the students create the following table. If necessary, give them some guidance on the selection of traits by providing some examples, such as the ones found in the example below.

Table 16.4:

Trait	Alleles	Genotypes	Phenotypes
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

Tell the students to use their imagination and pretend that Peeps are actual animals that live in the wild. Ask the students to identify the Peep’s natural environment and to come up with plausible allele frequencies based on the environment they decide upon. After the students have done so, have them answer the following questions:

1. What alleles are fixed in your population?
2. What alleles have the highest allele frequency in the population? The lowest?

At the conclusion of this activity, you may want to instruct the students to hold on to their Peep population for further study (see Lesson 13.2 & 13.3 activities in this chapter). Or you may wish to invite the students to prey upon their Peeps!

- Here’s an example of what a student group could create:

My population of Peeps come in two colors, pink and yellow. Some have eyes that are evenly spaced apart while others have eyes that are not. All of them have dark brown eyes and are covered with a sugary coating.

Table 16.5:

Trait	Alleles	Genotypes	Phenotypes
Body color	A - pink, a - yellow	AA, Aa, aa	pink or yellow
Coating (skin)	B - sugar	BB	sugar
eye color	C - brown	CC	brown
eye symmetry	D - symmetrical, d - asymmetrical	DD, Dd, dd	symmetrical or asymmetrical

Activity: “Toothpick Fish”

“Toothpick Fish” is a fun activity to help your students understand genetics in an evolutionary and ecological context. Using colored toothpicks to represent different alleles, students will make “fish” by combining two toothpicks. Then, they will mate their fish and natural selection will select for certain phenotypes based on the current environment. As the environment changes, the allele frequencies in the students’ fish populations will change.

The complete activity including teacher’s guide and answer key can be found here: <http://chroma.gs.washington.edu/outreach/genetics/download/toothpickfish.pdf>

- Please be aware that some students may have difficulty distinguishing between red and green toothpicks. Either pair these students with students who can distinguish the two different colors or use a different color of toothpick.

Differentiated Instruction: Word Wall

English-language learners may benefit from learning common root words that they can then use to understand a variety of words. This lesson contains several vocabulary terms that contain root words with very distinct meanings. Post the following onto a wall for students to see. Have students refer to the word wall as they study the lesson content. (ELL)

Table 16.6:

Root Word	Meaning	Vocabulary	Definition
homo-	same	homozygous	Describes a genotype or individual having two copies of the same allele for a gene.
hetero-	different	heterozygous	Describes a genotype or individual having two different alleles for a gene.
-zygous	having a zygote	homozygous, heterozygous	-
geno-	relating to genes	genotype	The genetic makeup of an organism; specifically, the two alleles present.
pheno-	phenotype	physical appearance	The genetic makeup of an organism; specifically, the two alleles present.
-type	variation of	genotype, phenotype	-

Enrichment: Human Alleles

Have students research the frequency of certain human alleles by going to ALFRED, the ALlele FREquency Database: <http://alfred.med.yale.edu/>

Students may search for alleles by chromosome (loci), geographic distribution, and keyword search.

Science Inquiry

Formulating a Hypothesis

Ask students to form a hypothesis as to why certain harmful mutations persist in a population's gene pool. For example, mention type 1 diabetes which is a genetic disorder caused by a mutation. Ask students why this particular disease still exists in the human population? After the students have formed their hypotheses, you may want to direct them to this discussion on the evolution of diabetes: <http://survivalofthesickestthebook.com/blog/?p=196>

Reinforce and Review

Outline the Lesson

Have students outline the lesson individually or in pairs on a piece of paper. Instruct students to use the heading structure of their Flex Book in building their outline.

Lesson Worksheets

Copy and distribute the four lesson worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 13.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 13.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Imagine how Darwin felt, knowing that traits were passed on to offspring and that heritable variations “somehow” appeared. What key discoveries now explain these facts?

- As we noted in the last chapter, Theodosius Dobzhansky is famous for his statement, “Nothing in biology makes sense except in the light of evolution.” Do you agree that people cannot understand biology without understanding evolution?
- How does evolutionary theory “make sense of” your similarities to your parents and siblings? Your differences from them? Similarities among all humans? Differences among us?

Lesson Assessment

- Have students complete the Lesson 13.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

16.3 Lesson 13.2: Genetic Change in Populations

Key Concepts

A change in allele frequency (evolution) can be caused by gene flow, genetic drift, mutation, or natural selection. If a population is not experiencing any changes in allele frequencies, it is in Hardy-Weinberg equilibrium.

Lesson Objectives

- Compare and relate macroevolution to microevolution.
- Define microevolution in terms of allele frequencies.
- Define genetic equilibrium for a population.
- List the five conditions for genetic equilibrium according to the Hardy-Weinberg model.
- State and explain the generalized equation for Hardy-Weinberg equilibrium.
- Explain how to use the Hardy-Weinberg equation to solve for allele or genotype frequencies.
- Discuss the reasons why the 5 conditions for Hardy-Weinberg equilibrium are rarely met.
- Explain how mutation disrupts genetic equilibrium.
- Predict the possible effects of mutation, and analyze the probability of each type of effect.
- Contrast mutation in microorganisms to mutation in multicellular organisms.
- Define gene flow.

- Describe two possible effects of gene flow on the genetics of a population.
- Define genetic drift.
- Describe three possible effects of genetic drift on populations and/or specific alleles.
- Explain and give an example of the bottleneck effect.
- Clarify and give an example of the concept of “founder effect.”
- Compare and contrast genetic drift and natural selection as causes of evolution.
- Discuss natural selection and evolution in terms of phenotypes and allele frequencies.
- Explain the distribution of phenotypes for a trait whose genetic basis is polygenic.
- Using a normal distribution of phenotypic variation, interpret directional, disruptive, and stabilizing patterns of selection.
- Define fitness as it relates to natural selection.
- Describe how natural selection can sometimes lead to the persistence of harmful or even lethal allele.
- Analyze the logic of kin selection.

Lesson Vocabulary

Table 16.7:

Lesson 13.2 Vocabulary		
microevolution	macroevolution	Hardy-Weinberg model
genetic equilibrium	gene flow	genetic drift
bottleneck effect	founder effect	adaptive radiation
directional selection	disruptive selection	stabilizing selection
fitness	kin selection	

Check Your Understanding

Recalling Prior Knowledge

Show students the video, “A Mutation Story”, found at the following website: http://www.pbs.org/wgbh/evolution/library/01/2/1_012_02.html

This 5 – minute video revisits the sickle-cell anemia mutation introduced in the last lesson. It also introduces the relationship between the sickle cell mutation and the disease malaria that is discussed in this lesson.

Teaching Strategies

Activity: “My Brother’s Keeper”

To help students better understand the concept of Kin Selection, have the students complete the following case study. You may wish to have the students work in small groups, complete the case individually for homework, or go through the case together as a class. However, the most successful method to employ is to have the students complete each part in a small group or individually and then discuss their responses with the class before moving on to the next part of the case.

“My Brother’s Keeper: A Case Study in Evolutionary Biology and Animal Behavior” by Kari Benson http://www.sciencecases.org/kin_selection/kin_selection.asp

The teaching notes and answer key for this case study can be found here: http://www.sciencecases.org/kin_selection/kin_selection_notes.asp

In this case, students will examine the seemingly strange behavior of Belding’s ground squirrels. The case is broken down into parts. The first part provides an introduction and asks students to generate hypotheses for the squirrels’ strange behavior. Tell students to come up with at least three hypotheses. The second part asks students to fill in their hypotheses into a table to keep them organized. The third part of the case study provides data for the students to test their hypotheses against. You should highlight that the “Expected” data in the graph is referring to Sherman’s hypothesis. Tell the students to pay attention only to the “Observed” data in the graph in order to evaluate their own hypotheses. The fourth part of the case study includes questions for the students to answer regarding the case.

Parts five through eight of the case study are college-level and quite advanced. They are not recommended, however, they could be used for enrichment for students who would like to try something harder.

Activity: “Peep Genetics”

This activity can be used as a stand-alone activity or it can be a continuation of the Peep activity from the first lesson. Peeps, animal-shaped marshmallow candy, can be used in a fun activity to help students practice solving Hardy-Weinberg problems. While they are easy to find in stores around certain holidays (Easter, Halloween, Valentine’s Day), they are available year-round. If Peeps are not available, you can substitute them for a different type of animal-shaped food, or have the students create their own imaginary organism.

Students should be divided into groups of 2-3 and each group given a “population” of Peeps (two packages of different color). In this activity, tell students to focus on only one trait that the Peeps have that comes in two variations (due to two alleles). For example, students could focus on body color. Instruct the students to choose which allele they would like to

be dominant and which one recessive. This is all up to their imagination as Peeps are not real animals and don't actually have alleles!

For example, a student group with two packages of Peeps, one pink and one yellow, could imagine that the pink allele (A) is dominant to the yellow (a) and that a Peep with a genotype of AA is pink, Aa is pink, and aa is yellow.

Tell the students to pretend their Peep population is currently in Hardy Weinberg equilibrium and have them answer the following questions:

1. Is it possible to tell the genotype of any of the Peeps just by looking at them? If so, which ones?
2. If the frequency of allele A in your population is 0.4, what is frequency of allele a?
3. If the frequency of homozygotes is 0.36, what is the frequency of heterozygotes?
4. List reasons why it is unlikely that your population of Peeps will stay in Hardy Weinberg equilibrium for very long.

Answer key

- Answers will be provided to teachers upon request at teacher-requests@ck12.org.

At the conclusion of this activity, you may wish to invite the students to prey upon their Peeps!

Differentiated Instruction: Main Ideas/Detail Chart

Instruct individual students, pairs, or groups to divide a sheet of paper in half and on the left side write the main ideas from a passage or lesson (skipping several lines between the main ideas). On the right side, instruct students to fill in important details about each main idea as they read. Then, instruct students to compare their paper with a neighbor or together as a class in order to fill in main ideas they may have missed. (LPR)

Enrichment: Reading

Have students read the following selection from *The Survival of the Sickest*: http://www.survivalofthesickestthebook.com/excerpts_8.php

The book is based on the premise that certain diseases exist because natural selection has actually selected for them. In this selection, students will read about human aging and death and the hypothesis that aging and death has actually been selected by nature! Ask the students to share their reaction to the excerpt on a sheet of paper. If possible, let the students use the internet to research questions they might have after reading the excerpt.

Science Inquiry

Formulating a Hypothesis

Ask the students to hypothesize what would happen to the sickle cell anemia allele over time if malaria was eradicated. Students should describe data that would support or disprove their hypothesis.

Reinforce and Review

Practice Problems

The following website contains a number of practice problems students should complete to perfect their ability to perform Hardy Weinberg problems: http://www.biologycorner.com/worksheets/hardy_weinberg2.html

Lesson Worksheets

Copy and distribute the four lesson worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 13.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 13.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- This lesson discussed probable past microevolution of alleles for genes for human skin color and hemoglobin. For what other genes (or heritable traits) can you suggest past selective pressures? Do you think certain human genes (or heritable traits) may be at genetic equilibrium? Give some examples, and explain your reasoning.

- Some people suggest that we humans have removed ourselves from natural selection. Do you agree?
- What are some consequences of understanding that chance variations and natural selection can result in the persistence of lethal alleles, such as the alleles for sickle-cell anemia and cystic fibrosis?
- Do you think it is important that people understand the biological basis of skin color? Explain.

Lesson Assessment

- Have students complete the Lesson 13.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

16.4 Lesson 13.3: The Origin of Species

Key Concepts

There are several different conceptual frameworks in place to define a species. Reproductive isolation and genetic divergence lead to speciation. There are two models, gradualism and punctuated equilibrium, that attempt to explain the rate at which evolution occurs.

Lesson Objectives

- Recognize that new discoveries since Darwin have added an understanding of speciation to evolutionary theory.
- Explain the concept of a species.
- Define the biological species concept and analyze its usefulness.
- Compare the biological species concept to morphological, genealogical, and ecological concepts.
- Analyze the reasons why biologists consider all humans to be members of the same species.
- Define speciation.
- Describe two conditions that can lead to speciation.
- Explain the results of speciation in terms of adaptation, chance, and changes in the environment.

- Distinguish allopatric from sympatric speciation.
- Describe an experiment which demonstrated allopatric speciation.
- Describe two general types of reproductive isolation.
- Explain how polyploidy can result in sympatric speciation.
- Discuss the use of hybridization to form new crop species.
- Analyze the importance of environmental complexity to sympatric speciation for animals.
- Compare and contrast the gradualist and punctuated equilibrium models of evolutionary change.
- Describe conditions that could increase the rate of speciation.
- Describe circumstances that could lower the rate of speciation.

Lesson Vocabulary

Table 16.8:

Lesson 13.3 Vocabulary		
speciation	species	biological species concept
reproductive isolation	reproductive barriers	morphological species concept
ecological species concept	ecological niche	genealogical species concept
evolutionary species concept	allopatric speciation	sympatric speciation
polyploidy	tetraploid	hybrid
gradualism	punctuated equilibrium	

Check Your Understanding

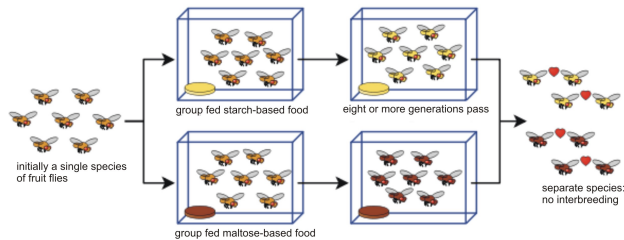
Recalling Prior Knowledge

Ask students to recall Darwin's Theory of Evolution. Discuss his ideas in relation to the concepts of gradualism and punctuated equilibrium, and ask the students which do they think Darwin would prefer based on the evidence he presented.

Teaching Strategies

Using Visuals: Figure 5

Project **Figure 5** for the entire class to see or direct students to look at **Figure 5** in their FlexBook. Ask students to write down what is occurring in the picture in their own words, without referring to the text in their book.



If a single population of fruit flies is divided, and the two subpopulations are separated for at least eight generations and fed different foods, members of the subgroups prefer to mate with individuals from their own feeding group. Although this behavioral reproductive barrier was not complete, Diane Dodd's data supports the hypothesis that geographic isolation can lead to heritable reproductive isolation.

Activity

Divide students into small groups of 2-3 and hand out copies of the case study, "As the Worm Turns: Speciation and the Apple Maggot Fly", found here: http://www.sciencecases.org/maggot_fly/maggot_fly.asp

The case study presents more background on the Hawthorn and Apple Maggot Fly that was discussed in their FlexBook. At the end of the background is a series of questions that the students should answer. The teaching notes for the case study can be found here: http://www.sciencecases.org/maggot_fly/maggot_fly_notes.asp

Differentiated Instruction: Compare/Contrast Table

Ask individual students, pairs, or groups to make or fill in a table contrasting the four different species concepts in this lesson. Here is a sample table the students could produce: (LPR)

Table 16.9:

Species Concept	Contrast*
Biological	Members can mate and produce offspring that can also reproduce; good for sexually reproducing organisms.
Morphological	Members share common structures and similar biochemistry; most commonly used method to define a species; good for sexually or asexually reproducing organisms.
Genealogical (Evolutionary)	Members share common ancestry without divergence.
Ecological	Members have a unique set of adaptations; good for asexually reproducing organisms.

Enrichment: Debate

Divide students into four teams and have the students debate the different ways to define a species. Ask that each group provide a detailed definition of their particular species concept, a rationale as to why it is the best way to define a species, and a sample organism that can be defined using their concept.

Science Inquiry

Developing a Research Plan

Have the students read the case study, “Something Fishy in Paxton Lake”, found here: <http://ublib.buffalo.edu/libraries/projects/cases/stickleback/stickleback.html>

The case study covers stickleback fish speciation. After a brief overview, the students are asked to design a lab experiment in which to test the hypothesis that stickleback fish in Paxton Lake have experienced speciation.

Reinforce and Review

Quizzing a Partner

Tell students to write five fill-in, matching, or true/false questions and then use them to quiz a partner.

Review Questions

Have students answer the Lesson 13.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 13.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Which definition of species – biological, morphological, ecological, or genealogical – do you prefer?
- To what extent do you think stabilizing, directional, and disruptive selection affect humans today?
- What effects might genetic engineering have on speciation?
- Do you find the evidence for sympatric speciation (the more disputed of the two forms) convincing?
- Are gradualist and punctuated equilibrium models mutually exclusive?
- Why don't disagreements about speciation threaten the theory of evolution by natural selection?

Lesson Assessment

- Have students complete the Lesson 13.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

16.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 17

TE Classification

17.1 Chapter 14: Classification

Outline

The chapter *Classification* consists of three lessons that explain Linnaean taxonomy and phylogenetic classification, and describe how organisms are currently classified.

- Lesson 14.1: Form and Function
- Lesson 14.2: Phylogenetic Classification
- Lesson 14.3: Modern Classification Systems

Overview

- Linnaean classification groups together organisms that have similar physical traits of form and function. Phylogenetic classification shows ancestor-descendant relationships based on ancestral and derived traits. A three-domain system is currently the most widely accepted classification system.
- The concept map below provides a visual representation of how the chapter concepts are related.

Pacing the Lessons

Use the table below as a guide for the time required to teach the lessons of this chapter.

Table 17.1:

Lesson	Number of Class Periods*
14.1 Form and Function	1.0
14.2 Phylogenetic Classification	1.5
14.3 Modern Classification Systems	1.5

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

The Kingdom of Pasta: Students develop a classification system for all the different kinds of “organisms” in the pasta “kingdom.” Including a scientific name for each kind and a classification key. (Lesson 14.1)

- <http://www.accessexcellence.org/AE/ATG/data/released/0070-JudithAllard/>

The Missing Link: Students use common nails, screws, and bolts to simulate the process of applying cladistics to living organisms or fossil life forms. (Lesson 14.2)

- http://www.pbs.org/wgbh/nova/teachers/activities/2905_link.html

Common Misconceptions

Mutually Exclusive Taxa

Some students may not understand the hierarchical structure of Linnaean taxonomy. They may think instead that taxonomic categories are mutually exclusive, so an organism cannot be classified in two different taxa, such as mammal and primate. You can address this misconception with a simple analogy. Explain that an ice cube tray is like a kingdom and the individual squares within the tray are like phyla. Add that each of the squares could be further subdivided to represent classes within phyla, and so on. Challenge students to think of other analogies.

Bacterial Domains

Students may question why bacteria should be placed in two different domains while all other living things are placed in just one domain. Make sure they understand that domains

group organisms on the basis of their evolutionary history. Explain that the two bacteria domains are like two families with just one child each, while the third domain is like one family with many children. The number of children doesn't affect how they are grouped in families. The only thing that matters is whether they have the same parents.

Managing Materials

The following materials are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 17.2:

Lesson	Strategy or Activity	Materials Needed
14.3	<ol style="list-style-type: none">1. Build Science Skills: Observing2. Activity	<ol style="list-style-type: none">1. Microscope and slides, small amount of compost2. Scrapbook supplies (e.g., paper, paper punch, binders, glue, scissors)

Other Web Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- Biological Diversity-Classification: This online chapter is a concise and well-illustrated introduction to biological classification and provides links to several other useful Web sites. http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookDivers_class.html
- Classification of Living Things: This excellent introduction to the principles of taxonomy includes crossword puzzles and flashcards for student use. <http://anthro.palomar.edu/animal/default.htm>
- Classification of Plants & Animals: This informative summary of plant and animal classification has numerous links to articles, activities, and quizzes pertaining to lesson content. <http://www.fi.edu/tfi/units/life/classify/classify.html>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons

of this chapter, in your students' FlexBook. You should also consult the standards correlation table that follows when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the *Classification* chapter, students should have read the chapters *Foundations of Life Science* and *History of Life*.
- Students should read the *Classification* chapter before reading chapters on particular groups of organisms (e.g., *Protists, Fungi, and Evolution* and *Classification of Plants*).
- It is recommended that you include all the lessons of this chapter in the FlexBook.

17.2 Lesson 14.1: Form and Function

Key Concepts

Scientists use taxonomy to classify organisms in order to make sense of the great diversity of living things. Linnaean taxonomy was the first classification system to be widely used. Linnaeus also invented the two-word method of naming species; binomial nomenclature.

Lesson Objectives

- Define taxonomy, and understand why scientists classify organisms.
- Describe Linnaean taxonomy and binomial nomenclature.

Lesson Vocabulary

Table 17.3:

Lesson 14.1 Vocabulary		
taxonomy	taxa	kingdom
species	Linnaeus	phylum
class	order	family
genus	binomial nomenclature	

Check Your Understanding

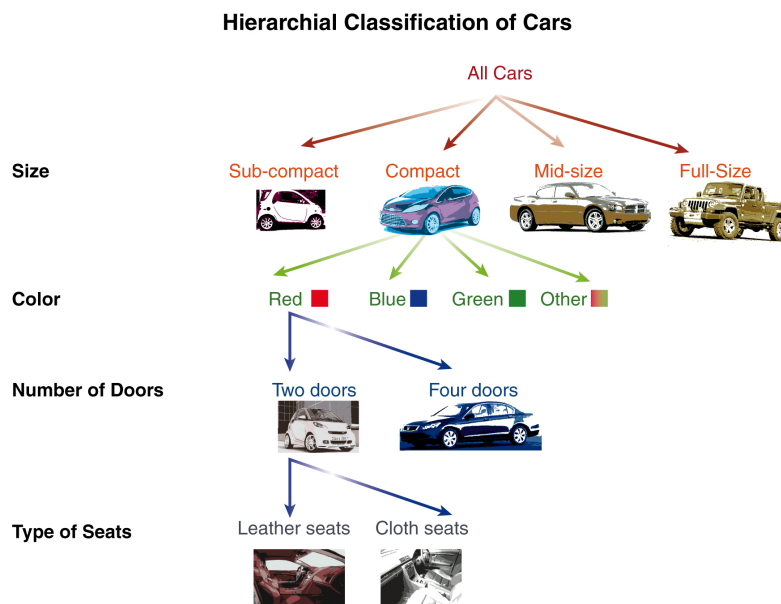
Recalling Prior Knowledge

Introduce the lesson by asking students if they know the scientific name for the human species (*Homo sapiens*). Call on volunteers to explain, or explain yourself if necessary, what the two parts of the name represent (the **genus** and **species** names). Tell the class they will learn more about how organisms are named and classified in this lesson.

Teaching Strategies

Build Science Skills: Classifying

Divide the class into groups, and ask each group to create a taxonomy of objects available in the classroom, such as students' shoes or books. Groups should decide which traits of the objects they will use for their classification, and then create a chart showing how the objects are classified. They can read about the car example in their FlexBook for ideas and use Figure 1 (below) as a model for their chart. Ask each group to share its completed taxonomy with the class. Discuss how the choice of traits determines which objects are grouped together.



Use Visuals: Table 1

Remind students that the examples of taxa in Table 1 (below) are those of our own species. Name another familiar species, and challenge students to identify the taxa to which it belongs. Have students complete the table as a homework assignment if they need to research any of the taxa for the species.

Table 17.4: **Classification of the Human Species**

Taxon	Name	Traits ¹
Kingdom	Animal	Organisms capable of moving on their own
Phylum	Chordate	Animals with a notochord (flexible rod that supports the body)
Class	Mammal	Chordates with fur or hair and milk glands
Order	Primate	Mammals with collar bones, grasping hands with fingers
Family	Hominid	Primates with three-dimensional vision, relatively flat face
Genus	<i>Homo</i>	Hominids with upright posture, large brain
Species	<i>sapiens</i>	Members of the genus <i>Homo</i> with a high forehead, thin skull bones

¹ Only one or two traits per taxon are listed in the table as examples. Additional traits may be needed to properly classify species.

Discussion

Help students appreciate the significance of binomial nomenclature by discussing a counterexample. Ask the class to brainstorm what might happen if everyone they knew had only a first name. (Students might know several different people with the same first name, so it could be very confusing. It also might be harder to tell which people are related to one another.)

- Ask: How does the use of first and last names help avoid confusion? (It gives unique names to most, if not all, of the people that an individual knows.)

- Ask: How does the use of first and last names indicate which people are related? (People with the same last name may be related, especially if the name is not very common.)

Tell the class that binomial nomenclature works the same way. It helps avoid confusion, and gives an indication of which organisms are related.

Differentiated Instruction: Cloze Prompts

Help students focus on the main ideas in the lesson. Pair less proficient readers with more proficient readers, and ask partners to complete the cloze sentences below while they read lesson content. **LPR**

- Taxonomy is ... (a method of organizing living things into groups.)
- Biologists classify organisms in order to ... (make sense of the incredible diversity of life on Earth.)
- Binomial nomenclature is ... (Linnaeus' method of naming species, in which each species is given a unique, two-word name consisting of the genus and species names.)

Enrichment: Board Game

Ask a small group of students, (students who need extra challenges), to create a taxonomy board game. The object of the game should be to correctly identify an organism's taxa, from kingdom to species, based on a series of increasingly specific clues about the organism's traits. The first player to correctly identify all of the taxa for the organism wins the game. Encourage other students to play the game so they can practice applying lesson concepts.

Science Inquiry

Problem Solving

Divide the class into groups, and give each group a description of a different species. Then challenge group members to solve the problem of the organism's identity, including both genus and species names. Students may need to do some online research to identify their organism. Give groups a chance to share their solutions and explain how they decided on their organism's identity. Field guides are a good source of information about common species. The web sites below are also useful for this purpose. <http://plants.usda.gov/> (You can use this web site to find descriptions of plants in your own state.) <http://depts.washington.edu/natmap/facts/> (This web site describes a diversity of animal species and is tailored to students in middle and high school.)

Reinforce and Review

Making a List

Ask pairs of students to list the taxa in Linnaean taxonomy in the correct sequence, starting with the kingdom. Then have them find an example of each taxon in their FlexBook.

Lesson Worksheets

Copy and distribute the four Lesson 14.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 14.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. Please send an email to teachers-requests@ck12.org to request sample answers.

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 14.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Can you think of other similarities that could be used group organisms?
- What other types of traits might related organisms share?
- What about similarities in molecules, such as DNA, among related organisms?

Lesson Assessment

- Have students complete the Lesson 14.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

17.3 Lesson 14.2: Phylogenetic Classification

Key Concepts

Phylogenetic classification is based on evolutionary relationships rather than just physical similarities, which were the basis of Linnaeus' classification. Cladistics is a method of determining evolutionary relationships by identifying ancestral and derived traits. Similarities in nucleic acid base sequences provide the most direct evidence of evolutionary relationships.

Lesson Objectives

- Understand the concept of phylogenetic classification.
- Outline how cladistics generates cladograms and identifies clades.
- Compare phylogenetic and Linnaean classification systems.
- Explain how nucleic acid base sequences are used in phylogenetic classification.

Lesson Vocabulary

Table 17.5:

Lesson 14.2 Vocabulary		
phylogeny	phylogenetic tree	common ancestor
cladistics	clade	cladogram
ancestral traits	derived traits	parsimony
phylogenetic classification		

Check Your Understanding

Drawing on Student Experiences

At least one day before you introduce the lesson, ask students to find and bring to class examples of family trees. Display the family trees in the classroom. If they do not have one, ask them to create one. Refer them back to the *Genetics* chapter.

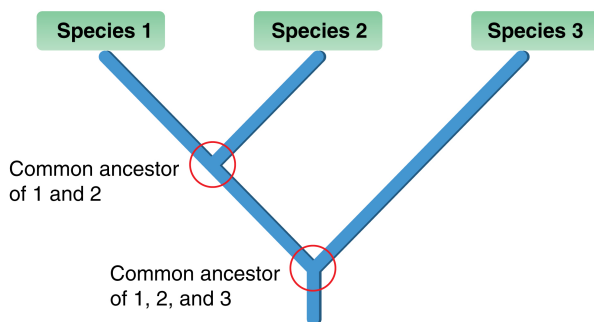
- Ask: What does a family tree show? (It shows the members of a family over several generations and how they are related to one another.)

Explain that similar trees can be constructed to show how species evolved over time, and how they are related to one another. Tell the class they will learn about this type of tree in this lesson.

Teaching Strategies

Use Visuals: Figure 2

Continue the family tree analogy to help students understand the role of common ancestors in phylogenetic classification. First have students examine **Figure 2** (below). Explain that species 1 and 2 in the figure are like siblings, while species 3 is like their aunt or uncle.



- Ask: What is the family equivalent of the common ancestor of species 1 and 2? (A parent.)
- Ask: What is the family equivalent of the common ancestor of all three species? (A grandparent of species 1 and 2, a parent of species 3.)
- Ask: Which two species would you expect to be most similar? Why? (Species 1 and 2, because they are more closely related to each other than either is to species 3.)

Use Visuals: Figure 4

Check that students understand what a cladogram represents. Have them study the cladogram of insect phylogeny in **Figure 4** (see below). Call on volunteers to answer the caption question. (The cladogram reveals that the clade of flies, butterflies, and moths shared a more recent common ancestor with the clade of wasps, bees, and ants, than either clade shared with beetles.)

- Ask: Which insects would you expect to be most and least similar to flies? Why? (You would expect butterflies and moths to be most similar to flies and beetles to be least similar to flies. This is because flies shared the most recent common ancestor with butterflies and moths, and the least recent common ancestor with beetles.)

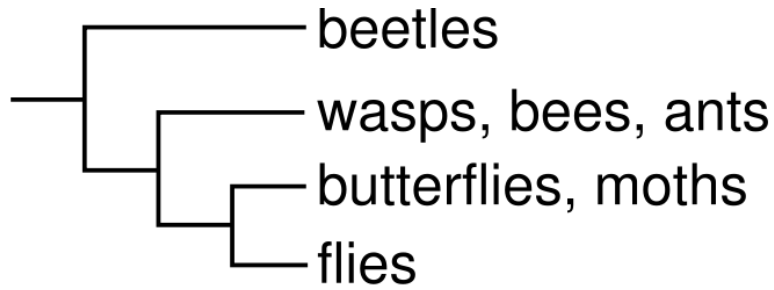


Figure 17.1: 4: Cladogram of Insect Phylogeny. Based on this cladogram, flies shared a more recent common ancestor with butterflies and moths than either group shared with other insects. What other evolutionary relationships does the cladogram reveal?

Activity

Have students go online to find a traditional Linnaean classification of the insects listed in the cladogram in Figure 4. (All four groups of insects are orders in the subclass of winged insects in the class Insecta.) Ask students to compare the traditional classification with the cladogram in the figure. What similarities and differences do they see? Discuss how the cladogram reveals evolutionary relationships while the traditional classification does not.

Differentiated Instruction: Gallery Walk

Write each set of questions below on a large sheet of paper, and post them on different walls of the classroom. Divide the class into groups, making sure that any special needs students can be assisted by others. Have the groups move around the room to discuss the posted questions and record their answers on the same sheets of paper. Discuss the answers as a class. Point out any misconceptions and identify the most accurate and complete responses.
SN

1. How is phylogeny different from taxonomy?
2. What is a phylogenetic tree? What does it show?
3. What is a clade? What is an example of a clade?
4. What are ancestral and derived traits? Give an example of each.

Enrichment: Diagram

Challenge students to find a cladogram for a mammalian order that interests them (like the sample cladogram for primates shown below). Make sure that each student selects a different order. Then have students create an illustrated phylogenetic tree for their order, using the cladogram as a starting point. Post their completed diagrams in the classroom, and encourage other students to examine and discuss them.

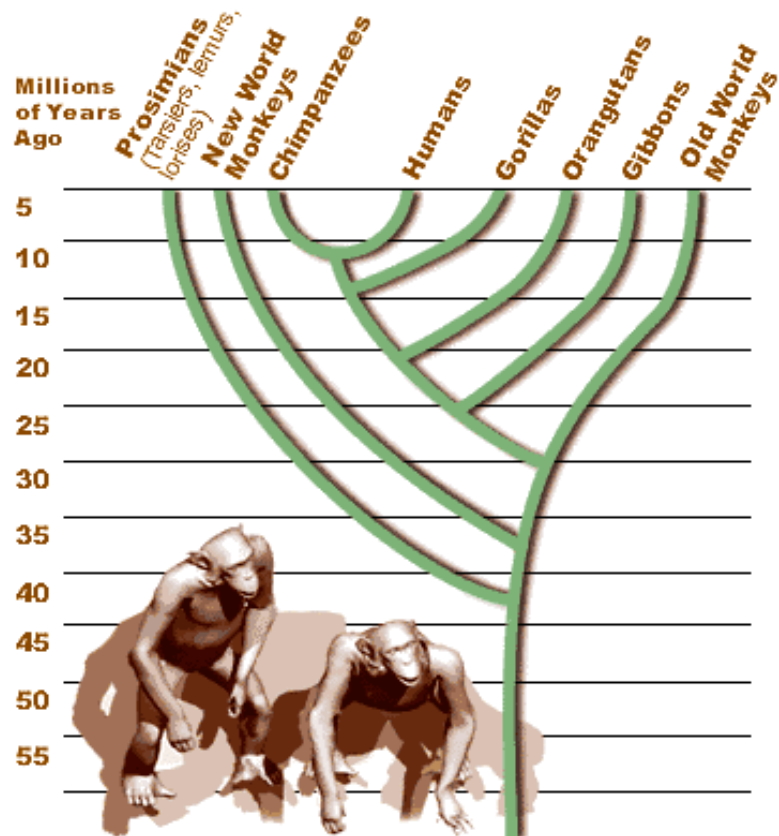


Figure 17.2: Darwin Philly Tree

Science Inquiry

Building a Model

Give students a chance to apply cladistic analysis by creating a cladogram for the “evolution” of a familiar technology. Examples such as the television or computer can be used (or music listening devices – record players to 8 track to cassette to walkmans to CDs to ipods). Divide the class into groups, and have each group select a technology. Tell students to do online research to identify the sequence in which major innovations occurred in their technology. Then have them create a cladogram to show how the technology “evolved” over time. Discuss as a class their completed cladograms. Discuss how cladograms in biology show the order derived traits evolve.

Reinforce and Review

Quizzing a Partner

Have each student write three to five true or false, or fill-in questions on the main ideas in the lesson. Then divide the class into pairs, and have partners use their questions to quiz each other. Students should find answers in their FlexBook for any questions they are not sure of.

Lesson Worksheets

Copy and distribute the four Lesson 14.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 14.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. Please send an email to teachers-requests@ck12.org to request sample answers.

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 14.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- How do you think microorganisms should be classified?
- Where do you think microorganisms should be placed in Linnaean taxonomy?
- Do you think a new taxon might be needed for microorganisms?

Lesson Assessment

- Have students complete the Lesson 14.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

17.4 Lesson 14.3: Modern Classification Systems

Key Concepts

As biologists learned more about life on Earth, they added the **Protista**, **Monera**, **Fungi**, and **Archaea** kingdoms to Linnaeus' original taxonomy. They also added a new taxon higher than the kingdom, called the domain. A three-domain system is currently the most widely accepted classification. It includes the domains **Bacteria**, **Archaea**, and **Eukarya**. This system may eventually need revision as knowledge of living things increases.

Lesson Objectives

- Identify the four new kingdoms that were added to the original Linnaean taxonomy.
- Describe the three domains of the three-domain system of classification.
- Explain why the three-domain system may need revision in the future.

Lesson Vocabulary

Table 17.6:

Lesson 14.3 Vocabulary		
Protista	prokaryote	eukaryote
Monera	fungi	domain
Bacteria	Archaea	Eukarya

Check Your Understanding

Facts and Figures

This lesson introduces microorganisms and how they are classified. Help students appreciate the number of Earth's microorganisms so they will understand the need to classify them. Tell the class, they are surrounded by an invisible sea of life forms that are too small to be seen without a microscope. In fact, the cells of microorganisms in, and on, their body contribute more to their mass, than do their own body cells, and they outnumber their own body cells ten to one.

Teaching Strategies

Build Science Skills: Observing

Give students an opportunity to view microorganisms by using a microscope to examine a drop of the water that contains a small amount of compost (available from any store with a landscaping/gardening department). Have students sketch and try to identify any organisms they observe. They can find online images, like the ones below, for comparison. They should look for cilia, flagellates, or other structures for locomotion in protozoa; bacteria may look like tiny beads or rods.

NOTE: Bottle Biology is an instructional materials development program funded by the National Science Foundation and administered by the University of Wisconsin-Madison, so I assume the images are public domain or freely usable. If not, they can simply be omitted.]

Activity

Divide the class into at least three groups, and assign each group one of the three domains: **Bacteria**, **Archaea**, **Eukarya**. Have each group find pictures of a wide range of organisms in their assigned domain and use them to create a scrapbook. Their aim should be to show the diversity of organisms in their domain as well as important traits shared by organisms in the domain. Encourage students to refer to the scrapbooks as they learn about the three domains.

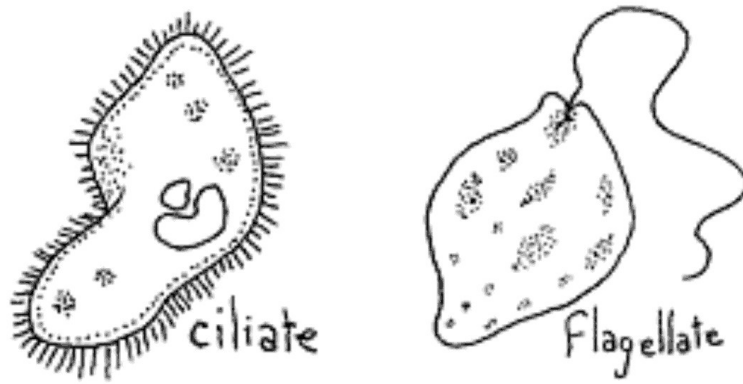


Figure 17.3: Protozoa

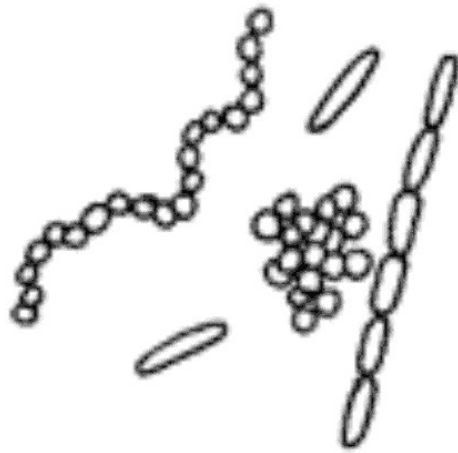


Figure 17.4: Bacteria

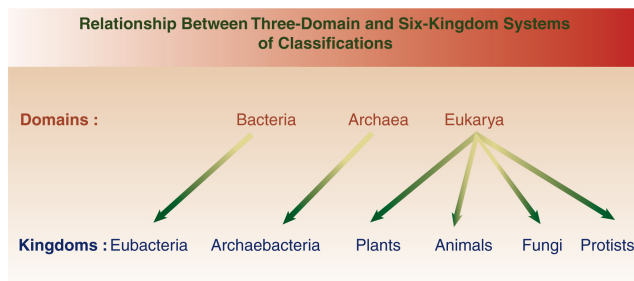
Discussion

Discuss the importance of ecological roles in the classification of organisms, using fungi as an example. Ask the following:

- What role do plants play in food chains? (They are producers.)
- Why do you think fungi were first classified in the plant kingdom? (Like plants, fungi cannot move on their own and they grow in soil.)
- Which important trait of plants do fungi lack? (The ability to make their own food by photosynthesis.)
- How do fungi obtain energy? (By breaking down dead organisms.)
- Are fungi producers or consumers? (Consumers.)

Use Visuals: Figure 6

Have students apply what they learned about cladograms in the last lesson to interpret the phylogenetic tree in Figure 6. Ask them to identify the three clades in the figure. (Each of the three domains is a clade. **Archaea** and **Eukarya** together form another clade.) Call on volunteers to explain what the clades reveal about the evolutionary history of the three domains.



Differentiated Instruction: Cluster Diagram

The ever-changing classification of organisms may be confusing for many students, including English language learners. Have these students focus on the currently accepted three-domain classification system. Pair them with native English speakers, and ask partners to create a cluster diagram for each of the three domains. The diagrams should include parallel information for each domain. A sample cluster diagram for the **Bacteria** domain is shown below. Urge students to share their cluster diagrams with the rest of the class. **ELL**

Sample Cluster Diagram {insert here}

Enrichment: Debate

Challenge a few students to learn more about mimivirus and the traits it shares with bacteria. Then ask the students to take sides and debate the issue of whether mimivirus should be classified in a new domain of life. Give them 5 – 10 minutes of class time to present their debate. Explain that this issue is just one of many that biologists are currently considering as they continue to revise classifications of Earth's organisms.

Science Inquiry

Problem Solving

Tell students to assume they are biologists who have just discovered a new organism in a sample of lake water. Write the following traits of the new organism on the board:

- Single, simple cell.
- Nucleus enclosed within a membrane.
- Contains chlorophyll. (Needed for photosynthesis.)

Have each student write a paragraph explaining how they think the organism should be classified. (The organism should be placed in the **Eukarya** domain because it has a nucleus enclosed within a membrane. It is protist because it has a single, simple cell.) Make sure students do not assume the organism is a bacterium because it has a single cell or a plant because it contains chlorophyll.

Reinforce and Review

Flashcards

Suggest to students that they make flashcards with the lesson vocabulary terms on one side and their definitions of the other side. They can use the cards to quiz themselves or each other on the major taxa covered in the lesson.

Lesson Worksheets

Copy and distribute the four Lesson 14.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs, as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 14.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. Please send an email to teachers-requests@ck12.org to request sample answers.

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 14.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What do you think ecology is?
- What do you think ecologists study?
- In addition to ways of obtaining energy, what traits of organisms do you think ecologists are likely to be most interested in?

Lesson Assessment

- Have students complete the Lesson 14.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

17.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

- (1) *Darwin Philly Tree*. Public Domain.
- (2) *Bacteria*. Public Domain.

(3) *Protozoa*. Public Domain.

(4) <http://en.wikipedia.org/wiki/File:Cladogram-example1.svg>. Commons.

Chapter 18

TE Biology Unit 5: Ecology

18.1 Unit 5: Ecology

Outline

This unit, *Ecology*, includes four chapters that investigate how living things interact with each other and how they relate to other aspects of their environment.

- Chapter 15: Principles of Ecology
- Chapter 16: Biomes, Ecosystems, and Communities
- Chapter 17: Populations
- Chapter 18: Ecology and Human Actions

Overview

The Ecology unit introduces the principles of ecology, including how energy flows through ecosystems and how matter is recycled. It gives an overview of Earth's major biomes, explores the nature of ecosystems, and describes community interactions. It also describes the characteristics of populations and explains how populations grow, with a focus on the human population. Finally, it relates how human actions have impacted biodiversity, natural resources, air quality, and climate change

Chapter 19

TE Principles of Ecology

19.1 Chapter 15: Principles of Ecology

Outline

The chapter *Principles of Ecology* consists of three lessons that introduce students to basic ideas of ecology.

- Lesson 15.1: The Science of Ecology
- Lesson 15.2: Flow of Energy
- Lesson 15.3: Recycling Matter

Overview

- This chapter explains fundamental ecological concepts and principles, such as the ecosystem concept and the competitive exclusion principle. It also explains how energy flows and matter continuously cycles through ecosystems.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the table below as a guide for the time required to teach the lessons of this chapter.

Table 19.1:

Lesson	Number of Class Periods*
15.1 The Science of Ecology	1.0
15.2 Flow of Energy	2.5
15.3 Recycling Matter	1.5

- Class periods are assumed to be 60 minutes long.

Managing Materials

The following materials are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 19.2:

Lesson	Strategy or Activity	Materials Needed
15.2	1. Activity	1. Microscope, slides, water containing plankton
15.3	1. Differentiated Instruction: Cycle Diagram	1. Toy trees and animals, different types of dry beans or pasta

Lab Links

The following labs are suitable for this chapter and are available online:

- Biodiversity and Ecosystems: Students undertake a field study to collect data on biotic and abiotic environmental factors in two different ecosystems. They also compare the biodiversity of the two ecosystems and relate it to the factors studied. The lab can be adapted to ecosystems near your school. (Lesson 1) <http://www.scribd.com/doc/396425/AP-Biology-Ecology-Lab>
- Observation and Hypothesis Testing in Ecology: This deceptively simple lab reinforces students' understanding of the experimental method, builds their observational skills, and gives them hands-on experience with ecological fieldwork. No special equipment or materials are needed. (Lessons 1–3) http://nsm1.nsm.iup.edu/rgendron/Obsn_Lab.doc

Other Web Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- This Web site has clear and interesting animations to help students understand inter-specific competition and the nitrogen cycle. (Lesson 1 and 3) <http://www.biology.ualberta.ca/facilities/multimedia/index.php?Page=280>
- Online Biology Book: The three ecology chapters in this concise and well-illustrated text cover many of the same topics as the FlexBook Ecology Unit chapters but with enough additional material to make them worth reading. For example, the phosphorus cycle and plate tectonics are included in the online chapters. You may find it helpful to read the chapters yourself. They could also be assigned for enrichment. <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html>

Common Misconceptions

Ecosystem Errors

A common student misconception is that ecosystems are simply collections of organisms. Ask students if they have ever heard the expression, “the whole is greater than the sum of its parts?” Explain why an ecosystem is a good example. An ecosystem is more than just the sum of its organisms. It also includes interactions among organisms and interactions between organisms and the environment. Therefore, an ecosystem is a complex entity that functions as a whole and is much more than its component parts.

Food Web Fallacies

There are several common misconceptions about food chains, including the following:

1. There is more biomass at the top of a food chain because organisms at the top are larger.
2. Energy is not lost as it passes up a food chain.
3. There is more energy at the top of a food chain because it accumulates up the chain.
4. Organisms higher in a food chain eat everything that is lower in the chain.
5. Populations higher in a food chain are bigger because they deplete populations lower in the chain.

Use these statements as a true-false quiz to identify which misconceptions are held by students in your class. Then call on volunteers to restate the misconceptions so they are true.

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons of this chapter, in your students' FlexBook. You should also consult the standards correlation table that follows when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the chapter *Principles of Ecology*, students should have read these chapters: *Foundations of Life Science* and *Chemical Basis of Life*.
- Students should read *Principles of Ecology* before reading the other three ecology chapters: *Biomes, Ecosystems, and Communities*; *Populations*; and *Ecology and Human Actions*.
- It is recommended that you include all the lessons of *Principles of Ecology* in the FlexBook.

19.2 Lesson 15.1: The Science of Ecology

Key Concepts

Ecology is the scientific study of living things and their interactions with the biotic and abiotic components of their environment. Ecologists study organisms and their environments at different levels, from the population to the biosphere. They also study ecosystems, which include communities of interacting species and their environments. Ecologists use a variety of methods, including field studies, to gather and analyze ecological data.

Lesson Objectives

- State what ecologists study, and identify levels of organization in ecology.
- Define ecosystem, niche, and habitat, and explain how the concepts are related.
- Describe methods of ecology, such as field studies, sampling, statistical analysis, and modeling.

Lesson Vocabulary

Table 19.3:

Lesson 15.1 Vocabulary			
ecology	organism	environment	
abiotic components	biotic components	biosphere	
population	community	ecosystem	
niche	habitat	competitive	exclusion
		principle	
field studies	descriptive statistics	range	
inferential statistics			

Check Your Understanding

Recalling Prior Knowledge

Most students are likely to have some familiarity with ecology from previous science classes. Help them recall what they already know by asking them to define in their own words these basic concepts from Lesson 15.1: ecology, environment, ecosystem, and niche. Tell the class they will learn more about these concepts when they read the lesson.

Teaching Strategies

Use Visuals: Figure 1

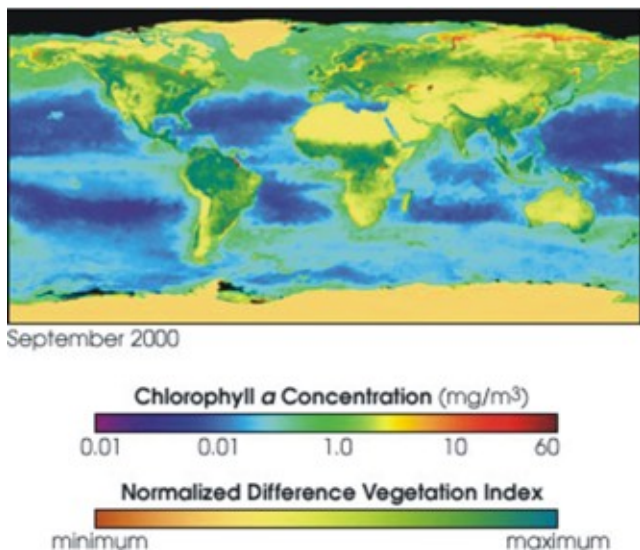
Help students appreciate the importance to living things of abiotic components in the environment. Have them look at the worldwide density of land vegetation in **Figure 1** (below). Then ask them to identify abiotic components that help explain the density in different parts of the world (e.g., temperature, rainfall).

- Point out that the map represents the density of vegetation in September.
- **Ask:** How might the density of land vegetation be different in the northern United States in February?

(Sample answer: The density would be lower because it would be too cold for most plants to grow.)

- **Ask:** Do you think there would be as much seasonal variation in the density of phytoplankton in the ocean? Why or why not?

(Sample answer: I think there would be less seasonal variation because the temperature of the ocean changes less from season to season.)



This image of Earth's surface shows the density of the chief life forms that produce food for other organisms in the biosphere. Plants are the chief food producers on land, and phytoplankton are the chief food producers in the ocean. The map shows the density of plants with a measure called the normalized difference vegetation index and the density of phytoplankton with the chlorophyll concentration.

Building Science Skills: Applying Concepts

Guide students in applying fundamental concepts of ecology through examples. First ask the class to think of several familiar organisms in nature (e.g., rabbit, robin, pine tree). Then, call on students to describe each of the following as they apply to the organisms: population, community, ecosystem, niche, and habitat. Have students refer to the FlexBook for assistance.

Discussion

Discuss possible outcomes when two species have overlapping niches and compete for some of the same resources. Point out that interspecific competition does not always result in one species going extinct. Instead, it may result in each species becoming more specialized so there is no longer overlap in their niches. On the board or an overhead transparency, draw a diagram like the one below to represent this outcome. Call on volunteers to fill in details to explain how this might happen.

- A. Two similar species have overlapping niches. This results in interspecific competition.
- B. Interspecific competition influences how the two species evolve by natural selection.

- C. Through evolution, the two species become different enough that they no longer have overlapping niches and compete with one another.

Differentiated Instruction: Word Wall

Pair English Language Learners with native English speakers, and have pairs work together to start an ecology word wall. Divide the following vocabulary terms among the pairs: organism, population, community, ecosystem, biosphere, niche, habitat, abiotic components, and biotic components. Ask them to post each word, its definition, and an illustrated example on a wall of the classroom. Have students add more vocabulary words to the word wall as they complete this and other ecology chapters in their FlexBook. **ELL**

Enrichment: Power Point Show

Assign each of four students one of the methods of ecology described in this lesson. Have students find examples of recent, credible ecological research in which the assigned method plays an important part. Then ask the four students to pool their information and create a PowerPoint show to share their examples and explain how and why each method was used. Allow time for them to present their PowerPoint show to the class.

Science Inquiry

Formulating a Hypothesis

Describe a classic case of competitive exclusion in which character displacement allows species with overlapping niches to coexist. Good examples include MacArthur's warblers and Darwin's finches (see URLs below).

- Ask students to formulate a hypothesis about the outcome of the case. (Students are likely to assume that one species would outcompete and replace another.)
- Describe the actual outcome. (Species avoid competition by evolving differences in the area of overlap.) http://www.stanford.edu/group/stanfordbirds/text/essays/MacArthur's_Warblers.html <http://cas.bellarmine.edu/tietjen/RootWeb/CompetitionSmall.htm>

Reinforce and Review

Outlining the Lesson

Divide the class into pairs, and have partners work together to outline the lesson. If necessary, explain how to use the heading structure of the lesson for the main entries of the outline.

Lesson Worksheets

Copy and distribute the four Lesson 15.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 15.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 15.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Which organisms in an ecosystem capture the energy from sunlight?
- How do they transform the energy so that other organisms in the ecosystem can use it?
- Why is the energy that enters an ecosystem eventually used up?

Lesson Assessment

- Have students complete the Lesson 15.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

19.3 Lesson 15.2: Flow of Energy

Key Concepts

Energy enters most ecosystems from sunlight. Organisms called producers use the energy to produce food, in the form of carbohydrates. Some of the energy is passed to consumers who eat the food and to decomposers who break down organic remains. These relationships can be shown with a food chain or food web.

Lesson Objectives

- Describe how autotrophs use energy to produce organic molecules.
- Identify different types of consumers, and give examples of each type.
- Explain how decomposers resupply elements to producers.
- Describe food chains and food webs, and explain how energy is transferred between their trophic levels.

Lesson Vocabulary

Table 19.4:

Lesson 15.2 Vocabulary		
producers	autotrophs	photoautotrophs
photosynthesis	phytoplankton	chemoautotrophs
chemosynthesis	oxidation	Archaea
consumers	heterotrophs	herbivores
zooplankton	plankton	carnivores
scavengers	omnivores	decomposers
detritus	detrivores	saprotrophs
food chain	food web	trophic levels
biomass		

Check Your Understanding

Recalling Prior Knowledge

Introduce the lesson by calling on a volunteer to go to the board and draw a simple food chain that contains at least three different organisms. Ask other students if they can name the roles of the organisms in the food chain. State that a food chain shows how energy flows

through an ecosystem. Tell students they will learn more about energy flow in this lesson.

Teaching Strategies

Activity

Stress the significance of plankton in aquatic food chains. Then give students a chance to observe live plankton under a microscope. Collect plankton and shortly before class begins, prepare live-mount slides. Tips for collecting plankton, preparing slides, and identifying organisms in plankton are available at the Web site below. Have students try to identify any organisms they observe and describe their ecological roles. <http://www.saddleback.edu/faculty/thuntley/ms20labs/planktonlab.pdf>

Discussion

Help students appreciate the diversity of consumers by discussing different types of consumers. Write the following types on the board: herbivore, carnivore, scavenger, omnivore. Call on students to state how each type of consumer obtains energy. Then have the class brainstorm examples of each type.

Discussion

Students may overlook the significant role of decomposers in ecosystems because they are typically omitted from food webs. Help the class imagine a world without decomposers.

- Ask: What would be different if there were no organisms to break down and consume dead organisms and other remains of living things?

(All the remains—including sewage, garbage, dead leaves, and yard waste—would rapidly accumulate. We would be drowning in dead organisms and other organic remains.)

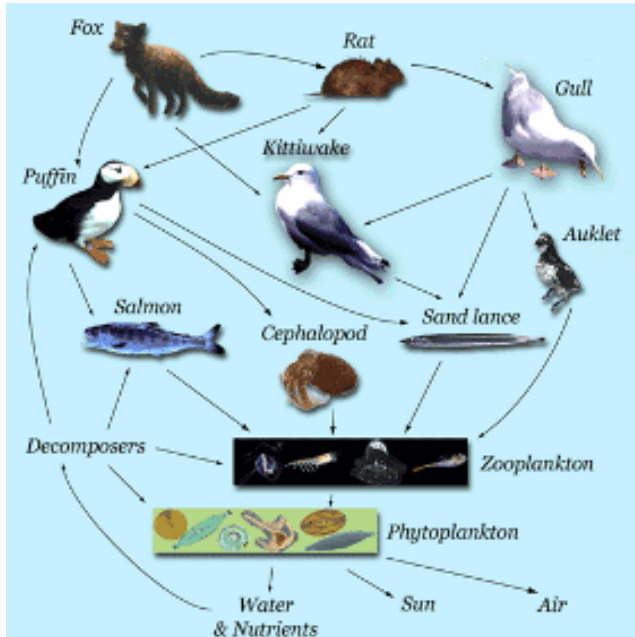
- Ask: Why do plants depend on decomposers?

(Decomposers break down remains to elements that plants need in order to produce food.)

Using Visuals: Figure 6

Have students examine the food web in **Figure 6** (below). Make sure they understand how the food web shows the flow of energy among organisms and how to identify trophic levels

of organisms from a food web. Call on students to describe at least three different paths through which energy flows from the phytoplankton to the fox. Then, for each path, ask them to identify the trophic level of the fox.

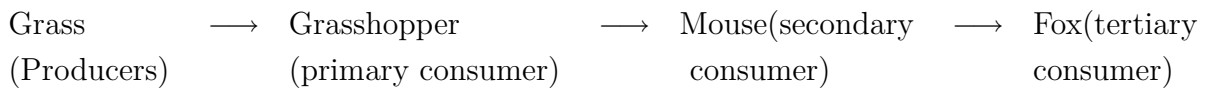


This aquatic food web consists of several intersecting food chains. Which organisms are producers in all the food chains included in the food web?

Differentiated Instruction: Flow Chart

Pair Less Proficient Readers with more proficient ones. Then ask partners to make a flow chart, like the one below, to show how energy flows through the following (or similar) organisms in an ecosystem: grass, grasshopper, mouse, and fox. Tell them to label the trophic level of each organism in the flow chart. **LPR**

Flow of Energy:



Enrichment: Diagram

Ask a few interested students to research the community of organisms that live in the ecosystem around a hydrothermal vent in the ocean floor. Then have them create an illustrated

food web showing how energy flows through the ecosystem. Set aside time for students to share their food web with the class. Ask them to explain how the producers in the food web make food and how the consumers use it.

Science Inquiry

Building a Model

Divide the class into groups and ask members of each group to list several different organisms that might be part of the same food web. They should list producers, different levels of consumers, and decomposers. Allow students to do online research as needed to refine or expand their list of organisms and learn more about them. Then have them create a food web that includes all the organisms on their list. Their aim should be to create a reasonably accurate food web that includes all the ecological roles. Post their completed food webs in the classroom.

Reinforce and Review

Quiz Game

Play a quiz game in which students compete to identify examples and explain the ecological roles of different types of organisms (e.g., photoautotrophs, herbivores, detritivores). You might award token prizes to students who answer correctly.

Lesson Worksheets

Copy and distribute the four Lesson 15.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 15.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 15.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Do you think abiotic components of ecosystems also play roles in recycling matter?
- What abiotic components do you think might be involved? For example, what abiotic components do you think might be involved in the cycling of water?

Lesson Assessment

- Have students complete the Lesson 15.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

19.4 Lesson 15.3: Recycling Matter

Key Concepts

Biogeochemical cycles recycle matter continuously through ecosystems. All chemical elements needed by organisms are recycled. Cycles of matter include the water cycle, carbon cycle, and nitrogen cycle.

Lesson Objectives

- Define and give examples of biogeochemical cycles that recycle matter.
- Describe the water cycle and the processes by which water changes state.
- Summarize the organic and geological pathways of the carbon cycle.
- Outline the nitrogen cycle and state the roles of bacteria in the cycle.

Lesson Vocabulary

Table 19.5:

Lesson 15.3 Vocabulary		
biogeochemical cycle	water cycle	sublimation
transpiration	precipitation	infiltration
runoff	groundwater	aquifer
carbon cycle	cellular respiration	subduction
volcanism	nitrogen cycle	nitrogen fixation
ammonification	nitrification	denitrification
anammox reaction		

Check Your Understanding

Facts and Figures

Tell the class that the average American uses about 100 gallons of water per day (about a quarter of it for toilet flushing). This means that each of us uses an average of 36,500 gallons of water per year.

- Ask: At this rate, why isn't water quickly used up? (Because it is constantly recycled.)
- Tell students they will learn in this lesson how water and other kinds of matter are recycled.

Teaching Strategies

Build Science Skills: Predicting

Students will have a deeper understanding of the water cycle if they can predict the effects on the cycle of changes in important parameters. As an example, challenge them to predict the effects on the water cycle of continued global climate change.

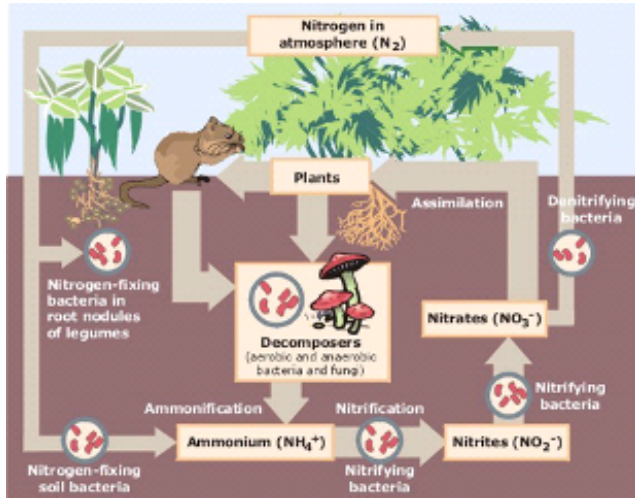
(Sample predictions: Less water would be stored in glaciers; more water would evaporate from the surface or it would evaporate faster.)

Activity

Have students play the carbon cycle game at the Web site below. They will pretend they are a carbon atom moving through the carbon cycle and win points by traveling to all the places that carbon is stored. This can be done as a whole class activity as well. Have students take notes on the information presented. http://www.windows.ucar.edu/earth/climate/carbon_cycle.html

Use Visuals: Figure 3

Help students appreciate the significant roles that bacteria and decomposers play in the nitrogen cycle. Have them look closely at the nitrogen cycle in **Figure 3**. Starting with nitrogen gas in the atmosphere, have them trace the pathways by which nitrogen gas that enters soil is converted to nitrates that plants can use.



- **Ask:** What types of bacteria help make nitrogen available to plants, and what do they do?

(Nitrogen-fixing bacteria change nitrogen gas to nitrates; nitrifying bacteria convert ammonium ions to nitrites and nitrites to nitrates.)

- **Ask:** If all the decomposers were removed from an ecosystem, what would happen to the nitrogen cycle?

(Nitrogen in organisms would not be released back to the soil to continue through the cycle.)

Differentiated Instruction: Cycle Diagram

Group students who are visually impaired, or have trouble with abstract concepts, with students who can assist them. Have the group create a three-dimensional cycle diagram to show how carbon cycles through the biosphere. They should use objects such as toy trees and toy animals to represent the organisms in the cycle and different types of dry beans or pasta to represent carbon dioxide and other carbon compounds. Give pairs a chance to demonstrate their diagram to the class by moving the carbon compounds through the cycle and explaining what is happening at each stage. **SN**

Enrichment: Word Puzzles

Ask a few students to create criss-cross or other word puzzles that incorporate at least a dozen of the lesson vocabulary terms. Distribute copies of the puzzles to the rest of the students and have them complete the puzzles as homework. The Web site below has applications students can use to create their puzzles. <http://puzzlemaker.discoveryeducation.com/>

Science Inquiry

Problem Solving

State that a greater concentration of carbon dioxide in the atmosphere is a major contributor to the greenhouse effect and global warming. Challenge the class to use their knowledge of the carbon cycle to think of ways that the concentration of carbon dioxide in the atmosphere could be reduced in order to help control global warming.

(Sample answers: Plant more trees and decrease the destruction of forests; reduce the mining and burning of fossil fuels; find and use alternatives to cement; reduce reliance on animal products and increase reliance on plant foods so fewer animals and more plants are raised.)

Reinforce and Review

Labeling a Drawing

Create a simple drawing of the water cycle with blanks instead of labels for each part or process of the cycle. Distribute copies of the drawing to students, and have them fill in the blanks. They can check their answers by looking at the water cycle diagram in Figure 1 of their FlexBook lesson. You can repeat this exercise for the carbon and nitrogen cycles. The water cycle diagram at <http://livingclassrooms.org/slurrrp/watercycle.html> can be used.

An unlabeled carbon cycle diagram can be found at <http://library.thinkquest.org/11226/why.htm>

An unlabeled nitrogen cycle diagram can be found at <http://st.mengrai.ac.th/users/9228/m31/hooi/com/e%20book/nitrogen-cycle.jpg>

Lesson Worksheets

Copy and distribute the four Lesson 15.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 15.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 15.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What factors do you think might cause ecosystems to differ in this way?
- What abiotic components of the environment do you think might be important?
- What about the amount of sunlight or precipitation that ecosystems receive? What roles do you think these abiotic components play in cycles of matter?

Lesson Assessment

- Have students complete the Lesson 15.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

19.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 20

TE Biomes, Ecosystems and Communities

20.1 Chapter 16: Biomes, Ecosystems and Communities

Outline

The chapter *Biomes, Ecosystems, and Communities* consists of four lessons that introduce Earth's biomes and the ways species interact in communities.

- Lesson 16.1: Biomes
- Lesson 16.2: Terrestrial Biomes
- Lesson 16.3: Aquatic Biomes
- Lesson 16.4: Community Interactions

Overview

- A biome is a group of similar ecosystems that covers a large area. Terrestrial biomes are determined primarily by climatic factors of temperature and moisture. Aquatic biomes are influenced mainly by distance from shore and depth of water. Species in communities interact in various ways, such as predation and parasitism.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 20.1:

Lesson	Number of Class Periods*
16.1 Biomes	1.5
16.2 Terrestrial Biomes	2.0
16.3 Aquatic Biomes	2.0
16.4 Community Interactions	1.5

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

- Biodiversity Activities: Combine the two biodiversity activities at the Web site below for a quick and easy simulation lab. Students learn how to calculate a biodiversity index and then use readily available materials to simulate how biodiversity can help make ecosystems resilient to disease. The biodiversity of Earth's biomes is a major thread that runs throughout this chapter, so the lab is relevant to all four lessons. (Lessons 16.1–16.4) <http://www.accessexcellence.org/AE/ATG/data/released/0534-KathyParis/index.php>
- Dissolved Oxygen and Aquatic Primary Productivity: Students investigate the role of sunlight and nutrients on primary productivity in an aquatic ecosystem. This is a good lab for AP students. It requires a science laboratory. (Lesson 16.3) <http://io.uwinnipeg.ca/~simmons/yseps/contents.htm>
- Destruction of a Wetland: Using activities 2 and 7 in the online document below, students construct and experiment with wetlands in glass jars. They learn how wetlands form, their salient characteristics, and how human activities affect wetlands and surrounding areas. Doing the lab will help students appreciate why wetlands should be protected. The lab requires only readily available materials. (Lesson 16.3) <http://nsgd.gso.uri.edu/michu/michue79002.pdf>
- Endosymbiosis: A Friend Within: Students study an example of mutualism in termites and protozoa. This lab is relatively advanced but, other than a microscope, requires few materials. (Lesson 16.4) http://www.accessexcellence.org/AE/AEC/AEF/1995/everson_endosymbiosis.php
- Ecological Succession Lab: Written for use in Michigan, this field lab can be tailored for use in other biomes. Students examine organisms in local ecosystems at different

points on a continuum of ecological succession. The lab helps students see ecological change as a continuous process rather than a series of discrete stages. http://www.msta-mich.org/downloads/mcfmeap/succession_lesson.pdf

Common Misconceptions

Keystone Species

Students commonly think that only species that are directly related in a food chain, such as predator and prey species, influence each other's populations. Describe as a counter example a keystone species, and explain how it influences the populations of many other species in its community. A good example is the elephant in African savannas. <http://www.fieldtripearth.org/article.xml?id=754>

Ecological Succession

Students may have the misconception that communities in ecosystems are unchanging. Explain that communities are constantly changing in most ecosystems. Have the class brainstorm examples of community changes they have observed in their own area, or point out examples yourself, such as weeds colonizing a vacant lot or a farm field reverting to woodland. Doing the ecological succession lab (described above) can also help students overcome this misconception.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 20.2:

Lesson	Strategy or Activity	Materials Needed
16.1	1. Activity	1. Globe
16.3	1. Activity 2. Science Inquiry: Building a Model	1. Materials to make a bulletin board, such as push pins and colored paper 2. Materials listed at the Web site: http://www.thewildclassroom.com/biomes/index.html

Table 20.2: (continued)

Lesson	Strategy or Activity	Materials Needed
16.4	<ol style="list-style-type: none"> 1. Activity 2. Enrichment: Display 	<ol style="list-style-type: none"> 1. Materials listed at the Web site: http://www.hawkquest.org/TA/XL/Survival-games.pdf 2. Materials to make a display, such as markers and poster board

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- Biomes: This Web site has many links to additional information and activities about world biomes. <http://www.theteacherscorner.net/thematicunits/biomes.htm>
- Biomes of the World: This Web site has lesson plans for each world biome and includes species and scientist profiles. <http://www.thewildclassroom.com/biomes/index.html>
- These Web sites have excellent information, climographs, and illustrations for major world biomes. They provide a wealth of information and visuals. They are useful for both teachers and students. <http://www.cotf.edu/ete/modules/msese/earthsysflr/biomes.html> <http://earthobservatory.nasa.gov/Experiments/Biome/> <http://www.ucmp.berkeley.edu/exhibits/biomes/index.php> <http://www.thewildclassroom.com/biomes/index.html>
- The online chapter Community and Ecosystem Dynamics covers most of the same topics as the FlexBook chapter and includes many excellent visuals. See it especially for the large, vivid photographs of the different biomes. <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookcommecosys.html>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons of this chapter, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the chapter *Biomes, Ecosystems and Communities*, students should have read the *Principles of Ecology* chapter.
- Students should read this chapter before reading the chapters *Populations* and *Ecology and Human Actions*.
- If class time is limited, you may wish to omit Lesson 16.3, Aquatic Biomes.

20.2 Lesson 16.1: Biomes

Key Concepts

Terrestrial biomes are defined mainly by climate, especially temperature and moisture. Climate determines a biome’s growing conditions for plants, its biodiversity, and the adaptations its organisms must have to survive there.

Lesson Objectives

- Define biome and climate, and explain how biomes are related to climate.
- Outline how climate determines growing conditions for plants and affects the number and biodiversity of plants in a biome.
- Explain how climate is related to biodiversity of biomes and adaptations of organisms.

Lesson Vocabulary

Table 20.3:

Lesson 16.1 Vocabulary		
biome	terrestrial biome	aquatic biome
climate	rain shadow	growing season
biodiversity		

Check Your Understanding

Previewing Visuals

Introduce the lesson by encouraging students to think about how and why biomes differ. Have students look at **Figure 1** (below) and describe how the two places look different. (One is covered with sand and has no visible plants; the other is densely covered with vegetation.) Ask the class to brainstorm factors that might explain why the two places differ so much in

plant cover.

(Sample answers: They might receive different amounts of precipitation; they might have different types of soil.)



Teaching Strategies

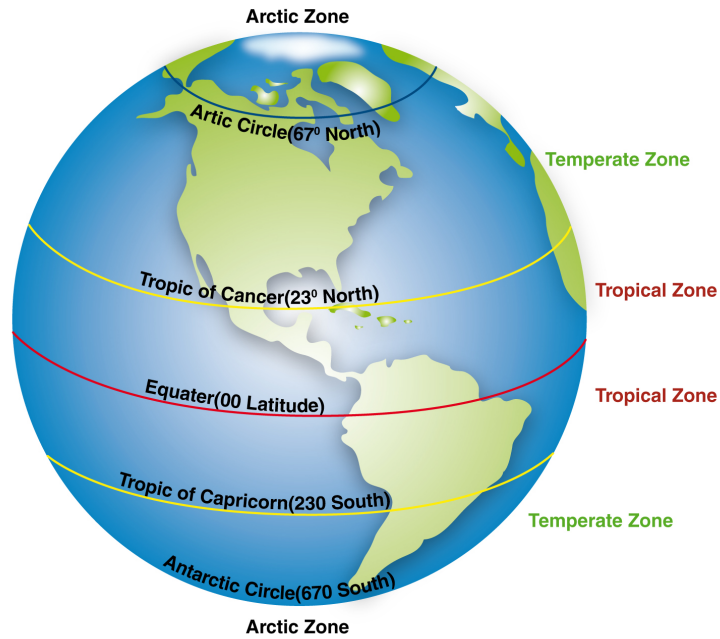
Discussion

Discuss weather and climate, and how they differ. Have students look at temperature or precipitation data for a major city in their area (see URL below). Ask them to compare a recent year's daily values with mean daily values. Explain how the single-year values and the mean values represent weather and climate, respectively. <http://www.wunderground.com/>

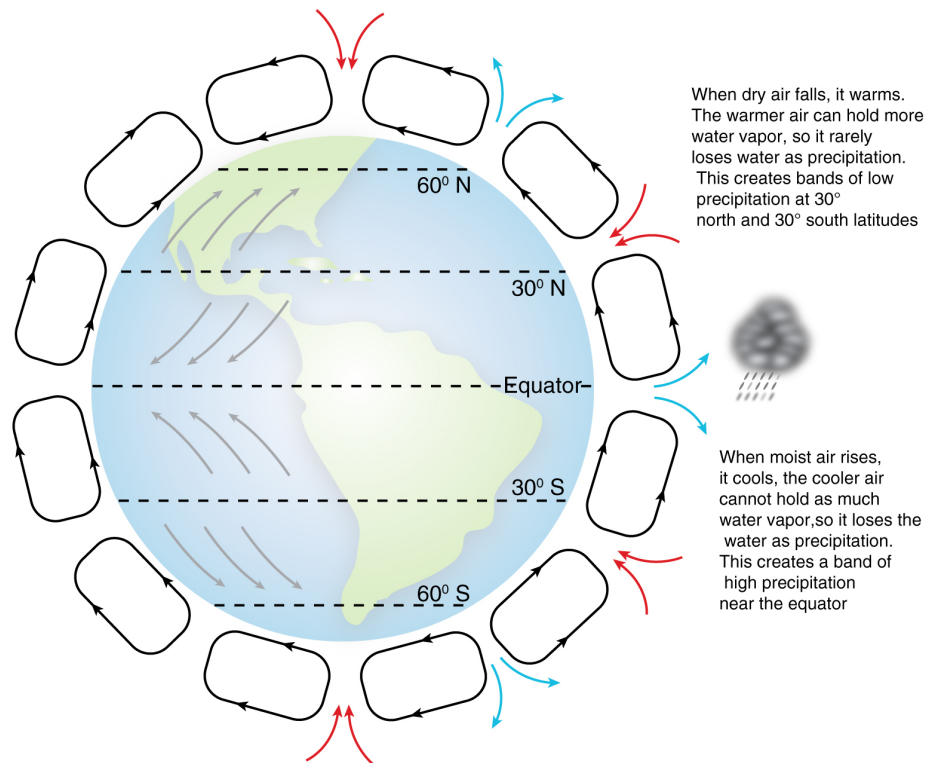
Using the map of the United States, click on a state/area, find a city of interest and click on that city for more detailed information, including the weather and climate history.

Activity

Bring a globe to class and let students use it to find the major climate zones shown in **Figure 2** (see below). When students read about the movement of air masses, divide the class into pairs, and have them use the globe to model the Coriolis effect, which is shown in **Figure 3** (below). One student can spin the globe counterclockwise while the other student slides a finger vertically on the surface of the spinning globe. Point out how the finger “travels” west across the globe. Explain how this relates to the direction of prevailing winds in **Figure 3**.



Major climate zones based on temperature include tropical, temperate, and arctic zones. The tropical zone extends from the Tropic of Capricorn to the Tropic of Cancer. The two temperate zones extend from the tropical zone to the arctic or antarctic circle. The two arctic zones extend from the arctic or antarctic circle to the north or south pole.



KEY:
 Blue arrows = direction of moist air masses
 Red arrows = direction of dry air masses
 Black arrows = direction of prevailing winds

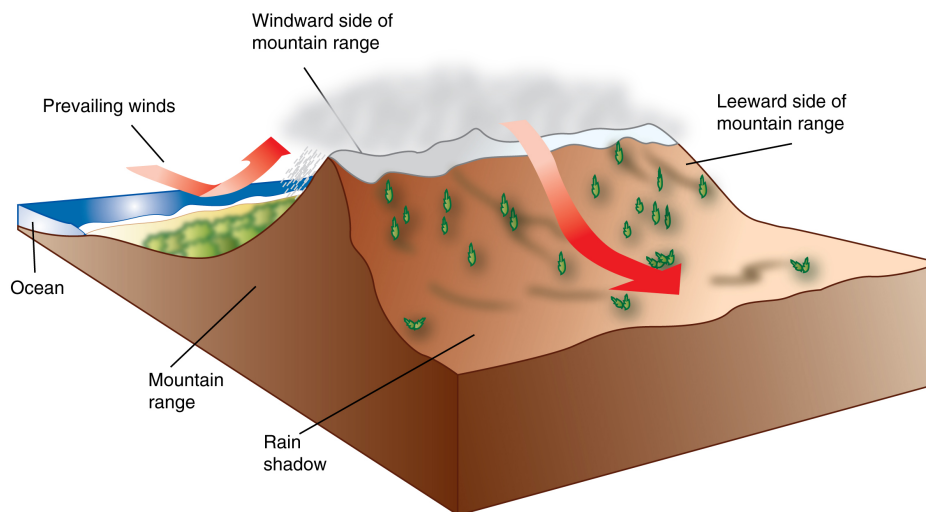
This model of Earth shows the direction in which air masses typically move and winds usually blow at different latitudes. These movements explain why some latitudes receive more precipitation than others.

Use Visuals: Figure 4

Have the class examine **Figure 4** and answer the caption question: *How has this affected plant growth on the two sides of the mountain range?*

(The windward side of the mountain range has a wet climate with many plants; the leeward side has a dry climate with few plants.)

Ask students to think of places in California that have these different climates (e.g., San Francisco and Death Valley). Discuss how distance from the ocean influences climate and growing conditions.



The windward side of this mountain range has a humid climate, whereas the leeward side has an arid climate. On the windward side, warm moist air comes in from the ocean, rises and cools, and drops its moisture as rain or snow. On the leeward side, the cool dry air falls, warms, and picks up moisture from the land. How has this affected plant growth on the two sides of the mountain range?

Differentiated Instruction: Word Wall

Pair English language learners with native English speakers, and have pairs add words to the ecology word wall. (See the DI activity in the *Principles of Ecology* chapter, Lesson 15.1) Assign pairs the following terms: biome, climate, weather, rain shadow, growing season, and biodiversity. Ask them to post their words on the word wall, along with definitions, examples, and illustrations. Have students continue to add to the world wall as they read

the rest of the chapter. (ELL)

Enrichment: Poster Presentation

Have interested students learn more about the biodiversity of different biomes. Then have them make posters with graphs and pictures to illustrate and explain the differences in biodiversity. Give students a chance to present their posters to the class.

Science Inquiry

Analyzing

Divide the class into groups, and assign each group a city in a different climate zone. All major climate zones should be covered. Have students find online data (see URL below) on mean temperature and precipitation for their assigned city. Give each group a turn to present its data to the class. Then have students analyze the data for each city and identify its climate zone. <http://www.wunderground.com/>

Reinforce and Review

Using Vocabulary

Ask students to use each of the boldface vocabulary terms in a sentence that conveys its meaning. Suggest that pairs of students exchange sentences and resolve any differences of opinion by referring to their FlexBook.

Online Quiz

Have students take the Ecology Biomes Quiz at the URL below. <http://www.lessonplansinc.com/science.php/biology/lessonplans/C120>

Lesson Worksheets

Copy and distribute the four Lesson 16.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 16.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 16.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Plants and the other organisms in terrestrial biomes are greatly influenced by climate.

- What is the climate like where you live?
- How hot or cold does it get, and how much precipitation usually falls?
- Discuss with your class the climate in your area and how it seems to affect plant growth.
- What plants and animals are naturally found in your part of the country?

Lesson Assessment

- Have students complete the Lesson 16.1 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

20.3 Lesson 16.2: Terrestrial Biomes

Key Concepts

Terrestrial biomes are generally classified on the basis of climatic factors and the types of plants that are the primary producers. Terrestrial biomes include: tundra, boreal forest, temperate forest, temperate grassland, chaparral, tropical forest, tropical grassland, and desert.

Lesson Objectives

- State how terrestrial biomes are classified and distributed around the globe.
- Outline abiotic and biotic factors in tundra and boreal forest biomes.
- Describe climatic factors and organisms of temperate zone biomes.
- List abiotic factors in deserts and adaptations of desert organisms.
- Identify abiotic factors and organisms in tropical biomes.

Lesson Vocabulary

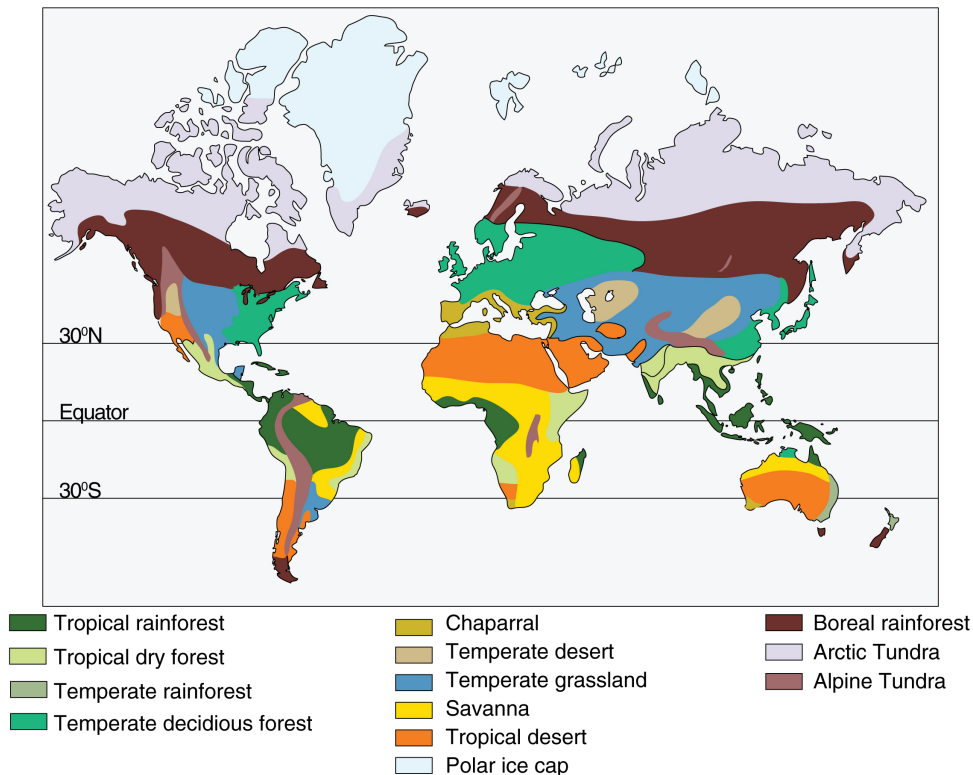
Table 20.4:

Lesson 16.2 Vocabulary		
tundra	arctic tundra	alpine tundra
tree line	permafrost	boreal forest
temperate deciduous forest	temperate rainforest	epiphyte
temperate grassland	chaparral	desert
tropical rainforest	tropical dry forest	tropical grassland

Check Your Understanding

Drawing on Student Experiences

Have students find their own biome on the map in **Figure 1** (below). Ask them to describe the climate and biodiversity of their biome, based on their own experiences. Tell them they will read about their own and other biomes in this lesson.







Distribution of Earth's major terrestrial biomes.

Teaching Strategies

Use Visuals: Figures 1 and 2

Guide students through an overview of lesson content using **Figures 1** and **2**. Ask students to choose one of the eight biomes described in the lesson, find its location on the map in **Figure 1** (above), and study its picture in **Figure 2** (below). As students examine the visuals, read aloud the climate and biodiversity facts for the biome (also in **Figure 2**). Repeat for all or some of the eight terrestrial biomes.

Biome: Other Name(s)	Type of Climate, Growing Season, Soil Quality	Biodiversity, Common Plants, Common Animals
Tundra: Arctic tundra (high latitudes) Alpine tundra (high altitudes)	<i>Type of climate:</i> arctic, arid <i>Growing season:</i> very short <i>Soil quality:</i> Very poor	  <i>Biodiversity:</i> very low <i>Plants:</i> mosses, grasses, and lichens; few herbaceous plants; no trees <i>Animals:</i> insects; birds (summer only); no amphibians or reptiles; mammals such as rodents, arctic hares, arctic foxes, polar bears; caribou (summer only); mountain goats and chinchillas (alpine tundra only)
Boreal Forest: Taiga Northern conifer forest	<i>Climate:</i> subarctic, semi-arid <i>Growing season:</i> short <i>Soil quality:</i> Poor	<i>Biodiversity:</i> low <i>Plants:</i> conifers such as cedar, spruce, pine, and fir; mosses and lichens <i>Animals:</i> insects; birds (mainly in summer); no amphibians or reptiles; mammals such as rodents, rabbits, minks, raccoons, bears, and moose; caribou (winter only)
Temperate Deciduous Forest: Temperate hardwood forest Temperate broadleaf forest	<i>Climate:</i> temperate, semi-humid <i>Growing season:</i> medium <i>Soil quality:</i> good <i>Climate:</i> temperate, semi-arid <i>Growing season:</i> medium <i>Soil quality:</i> excellent	 <i>Biodiversity:</i> high <i>Plants:</i> broadleaf deciduous trees such as beech, maple, oak, and hickory; ferns, mosses, and shrubs; many herbaceous plants <i>Animals:</i> insects, amphibians, reptiles, and birds; mammals such as mice, chipmunks, squirrels, raccoons, foxes, deer, black bears, bobcats, and wolves  <i>Biodiversity:</i> medium-high <i>Plants:</i> grasses; other herbaceous plants; no trees <i>Animals:</i> invertebrates such as worms and insects; amphibians, reptiles, and birds; mammals such as mice, prairie dogs, rabbits, foxes, wolves, coyotes, bison, and antelope; kangaroo (only in Australia)
Chaparral Mediterranean scrub forest	<i>Climate:</i> temperate, semi-arid <i>Growing season:</i> medium <i>Soil quality:</i> poor	<i>Biodiversity:</i> low-medium <i>Plants:</i> shrubs and small trees such as scrub oak and scrub pine <i>Animals:</i> insects, reptiles, and birds; mammals such as rodents and deer
Desert	<i>Climate:</i> temperate or tropical, arid <i>Growing season:</i> varies <i>Soil quality:</i> very poor	<i>Biodiversity:</i> none-low <i>Plants:</i> plants adapted to dryness, such as cacti, sagebrush, and mesquite; virtually no plants if extremely arid <i>Animals:</i> insects, reptiles, and birds; mammals such as rodents and coyotes
Tropical Rainforest	<i>Climate:</i> tropical, humid <i>Growing season:</i> year-round <i>Soil quality:</i> excellent	<i>Biodiversity:</i> very high <i>Plants:</i> tall flowering, broadleaf evergreen trees; vines and epiphytes; few plants on forest floor <i>Animals:</i> insects, amphibians, reptiles, and birds; mammals such as monkeys, sloths, leopards, jaguars, pigs, and tigers
Tropical Grassland Savanna	<i>Climate:</i> tropical, semi-arid <i>Growing season:</i> year-round <i>Soil quality:</i> poor	<i>Biodiversity:</i> low-medium <i>Plants:</i> grasses; scattered clumps of trees <i>Animals:</i> insects, reptiles, and birds; mammals such as zebras, giraffes, antelopes, lions, cheetahs, and hyenas

These eight biomes are described more fully in the text. Refer to **Figure 1** to see where each biome is found.

Activity

Have students match biomes with temperature and precipitation graphs by doing the Great Graph Match activity at the Web site below. <http://earthobservatory.nasa.gov/Experiments/Biome/graphindex.php>

Build Science Skills: Comparing and Contrasting

On the board, start a table (like the table shown below) to compare and contrast two different biomes at their latitude, including their own biome. Call on students to go to the board and fill in the cells of the table. As a class, discuss reasons for the similarities and differences between the two biomes. Can also add average precipitation/temperature (using information from the previous activity).

Table 20.5:

Lesson	Biome 1: Name	Biome 2: Name
Location (e.g., altitude; coastal or inland)	?	?
Important Abiotic Factors	?	?
Major Plant and Animal Species	?	?
Level of Biodiversity	?	?

Discussion

Discuss the effects of continued global warming on the future of Earth's biomes. Help students appreciate the interrelatedness of all of Earth's biomes, using examples such as the effect on ocean levels of polar ice melting.

Activity

Have students complete the activity To Plant or Not to Plant at the Web site below. They will view plant specimens and their characteristics, and then match the specimens with the biome in which they are found, based on growing conditions in the biomes. http://earthobservatory.nasa.gov/Experiments/Biome/plant_it.php

Differentiated Instruction: KWL

Ask students who need help with reading to complete a Know/Want to Know/Learned (KWL) chart for one or more of the eight biomes shown in **Figure 1**. They should fill in the first two columns of the chart before they read the lesson, and the last column after they read the lesson. A sample completed chart for the tropical rainforest biome is shown below. Ask students to share what they learned with the class. (LPR)

Table 20.6:

Know	Want to Know	Learned
Tropical rainforests are wet and are found near the equator.	Are all tropical areas wet and covered by rainforest?	Some tropical areas are dry and covered by grasses.

Enrichment: Web Site

Set up a biome Web site, and ask each of eight students to create a page for the Web site about one of the eight biomes in the lesson. Their Web pages should convey the nature of the biomes (e.g., abiotic factors, major species, biodiversity) and include visuals such as graphs and pictures in addition to text. Encourage all the students in class to visit the biome Web site. Students can also create a PowerPoint presentation.

Science Inquiry

Formulating a Hypothesis

Divide the class into groups, and ask each group to formulate a specific hypothesis about the effects of continued global warming on one or more terrestrial biomes. Remind students that a scientific hypothesis must be testable and should be based on evidence and reason. Record their hypotheses on the board, and ask them to explain the evidence and reasoning behind them. As a class, discuss the relative merits of each hypothesis, including whether it is testable.

Reinforce and Review

Labeling a Drawing

Give students copies of **Figure 1** without the key. Just print out this figure and cut the legend off. Have the students label as many of the major terrestrial biomes as they can. They can look at **Figure 1** in the FlexBook to check their work and find any missing biomes.

Lesson Worksheets

Copy and distribute the four Lesson 16.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 16.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 16.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

The land areas where terrestrial biomes are found cover only 30 percent of Earth's surface. The rest of the surface is covered by water.

- What types of biomes do you think occur in water?
- How do you think water biomes might be classified?
- What do you think are some of the organisms that live in water biomes?

Lesson Assessment

- Have students complete the Lesson 16.2 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

20.4 Lesson 16.3: Aquatic Biomes

Key Concepts

Aquatic biomes are generally divided into zones based on distance from shore and depth of water. Aquatic biomes may be either saltwater or freshwater biomes. Saltwater biomes include neritic, oceanic, and benthic biomes. Freshwater biomes include lakes, rivers, and wetlands.

Lesson Objectives

- Describe how aquatic biomes are divided into zones, and list types of aquatic organisms.
- Identify marine biomes, and state which biomes have the highest biodiversity.
- Name types of freshwater biomes, and describe how they differ from one another.

Lesson Vocabulary

Table 20.7:

Lesson 16.3 Vocabulary		
photic zone	aphotic zone	upwelling
littoral zone	pelagic zone	neritic zone
oceanic zone	benthic zone	plankton
nekton	benthos	marine biome
neritic biome	oceanic biome	epipelagic zone
mesopelagic zone	bathypelagic zone	abyssopelagic zone
hadopelagic zone	benthic biome	sublittoral zone
bathyal zone	abyssal zone	hadal zone
intertidal zone	estuary	coral reef
freshwater biome	limnetic zone	profundal zone
turnover	riparian zone	wetland

Check Your Understanding

Recalling Prior Knowledge

Have students recall what organisms are the chief producers in aquatic ecosystems.

(Phytoplankton.)

- **Ask:** Where do phytoplankton get energy to produce food?

(From sunlight.)

- **Ask:** Where in a body of water is there likely to be the most sunlight?

(Near the surface of the water.)

- Tell the class they will learn more about aquatic organisms and where they live in this lesson.

Teaching Strategies

Discussion

Discuss factors that delineate aquatic biomes (sunlight and nutrients) and why they differ from factors that delineate terrestrial biomes (temperature and precipitation).

- **Ask:** Why do aquatic biomes near the shore have the most nutrients?

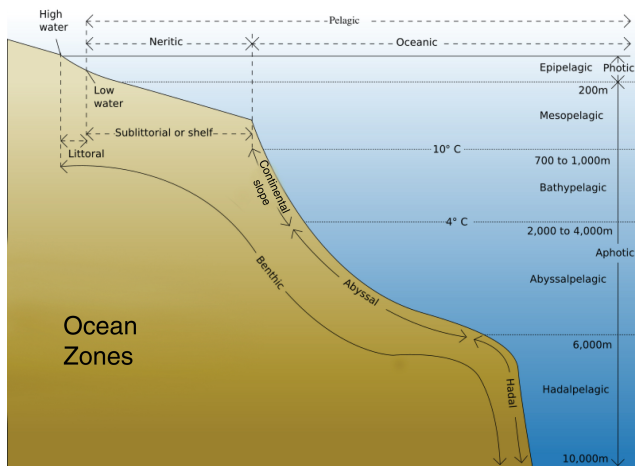
(Most nutrients enter the water in runoff from the land.)

- **Ask:** Why do aquatic biomes near the surface of the water have the most producers?

(There is more sunlight near the surface, and producers need sunlight to make food.)

Use Visuals: Figure 1

Have students find several of the ocean zones in **Figure 1**, based on distance from shore and depth of water. Then discuss why these two factors are used to classify aquatic biomes.



The ocean is divided into many different zones, depending on distance from shore and depth of water. The pelagic zone is divided into neritic and oceanic zones based on distance from shore. Into what additional zones is the pelagic zone divided on the basis of water depth? What additional zones make up the benthic zone?

Activity

Divide the class into groups, and assign each group an aquatic biome. Make sure all of the biomes are assigned. Ask students to find facts and figures about their biome and pictures

of some of the organisms that live there. Then have groups combine their information and illustrations to create an aquatic biome bulletin board. Encourage students to refer to the bulletin board as they study the lesson.

Differentiated Instruction: Gallery Walk

Post the names of aquatic biomes on large sheets of paper in different parts of the room, one name per sheet. Divide the class into small groups, being sure to include any special needs students with other students who can assist them. Ask groups to walk around the room to discuss the biomes and record what they know about them on the sheets of paper. They should also read and respond to the information written by other groups. After each group has covered all the biomes, discuss what the groups wrote and clear up any misconceptions. (SN)

Enrichment: Teaching a Topic

Ask one or more students to each prepare a lesson on one of the aquatic biomes. The lesson should cover the biome in greater depth than the FlexBook and include a PowerPoint presentation, handouts, or other visuals. Schedule class time for students to present their lessons.

Science Inquiry

Building a Model

Have students build a model aquatic biome. They can use one of the aquatic biome *Hands-On Biome Building* activities at the Web site below (listed under Lesson Plans). The activity will help students understand how biotic and abiotic factors shape an aquatic biome. Encourage interested students to do the extension exercises listed at the bottom of the activity. <http://www.thewildclassroom.com/biomes/index.html>

Reinforce and Review

Outlining the Lesson

Suggest that students create an outline of the Marine Biomes and Freshwater Biomes sections of the lesson. The outline should incorporate the headings and subheadings (see sample outline below), as well as important details. Outlining will help students organize the information in the lesson and distinguish between marine and freshwater biomes.

Sample Outline (important details should be added)

I. Marine Biomes

A. Neritic Biomes

B. Oceanic Biomes

C. Benthic Biomes

D. Other Marine Biomes

II. Freshwater Biomes

A. Standing Freshwater Biomes

B. Running Freshwater Biomes

C. Wetlands

Lesson Worksheets

Copy and distribute the four Lesson 16.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 16.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 16.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Next we discuss community interactions. Abiotic factors such as water depth affect organisms in aquatic biomes. Organisms in all biomes are also affected by biotic factors, which include their interactions with other species.

- How do you think different species interact?

- What types of relationships do you think different species might have with each other?
- How could these relationships affect the evolution of the species involved?

Lesson Assessment

- Have students complete the Lesson 16.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

20.5 Lesson 16.4: Community Interactions

Key Concepts

All biomes have communities of interacting species. Types of community interactions include predation, competition, and symbiosis. Symbiosis, in turn, includes mutualism, commensalism, and parasitism. Following a disturbance in an ecosystem, communities go through a series of changes, referred to as ecological succession.

Lesson Objectives

- State the significance of the community in ecology, and list types of community interactions.
- Define predation, and explain how it affects population growth and evolution.
- Describe competition, and outline how it can lead to extinction, or specialization of species.
- Define symbiosis, and identify major types of symbiotic relationships.
- Describe ecological succession, and explain how it relates to the concept of a climax community.

Lesson Vocabulary

Table 20.8:

Lesson 16.4 Vocabulary		
community	predation	true predation
grazing	keystone species	biological pest control

Table 20.8: (continued)

Lesson 16.4 Vocabulary		
camouflage	mimicry	co-evolution
competition	intraspecific competition	interspecific competition
symbiosis	mutualism	commensalism
parasitism	ecological succession	pioneer species
primary succession	secondary succession	climax community

Check Your Understanding

Previewing Visuals

Introduce community interactions with a visual example. Have students look at the lion and buffalo in **Figure 1**.

- **Ask:** What kind of relationship do the lion and buffalo have?

(Predator-prey relationship.)

- Tell students that predator-prey interactions are just one of many types of interactions between species that they will read about in this lesson.



An adult male lion and a lion cub feed on the carcass of a South African cape buffalo.

Teaching Strategies

Using Visuals: Figure 2

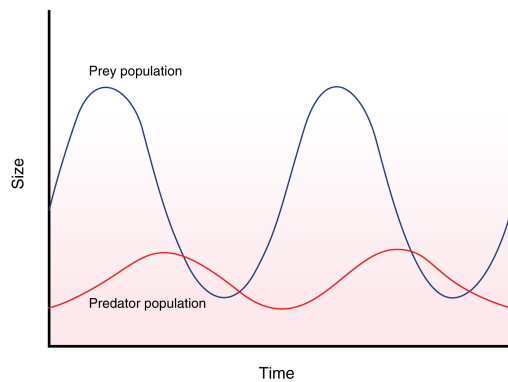
Make sure students understand predator-prey population dynamics. Ask them to explain the rise and fall of the two populations in **Figure 2**.

- **Ask:** Why does the predator population start rising after the prey population rises.

(More prey can support a bigger predator population.)

- **Ask:** Why does the prey population start rising after the predator population falls?

(Fewer predators allow more prey to survive.)



As the prey population increases, the predator population starts to rise. With more predators, the prey population starts to decrease, which, in turn, causes the predator population to decline. This pattern keeps repeating. There is always a slight lag between changes in one population and changes in the other population.

Discussion

The FlexBook gives an aquatic example of a keystone species. Give students a terrestrial example as well: elephants in African grasslands. Explain that the grazing of elephants prevents grasslands from turning into woodlands.

refer to: <http://www.fieldtripearth.org/article.xml?id=754>

- **Ask:** Why are conservation efforts often directed toward keystone species?

(Keystone species are needed to keep the whole ecosystem from changing significantly or even collapsing entirely. If the keystone species is not conserved, many other species will be jeopardized.)

Activity

Involve the class in the activity *Sight Hunting—Camouflage and Natural Selection*, at the Web site below. Students will simulate a hunt for camouflaged animals by predators that hunt using sight. After the activity, discuss the evolution of camouflage by natural selection. Ask students how the traits of the surviving “prey” in the activity would influence the next generation of the “prey” species. <http://www.hawkquest.org/TA/XL/Survival-games.pdf>

Differentiated Instruction: Compare/Contrast Table

Pair less proficient readers with more proficient readers, and have pairs make a table comparing and contrasting the three types of symbiotic relationships described in the lesson. Tell them to include examples of each type of relationship in their table. (LPR)

Enrichment: Display

Ask a group of students to create a classroom display that shows how primary ecological succession occurs. They should create a series of dioramas or illustrated panels that show the sequence of ecosystem changes through time. Encourage other students to study and discuss the display.

Science Inquiry

Making Observations

Have students find and photograph areas in their neighborhood that have recently been disturbed. Possible areas might include building sites, road construction sites, and new landscaping projects. Make sure students obtain permission to photograph any private property or people. Ask them to share their photographs. As a class, discuss how the areas would change if they were left undisturbed to go through succession.

- **Ask:** Would succession be primary or secondary?

- **Ask:** What succession of organisms would inhabit the area?

Have students continue to observe any areas that remain undisturbed and periodically report their observations to the class.

Reinforce and Review

Flashcards

Have pairs of students make flashcards for the types of community interactions described in the lesson. They can use the flashcards to quiz each other on the concepts.

Lesson Worksheets

Copy and distribute the four Lesson 16.4 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 16.4 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 16.4 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

The size and growth of populations in a community is influenced by species interactions. For example, predator-prey relationships control the population growth of both predator and prey species.

- How would populations grow without these influences?
- What other factors do you think might affect population growth?

- What factors do you think may have affected the growth of the human population?

Lesson Assessment

- Have students complete the Lesson 16.4 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

20.6 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 21

TE Populations

21.1 Chapter 17: Populations

Outline

The chapter *Populations* consists of three lessons that explore the biology of populations.

- Lesson 17.1: Characteristics of Populations
- Lesson 17.2: Population Dynamics
- Lesson 17.3: Human Population Growth: Doomsday, Cornucopia, or Somewhere in Between?

Overview

- This chapter describes the characteristics of populations, explains how populations grow, and outlines the history of the human population and the problem of overpopulation.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 21.1:

Lesson	Number of Class Periods*
Lesson 17.1 Characteristics of Populations	1.5
Lesson 17.2 Population Dynamics	3.0
Lesson 17.3 Human Population Growth: Doomsday, Cornucopia, or Somewhere in Between?	2.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

- Counting FishStix: Students explore how scientists estimate the size of a fish population using a common visual census technique. (Lesson 17.1) <http://uncw.edu/aquarius/education/lessons/Aq%20FishStix.pdf>
- Populus: This software provides a set of simulations for modeling population dynamics. Modules allow students to input starting values and see graphical outputs of population change. (Lesson 17.2) <http://www.cbs.umn.edu/populus>

Common Misconceptions

Population vs. Community

Students commonly confuse the terms population and community. Make sure they understand that a population consists only of members of the same species who live in the same area, whereas a community consists of members of different species that live in the same area. In other words, a community consists of more than one population.

Exponential vs. Logistic Growth

Students may assume that the exponential and logistic models of population growth are opposite to one another or mutually exclusive. Explain that the logistic growth model actually begins with exponential growth. However, growth slows at high population sizes as resources are depleted and/or wastes accumulate so exponential growth can no longer be maintained. In short, logistic growth is a modification of the exponential growth model.

Managing Materials

The materials listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 21.2:

Lesson	Strategy or Activity	Materials Needed
17.2	1. Building Science Skills: Applying Concepts	1. calculator, graph paper

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- *Populations*: This Web site provides links to many different population biology articles, activities, quizzes, games, simulations, and labs. <http://www.nclark.net/Populations>
- *How Do Populations Grow?*: This Web site provides several activities that investigate linear and exponential models of population growth, carrying capacity, population crashes, the effects of invasive species on other populations within an ecosystem, and the history of human population growth. <http://naturalsciences.sdsu.edu/classes/lab2.7/lab2.7.html#anchor10771668>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons of this chapter, in your students' FlexBook. You should also consult the standards correlation table that follows when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the chapter *Populations*, students should have read the chapters *Principles of Ecology* and *Biomes, Ecosystems, and Communities*.
- If you incorporate the chapter *Populations* in your FlexBook, it is recommended that you include all three lessons of the chapter.

21.2 Lesson 17.1: Characteristics of Populations

Key Concepts

A population is a group of organisms of a single species living within a certain area. Population density is the number of organisms per unit area. Species may have a minimum viable population size. Populations are distributed in various patterns, such as uniform, random, or clumped dispersion. The age-sex structure of a population is related to its birth rate and death rate, so it may reflect the health of the population. Survivorship curves show the number of individuals in a population surviving to each age. They correlate with reproductive strategies.

Lesson Objectives

- Recognize that human concern about overpopulation dates to ancient Greek times.
- Explain that cornucopians believe that technology will solve population problems.
- Connect the study of the biology of natural populations to a better understanding of human population issues.
- Define a biological population.
- Give reasons why biologists study populations.
- Compare the importance of population size to that of population density.
- Explain how conservation biologists use Minimum Viable Population (MVP) and Population Viability Analysis (PVA).
- Explain how patchy habitats influence the distribution of individuals within a population.
- Define and explain the reasons for three patterns of dispersion within populations.
- Describe how population pyramids show the age and sex structures of populations.
- Interpret population pyramids to indicate populations' birth and death rates and life expectancy.
- Analyze the effect of age at maturity on population size.
- Explain the structure and meaning of a generalized survivorship curve.
- Compare and contrast the three basic types of survivorship curves.

Lesson Vocabulary

Table 21.3:

Lesson 17.1 Vocabulary		
age at maturity	age-sex structure	birth rate (b)
cornucopian	death rate (d)	dispersion

Table 21.3: (continued)

Lesson 17.1 Vocabulary			
life expectancy	minimum viable population	overpopulation	
population	population density	population analysis	viability
survivorship curve			

Check Your Understanding

Facts and Figures

Pique student interest in populations by sharing these facts and figures:

- Bacteria populations have some of the fastest rates of growth of any species. They can multiply from one to millions in about 12 hours.
- The populations of most other species grow much more slowly. For species with slow growth rates, it may take thousands of years for populations to increase to millions of individuals, and many never grow that large.
- It took the human population tens of thousands of years to grow to the 1 million mark, but it has grown by several billion people just during the last 100 years.

Tell students they will learn more about populations and how they grow in this chapter.

Teaching Strategies

Build Science Skills: Applying Concepts

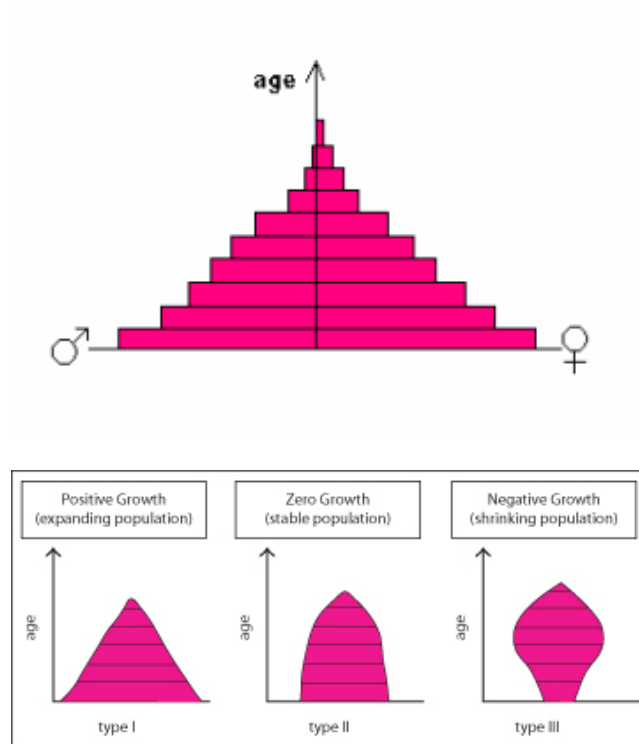
Make sure students understand the concept of population density by having them calculate the density of a hypothetical population. State the number of individuals in the population and the area, in square kilometers, that the population inhabits. Then tell students to calculate the number of individuals per square kilometer. Discuss why this is an average value and how population density may vary within the total area occupied by a population. Ask the class to describe how human population density varies within their own state, county, or community.

Use Visuals: Figures 5 and 6

Have students compare **Figure 5** and **Figure 6**. Make sure students are aware that the left and right sides of the graphs in **Figure 6** represent males and females, respectively, as

in **Figure 5**. Call on students to describe in words the age-sex structure of each type of population in **Figure 6**. Then, from the proportion of individuals by age and sex, have them predict other population parameters.

- **Ask:** Which type of population has the highest birth rate? (Type I)
- **Ask:** Which type of population has the shortest life expectancy? (Type I)



Discussion

Discuss age at maturity in a variety of populations. Include species with very different ages at maturity, such as those that mature in a year or less (e.g., insects such as butterflies) and those that take many years to mature (e.g., large mammals such as humans).

- **Ask:** How does age at maturity affect population growth?

(A younger age at maturity increases the potential for rapid population growth.)

Differentiated Instruction: KWL

Help students focus their reading by having them create a KWL chart. Before they read the lesson, they should fill in the Know and Want to Know columns. You might suggest

that they preview the figures in the lesson to stimulate their curiosity about populations. Students can fill in the Learned column as they read. Discuss anything they wanted to know but didn't learn when they read the lesson. **LPR**

Enrichment: Essay

Ask interested students to learn more about one of the important works on population cited in the introduction to the lesson (i.e., Paul Ehrlich's *Population Bomb*, Garrett Hardin's *The Tragedy of the Commons*, Thomas Malthus' *An Essay on the Principle of Population*). Then ask the students to write a short essay in which they state and justify their own view of the opinions expressed by the author.

Science Inquiry

Analyzing Data

Divide the class into groups, and direct groups to the Web site below. Have each group print two population pyramids for the year 2000: one for the United States and one for a third world country, such as Bangladesh, Guatemala, or Kenya. Tell students to analyze the age and sex structure of each population, based on the population pyramids, and infer how the two populations' birth, death, and growth rates compare. Give groups a chance to share and discuss their graphs and inferences.

- <http://www.census.gov/ipc/www/idbpyr.html>

Reinforce and Review

Using Vocabulary

Have students write a paragraph in which they use a topic from the lesson and at least five lesson vocabulary words. Have volunteers read their paragraph to the class.

Lesson Worksheets

Copy and distribute the four Lesson 17.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 17.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 17.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Do you think Earth's human population has a patchy distribution? Why or why not?
- Do people show clumped, uniform, or random dispersion? Why?
- How do you think birth rates compare with death rates in the human population? Predict the shape of a population pyramid for humans.
- At this point in your study of population biology, do you consider yourself a Malthusian, following the ideas of Thomas Malthus, or a cornucopian?

Lesson Assessment

- Have students complete the Lesson 17.1 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teacher-requests@ck12.org to request material.**

21.3 Lesson 17.2: Population Dynamics

Key Concepts

Populations change in size through births, deaths, and population movements such as migration. Precocial and altricial species have different reproductive strategies to maximize

population growth. Under ideal conditions, most populations have the potential to grow exponentially (J-curve); in reality, most populations grow logistically (S-curve). The environment places an upper limit, called the carrying capacity, on population size. Some limits on growth, such as predation, are density-dependent. Others limits, such as rainfall, are density-independent.

Lesson Objectives

- Define population dynamics.
- Describe exponential (J-curve) growth, and explain the conditions under which it occurs.
- Explain Malthus' ideas about human population growth and their significance to evolutionary theory.
- Discuss births and deaths, and balancing costs of reproduction and survival.
- Clarify the relationship between population growth rate, birth rate, and death rate.
- Compare tradeoffs between survival and reproduction of altricial species to those of precocial and nest parasite species.
- Describe the relationship between age at maturity and growth rate.
- Analyze the equation for population growth rate.
- Describe several means of dispersal, and its importance to population density.
- Define migration and explain possible effects on population density and growth.
- Compare nomadism, irruption, range expansion, and colonization in terms of their effects on population density.
- Give examples of population growth patterns in nature.
- Describe logistic (S-curve) growth, and explain the conditions under which it occurs.
- Analyze the concept of carrying capacity in terms of population growth and resource availability.
- Compare and contrast density-dependent and density-independent limiting factors.
- Relate predator-prey cycles to density-dependent population control.
- Compare and contrast the adaptations and environmental characteristic of r-selected species with those of K-selected species.

Lesson Vocabulary

Table 21.4:

Lesson 17.2 Vocabulary			
altricial	birth rate (b)	carrying capacity	
colonization	death rate (d)	density-dependent	factor

Table 21.4: (continued)

Lesson 17.2 Vocabulary		
density-independent factor	dispersal	emigration (e)
exponential model (J-curve)	immigration (i)	intraspecific competition
irruption (invasion)	K-selected species	limiting factor
logistic model (S-curve)	migration	nomadism
population	population dynamics	population growth rate (r)
precocial	predator-prey cycle	r-selected species
range expansion		

Check Your Understanding

Recalling Prior Knowledge

On the board, write the equation for population growth rate:

$$r = b - d$$

- **Ask:** What do b and d represent?

(birth rate and death rate, respectively)

- **Ask:** What does r represents?

(The change in population size, or growth rate, so growth rate = birth rate – death rate.)

Tell the class they will learn more about how populations grow in this lesson, including factors besides births and deaths that can change population size.

Teaching Strategies

Building Science Skills: Applying Concepts

Exponential growth may be a difficult concept for many students to grasp. Help students understand exponential growth by applying it to small numbers and contrasting it with simple linear growth. Write the following table on the board, and call on students to fill in the population sizes in each row for years 2–5.

Table 21.5:

Population Size	Year 1	Year 2	Year 3	Year 4	Year 5
Size = size in previous year plus two (size + 2)	2	?	?	?	?
Size = size in previous year squared (size ²)	2	?	?	?	?

Answers available upon request. Please send an email to teachers-request@ck12.org.

- Ask students to sketch two simple line graphs based on the completed table (with $x = \text{years}$ and $y = \text{population size}$). Ask them to identify which graph represents exponential growth. Have students calculate the rate of growth for each set of numbers between years 1 and 2 and between years 4 and 5. Point out how the rate of growth increases with exponential growth but stays the same with linear growth.

Discussion

Review the differences between precocial and altricial reproductive strategies. Check students' comprehension by asking them which strategy is used by familiar animals not given as examples in the text (e.g., frogs, humans). Discuss how the two strategies relate to predation pressure. Explain why a precocial strategy is adaptive when predation rates are high in early life.

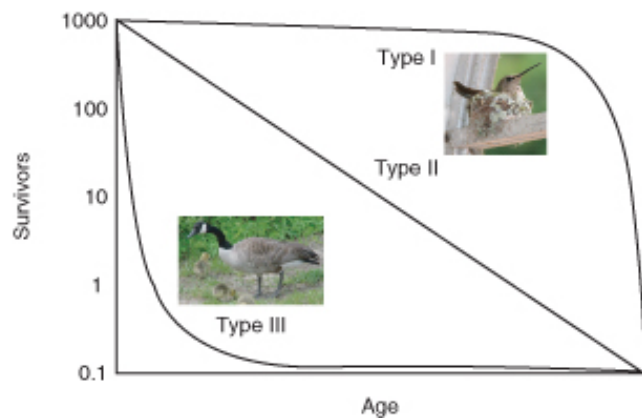
Activity

Recommend that students go to the Web site below and play a game in which they set the levels of important environmental variables (e.g., temperature, food, predators) and observe how population growth is affected. They can choose to simulate population growth of rabbits or microorganisms. Students may be amazed at how quickly both populations grow under ideal conditions. The Web site also provides teacher notes and student worksheets.

- <http://www.activescience-gsk.com/module3/home.html>

Use Visuals: Figure 5

Discuss how the survivorship curves in **Figure 5** relate to precocial and altricial reproductive strategies. Make sure students understand that the x -axis represents ages from birth to death and the y -axis represents the number of individuals still alive at each age. Explain how a survivorship curve relates to a population pyramid (such as the population pyramid in **Figure 5** of Lesson 17.1).



Differentiated Instruction: Concept Map

Pair English language learners with native English speakers, and have partners create a concept map of lesson content. **ELL**

Enrichment: Research Proposal

Ask students to research migration in birds and use what they learn to develop a reasonable research question a scientist might raise about migration in a newly discovered species of migratory bird. Have students state their question as a hypothesis and identify data that would need to be collected to test their hypothesis. Students can begin their research at the following web sites:

- <http://www.npwr.usgs.gov/resource/birds/migratio/index.htm>
- <http://www.zoosociety.org/Conservation/BWB-ASF/Library/BirdMigrationFacts.php>
- <http://www.earthlife.net/birds/migration.html>

Science Inquiry

Analyzing Data

Ask students to go to the web site below and do the activity on the Kaibab deer population of Arizona. The activity focuses on density-dependent changes in carrying capacity. Students will analyze how and why the deer population changed during the early decades of the 20th century and make recommendations for regulating the population.

- <http://www.biologycorner.com/worksheets/kaibab.html>

Reinforce and Review

Drawing a Graph

Tell the class to sketch line graphs representing exponential growth and logistic growth. Call on students to explain how the two graphs differ.

Lesson Worksheets

Copy and distribute the four Lesson 17.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 17.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 17.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Why do you think Malthus' predictions of widespread famine and war have not (yet?) been realized? Do you think his ideas make sense for the future?
- Are humans altricial or precocial? Why?
- In your opinion, could delaying age of first childbirth help solve human population problems?
- How important do you think dispersal, range expansion, or immigration are for human populations?
- Do you think humans have more r-selected adaptations or more K-selected adaptations?

Lesson Assessment

- Have students complete the Lesson 17.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teacher-requests@ck12.org to request material.

21.4 Lesson 17.3: Human Population Growth: Doomsday, Cornucopia, or Somewhere in Between?

Key Concepts

Overall, the human population increased slowly for thousands of years but started to grow rapidly about 200 years ago. This suggests an exponential model of population growth. The current world population is growing rapidly, but population growth rates vary from country to country. Developed countries went through a demographic transition, with population growth initially increasing and then slowing as first death rates and later birth rates fell to low levels. Whether less developed countries will follow suit is uncertain. Many people think that the human population is already too large and cite environmental degradation and other evidence in support of their “doomsday” view. Other people think that the human population has not yet reached its carrying capacity or that technology will be able to fix issues associated with overpopulation.

Lesson Objectives

- Contrast the neo-Malthusian or “limits to growth” and the cornucopian or “technological fix” views of human population growth.
- Compare the overall pattern of human population growth to the J-curve (exponential) and S-curve (logistic) models.
- Analyze the factors which have influenced human population growth from our beginnings 200,000 years ago to 1804, when we first reached the one billion mark.
- Describe the four stages of human population growth as outlined by the demographic transition model.
- Evaluate the demographic transition model as it applies to European population growth in the late 18th and 19th centuries.
- Evaluate the demographic transition model as it applies to less developed countries.
- Apply the demographic transition model to recent changes in developed countries.
- Using age-sex structures, contrast population growth in developed countries to growth in undeveloped countries.
- Explain the concept of replacement fertility rate.
- Discuss the implications of stage 5 population dynamics.
- Know and understand predictions for future worldwide human population growth.
- Analyze limiting factors and technological advances which may contribute to a carrying capacity for the human population.
- Explore the concept of sustainability as a goal for economic, social, and environmental decision making.
- Explain the tool of ecological footprint analysis as a means of evaluating the sustainability of lifestyles for individuals, countries, and the world.
- Calculate your ecological footprint and compare it to averages for your country and the world.
- Recognize our human potential to make decisions which could direct future population growth.
- Explore some options for social, political, and cultural change, and for environmental conservation which could help to balance population dynamics and resource utilization.

Lesson Vocabulary

Table 21.6:

Lesson 17.3 Vocabulary			
carrying capacity		cornucopian	demographic transition theory
density-dependent factor	factor	density-independent factor	ecological footprint

Table 21.6: (continued)

Lesson 17.3 Vocabulary		
exponential model (J-curve)	K-selected species	logistic model (S-curve)
neo-Malthusians	population	r -selected species
replacement fertility		

Check Your Understanding

Facts and Figures

Have students go to the Web site below and observe the world population clock. They will see the number of new individuals added to the human population, second by second, as they watch. They can also compare the current number with the size of the human population in previous years, back to 1970. They might want to see, for example, how much the human population has grown since the year they were born or even since they started the current school year. Ask students to predict long they think it will take the human population to reach the 7 billion mark (or some other milestone) at the rate it is currently growing. Tell students they will learn in this lesson why the human population is increasing so rapidly today.

- <http://www.ibiblio.org/lunarbin/worldpop/>

Teaching Strategies

Building Science Skills: Making Inferences

Discuss factors that have had a major impact on the human population, such as the invention of agriculture, urbanization, and the industrial revolution. Then ask students to infer how each factor may have affected birth or death rates. (E.g., increasing urbanization may have increased death rates by leading to overcrowding and epidemics of infectious diseases, such as bubonic plague.)

Activity

Assign the online article below about the growth of the human population, and have students answer the questions that follow. The article explains how birth and death rates, migration, and population growth are related. Factors that affect birth and death rates are

also discussed. Students are asked to calculate birth and death rates and other population parameters, using real-world data. Answers to the questions are also provided.

- <http://www.worldbank.org/depweb/english/modules/social/pgr/index.html>

Use Visuals: Figure 5

Have students look closely at the graphical representation of demographic transition theory shown in **Figure 5**.

- **Ask:** During which stages does population size remain about the same? Why?

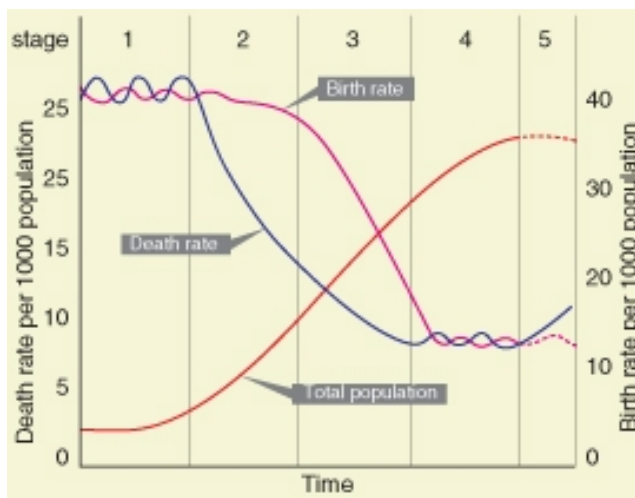
(Stages 1 and 5 because birth and death rates are about the same during these two stages.)

- **Ask:** Why does population grow rapidly during stage 2?

(Death rates have fallen but birth rates are still high.)

- **Ask:** Which model of population growth is represented by the red line in the graph? How can you tell?

(The logistic model; you can tell by the S shape of the curve representing population size over time.)



Discussion

Discuss how the age-sex structure of a population typically causes a population's growth rate to lag behind a drop in the fertility rate. Point out that a population with a high fertility rate has a large proportion of young people. When they reach reproductive age, even if individuals start having fewer children (i.e., the fertility rate drops), their large numbers will keep the birth rate high and the population growing for many years to come.

Differentiated Instruction: Think-Pair-Share

Ask students to think about the five questions listed below. Then, pair less proficient with more proficient readers, and ask partners to discuss how they would answer the questions.

LPR

1. How did the human population grow up until about 1800?
2. How has the human population grown during the last 200 years?
3. What is demographic transition theory?
4. What are some signs that there are too many people on Earth today?
5. How is the human population likely to grow in the future?

Enrichment: Debate

Ask two small groups of students to debate issues related to human population growth and overpopulation. Assign one group the cornucopian view and the other group the neo-Malthusian view. Students should research their assigned point of view and try to find evidence to support it. Set aside class time for students to present their debate.

Science Inquiry

Using Simulation

Download the international population simulator at the web site below, and assign each student a different country to investigate. Ask them to do background research on their assigned country to provide a context for its demographic parameters. Then have them use the simulator to test how different levels of fertility and life expectancy affect population growth and the age-sex structure in their assigned country. Finally, ask students to write a summary of what they learned about human population dynamics by using the simulation program.

- <http://geosim.cs.vt.edu/Java/IntlPop/IntlPop.html>

Reinforce and Review

Making a Graph

Have students sketch a simple graph to represent the four stages of demographic transition theory. Tell them to include separate lines for births, deaths, and population size. Remind them to label their graph. Completed graphs should resemble **Figure 5** (shown above).

Lesson Worksheets

Copy and distribute the four Lesson 17.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 17.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 17.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Now that you have studied some of the data on human population growth, return to the questions in the introduction to this lesson and consider whether your answers have changed.
 1. Are we built for growth—or for efficient use of resources?
 2. Does our growth pattern resemble a J- or an S-curve? Why?
 3. Do you think Earth has a carrying capacity for humans?
 4. Do you think we are in danger of extinction?
 5. What exactly is our “population problem,” and what do you think we should do to solve it?

- Jared Diamond, reflecting on the fates of past societies facing problems of sustainability, in *Collapse: How Societies Choose to Fail or Succeed* (2005), p. 522, says: “Two types of choices seem to me to have been crucial in tipping ... outcomes towards success or failure: long-term planning and willingness to reconsider core values. On reflection, we can also recognize the crucial role of these same two choices for the outcomes of our individual lives.” Do you think the worldwide human population will be able to make these choices wisely?

(Answers may vary; accept all reasonable responses.)

Lesson Assessment

- Have students complete the Lesson 17.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teacher-requests@ck12.org to request material.

21.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 22

TE Ecology and Human Actions

22.1 Chapter 18: Ecology and Human Actions

Outline

The chapter *Ecology and Human Actions* consists of four lessons that explain how human actions have affected Earth's biodiversity, natural resources, and climate.

- Lesson 18.1: The Biodiversity Crisis
- Lesson 18.2: Natural Resources
- Lesson 18.3: Natural Resources II: The Atmosphere
- Lesson 18.4: Climate Change

Overview

- After many generations of careless actions, humans now must protect biodiversity and natural resources as well as reduce pollution for the health of the planet and its ecosystems and organisms.
- It can be argued that this is one of the most important topics facing society (and the planet) today.
- The concept map below provides a visual representation of how the chapter concepts are related.

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 22.1:

Lesson	Number of Class Periods*
Lesson 18.1 The Biodiversity Crisis	3.0
Lesson 18.2 Natural Resources	1.5
Lesson 18.3 Natural Resources II: The Atmosphere	1.5
Lesson 18.4 Climate Change	1.5

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

- Environmental Impact Project: In this group project, students research a local ecosystem and design an environmentally friendly development project for an undeveloped or poorly developed site. The project will give students insights into the many ways that human actions may affect ecosystems. (Lessons 18.1–18.3) <http://www.lessonplansinc.com/science.php/biology/lessonplans/C96/>
- Saving Humpty Dumpty: Using a familiar manufactured product (shoes), students investigate how the product’s “life cycle” (including design, manufacturing, retailing, consumer use, and disposal) affect the environment. They also explore ways to reduce, reuse, or recycle resources in the product’s life cycle. (Lesson 18.1) <http://mypages.iit.edu/~smile/chbi0800.htm>
- How Much Land Does It Take to Produce Your Food? Students determine the amount of land needed to produce the food they eat in a year. They also compare the land needed to produce animal foods with the land needed to produce plant foods. The lab has three different levels, so you can customize it for your own students. (Lessons 18.1 and 18.2) <http://www.accessexcellence.org/AE/AEPC/WWC/1991/land.php>
- Acid Rain and How It Affects Our Environment: Students observe how acid affects different materials, including stone, plant, and animal materials, and then relate their observations to the effects of acid rain on the environment. (Lesson 18.3) <http://mypages.iit.edu/~smile/bi8811.html>
- Smog City: Students create an experiment (following the format of the scientific method) and run a simulator to investigate the causes and health effects of smog and ground-level ozone. The Web site includes teacher instructions, student worksheets, class discussion questions, and links to additional information. (Lesson 18.3) <http://www.ciese.org/curriculum/airproj/ozonesmogcity.html>
- Rainforests of Madagascar: Role Playing and Decision Making: Students play the roles of individuals involved in using, destroying, or protecting a threatened rainforest. The

activity will help students appreciate the complexity of global environmental problems and the need for cooperative efforts to solve them. (Lesson 18.1–18.4) http://www.accessexcellence.org/AE/AEPC/WWC/1991/rainforest_role.php#1

- Too Cool for School: The Greenhouse Experiment: In part I of this lab, students create a town and assess how various activities create greenhouse gases. In part II, they use a model to collect temperature data and investigate the greenhouse effect. (Lesson 18.4) http://www.keystonecurriculum.org/highschool/2009_lessons_word_pdf_ppt/13-Too%20Cool%20for%20School.pdf

Common Misconceptions

Some Species Do Not Matter

Many people think that some species are unimportant and that they may be sacrificed for human benefit without serious consequences. Describe a real or hypothetical example to demonstrate the impact on an ecosystem of the extinction of an apparently insignificant species. For example, describe how the loss of a single pollinator might cause a flowering plant species to go extinct and how the effects of this loss might be felt all the way up the food chain.

Global Warming Misinformation

Students are likely to be exposed to a great deal of misinformation about climate change and its causes. Use the following common misconceptions as a quiz to identify which misconceptions students believe. Then restate each misconception as a true statement. Provide additional information about each true statement as needed to explain why it is true.

1. Global warming is not really happening.
2. Global warming is not a serious problem.
3. Global warming is completely natural.
4. Preventing global warming is bad for the economy.
5. There is nothing I can do to help stop global warming.

Managing Materials

The materials listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 22.2:

Lesson	Strategy or Activity	Materials Needed
18.1	<ol style="list-style-type: none"> 1. Activity 2. Science Inquiry: Using Simulation 	<ol style="list-style-type: none"> 1. 15 small plastic bottles (such as empty vitamin bottles); 15 different types of dried beans, seeds, beads, or similar small items 2. per student: 1 index card
18.2	<ol style="list-style-type: none"> 1. Activity 2. Demonstration 3. Reinforce and Review: Flashcards 	<ol style="list-style-type: none"> 1. 100 pennies 2. 1 large apple, sharp knife 3. per pair of students: 26 index cards
18.3	<ol style="list-style-type: none"> 1. Demonstration 2. Science Inquiry: Making Observations 	<ol style="list-style-type: none"> 1. reaction flask (Erlenmeyer), rubber stopper for flask with hole and tubing, small beaker, sodium nitrite (NaNO_2), 10% sulfuric acid (H_2SO_4), pH indicator strips, safety goggles 2. per student: 1 colored and 1 white index card, about 1 meter of string, pair of scissors, paper punch, clear wide packing tape, hand lens or microscope
18.4	<ol style="list-style-type: none"> 1. Activity (<i>Terrestrial Sequestration</i>) 	<ol style="list-style-type: none"> 1. per group: 6 test tubes, 2 test tube racks, 6 rubber stoppers, 1 250 – mL beaker, 150 mL phenol red, elodea plant leaves, 1 250 – mL flask, rubber stopper for flask with hole and tubing, baking soda, vinegar, lamp, microspoon spatula, student worksheets (from Web site)

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- Biodiversity Hotspots: This Web site provides comprehensive information on biodiversity hotspot science and detailed information, maps, and human impacts on the most important biodiversity hotspots around the world. It is an excellent resource for both teachers and students. <http://www.biodiversityhotspots.org/Pages/default.aspx>
- Biodiversity: Visit this frequently updated Web site for articles on the importance of biodiversity, threats to biodiversity, global warming, and other environmental issues. The Web site also provides many links to other relevant sites. <http://www.globalissues.org/issue/169/biodiversity>
- Natural Resources Defense Council: The Web site of this organization has many articles about preserving natural resources and curbing global warming. It is a good source for current news stories relating to these issues. <http://www.nrdc.org/>
- Tidbits for Teachers and Students: The URL below is part of the Natural Resources Conservation Services (USDA) Web site. It provides a diversity of conservation education materials for K–12 teachers. The materials include articles, facts and figures, activity ideas, and lesson plans. <http://www.nrcs.usda.gov/feature/education/>
- United Nations Environment Program: The Web site of this UN body has films, photos, interviews, podcasts, posters, an ask-the-expert feature, animations, publications (including interactive e-books), and other resources, all pertaining to global environmental issues. <http://unep.org/>
- World Bank: This international organization invests heavily in environmental causes. It is a good source for data, publications, and multimedia on global and regional environmental issues. <http://www.worldbank.org/>
- Air Pollution: What’s the Solution?: This Web site has many student exercises and labs pertaining to air pollution, including its causes and effects. Each activity comes with teacher instructions, student worksheets, and links to other Web sites that provide any necessary data. <http://www.ciese.org/curriculum/airproj/index.html>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons of this chapter, in your students’ FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the chapter *Ecology and Human Actions*, students should have read the chapters *Foundations of Life Science* and *Principles of Ecology*.

- If you incorporate the chapter *Ecology and Human Actions* in your FlexBook, it is recommended that you include all four lessons of the chapter.

22.2 Lesson 18.1: The Biodiversity Crisis

Key Concepts

Biodiversity includes genetic, species, and ecosystem diversity. Biodiversity has many benefits. Direct benefits range from supplying humans' basic needs to inspiring technological designs and innovations. Indirect benefits range from increasing ecosystem stability to nutrient recycling and waste disposal. Human actions have caused and continue to cause a sixth mass extinction. Human-caused habitat loss is currently the primary cause of extinction. There are many ways that individuals can help protect biodiversity. They include making wise choices when consuming products and energy, disposing of wastes, and managing land.

Lesson Objectives

- Compare humans to other species in terms of resource needs and use, and ecosystem service benefits and effects.
- Define the concept of biodiversity.
- Quantify Earth's species diversity, according to scientists' current understanding.
- Describe patterns of biodiversity in space.
- Trace changes in biodiversity throughout Earth's history.
- Examine the evidence for the sixth extinction.
- Compare the sixth extinction to major extinctions before humans.
- Discuss the direct economic benefits of biodiversity.
- Evaluate ecosystem services provided by biodiversity.
- List the intangible (cultural, spiritual, religious) benefits of biodiversity.
- Relate biodiversity to social and political stability.
- Consider that biodiversity has intrinsic value apart from benefits to humans.
- Assess the potential for early human activities to contribute to ice age extinctions of large animals.
- Identify habitat loss as the primary cause of the sixth extinction.
- Relate the introduction of exotic species to loss of biodiversity.
- Explain the extent to which overexploitation has affected all levels of biodiversity.
- Connect energy use to extinction.
- Describe the effects of population growth and unequal distribution of resources on biodiversity.
- Recognize that pollution of water, land, and air contributes to the loss of species.
- Acknowledge that your daily activities and decisions can significantly help to protect

biodiversity.

- Evaluate your consumption—of food, clothing, furniture, and cleaning products.
- Appreciate the importance of water resources and know how to use them wisely.
- Evaluate your choice and use of energy sources.
- Assess the importance of minimizing waste and of using best practices for waste disposal.
- Know how to avoid transporting and releasing exotic species.
- Realize that you can practice sustainable management of your own land, from small yards to local, state, and federal lands, which also belong to you.
- Describe sustainability and its role in decision making.
- Explain how learning and active citizenship can contribute to protecting biodiversity.

Lesson Vocabulary

Table 22.3:

Lesson 18.1 Vocabulary		
air pollution	biodiversity hotspot	biodiversity
biological magnification	bionics	carbon sequestration
desertification	ecosystem diversity	ecosystem services
ecosystem	endemic species	epiphyte
exotic (alien) species	extirpation	genetic diversity
genetic pollution	global warming	greenhouse effect
keystone species	monoculture	natural resource
pollution	salination	species diversity
sustainable forest management	sustainable use	

Check Your Understanding

Recalling Prior Knowledge

Students are likely to have been exposed to the term *biodiversity* in previous classes. Ask them to recall what the term means. If they can not provide a satisfactory definition, work with them to determine the literal meaning of the term based on the word parts *bio-* (life, living organisms) and *diversity* (difference, variety). Tell students they will learn in this lesson about threats to Earth's biodiversity and why preserving biodiversity matters.

Teaching Strategies

Activity










Use activity 1 at the web site below to introduce the concept of biodiversity and how it is measured. In the activity, students calculate a diversity index for each of several different “habitats,” represented by plastic bottles that contain a variety of different dried beans, seeds, or other small items. Then, based on its diversity index, students decide what type of real-world habitat each bottle “habitat” best represents.

- <http://www.accessexcellence.org/AE/ATG/data/released/0534-KathyParis/index.php>

Using Visuals: Figure 4 and Table 1

Have students compare the land areas of Minnesota (left) and Costa Rica (right) in **Figure 4** with the biodiversity of each location in **Table 1**. Use a world map or globe to show the class where the two places are located, and describe how the two places differ in climate. As a homework assignment, have students research the number of species in their own state of each group of organisms listed in the table. Discuss how the location and climate of their state compare with Minnesota and Costa Rica. Then ask students to draw general conclusions about the relationship between climate and biodiversity.



Group of Organisms	Number of Species: Minnesota	Number of Species: Costa Rica	Number of Species: Your State
Amphibians	18	150	
Reptiles	27	210	
Birds	400 (but 96 of these migrate, spending winter in the Rainforest)	848	
Hummingbirds	1	852	
Mammals	80	200	
Bats	7	100	
Butterflies	140	1000	
Orchids	42	1200	
Trees	43	2500	

Note that a column is included for your students to research your own state or region.

Discussion

Under the text heading *Biodiversity Patterns in Space*, have students find the statement “diversity begets diversity.” Explain that the word begets means “produces.” Then call on students to explain why the statement is true (more species lead to more niches). Ask the class to think of examples that illustrate this idea (e.g., flowering plants provide niches for

pollinators).

Activity

Challenge students to use Internet sources to find examples of particular species that demonstrate the value of biodiversity. For example, they might identify species that provide medicines, warn of toxins, maintain air or water quality, recycle nutrients, or dispose of wastes. If possible, students should print photos of the species they identify. Set aside class time for them to share their examples, or have them use their examples to create a bulletin board display.

Building Science Skills: Identifying Cause and Effect

Discuss the sixth mass extinction, and ask students to identify human actions that are most responsible for it. Then focus on habitat loss, which is the primary cause of extinction today. Have students explain how human actions cause habitat loss and how habitat loss affects other organisms. Urge them to think of specific examples.

Activity

Ask students to write a letter to the editor of a local newspaper outlining ways that individuals can help protect biodiversity and why protecting biodiversity is important. They should tailor the suggestions to their local community as much as possible. For example, if curbside recycling is available, they might urge citizens to take advantage of it. If it isn't available, they might suggest alternative ways to recycle, such as taking recyclables to a drop box location. In either case, they should also explain how recycling helps protect biodiversity.

Differentiated Instruction: Cluster Diagram

Pair English language learners with native English speakers, and ask partners to create a cluster diagram for biodiversity. You may want to give them copies of the diagram below and have them complete it. **ELL**

[insert sample diagram]

Enrichment: Book Report

Recommend to interested students that they read one of the following classics of ecology:

- The Yosemite (1912) by John Muir (who founded the Sierra Club and is known as the “father of the conservation movement”)
- Sand County Almanac (1949) by Aldo Leopold (a collection of essays that is called the “conservationist Bible”)
- Silent Spring (1962) by Rachel Carson (a book that is widely credited with helping to launch the modern environmental movement).

Ask students to write a book report that includes a summary, the author’s main conclusions or recommendations, and their own personal reactions to the work. Collect their book reports in a binder, and make them available for the rest of the class to read.

Science Inquiry

Using Simulation

With the class, do the simulation activity, *Biological Diversity—How It Stops Disease from Spreading* (activity 2), at the Web site below. In this simulation, students represent trees in two different forests: a second growth monoculture of Douglas firs, and an old growth forest with several different tree species. Students will observe that disease spreads throughout the monoculture forest and kills most of the tree, whereas it stops spreading after just a few trees die in the biodiverse forest.

- <http://www.accessexcellence.org/AE/ATG/data/released/0534-KathyParis/index.php>

Reinforce and Review

Outlining the Lesson

Have students choose partners and ask partners to outline the lesson. Suggest that they save their outline for reviewing the lesson.

Lesson Worksheets

Copy and distribute the four Lesson 18.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 18.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 18.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Most of this lesson considered species and ecosystem diversity. Why is genetic diversity also very important?
- How does biodiversity in your area compare to the general global pattern of biodiversity? Give some reasons why it may or may not follow general trends.
- Choose one other area in which you are interested, and make the same comparison.
- Do you find the extinction statistics presented in this lesson alarming? Why do you think we don't hear more about the sixth extinction and the predicted loss of biodiversity?
- Which values of biodiversity do you feel are most compelling?
- Which solutions will you adopt in your daily life?

Lesson Assessment

Have students complete the Lesson 18.1 Quiz.

22.3 Lesson 18.2: Natural Resources

Key Concepts

Renewable resources, such as sunlight and trees, are in no danger of being used up, or can be replenished as quickly as they are used. However, renewable resources, such as forests, must be carefully utilized, to prevent them from being used too quickly. Nonrenewable resources, such as coal, are at risk of being used up because they are finite or not replenished quickly enough to keep up with human use. Even renewable resources can be ruined by careless use. For example, soils can be ruined through acidification and salination, and water can be ruined through pollution. Humans must take steps to preserve both renewable and nonrenewable resources for the health of ecosystems and use by future generations.

Lesson Objectives

- Distinguish between renewable and nonrenewable resources.
- List the major energy and material resources upon which humans depend.
- Discuss the stresses that increasing human consumption places on resource renewal.
- Sequence the events which lead to the formation of fossil fuels.
- Assess levels of depletion of nonrenewable energy resources.
- Analyze the ways in which technology and consumption result in overharvesting, pollution, atmospheric changes, and habitat loss.
- Evaluate the effects of population growth on resource use and environmental pollution.
- Relate inequalities in resource distribution to global political stability.
- Compare the concept of sustainable use to that of renewable vs. nonrenewable resources.
- Describe the nature and uses of soil resources.

Describe how human activities, including technology, affect ecosystem services such as:

1. soil generation
2. waste disposal
3. nutrient cycling
4. recycling dead organic materials
5. fertility of the land

- Discuss effects of population growth, technology, and consumption on land and soil resources.
- Relate soil erosion, pollution, and land development to ecosystem stability.
- Connect soil erosion, pollution, and land development to global stability.
- Evaluate the effects of changes in these services for humans.

- Review conflicts between agricultural technology, environment, and society.
- Recognize tradeoffs required by nuclear power plants: reduced emissions vs. radioactive fuels and waste.
- Analyze the ways in which humans have altered soil and land resources for other species.
- Identify the extent of terrestrial ecosystem loss and its effects on biodiversity.
- Interpret the effects of soil pollution on biodiversity.
- Describe how human activities, including technology, affect ecosystem services such as:

1. the hydrologic cycle
2. waste disposal
3. nutrient cycling

- Evaluate the effects of changes in these services for humans.
- Discuss the effects of population growth, technology, and consumption on water resources.
- Explain the effects of overdrafting, pollution, and atmospheric changes on ecosystem stability.
- Relate overdrafting and pollution to global stability.
- Analyze the ways in which humans have altered water resources for other species.
- Identify the extent of wetland loss and its effects on biodiversity.
- Interpret the effects of water pollution on biodiversity.

Lesson Vocabulary

Table 22.4:

Lesson 18.2 Vocabulary		
acid rain	algal bloom	anthropogenic sources
biodiversity	biological magnification	dead zone
desertification	ecosystem	eutrophication
global warming	greenhouse effect	natural resource
nonpoint source pollution	nonrenewable resource	ozone depletion
point source pollution	pollution	primary pollutants
renewable energy sources	renewable resource	salination
secondary pollutants	soil erosion	sustainable use
virtual water	wetland	

Check Your Understanding

Recalling Prior Knowledge

Students will have learned something about natural resources in previous science classes. Encourage them to recall how renewable resources differ from nonrenewable resources by asking them to name several examples of each type of resource. (e.g., solar and wind energy and timber for renewable resources; natural gas and coal for nonrenewable resources)

Teaching Strategies

Activity

Do a simple activity to make the point that it becomes more and more difficult and costly to find nonrenewable resources as they are used up. Before class begins, hide 100 pennies around the classroom. Then, when students arrive for class, give them two minutes to find as many pennies as they can. Tally the number of pennies found in the two-minute interval. Repeat this process, two minutes at a time, until no more pennies are found in two minutes. Students will observe that fewer pennies can be found in each two-minute interval as the number of hidden pennies dwindles. Relate this observation to the time and expense involved in finding new sources of nonrenewable resources, such as fossil fuels, as they are used up.

Demonstration

Do this simple demonstration to show students how little of Earth's surface is actually available for human food production. It will help them appreciate the importance of conserving arable land and soils.

1. While students watch, use a sharp knife to cut a large apple into quarters. Set aside three of the quarters, and explain that they represent sections of Earth that are covered with oceans.
2. Cut the fourth quarter in half, and set one of the pieces aside, explaining that it represents land that is too swampy, cold, or mountainous for people to live on.
3. Cut the other piece ($\frac{1}{8}$ of the whole apple) into four equal sections. Set aside three of these sections, explaining that they represent areas that are unsuitable for growing food (too rocky, cold, wet, etc.).
4. Finally, peel the remaining piece ($\frac{1}{32}$ of the whole apple), and ask students what the peel represents. (the only portion of Earth's surface that people can use for food production)

Activity

Divide the class into small groups, and have them do the activity *Mix and Match Ecology: Human Impact* at the web site below. Give each group a copy of the worksheet provided at the web site, and tell group members to brainstorm possible relationships between a given human impact (column 1), a particular ecological community (column 2), and one or more natural resources (column 3). They should develop a scenario that explains how the three factors are related. (E.g., a parking lot uphill from a forest allows snow melt to carry dissolved rock salt to the forest, which causes salination and prevents trees and other plants from absorbing water.) Call on each group to present its most creative scenario to the class. Follow up with a discussion of the extension questions that are also provided at the Web site.

- <http://www.learnnc.org/lp/pages/4766>

Discussion

Have students read the online EPA chapter *Wetland Functions* (see web site below) as a homework assignment. The chapter elaborates on the ecosystem services of wetlands that are listed in this lesson. The next day, lead the class in a discussion of the importance of wetlands and why they should be preserved.

- <http://www.epa.gov/region01/students/pdfs/wetch3.pdf>

Differentiated Instruction: Main Ideas/Details Chart

Pair less proficient and more proficient readers, and ask partners to work together to make a main ideas/details chart of lesson content. Suggest that they write at least one main idea for each of the major headings in the lesson. **LPR**

Enrichment: Creating a Video

Ask a small group of interested students to make a short video that shows how individuals and families can conserve water. Encourage them to think of creative ways to demonstrate how much water people waste in routine activities and the simple steps people can take to reduce the waste. For example, they might show how many gallon jugs of water are wasted by letting the water run while brushing teeth or shaving and compare it with the much smaller amount used when the water is turned off while doing these activities. Another idea might be to show how much water collects in a stoppered bathtub during a 10 – minute vs. 5 – minute shower. If possible, arrange for students to show their video to the entire student body.

Science Inquiry

Problem Solving

Students will better understand how land use affects water quality by doing the activity We All Live Downstream (see URL below). In the activity, students assume they have been assigned a certain section of riverfront property to develop and a grant of one million dollars for the development. They are asked to describe the property, outline how they would develop it, explain why they would develop it that way, and predict how the development is likely to affect the quality of river water. <http://www.accessexcellence.org/AE/ATG/data/released/0497-AlondaDroege/description.php>

Reinforce and Review

Flashcards

Instruct students to write each vocabulary term on the front of an index card and its definition on the back. Then have students choose partners and use their cards to quiz each other on the terms.

Lesson Worksheets

Copy and distribute the four Lesson 18.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 18.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 18.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What is your own concept of natural resources? What relationship between humans and the Earth does it contain?
- Aldo Leopold wrote: “There are two spiritual dangers in not owning a farm. One is the danger of supposing that breakfast comes from the grocery, and the other that heat comes from the furnace.” Is your life close enough to “the farm” to recognize and fully appreciate the values of soil and of energy resources?
- Were you surprised by the virtual water data for beef or jeans? What other “virtual resources” are part of the products we consume?
- What kinds of legislation help to incorporate this level of water use into prices? What types of legislation prevent water use from being included in costs?
- Compare this statement from The Great Law of the Iroquois Confederacy to the contemporary concept of sustainable use: “In every deliberation we must consider the impact on the seventh generation... even if it requires having skin as thick as the bark of a pine.”

Lesson Assessment

Have students complete the Lesson 18.2 Quiz.

22.4 Lesson 18.3: Natural Resources II: The Atmosphere

Key Concepts

The natural characteristics of the atmosphere have been modified by both primary and secondary pollutants. Most air pollution can be traced to fossil fuels, but many other human actions also contribute — from cattle ranching to mining. Pollutants in the air harm the health of living organisms and damage the natural and human-made environment. They also lead to acid rain and depletion of the ozone layer, both of which are serious global problems. Reducing air pollution requires individual efforts, such as reducing energy use; national policies, such as legislating for fuel efficiencies; and international agreements, such as limits on emissions.

Lesson Objectives

- Recognize that Earth’s atmosphere provides conditions and raw materials essential for life.
- Review the changes in the atmosphere over the history of Earth.
- Describe the dynamic equilibrium which characterizes the natural atmosphere.
- Analyze the ways in which population growth, fossil fuel use, industrialization, technology, and consumption result in atmospheric changes.
- Explain the effects of these changes on ecosystems.
- Relate these effects to current global stability.
- Describe how human activities, including technology, affect ecosystem services such as:

1. nutrient cycling
2. the hydrologic cycle
3. waste disposal

- Evaluate the effects of changes in these services for humans.
- Identify the ways in which humans have altered the air for other species.
- Relate air pollution to ecosystem loss.
- Interpret the effects of air pollution on biodiversity.
- Define acid rain.
- List the natural and anthropogenic causes of acid rain.
- Identify the effects of acid rain.
- Discuss solutions specific to the problem of acid rain.
- Locate and describe the origin of the ozone layer.
- Distinguish between ozone depletion and the ozone hole.
- Explain the role of ozone in absorbing ultraviolet radiation.
- Indicate the ways in which the ozone layer varies naturally.
- Discuss the relationship between recent changes in the ozone layer and human activities.
- Describe the measures taken to restore the ozone layer and evaluate their effectiveness.

Lesson Vocabulary

Table 22.5:

Lesson 18.3 Vocabulary		
acid rain	aerosols	air pollution
algal bloom	anthropogenic sources	biodiversity
ecosystem	eutrophication	global dimming
global warming	greenhouse effect	light pollution

Table 22.5: (continued)

Lesson 18.3 Vocabulary		
nonpoint source pollution	ozone depletion	ozone hole
ozone layer	point source pollution	pollution
primary pollutants	secondary pollutants	sustainable use

Check Your Understanding

Drawing on Student Experiences

Ask students whether they have ever heard a weather report that included the air quality index (AQI). Explain that the air quality index, also known as the air pollution index (API), is a number used by government agencies to characterize the quality of the air at a given location. As the AQI increases, an increasingly large percentage of the population is likely to experience adverse health effects. Tell students they will read about air pollution in this lesson.

Teaching Strategies

Activity

Have students do the activity *What Are the Sources of Air Pollutants?* at the web site below. The activity may be done individually, in groups, or as a class project. In the activity, students analyze air pollutant data for their own state and make inferences about its sources. At the web site, teacher notes and a student worksheet are provided, along with links to data pages.

- <http://www.ciese.org/curriculum/airproj/gensources.html>

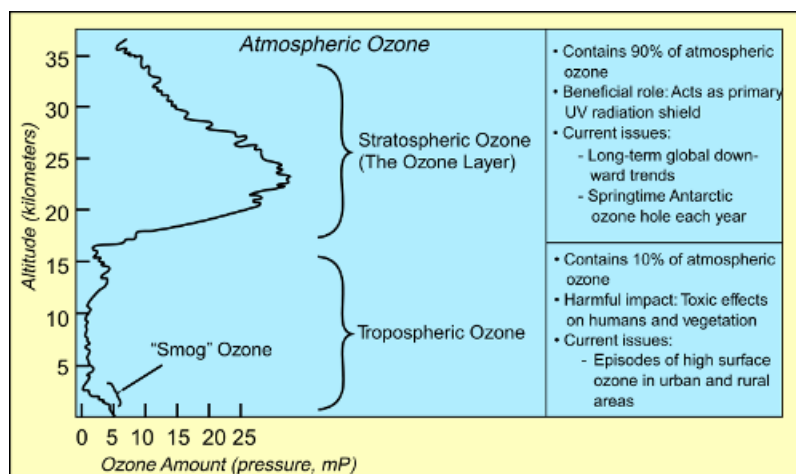
Demonstration

Show students how acid rain forms with the demonstration described at the web site below. The web site gives a list of materials and describes how to set up and carry out the procedure. A student worksheet, background information, and extension ideas are also provided.

- <http://www.spice.centers.ufl.edu/Its%20Raining%20its%20Pouring...Acid%20Rain/Shanna%20lesson%201.doc>

Using Visuals: Figure 9

Students may be confused about the two types of ozone in the atmosphere. Use **Figure 9** to distinguish between tropospheric ozone (“smog” ozone) and stratospheric ozone (the ozone layer). Explain why tropospheric ozone is harmful and stratospheric ozone is beneficial. Describe specific health effects of ground-level ozone (e.g., worsening of asthma and emphysema) and of depletion of the ozone layer (e.g., increase in skin cancers and cataracts).



Activity

Have students do the activity *Weather's Role* (see web site below) to investigate how weather conditions affect the formation of ground-level ozone. In the activity, students collect and analyze data and determine ozone levels. The web site includes animations, an air quality guide, an ozone map, and a worksheet for data analysis. Tips for teachers are also provided.

- <http://www.ciese.org/curriculum/airproj/ozoneweather.html>

Differentiated Instruction: Gallery Walk

Post a large sheet of paper on each wall of the classroom. Write one of the four questions below on each sheet. Assign students to small groups so that special needs students are included with other students who can assist them if necessary. Instruct groups to move around the room from one posted question to another. They should discuss each question and record an answer below it on the sheet. They should also read the responses of other groups and respond to them. Each group can use ink of a different color to distinguish their responses. After all the groups have finished, discuss the responses with the class as a whole. Point out any errors or misconceptions, and underscore the most important points. **SN**

1. What is air pollution?
2. What causes of air pollution?
3. How does air pollution affect ecosystems?
4. How can air pollution be prevented?

Enrichment: Teaching a Topic

Ask students who have studied chemistry to teach a lesson on the chemical reactions that take place in the ozone cycle or the formation of acid rain. Suggest that they create a PowerPoint presentation for their lesson.

Science Inquiry

Analyzing Data

Assign the activity *Particulate Matter Investigation* at the web site below. In the activity, students collect and analyze particulates in the air at an outdoor location. They also make inferences about possible sources of the particulates. The web site provides teacher notes and student worksheets for the activity.

- http://www.ciese.org/curriculum/airproj/pm_investigation.html

Reinforce and Review

Quizzing a Partner

Ask each student to write at least five objective questions (with answers) about lesson content. Then have students choose partners and quiz each other with the questions.

Lesson Worksheets

Copy and distribute the four Lesson 18.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 18.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 18.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- What are the major ecosystem services provided by our atmosphere?
- Could you now explain to a friend or family member the difference between the “hole in the ozone” and “global warming?”
- In what ways have we already begun to add the costs of atmospheric changes to our economic system?
- Can you think of additional ways in which we could build in these costs?
- How can we gain support for adding environmental costs to economic costs?

Lesson Assessment

Have students complete the Lesson 18.3 Quiz.

22.5 Lesson 18.4: Climate Change

Key Concepts

The greenhouse effect is a natural feature of Earth’s atmosphere that maintains Earth’s temperature within a range that supports life. Global warming refers to the recent increase in Earth’s average temperature, which has resulted from an enhanced greenhouse effect. This, in turn, has been caused mainly by an increase in atmospheric carbon dioxide due to the burning of fossil fuels. Global warming is melting sea ice and glaciers, raising ocean levels, increasing droughts and severe weather, and causing many other adverse changes. It has widespread ecosystem and socioeconomic effects and threatens political stability. Preventing climate change requires a reduction in greenhouse gas emissions, which in turn depends on individual, national, and international efforts.

Lesson Objectives

- Explain the mechanism of the greenhouse effect.
- Recognize that the greenhouse effect maintains an equilibrium.
- Compare greenhouse conditions on Earth to those on Mars and Venus.
- Explain the extent of current increases in Earth's temperature.
- Review past changes in Earth's temperatures.
- Summarize the evidence and support for greenhouse gases as the cause of recent global warming.
- Discuss the significance of global warming for Earth's ecosystems.
- Relate global warming to current global stability.
- List the atmospheric gases that absorb Earth's thermal radiation, and their sources.
- Evaluate possible solutions to the problem of global climate change.
- Recognize the tradeoffs required by nuclear power plants: reduced emissions vs. radioactive fuels and waste.

Lesson Vocabulary

Table 22.6:

Lesson 18.4 Vocabulary		
anthropogenic sources	carbon sink	carbon offsetting
carbon sequestration	carbon-neutral	emissions cap
emissions trading	global warming	greenhouse effect
greenhouse gas	planetary engineering	runaway greenhouse effect

Check Your Understanding

Facts and Figures

Introduce global warming by sharing these facts and figures with your class:

- The average global temperature has increased faster during the last 50 years than at any other time in recorded history.
- The first decade of the 21st century was the hottest decade on record, and 2005 was the hottest year ever recorded.
- During the same decade, global carbon dioxide from all sources increased by more than 33 percent.
- Between 2000 and 2005, global carbon dioxide from fossil fuels alone increased by 400 percent over the previous 10 years.

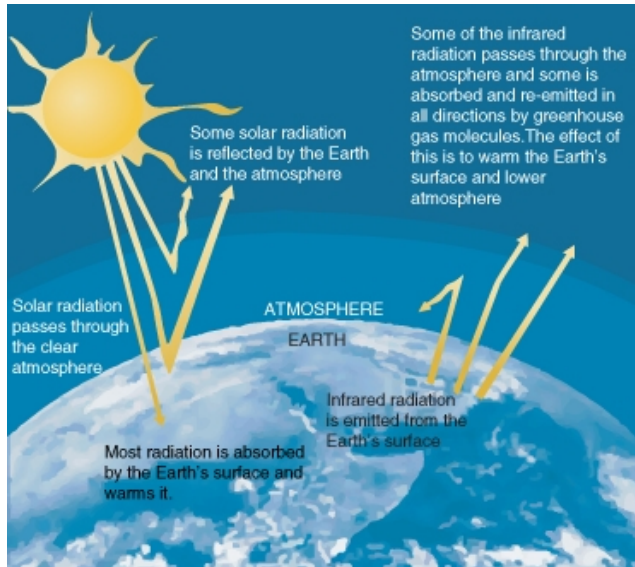
- Glaciers all over the world are melting three times faster now than in the 1970s; and the average glacier has melted 25 feet just since 1997.

Tell students they will learn more about global warming—including what causes it, how it affects ecosystems, and what can be done about it—when they read this lesson.

Teaching Strategies

Using Visuals: Figure 2

Before students read about global warming, make sure they understand the greenhouse effect by working through the diagram in **Figure 2** with the class.



Discussion

Discuss how the greenhouse effect is related to global warming. Specifically, discuss the following points:

- The greenhouse effect is a natural consequence of Earth's atmosphere.
- Without the greenhouse effect, Earth's average temperature would be much lower.
- Anthropogenic changes in Earth's atmosphere (especially increased CO_2) have increased the greenhouse effect and Earth's average temperature.

Activity

Have students work in groups on the activity *Terrestrial Sequestration—Photosynthesis and Cellular Respiration* (see web site below). In the activity, students investigate how the carbon cycle relates to global climate change and how climate change affects their own lives. The web site provides teachers with background information and a PowerPoint presentation. It also has a student procedure sheet and data table for recording observations.

- http://www.keystonecurriculum.org/highschool/2009_lesson_intros/21_Terrestrial_Sequest_HS09.html

Building Science Skills: Identifying Cause and Effect

Assign each student one of the effects of global climate change listed in the lesson in the section headed *Global Warming*. Then, as a homework assignment, ask students to write a paragraph in which they explain in detail how global warming causes their assigned effect. Encourage students to do additional research, starting with the links below, before they write. Call on several students to read their completed paragraphs to the class. Make sure that a diversity of effects (i.e., physical, ecosystem, socioeconomic, and political) are covered.

- <http://www.nrdc.org/globalWarming/fcons.asp>
- <http://www.enviroliteracy.org/article.php/1334.html>
- <http://climateprogress.org/2009/12/10/global-warming-impactsfrom-a-to-z/>

Activity

Have students do the activity *Eating Up Energy* (see web site below), in which they use a simulation to compare energy consumption and carbon dioxide emissions in different countries around the globe. The activity uses candy to represent energy consumption and wrappers from the candy to represent carbon dioxide emissions. After students complete the activity, they can eat the candy.

- http://www.keystonecurriculum.org/highschool/2009_lesson_intros/17_EatingUpEnergy_HS09.html

Differentiated Instruction: Concept Map

Pair less proficient readers with more proficient readers, and ask partners to create a concept map about global warming. Concept maps should include both causes and effects of global warming. Call on a few pairs to share their concept maps with the class. **LPR**

Enrichment: Survey

Ask interested students to undertake a survey of other students in their school about global warming. The questions in the survey should allow them to determine knowledge and opinions about the seriousness of global warming and the extent to which it is caused by human actions. After students gather survey responses, have them analyze the responses for misunderstandings about global warming. Then ask them to prepare a brief fact sheet that addresses the misunderstandings. Suggest that they make copies of the fact sheet and distribute it to survey participants and other students.

Science Inquiry

Problem Solving

Assign students to teams to play the *Wedge Game*, which is described at the web site below. The purpose of the game is to select strategies for solving the problem of global carbon emissions. The strategies must be plausible and politically acceptable, and they must also take into account potential physical and economic limitations.

- http://www.keystonecurriculum.org/highschool/2009_lesson_intros/22_WedgeGame_HS09.html

Asking Questions

Have students learn about polar bears and follow polar bears live as they are tracked by the World Wildlife Fund's polar bear tracker (see web site below). Then challenge the class to brainstorm research questions pertaining to global warming that could be addressed with data from the polar bear tracker.

- http://www.panda.org/what_we_do/where_we_work/arctic/area/species/polarbear/polar_bear/

Reinforce and Review

Using Vocabulary

Ask students to write a concise paragraph in which they use at least five of the following lesson vocabulary terms: **carbon offsetting**, **carbon sequestration**, **carbon neutral**, **emissions trading**, **emissions cap**, **global warming**, **greenhouse effect**, and **greenhouse gas**. Call on several students at random to read their paragraphs to the class.

Lesson Worksheets

Copy and distribute the four Lesson 18.4 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 18.4 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 18.4 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Do you think global warming is a good example of an “ecosystem service” or perhaps a “ biosphere service”? Explain your reasoning.
- How is the greenhouse effect both positive and negative?
- Which of the suggestions for preventing climate change do you think are most realistic for you?
- How might you, as an individual, contribute to national and international solutions to climate change?
- How might we do a better job of building the costs of global warming into the economics of fossil fuel use, deforestation, agriculture, and cattle production?

Lesson Assessment

Have students complete the Lesson 18.4 Quiz.

22.6 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 23

TE Biology Unit 10: Human Biology

23.1 Outline

This unit, *Human Biology*, includes seven chapters to introduce high school students to the study of human biology:

Chapter 35: The Human Body

Chapter 36: Nervous and Endocrine Systems

Chapter 37: Skeletal, Muscular, and Integumentary Systems

Chapter 38: Circulatory and Respiratory Systems

Chapter 39: Digestive and Excretory Systems

Chapter 40: Immune System and Disease

Chapter 41: Reproductive System and Human Development

23.2 Overview

The Human Body introduces the student to the levels of organization of the human body and explains the processes of homeostasis and regulation.

Chapter 24

TE The Human Body

24.1 Chapter 35: The Human Body

Outline

The chapter *The Human Body* consists of two lessons that introduce students to the overall plan of the human body. These lesson serve as an introduction to the chapters that follow.

- Lesson 35.1: Organization of the Human Body
- Lesson 35.2: Homeostasis and Regulation

Overview

- The human body is organized at four levels: cells, tissues, organs and organ systems. Homeostasis, which occurs when organ systems work together, is an organism's ability to maintain a constant internal environment.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the table below as a guide for the time required to teach the lessons of *The Human Body*.

Table 24.1:

Lesson	Number of Class Periods*
35.1 Organization of the Human Body	1.5
35.2 Homeostasis and Regulation	1.0

- Class periods are assumed to be 60 minutes long.

Managing Materials

The following items are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for *The Human Body*.

Table 24.2:

Lesson	Strategy or Activity	Materials Needed
35.1	Activity	Slides of various types of cells. (http://www.carolina.com/category/life+science/microscope+slides.do)

Web Resources

You may find these web based resources helpful when teaching *The Human Body*:

- General information:

<http://en.wikipedia.org>

http://en.wikibooks.org/wiki/Human_Physiology

- Additional figures showing tissue and organ systems.

<http://web.jjay.cuny.edu/~acarp/NSC/14-anatomy.htm>

- Web site for dietary guidelines and health.

www.ck12.org

<http://www.health.gov/dietaryguidelines/>

- Human Body Systems PowerPoint Presentation

<http://www.youtube.com/watch?v=SSqwRkDLyH4>

Common Misconceptions

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons from this chapter, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of this chapter, students should have read Chapters 1-9.
- Students should read this chapter before reading the remaining chapters of the *Human Biology* unit.
- It is recommended that you include all the lessons of this chapter in the FlexBook.

24.2 Lesson 35.1: Organization of the Human Body

Key Concepts

The human body is organized at four levels, cells, tissues, organs and organ systems. The cell is the smallest unit capable of carrying out life processes in your body. A tissue is a group of connected cells that have a similar function within an organism. An organ is a structure made of two or more different types of tissue that work together for a common purpose, and an organ system, like the digestive system, is made of more than one organ.

Lesson Objectives

- Describe the levels of organization of the human body.
- Outline the role of a specialized cell.
- Identify the properties that make body cells and stem cells different from each other.
- List three types of stem cells.
- Identify the four tissue types found in the human body.

- Summarize how tissues and organs relate to each other.
- Name two body systems that work together for a common purpose.

Lesson Vocabulary

Table 24.3:

Lesson 35.1 Vocabulary		
cells	differentiation	totipotent
pluripotent	stem cell	embryonic stem cells
adult stem cells	tissue	epithelial tissue
muscle tissue	nervous tissue	connective tissue
organ	organ system	

Check Your Understanding

Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know from the chapter *Cell Structure and Function*, the vertebrate body plan (the “Introduction to Animals” section of *Introduction to Animals and Invertebrates*), and the mammalian body plan in *Mammals*.

Teaching Strategies

Activity

If slides are available or if it is economical to order them (<http://www.carolina.com/category/life+science/microscope+slides.do>), have students examine prepared slides of different types of cells. Look at nerve cells, white blood cells, kidney cells, stomach cells and muscle cells. Also tissues, such as epithelial, muscle, nervous, and connective. Have students draw their observations into their lab notebooks. Ask them to add comments on the structure of the cells. After the students have examined the slides, have a discussion with them as to how the cells and tissues are either similar or different, and how the structures they see relate to the types of functions carried out.

Using Visuals: Figure 4

Have students examine **Figure 4** in their FlexBook.

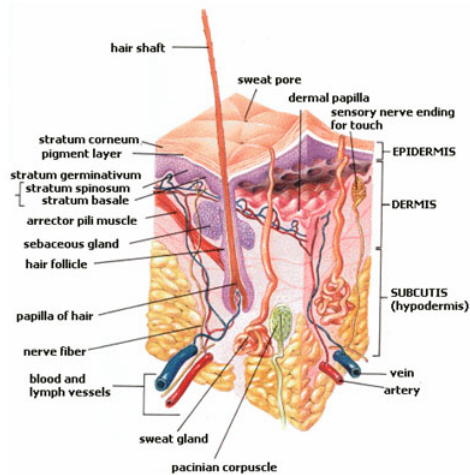


Figure 24.1: Your skin is the largest organ in your body. In this cross section image of skin, the four different tissue types (epithelial, connective, nervous, and muscle tissues) can be seen working together.

Have students classify structures of the skin into one of the four different tissue types (connective, nervous, muscle, epithelial). Allow about 10 minutes for students to classify the structures. Ask for responses and start a table on the board of the responses. Follow with a class discussion.

Enrichment: Building Science Skills: Making Inferences

An example of an organ system (digestive system), with an explanation of how the organs work together for the particular function, is described in the *Organ and Organ Systems* section. Have the students who need extra challenges explain another organ system(s) listed in **Table 1**. They should explain how the various organs, tissues, and structures involved work together for the related function. Have them write a brief description of their chosen system and present to class.

Science Inquiry

Problem Solving

Present a situation to the class where one of the students has cut his or her finger. What lesson concepts could be applied to explain the tissues that have been affected? Challenge students by asking at a tissue level how healing might take place. (Answers will vary, however, at this time, answers should incorporate at least three of the four tissue types.)

Reinforce and Review

Flashcards

Have students make flashcards for the vocabulary terms in the lesson. They should write each word on one side on an index card, and a definition and example on the other side. Then ask students to choose partners and use their flashcards to quiz each other on the terms. Students should review relevant parts of the FlexBook for any terms they miss.

Lesson Worksheets

Copy and distribute the four Lesson 35.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. **Answer Keys are available upon request at teacher-requests@ck12.org.**

Review Questions

Have students answer the Lesson 35.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 35.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- The smallest unit capable of carrying out life processes in your body is a single cell. Cells organize into tissues, which organize into organs. Groups of organs work together as organ systems. Consider how the last meal you consumed is interacting with each level of organization in your body.
- Think about the advantages and disadvantages of having a body composed of many small cells as opposed to a single large cell.

Lesson Assessment

- Have students complete the Lesson 35.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

24.3 Lesson 35.2: Homeostasis and Regulation

Key Concepts

Maintaining a constant internal environment by providing the cells with what they need to survive (oxygen, nutrients, and removal of waste) is necessary for the well-being of individual cells and the entire body. The many processes by which the body controls its internal environment are collectively called homeostasis. There are a number of homeostatic processes which use mainly negative feedback regulation loops. Homeostasis can be disrupted by internal and external influences.

Lesson Objectives

- Identify the process by which body systems are kept within certain limits.
- Explain the role of feedback mechanisms in homeostasis.
- Distinguish negative feedback from positive feedback.
- Identify and example of two organ systems working together to maintain homeostasis.
- Summarize the role of the endocrine system in homeostasis.
- Outline the result of a disturbance in homeostasis of a body system.

Lesson Vocabulary

Table 24.4:

Lesson 35.2 Vocabulary		
homeostasis	negative feedback	positive feedback
thermoregulation	osmoregulation	glucoregulation
hormone		

Check Your Understanding

Drawing on Student Experiences

Draw on student examples in their own lives, or of people they know of where heredity, lifestyle and/or environmental exposure has resulted in difficulties or disease (relate that to disrupting homeostasis). Point out correct explanations and any misconceptions.

Teaching Strategies

Using Visuals

Have students explain negative feedback using the control of blood glucose as an example.

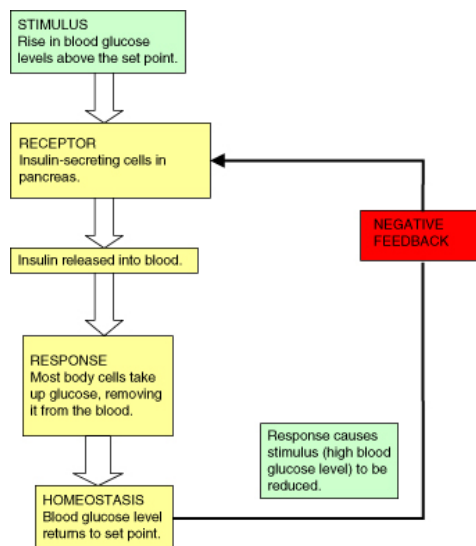


Figure 24.2: Control of blood glucose level is an example of negative feedback. Blood glucose concentration rises after a meal (the stimulus). The hormone insulin is released by the pancreas, and it speeds up the transport of glucose from the blood, and into selected tissues (the response). Blood glucose concentrations then decrease, which then decreases the original stimulus. The secretion of insulin into the blood is then decreased.

Building Science Skill: Applying Concepts

Have students pick one of the disorders listed in the section *Genetics*. (Type 1 diabetes, cancer, or heart disease.) Have them explain how procedures or lifestyle changes can help a person's body to regain homeostasis.

Differentiated Instruction: Think-Pair-Share

Assign questions or topics covered in this lesson to individual students to think about. For example, how does a specific lifestyle choice, like nutrition or physical activity, affect the homeostasis of the body. Make sure they be as specific as possible (see the examples given in the FlexBook under *External Influences: Lifestyle*). Pair LPR students with more proficient readers to work together on discussing the topics. (**LPR**)

Science Inquiry

Developing a Research Plan

Have students develop a simple research plan for testing how the effect of eating a meal has an effect on the blood glucose level. Ask the students to predict what meals may have a more dramatic effect on blood glucose levels. This can involve the use of a glucose meter to measure blood samples in individuals before and after eating a meal.

If your students want to further explore this topic and conduct experiment(s) with different types of food, ask the school nurse to be involved during any blood glucose measurements, and to dispose of contaminated materials. Ask the school nurse to supply a glucose meter and test strips.

Reinforce and Review

Making a Drawing

Have students create a simple sketch to demonstrate their understanding of a negative feedback loop.

Lesson Worksheets

Copy and distribute the four Lesson 35.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. May be done as homework.

Review Questions

Have students answer the Lesson 35.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 35.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Negative feedback is the most common feedback loop in biological systems. The system acts to reverse the direction of change. Positive feedback is less common in biological systems. The system acts to speed up the direction of change. Consider how your social interactions with teachers, parents and other students may be classified as either positive or negative feedback.
- When homeostasis is interrupted, your body can correct or worsen the problem, based on certain influences. In addition to genetic influences, there are external influences that are based on lifestyle choices and environmental exposures. Describe how your lifestyle may positively or negatively affect your body's ability to maintain homeostasis.

Lesson Assessment

- Have students complete the Lesson 35.2 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

24.4 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Image Sources

- (1) [*Niamh Gray-Wilson*]. CC-BY-CA.
- (2) <http://upload.wikimedia.org/wikipedia/commons/3/34/Skin.jpg>. Public Domain.

Chapter 25

TE Nervous and Endocrine Systems

25.1 Chapter 36: Nervous and Endocrine Systems

Outline

The chapter *Nervous and Endocrine Systems* consists of two lessons that introduce students to the structures and functions of the nervous and endocrine systems. Homeostatic imbalance in these systems is also discussed.

- Lesson 36.1: The Nervous System
- Lesson 36.2: The Endocrine System

Overview

- Your body has two systems that help you maintain homeostasis: the nervous system and the endocrine system. The nervous system is a complex network of nervous tissue that sends electrical and chemical signals. The endocrine system is a system of glands that releases chemical signals (hormones) into the bloodstream.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 25.1:

Lesson	Number of Class Periods*
36.1 The Nervous System	2.5
36.2 The Endocrine System	2.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

- Relationship between hours slept on school nights and reflex and response (Lesson 1) http://www.the-aps.org/education/k12curric/activities/pdfs/gonzalez_perez.PDF
- Reflexes and Reaction Time Lab (Lesson 1) <http://kvhs.nbed.nb.ca/gallant/biology/reflex.html>
- Virtual Cow's Eye Dissection http://www.exploratorium.edu/learning_studio/cow_eye/index.html

Common Misconceptions

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 25.2:

Lesson	Strategy or Activity	Materials Needed
36.1	<ol style="list-style-type: none"> 1. Enrichment: Teaching a Topic, Diagram, Diorama 2. Science Inquiry: Building a Model 	<ol style="list-style-type: none"> 1. Markers and poster board for diagram; use a box or platform and modeling clay 2. Use clear plastic tubing for the axon terminal and dendritic spine, and modeling clay for the synaptic vesicles, the neurotransmitters, and the neurotransmitter receptors.

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching *Nervous and Endocrine Systems*:

The Nervous System

- (http://training.seer.cancer.gov/module_anatomy/unit5_2_nerve_tissue.html) please check this url—LINK NOT VALID
- <http://brainmaps.org/>
- <http://teens.drugabuse.gov/index.asp>
- <http://www.nida.nih.gov/scienceofaddiction>

The Endocrine System

- Adapted from abstract: Anabolic Androgenic Steroids: A Survey of 500 Users Andrew B. Parkinson; Nick A. Evans (Medicine and Science in Sports and Exercise) at <http://www.medscape.com/viewarticle/533461>
- Adapted from: http://www.ncbi.nlm.nih.gov/sites/entrez?cmd=Retrieve&db=pubmed&dopt=AbstractPlus&list_uids=11927236
- http://www.lcsc.edu/healthocc/enable03/glands/03072_3.htm
- <http://web.indstate.edu/thcme/mwking/peptide-hormones.html#receptors>
- <http://web.indstate.edu/thcme/mwking/steroid-hormones.html>
- http://www.ncbi.nlm.nih.gov/sites/entrez?cmd=Retrieve&db=pubmed&dopt=AbstractPlus&list_uids=15589268
- <http://www.nlm.nih.gov/medlineplus/ency/article/000844.htm#Definition>
- <http://www.hormone.org/>

- <http://www.nlm.nih.gov/medlineplus/endocrinesystem>
- <http://health.nih.gov/search.asp/24>
- <http://www.askabiologist.org.uk/>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to choose the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter or certain lessons in this chapter in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook.

- To understand the content of this chapter, students should have read the *Foundations of Life Science*, *Chemical Basis of Life*, *Cell Structure and Function*, and *The Human Body* chapters.
- Students should read this entire chapter before reading the remaining chapters of the FlexBook.
- It is recommended that you include all the lessons of this chapter in the FlexBook.

25.2 Lesson 36.1: The Nervous System

Key Concepts

The nervous system is a complex network of nervous tissue that sends electrical and chemical signals. It includes the central nervous system (CNS) and the peripheral nervous system (PNS). The central nervous system is made up of the brain and spinal cord, and the peripheral nervous system is made up of the nervous tissue that lies outside the CNS, such as the nerves in the legs, arms, hands, feet and organs of the body. The electrical signals of the nervous system move very rapidly along nervous tissue, thus helping the body to react immediately to change.

Lesson Objectives

- Identify the type of cells that make up nervous tissue.
- Describe the structure of a neuron.
- Relate membrane potential to action potential.
- Outline the role of neurotransmitters in neuron communication.
- Distinguish between the sensory and motor divisions of the peripheral nervous system.
- Describe the structure of the eye and identify the roles of rods and cones in vision.

- Describe the structure of the ear and identify the structures that are important to hearing and balance.
- Distinguish between the receptors for pain, pressure, and temperature.
- Identify the main effect of psychoactive drugs on the CNS.
- Summarize the mechanism of addiction.

Lesson Vocabulary

Table 25.3:

Lesson 36.1 Vocabulary		
action potential	agonists	antagonists
astrocytes	autonomic nervous system (ANS)	axon
axon terminal	brain stem	cerebellum
central nervous system (CNS)	chemical synapse	cochlea
cone cells	dendrites	diencephalons
dorsal root	drug	drug abuse
electrical synapse	endocrine system	glial cell
hallucinogens	hearing	hypnotics (depressants)
interneurons	medicine (or medication)	membrane potential
midbrain	motor division	motor neurons
myelin sheath	nerve	nervous system
neuromuscular junction	neuron	neurotransmitter
nociceptor	Nodes of Ranvier	olfactory receptors
oligodendrocytes	parasympathetic division	peripheral nervous system (PNS)
pinna	psychoactive drug	reflex
resting potential	reuptake	rod cells
Schwann cells	sensory division	sensory neurons
sight (vision)	sodium-potassium pump	somatic nervous system
spinal cord	stimulant	sympathetic division

Table 25.3: (continued)

Lesson 36.1 Vo-		
cabulary		
synapse	synaptic cleft	threshold
touch	ventral root	voltage

Check Your Understanding

Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know from the chapters *Cell Structure and Function*, *Mammals*, and *The Human Body*. Make a list on the board, challenging the class to name at least 10 concepts they believe are important. These may include the four types of tissues, the cell membrane, concepts associated with transport (of ions) across the cell membrane, etc.

Teaching Strategies

Activity

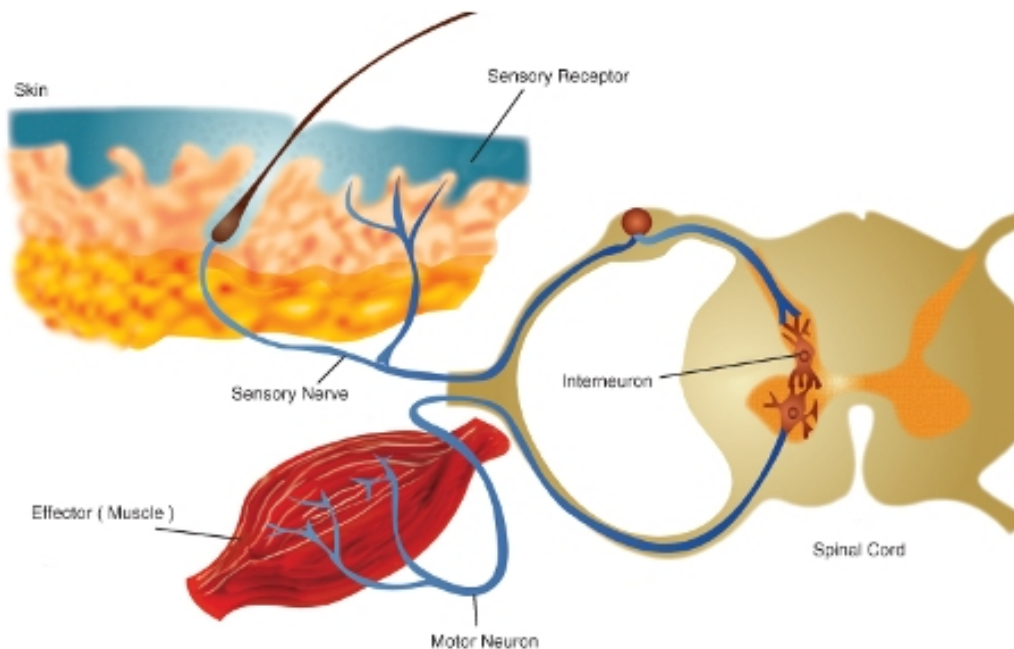
Associated with Action Potential. Students will make bead neurons and use them as models to understand the structure and function of neurons and how they communicate with each other. <http://brainu.org/bead-neuron>

Discussion

Have the students review the section on *Neurotransmitters and Disease* in their FlexBook. Have a discussion and make a table on the board of the four disorders discussed (depression, Parkinson's Disease, tetanus, and botulism), along with the neurotransmitters and medications or treatments involved for each one.

Using Visuals: Figure 19

Have students examine **Figure 19** in their FlexBook. Have them explain the example of a person stepping on a sharp object, as given in the FlexBook, illustrating by use of the figure (perhaps shown in an overhead projector) the components of the reflex. See if they can come up with other examples and similarly illustrate those.



The components of a reflex. A sensory receptor that detects a stimulus and sends nerve signals to the spinal cord. These signals activate motor neurons that lead back to the effector (muscle).

Building Science Skills: Applying Concepts, Comparing and Contrasting

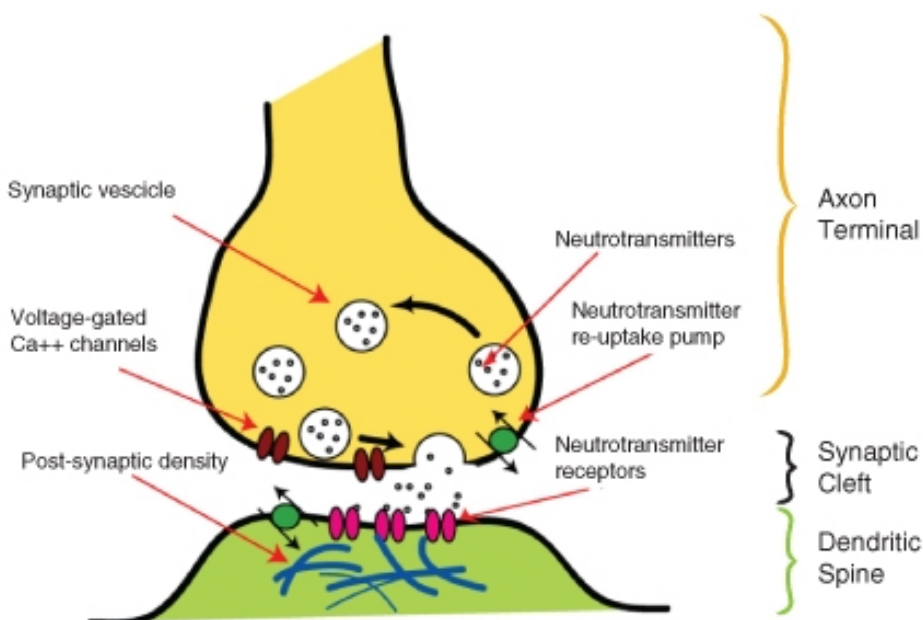
Divide the class into groups and assign each a different sense (sight, hearing, balance, taste, smell and touch). Have them look over the relevant sections in their FlexBooks and list the types of receptors and the areas of the brain involved for each sense, along with any other relevant or interesting facts. Have each group present to the rest of the class, making sure every individual in each group presents at least one fact. Have a class discussion afterwards about the similarities and differences found and create a table on the board.

Differentiated Instruction: Think-Pair-Share

This exercise can go along with the **Building Science Skills** strategy above. When the class is divided into groups, pair ELL students with native speakers, LPR students with more proficient readers, and SN students with students who do not have these needs, to work together on discussing the topic. **ELL LPR SN**

Enrichment: Teaching a Topic, Diagram, Diorama

Have students teach the topic in the section **Drugs and the Brain: How Psychoactive Drugs Work**, to the rest of the class, by taking an example from **Table 3** (See FlexBook: *Some Psychoactive Medicines and Their Uses*) and illustrating it with use of **Figure 32**. They could do this by means of either a diagram or diorama.



The release of neurotransmitter into the synaptic cleft. Depending on its method of action, a psychoactive substance may block the receptors on the post-synaptic neuron, or block reuptake, or affect neurotransmitter synthesis in the pre-synaptic neuron.

Science Inquiry

Building a Model

Challenge groups of students to make a model of how a drug molecule can alter neurotransmission. They should first review the section **Drugs and the Brain: How Psychoactive Drugs Work** and review **Figure 32** (see **Enrichment**, above) to see three possible methods of action of a psychoactive substance.

Reinforce and Review

Quizzing a Partner

Tell students to write a few fill-in, matching, or true/false questions and then use them to quiz a partner.

Lesson Worksheets

Copy and distribute the four Lesson 36.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 36.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 36.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- The electrical signals of the nervous system move very rapidly along nervous tissue, while the chemical signals of the endocrine system act much more slowly, and over a longer period of time. Identify some of the advantages to having two different speeds for communications in the body.
- Identify ways that psychoactive drug abuse may negatively affect organ systems other than the nervous system.
- The cerebral cortex controls functions such as consciousness, reasoning, emotions, and language. The brain stem is the lower part of the brain that is involved with unconscious, autonomic functions. Consider why consciousness and reasoning are called “higher functions” in relation to the “lower functions” of breathing and heartbeat.

Lesson Assessment

- Have students complete the Lesson 36.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

25.3 Lesson 36.2: The Endocrine System

Key Concepts

The endocrine system is a system of organs that releases chemical message molecules, called hormones, into the blood. Unlike the nervous system whose action helps the body react immediately to change, the endocrine system controls changes that happen to the body over a long period of time. The two systems work closely together to help us respond to our environment. The endocrine system is important in controlling metabolism, growth and development, reproduction, and salt, water and nutrient balance of blood and other tissues (osmoregulation).

Lesson Objectives

- Identify the main functions of the endocrine system.
- Identify the structures that produce hormones.
- Outline how hormones affect certain cells and not others.
- Describe two ways that hormones influence the function of cells.
- Identify the two glands that serve as the major control centers of the endocrine system.
- Identify the effects of adrenal hormones on the body.
- Examine the importance of the islets of Langerhans.
- Outline the role of the sex hormones in reproduction.
- Identify non-endocrine organs that secrete hormones.
- Examine how feedback mechanisms control hormone levels and body functions.
- Identify the role of hormone antagonists in the control of substances in the body.
- Identify two medical uses of hormones.

Lesson Vocabulary

Table 25.4:

Lesson 36.2 Vocabulary					
amino acid-based hormones	antagonistic	cholesterol-based hormones			
circadian rhythms	cortisol	direct gene activation			
endocrine glands	endocrine system	exocrine glands			
feedback control mechanism	glucagon	gonads			
hormone-like substances	hormones	hypersecretion			
hyposecretion	islets of Langerhans	negative feedback			
neuropeptides	positive feedback	prostaglandins			
puberty	second messenger system	sex hormones			
signal pathway	target cell				

Check Your Understanding

Recalling Prior Knowledge

As in Lesson 36.1, introduce lesson concepts by asking students to recall what they know from the chapters *Cell Structure and Function*, *Mammals*, and *The Human Body*.

Teaching Strategies

Discussion

Have the students review the section on **Hormone Antagonists** in their FlexBooks. Have a discussion of the actions of a hormone antagonist pair, as in the example of insulin and glucagon, and how they act together to keep your blood glucose concentration within a narrow range even after you eat food containing carbohydrates, such as a muffin, as in **Figure 16**. Discuss the other antagonistic pair mentioned (GHRH and GHIH) and also endocrine glands that work together, as in **Table 6**.

Using Visuals: Figure 11

Have students review the section, Adrenal Glands, and examine **Figure 11** [Insert Fig. 11 here] in their FlexBook. Have them pick out the two adrenal hormones (epinephrine

and norepinephrine) that are involved in **Figure 11**, and how the hormones work in this situation.

Differentiated Instruction: Main Ideas/Details Chart

Have pairs of students divide a sheet of paper into thirds. In the first column have them list each source for each hormone type (for example, the pituitary in the brain); in the second column list the hormones produced (i.e., the pituitary produces such hormones as ACTH); and in the third column the target cells and functions (i.e., ACTH targets the adrenal gland and stimulates the adrenal cortex). Pair English language learners with native speakers of English; pair less proficient readers with proficient readers. **ELL, LPR**

Enrichment: Teaching a Topic: Poster Presentation or Interview

Have students teach the topic **Homeostatic Imbalance: Endocrine System Disorders** to the rest of the class. Have them do this with either a poster presentation of the endocrine system disorders presented in the FlexBook lesson, how homeostatic imbalance causes the disorder, and what therapies or treatment might be available to treat the disorder. If possible, have the students invite someone who has an endocrine system disorder to the class and have the students ask the person how he or she deals with the therapies or treatment on a daily basis. Or have the students invite a researcher who is doing research on an endocrine system disorder and have them ask him or her more about the research and how it might help people with the disorder. After the interview, have the rest of the class ask any additional questions they might wish to ask.

Science Inquiry

Problem Solving

Have students discuss how each of the concepts of **Homeostatic Imbalance: Endocrine System Disorders**: hyposecretion, hypersecretion, and hormone insensitivity, can be used to help come up with a therapy or treatment for the disorders discussed.

Reinforce and Review

Outlining the Lesson

Have students work in pairs and outline the lesson. Explain to students how to use the heading structure of the SE lesson in building their outlines.

Lesson Worksheets

Copy and distribute the four Lesson 36.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 36.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 36.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Think about some of the problems people may have with their muscular systems if their nervous systems are not functioning correctly.
- Propose what would happen if the hypothalamus did not produce ADH.
- Why are negative feedback loops more common than positive feedback loops?

Lesson Assessment

- Have students complete the Lesson 36.2 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

25.4 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 26

TE Skeletal, Muscular, and Integumentary Systems

26.1 Chapter 37: Skeletal, Muscular, and Integumentary Systems

Outline

This chapter *Skeletal, Muscular, and Integumentary Systems* consists of three lessons that introduce students to the structures and functions of these three systems, and the consequences of homeostatic imbalance in them.

- Lesson 37.1: Skeletal System
- Lesson 37.2: Muscular System
- Lesson 37.3: Integumentary System

Overview

- The skeletal, muscular, and integumentary systems are all well adapted for their functions. Some of their functions overlap, as both the skeletal and muscular systems aid in movement and posture, the skeletal and integumentary systems help protect the body in various ways, and both the muscular and integumentary systems are involved with temperature regulation. Other functions are unique to their system, as in mineral storage in the skeleton, joint stability by the muscles, and sensory reception by the skin.
- The concept map below provides a visual representation of how the chapter concepts

are related.

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of *Skeletal, Muscular, and Integumentary Systems*.

Table 26.1:

Lesson	Number of Class Periods*
37.1 Skeletal System	1.5
37.2 Muscular System	1.0
37.3 Integumentary System	1.5

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for *Skeletal, Muscular, and Integumentary Systems* and are available online:

- Quizzes and interactive exercises: <http://www6.district125.k12.il.us/science/anatomy/ch7.html>

Common Misconceptions

Crime Scene TV Shows

This can fit in anywhere in the unit. This can be a fun discussion, given that many students probably watch a crime scene tv show from the amount that are on air. Have students come up with some of the misconceptions that they get when they watch the shows. For example, the shows give the sense that lab tests give results that are instantaneous. Instead, tests often take days to weeks before results are reported. Another misconception might be that the results are conclusive. Often results are not 100 percent accurate. Discussion of these misconceptions can even relate back to study of *Foundations of Life Science*.

Managing Materials

The items listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for *Skeletal, Muscular, and*

Table 26.2:

Lesson	Strategy or Activity	Materials Needed
37.1	1. DI: Word Wall 2. Enrichment	1. Bulletin Board or tape for the wall. 2. Model of skeleton; samples of bone types – ordered from Carolina Biological (see Lesson).
37.3	1. Enrichment 2. Science Inquiry: Building A Model	1. Any necessary props or costumes. 2. Modeling clay, plastic straws, colored coated wire.

Additional Web-Based Resources

You may find these additional internet resources helpful when teaching *Skeletal, Muscular, and Integumentary Systems*:

Skeletal System

- http://training.seer.cancer.gov/module_anatomy/unit3_5_skeleton_divisions
- http://training.seer.cancer.gov/module_anatomy/unit3_1_bone_functions
- <http://yucky.discovery.com/noflash/body/pg000124>
- <http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookMUSKEL>
- <http://en.wikipedia.org>

Muscular System

- Zierath JR, Hawley JA (2004) Skeletal Muscle Fiber Type: Influence on Contractile and Metabolic Properties. *PLoS Biol* 2(10): e348 doi:10.1371/journal.pbio.0020348 (Published: October 12, 2004.); Available online at: <http://biology.plosjournals.org/perlserv/?request=getdocument&doi=10.1371/journal.pbio.0020348>
- http://training.seer.cancer.gov/module_anatomy/unit4_1_muscle_functions
- <http://www.nismat.org/phycor/muscle>
- http://www.berkeley.edu/news/media/releases/2006/04/19_lactate

- <http://www.cdc.gov/nccdphp/dnpa/physical/components/index>
- <http://www.cdc.gov/nccdphp/dnpa/physical/terms/index>
- <http://muscle.ucsd.edu/musintro/hypertrophy>
- http://www.physsportsmed.com/issues/2002/07_02/puffer
- <http://www.nlm.nih.gov/medlineplus/ency/article/000688>
- <http://www.imcpl.org/kids/guides/health/muscularsystem>
- http://training.seer.cancer.gov/module_anatomy/unit4_1_muscle_functions
- <http://en.wikipedia.org>

Integumentary System

- http://training.seer.cancer.gov/ss_module14_melanoma/unit02_sec01_anatomy
- <http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookINTEGUSYS>
- <http://www.cancer.gov/cancertopics/understandingcancer/environment>
- <http://www.cancer.gov/cancertopics/understandingcancer/cancer/Slide54>
- http://animaldiversity.ummz.umich.edu/site/topics/mammal_anatomy/hair
- <http://www.cancer.gov/cancertopics/understandingcancer/cancer>
- <http://www.cdc.gov/excite/skincancer/index>
- <http://www.niams.nih.gov/hi/topics/acne/acne>
- <http://en.wikipedia.org>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include *Skeletal, Muscular, and Integumentary Systems*, or specific lessons in this chapter, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of *Skeletal, Muscular, and Integumentary Systems*, students should have read *Foundations of Life Science, Chemical Basis of Life, Cell Structure and Function*, and *The Human Body*.
- Students should read *Skeletal, Muscular, and Integumentary Systems* before reading the remaining chapters of the FlexBook.
- It is recommended that you include all the lessons of *Skeletal, Muscular, and Integumentary Systems* in the FlexBook.

26.2 Lesson 37.1: Skeletal System

Key Concepts

The human skeleton is well adapted for the functions it must perform. The skeleton includes bones, cartilage, and ligaments. Functions of bones include support, protection, movement, mineral storage, and formation of blood cells. There are two types of bone tissue: compact and spongy. There are four main types of bones. Homeostatic imbalance can cause broken bones and such diseases as rickets. Vitamin D supplements can prevent this disease.

Lesson Objectives

- Identify the functions and structure of bones.
- Differentiate between the axial skeleton and appendicular skeleton.
- Distinguish between spongy bone and compact bone.
- Outline the process of osteogenesis (bone formation), and how bones grow.
- Classify bones based on their shape.
- Identify three types of joints that are in the body, and give an example of each.
- Identify three disorders that result from homeostatic imbalances of bones or the skeleton.

Lesson Vocabulary

Table 26.3:

Lesson 37.1 Vocabulary		
appendicular skeleton	axial skeleton	bone marrow
bone matrix	cartilage	compact bone
endochondrial ossification	endoskeleton	epiphyseal plate
fracture	haversian canal	intramembranous ossification
joint	ligament	osteoarthritis
osteoblast	osteoclast	osteocyte
osteons	osteoporosis	periosteum
rickets	spongy bone	synovial fluid

Check Your Understanding

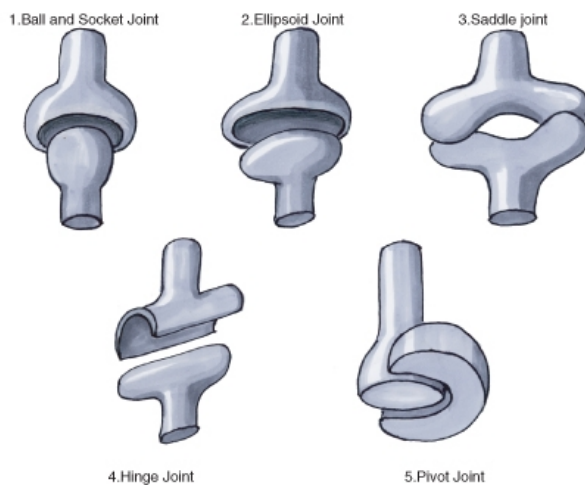
Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know from the chapters *Cell Structure and Function*, *Mammals*, and *The Human Body*.

Teaching Strategies

Using Visuals

Have students examine **Figure 13** in their FlexBook. Have them look at the different types of synovial joints with respect to the shapes of the joints, and the corresponding types of movements allowed. Suggest they move some of their own joints in the examples given to see how the different joints move.



Discussion

Have the students review the information on rickets, under the section Homeostatic Imbalances of Bone. Discuss what the possible causes of the disease are, its occurrence in both children and adults, its effects, and possible ways of preventing it.

Differentiated Instruction: Word Wall

Post lesson vocabulary words and their definitions on a bulletin board or wall. Have students refer to the word wall as they study lesson content. Pair ELL students with native speakers,

LPR students with more proficient readers, and SN students with students who are not special needs. (ELL, LPR, SN)

Enrichment: Demonstration

If possible, order a model of a human skeleton and perhaps some samples of different bone types. (Go to <http://www.carolina.com/category/life+science/anatomical+models+and+skeletons.do>) Have the students show the rest of the class the various parts of the skeleton and the different bone types. Also have them demonstrate how the different types of joints work. All of the students can also examine the types of movement that some of their own joints make (for example, ankles, knees, hips, wrists, elbows, shoulders, and fingers).

Science Inquiry

Developing a Research Plan

Have students develop a simple research plan for how they would show that bones can continue to increase in thickness or diameter throughout life in response to stress from increased muscle activity, or to weight-bearing exercise. (See last paragraph under the section Bone Elongation.) For example, students could come up with specific exercises to increase muscle activity, and then show ways to measure muscle thickness or diameter.

Reinforce and Review

Labeling a Drawing

Provide students with an unlabeled drawing (for example, **Figure 2** of the skeleton) and tell pairs of students to add the labels. Or the diagram from the following web site may be used:

- http://en.wikivisual.com/images/1/15/Human_skeleton_diagram.png

Lesson Worksheets

Copy and distribute the three Lesson 37.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 37.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 37.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Consider how what you eat today can influence your chance of developing osteoporosis later in life.
- Forensic pathologists can estimate the age of a deceased person even if only their skeleton remains. Consider how this is possible.

Lesson Assessment

- Have students complete the Lesson 37.1 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

26.3 Lesson 37.2: Muscular System

Key Concepts

The human body has three types of muscle tissue: skeletal, smooth, and cardiac. Nearly all movement in the body is the result of muscle contraction. In addition to movement, muscle contraction also maintains posture, stabilizes joints, and helps in heat production. Aerobic, anaerobic, and flexibility exercises affect muscles in different ways. Homeostatic imbalances of the muscular system can cause various disorders.

Lesson Objectives

- Outline the major role of the muscular system.
- Relate muscle fibers, fascicles, and muscles to the muscular system.
- Explain how muscle fibers contract.
- Examine the role of ATP and calcium in muscle contraction.
- Outline how muscles move bones.
- Explain how muscles respond to aerobic and anaerobic exercise.

Lesson Vocabulary

Table 26.4:

Lesson 37.2 Vocabulary		
actin	aerobic respiration	anaerobic glycolysis
anaerobic respiration	atrophy	cardiac muscle
delayed onset muscle soreness (DOMS)	extensor	flexor
hypertrophy	isometric contraction	isotonic contraction
muscle contraction	motor unit	muscle fiber
myofibril	myosin	sarcomeres
skeletal muscle	smooth muscle	tendinitis

Check Your Understanding

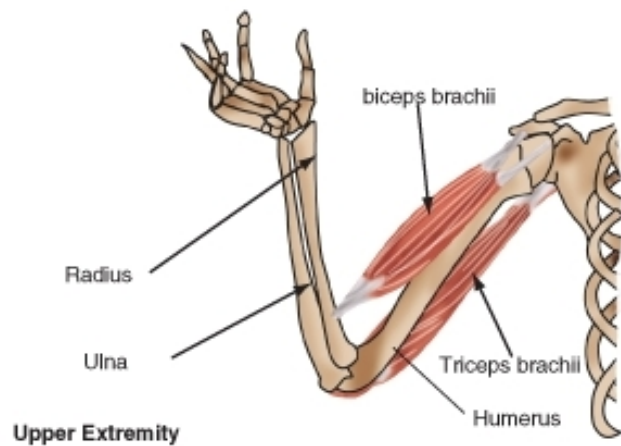
Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know from the chapters *Cell Structure and Function*, *Cellular Respiration*, *Mammals*, and *The Human Body*. Make a table on the board of student responses.

Teaching Strategies

Using Visuals

Have students examine **Figure 15** in their FlexBook. Discuss with them how the movement of the elbow joint involves muscles and bones, and have them bend and straighten their arms to see how this joint operates.



Discussion

Have the students review the section on Muscles and Exercise and have a discussion on different types of exercises and how they affect muscles. Perhaps students can discuss different kinds of exercises they do, or would like to do, and what changes they have noticed in themselves.

Differentiated Instruction: KWL

Have students make a KWL chart, where K= Know, W=Want to Know, and L=Learned. Students should fill in the K and W columns before reading and the L column after reading the lesson. Pair English language learners with native speakers of English, less proficient readers with proficient readers, and students who are not special needs students with those that are. (ELL LPR SN)

Enrichment: Leading a Discussion

Have the students lead a discussion on the benefits of physical exercise and how students can incorporate physical exercise into their daily lives. Discuss the pros and cons of having the public schools have mandatory physical education or other ways to get kids to lead more active lives.

Science Inquiry

Developing a Research Plan

As discussed in the lesson, Muscular Hypertrophy, athletic heart syndrome is hypertrophy of cardiac muscle in response to exercise. Have students design a research plan in which the presence of athletic heart syndrome could be examined in both athletes and non-athletes, by measuring their resting pulse rates after exercise.

Reinforce and Review

Asking Questions

Have students turn in questions they have about lesson content, on index cards. Then, answer or review material relevant to those questions that are asked most frequently.

Lesson Worksheets

Copy and distribute the four Lesson 37.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 37.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 37.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Identify ways in which damage to the integumentary system (for example, in a person with a severe burn) may affect the muscular and skeletal systems.

- Consider how the daily exercise routine and diet of an Olympic weightlifter would differ from that of a professional marathon runner.

Lesson Assessment

- Have students complete the Lesson 37.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

26.4 Lesson 37.3: Integumentary System

Key Concepts

The integumentary system is the external covering of the body and is made up of skin, hair, and nails. It has multiple roles in homeostasis, including protection, temperature regulation, sensory reception, biochemical synthesis, and absorption. Homeostatic imbalances can lead to skin conditions as well a range of cancers.

Lesson Objectives

- Identify the structures that make up the integumentary system.
- Outline the role of the skin in providing a physical barrier to the external environment.
- Distinguish between the two layers that make up the skin.
- Identify two types of glands that are found in the skin.
- Outline the function of melanin.
- Outline the structure of hair.
- Examine the structure of nails, and compare them to the structure of nails.

Lesson Vocabulary

Table 26.5:

Lesson 37.3 Vocabulary		
dermis	epidermis	integumentary
system	melanin	melanocytes
mutation	papillary region	sebaceous gland
sebum	subcutaneous tissue	reticular region

Check Your Understanding

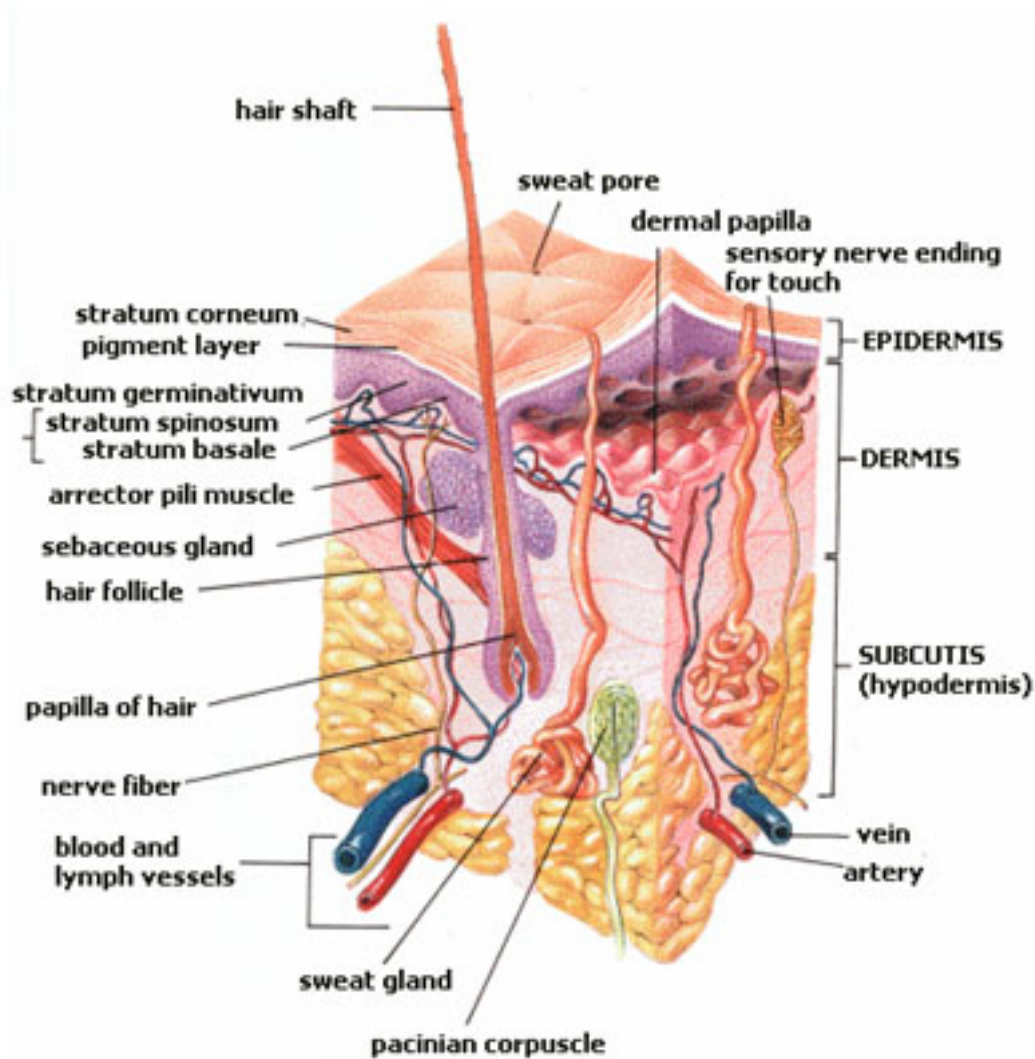
Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know from the chapters *Cell Structure and Function*, *Mammals*, and *The Human Body*. Compile a list on the board.

Teaching Strategies

Using Visuals

Have students examine **Figure 2** in their FlexBook. See if they can identify the different structures that correspond to the homeostatic functions of the skin, under the section, *Functions of Skin: Skin and Homeostasis*.



Discussion

Have the students discuss how the skin works to protect the body against large changes in temperature (see Functions of Skin: Skin and Homeostasis). How do these mechanisms include both the nervous and muscular systems?

Differentiated Instruction: Main Ideas/Details Chart

Have groups of students divide a sheet of paper in half and on the left side write the main ideas from a passage or lesson. On the right side, have them fill in important details about each main idea as they read. If a group has English Language Learners, make sure there are

also native speakers of English in the group. Do the same with Less Proficient Readers and Special Needs students. (**ELL LPR SN**)

Enrichment: Perform a Skit or Write a Rap Song

Have the students write and perform a skit or write a rap song about the skin and the dangers of too much sunlight.

Science Inquiry

Building a Model

Have students build a model of the layers that make up your skin, as in **Figure 2** (above).

Reinforce and Review

Using Vocabulary

Have students use the lesson vocabulary words in sentences or a brief paragraph.

Lesson Worksheets

Copy and distribute the four Lesson 37.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. **Answer Keys are available upon request at teacher-requests@ck12.org.**

Review Questions

Have students answer the Lesson 37.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 37.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Identify reasons why you should wear sunblock with an SPF value of at least 15 everyday.
- Consider what might happen if hair, fingernails and toenails contained sensory receptors.

Lesson Assessment

- Have students complete the Lesson 37.3 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

26.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org

Chapter 27

TE Circulatory and Respiratory Systems

27.1 Chapter 38: Circulatory and Respiratory Systems

Outline

The chapter *Circulatory and Respiratory Systems* consists of three lessons that introduce students to the structures and functions of the circulatory and respiratory systems, the composition and characteristics of blood, and diseases of all three.

- Lesson 38.1: Circulatory System
- Lesson 38.2: Blood
- Lesson 38.3: Respiratory System

Overview

- The cardiovascular system is comprised of the heart, the blood vessels, and the blood. It moves nutrients, hormones, gases, and wastes to and from cells in the body. The respiratory system obtains oxygen and releases carbon dioxide.
- The concept map below provides a visual representation of how the chapter concepts are related.

[insert concept map]

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 27.1:

Lesson	Number of Class Periods*
38.1 Circulatory System	1.5
38.2 Blood	1.0
38.3 Respiratory System	2.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

Circulatory System:

- http://www.sciencebuddies.org/science-fair-projects/project_ideas/HumBio_p014.shtml

Blood Labs testing for blood types:

- <http://www.aai.org/committees/education/Curriculum/2006/BensonFelicia.pdf>
- <http://www.aai.org/committees/education/curriculum/2004/Schmit.pdf>

Blood Type Calculator:

- http://www.biology.arizona.edu/human_bio/problem_sets/blood_types/inherited.html

Respiratory System:

- http://www.lung.ca/children/pdfs/grades7_12_experiment_tarcollector.pdf (see Lesson 38.3)
- http://www.sciencebuddies.org/science-fair-projects/project_ideas/HumBio_p003.shtml (see Lesson 38.3)
- Diffusion Dance – see Activity 4 in the following link: <http://scienceu.fsu.edu/guidebook/fl/pdf/module2.pdf>

Common Misconceptions

The Color of Blood

Many people hold the misconception that blood is blue at some point during circulation. So what is the color of blood? The color of blood always remains within the red spectrum. (bright red when oxygenated, and a deep red-maroon color when deoxygenated). There is no time in the human body when blood is ever blue, though there seems to be a common misconception among students. The following web site provides additional information.

<https://www.msu.edu/user/kalinkat/professionalpages/TechMatrixMaterials/documentaryblood.htm>

Managing Materials

The materials listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 27.2:

Lesson	Strategy or Activity	Materials Needed
38.1	1. Enrichment	1. Props for role play if possible.
38.2	1. DI: Word Wall	1. Bulletin Board
38.3	1. Science Inquiry: Problem Solving	1. Empty 2-liter soda bottle, plastic tubing, bucket, Bromothymol blue (which can be purchased from many biological supply companies), straw.

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching *Circulatory and Respiratory Systems*:

Circulatory System

- <http://www.fi.edu/learn/heart/index.html>

Respiratory System

- http://www.biology.arizona.edu/chh/problem_sets/lung_toxicology/lung_toxicology.html

Indoor Air Quality in the schools:

- <http://www.epa.gov/iaq/schools/teachers.html>

Games and exercises about respiration, lungs, etc.:

- <http://www.lung.ca/children/games/index.html>

Smoking:

- <http://www.lungsareforlife.ca/>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include *Circulatory and Respiratory Systems*, or specific lessons in this chapter, in your students' FlexBook. You should also consult the standards correlation table that follows when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of *Circulatory and Respiratory Systems*, students should have read *Foundations of Life Science*, *Cell Structure and Function*, and *The Human Body* chapters.
- Students should read *Circulatory and Respiratory Systems* before reading the remaining chapters of the FlexBook.
- It is recommended that you include all the lessons of *Circulatory and Respiratory Systems* in the FlexBook.

27.2 Lesson 38.1: Circulatory System

Key Concepts

The cardiovascular system is an organ system comprised of the heart, the blood vessels, and the blood. It moves nutrients, hormones, gases and wastes to and from body cells, and distributes heat to maintain homeostasis. Homeostatic imbalances can result in various diseases, usually related to atherosclerosis.

Lesson Objectives

- Identify the functions and components of the cardiovascular system.
- Describe the structure of the heart.
- Outline the flow of blood through the heart.
- Compare the structures of arteries, veins, and capillaries.
- Compare pulmonary circulation and systemic circulation.
- Outline the functions of the lymphatic system.
- Describe the importance of the coronary arteries.
- Outline the process of atherosclerosis.
- Describe ways of preventing cardiovascular diseases.

Lesson Vocabulary

Table 27.3:

Lesson 38.1 Vocabulary		
arteriole	artery	atria
atrioventricular node	atrioventricular valves	blood pressure
Bundle of His	cardiovascular system	capillary
coronary circulation	diastole	heart
hypertension	pulmonary circulation	Purkinje fibers
semilunar valves	sinoatrial node	sphygmomanometer
systemic circulation	systole	vascular resistance
vasoconstriction	vasodilatation	vein
ventricles	venule	

Check Your Understanding

Recalling Prior Knowledge

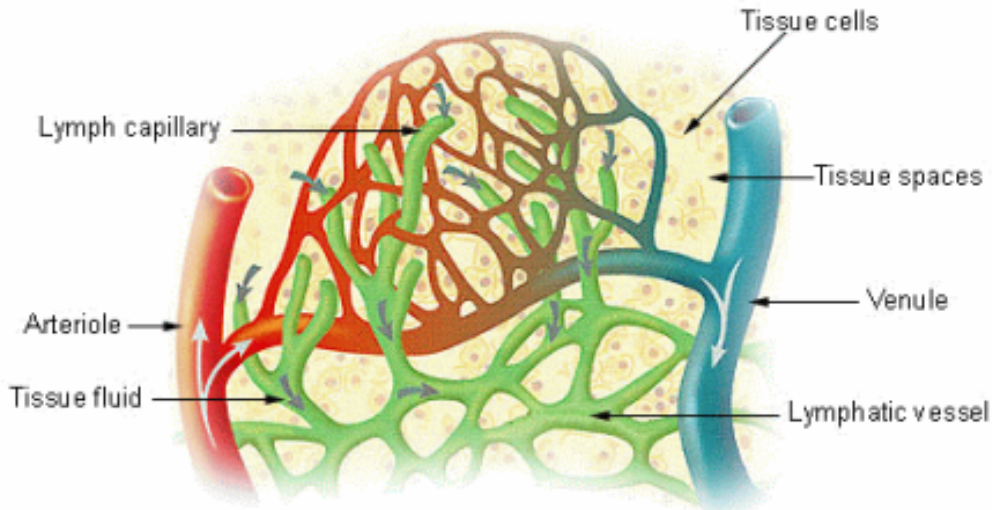
Introduce lesson concepts by asking students to recall what they know from the chapters *Cell Structure and Function*, *Mammals*, and *The Human Body*. Compile a list on the board.

Teaching Strategies

Using Visuals: Figure 18

Have students examine **Figure 18** and review Lymphatic Circulation in their FlexBook. Have them compare and contrast circulation of the lymph with that of blood.

Lymph Capillaries in the Tissue Spaces



Using Visuals: Figure 14; Activity

Hand out copies of the pulmonary circulation in black and white. Have them color the oxygenated blood red, and the deoxygenated blood blue. This is a good review for both the functions of arteries and veins and of pulmonary circulation. Have a discussion of the results.

Differentiated Instruction: Frayer Model

Have pairs of students draw a large box and divide it into four parts labeled Definition, Drawing, Example, and Non-example. Assign students a vocabulary word and tell them to fill in the parts of the box for that word. Pair English Language Learners with native speakers of English and Less Proficient Readers with more proficient readers. **ELL LPR**

Enrichment: Role Play

Have students present a few situations to the rest of the class, where one student plays a role where he or she has an unhealthy habit (such as smoking, watching too much television, not getting enough exercise, eating fast food) that can lead to heart disease, with another student interacting with them and explaining how that habit can lead to heart disease. Have a class discussion after the role play.

Science Inquiry

Analyzing Data

Have students go online to the link suggested at Strong, J.P., et al, (Under *Further Reading/Supplemental Links* in the FlexBook) on the study, *Prevalence and Extent of Atherosclerosis in Adolescents and Young Adults*. Have them briefly explain the study, examine some of the data and see what conclusions they can draw as to possible causes or correlations with respect to atherosclerosis.

- <http://jama.ama-assn.org/cgi/content/full/281/8/727>

Reinforce and Review

Making a List

Have students make a list of non-controllable and controllable risk factors associated with various forms of cardiovascular disease. Have partners compare and discuss their lists and then go back to the section on Preventing Cardiovascular Diseases to see if they missed anything.

Lesson Worksheets

Copy and distribute the four Lesson 38.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 38.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 38.1 in their FlexBook. Then, discuss the questions with the class. Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- How may factors such as the region of the world in which you live or your type of employment contribute to your risk of developing cardiovascular disease?
- Hypothesize about the role of blood in your excretory system.

Lesson Assessment: Lesson 38.1 Quiz

- An answer key is available upon request at teacher-requests@ck12.org.

27.3 Lesson 38.2: Blood

Key Concepts

Blood is a fluid connective tissue. Arterial blood carries oxygen and nutrients to all the body's cells, and venous blood carries carbon dioxide and other metabolic wastes away from the cells. Many blood disorders are genetic; others are a result of nutrient deficiency or are cancers of the blood.

Lesson Objectives

- List three functions of blood.
- Describe the composition of blood.
- Outline the process of blood clotting.
- Identify two major blood group systems.
- Outline the significance of blood type in transfusions.
- Describe two diseases of the blood.

Lesson Vocabulary

Table 27.4:

Lesson 38.2 Vocabulary			
agglutination		antibodies	blood
blood type (blood group)	(blood group)	coagulation	coagulation factors
erythrocytes		haemochromatosis	hematopoiesis
heme		hemoglobin	hemophilia
hormones		leukemia	lymphoma

Table 27.4: (continued)

Lesson 38.2 Vocabulary		
plasma serum albumin	sickle-cell disease	thrombocytes
universal donors	universal recipients	

Check Your Understanding

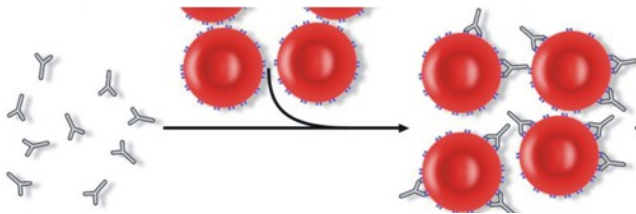
Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know from the chapters Cell Structure and Function, Mammals, and The Human Body.

Teaching Strategies

Using Visuals: Figure 6

Have the students review **Figure 6** on the agglutination of blood. Review **Table 1** as well. Discuss the process of agglutination as well as which blood types, when mixed together, would cause agglutination.



Antigens on the red blood cell surface. Antibodies attach to the antigens on the red blood cell, causing the blood cells to clump together. This leads to agglutination of the blood.

Building Science Skills: Classifying

Have students review the components of blood, then read over the diseases listed under Homeostatic Imbalances of the Blood. See if they can find how different components are affected in the diseases.

Differentiated Instruction: Word Wall

Post lesson vocabulary words and their definitions and examples on a bulletin board. Have students refer to the word wall as they study lesson content. Pair ELL students with native

speakers and LPR students with more proficient readers to work together on studying lesson content. **ELL LPR**

Enrichment: Crossword Puzzle

Have the students make a crossword puzzle using vocabulary words from the lesson and share it with the rest of the class.

Science Inquiry

Asking a Question

Have students review *Functions of Blood*, then go to the following web sites and review some of the basics of the effects of high altitude on respiration and oxygen level in blood. Have students come up with a suitable research question related to this topic, given some of the real observations mentioned on these sites. This should also be an interesting and fun topic and is an on-going area of research. In addition, they can click onto current news releases (at site #s 3 and 4) and find out what is being done currently.

Background information on high-altitude adaptations: <http://www.abc.net.au/science/articles/2002/12/03/739204.htm>

High-altitude sickness: <http://www.k2news.com/lesson21.htm>

How the body uses oxygen: <http://www.pbs.org/wgbh/nova/everest/exposure/body.html>

Some measurements, including oxygen level in blood, on climb up to Mt. Everest: <http://www.pbs.org/wgbh/nova/everest/expeditions/97/higher3.html>

Reinforce and Review

Quizing a Partner

Have students write a few fill-in, matching, or true/false questions and then use them to quiz a partner.

Lesson Worksheets

Copy and distribute the four Lesson 38.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 38.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 38.2 in their FlexBook. Then, discuss the questions with the class. Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- How might the composition of your blood change during a 24-hour period?
- What do you think is the relationship between the cardiovascular system, blood, and the respiratory system?

Lesson Assessment: Lesson 38.2 Quiz

- An answer key is available upon request at teacher-requests@ck12.org.

27.4 Lesson 38.3: Respiratory System

Key Concepts

The main function of the respiratory system is to obtain oxygen and to release carbon dioxide. The main structures involved include the nose and nasal cavity, the pharynx, the larynx, the trachea, and the lungs. Movement of the diaphragm plays a major role in inhalation and exhalation. Most of the carbon dioxide in the blood is in the form of bicarbonate. Two chronic respiratory diseases are emphysema and asthma.

Lesson Objectives

- Distinguish between external and internal respiration.
- Identify the structures of the respiratory system.
- Outline the process of inhalation.
- Describe how carbon dioxide is carried in the blood.
- Compare the causes of emphysema and asthma.

Lesson Vocabulary

Table 27.5:

Lesson 38.3 Vocabulary		
external respiration	cellular respiration	epiglottis
bronchi	gas exchange	emphysema
pneumonia	internal respiration	nasal cavity
larynx	alveoli	lung volume
bronchitis	tuberculosis	respiration
pharynx	trachea	diaphragm
respiratory disease	asthma	lung cancer

Check Your Understanding

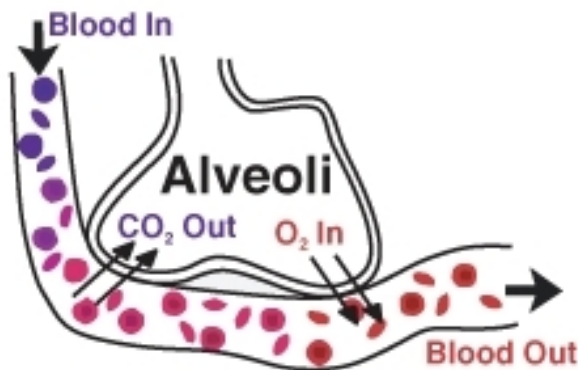
Recalling Prior Knowledge

Introduce lesson concepts by asking students to recall what they know from the chapters *Cell Structure and Function*, *Mammals*, and *The Human Body*. Make a chart on the board.

Teaching Strategies

Using Visuals: Figure 4

Have the students review the section Pulmonary Gas Exchange, and study **Figure 4**. Discuss how gas exchange occurs through the process of diffusion.



Gas exchange happens in the lungs through diffusion. Deoxygenated blood has a high concentration of CO₂ and a low O₂ concentration. CO₂ moves out of the blood and into the

alveoli, where the concentration of CO₂ is lower. Likewise, O₂ moves from an area of higher concentration (the alveoli), to an area of lower concentration (the blood).

Discussion

Refer to the exercise described on the internet where it is demonstrated how cigarette smoke causes the accumulation of tar [this could also be a demonstration or class activity, but if getting cigarettes is a problem, then use it as a discussion]. Review the section in this lesson on *Diseases and Disorders* and discuss how cigarette smoke is a factor, especially in the diseases, emphysema and lung cancer.

- http://www.lung.ca/children/pdfs/grades7_12_experiment_tarcollector.pdf

Differentiated Instruction: Compare/Contrast Table

Have groups of students make a compare/contrast table for the section on Diseases and Disorders. Have them compare and contrast with respect to whether the disease is obstructive or restrictive, in what structures the disease occurs, what segment of the population is effected, what causes it or makes it worse, what the symptoms are, and if there are any effective treatments or cures. Have English Language Learners work with native speakers of English and Less Proficient Readers work with more proficient readers. **ELL LPR**

Enrichment: Survey

Have students conduct surveys (see sites below), present their results to the rest of the class, then open the topic up for discussion. The students conducting the surveys will need to find out which school staff members to survey regarding both the survey about “How Asthma-Friendly is Your School?” and the one on indoor air quality in the schools. Depending on the results found, this could lead to further involvement with the students and the schools to make their environment a healthier one.

Asthma survey:

- <http://www.lungusa.org/atf/cf/%7B7A8D42C2-FCCA-4604-8ADE-7F5D5E762256%7D/asfi2007pg31.pdf>

Indoor Air Quality in the schools:

- <http://www.epa.gov/iaq/schools/teachers.html#Learn%20More%20About%20the%20IAQ%20TfS%20Program>

Science Inquiry

Problem Solving

Ask students if they can come up with a method to test lung capacity and how they also could measure the amount of carbon dioxide produced when you exhale. Refer to the activity below, which looks at lung capacity being equal to the amount of water displaced by air in a bottle, and a chemical indicator, which changes color according to the amount of carbon dioxide in solution. If time allows one or both activities can be conducted in class, and students can examine how respiration changes before and after a physical activity, such as jumping up and down for a certain time period.

- http://www.sciencebuddies.org/science-fair-projects/project_ideas/HumBio_p003.shtml

Reinforce and Review

Labeling a Drawing

Provide students with an unlabeled drawing of Figure 2 (Conducting Passages) and have students work individually and add the labels. A copy of this figure can be made, and the labels can be easily removed. Additional unlabeled diagrams can be found on the internet.

Lesson Worksheets

Copy and distribute the four Lesson 38.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 38.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 38.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- How might the amount of oxygen in the air affect your respiratory and circulatory systems?
- Can you identify any structures that are part of both the respiratory and digestive systems?

Lesson Assessment: Lesson 38.3 Quiz

- An answer key is available upon request at teacher-requests@ck12.org.

27.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 28

TE Digestive and Excretory Systems

28.1 Chapter 39: Digestive and Excretory Systems

Outline

The chapter *Digestive and Excretory Systems* consists of three lessons that provide an overview of the digestive and excretory systems and their functions.

- Lesson 39.1: Food and Nutrients
- Lesson 39.2: Digestive System
- Lesson 39.3: Excretory System

Overview

- This chapter describes nutrients that are needed by the body and how to eat in order to get the right balance of nutrients. It also explains how foods are broken down to obtain nutrients and how wastes are excreted from the body.
- The concept map below provides a visual representation of how the chapter concepts are related.

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 28.1:

Lesson	Number of Class Periods*
39.1 Food and Nutrients	2.5
39.2 Digestive System	2.0
39.3 Excretory System	1.5

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

- Testing Food for Nutrients: Students use chemical reagents to test unknown food samples for specific nutrients. (Lesson 39.1) <http://www.geocities.com/CapeCanaveral/Hall/1410/lab-B-09.html>
- Digestive Enzymes: Students investigate the role of the enzymes amylase and pepsin in the digestion of different foods. (Lesson 39.2) <http://www.accessexcellence.org/AE/ATG/data/released/0334-RobertGoodman/index.php>

Common Misconceptions

Misinformation about Sugars and Fats

Misconceptions about food and nutrients are common. For example, students may think that sugars and fats are “bad” for them and conversely that all sugar-free and fat-free foods are healthful. Make sure students understand that sugars and fats are needed by the body for energy and other vital purposes, although it is important to choose healthful sources of these nutrients, such as the sugars in fresh fruits and the lipids in nuts and vegetable oils. Also explain that sugar-free and fat-free foods are healthful only if they provide nutrients, such as fiber, proteins, or vitamins.

Digestive System Myths

There are several common misconceptions about the digestive system. Some of these include:

- The stomach makes up most of the digestive system, and most digestion takes place there.
- Food goes from the stomach into the blood stream.

- Most of the food we eat is excreted through the anus.
- Foods that the body does not need stay in the intestine and are eliminated from the body.

Read these misconceptions to the class, and ask students which if any of them they think are true. Call on students who think they are false to explain why.

Managing Materials

The materials listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 28.2:

Lesson	Strategy or Activity	Materials Needed
39.1	1. Activity 2. Differentiated Instruction: Gallery Walk	1. food labels (contributed by students) 2. large sheets of paper
39.2	1. Activity 2. Demonstration	1. soda crackers 2. short length of rubber tubing, marble
39.3	1. Demonstration	1. fresh beef kidney, scalpel or sharp knife

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- Nutrition: This Web site provides easy online access to government information on nutrition. http://www.nutrition.gov/nal_display/index.php?info_center=11&tax_level=1
- The Digestive System: This well-illustrated online chapter provides a useful ancillary to Lesson 39.2. <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookDIGEST.html>
- The Human Body—Body Systems: This Web site provides numerous links with online quizzes, animations, and articles on the digestive system. <http://www.teachers.ash.org.au/jmresources/systems/body.html>
- The Excretory System: This online chapter contains excellent illustrations and a somewhat different perspective on the content of Lesson 39.3. <http://www.emc.maricopa.edu>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons of this chapter, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the chapter *Digestive and Excretory Systems*, students should have read the chapters *Chemical Basis of Life* and *The Human Body*.
- If you incorporate the chapter *Digestive and Excretory Systems* in your FlexBook, it is recommended that you include all three lessons of the chapter.

28.2 Lesson 39.1: Food and Nutrients

Key Concepts

The human body needs food to provide it with macronutrients (carbohydrates, proteins, and lipids) and micronutrients (vitamins and minerals). Balanced eating involves consuming a variety of healthful foods that contain adequate amounts of nutrients and energy. Energy needs depend on activity levels, and taking in more energy than needed may result in obesity. Eating disorders are complex behavioral problems that may require psychiatric treatment.

Lesson Objectives

- Identify classes of macronutrients and describe their roles in the body.
- Describe balanced eating and explain how it helps prevent obesity.
- State functions and food sources of vitamins and minerals.
- Describe eating disorders, their causes, and treatment.

Lesson Vocabulary

Table 28.3:

Lesson 39.1 Vocabulary		
nutrients	macronutrients	micronutrients

Table 28.3: (continued)

Lesson 39.1 Vocabulary		
carbohydrates	proteins	essential amino acids
complete proteins	incomplete proteins	lipids
triglyceride	saturated fatty acids	unsaturated fatty acids
hyponatremia	MyPyramid	obesity
metabolic syndrome	vitamins	minerals
eating disorder	binge eating disorder	anorexia nervosa
bulimia nervosa		

Check Your Understanding

Drawing on Student Experiences

Call on several volunteers to state what they ate the previous day or earlier on the same day. Make a list on the board. Challenge the class to identify nutrients in some of the foods they mention. Tell the class they will learn more about the nutrients in food in this lesson.

Teaching Strategies

Build Science Skills: Applying Concepts

Have students determine the total number of Calories they require each day to maintain their weight, based on their gender, weight, height, age, and activity level (they can use one of the online Calorie calculators below). Tell students that about 30 percent of the Calories in a balanced diet should come from fats, about 15 percent from proteins, and the rest from carbohydrates. Based on this information and their total Calorie needs, have them calculate the recommended number of Calories of each macronutrient they should consume each day. As a homework assignment, ask students to read food labels to find the fat, protein, and carbohydrate Calories they consume in a typical day. Have them compare the recommended number of Calories of each macronutrient with the number they actually consume. If their consumption pattern does not match the recommended pattern, tell them to think of ways (and write these down) they could change their eating habits for a better match.

- <http://www.webcalcsolutions.com/Nutrition-Calculators.asp>
- <http://calorieneedscalculator.com/>

Activity

Have students use the interactive tools at the URL below to customize MyPyramid for their age, gender, height, weight, and activity level. They can use other tools at the Web site to generate a healthy eating plan and track their nutrient intake.

- <http://www.mypyramid.gov/>

Activity

Have each student to bring a food label to class. Based on their food label, tell them to calculate the nutrient density of the food for proteins and at least one vitamin or mineral that the food contains. As a class, discuss which foods are the most and least nutrient dense for the nutrients considered. Relate nutrient density of the foods to the role they should play in a healthful diet. Examples of many food labels can also be found on-line.

Use Visuals: Tables 3 and 4

Review the information in **Tables 3** and **4** (see below) with the class. Point out the diversity of body functions that depend on particular vitamins and minerals. Have students identify foods that are rich in more than one vitamin or mineral.

- **Ask:** What single food is a good source of vitamins A, B2, B9, E, and K, and is also a good source of calcium and magnesium? (spinach)

Table 28.4: **Vitamins**

Vitamin (Chemical Name)	Functions in the Body	Good Food Sources	Recommended Daily Intakes for Ages 14–18 yr
Vitamin A (Retinoids)	Needed for good vision, reproduction, and fetal development	Carrots, spinach, milk, eggs	Males: 900 μg Females: 700 μg
Vitamin B ₁ (Thiamine)	Helps break down macronutrients; essential for proper functioning of nerves	Whole wheat, peas, beans, fish, peanuts, meats	Males: 1.2 mg Females: 1.0 mg
Vitamin B ₂ (Riboflavin)	Helps the body process amino acids and fats; acts as antioxidant	Milk, liver, green leafy vegetables, almonds, soybeans	Males: 1.3 mg Females: 1.0 mg

Table 28.4: (continued)

Vitamin (Chemical Name)	Functions in the Body	Good Food Sources	Recommended Daily Intakes for Ages 14–18 yr
Vitamin B ₃ (Niacin)	Helps release energy from macronutrients; needed for healthy skin and nerves	Beets, beef liver, pork, turkey, fish, sunflower seeds, peanuts	Males: 16 mg Females: 14 mg
Vitamin B ₅ , (Pantothenic Acid)	Helps form critical enzymes for synthesis of macronutrients	Whole grains, legumes, eggs, meat	Males: 5 mg* Females: 5 mg*
Vitamin B ₆ (Pyridoxine)	Forms enzymes needed for amino acid synthesis and energy storage	Cereals, yeast, liver, fish, avocados, nuts, green beans	Males: 1.3 mg Females: 1.2 mg
Vitamin B ₇ (Biotin)	Enables synthesis of fatty acids; helps store energy; keeps level of blood sugar stable	None	Males: 25 μg * Females: 25 μg *
Vitamin B ₉ (Folate)	Needed to make red blood cells	Liver, green leafy vegetables, dried beans and peas	Males: 400 μg Females: 400 μg
Vitamin B ₁₂ (Cyanocobalamin)	Needed for normal functioning of nervous system and formation of blood	Meat, liver, milk, shellfish, eggs	Males: 2.4 μg Females: 2.4 μg
Vitamin C (Ascorbic Acid)	Needed to make many biological chemicals; acts as antioxidant	Citrus fruits such as oranges, red peppers, broccoli, kiwi	Males: 75 mg Females: 65 mg
Vitamin D (Ergocalciferol and Cholecalciferol)	Helps maintain blood levels of calcium; needed for healthy bones and teeth	Salmon, tuna, eggs, mushrooms	Males: 5 μg Females: 5 μg

Table 28.4: (continued)

Vitamin (Chemical Name)	Functions in the Body	Good Food Sources	Recommended Daily Intakes for Ages 14–18 yr
Vitamin E (Tocopherol)	Acts as antioxidant; protects cell membranes from LDL cholesterol damage	Vegetable oils, nuts, green leafy vegetables, whole grains, fish	Males: 15 mg Females: 15 mg
Vitamin K (Naphthoquinone)	Helps transport calcium; helps blood clot	Kale, spinach, Brussels sprouts, milk, eggs, soy products	Males: 75 μg^* Females: 75 μg^*

- Recommended daily intakes not established; figures given are adequate daily intakes.

Table 28.5: **Minerals**

Mineral Name (Symbol)	Functions in the Body	Good Food Sources	Recommended Daily Intakes (mg) for Ages 14–18 yr
Calcium (Ca)	Needed for nerve and muscle action; builds bone and teeth; helps blood clot	Milk, soy milk, green leafy vegetables, sardines	Males: 1300* Females: 1300*
Chloride (Cl)	Helps maintain water and pH balance; helps form stomach acid	Table salt, most processed foods	Males: 2300* Females: 2300*
Magnesium (Mg)	Needed to form several enzymes	Whole grains, green leafy vegetables, nuts, seeds	Males: 410 Females: 360
Phosphorus (P)	Component of bones, teeth, lipids, and other important molecules in the body	Meat, poultry, whole grains	Males: 1250 Females: 1250

Table 28.5: (continued)

Mineral Name (Symbol)	Functions in the Body	Good Food Sources	Recommended Daily Intakes (mg) for Ages 14–18 yr
Potassium (K)	Needed for muscle and nerve function; helps maintain salt-water balance in body fluids	Meats, grains, orange juice, potatoes, bananas	Males: 4700* Females: 4700*
Sodium (Na)	Needed for muscle and nerve function; helps maintain salt-water balance in body fluids	Table salt, most processed foods	Males: 1500* Females: 1500*
Sulfur (S)	Necessary component of many proteins	Whole grains, meats, seafood, eggs	Males: 1300* Females: 1300*

- Recommended daily intakes not established; figures given are adequate daily intakes.

Discussion

Discuss eating disorders, including their possible causes, consequences, and treatment. Be sure to stress that eating disorders may be life threatening and that they require medical treatment. Anorexia nervosa and bulimia nervosa occur most often in teenage girls, so the issue is an important one to discuss with high school students.

Differentiated Instruction: Gallery Walk

On large sheets of paper, write the names of the macronutrients, one macronutrient per sheet, and post the sheets in different places around the classroom. Place any English language learners in groups with native English speakers, and have groups walk around the room reading and responding to the posted nutrients. For each nutrient, tell them to list (on the same large sheet of paper) a good food source of the nutrient and one of the nutrient's roles in the body. After all the groups have finished, discuss their responses as a class. Be sure to point out and correct any errors in the responses. **ELL**

Enrichment: Survey

Ask students who need extra challenges to take a survey of the nutritional knowledge of other students, friends, or family members. They should first prepare a list of questions to assess what respondents know about nutrients and their role in a healthful diet. They might ask questions such as:

- “How many calories does the average person need each day?”
- “What are examples of high-fiber foods?”
- “Why is it important to limit the amount of fat that you eat?”

After students finish their survey, have them summarize the results and present the summary to the class. As a class, discuss the role of nutritional knowledge in healthful eating.

Science Inquiry

Developing a Research Plan

Explain to the class that people who exercise regularly are less likely to be obese than people who do not exercise. Point out that regular exercisers may also tend to be more careful about what they eat, which might affect their weight as well. Ask students to develop a research plan that would allow them to correlate the effects of exercise alone on weight, without the possible confounding effects of diet. (Their plans should compare the weights of a sample of people who exercise regularly with the weights of a sample of people who do not exercise. They should control for the effects of diet on weight by including in the samples only people who eat a similar diet.)

Reinforce and Review

Completing a Chart

Make copies of MyPyramid in **Figure 1**, without the key, and distribute the copies to students. Ask students to label the colored bands with the food groups they represent and to list at least two foods in each food group.



Lesson Worksheets

Copy and distribute the four Lesson 39.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 39.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 39.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- You need nutrients for energy and building materials. Balanced eating provides you with foods that contain the nutrients you need. How does your body obtain the nutrients from food?
- What processes break down food and make nutrients available to the body?
- What organs carry out these processes?

Lesson Assessment

- Have students complete the Lesson 39.1 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

28.3 Lesson 39.2: Digestive System

Key Concepts

The organs of the digestive system break down foods into nutrient molecules that the body can use, enable the absorption of the nutrients by the blood, and excrete any remaining solid wastes. There are many diseases that can affect the digestive system, including infections, food allergies, and inherited disorders.

Lesson Objectives

- Describe the organs and major functions of the digestive system.
- Explain how the mouth, esophagus, and stomach start the digestion of food.
- Explain how the small intestine completes digestion and absorbs nutrients.
- State the functions of the large intestine and the roles of intestinal bacteria.
- Identify and describe diseases of the digestive system.

Lesson Vocabulary

Table 28.6:

Lesson 39.2 Vocabulary			
gastrointestinal tract	(GI)	upper GI tract	lower GI tract
peristalsis		mucous membranes	liver
gall bladder		pancreas	mechanical digestion
chemical digestion		absorption	amylase
pharynx		esophagus	stomach
small intestine		duodenum	jejunum
ileum		large intestine	cecum
colon		rectum	inflammatory bowel disease
gastritis		stomach ulcer	celiac disease
irritable bowel syndrome			

Check Your Understanding

Recalling Prior Knowledge

Call on students, one after another, to state anything they know about digestion or the digestive system. Continue until no more new information is forthcoming. Tell students they will learn more about digestion and the digestive system in this lesson.

Teaching Strategies

Activity

Students may fail to appreciate that chemical digestion actually begins in the mouth. Give them a chance to experience amylase in saliva breaking down complex carbohydrates to simple sugars. Have them chew a soda cracker for several minutes before swallowing. They should chew the cracker until they notice that it starts to taste sweet. Call on a volunteer to explain what has happened to the cracker to make it taste sweet.

Demonstration

State the significance of peristalsis in the digestive system. Then demonstrate peristalsis by pushing a marble through a short length of rubber tubing. Tell the class that the tube represents the esophagus and the marble represents a bolus of food. Keep squeezing the tubing just above the marble until the marble moves completely through the tubing and out

the other end. Give a few students a chance to squeeze the marble through the tubing as well. Remind the class that peristalsis moves food through the entire digestive system, not just the esophagus.

Activity

Suggest that students use the online interactive animation at the URL below to see how different foods are broken down by the digestive system.

- <http://kitses.com/animation/digestion.html>

Differentiated Instruction: Flow Chart

Match special needs students with students who excel, and ask partners to create a flow chart showing the organs that food passes through as it is broken down by the digestive system. Have students illustrate their flow chart with simple sketches or online illustrations of the digestive organs, and, for each organ, ask them to write a few words summarizing its role in digestion. **SN**

Enrichment: Writing a Rap

Challenge interested students to write a rap song that describes how food is broken down as it passes through the digestive system. Set aside class time for the students to present their rap to the class.

Science Inquiry

Analyzing Data

Assign the activity Understanding Digestion at the URL below. In the activity, students analyze published data for a better understanding of digestion. They also generate new explanations and apply concepts to novel situations. The Web site includes a lesson plan, data tables, and student worksheets.

- <http://www.bio.indiana.edu/~summerresearch/docs/Digestion-All.pdf>

Reinforce and Review

Online Quiz

Ask students to complete this interactive online activity to review the location and function of digestive system organs.

- <http://science.waltermack.com/flashTeacherTools/biology/digestiveSystemBuilder2a.swf>

Lesson Worksheets

Copy and distribute the four Lesson 39.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 39.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 39.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- The large intestine eliminates the waste that remains after food is digested. More waste is produced when cells break down nutrients for energy and building materials. How is this waste removed from the body? Is it eliminated by the large intestine? Is it removed in some other way?

Lesson Assessment

- Have students complete the Lesson 39.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

28.4 Lesson 39.3: Excretory System

Key Concepts

The body maintains homeostasis by keeping internal conditions more or less constant. One way it does this is through excretion, which is the removal of wastes and excess water from the body. The kidneys are the major organs that excrete wastes and excess water. They filter the blood and form urine. Diseases that may harm the health of the kidneys include kidney stones, infections, and diabetes.

Lesson Objectives

- Define homeostasis and excretion, and explain why they are necessary for life.
- Describe the urinary system, kidneys, and nephrons; summarize the processes involved in excretion.
- Identify roles of the kidneys in homeostasis.
- Name diseases of the urinary system, and explain how dialysis helps treat kidney failure.

Lesson Vocabulary

Table 28.7:

Lesson 39.3 Vocabulary		
homeostasis	excretion	receptor
control center	effector	negative feedback
positive feedback	kidney	urinary system
bladder	urethra	urine
nephrons	glomerulus	Bowman's capsule
renal tubule	filtration	reabsorption
loop of Henle	erythropoietin	rennin
kidney stones	dialysis	

Check Your Understanding

Facts and Figures

Spark interest in the excretory system by sharing with the class the following kidney facts and figures:

- Each kidney is only about the size of a computer mouse.
- Each kidney contains of more than one million filters (nephrons) that are so tiny they can be seen only with a high-powered microscope.
- The kidneys filter all of the body's blood supply (about 1.5 gallons) many times each day.

Tell students they will learn more about the kidneys and excretory system in this lesson.

Teaching Strategies

Discussion

Help students understand the concepts of homeostasis and negative feedback by discussing a familiar example: the regulation of the temperature inside a house by a thermostat, furnace, and air conditioner. Call on volunteers to draw a diagram on the board that shows how the thermostat controls the furnace and air conditioner, using the feedback of air temperature inside the house. Relate this to the way the kidneys maintain homeostasis using the feedback of the blood concentration of water, ions, and other substances.

Demonstration

Obtain and bring to class a fresh beef kidney (available at a meat market or the meat department of a supermarket). First point out the ureter and the renal artery and vein. Then, using a scalpel or sharp knife, dissect the kidney lengthwise so the medulla and cortex are visible. Give students a chance to observe these structures. Discuss the function of each structure in the filtration of blood and the formation of urine.

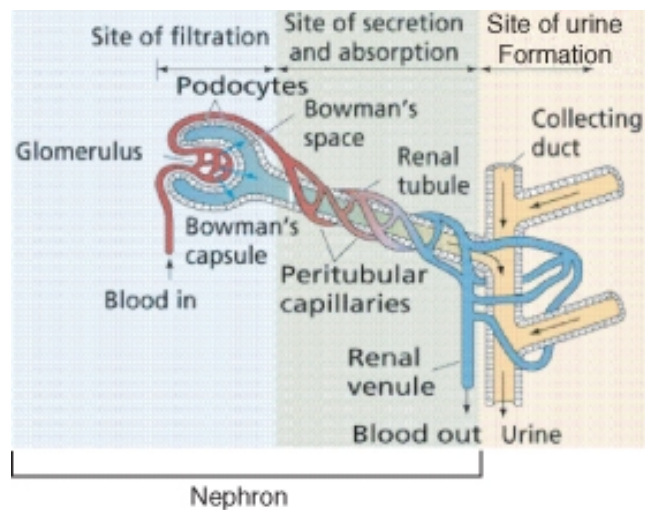
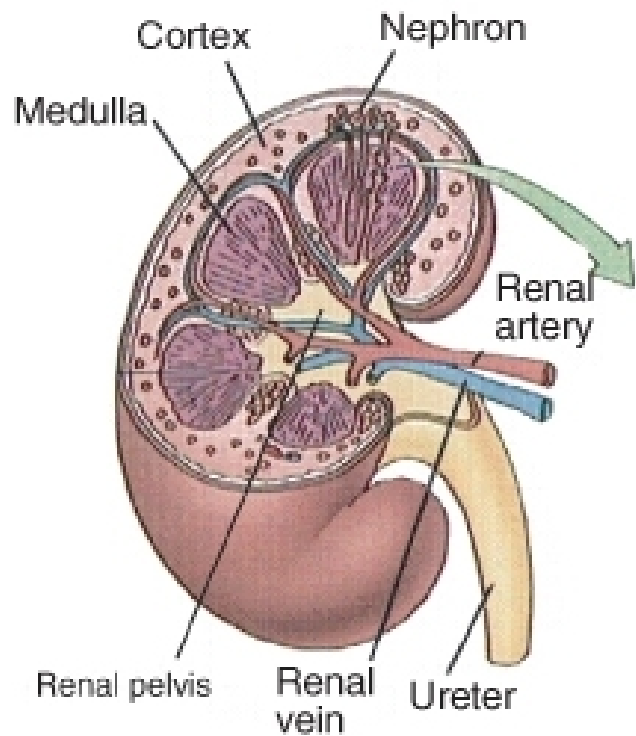
Activity

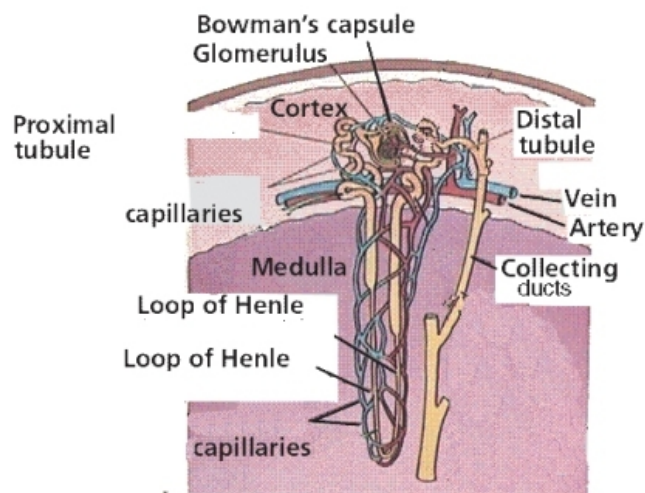
Have students use the interactive animation at the URL below to explore how the kidneys function.

- <http://www.biologymad.com/resources/kidney.swf>

Use Visuals: Figures 3–5

Call students' attention to **Figure 3–5**. Ask them to find the same structures in each figure so they will understand how the illustrations are related. Work with them to trace the path of blood and filtrate through the structures. As you do, ask them to explain what happens in each structure. (e.g., Glomerulus, filters the blood; Bowman's space, collects the filtrate)





Build Science Skills: Making Models

Challenge groups of students to design a model of the kidney that shows how the kidney removes wastes or excess water from the blood. (Ideas might include using a coffee filter to remove particles of sand from water or using a sponge to soak up excess water from a container.) Give groups a chance to share their ideas with one another and discuss how well the models represent kidney functions.

Differentiated Instruction: Cloze Prompts

Use cloze prompts to help less proficient readers focus on key content. Provide students with a list of main idea sentences from the lesson that have important terms left blank. Ask students to complete the sentences as they read the lesson. Suggest that students compare their completed sentences with those of another student. If any of the completed sentences differ significantly, they should reread relevant portions of the lesson to resolve the differences. **LPR**

Enrichment: Interview

Ask interested students to do an online search for a nearby kidney dialysis center. Then have them contact the center to obtain a brochure, flyer, or other written information about dialysis and the center. If possible, have them visit the center and interview center nurses or other personnel about the dialysis process. Give the students an opportunity to report what they learn to the class.

Science Inquiry

Formulating a Hypothesis

Tell the class that high blood pressure is a leading cause of kidney failure. Then challenge students to formulate a hypothesis to explain why high blood pressure may cause kidney failure.

(High blood pressure may damage blood vessels in the kidneys so they can no longer adequately remove wastes and excess water from the body.)

Reinforce and Review

Quiz Game

Play a Jeopardy-style quiz game with the class to review lesson concepts. Read the definition of each boldface vocabulary term and call on students to identify the term in the form of a question. For example, state: “This hormone is secreted by the kidney when blood pressure falls.” (Answer: What is rennin?) You may want to award token prizes to students who answer correctly.

Lesson Worksheets

Copy and distribute the four Lesson 39.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 39.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 39.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- A transplanted kidney may be rejected unless medication is taken to suppress the immune system. Why does the immune system reject transplanted organs?
- How does the immune system recognize transplanted organs as foreign to the body?
- What happens when the immune system “attacks” a transplanted organ?

Lesson Assessment

- Have students complete the Lesson 39.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

28.5 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 29

TE Immune System and Disease

29.1 Chapter 40: Immune System and Disease

Outline

The chapter *Immune System and Disease* consists of 4 lessons that gives students an overview of the human immune system, carcinogens, and bioterrorism.

- Lesson 40.1: Nonspecific Defenses
- Lesson 40.2: Immune Response
- Lesson 40.3: Immune System Diseases
- Lesson 40.4: Environmental Problems and Human Health

Overview

- This chapter focuses on human defenses and selected human diseases. Topics include nonspecific defenses, humoral and cell-mediated immunity, and diseases of the immune system, including AIDS. There is also a lesson on environmental problems that affect human health.

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons for *Immune System and Disease*.

Table 29.1:

Lesson	Number of Class Periods*
40.1 Nonspecific Defenses	0.5
40.2 Immune response	1.5
40.3 Immune System Diseases	1.0
40.4 Environmental Problems and Human Health	1.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for Immune System and Disease and are available online:

- The Howard Hughes Medical Institute Biointeractive website contains a selection of virtual labs, including an Immunology Lab. In this laboratory, students learn how antibodies are used in medical diagnostics. There is a step-by-step demonstration of one such test called enzyme-linked immunosorbent assay (ELISA) <http://www.hhmi.org/biointeractive/vlabs/>
- The Center for Innovation in Engineering and Science Education at the Stevens Institute of Technology has developed an Air Pollution Curriculum for students in grades 6-12. Teachers can use this interactive website with their students and access real-time air pollution data. The site also lists the curriculum's alignment with the National Science Education Standards. <http://www.k12science.org/curriculum/airproj/index.html>

Common Misconceptions

Vaccine-Preventable Diseases

A common misconception is that vaccine-preventable diseases have been virtually eliminated from the United States, so there is no need for children to be vaccinated. In reality, most diseases for which there are vaccinations have not been eliminated from the human population. The importance of vaccinations for self-protection and for protection of others remains.

Vaccines Cause Autism

A single published study in 1998 that suggested a possible link between the MMR vaccine and autism generated a huge amount of publicity. Since that time, numerous additional

studies have failed to show a cause and effect relationship between the MMR vaccine and autism. For further information, see the CDC webpage at <http://www.cdc.gov/ncbddd/autism/vaccines.htm>

These and 10 other misconceptions are listed and debunked at the Quackwatch website: <http://www.quackwatch.com/03HealthPromotion/immu/immu00.html>

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching Immune System and Disease:

- The Centers for Disease Control and Prevention (CDC) website is a portal of information about HIV/AIDS. <http://www.cdc.gov/hiv/default.htm>
- The “Get the Lead Out! Game” contains participatory activities that introduce students to the hazards of lead ingestion to human health. The website contains both a student handout and Teacher Preparation Notes. http://serendip.brynmawr.edu/sci_edu/waldron/#lead

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include *Immune System and Disease*, or specific lessons in *Immune System and Disease*, in your students’ FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of *Immune Systems and Disease*, students should have read *Cell Structure and Function* and *Molecular Genetics*.
- If time is limited, you may want to omit Lesson 40.4.

29.2 Lesson 40.1: Nonspecific Defenses

Key Concepts

The first line of defense against pathogens are physical barriers (such as the skin), chemical barriers such as mucus and acidic pH, and biological barriers, namely, beneficial or neutral organisms living on humans that effectively crowd out pathogens. The second line of defense is the inflammatory response and phagocytosis by white blood cells. Cytokines, histamines, and white blood cells are key players in the second line of defense.

Lesson Objectives

- Describe mechanical, chemical, and biological barriers that keep most pathogens out of the human body.
- Explain how the inflammatory response and white blood cells help fight pathogens that enter the body.

Lesson Vocabulary

Table 29.2:

Lesson 40.1 Vocabulary		
biological barriers	chemical barriers	cytokines
fever	histamines	inflammatory response
lysozymes	mechanical barriers	mucus
nonspecific defenses	pathogens	phagocytosis
white blood cells		

Check Your Understanding

Facts and Figures

People have known about the immune system for thousands of years. As early as the Middle Ages, people were immunized against smallpox by exposing them to the dried smallpox pustules from infected people. Today, children worldwide are routinely immunized against many pathogens that once commonly caused serious illness and even death.

Teaching Strategies

Using Visuals: Table 2: Types of Leukocytes

Type of Leucocyte	Approximate percent of all Leukocytes	Roles in Defense and other Actions
Monocyte, Macrophage	<6%	Phagocytosis; releasing cytokines
Neutrophil	65%	Phagocytosis; fighting fungus infections
Eosinophil	4%	Fighting protozoan infections
Basophil	<1%	Releasuring histamines
Lymphocyte	25%	Making antibodies; destroying cells infected by pathogens

Table 2 shows the 5 types of leukocytes. Ask your students: How can you tell that these cells are eukaryotic? (They have nuclei.)

Next, ask them if they notice anything strange about the nuclei. (Many white blood cells are multinucleated.)

Perusing the micrographs in this table also affords you the opportunity to review prokaryotic and eukaryotic cell structure.

Discussion: Mechanical Barriers

With your class, stimulate a discussion of mechanical barriers by asking them questions. You can use the following question to begin the discussion:

“What properties of the skin make it an effective mechanical barrier to pathogens?”

(The skin forms a physical barrier to pathogens and is a nearly waterproof coating). [Note to teacher: The tight junctions that connect adjacent epithelial cells form a tight barrier—nothing can “sneak” between epithelial cells because of these junctions—not even water. To traverse across skin epithelial cells, molecules must be able to be transported

or diffuse across the selectively permeable plasma membrane.

Differentiated Instruction: Main Ideas/Details Chart

For this activity, instruct pairs of students to draw a line lengthwise down the middle of a piece of notebook paper. On the left side of the page, they should write the main ideas from the section “Second Line of Defense” in Lesson 40.1. On the right side, they describe important details about each main idea as they read. Some suggested main ideas are: the inflammatory response, types of white blood cells, and function of each type of white blood cell. **ELL**

Enrichment: Writing a Rap Song

Keeping track of all of the different types of white blood cells can be challenging for students. Your advanced and creative students can compose a rap that names and describes each of the white blood cell types.

Science Inquiry

Analyzing Data

Table 2: Types of Leukocytes, shows 5 types of leukocytes and the approximate percentage each type comprises of all leukocytes. Given this relative frequency distribution, ask your students to calculate how many leukocytes of each type would be present in an average sample of 10,000 leukocytes. (macrophage, <600; neutrophil, 6500; eosinophil, 400; basophils, <100; lymphocytes, 2500)

Note to teacher: In some types of leukemia (a type of cancer) certain types of white blood cells are overproduced. The overproduced white blood cells can be either mature or immature, depending upon the type of leukemia. *http://www.ucsfhealth.org/adult/medical_services/cancer/leukemia/conditions/aml/signs.html for more information.

Reinforce and Review

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Using Vocabulary

Students can use each of the lesson vocabulary words in sentences. See if students can use two or more vocabulary words in a single sentence.

Lesson Worksheets

Copy and distribute the four Lesson 40.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 40.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 40.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

The body's first and second lines of defense are the same regardless of the particular pathogen involved. The body's third line of defense is different. It defends the body against specific pathogens.

- Think about how the immune system could identify a particular pathogen.
- Can you develop possible mechanisms for how these pathogens could be destroyed?
- What roles do you think various cell types (such as lymphocytes) play in the specific defenses of the immune system?

Lesson Assessment

- Have students complete the Lesson 40.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

29.3 Lesson 40.2: Immune Response

Key Concepts

The lymphatic system is a key part of the immune system, and it is comprised of the tonsils, thymus gland, spleen, lymph nodes, and lymphatic vessels. Cells of the immune system include B lymphocytes and T lymphocytes. B lymphocytes activate the humoral immune response by binding to antigens and producing antibodies. T lymphocytes are responsible for the cell-mediated immune response in which abnormal cells (such as virally-infected or cancerous cells) are destroyed.

Lesson Objectives

- Describe the lymphatic system and state its general functions in the immune response.
- Explain the role of antigens in the immune response.
- List the steps that occur in a humoral immune response.
- Identify roles of different types of T cells in a cell-mediated immune response.
- Define immunity and distinguish between active and passive immunity.

Lesson Vocabulary

Table 29.3:

Lesson 40.2 Vocabulary		
active immunity	antibody	antigen
antigen receptor	B lymphocytes (B cells)	cell-mediated immunity
cytotoxic T cells	helper T cells	immunity
immune response	immunization	lymph
lymph nodes	lymphatic system	lymphatic vessels
lymphocytes	memory cells	passive immunity
phagocytosis	plasma cells	red bone marrow
regulatory T cells	spleen	T lymphocytes (T cells)
thymus	tonsils	

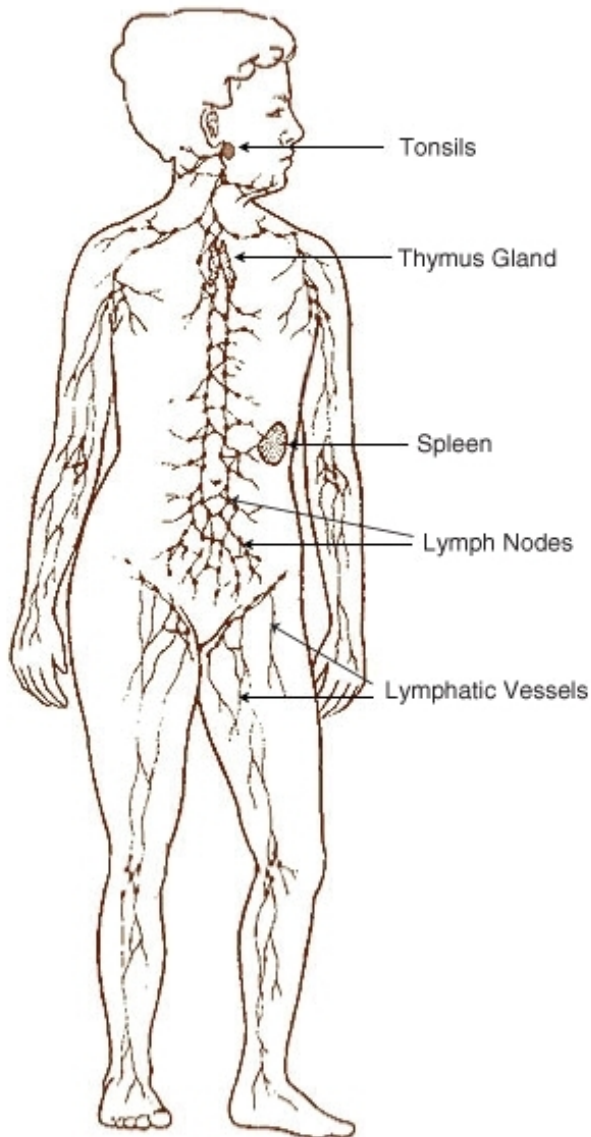
Check Your Understanding

Recalling Prior Knowledge

Ask your students to review and discuss what they learned from the *Cell Structure and Function* chapter. Focus specifically on the plasma membrane, plasma membrane proteins, and signal transduction. Such a review will help students understand both antibody-antigen binding and binding of T cells to antigen-presenting cells. List student responses on the board and follow with a class discussion.

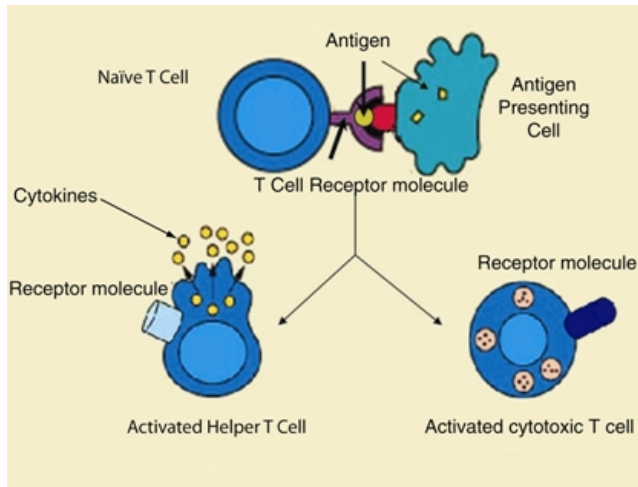
Teaching Strategies

Using Visuals: Figure 1: Human Lymphatic System



Use this figure as a prop to review the components of the Lymphatic System and their functions. One example follows: Lymphatic vessels: a network of branching tubules that transports lymph throughout the body. Unlike the circulatory system, which is driven by the pumping of the heart, lymph flow is driven by contractions of the lymph vessels themselves and by skeletal muscle contraction, which in turn compresses the lymph vessels and drives flow.

Using Visuals: Figure 5: Activation of a Naïve T Cell



Use this figure to explain the T cell activation by an antigen-presenting cell. Focusing on this diagram also gives you the chance to review receptor-ligand binding and signal transduction. Specifically, the T cell receptor molecule is an integral membrane protein that binds specifically to its ligand (the presented antigen fragment on the surface of the antigen-presenting cell). This binding activates a signal transduction pathway that results in a specific response (secretion of cytokines from an activated T helper cells or activation of cell division in a Cytotoxic T cell).

Differentiated Instruction: Compare/Contrast Table

Assign your students to small groups. Pair ELL, LPR, and SN students with complementary students. The groups make a compare/contrast table of B cells and T cells. An example of such a table is below:

Table 29.4:

Type of Cell	Site of Origin	Site of Maturation	Types	Functions
B Cell	Bone marrow	Red bone marrow	Plasma, memory	Produce antibodies in the humoral immune response; Cell memory of a particular pathogen so if the pathogen is encountered in the future, the second immune response is extremely rapid.
T Cell	Bone marrow	Thymus	Helper, cytotoxic, memory, regulatory	Manage the immune response by regulating T cell and B cell activity; Lyse infected, damaged, or cancerous cells; Retain memory of a pathogen such that a second encounter produces a rapid immune response against the pathogen; End the cell-mediated immune response when appropriate.

Enrichment: Website Research

The human body has a lymphatic system, which is a major part of the immune system. Other species have a lymphatic system too. Even insects have a lymphatic system. Instruct your advanced students to formulate a hypothesis about why insects would need a lymphatic system. They can then view a video on NASA's "Flies in Space" website on the *Drosophila* Immune System to see how good their hypothesis was.

- <http://quest.nasa.gov/projects/flies/species.html>

After viewing the *Drosophila* video, students can read about the human immune system and the effect of microgravity on the human immune system. The website reinforces the concept that different species share similar strategies to accomplish a particular function (in this case, defenses against pathogens). It also introduces a new question to the students: what is the effect of space on the physiology of an organism?

- <http://quest.nasa.gov/projects/flies/index.html>

Science Inquiry

Formulating a Hypothesis

The blood contains both red blood cells and white blood cells. Have your students work in small groups to come up with a hypothesis on the relatedness of red blood cells and white blood cells. Discuss the ideas as a class. (Both cell types are derived from stem cells in the bone marrow.)

Reinforce and Review

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Asking Questions

In autoimmune diseases, the body mounts an immune response against some of its own proteins. **Ask your students**, how could such an aberrant response cause disease? How could physicians treat this kind of disease? Asking these questions will segue into the next lesson.

Lesson Worksheets

Copy and distribute the four Lesson 40.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 40.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 40.2 in their FlexBook. Then, discuss the questions with the class.

- Sometimes the immune system makes mistakes and things go wrong. What if the immune system responded to a harmless allergen as though it were a deadly pathogen?
- What if the immune system responded to normal body cells as though they were foreign invaders?
- What if pathogens attacked and destroyed cells of the immune system itself? Would it still be able to function?

Lesson Assessment

- Have students complete the Lesson 40.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

29.4 Lesson 40.3: Immune System Diseases

Key Concepts

The immune system does not always function flawlessly. Sometimes, in the case of an allergy or autoimmune disease, the immune system is inappropriately active. In other cases, such

as those of congenital or acquired immunodeficiency, normal immune system function is impaired.

Lesson Objectives

- Explain how allergies occur and list common allergens.
- Describe how autoimmune diseases affect the body.
- Define immunodeficiency and identify ways it can be acquired.
- Explain how HIV is transmitted and how it causes AIDS.

Lesson Vocabulary

Table 29.5:

Lesson 40.3 Vocabulary			
Acquired immunodeficiency		AIDS	Allergen
Allergic rhinitis		Allergy	Anaphylaxis
Antihistamines		Autoimmune diseases	Delayed hypersensitivity reaction
Epinephrine		HIV	Immediate hypersensitivity reaction
Immunodeficiency		Molecular mimicry	Opportunistic diseases

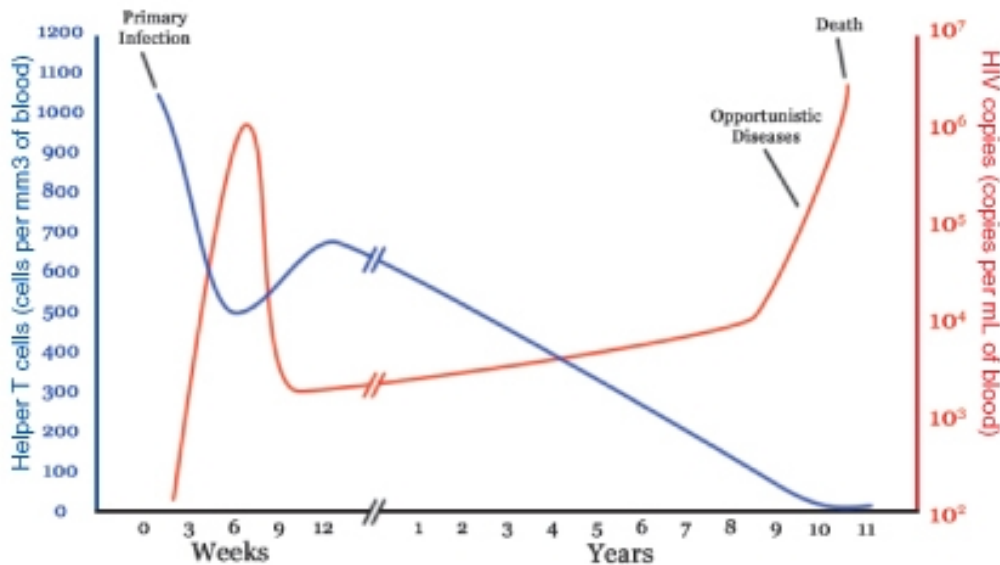
Check Your Understanding

Drawing on Student Experiences

Take a poll of your students. First, ask them if they believe they have any allergies. Tally the results of the number of students who have allergies. Next, ask them to what are they allergic? Do any of your students carry injectable epinephrine? Such personal responses will generate student interest in this lesson.

Teaching Strategies

Using Visuals: Figure 13: Average Numbers of Helper T cells and HIV copies in untreated HIV infections



This graph is a dramatic visual illustrating the effects of HIV on infected humans. Some students do not take the time to peruse axis labels and units. Use this opportunity to carefully explain the x- and y-axes of the graphs.

The x-axis measures units of time. Note the time gap in the x-axis (gap is between 12 weeks and 1 year). Point out that the y-axis on the left-hand side of the figure measures the number of Helper T cells (cells per mm³ blood). The blue line is a graphical representation of the number of Helper T Cells over time. As you can see, the overall number of Helper T Cells decreases dramatically over time in HIV-infected individuals. The red line graphs the relationship between time and the number of HIV copies (per mL of blood). You can see that the number of viral particles increases, then sharply decreases over the first 12 weeks post infection, and increases again from years 1-9, and then increases sharply after 9 years until death.

Building Science Skills: Interpreting Data

HIV and AIDS may impact your students indirectly or directly. Go to the Center for Disease's Control (CDC) website page with the Fact Sheet on HIV/AIDS among Youth. There is a downloadable PDF of the Fact Sheet on this site. Along with numerous statistics on HIV/AIDS in the United States, there is a multiple bar graph depicting the relative frequency

distribution of HIV-infected and AIDS diagnosed people among different age groups. Discuss the distribution with your students.

- <http://www.cdc.gov/hiv/resources/factsheets/youth.htm>.

Differentiated Instruction: KWL

Instruct your students to make a KWL chart, where K = Know, W = Want to Know, and L = Learned. Students should fill in the K and W columns before reading the lesson, and the L column after reading a particular passage or lesson. In some cases their *Want to Know* questions may remain unanswered even after they have read the lesson. Such questions could provide a rich topic for further class discussion. **SN**

Enrichment: Debate: What causes autoimmunity?

Students requesting additional enrichment can research the medical and scientific literature for evidence for and against the “molecular mimicry” hypothesis of autoimmunity. Advise them to select one autoimmune disease on which to focus so that the project remains manageable. The culmination of their evidence-finding can be a mock debate presented to the class, or a research paper.

Some suggested resources as a starting point:

- <http://www.mult-sclerosis.org/MolecularMimicry.html>
- http://en.wikipedia.org/wiki/Molecular_mimicry

Science Inquiry

Analyzing Data

Use the Fact Sheets on the CDC website as data sources for analysis. Groups of students can choose or be assigned a Fact Sheet. Each group can summarize in bullet form the top 3 or 4 facts from their chosen Fact Sheet.

- <http://www.cdc.gov/hiv/resources/factsheets/index.htm>

Reinforce and Review

Review the Lesson

Either you or a student(s) can lead a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Outlining the Lesson

Using a blackboard, whiteboard, or overhead projector, outline the Lesson with your class. Explain how you use the heading structure from the FlexBook to construct the outline.

Lesson Worksheets

Copy and distribute the four Lesson 40.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 40.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teacher-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 40.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

You read in this lesson that some types of cancer attack cells of the immune system and cause immunodeficiency. Cancer has previously been described as resulting from a loss of regulation of the cell cycle.

- Why do you think immunodeficiency may lead to some cancers?
- Can you think of a relationship between pathogens, the immune system, and the development of cancer?

Lesson Assessment

- Have students complete the Lesson 40.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

29.5 Lesson 40.4: Environmental Problems and Human Health

Key Concepts

Cancer is often caused by genetic mutations induced by carcinogens. These changes remove cell cycle controls, and the cancerous cells divide uncontrollably, forming a tumor and sometimes metastasizing. Human health is compromised by both indoor and outdoors pollutants such as ozone, particulates, and carbon monoxide. A form of terrorism is bioterrorism, which is the deliberate use of biological agents to cause harm.

Lesson Objectives

- Explain how carcinogens cause cancer and list ways that cancer can be treated or prevented.
- Identify causes of air pollution and describe how air pollution affects human health.
- Define bioterrorism and explain how bioterrorism threatens human health.

Lesson Vocabulary

Table 29.6:

Lesson 40.4 Vocabulary		
air quality index (AQI)	bioterrorism	cancer
carbon monoxide	carcinogen	carcinoma
lymphoma	oncogenes	ozone
particulates	proto-oncogenes	sarcoma
sick building syndrome (SBS)	tumor	tumor-suppressor genes

Check Your Understanding

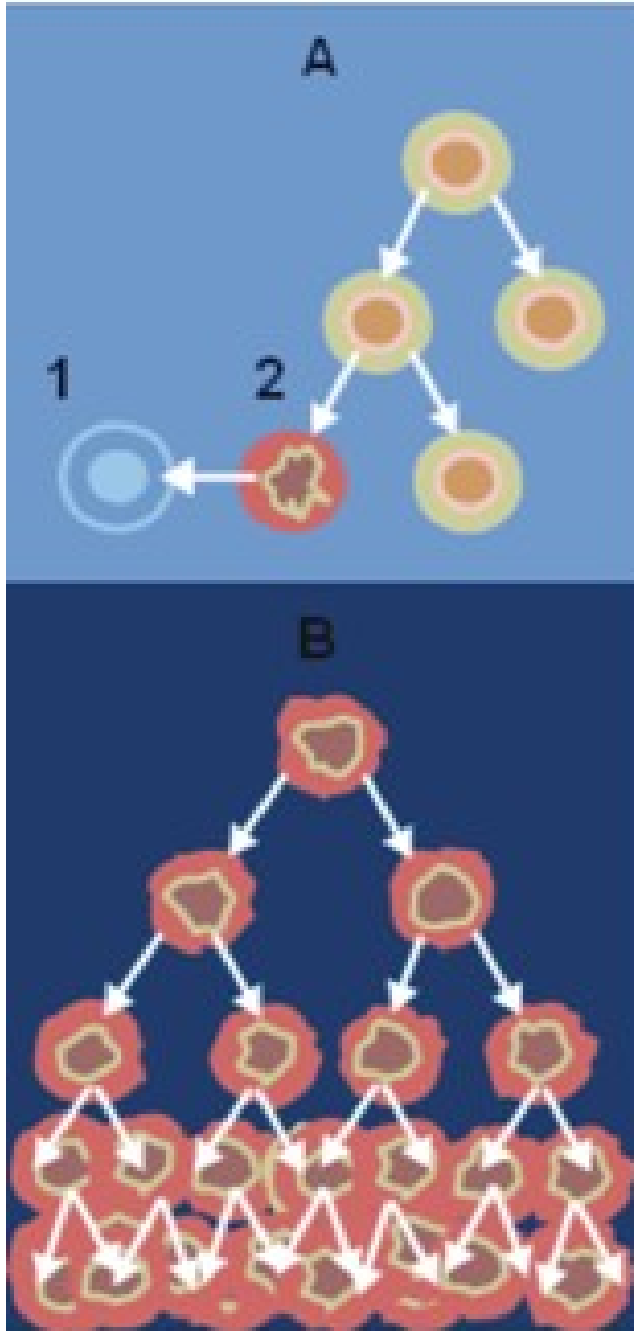
Drawing on Student Experiences

Ask your students if they know someone who was/is affected by either cancer or air pollution (the latter case would include asthmatics who cannot go outdoors on certain high pollution days). They can write down their responses in journal form. Since this may be an intensely private topic, there is no need for a class discussion.

Teaching Strategies

Using Visuals: Figure 1

The two panels in **Figure 1** illustrate the morphological changes in cancer cells (A and B), and the altered division patterns (B). Spend some time explaining this figure to your students. Emphasize that abnormal cells arise in all humans, but the majority of time, they are rapidly detected and eliminated.



Demonstration

For this activity, you will show to your students two air filters; one that is new, and the other, which has been used. The filters can be from a home heating system or from an automobile. The contrast between the two will be striking (the former will be clear, and

the latter filled with particulates). This teaching strategy will highlight the abundance of particulate molecules in the air that we breathe.

Differentiated Instruction: Main Ideas/Details Chart

Instruct individual students to divide a sheet of paper in half. On the left side, they write the main ideas the lesson. Tell them to skip several lines between the main ideas. On the right side, students should complete the chart with important details about each main idea.

LPR

Enrichment: Research

Students who seek enrichment activities can investigate some novel cancer therapies. They can summarize their results in a written report, an oral presentation, or share their finding through social media. As a starting point, students can visit the website below:

- <http://www.cancer.gov/cancertopics/treatment>

Science Inquiry

Analyze Data

From the SE, Analyze Table 1: Common Cancers among Adult Males and Females in the United States

Table 29.7: **Common Cancers among Adult Males and Females in the United States**

Adult Males			Adult Females		
Most Common Cancers (percent of all cancers)	Most Causes of Deaths (percent of all cancer deaths)	Common of Cancer (percent of all cancer deaths)	Most Common Cancers (percent of all cancers)	Most Causes of Deaths (percent of all cancer deaths)	Common of Cancer (percent of all cancer deaths)
Prostate cancer(33%)	Lung cancer(31%)		Breast cancer(32%)	Lung cancer(27%)	
Lung cancer(13%)	Prostate cancer(10%)		Lung cancer(12%)	Breast cancer(15%)	
Colorectal cancer(10%)	Colorectal cancer(10%)		Colorectal cancer(11%)	Colorectal cancer(10%)	
Bladder cancer(7%)	Pancreatic cancer(5%)		Endometrial cancer(6%)	Ovarian cancer(6%)	

Instruct your students to analyze the following statistics about the incidence and pattern of certain cancers in the United States.

- 1. What is the most common cancer in adult females in the United States? (breast)
- 2. What is the cause of the most cancer deaths in the United States? (Lung)
- 3. Is the most common cancer the same as the cancer causing the most deaths in adult females in the United States? Explain some potential reasons for your findings. (No, breast cancer is most common, but lung cancer causes the most cancer deaths). There are several potential reasons for such a discrepancy: lung cancer could be less treatable than breast cancer; breast cancer could be more commonly screened for and thus more easily detected; or women could be on the alert more for breast cancer symptoms (a breast lump) than for lung cancer symptoms (coughing, which is symptomatic of many other health problems could be ignored).

You can create a similar list of questions for cancers in adult males - if time permits.

Reinforce and Review

Review the Lesson

Either you or a student(s) leads a discussion to review the lesson. You can use the Lesson Summary from the FlexBook. Clarify any issues and answer any questions students may have.

Asking Questions

Teachers, you can direct each student to pass in a written question they have about the lesson. You can answer, or review material relevant to, those questions that are asked most frequently.

Lesson Worksheets

Copy and distribute the four Lesson 40.4 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Lesson 40.4 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 40.4 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

High levels of certain hormones can increase the risk of some types of cancer. For example, high levels of estrogen can increase the risk of breast cancer. Estrogen is a female sex hormone.

- What are sex hormones?
- How do sex hormones normally affect the body?
- How are male and female sex hormones different?

Lesson Assessment

- Have students complete the Lesson 40.4 Quiz.

The lesson quiz and answer key are available upon request. **Please send an email to teachers-requests@ck12.org to request material.**

29.6 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.

Chapter 30

TE Reproductive System and Human Development

30.1 Chapter 41: Reproductive System and Human Development

Outline

The chapter *Reproductive System and Human Development* consists of four lessons that explain how humans reproduce and develop and how sexually transmitted diseases spread.

- Lesson 41.1: Male Reproductive System
- Lesson 41.2: Female Reproductive System
- Lesson 41.3: Fertilization, Gestation, and Development
- Lesson 41.4: Sexually Transmitted Diseases

Overview

- The male and female reproductive systems include organs and hormones that enable reproduction. STDs are transmitted mainly through sexual contact.
- The concept map below provides a visual representation of how the chapter concepts are related.

Pacing the Lessons

Use the **Class Periods per Lesson** table below as a guide for the time required to teach the lessons of this chapter.

Table 30.1:

Lesson	Number of Class Periods*
41.1 Male Reproductive System	1.0
41.2 Female Reproductive System	2.0
41.3 Fertilization, Gestation, and Development	2.5
41.4 Sexually Transmitted Diseases	1.0

- Class periods are assumed to be 60 minutes long.

Lab Links

The following labs are suitable for this chapter and are available online:

- **Fantastic Voyage:** By doing this lab, students learn about human organ systems through the creation of 3-D models and other materials. The lab can be tailored to the chapter by having students focus only on the male and female reproductive systems. (Lessons 41.1 and 41.2) http://www.accessexcellence.org/AE/AEC/AEF/1995/allard_voyage.php
- **The Spread of HIV Through a Population:** In this lab, students model the spread of HIV through a population of teens. Students also address ethical issues associated with sexual behavior and the spread of HIV and other STDs. (Lesson 41.4) http://www.accessexcellence.org/AE/AEC/AEF/1994/glasscock_hiv.php

Common Misconceptions

Fertilization and Development

Students may hold one or more of the common misconceptions below about fertilization or fetal development. Discuss the misconceptions with the class and make sure students are aware of the relevant facts.

- Fertilization occurs in the vagina.
- The sex of an embryo is determined only after the cells have started to divide.

- The fetus does not produce waste products.
- The fetus does not need oxygen until after birth.

Sexually Transmitted Diseases

Misconceptions about how STDs spread are common. They are also dangerous because they can increase the risk of exposure to infection. Ask students whether the following STD myths are true or false. Call on students who know they are false to explain why.

- You can get an STD from a toilet seat.
- You cannot get STDs through oral sex.
- You cannot get STDs from tattooing or body piercing.

Managing Materials

The materials listed in the **Materials List** table below are needed to teach the strategies and activities described in the Teachers Edition of the FlexBook for this chapter.

Table 30.2:

Lesson	Strategy or Activity	Materials Needed
41.1	1. Demonstration	1. prepared slide of human sperm cells
41.3	1. Building Science Skills: Observing 2. Science Inquiry: Building Models	1. gallon-size Ziploc storage bag, raw egg (in the shell) 2. modeling clay in different colors

Additional Web-Based Resources

You may find these additional Web-based resources helpful when teaching this chapter:

- Sexual Health and Reproduction: This activity provides questions and reliable Web site links to guide student investigations of fetal development and pregnancy, changes in boys and girls during puberty, and sexually transmitted diseases. The Web site would be useful for student research projects or additional information on chapter topics. http://serendip.brynmawr.edu/sci_edu/waldron/#sex
- Reproductive System: At the web site below, you or your students can access several online videos and photographs relating to human reproduction and the male and female

reproductive systems. The Web site also has a feature that allows you to create a presentation with the photos. <http://www.neok12.com/Reproductive-System.htm>

- Developmental Biology: This Web site has an informative tutorial on human reproduction, from fertilization through birth. http://www.biology-online.org/7/1_fertilisation.htm
- Sexually Transmitted Infections: The web sites below have more information on specific STDs. You may want to share these Web sites with students. <http://www.iwannaknow.org/stiwatch.html> <http://www.birdsandbees.org/STIWhatIsIt.htm>

Making the FlexBook Flexible

An important advantage of the FlexBook is the ability it gives you, the teacher, to select the chapters and lessons that you think are most important for your own classes. The following information is provided to help you decide whether to include this chapter, or specific lessons of this chapter, in your students' FlexBook. You should also consult the standards correlation table when selecting chapters and lessons to include in the FlexBook for your classes.

- To understand the content of the chapter *Reproductive System and Human Development*, students should have read the chapters *The Human Body* and *Nervous and Endocrine Systems*.
- If you incorporate the chapter *Reproductive System and Human Development* in your FlexBook, it is recommended that you include all four lessons of the chapter.

30.2 Lesson 41.1: Male Reproductive System

Key Concepts

The male reproductive system forms before birth but does not become capable of reproduction until it matures during puberty. It includes organs, glands, and other structures that produce and deliver sperm and secrete testosterone. Sperm are produced in the testes through the process of spermatogenesis and leave the body through the penis during ejaculation.

Lesson Objectives

- Explain how the male reproductive system develops before birth and matures during puberty.
- Identify structures of the male reproductive system and their functions.
- Describe how sperm are produced and how they leave the body.

Lesson Vocabulary

Table 30.3:

Lesson 41.1 Vocabulary		
acrosome	adolescent growth spurt	Cells of Leydig
epididymis	fertilization	luteinizing hormone (LH)
male reproductive system	primary sex characteristics	puberty
secondary sex characteristics	semen	seminiferous tubules
Sertoli cells	sperm	spermatogonia
spermatogenesis	testosterone	

Check Your Understanding

Recalling Prior Knowledge

Students are likely to have heard the term *puberty* before. Ask them to define it. (The physical changes associated with sexual maturation.) Tell students they will learn about puberty in this chapter, starting with puberty in boys in this lesson.

Teaching Strategies

Activity

Students can learn more about the male reproductive system at the interactive InnerBody Web site (starting with the web site below). This is a good way for students to find answers to questions they may be too embarrassed to ask in class. They can click on specific organs to read more about them and to see enlarged, cross-sectional images. Have the students explore this site and write a brief description of what they learned.

- <http://www.innerbody.com/image/repmov.html#>

Demonstration

Order a prepared slide of human sperm cells from an online source (see web site below). Bring the slide into focus under a microscope, and have students take turns viewing it or

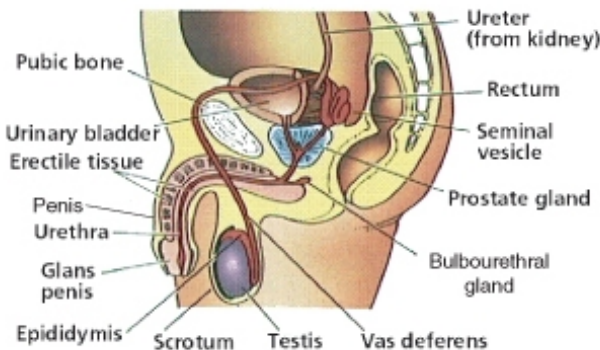
else use a microprojector to display it. Tell students to sketch what they observe and to label the head, midpiece, and tail. With the class, discuss the function of each of these parts of sperm cells.

- <http://www.carolina.com/nav/p/category/life+science/microscope+slides/histology+slides.do?sortby=ourPicks&page=2>

Using Visuals: Figure 1

Have students use **Figure 1** to trace the path of sperm through the male reproductive system, from the production of immature sperm in the testes to the ejaculation of mature sperm from the penis. Call on students to answer questions such as these as you discuss the processes:

- Where are sperm produced, and where do they go next to mature? (Sperm are produced in the testes, and they go next to the epididymis to mature.)
- Where are sperm stored after they mature? (in the epididymis)
- What ducts do sperm pass through in order to leave the body? (first the vas deferens and then the urethra)
- What glands do the sperm pass on the way, and what is their role? (Sperm pass the seminal vesicles, prostate gland, and bulbourethral glands; the glands add secretions that control the pH of semen and provide nutrients to sperm.)



Discussion

Briefly review the differences between mitosis and meiosis and between haploid and diploid cells. Then, discuss with the class how and why spermatogenesis produces cells that are haploid.

- What type of cell do you think a female gamete, or egg, must be? (haploid)

Differentiated Instruction: Flow Chart

Pair English language learners with native English speakers, and ask each pair to create a simple flow chart showing the steps of spermatogenesis. Tell them to draw sketches of the cells involved at each step in the process. The sketches should show whether the cells are haploid or diploid. Students should also label the cells at each step with the correct terms.
ELL

Enrichment: Crossword Puzzle

Challenge a few students to make crossword puzzles using lesson vocabulary terms. They can create the puzzles by hand or use an online puzzle maker (see web site below). Make copies of their puzzles and pass them out to the class for vocabulary review.

- <http://puzzlemaker.discoveryeducation.com/>

Science Inquiry

Formulating a Hypothesis

Tell the class that human actions have added chemicals to the natural environment that act like estrogens, which are female sex hormones. Processes such as manufacturing, the use of pesticides, and the breakdown of plastics are just a few of the ways that these estrogen-like chemicals have ended up in water, soil, and food chains, where humans are exposed to them. Divide the class into groups, and have each group formulate a hypothesis regarding how environmental estrogens might affect male embryonic development, male development during puberty, or spermatogenesis in adult males. Give groups a chance to share their hypotheses and explain the reasoning behind them.

There are numerous web sites available that discuss this topic. Some examples:

- <http://www.envtox.ucdavis.edu/cehs/TOXINS/estrogens.htm>
- http://www.energeticnutrition.com/vitalzym/xeno_phyto_estrogens.html
- <http://www.som.tulane.edu/cbr/ecme/eehome/default.html>

Reinforce and Review

Labeling a Drawing

Make and distribute copies of the Male Reproductive System Diagram below. Ask students to label the main structures in the diagram and to list their functions.

[insert diagram]

Lesson Worksheets

Copy and distribute the four Lesson 41.1 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 41.1 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 41.1 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- By the time they finish puberty, males have developed the traits of mature adults of their own sex. They differ from mature females in many ways. How do these differences between sexually mature males and females come about?
- What causes females to develop differently during puberty?
- When do girls begin puberty, what changes do they go through, and what hormones control the changes?

Lesson Assessment

- Have students complete the Lesson 41.1 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

30.3 Lesson 41.2: Female Reproductive System

Key Concepts

The female reproductive system forms before birth but does not become capable of reproduction until it matures during puberty. It includes organs and other structures that produce and release eggs, secrete female sex hormones, and support the development and birth of a fetus. Immature eggs form in the ovaries before birth. Generally, each month, starting in puberty, one egg matures and is released from an ovary. The menstrual cycle includes events that take place in the ovary, such as ovulation, and changes in the uterus, including menstruation. The cycle is controlled by the ovarian hormones estrogen and progesterone and by the pituitary hormones LH and FSH.

Lesson Objectives

- Explain how the female reproductive system develops before birth and matures during puberty.
- Identify structures of the female reproductive system and their functions.
- Describe how eggs are produced and how they are released from the ovaries.
- Sequence the events of the menstrual cycle, and explain how hormones control the cycle.

Lesson Vocabulary

Table 30.4:

Lesson 41.2 Vocabulary		
adolescent growth spurt	corpus luteum	egg (ovum)
estrogen	Fallopian tube	female reproductive system
follicle	follicle-stimulating hormone	luteinizing hormone
menarche	menopause	menstruation
oogenesis	ovary	ovulation
progesterone	uterus	vulva

Check Your Understanding

Recalling Prior Knowledge

Based on the knowledge that students now have about the male reproductive system, challenge them to predict and record answers to the following five questions about the female reproductive system:

1. Why do female embryos develop female reproductive organs?
2. What triggers the start of puberty in girls?
3. What changes occur during puberty in girls?
4. What is the major sex hormone in girls?
5. What organ produces gametes in females?

Tell students to save their answers and check to see if they were correct after they read this lesson.

Teaching Strategies

Activity

Students can learn more about the female reproductive system and its organs at the interactive InnerBody Web site. This is a good way for students to find answers to questions they may be too embarrassed to ask in class. Have them explore this site; they can click on specific organs to read more about them and to see enlarged, cross-sectional images.

- <http://www.innerbody.com/image/repfov.html>

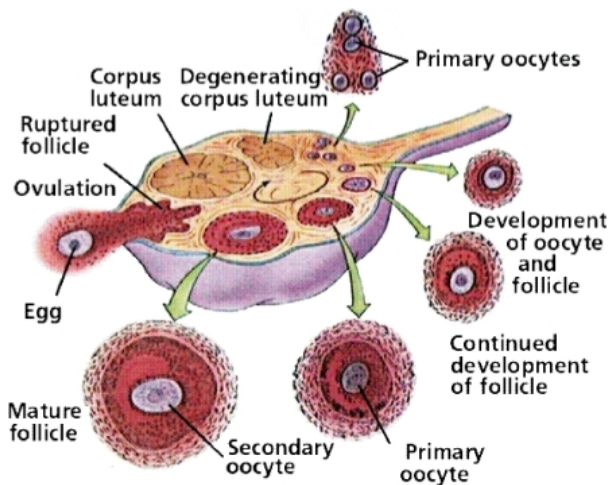
Demonstration

Demonstrate how the timing and events of the adolescent growth spurt differ in females and males by showing students graphs that compare the rates of growth and heights attained at each age in girls and boys. The graphs demonstrate that the growth spurt in height occurs earlier and is over sooner in girls and that the peak rate of growth is not as rapid in girls. They also demonstrate that girls are shorter, on average, when they begin the spurt because it starts earlier for them. Discuss how these differences in the growth spurt result in the average female being shorter than the average male by adulthood.

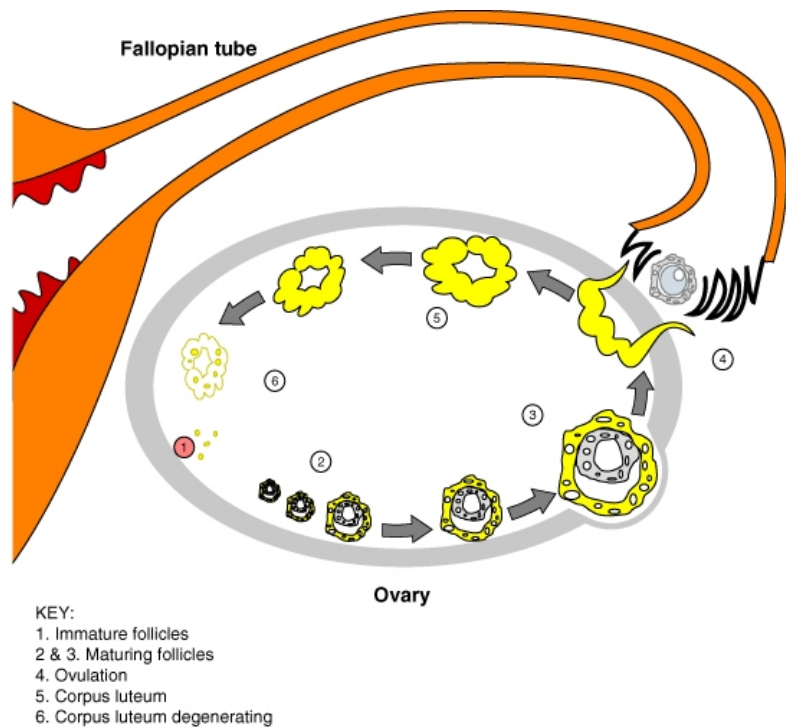
- http://www.racgp.org.au/AM/images/afp/200509simm_fig1.gif
- <http://www.bbc.co.uk/schools/ks3bitesize/science/images/heights.gif>

Using Visuals: Figures 4 and 5 and Table 2

Use the illustrations in the text to teach the important ovarian events in female reproduction. First, have students compare the diagrams in **Figure 4** and **Figure 5**. Ask them to find the names in **Figure 4** for the numbered structures in **Figure 5** so they will see how the two figures are related (e.g., 3 = secondary oocyte in a mature follicle; 4 = egg during ovulation). Then, ask them to explain what happens between each of the stages of the developing follicle in **Figure 4** by referring to **Table 2** (e.g., primary oocytes undergo meiosis 1 to become secondary oocytes). Finally, point out in **Figure 5** how the egg is swept into the Fallopian tube after it bursts from the ovary. Explain that, if fertilization occurs, it usually happens in the Fallopian tube.



This diagram shows the monthly cycle the ovary goes through in a post-pubertal female. First, an oocyte and its surrounding follicle starts to mature. When the secondary oocyte is mature, it bursts from the follicle and ovary. Then the ruptured follicle develops into a corpus luteum, which produces progesterone. If the egg is not fertilized by a sperm, the corpus luteum degenerates and virtually disappears from the ovary.



This diagram also shows the events of the menstrual cycle that occur in the ovary. After a secondary oocyte bursts from the ovary, it usually is swept into a Fallopian tube. The waving, fringelike ends of the tube help capture the egg.

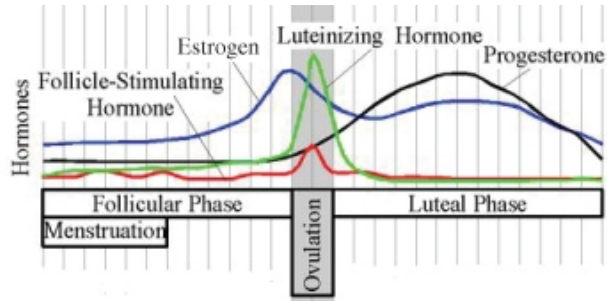
Table 30.5: **Oogenesis and Cell Division**

Type of Cell	Number of Chromosomes	Process
Oogonium	Diploid	Mitosis
Primary oocyte	Diploid	Meiosis 1
Secondary oocyte	Haploid	Meiosis 2
Ovum (mature egg)	Haploid	Fertilization

Discussion

To show the cyclical nature of the menstrual cycle and ovulation, the text focuses on what happens when an egg is not fertilized during a cycle. Make sure students also know what happens in the ovary and uterus when an egg is fertilized. Explain that the corpus luteum does not degenerate and that it keeps producing progesterone. This hormone, in turn, promotes gestation by maintaining the endometrium, which helps nourish the embryo. Challenge students to predict how the hormone levels in **Figure 7** would differ if the egg were fertilized.

(The level of progesterone would remain high rather than drop off during the luteal phase.)



This graph shows how hormone levels change during the menstrual cycle.

Differentiated Instruction: Cycle Diagram

Pair less proficient readers with more proficient readers, and ask pairs to make a cycle diagram of the menstrual cycle. Suggest that they use the information in Table 3 as a basis for their diagram. **LPR**

Enrichment: Poster Presentation

Ask a small group of students who demonstrate in-depth understanding of the lesson to create a poster about one of the lesson topics, such as egg production or the menstrual cycle. Set aside a few minutes of class time for students to present their poster to the class.

Science Inquiry

Developing a Research Plan

Divide the class into groups, and have each group research factors that may influence the age at which girls begin menstruating (e.g., stress, nutrition, genes). Suggest that they start their research with the web sites listed below. Then have each group develop a research plan to test the effects of one of the factors on age at menarche in girls. Specifically, they should identify the dependent and independent variables they would test and which variables they would control. Give groups a chance to present their research plans to the class. Encourage other students to provide feedback.

- <http://www.mum.org/menarage.htm>
- http://en.wikipedia.org/wiki/Menarche#Timing_of_menarche

Reinforce and Review

Online Quiz

Have students take the online quiz *Female Reproductive System* at the web site below.

- <http://qldscienceteachers.tripod.com/alternative/quiz/female.html>

Lesson Worksheets

Copy and distribute the four Lesson 41.2 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 41.2 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 41.2 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- If an egg is fertilized by a sperm and implants in the uterus, the endometrium helps support and nourish it. However, the new organism soon needs more nutrients than the endometrium can provide. It needs to obtain nutrients from the mother's blood. How does this happen?
- What structures are involved with pregnancy? When do they develop?

Lesson Assessment

- Have students complete the Lesson 41.2 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

30.4 Lesson 41.3: Fertilization, Gestation, and Development

Key Concepts

Fertilization is the union of a sperm and an egg, which forms a zygote. The embryonic stage begins when the zygote implants in the uterus. The fetal stage begins about two months after fertilization and continues until birth. The placenta allows nutrients and wastes to be exchanged between the mother and fetus. During childbirth, the fetus is pushed from the mother's body through the vagina. Following birth, growth and development are most rapid during infancy and slower throughout the rest of childhood until puberty. Adolescence involves mental, emotional, and social changes in addition to the physical changes of puberty. Adulthood is divided into stages that correspond with typical changes in social and health status. Aging occurs as cells lose their ability to divide.

Lesson Objectives

- Explain how fertilization, cleavage, and implantation lead to the formation of an embryo.
- Describe how the embryo forms specialized cells and organs through the processes of gastrulation, differentiation, and organogenesis.
- Identify major events in the growth and development of the fetus.
- Explain how the placenta provides the fetus with oxygen and nutrients and eliminates fetal wastes.
- Describe how an expectant mother can help her fetus grow and develop normally, and summarize the events of childbirth.
- Sequence milestones in growth and development from infancy through adolescence.
- Describe the life stages of early and middle adulthood and old age, and explain why aging occurs.

Lesson Vocabulary

Table 30.6:

Lesson 41.3 Vocabulary		
adolescence	amniotic fluid	blastocyst

Table 30.6: (continued)

Lesson 41.3 Vocabulary		
cleavage	differentiation	ectoderm
embryo	embryoblast	endoderm
fertilization	fetus	gastrulation
implantation	infancy	mesoderm
morula	organogenesis	placenta
pregnancy	trophoblast	

Check Your Understanding

Facts and Figures

Share these facts and figures with students to generate interest in lesson content:

- The average human gestation period is 38 weeks from fertilization to childbirth.
- During this time, the zygote grows from 0.1 mm in diameter to a newborn about 500 mm long.
- During the same time, the volume of the uterus grows from 6 mL (about 1 tsp) to about 5000 mL.

Tell students they will learn more about the amazing process of human gestation in this lesson.

Teaching Strategies

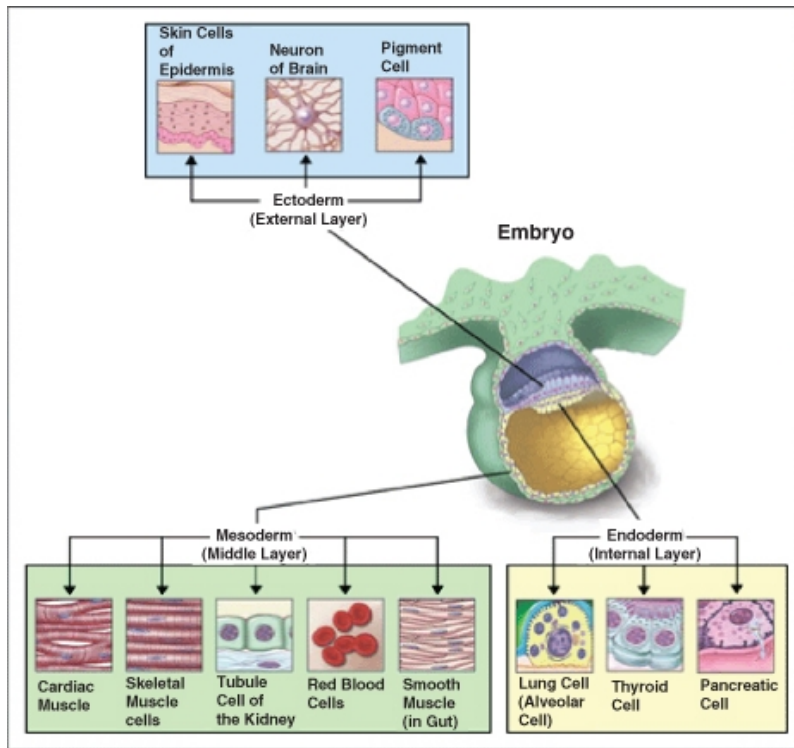
Activity

Students can learn more about fertilization, fetal development, and birth at the interactive InnerBody web site. Have students explore the first web site listed below. By clicking on a specific stage, they can read more about that stage and follow the development of the embryo or fetus. The Visual Embryo web site, also listed below, is another good source of information about, and images of, embryonic and fetal development.

- <http://www.innerbody.com/image/repo04.html>
- <http://www.visembryo.com/baby/>

Using Visuals: Figure 4

Have students refer to **Figure 4** when you discuss gastrulation and cellular differentiation. Point out that none of the embryo's cells are specialized to have a specific structure and function until they become differentiated. These unspecialized cells are called embryonic stem cells, and they have the capacity to specialize into any type of cell. Explain that cellular differentiation occurs through gene regulation, which results in the expression of only a subset of all the genes present in the cell. In other words, cells of all types have the same genes, but different genes are turned on in each type of cell.



The three cell layers of the embryo develop into different types of cells. For example, the ectoderm develops into skin cells, the mesoderm into muscle cells, and the endoderm into lung cells.

Building Science Skills: Observing

Do this simple activity so students can observe how the amnion and amniotic fluid protect a fetus. Place a raw egg (in the shell) in a gallon-size Ziploc storage bag. Fill the bag to capacity with water, and then seal it. Tell the class that the bag represents the amnion, the water represents amniotic fluid, and the egg represents a fetus. Call on a volunteer to try to break the egg without opening the bag as the rest of the class observes. The water in the bag should cushion the egg and protect it from breaking. Explain that the amniotic fluid

plays a similar role in cushioning and protecting a fetus.

Demonstration

To demonstrate some of the ways children grow and develop, ask several volunteers to bring in pictures of themselves when they were infants or toddlers. Display the photos on a bulletin board, and challenge the class to match each picture with the student it represents. Then, discuss with the class some of the ways that the individuals have changed since infancy or early childhood, as well as ways that they have not changed. Guide students in drawing conclusions about the most important developments that occur in childhood.

Activity

Ask students to interview three trusted adults, one in each stage of adulthood as defined in the FlexBook, about their own experiences with the changes of adulthood. For example, students might ask such questions as:

- What do you think are the best and worst aspects of this stage of adulthood?
- What physical changes or health problems have you experienced during this stage?
- In what ways are you different now than you were in the previous stage of life?

Have the students summarize what they learn in a brief written report.

Differentiated Instruction: Flow Chart

Place less proficient readers in small groups with more proficient readers, and ask each group to make a simple flow chart that shows stages of development from fertilization to birth. Tell students to use their FlexBook to identify important milestones that occur at each stage. Display their flow charts in the classroom. **LPR**

Enrichment: Debate

Ask several students to debate the pros and cons of stem cell research, including both scientific and ethical/religious concerns. Assign a few students to represent each point of view. To research the issue, students can start with the online articles below. As they read, they should list facts, figures, and specific arguments that support their assigned point of view. Set aside class time for the students to present their debate.

- <http://www.pbs.org/wgbh/nova/miracle/stemcells.html>
- <http://www.npr.org/templates/story/story.php?storyId=5252449>
- <http://stemcells.nih.gov/info/ethics.asp>

Science Inquiry

Building Models

Divide the class into small groups, and have each group build three-dimensional models that show the growth and development of an embryo from fertilization through gastrulation, including the blastocyst stage. Provide them with modeling clay in different colors to create their models, and ask students to be as detailed as possible. Give groups a chance to explain their models to the class, including the changes that have occurred between each stage.

Reinforce and Review

Outlining the Lesson

Have students outline the lesson, using the text headings as main topics in their outline. They should complete the outline by adding the most important points under each heading.

Lesson Worksheets

Copy and distribute the four Lesson 41.3 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 41.3 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 41.3 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- Many diseases become more common as people age, but some diseases are more common in adolescents and young adults, including sexually transmitted diseases (STDs).

What are examples of STDs?

- How common are STDs in teens and young adults?
- Why are STDs more common during these two stages of life?

Lesson Assessment

- Have students complete the Lesson 41.3 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

30.5 Lesson 41.4: Sexually Transmitted Diseases

Key Concepts

Sexually transmitted diseases, or STDs, are diseases caused by pathogens that spread through sexual contact. Abstinence from sexual activity is the only completely effective way to prevent the spread of STDs. Bacterial STDs include chlamydia, gonorrhea, and syphilis. These diseases can be cured with antibiotics. Viral STDs include genital herpes, hepatitis B, and genital warts. Viral STDs cannot be cured, but some can be prevented with vaccines.

Lesson Objectives

- Explain how STDs are transmitted and how they can be prevented.
- Identify and describe three common bacterial STDs.
- Identify and describe three common viral STDs.

Lesson Vocabulary

Table 30.7:

Lesson 41.4 Vocabulary		
chlamydia	genital herpes	gonorrhea
hepatitis B	pelvic inflammatory disease (PID)	sexually transmitted disease (STD)
syphilis		

Check Your Understanding

Facts and Figures

Introduce STDs and impress students with their prevalence by sharing these facts and figures:

- More than half of all people will have an STD at some point in their lifetime.
- Each year, one in four teens contracts an STD, many after their first sexual encounter.
- One in two sexually active people will contract an STD by age 25.

Tell students they will learn more about STDs, including how to prevent them, in this lesson.

Teaching Strategies

Activity

Divide the class into groups, and assign each group a different sexually transmitted disease. Ask groups to learn more about their assigned disease, starting with the web sites below, and to prepare a fact sheet on the disease. Fact sheets should include signs and symptoms of the disease, the organism that causes it, its incidence, and how it is treated and prevented. Students should also print at least one illustration to add to their fact sheet, such as a picture of the organism that causes the disease. Finally, have groups assemble their fact sheets to create an STD bulletin board or mobile.

- <http://www.cdc.gov/STD/>
- <http://www.ashastd.org/>
- http://kidshealth.org/teen/sexual_health/stds/std.html
- <http://www.healthline.com/channel/sexually-transmitted-diseases.html>

Discussion

Remind students that rates of new STD infections are higher in teens and young adults than in any other age group. Ask the class to brainstorm factors that might help explain why. (e.g., lack of knowledge about STDs and how they spread, feelings of invincibility, poor decision-making skills, peer pressure to become sexually active or engage in other risk behaviors, high rates of sexual activity, tendency to have multiple sexual partners, lack of availability of condoms). Develop a list of student responses on the board. Discuss with the class ways each factor might be addressed to lower STD infection rates in teens and young adults.

Activity

Have groups of students apply the decision-making steps below to a hypothetical situation in which a teen is faced with a decision about an action that could possibly put him or her at risk of infection with STDs. For example, the teen might be under pressure to become sexually active, use intravenous drugs, or get a tattoo or body piercing from a questionable establishment. Ask groups to role-play their situations and the decision-making process. Discuss as a class whether applying the decision-making steps helped them arrive at healthful decisions.

1. Define the problem.
2. List possible options.
3. State potential consequences of each option.
4. Choose an option and act on it.
5. Evaluate the results.

Using Visuals: Table 1

Use Table 1 (see below) to underscore the importance of diagnosing and treating STDs. Explain that the last row of the table lists life-threatening health problems that are likely to develop when syphilis is not treated.

- **Ask:** How can syphilis be cured? (with antibiotics)
- **Ask:** How can syphilis be prevented? (The only 100 percent effective way is abstinence.)

Point out that syphilis has no symptoms during the latent stage, which may last for years. When it does have symptoms, they are similar to the symptoms of many other diseases, which is why syphilis is often called “the great imitator.” Suggest that students visit the web Site below to discover how syphilis can be correctly diagnosed, even when no signs or symptoms are present.

- <http://www.urologychannel.com/std/syphilis.shtml>

Table 30.8: Stages of Syphilis Infection

Stage	Time After Initial Infection	Signs and Symptoms
Primary	2 days	Small sore on genitals
Secondary	1–6 months	Rash, fever, sore throat, headache

Table 30.8: (continued)

Stage	Time After Initial Infection	Signs and Symptoms
Latent	6–12 months	None
Tertiary	1–10 years	Chronic inflammation, damage to aorta and heart, narrowing of arteries, stroke, meningitis, muscle weakness

Building Science Skills: Applying Concepts

Ask students to explain why it is more important to have vaccines for viral STDs than for bacterial STDs. (Unlike bacterial STDs, which can be cured with antibiotics, viral STDs cannot be cured. Therefore, it is more important to prevent them in the first place with vaccines.)

Activity

Assign the Sexually Transmitted Diseases Problem Set at the web site below. The interactive problems test students' knowledge of STDs, including symptoms, transmission, and treatment. If students answer a problem correctly, they are reinforced with a concise explanation of the answer. If they answer a problem incorrectly, they are directed to a tutorial that will help them solve it.

- http://www.biology.arizona.edu/human_bio/problem_sets/stds/stds.html

Differentiated Instruction: Venn Diagram

Pair beginning and advanced English language learners, and ask pairs to make a Venn diagram comparing and contrasting bacterial and viral STDs. Tell them to include examples of each type of STD in their diagram. The lists below show information students should include within each circle of the diagram and in the area where the circles overlap. **ELL True only of bacterial STDs:**

- Caused by bacteria
- Can be cured with antibiotics
- Examples: chlamydia, gonorrhea, syphilis

True only of viral STDs:

- Caused by viruses
- Cannot be cured with antibiotics
- May be prevented with vaccines
- Examples: genital herpes, hepatitis B, genital warts

True of both bacterial and viral STDs (area of overlap):

- Spread through sexual activity
- Caused by pathogens
- May be prevented through abstinence

Enrichment: Interview

Arrange for interested students to interview a public health worker at their local or state health department regarding STDs in their community or state. Students should ask about rates of specific STDs, how STDs are monitored and reported, and what the health department does to reduce their spread. Give students a chance to report back to the class on what they learn.

Science Inquiry

Analyzing Data

Divide the class into groups, and direct them to the interactive CDC web site *Sexually Transmitted Diseases—Interactive Data 1996-2008* (or most recent year). The web site allows users to generate data tables and graphs of STD rates for any combination of parameters, including by specific disease, state, year, gender, and/or age group. Instruct students to use the web site to generate tables or graphs that allow them to address such questions as:

1. How do rates of all STDs combined (or of specific STDs) compare in people aged 15–19 and people aged 20-24?
2. Which gender of teens aged 15-19 has higher rates of all STDs combined (or of specific STDs)?
3. Which specific STD has the highest rate in this age group?
4. Which state has the highest or lowest rate of STDs in this age group?
5. What is the annual trend in rates of all STDs combined (or of specific STDs) in this age group?

- <http://wonder.cdc.gov/std-std-v2008-race-age.html>

Reinforce and Review

Asking Questions

Ask students to turn in a question they have about STDs on an index card or scrap of paper. Then answer appropriate questions, or review material related to, their questions.

Lesson Worksheets

Copy and distribute the four Lesson 41.4 worksheets in the Supplemental Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content. You may want to assign the worksheets as homework.

Review Questions

Have students answer the Lesson 41.4 Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Points to Consider

Ask students to read the Points to Consider at the end of Lesson 41.4 in their FlexBook. Then, discuss the questions with the class.

Sample answers will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

- From fertilization to old age, the human body is like a fantastic machine. It controls its own growth and development, protects itself from dangers in the outside world and has amazing abilities to act, think, and feel. Like other living things, human beings are marvels of nature.
- What have you learned about human beings and other organisms by reading this FlexBook?

Lesson Assessment

- Have students complete the Lesson 41.4 Quiz.

The lesson quiz and answer key are available upon request. Please send an email to teachers-requests@ck12.org to request material.

30.6 Worksheet Answer Keys

- Available upon request. Please request by email: teacher-requests@ck12.org.