# Chapter Resources for Differentiated Instruction

## The Environment and Change Over Time

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<td>all students</td>
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<td>all students</td>
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**AL** Approaching Level  **OL** On Level  **BL** Beyond Level  **ELL** English-Language Learner

Teacher evaluation will determine which activities to use or modify to meet any **ELL** student’s proficiency level.
<table>
<thead>
<tr>
<th>Title</th>
<th>Frequency</th>
<th>Overview</th>
<th>Appropriate For</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get Ready to Read: What do you think?</td>
<td>1/Chapter</td>
<td>Using the Get Ready to Read anticipation guide in the Student Edition? This page matches the anticipation guide in the Student Edition. Students can complete this at the beginning of a chapter and check their responses at the end.</td>
<td>all students</td>
</tr>
<tr>
<td>Quick Vocabulary</td>
<td>1/Chapter</td>
<td>Need some options to preteach vocabulary and help students with vocabulary development? By folding the Quick Vocabulary sheet in half, students will have an easy reference tool. Lesson vocabulary, along with academic vocabulary, review vocabulary, or multiple-meaning words, are listed and defined. Students can add other words that they need to remember as well.</td>
<td>all students</td>
</tr>
<tr>
<td>Student Lab Safety Form</td>
<td>1/Chapter</td>
<td>Need a standard lab safety form? Each FastFile includes this form that students can complete prior to each lab. Students indicate that they understand all aspects of the lab. There is a place for the student and you to sign it.</td>
<td>all students</td>
</tr>
<tr>
<td>Launch Lab</td>
<td>1/Lesson</td>
<td>Want a lab recording page for Student Edition Launch Labs? Each recording page matches the Student Edition Launch Labs, so students do not need to use their textbooks in the lab.</td>
<td>all students</td>
</tr>
<tr>
<td>Content Vocabulary*</td>
<td>1/Lesson</td>
<td>Want to help students who need more vocabulary practice? Content Vocabulary pages provide review and reinforcement activities. Use these pages to help students master content terms.</td>
<td>all students</td>
</tr>
<tr>
<td>Lesson Outline*</td>
<td>1/Lesson</td>
<td>Want an outline of the chapter for a substitute teacher, for absent students, or for students to use for review? Lesson outlines follow the head and subhead structure of the Lesson, emphasizing the major content objectives. They can be used in many ways. In addition to those listed above, they can help you organize teaching notes and accompany student reading.</td>
<td>all students</td>
</tr>
<tr>
<td>MiniLab</td>
<td>1/Lesson</td>
<td>Want a lab recording page for Student Edition MiniLabs? This recording page matches the Student Edition MiniLab, so students do not need to use their textbooks in the lab.</td>
<td>all students</td>
</tr>
<tr>
<td>Title</td>
<td>Frequency</td>
<td>Overview</td>
<td>Appropriate For</td>
</tr>
<tr>
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<td>---------------------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
</tbody>
</table>
| Content Practice (Leveled)       | 1/Lesson  | **Need more options for content review?** Content Practice A is designed to help students who have difficulties learning and understanding the vocabulary and Key Concepts of each lesson:  
  - **Form A**—helps struggling students grasp lesson content  
  - **Form B**—provides on-level and beyond-level reinforcement of lesson content | AL, OL, BL      |
| Language Arts Support            | 1/Chapter | **Looking for a way to help students build reading and writing skills in science?** Language Arts Support pages provide practice using vocabulary, language structure clues, and writing skills with science content. | all students    |
| Math Skills                      | 1/Chapter | **Want help for students who need to practice math skills?** This page provides additional practice of the Math Skill in the Student Edition. | all students    |
| School to Home                   | 1/Lesson  | **Looking for a way to help students with the content?** The School to Home page provides support for a home-learning partner to help a student better understand the Big Idea of a chapter. | all students    |
| Key Concept Builders             | 4/Lesson  | **Have students who need more practice with Key Concepts?** Key Concept Builders present the content in a context different from the Student Edition. These pages can be used whenever a student is struggling with any of the lesson’s Key Concepts. | AL             |
| Enrichment                       | 1/Lesson  | **Looking for ways to help students to broaden their understanding of lesson concepts?** Use Enrichment pages to further explore information and Key Concepts introduced in a lesson. | all students    |
| Challenge                        | 1/Lesson  | **Want to motivate the independent learner?** The Challenge activity extends information in the Student Edition and challenges a student’s abilities. The activity can be completed in class or at home. | BL             |
| Lesson Quiz (Leveled)            | 1/Lesson  | **Need options to evaluate students after each lesson?** These quizzes are developed around the Key Concepts of a lesson:  
  - **Quiz A**—provides more guided questions  
  - **Quiz B**—provides more short-answer and completion questions | AL, OL, BL      |

Teacher evaluation will determine which activities to use or modify to meet any student’s proficiency level.
<table>
<thead>
<tr>
<th>Title</th>
<th>Frequency</th>
<th>Overview</th>
<th>Appropriate For</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill Practice</td>
<td>1/Chapter</td>
<td>Need a lab recording page for the Skill Practice? This corresponds to the Skill Practice in the Student Edition. Write-on lines are included for answers. Tables/charts/graphs are included for recording observations, or space is provided for drawing tables/charts/graphs. Students do not need to use their textbooks in the lab.</td>
<td>all students</td>
</tr>
<tr>
<td>Lab (Leveled)</td>
<td>1/Chapter</td>
<td>Want leveled lab recording pages for the Lab in the Student Edition? These pages provide leveled versions of the Student Edition Lab. Write-on lines are included for answers. Tables/charts/graphs are often included for recording observations, or space is provided for creating tables/charts/graphs:</td>
<td>AL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Version A—This version follows the student edition lab but each step of the procedure is broken down sentence by sentence. Included are check-off boxes that provide easier processing for struggling learners.</td>
<td>AL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Version B—This version is the student edition lab.</td>
<td>OL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Version C—This version is designed to be a challenge for independent learners. Students must complete version B before doing version C.</td>
<td>BL</td>
</tr>
<tr>
<td>Chapter Key Concepts</td>
<td>1/Chapter</td>
<td>Have students who need more practice with Key Concepts related to the Big Idea? This practice page is designed to reinforce chapter content for struggling students before they take the chapter test.</td>
<td>AL</td>
</tr>
<tr>
<td>Builder</td>
<td></td>
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</tr>
<tr>
<td>Chapter Test (Leveled)</td>
<td>1/Chapter</td>
<td>Need options to assess each student according to his or her abilities? These leveled chapter tests accommodate all students:</td>
<td>AL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Version A—provides students with more guided questions</td>
<td>AL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Version B—more short-answer and completion questions</td>
<td>OL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Version C—challenges students with more difficult and open-ended questions</td>
<td>BL</td>
</tr>
<tr>
<td>Teacher Pages</td>
<td></td>
<td>Want all the answers in one place? These pages contain the answers for all the practice pages.</td>
<td></td>
</tr>
</tbody>
</table>

**AL** Approaching Level  **OL** On Level  **BL** Beyond Level  **ELL** English-Language Learner

Teacher evaluation will determine which activities to use or modify to meet any student's proficiency level.
Get Ready to Read

The Environment and Change Over Time

What do you think?
Before you read, decide if you agree or disagree with each statement. On the line before each statement, place an A if you agree or a D if you disagree. As you read this chapter, see if you change your mind about any of the statements.

<table>
<thead>
<tr>
<th>Before You Read</th>
<th>Statements</th>
<th>After You Read</th>
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<tbody>
<tr>
<td></td>
<td>1. Original tissues can be preserved as fossils.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Organisms become extinct only in mass extinction events.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Environmental change causes variations in populations.</td>
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</tr>
<tr>
<td></td>
<td>4. Variations can lead to adaptations.</td>
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<tr>
<td></td>
<td>5. Living species contain no evidence that they are related to each other.</td>
<td></td>
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<tr>
<td></td>
<td>6. Plants and animals share similar genes.</td>
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</tr>
</tbody>
</table>

What have you learned?
After you read each lesson, return to this worksheet to see if you have changed your mind about any of the statements related to that lesson. Place a C after each statement that is correct or an I for those that are incorrect.
Lesson 1

**biological evolution** change over time in populations of related organisms

**cast** fossil copy of an organism in a rock

**extinction** when all individuals of a species have died

**fossil record** set of all the fossils ever discovered on Earth

**geologic time scale** chart that divides Earth's history into different time units

**isotopes** atoms of the same element that have different numbers of neutrons

**mold** impression of an organism in a rock

**tissue** similar cells that work together and perform a function

**trace fossil** preserved evidence of the activity of an organism

Lesson 2

**adaptation** characteristic of a species that enables the species to survive in its environment

**camouflage** adaptation that enables species to blend in with their environments

**convince** to overcome by argument

**mimicry** resemblance of one species to another species

**natural selection** process by which populations of organisms with variations that help them survive in their environments live longer, compete better, and reproduce more than those that do not have the variations

**naturalist** person who studies plants and animals by observing them

**selective breeding** the breeding of organisms for desired characteristics

**variation** slight difference in the appearance of individual members of a species
Lesson 3

analogous structure  body part
  found in multiple species that
  performs a similar function but
  differs in structure

comparative anatomy  study of
  similarities and differences among
  structures of living species

embryology  science of the
  development of embryos from
  fertilization to birth

homologous structure  body part
  found in mulitple species that is
  similar in structure and position
  but different in function

vestigial structure  body part that
  has lost its original function
  through evolution
Student Lab/Activity Safety Form

Student Name: ________________________ Date: ________________

Lab/Activity Title: ________________________

• Carefully read the entire lab and answer the following questions.
• Return this completed and signed safety form to your teacher to initial before you begin the lab/activity.

1. Describe what you will be doing during this lab/activity. Ask your teacher any questions you might have regarding the lab/activity.

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

2. Will you be working alone, with a partner, or with a group? (Circle one.)

3. What safety precautions should you take while doing this lab/activity?

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

4. Write any steps in the procedure, additional safety concerns, or lab safety symbols that you do not understand.

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

Student Signature ________________________
# Lesson 1 | Fossil Evidence of Evolution

## Student Labs and Activities

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<tr>
<td>Content Vocabulary (ELL)</td>
<td>9</td>
<td>all students</td>
</tr>
<tr>
<td>Lesson Outline (ELL)</td>
<td>10</td>
<td>all students</td>
</tr>
<tr>
<td>MiniLab</td>
<td>12</td>
<td>all students</td>
</tr>
<tr>
<td>Content Practice A</td>
<td>13</td>
<td>AL</td>
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<tr>
<td>Content Practice B</td>
<td>14</td>
<td>OL, BL</td>
</tr>
<tr>
<td>Language Arts Support</td>
<td>15</td>
<td>all students</td>
</tr>
<tr>
<td>Math Skills</td>
<td>17</td>
<td>all students</td>
</tr>
<tr>
<td>School to Home</td>
<td>18</td>
<td>all students</td>
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<tr>
<td>Key Concept Builders</td>
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<td>AL</td>
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<td>Enrichment</td>
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<td>all students</td>
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<tr>
<td>Challenge</td>
<td>24</td>
<td>BL</td>
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<tr>
<td>Skill Practice</td>
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## Assessment

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<td>Lesson Quiz B</td>
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<td>OL, BL</td>
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## Teacher Support

Answers (with Lesson Outlines) | T2

Teacher evaluation will determine which activities to use or modify to meet any (ELL) student's proficiency level.
How do fossils form?

Evidence from fossils helps scientists understand how organisms have changed over time. Some fossils form when impressions left by organisms in sand or mud are filled in by sediments that harden.

**Procedure**

1. Read and complete a lab safety form.
2. Place a container of moist sand on top of newspaper. Press a shell into the moist sand. Carefully remove the shell. Brush any sand on the shell onto the newspaper.
3. Observe the impression, and record your observations in the Data and Observations section below.
4. Pour plaster of paris into the impression. Wait for it to harden. \* The mix gets hot as it sets—do not touch it until it has hardened.
5. Remove the shell fossil from the sand, and brush it off.
6. Observe the structure of the fossil, and record your observations.

**Data and Observations**

**Think About This**

1. What effect did the shell have on the sand?

2. **Key Concept** What information do you think someone could learn about the shell and the organism that lived inside it by examining the fossil?
Fossil Evidence of Evolution

Directions: In the puzzle below, each number will correspond to one letter of the alphabet. For example, 7 = I. Shaded letters will not be used. Crack the code by using the clues for hints. After you read the clues and fill in the blanks, complete the chart with the number that corresponds to each letter you have used.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
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<td>7</td>
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<tr>
<th>N</th>
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<th>P</th>
<th>Q</th>
<th>R</th>
<th>S</th>
<th>T</th>
<th>U</th>
<th>V</th>
<th>W</th>
<th>X</th>
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</tbody>
</table>

1. a chart of Earth’s past
   \[16 \ 2 \ 26 \ 23 \ 26 \ 16 \ 7 \ 25 \ 13 \ 7 \ 6 \ 2 \ 22 \ 25 \ 17 \ 23 \ 2 \]

2. change over time
   \[19 \ 7 \ 26 \ 23 \ 26 \ 16 \ 7 \ 25 \ 17 \ 23 \ 2 \ 12 \ 26 \ 23 \ 24 \ 13 \ 7 \ 26 \ 15 \]

3. evidence of an organism’s activity
   \[13 \ 4 \ 17 \ 25 \ 2 \ 20 \ 26 \ 22 \ 22 \ 7 \ 23 \]

4. occurs when no individuals of a species remain
   \[2 \ 8 \ 13 \ 7 \ 15 \ 25 \ 13 \ 7 \ 26 \ 15 \]

5. atoms of the same element that have different numbers of neutrons
   \[7 \ 22 \ 26 \ 13 \ 26 \ 11 \ 2 \ 22 \]

6. all fossils ever discovered on Earth
   \[20 \ 26 \ 22 \ 22 \ 1 \ 7 \ 23 \ 4 \ 2 \ 25 \ 26 \ 4 \ 10 \]

7. impression of an organism in rock
   \[6 \ 26 \ 23 \ 10 \]

8. similar cells that work together
   \[13 \ 7 \ 22 \ 22 \ 24 \ 2 \]

9. fossil copy of an organism in a rock
   \[25 \ 17 \ 22 \ 13 \]
Fossil Evidence of Evolution

A. The Fossil Record
   1. ________________ are the preserved remains or evidence of once-living organisms.
   2. All the fossils ever discovered on Earth make up the ________________.
   3. Fossils help scientists figure out what species that no longer ________________ looked like when the organisms were alive.

B. Fossil Formation
   1. Most fossils are formed of the ________________ parts of an organism.
   2. Sometimes when the remains of an organism get buried in mud, wet sand, or other sediments under a body of ________________, the molecules that formed the remains get replaced by ________________ in the water.
      a. This type of fossil formation is called ________________.
      b. Most mineralized fossils are formed of shell or ________________, but wood can also become a mineralized fossil.
   3. In ________________, a fossil forms when a dead organism is compressed over time and pressure drives off the organism's liquids and gases.
   4. Sometimes organisms or parts of organisms make a(n) ________________ in sand or mud.
      a. The kind of fossil that forms as an impression in rock is called a(n) ________________.
      b. If the impression gets filled with sediments that harden to rock, a(n) ________________ is the result.
      c. Molds and casts show only ________________ features of organisms.
   5. The preserved evidence of the activity of an organism, such as its tracks, is called a(n) ________________ fossil.
   6. In rare cases, the original ________________ of an organism can be preserved, such as ________________ frozen in ice.

C. Determining a Fossil's Age
   1. Scientists cannot date most ________________ directly. Instead they usually find the age of the ________________ around the fossils.
Lesson Outline continued

2. In _______ dating, scientists determine the relative order in which rock layers were deposited.
   a. In a(n) _______ rock formation, the older layers of rock are below the younger layers of rock.
   b. Relative-age dating has helped scientists figure out the order that _______ have appeared on Earth.

3. Absolute-age dating is more _______ than relative-age dating and involves _______ isotopes that decay to become stable isotopes over time.

D. Fossils over Time

1. The _______ is a chart that divides Earth’s history into different time units.

2. Earth’s history is divided into four _______.

3. Earth’s most recent eon—the _______ eon—is subdivided into three _______.

4. Neither eons nor eras are _______ in length.

5. When scientists began developing the geologic time scale in the 1800s, they did not have _______ dating methods, so they marked time boundaries with _______.

E. Extinctions

1. When the last individual organism of a species dies, a(n) _______ has occurred.
   a. A(n) _______ extinction occurs when many species die off within a few million years or less.
   b. The fossil record shows evidence of _______ mass extinctions during the Phanerozoic eon.
   c. Extinctions can occur if the _______ changes quickly; for example, as a result of a meteorite impact.
   d. Extinctions can also occur if the environment changes _______; for example, as a result of the formation of mountain ranges.

2. The fossil record contains clear evidence of the extinction of species over time as well as evidence of the appearance of many new _______.
How do species change over time?

Over long time periods on Earth, certain individuals within populations of organisms were able to survive better than others.

Procedure

1. Choose a species from the Species I.D. Cards.
2. On chart paper, draw six squares in a row and number them 1–6, respectively. Use colored pencils and markers to make a comic strip showing the ancestral and present-day forms of your species in frames 1 and 6.
3. Use information from the I.D. Card to show what you think would be the progression of changes in the species in frames 2–5.
4. In speech bubbles, explain how each change helped the species to survive.

Analyze and Conclude

1. Infer why a scientist would identify a fossil from the species in the first frame of your cartoon as the ancestral form of the present-day species.

2. Key Concept How would the fossils of the species at each stage provide evidence of biological change over time?
### Content Practice A

**LESSON 1**

### Fossil Evidence of Evolution

**Directions:** On the line before each label, write the letter of its correct location on the scale.

1. ____ Archean
2. ____ Cenozoic
3. ____ Hadean
4. ____ Mesozoic
5. ____ Paleozoic
6. ____ Phanerozoic
7. ____ Precambrian
8. ____ Proterozoic

### The Geologic Time Scale

<table>
<thead>
<tr>
<th>Eras</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cretaceous, Jurassic</td>
</tr>
<tr>
<td>B</td>
<td>Tertiary</td>
</tr>
<tr>
<td>C</td>
<td>Permian, Carboniferous</td>
</tr>
<tr>
<td>D</td>
<td>Devonian, Ordovician</td>
</tr>
<tr>
<td></td>
<td>Cambrian</td>
</tr>
</tbody>
</table>

- **Quaternary**
- **Cenozoic**
- **Hadean**
- **Mesozoic**
- **Paleozoic**
- **Phanerozoic**
- **Precambrian**
- **Proterozoic**

**Time Scale**

- 0: Archean
- 1.8: Cenozoic
- 146: Hadean
- 251: Mesozoic
- 359: Paleozoic
- 488: Phanerozoic
- 542: Precambrian

- 4,000: Proterozoic
- 4,500: Cambrian
- 5,000: Ordovician
- 5,500: Silurian
- 6,000: Devonian
- 6,500: Carboniferous
- 7,000: Permian
- 7,500: Triassic
- 8,000: Jurassic
- 8,500: Cretaceous
- 9,000: Tertiary
- 9,500: Quaternary
- 10,000: Hadean
Content Practice B

LESSON 1

Fossil Evidence of Evolution

Directions: Answer each question on the lines provided. Use complete sentences.

1. What is a fossil record, and what does it show?

2. What additional important evidence do trace fossils provide?

3. What advantage does absolute-age dating have over relative-age dating? Explain.

4. How does the geologic time scale organize Earth’s history?

5. How do fossils give evidence of biological evolution?
Writing Activity: Describing a Scientific Process Using Transitional Words

Learning the Skill

“First, turn left on Main Street. Then, go two blocks to Elm Road and turn left. Finally, go to the end of the block. I live in the red house on the right.”

Have you ever had to give someone directions to get to your house? If you have, you probably used words such as first, then, and finally to make the directions clear. These kinds of words are called transitional words.

When you give someone directions to your house, you are describing a process. Transitional words are also important in describing any scientific process. Consider the following description of the process of mineralization:

First, mineralization begins when a dead organism is buried under sediments in a stream or river. Then, minerals in the water replace the organism’s original material or fill in the spaces in a dead organism’s tissues. As a result, the material slowly hardens into rock, forming a fossil.

Transitional words help clarify when each step in the process of mineralization happens. Other transitional words you can use when describing a process are afterward, before, once, next, last, at first, another, in the beginning, after, in the meantime, over time, and at the same time.

Practicing the Skill

Directions: For each occurrence named below, write a few sentences describing what happens during the process. Use transitional words in your description.

1. carbonization

2. formation of a mold and cast
Language Arts Support

LESSON 1

Applying the Skill

Directions: Use what you have learned about transitional words to explain the process of extinction with a clear explanation of the different factors involved.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
**Use Scientific Notation**

The geologic time scale covers millions and billions of years of Earth's history. The Hadean eon, for example, covers a time span that starts over 4,000,000,000 years ago. Scientific notation can make it easier to work with very large numbers like those used to measure geologic time.

The oldest fossils visible without magnification are about 565,000,000 years old. Express this number in scientific notation.

**Step 1** Rewrite the number with a decimal point after the first digit.

5.65000000

**Step 2** Count the number of places you moved the decimal point. If a number does not show a decimal point, the decimal point is at the right end of the number. You moved the decimal point 8 places to the left.

**Step 3** Drop the zeros, and write the number of places you moved the decimal point as a power of ten.

5.65 \times 10^8

**Practice**

1. The Cambrian period covers a time span that starts approximately 543,000,000 years ago. Express this number in scientific notation.

2. Fossil evidence of microscopic life has been found in rocks that are 3,400,000,000 years old. Express this number in scientific notation.

3. About $4 \times 10^3$ genera are known to exist today. Express this number in standard notation and in words.

4. A mass extinction event occurred about 200,000,000 years ago, in the late Triassic. Express this number in scientific notation.

5. The current geologic period, the Quaternary, began around 1,800,000 years ago. Express this number in scientific notation.

6. A huge meteorite struck Earth around $6.5 \times 10^7$ years ago. How many thousands, millions, or billions of years ago was that?
Fossil Evidence of Evolution

Directions: Use your textbook to respond to each statement.

1. The diagram below represents a group of undisturbed rock layers. Draw one fossil in each of these rock layers: B, C, E, and G.

2. Write the terms older and younger on the correct lines on either end of the arrow to correctly indicate the ages of the rocks in the rock layer diagram.

3. Look at the fossil you drew in rock layer C.
   a. Which fossil (or fossils) are older? ___________________________________________________________________
   b. Which fossil (or fossils) are younger? ___________________________________________________________________

4. Which fossil is the youngest? ___________________________________________________________________

5. What method of fossil dating does this activity represent? ___________________________________________________________________

6. Which type of rock is most likely found in layers B, C, E, and G? Explain your reasoning.

   ____________________________________________________________________

7. If rock layers A, D, and F are igneous rock, which type of dating could also be carried out? Explain your response.

   ____________________________________________________________________
### Fossil Evidence of Evolution

**Key Concept**  How do fossils form?

**Directions:** Answer each question in the space provided.

<table>
<thead>
<tr>
<th>Fossil Formation</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What are the different types of fossils?</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>What conditions existed for this type of fossil to form?</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>How did this type of fossil form?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Does this fossil show physical structure, movement, or behavior—or all three?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fossil Evidence of Evolution

Key Concept  How do fossils form?

Directions: On each line, write the letter(s) of the term(s) that correctly matches the description. Some terms will be used more than once.

1. Original tissues of the organism can be preserved.
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

2. Sediment fills an impression left in the sand.
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

3. organism buried in the sand
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

4. Dead organism is compressed over time.
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

5. preserves an organism’s movement
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

6. a fossil copy of the organism in a rock
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

7. includes mammoths frozen in ice
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

8. Tracks fill with sediment that hardens.
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

9. Minerals in water replace an organism’s original material and harden into rock.
   - A. mineralization
   - B. carbonization
   - C. molds and casts
   - D. trace fossils
   - E. original material

10. Pressure drives off gases and liquids, leaving an outline of plant leaves, fish, and insects.
    - A. mineralization
    - B. carbonization
    - C. molds and casts
    - D. trace fossils
    - E. original material

11. An impression of an organism is left in rock.
    - A. mineralization
    - B. carbonization
    - C. molds and casts
    - D. trace fossils
    - E. original material

12. The process requires mud or sand.
    - A. mineralization
    - B. carbonization
    - C. molds and casts
    - D. trace fossils
    - E. original material

13. Some organisms have been preserved in tar pits.
    - A. mineralization
    - B. carbonization
    - C. molds and casts
    - D. trace fossils
    - E. original material

14. Only the external features of the organism are shown.
    - A. mineralization
    - B. carbonization
    - C. molds and casts
    - D. trace fossils
    - E. original material

15. can result in a fossil of wood
    - A. mineralization
    - B. carbonization
    - C. molds and casts
    - D. trace fossils
    - E. original material

16. preserves the internal structure of an organism
    - A. mineralization
    - B. carbonization
    - C. molds and casts
    - D. trace fossils
    - E. original material
Fossil Evidence of Evolution

Key Concept  How do scientists date fossils?

Directions: On the line before each statement, write T if the statement is true or F if the statement is false. If the statement is false, change the underlined word(s) to make it true. Write your change on the line following the statement.

1. Scientists are able to directly date most fossils using a variety of techniques.

2. The most precise type of dating used for determining a fossil’s age is relative-age dating.

3. Calculating the age of igneous rock is part of the process used in absolute-age dating.

4. Determining the approximate order in which rock layers were deposited is an important part of absolute-age dating.

5. The ratio of unstable isotopes to stable isotopes is part of absolute-age dating.

6. Relative-age dating is especially useful in studying disturbed rock layers.

7. An understanding in relative-age dating is that one rock layer is either older or younger than a nearby rock layer.

8. An approximate age of a species is determined using absolute-age dating.

9. Geologic time scales divide Earth’s history into different units of time.

10. Fossil evidence shows that unicellular organisms lived on Earth 3.4 billion years ago.

11. In relative-age dating, the age of species found in sedimentary rock layers is determined by the age of igneous rock.

12. Understanding the process of radioactive decay is part of absolute-age dating.
Fossil Evidence of Evolution

Key Concept  How are fossils evidence of biological evolution?

Directions: Use the diagram to answer each question or respond to each statement on the lines provided.

1. What is suggested when many fossils are found in one rock layer, but none are found in the layer above it?

2. Within what period of time can a mass extinction occur?

3. Compare the environmental change that causes extinction with the environmental change that causes gradual species change.

4. How many major extinction events have occurred in Earth's history?

5. List the order of extinction events from the earliest time period to the most recent.
Stratigraphy is the study of how rock strata, or layers, formed as sedimentary rocks through time. Stratigraphy gives scientists a lot of information about the succession of events in Earth's history.

**The Principle of Superposition**

The Principle of Superposition states that lower layers of rock are older than the upper layers. This means that each successive layer moving toward the surface is younger than the layer below it as long as the layers of rock are undisturbed.

But Earth is constantly on the move, and few areas, if any, have remained undisturbed through time. Tectonic plates move, and Earth's crust crumples, tilts, and caves. Volcanoes erupt, lava flows, and earthquakes shake things up. Plate movements and volcanoes build up Earth, and erosion wears it down. How does this affect superposition and the determination of the age of fossils? Other principles help scientists understand how to interpret Earth's changes.

**The Principle of Original Horizontality**

This principle states that sediments are laid down over time in a horizontal layer. For example, sediment accumulating on the floor of an ancient shallow sea gradually builds in a flat, horizontal layer. This principle can explain how a fossil can be found at 500 feet that is exactly the same age as one found at 1000 feet.

**The Principle of Lateral Continuity**

This principle simply states that strata form in lateral layers that can extend for great distances. This depends on the conditions under which the sediments were originally deposited. When long lateral strata exist, scientists can relate the history of an area and its fossils to another area some distance away.

**The Principle of Faunal Succession**

This principle means that evidence of a succession of life (fossils) occurs through a vertical section of rock layers and that the same succession occurs through a vertical section of rock layers in other places as well. Some places with similar vertical succession are separated by oceans and great distances the world over.

**Applying Critical-Thinking Skills**

**Directions:** Answer each question or respond to each statement.

1. **Analyze** You are examining rock strata exposed as road crews cut away a section of a mountaintop to build a highway. You notice a layer at the peak—some of which is exposed—that plunges to the right almost vertically down to the roadway. As it descends, other layers begin to border it on both sides, and at the roadway, it has layers of sediment on both sides for hundreds of meters. This gives the appearance on the surface of a gently rolling mountaintop. Which principle of stratigraphy most closely applies to this formation?

2. **Compose** a scenario of Earth’s history that includes the discovery of fossils that vary widely in age but are found at the same depth in sample rock cores.
**Challenge**

**LESSON 1**

**Dating Fossils**

You are a scientist working in a museum of natural history in a large city. A box of Paleozoic fossils has been donated to the museum, and it is your task to place the fossils in a display in the order of their relative ages. The following is a detailed list of what you know about the fossils:

1. There are eight fossils: *Fanlika devonensis*, *Dragona silurius*, *Crawlitus fishensis*, *Nautilius ordovian*, *Bottelinia cambriae*, *Spiralla fossilii*, *Fernila treelinsis*, and *Froggela slitherae*.

2. There are five rock strata, each from successive geologic periods. There is at least one fossil from each stratum, and one stratum contains three fossils.

3. *Crawlitus fishensis* is older than *Fanlika devonensis* and younger than *Bottelinia cambriae*.

4. Most are named something like the period of geologic history they are from.

5. *Fernila treelinsis* is a land plant fossil.

6. *Dragona silurius* is in the layer between *Spiralla fossilii* and *Crawlitus fishensis*.

7. *Froggela slitherae* is an amphibian fossil.

8. *Nautilius ordovian* is the next-to-oldest fossil.

9. None of the fossils are Precambrian, and all are older than Permian.

**Create a Fossil Key for a Museum Exhibit**

Using poster paper and colored markers or pencils, create a key for visitors to your museum display of the fossils. You will draw a rock column that shows the number of strata that you need to correctly place all the fossils in their order of appearance in the fossil record within each stratum. Then write the name of the fossil in its correct stratum along with the geologic period. You may use a copy of the geologic time scale from your textbook or from another source.
Can you observe changes through time in collections of everyday objects?

Everyday objects that are invented, designed, and manufactured by humans often exhibit changes over time in both structure and function. How have these changes affected the efficiency and/or safety of some common items?

Materials
picture sets of items that have changed over time

Learn It
When scientists observe phenomena, they use words or numbers to describe what they see. When scientists observe, they use their senses, such as sight, hearing, touch, and smell. They examine the entire object or situation first, then look carefully for details.

Try It
1. Working with your group members, choose a set of items that you wish to observe, such as telephones, bicycles, or automobiles.
2. Examine the pictures and observe how the item has changed over time.
3. Record your observations.

4. Observe details of the structure and function of each of the items. Record your observations.
Skill Practice continued

Apply It

5. Present your results in the form of an illustrated time line, a consumer magazine article, a role-play of a person-on-the-street interview, a television advertisement, or an idea of your own approved by your teacher. Use the space below to develop ideas for your presentation.

6. Key Concept Identify how your product changed over time and in what ways the changes affected the efficiency and/or safety of the product.
Lesson Quiz  A  

LESSON 1

Fossil Evidence of Evolution

Multiple Choice
Directions: On the line before each question, write the letter of the correct answer.

1. What can be learned about a fossil using relative-age dating?
   A. its age in years
   B. its age compared to other fossils
   C. its age based on radioactive decay

2. What is a major cause of extinctions?
   A. biological evolution
   B. environmental change
   C. carbonization and mineralization

Matching
Directions: On the line before each definition, write the letter of the term that matches it correctly. Each term is used only once.

Matching Set 1

3. the impression of an organism in a rock
   ______ A. cast
   ______ B. original-material fossil
   ______ C. trace fossil
   ______ D. mold

4. the fossil copy of an organism in a rock

5. the preserved evidence of the activity of an organism

6. the preserved tissues of an organism

Matching Set 2

7. all the fossils ever discovered on Earth
   ______ E. geologic time scale
   ______ F. fossil record

8. a chart that divides Earth’s history into units

9. the change over time in populations of related organisms
   ______ G. biological evolution
Lesson Quiz B

Fossil Evidence of Evolution

Matching

Directions: On the line before each definition, write the letter of the term that matches it correctly. Not all terms are used.

_____ 1. the impression of an organism in a rock     A. cast
_____ 2. the fossil copy of an organism in a rock    B. fossil record
_____ 3. the preserved evidence of the activity of an organism
_____ 4. the preserved tissues of an organism
_____ 5. all the fossils ever discovered on Earth
_____ 6. a chart that divides Earth’s history into units
_____ 7. the change over time in populations of related organisms

Short Answer

Directions: Respond to each statement on the lines provided.

8. Contrast relative-age dating and absolute-age dating.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

9. Explain the cause-and-effect relationship between extinction and environmental change.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
## Lesson 2 | Theory of Evolution by Natural Selection

### Student Labs and Activities

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<th>Page</th>
<th>Appropriate For:</th>
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<td>all students</td>
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<tr>
<td>MiniLab</td>
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<td>all students</td>
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<td>Challenge</td>
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### Assessment

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### Teacher Support

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<tbody>
<tr>
<td>Answers (with Lesson Outlines)</td>
<td>T4</td>
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</tbody>
</table>

**Note:** Teacher evaluation will determine which activities to use or modify to meet any English-Language Learner (ELL) student’s proficiency level.
Are there variations within your class?

All populations contain variations in some characteristics of their members.

**Procedure**

1. Read and complete a lab safety form.
2. Use a **meterstick** to measure the length from your elbow to the tip of your middle finger in centimeters. Record the measurement in the Data and Observations section below.
3. Add your measurement to the class list.
4. Organize all of the measurements from shortest to longest.

**Data and Observations**

**Think About This**

1. What are the shortest and longest measurements?

2. How much do the shortest and longest lengths vary from each other?

3. **Key Concept** Describe how your results provide evidence of variations within your classroom population.
Content Vocabulary

Theory of Evolution by Natural Selection

Directions: Explain the relationship between the terms in each pair on the lines provided. Use complete sentences.

1. camouflage, mimicry

2. scientist, naturalist

3. adaptation, variation

4. natural selection, selective breeding

5. convince, suspect
Theory of Evolution by Natural Selection

A. Charles Darwin

1. Charles Darwin was a(n) ________________, a person who studies plants and animals by observing them.

2. Darwin was not the first to develop a theory of ________________, but his theory is the one best supported by evidence today.

3. The type of tortoise, mockingbird, and finch that live on each of the Galápagos Islands was slightly different; Darwin later figured out that some varieties were different enough to be classified as different ________________.

B. Darwin’s Theory

1. Darwin noticed that there was a relationship between each ________________ and the food sources of the island it lived on.

2. The species of tortoise that lived on an island with tall cacti had ________________ necks; the species of tortoise that lived on an island with lots of short grass had ________________ necks.

3. Darwin thought all the Galápagos tortoises shared a common ________________ that came to one of the islands millions of years ago.

4. Darwin knew that in any species, members of the same species each have slight differences, called ________________.

5. Darwin didn’t know about ________________, but he realized that ________________ in populations could help explain how the different species of Galápagos tortoises and other organisms evolved.
   a. Darwin knew that food is a(n) ________________ resource, so members of a species that live in the same area compete for food.
   b. If a variation ________________ a tortoise, allowing it to compete for food better than other tortoises, the tortoise lived longer, reproduced more, and passed on its variations to its ________________.

6. ________________ is the process by which populations of organisms with variations that help them survive in their environments live longer, compete better, and reproduce more than populations that do not have the ________________.
Lesson Outline continued

C. Adaptations

1. A(n) __________________ is a characteristic of a species that enables the
   species to survive in its environment.

2. Scientists classify adaptations into __________________ categories.
   a. __________________ adaptations involve shape, size, color, and other
      physical features; the length of a Galápagos tortoise species’ neck is an example
      of this type of adaptation.
   b. __________________ adaptations involve the way organisms act; hunting
      at night is an example of this type of adaptation.
   c. __________________ adaptations involve internal body systems that affect
      organisms’ biochemistry; expanding blood vessels that cool a jackrabbit’s blood is
      an example of this type of adaptation.

3. A structural adaptation that aids members of a species in blending in with their
   environment is called __________________.

4. An adaptation in which one species resembles another species is
   called __________________.

5. The living and the nonliving parts of the __________________ are always
   changing; species that cannot __________________ to such changes will
   become extinct.

D. Artificial Selection

1. Darwin’s theory of evolution by __________________ predicts that species
   will develop adaptations and, therefore, eventually closely match Earth’s changing
   environments.

2. __________________ is the breeding of organisms for desired characteristics.

3. Darwin realized that __________________ and __________________ are similar processes.
   a. In __________________, nature causes the changes in the species; in
      __________________, humans cause the changes in the species.
   b. For this reason, Darwin called selective breeding __________________ selection.

4. __________________ explains and supports Darwin’s theory.
Who survives?

Camouflage helps organisms blend in. This can help them avoid predators or sneak up on prey. Camouflage helps organisms survive in their environments.

Procedure

1. Read and complete a lab safety form.
2. Choose an area of your classroom where your moth will rest with open wings during the day.
3. Use scissors, paper, markers, and a ruler to design a moth that measures 2–5 cm in width with open wings and will be camouflaged where it is placed. Write the location where the moth is to be placed. Give the location and your completed moth to your teacher.
4. On the following day, you will have 1 minute to spot as many moths in the room as you can.
5. In the Data and Observations section below, record the location of moths spotted by your team.
6. Find the remaining moths that were not spotted. Observe their appearance.

Data and Observations

Analyze and Conclude

1. Compare the appearances and resting places of the moths that were spotted with those that were not spotted.

2. **Key Concept** Explain how camouflage enables an organism to survive in its environment.
Content Practice A

LESSON 2

Theory of Evolution by Natural Selection

Directions: Complete the concept map by choosing terms from the word bank and writing them on the correct lines. Each term is used only once.

behavioral  extinction  functional  structural  variations

Theory of Evolution by Natural Selection

Environmental changes

1. ______________________

2. ______________________  survival

adaptations

3. ______________________  4. ______________________  5. ______________________
Theory of Evolution by Natural Selection

Directions: On each line write the letter of the term from the word bank that matches the definition correctly. Some terms will not be used.

A. adaptations  E. ancestor  I. artificial selection
B. behavioral adaptation  F. camouflage  J. functional adaptation
C. mimicry  G. naturalist  K. natural selection
D. selective breeding  H. structural adaptation  L. variations

1. the breeding of organisms for desired characteristics
2. characteristics of a species that enable it to survive
3. explains how populations change as their environment changes
4. slight differences in the appearance of individual members of a species
5. an adaptation that involves the way an organism behaves
6. an adaptation that enables a species to blend in with its environment
7. an adaptation that involves internal body systems that affect biochemistry
8. an adaptation that involves color, shape, and other physical characteristics
9. the resemblance of one species to another species
10. the results of selective breeding
**School to Home**

**LESSON 2**

**Theory of Evolution by Natural Selection**

**Directions:** Use your textbook to complete the table. The table below lists four steps that contribute to the process of natural selection. For each step listed in the first column, describe its importance in the space provided in the second column.

<table>
<thead>
<tr>
<th>Natural Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1: Reproduction</strong></td>
</tr>
<tr>
<td>a.</td>
</tr>
<tr>
<td><strong>Step 2: Variation</strong></td>
</tr>
<tr>
<td>b.</td>
</tr>
<tr>
<td><strong>Step 3: Competition</strong></td>
</tr>
<tr>
<td>c.</td>
</tr>
<tr>
<td><strong>Step 4: Selection</strong></td>
</tr>
<tr>
<td>d.</td>
</tr>
</tbody>
</table>
The Theory of Evolution by Natural Selection

Key Concept Who was Charles Darwin?

Directions: On each line, write the word or term that correctly completes each sentence.

Charles Darwin was an English 1. __________________ who lived in the 1800s. He was interested in plants and 2. __________________, and spent long hours studying their habitats. While serving as a naturalist on the British naval ship, the 3. __________________, Darwin had the opportunity to study plant and animal life on the 4. __________________. What he found fascinated him.

The Galápagos Islands are found off the coast of 5. __________________ in the Pacific Ocean. Darwin found the environments on the Galápagos Islands quite different. Some were 6. __________________. Some were more humid. Others were a mix of environments. Giant 7. __________________ lived on the islands, but as Darwin learned, the tortoises on each island looked different. This made Darwin curious. Darwin also found that a variety of 8. __________________ and finches lived on the Galápagos Islands. He determined that he had come across several different 9. __________________.

Darwin realized that a 10. __________________ existed between species and food sources on the islands. Importantly, he recognized that the tortoise species were related. He believed they shared a common 11. __________________. But, why were they so different? Some tortoises had short necks; some had long necks. Darwin's observations showed that tortoises with 12. __________________ necks lived on islands with short grass. Tortoises with 13. __________________ necks could stretch them and gobble the cacti growing on the island.

Darwin decided that the 14. __________________ he observed were a key to how organisms evolve. He developed the theory of evolution by 15. __________________. This theory says that populations of organisms with 16. __________________ that help them survive in their environment live longer, compete better, and 17. __________________ more than those that do not have the variations. Darwin believed he found the understanding of how 18. __________________ change as their environments change.
The Theory of Evolution by Natural Selection

Key Concept: How does Darwin’s theory of evolution by natural selection explain how species change over time?

Directions: Use the diagram to answer each question or respond to each statement on the lines provided.

1. What is natural selection?

2. What happens to characteristics found in one generation of a species as it reproduces and has offspring?

3. What is a variation?

4. How do variations in a species occur?

5. How are variations part of the theory of evolution by natural selection?

6. How does natural selection explain the diversity of species Darwin observed on the Galápagos Islands?
The Theory of Evolution by Natural Selection

Key Concept  How does Darwin’s theory of evolution by natural selection explain how species change over time?

Directions: On each line, write V if the statement is about variations or A if the statement is about adaptations.

1. There are three categories of these: structural, behavioral, and functional.  
2. If this is helpful to one individual, it can spread to all members of a population.  
3. Every species has many of these.  
4. An example is a jackrabbit’s powerful legs.  
5. These are slight differences in the appearance of individual members of a species.  
6. These arise naturally in populations.  
7. These are a result of random mutations in an animal’s phenotype.  
8. Moving in herds for protection is an example of this.  
9. A drop in body temperature as characteristic of a species is an example of this.  
10. More of these occur as time passes, so they eventually accumulate.  
11. This is characteristic of a species and enables the species to survive in an environment.  
12. These involve color and shape seen in an entire species.  
13. As a result of natural selection, these spread from one individual to other members of a population.  
14. All members of the saddleback tortoise have these.  
15. These might help a few members of a population compete for food.
**The Theory of Evolution by Natural Selection**

**Key Concept** How are adaptations evidence of natural selection?

**Directions:** Respond to each statement in the space provided.

<table>
<thead>
<tr>
<th>Environmental Adaptations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Explain</strong> camouflage. Draw an example showing how camouflage helps an animal survive.</td>
</tr>
<tr>
<td>2. <strong>Explain</strong> mimicry. Draw an example of how mimicry helps an animal survive.</td>
</tr>
<tr>
<td>3. <strong>Explain</strong> selective breeding, including why selective breeding is not a change caused by natural selection.</td>
</tr>
<tr>
<td>4. <strong>Describe</strong> a structural adaptation that affects mouth shape. Draw an example of a mouth-shape adaptation.</td>
</tr>
<tr>
<td>5. <strong>Explain</strong> what happens to a species if it is unable to adapt to environmental changes. Give an example of how the environment might quickly change such that a species would not have time to adapt.</td>
</tr>
</tbody>
</table>
Charles Darwin’s Adventure

Darwin was just 22 years old when he was recommended to join the British crew of the HMS Beagle in its five-year mapping expedition.

The HMS Beagle’s captain was charged with mapping the coast of South America. For three years, Darwin trekked and collected fossils along the coast of South America. He walked and explored, and would meet the ship in a port down the coast several months later.

The Galápagos Islands

Finally, with Darwin aboard, the Beagle left the South American coast. They made port on one of the Galápagos Islands, 1000 km (620 mi) to the east. These islands were a popular shipping stop, where crews would hunt the large tortoises and purchase goats from the British governor. In this way, the crews of all the ships that stopped there would stock up on supplies, make repairs, and purge their ships of rats and other vermin before setting sail again.

Applying Critical-Thinking Skills

Directions: Answer each question or respond to each statement.

1. **Analyze** Invasive or exotic species are one of the major threats to biodiversity. These are species that are taken from one environment and put into another environment. These species often grow out of control, outcompete, and crowd out the native species. Choose two animals mentioned in the article that may be invasive or exotic and explain how they each might damage the ecology of the Galápagos Islands.

2. **Infer** What might have been an advantage for Darwin to not publish his theory on natural selection for more than 30 years after his expedition on the HMS Beagle?

3. **Describe** What is meant by the statement that the five weeks Darwin spent on the Galápagos Islands may have been one of the most important stopovers in the history of biological science?
**Challenge**

**Predators and Prey**

Predators and prey have a wide variety of adaptations to find food or to avoid being eaten. One strategy involves looking like a predator in the way that the harmless king snake mimics the poisonous coral snake. Another strategy relies on being highly identifiable. Some poisonous frogs are brilliantly colored. A predator learns after one experience to leave that one alone. Some species use camouflage to blend into the background, such as a beetle that looks like the leaf it sits on.

**Analyze the Advantage of Variation**

What happens if the background changes? Consider what might happen to a population of lizards if their background environment changed. Say you have studied this lizard species for six years and kept track of its population numbers. The lizard species has two variations: a straw-colored variant and a gray-colored variant. The species’ main habitat is in the semiarid grasslands of the central plains of the United States. In the open plain, the straw-colored variant is dominant. In one area, irrigation began in January of 2004 to support the farming of food crops. In this area, over a period of six years, you have collected the following population data:

**Directions:** Answer the following questions on a separate sheet of paper.

<table>
<thead>
<tr>
<th>End of Year</th>
<th>Straw-Colored Lizards</th>
<th>Gray-Colored Lizards</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>550</td>
<td>70</td>
</tr>
<tr>
<td>2005</td>
<td>240</td>
<td>150</td>
</tr>
<tr>
<td>2006</td>
<td>480</td>
<td>200</td>
</tr>
<tr>
<td>2007</td>
<td>400</td>
<td>220</td>
</tr>
<tr>
<td>2008</td>
<td>260</td>
<td>280</td>
</tr>
<tr>
<td>2009</td>
<td>200</td>
<td>350</td>
</tr>
</tbody>
</table>

1. During which year of study were the two variations closest in number?
2. What reason can be inferred for the change in color-variation dominance over the period of this study?
3. If you have concluded that human impact has had an influence on the population of lizards, explain why this is not selective breeding.
Lesson Quiz A

Theory of Evolution by Natural Selection

True or False

Directions: On the line before each statement, write T if the statement is true or F if the statement is false. If the statement is false, change the underlined word(s) to make it true. Write your changes on the lines provided.

____ 1. Charles Darwin was a naturalist.

____ 2. The breeding of organisms for desired characteristics is called natural selection.

____ 3. Camouflage is the resemblance of one species to another species.

Multiple Choice

Directions: On the line before each question or statement, write the letter of the correct answer.

____ 4. How did Charles Darwin study plants and animals?
   A. by making scientific models
   B. by experimenting in the laboratory
   C. by observing them in their habitats

____ 5. A jackrabbit’s powerful legs are an example of a
   A. structural adaptation.
   B. functional adaptation.
   C. behavioral adaptation.

____ 6. Mutations in genes cause
   A. variation.
   B. competition.
   C. reproduction.

____ 7. According to Darwin’s theory, what process causes populations to change as their environment changes?
   A. natural selection
   B. artificial selection
   C. selective breeding
Lesson Quiz  B

Theory of Evolution by Natural Selection

Short Answer

Directions: Respond to each statement on the lines provided.

1. Describe how a naturalist such as Darwin studies plants and animals.
   ____________________________________________________________
   ____________________________________________________________

2. Explain why artificial selection supports Darwin’s theory of natural selection.
   ____________________________________________________________
   ____________________________________________________________

3. Compare and contrast camouflage and mimicry.
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

4. Relate variations in a population to genetic mutations.
   ____________________________________________________________
   ____________________________________________________________

5. Identify the process that causes species to change when their environments change.
   ____________________________________________________________
   ____________________________________________________________

Completion

Directions: On each line, write the term from the word bank that correctly completes each sentence. Not all terms are used.

<table>
<thead>
<tr>
<th>behavioral</th>
<th>environmental</th>
<th>functional</th>
<th>structural</th>
</tr>
</thead>
</table>

6. Traveling in a herd is a(n) __________________________ adaptation.

7. The shape and size of a bird’s bill is a(n) __________________________ adaptation.

8. A decrease in body temperature during hibernation is a(n) __________________________ adaptation.
## Lesson 3 | Biological Evidence of Evolution

<table>
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<td>all students</td>
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<td>Content Vocabulary [ELL]</td>
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<td>Lesson Outline [ELL]</td>
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<td>MiniLab</td>
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<td>School to Home</td>
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<tr>
<td>Key Concept Builders</td>
<td>55</td>
<td>AL</td>
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<tr>
<td>Enrichment</td>
<td>59</td>
<td>all students</td>
</tr>
<tr>
<td>Challenge</td>
<td>60</td>
<td>BL</td>
</tr>
<tr>
<td>Lab A</td>
<td>63</td>
<td>AL</td>
</tr>
<tr>
<td>Lab B</td>
<td>66</td>
<td>OL   BL</td>
</tr>
<tr>
<td>Lab C</td>
<td>69</td>
<td>BL</td>
</tr>
<tr>
<td>Chapter Key Concepts Builder</td>
<td>70</td>
<td>AL</td>
</tr>
</tbody>
</table>

### Assessment

<table>
<thead>
<tr>
<th></th>
<th>Page</th>
<th>Appropriate For:</th>
</tr>
</thead>
<tbody>
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<td>AL</td>
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<td>Lesson Quiz B</td>
<td>62</td>
<td>OL   BL</td>
</tr>
<tr>
<td>Chapter Test A</td>
<td>71</td>
<td>AL</td>
</tr>
<tr>
<td>Chapter Test B</td>
<td>74</td>
<td>OL</td>
</tr>
<tr>
<td>Chapter Test C</td>
<td>77</td>
<td>OL</td>
</tr>
</tbody>
</table>

### Teacher Support

Answers (with Lesson Outlines) | T6


Teacher evaluation will determine which activities to use or modify to meet any [ELL] student's proficiency level.
How is the structure of a spoon related to its function?

Would you eat your morning cereal with a spoon that had holes in it? Is using a teaspoon the most efficient way to serve mashed potatoes and gravy to a large group of people? How about using an extra large spoon, or ladle, to eat soup from a small bowl?

**Procedure**

1. Read and complete a lab safety form.
2. In a small group, examine your set of spoons and discuss your observations.
3. Sketch or describe the structure of each spoon in the Data and Observations section below. Discuss the purpose that each spoon shape might serve.
4. Label the spoons in your Science Journal with their purposes.

**Data and Observations**

**Think About This**

1. **Describe** the similarities and differences among the spoons.

   __________________________________________________________

   __________________________________________________________

   __________________________________________________________

2. If spoons were organisms, what do you think the ancestral spoon would look like?

   __________________________________________________________

3. **Key Concept** Explain how three of the spoons have different structures and functions, even though they are related by their similarities.

   __________________________________________________________

   __________________________________________________________

   __________________________________________________________
Biological Evidence of Evolution

Directions: On each line, write the term from the word bank that correctly completes each sentence. NOTE: You may need to change a term to its plural form.

analogous structure      comparative anatomy      embryology
homologous structure    vestigial structure

1. The forelimbs of bats, humans, and frogs are examples of ____________________.

2. The wings of birds and flies are examples of ____________________.

3. The wings of flightless cormorants are examples of ____________________.

4. A scientist working in the field of ____________________ might research the development of internal structures of organisms before the organisms are born.

5. ____________________ is the study of the similarities and differences among structures of living species.
Biological Evidence of Evolution

A. Evidence for Evolution

1. Evolution does not occur in a straight line with one species
   __________________________ another in a series of orderly steps.
   a. Living species that are closely related share a
      common ______________________.
   b. How closely related two species are depends when they
      __________________________, or split, from their common ancestor.

2. The study of similarities and differences among structures of living species is
called ______________________.
   a. Body parts of organisms that are similar in position but different in function are
called ______________________. The forelimbs of different mammals are
   examples.
   b. If species have homologous structures, this suggests that the species
      are ______________________.
   c. The more similar two structures are to each other, the more likely it is that the
      species have evolved from a recent ______________________.
   d. ______________________ are body parts that perform a similar function but
differ in structure. The wings of flies and birds are examples.
   e. The existence of analogous structures indicates that the species are
      not ______________________ related.

3. Body parts that have lost their original function through evolution are called
   ______________________. The ______________________ of flightless birds are
   an example.
   a. The best explanation for ______________________ is that the species that have
      vestigial structures are ______________________ to ancestral species that still
      use the structures for a specific purpose.
   b. Whales have a tiny ______________________ bone, which is a vestigial
      structure for walking on land.
Lesson Outline continued

4. Studying the development of ________________ can also provide scientists with evidence that certain species are related.
   a. ________________ is the study of the development of embryos from fertilization to birth.
   b. All species of ________________ have pharyngeal pouches at some stage during their development.
   c. The similarities in location and function of the ________________ is a sign that the vertebrate species share a common ancestor.

5. The study of gene structure and function is called ________________.
   a. The existence of ________________ provides evidence of evolution because they have been shown to be the source of variation upon which ________________ acts.
   b. The more closely related two species are, the more similar their ________________ and ________________ are.
   c. Studies in molecular biology have shown that some stretches of ________________ that are common to many species change through time at steady, predictable rates like a kind of molecular clock.
   d. Scientists use this molecular clock to estimate the time in the past when living species ________________ from common ancestors.

B. The Study of Evolution Today

1. Since the publication of Darwin’s theory, scientists have ________________, refined, and ________________ his work.

2. Scientific studies of fossils, anatomy, embryology, and molecular biology have provided evidence of relatedness among ________________ and ________________ species.

3. The continuous discovery of new ________________ that have features of species that lived before and after them is strong evidence of evolution of species.

4. Scientists today are studying how ________________ can be reorganized in simple ways that cause dramatic changes in organisms.

5. Though scientists now study evolution at the ________________ level, the basic principles of Darwin’s theory of evolution by natural selection have remained unchanged for more than ________________ years.
**How related are organisms?**

Proteins, such as cytochrome \(c\), are made from combinations of just 20 amino acids. The graph below shows the number of amino acid differences in cytochrome \(c\) between humans and other organisms.

**Procedure**

Use the graph at the right to answer the questions below.

**Analyze and Conclude**

1. Identify Which organism has the least difference in the number of amino acids in cytochrome \(c\) compared to humans? Which organism has the most difference?

2. Infer Which organisms do you think might be more closely related to each other: a dog and a turtle or a dog and a silkworm? Explain your answer.

3. **Key Concept** Notice the differences in the number of amino acids in cytochrome \(c\) between each organism and humans. How might these differences explain the relatedness of each organism to humans?
Biological Evidence of Evolution

Directions: Label the diagram by writing the correct term from the word bank on each line.

- analogous structures
- comparing sequences
- developmental biology
- divergence
- homologous structures
- vestigial structures

Biological Evidence of Evolution

1. comparative anatomy
2. pharyngeal pouches
3. diversity
4. molecular biology
5.
6.
Content Practice B

Biological Evidence of Evolution

Directions: On each line, write the letter of the term that correctly matches the definition. Some terms may be used more than once or not at all.

1. body parts of organisms that are similar in structure but not in function
   A. comparative anatomy
   B. homologous structures
   C. analogous structures
   D. vestigial structures
   E. developmental biology
   F. pharyngeal pouches
   G. molecular biology
   H. evolution
   I. divergence
   J. embryology
   K. diversity

2. the study of life from fertilization to birth

3. several species that share a common ancestor

4. the study of gene structure and function

5. the study of similarities and differences among structures of organisms

6. body parts of organisms that form a similar function but differ in structure

7. a body part shared by all vertebrate embryos at different stages of development

8. structures that suggest particular species are related

9. the use of a molecular clock helps scientists to understand this

10. body parts that are present but no longer have a function

11. Differences in these structures suggest that certain species are not related.

12. body part found in fish, reptiles, birds, and humans during development

13. field of study that looks at gene sequences

14. the pelvic bones found in whales as an example
Biological Evidence of Evolution

Directions: Use your textbook to answer each question.

1. Homologous structures are body parts that are similar in structure and position but differ in function.
   How do homologous structures support the theory that many Earth species are related?

2. Some organisms have body parts, called vestigial structures, that no longer serve their original function.
   What is the best explanation for the presence of vestigial structures?

3. Developmental biology is the science of the development of embryos from fertilization to birth.
   What does the presence of pharyngeal pouches during the development of fish and other vertebrates suggest?

4. Molecular biology is the study of gene structure and function.
   How can genes be used to determine how closely two species are related?

5. Some DNA sequences mutate at a regular, predictable rate. This molecular clock is a tool scientists use to learn about species.
   How can scientists use this information to learn about the relationships between species?
Key Concept Builder

Biological Evidence of Evolution

Key Concept  What evidence from living species supports the theory that species descended from other species over time?

Directions: Use the diagram to answer each question on the line provided.

1. What do living species that are closely related share?

2. What does the degree to which a species is related depend on?

3. What do scientists study when they are looking for ancestral relationships?

4. What is comparative anatomy?

5. What other information could you add to the comparative anatomy oval?

6. How are vestigial structures evidence of evolution?

7. What other information could you add to the developmental biology oval?

8. What evidence does molecular biology provide of evolution?
**Biological Evidence of Evolution**

**Key Concept** What evidence from living species supports the theory that species descended from other species over time?

**Directions:** Answer each question in the space provided.

<table>
<thead>
<tr>
<th>Evidence of Evolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Homologous Structures</strong></td>
</tr>
<tr>
<td>1. What are examples of homologous structures, and how are they evidence of evolution?</td>
</tr>
<tr>
<td><strong>Vestigial Structures</strong></td>
</tr>
<tr>
<td>4. What are vestigial structures, and how are they evidence of evolution?</td>
</tr>
<tr>
<td><strong>Analogous Structures</strong></td>
</tr>
<tr>
<td>2. What are examples of analogous structures, and how are they evidence of evolution?</td>
</tr>
<tr>
<td><strong>Comparing Sequences</strong></td>
</tr>
<tr>
<td>5. Why are DNA strands evidence of evolution?</td>
</tr>
<tr>
<td><strong>Pharyngeal Pouches</strong></td>
</tr>
<tr>
<td>3. What are pharyngeal pouches, and how are they evidence of evolution?</td>
</tr>
<tr>
<td><strong>Divergence</strong></td>
</tr>
<tr>
<td>6. How is divergence evidence of evolution?</td>
</tr>
</tbody>
</table>
**Biological Evidence of Evolution**

**Key Concept** How are Earth’s organisms related?

**Directions:** On each line, write the term from the word bank that correctly completes each sentence. Some terms may be used more than once or not at all.

**Key Concept Builder**

1. According to the diagram, ________________ among mammals took place about 75 mya.
2. Scientists are able to determine common ________________ by studying molecular data.
3. Darwin’s theory of evolution by ________________ states that animals change over long periods of time.
4. Scientists are closely studying how ________________ reorganize themselves.
5. Some scientists, however, think new ________________ evolve quickly.
6. Still, among scientists, the principles of ________________ remain unchanged and highlight how animals evolve.
7. The main tool for the study of evolution is careful observation of ________________ and the anatomy of animals.
8. Scientists also study animal ________________.
9. What no one doubts is the wide ________________ among organisms on Earth.
10. The ________________ that took place among mammals helps us understand why whales and dolphins are ________________ and not fish.
Biological Evidence of Evolution

Key Concept  How are Earth’s organisms related?

Directions: Use the flowchart to answer each question on the lines provided.

1. What is the debate among scientists on how new species form?

2. How does divergence explain how organisms on Earth are related?

3. How do genes play a role in diversity?

4. Why is the theory of natural selection part of the study of evolution?
Can you learn about dinosaurs by watching birds at a feeder? Scientists generally agree that dinosaurs were a type of reptile and that birds descended from reptiles. Scientists don’t agree, however, on how closely birds are related to dinosaurs.

**Comparing Traits**

To see how closely related birds might be to dinosaurs, scientists compare and contrast living birds with fossils of primitive species that might be related to birds. Using complex computer programs, they look for matches in at least 80 physical traits of modern birds. These traits include the skull, teeth, neck, pelvis, tail, shoulder, bones, feet, ankles, and stance.

Scientists have found several species of dinosaurs that had feathers. Several other dinosaur species have bones that are similar to modern birds but unlike any other living animal. Some dinosaurs also had wrists that could bend in a flapping motion, like a wing, and toes that were arranged so they could grasp branches.

**Mismatched Traits**

Other traits make some scientists question the relationship between birds and dinosaurs.

After studying photographs of dinosaur fossils, some scientists think the abdominal cavity of several birdlike dinosaurs was more like those of modern-day crocodiles than birds. Crocodiles have a division in the chest cavity that allows the lungs to fill with air. When muscles attached to the liver and diaphragm contract, air is pulled into the lungs. Birds, in contrast, do not have this system. They have lungs that allow air to flow through them without the help of a diaphragm.

**Not a Simple Question**

Before deciding if there is a link between birds and dinosaurs, scientists still must answer several questions. Were dinosaurs cold-blooded (like reptiles) or warm-blooded (like birds)? Some dinosaurs with feathers probably could not fly. Did the feathers develop to attract mates, or did they develop to insulate the dinosaurs? If the feathers could keep the dinosaurs warm, the dinosaurs may have been warm-blooded.

It’s likely that only one-fourth of all dinosaurs have been found in the fossil record so far. That means that many links between birds and dinosaurs or between birds and another ancestor have yet to be found.

**Applying Critical-Thinking Skills**

Directions: Answer each question or respond to each statement.

1. **Classify** How would you define *bird*, if a dinosaur with feathers is not a bird?

2. **Evaluate** A species called *Microraptor zhaoianus* had feathers and toes that could have grasped tree branches, yet it probably could not fly. It had lightweight bones similar in structure to modern-day birds’ bones. It had a long tail like a dinosaur’s, and its teeth were arranged like those of a dinosaur. Other dinosaur “birds” were much larger, however. *Microraptor* was about as big as a crow. Does any of this information help you answer the following questions: Are birds modern-day dinosaurs? Were dinosaurs cold- or warm-blooded? Did birds learn to fly from the ground up or from the trees down? Explain.
Is It Homology or Analogy?

Scientists often consider species in relation to one another to detect patterns of evolution. Some relationships are obvious, or seem to be, such as the beaks of certain birds. Other relationships are not as clearly obvious.

**Homology**

Homologous structures in different species may or may not be similar in appearance. These structures often perform different functions. They are homologous because they arise from a structure in a shared ancestor. A penguin’s flipper and an alligator’s foreleg are homologous structures. They have the same bones, although they are different in shape—one is used for swimming and the other for walking on land.

**Analogy**

Analogous structures have an *identical* function and could even be vaguely similar in appearance, but they have different internal anatomy and different origins. A bird’s wing and a bee’s wing are analogous, for example.

**Vestigial**

Many organisms have structures that have no known function at all. The feature seems to be something left over from an ancestor that evolution just hasn’t gotten rid of quite yet. This is exactly what a vestigial structure is—like a human appendix.

**Classify Body Parts**

Examine the list of animal structures below. Sort them into three lists of three according to whether they are vestigial, homologous, or analogous features. Then construct a three-page brochure that illustrates each set of structures and that explains what they are and why you have categorized them as you have. You may draw the structures or find pictures to cut out.

- your nose, airplane wing, human tailbone, bat wing, a pig’s snout, butterfly wing, whale pelvic bone, an elephant’s trunk, cormorant wing
Biological Evidence of Evolution

Matching

Directions: On the line before each definition, write the letter of the term that matches it correctly. Each term is used only once.

Matching Set 1

1. body parts that are similar in structure and position but different in function
   - A. vestigial structures
   - B. analogous structures
   - C. homologous structures

2. body parts that have lost their original function through evolution
   - A. vestigial structures
   - B. analogous structures
   - C. homologous structures

3. body parts that are similar in function but different in structure
   - A. vestigial structures
   - B. analogous structures
   - C. homologous structures

Matching Set 2

4. study of the similarities and differences among structures of living species
   - D. embryology
   - E. molecular biology
   - F. comparative anatomy

5. study of gene structure and function

6. study of embryos from fertilization to birth

Multiple Choice

Directions: On the line before each question, write the letter of the correct answer.

7. Which statement is NOT a theory about how change occurs in species?
   - A. Change happens in quick bursts.
   - B. Change happens in a slow, steady way.
   - C. Change happens only when a species becomes extinct.

8. Why is the formation of new species difficult to study?
   - A. Species formation occurs too rapidly to be observed.
   - B. The fossil record of species formation is incomplete.
   - C. Evidence of species formation has not been discovered.
Lesson Quiz B

Biological Evidence of Evolution

Completion

Directions: On each line, write the term that correctly completes each sentence.

1. The tiny pelvic bones found in whales are an example of ______________________.
2. ______________________ is the study of similarities and differences among the structures of living things.
3. Insect wings and bird wings are examples of ______________________.
4. Human arms and bat wings are examples of ______________________.
5. The study of gene structure and function is called ______________________.
6. ______________________ is the study of embryos from fertilization to birth.

Short Answer

Directions: Respond to each statement on the lines provided.

7. Describe two differing scientific ideas about the rate at which species change.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

8. Identify two reasons that species formation is difficult to study.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Lab A

Model Adaptations in an Organism

Conditions on our planet have changed since Earth formed over 4.5 billion years ago. Changes in the amounts of gases in the atmosphere, the temperature, and the amount of precipitation make Earth different today from when it first formed. Other events, such as volcanic eruptions, meteorite strikes, tsunamis, or wildfires, can suddenly change the conditions in certain environments. As you have read, Earth’s fossil record provides evidence that, over millions of years, many organisms developed adaptations that allowed them to survive as conditions on Earth changed.

Ask a Question
How do adaptations allow an organism to survive changes in the environment?

Materials
clay colored pencils
colored markers toothpicks
construction paper
Also needed: creative construction materials, glue, scissors

Safety

Make Observations

☐ 1. Read and complete a lab safety form.
☐ 2. Get Version 1.0 of the organism you will model from your teacher.
☐ 3. Your teacher will describe Event 1 that has occurred on Earth while your organism is alive.
   ☐ Use markers and a piece of construction paper to design adaptations to your organism that would allow it to survive the changing conditions that result from Event 1.
   ☐ Label the adapted organism Version 1.1.
☐ 4. For each event that your teacher describes, design and draw the adaptations that would allow your organism to survive the changing conditions.
   ☐ Label each new organism Version 1.X, filling in the X with the next version number.
☐ 5. Use the materials provided to make a model of the final version of your organism, showing all of the adaptations.
Lab Tips

- Make sure you think of all of the implications of an environmental change event before you decide upon an adaptation.
- Decide upon your reasoning for the adaptation before putting the adaptation on your model.

Form a Hypothesis

6. After reviewing and discussing all of the adaptations of your organism, form a hypothesis about how physical adaptations help an organism survive changes to the environment.

Test Your Hypothesis

7. Research fossil record evidence that shows an adaptation that developed and allowed one type of organism to survive under the conditions of a major environmental event.
   - Describe the major environmental event.
   - Describe the adaptation that you will research.

8. Record the information about that adaptation.
9. **Compare** the adaptations that the different groups gave their organisms to survive each event described by your teacher.

What kinds of different structures were created to help each organism survive?

**The Big Idea**

Describe three variations in human populations that would allow some individuals to survive severe environmental changes.

**Communicate Your Results**

Present your completed organisms to the class and/or judges of “Ultimate Survivor.” Explain the adaptations and the reasoning behind them in either an oral presentation or a demonstration, during which classmates and/or judges will review the models.
Lab B

2 class periods

Model Adaptations in an Organism

Conditions on our planet have changed since Earth formed over 4.5 billion years ago. Changes in the concentrations of gases in the atmosphere, temperature, and the amount of precipitation make Earth different today from when it first formed. Other events, such as volcanic eruptions, meteorite strikes, tsunamis, or wildfires, can drastically and rapidly change the conditions in certain environments. As you have read, Earth’s fossil record provides evidence that, over millions of years, many organisms developed adaptations that allowed them to survive as Earth’s environmental conditions changed.

Ask a Question
How do adaptations allow an organism to survive changes in the environment?

Materials
clay colored pencils
colored markers toothpicks
construction paper

Also needed: creative construction materials, glue, scissors

Safety

Make Observations
1. Read and complete a lab safety form.
2. Obtain Version 1.0 of the organism you will model from your teacher.
3. Your teacher will describe Event 1 that has occurred on Earth while your organism is alive. Use markers and a piece of construction paper to design adaptations to your organism that would allow it to survive the changing conditions that result from Event 1. Label the adapted organism Version 1.1.
4. For each event that your teacher describes, design and draw the adaptations that would allow your organism to survive the changing conditions. Label each new organism Version 1.X, filling in the X with the appropriate version number.
5. Use the materials provided to make a model of the final version of your organism, showing all of the adaptations.
Lab B continued

Form a Hypothesis

6. After reviewing and discussing all of the adaptations of your organism, formulate a hypothesis about how physical adaptations help an organism survive changes to the environment.

________________________________________

________________________________________

________________________________________

Test Your Hypothesis

7. Research evidence from the fossil record that shows one adaptation that developed and enabled an organism to survive over time under the conditions of one of the environmental events experienced by your model organism. Describe the adaptation that you will research in the space below.

________________________________________

________________________________________

________________________________________

8. Record the information about that adaptation.

________________________________________

________________________________________

________________________________________

________________________________________

Lab Tips

- Make sure you think of all of the implications of an environmental change event before you decide upon an adaptation.
- Decide upon your reasoning for the adaptation before putting the adaptation on your model.
Lab B continued

Analyze and Conclude

9. **Compare** the adaptations that the different groups gave their organisms to survive each event described by your teacher. What kinds of different structures were created to help each organism survive?

10. **The Big Idea** Describe three variations in human populations that would allow some individuals to survive severe environmental changes.

Communicate Your Results

Present your completed organisms to the class and/or judges of “Ultimate Survivor.” Explain the adaptations and the reasoning behind them in either an oral presentation or a demonstration, during which classmates and/or judges will review the models.

**Extension**

Compare the organisms made by groups in your class to the organisms created by groups in other sections. Observe the differences in the adaptations of the organisms. In each section, the events were presented in a different order. How might this have affected the final appearance and characteristics of the different organisms?
Beyond Darwin

Directions: Use the information and data from the Lab Model Adaptations in an Organism to perform this lab.

You have learned that major environmental events in Earth’s history caused some species to perish while other species thrived. Species with characteristics that were favorable under the new environmental conditions were able to find food and reproduce, gradually changing the characteristics of future generations. Although Charles Darwin is rightfully credited with publishing these and other insights into evolution, he was not the first or last person to move evolutionary biology forward. In this investigation, you will research some of the other great thinkers and place a summary of their contributions on a time line of evolutionary thought. You will then consider the lab Model Adaptations in an Organism that you completed and infer how the lab relates to each of the ideas put forth.

• Jean Baptiste Lamarck
• Carolus Linnaeus
• Thomas Malthus
• Ernst Mayr
• Gregor Mendel
• James Watson and Francis Crick
• Alfred Russel Wallace
• Alfred Wegener

Please note that you must complete Lab B before beginning Lab C. Also, have your teacher approve your design and safety procedures before beginning your experiment.
The Environment and Change Over Time

End-of-Chapter Practice

Directions: Work with a partner to study trilobite fossils.

Background Information: Some 450–400 mya, a shallow sea covered Wisconsin. The land mass was south of the Equator. The coral reef of the warm sea was alive with trilobites.

- You and your partner will research the evolution and extinction of trilobites and use the information for visual presentation. First, plan your research.

<table>
<thead>
<tr>
<th>Ways to study trilobite fossils:</th>
<th>Places to find information on environmental changes over the last 500 million years.</th>
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Then,

- Make a careful observation of trilobite fossils. Take detailed notes.
- Why are trilobites considered arthropods?
- Create a chart to show where trilobites fit into the evolution of species.
- Do trilobites show evidence of any adaptations that helped them survive for 250 million years? Did the environment change?
- Create a visual presentation on the evolution and extinction of trilobites.

- Team up with other students in your class to share information and create a class presentation.
- Present the history of trilobites to your class.
- Be prepared to answer questions from students and your teacher.

The presentation should include the following:
- observations of trilobite fossils or photos of trilobite fossils
- interesting and informative chart or diagrams
- equal participation by everyone
Chapter Test A

The Environment and Change Over Time

Multiple Choice
Directions: On the line before each question or statement, write the letter of the correct answer.

____ 1. Which process forms fossils?
   A. variation
   B. adaptation
   C. mineralization

____ 2. The sudden disappearance of a type of fossil in the fossil record is evidence of
   A. extinction.
   B. camouflage.
   C. carbonization.

____ 3. Homologous body parts do NOT always have similar
   A. locations.
   B. functions.
   C. structures.

____ 4. Patterns in the fossil record show that species on Earth
   A. change over time.
   B. adapt to all environmental changes.
   C. appear on Earth independent of existing species.

____ 5. What determines how closely related two species are?
   A. how much they compete for food
   B. how closely they live to one another
   C. how recently they shared a common ancestor

Matching
Directions: On the line before each definition, write the letter of the term that matches it correctly. Each term is used only once.

____ 6. studying relationships between organisms by comparing their structures
   A. molecular biology
   B. comparative anatomy
   C. embryology

____ 7. studying relationships between organisms by comparing their embryos

____ 8. studying relationships between organisms by comparing their genes and proteins
Interpreting a Diagram

Directions: Complete this concept map by choosing terms from the word bank and writing them in the correct spaces. Each term is used only once.

adaptation  behavioral  camouflage  functional  structural  variation

Through

natural selection,

a helpful

9. ___________________

can lead to an

adaptation

that can be classified as

10. ___________________

such as

13. ___________________

and

mimicry.

11. ___________________

such as

hunting at night.

12. ___________________

such as

change in body temperature during hibernation.
Short Answer

Directions: Respond to each statement on the lines provided.

14. **Identify** and describe two ways that scientists can find the age of a fossil.

15. **Explain** what a molecular clock is and identify what scientists can learn about two species by using a molecular clock.

16. **List** two observations that naturalist Charles Darwin used in the development of his theory of evolution by natural selection.

Concept Application

Directions: Respond to each statement on the lines provided. Use complete sentences.

17. **Predict** how environmental change would affect a species that could not adapt to the change.

18. **Explain** the formation of fossil casts and carbon films, and identify the types of organisms that leave each category of fossil behind.
Chapter Test  B

The Environment and Change Over Time

Multiple Choice

Directions: On the line before each question or statement, write the letter of the correct answer.

1. An example of a fossil formed by mineralization is
   A. an insect in amber.
   B. a mammoth in ice.
   C. a piece of petrified wood.
   D. a carbon outline of a fern.

2. Which situation offers evidence of extinction?
   A. appearance of a new species in the fossil record
   B. disappearance of a type of fossil in the fossil record
   C. appearance of several fossils with similar body plans
   D. presence of identical fossils throughout the fossil record

3. Which structure is homologous to the human arm?
   A. a fish’s gill
   B. a bird’s bill
   C. a bat’s wing
   D. an insect’s wing

Matching

Directions: On the line before each definition, write the letter of the term that matches it correctly. Some terms may be used more than once or not at all.

4. studying biological evolution by examining homologous structures
   A. molecular biology
   B. comparative anatomy
   C. embryology

5. studying biological evolution by comparing structures present in embryos, such as pharyngeal pouches

6. studying biological evolution by using the rate of mutations in genes as a tool

7. studying biological evolution by analyzing vestigial structures

8. studying biological evolution by determining similarity in organisms of cytochrome c

The Environment and Change Over Time
Interpreting a Diagram
Directions: Complete this concept map by choosing terms from the word bank and writing them in the correct spaces. Not all terms are used.

- behavioral
- camouflage
- divergence
- extinction
- homologous
- natural selection
- structural
- variation

Through

9. _______________

a helpful

10. _______________

can lead to an adaptation

that can be classified as

11. _______________

such as such as such as

12. _______________

such as hunting at night.

13. _______________

and mimicry.

such as change in body temperature during hibernation.
Chapter Test B continued

Short Answer

Directions: Respond to each statement on the lines provided.


15. Identify two facts about species on Earth that can be learned by examining patterns in the fossil record.

16. Compare two types of evidence that could be used to determine how closely related two species are.

17. Point out how Charles Darwin used observation to develop his theory of evolution by natural selection.

Concept Application

Directions: Respond to each statement on the lines provided. Use complete sentences.

18. Determine two possible changes that might occur in a green insect species if the green grass it uses for camouflage turns brown due to drought.
Chapter Test C

The Environment and Change Over Time

Multiple Choice
Directions: On the line before each question, write the letter of the correct answer.

1. Which type of fossil would best preserve an extinct organism’s internal organs and tissues?
   A. a cast fossil
   B. a trace fossil
   C. a mold fossil
   D. an original-material fossil

2. What can be inferred about a particular time period if fossils show a high rate of extinctions?
   A. There was no competition among species.
   B. There was a great amount of species adaptation.
   C. There were no similar species during the period.
   D. There was a large amount of environmental change.

3. Which would give you the most information about the function of a particular body structure?
   A. knowing other vestigial structures
   B. knowing other divergent structures
   C. knowing other analogous structures
   D. knowing other homologous structures

Completion
Directions: On each line, write the term from the word bank that correctly completes each sentence. Some terms may be used more than once or not at all.

comparative anatomy       embryology
molecular biology          vestigial structures

4. ______________________ provides evidence of evolution, such as the presence of pharyngeal pouches in different organisms during development.

5. Vestigial structures are evidence from ______________________ that show how species have changed over time.

6. In the field of ______________________, comparisons of cytochrome c give evidence of evolution.

7. ______________________, such as the study of homologous structures, shows how living species are related.

8. ______________________ includes the use of predictable rates of DNA mutation to determine the relatedness of species.
Interpreting a Diagram

Directions: Complete this concept map by writing the correct term in each space.

Through

natural selection,

a helpful

9. ______________

can lead to an

adaptation

that can be classified as

10. ______________

such as

11. ______________

such as

12. ______________

such as

mimicry.

functional

change in body temperature during hibernation.

hunting at night.

Short Answer

Directions: Respond to each statement on the lines provided.

13. Deduce whether natural selection would occur in an environment with unlimited resources. Explain your response.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
14. **Assess** how the geologic time scale might be different if it were created after absolute-age dating methods were developed.

________________________________________________________________________
________________________________________________________________________

15. **Defend** the following statement: In forming his theory of evolution, Darwin’s most important skill was observation.

________________________________________________________________________
________________________________________________________________________

**Concept Application**

**Directions:** Respond to each statement on the lines provided. Use complete sentences.

16. **Choose** an example to explain how a rise in the average temperature of a region could impact the usefulness of a particular adaptation in a population.

________________________________________________________________________
________________________________________________________________________

17. Scientists have discovered the fossils of two animal species. **Plan** a method that they could use to determine how closely related the two living species are. What would the fossils need to provide for the scientists to carry out their plan?

________________________________________________________________________
________________________________________________________________________

18. The fossil record consists of all the fossils ever discovered. **Explain** how the fossil record proves the occurrence of biological evolution.

________________________________________________________________________
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The Environment and Change Over Time
# Teacher Pages

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</table>

*The Environment and Change Over Time*
Lesson Outline for Teaching

Lesson 1: Fossil Evidence of Evolution

A. The Fossil Record

1. Fossils are the preserved remains or evidence of once-living organisms.
2. All the fossils ever discovered on Earth make up the fossil record.
3. Fossils help scientists figure out what species that no longer exist looked like when the organisms were alive.

B. Fossil Formation

1. Most fossils are formed of the hard parts of an organism.
2. Sometimes when the remains of an organism get buried in mud, wet sand, or other sediments under a body of water, the molecules that formed the remains get replaced by minerals in the water.
   a. This type of fossil formation is called mineralization.
   b. Most mineralized fossils are formed of shell or bone, but wood can also become a mineralized fossil.
3. In carbonization, a fossil forms when a dead organism is compressed over time and pressure drives off the organism’s liquids and gases.
4. Sometimes organisms or parts of organisms make a(n) impression in sand or mud.
   a. The kind of fossil that forms as an impression in rock is called a(n) mold.
   b. If the impression gets filled with sediments that harden to rock, a(n) cast is the result.
   c. Molds and casts show only external features of organisms.
5. The preserved evidence of the activity of an organism, such as its tracks, is called a(n) trace fossil.
6. In rare cases, the original tissues of an organism can be preserved, such as mammoths frozen in ice.

C. Determining a Fossil’s Age

1. Scientists cannot date most fossils directly. Instead they usually find the age of the rocks around the fossils.
2. In relative-age dating, scientists determine the relative order in which rock layers were deposited.
   a. In a(n) undisturbed rock formation, the older layers of rock are below the younger layers of rock.
   b. Relative-age dating has helped scientists figure out the order that species have appeared on Earth.
Lesson Outline continued

3. Absolute-age dating is more precise than relative-age dating and involves radioactive isotopes that decay to become stable isotopes over time.

D. Fossils over Time
   1. The geologic time scale is a chart that divides Earth’s history into different time units.
   2. Earth’s history is divided into four eons.
   3. Earth’s most recent eon—the Phanerozoic eon—is subdivided into three eras.
   4. Neither eons nor eras are equal in length.
   5. When scientists began developing the geologic time scale in the 1800s, they did not have absolute-age dating methods, so they marked time boundaries with fossils.

E. Extinctions
   1. When the last individual organism of a species dies, a(n) extinction has occurred.
      a. A(n) mass extinction occurs when many species die off within a few million years or less.
      b. The fossil record shows evidence of five mass extinctions during the Phanerozoic eon.
      c. Extinctions can occur if the environment changes quickly; for example, as the result of a meteorite impact.
      d. Extinctions can also occur if the environment changes gradually; for example, as a result of the formation of mountain ranges.
   2. The fossil record contains clear evidence of the extinction of species over time as well as evidence of the appearance of many new species.

Discussion Question
Compare and contrast relative-age and absolute-age dating.

In relative-age dating, scientists determine the relative order in which rock layers were deposited. In an undisturbed rock formation, the bottom layers are oldest and the top layers are youngest. Relative-age dating helps scientists determine the relative order in which species have appeared on Earth over time. Absolute-age dating is more precise than relative-age dating. Scientists take advantage of radioactive decay, a natural clocklike process in rocks, to learn a rock’s absolute age in years. In radioactive decay, unstable isotopes in rocks change into stable isotopes over time. Scientists measure the ratio of unstable isotopes to stable isotopes to find the absolute age of a rock. This ratio is best measured in igneous rocks. To measure the age of sedimentary rock layers, where most fossils are embedded, scientists calculate the ages of igneous layers above and below them. Then, they can estimate the ages of the fossils embedded within the sedimentary layers.
Lesson Outline for Teaching
Lesson 2: Theory of Evolution by Natural Selection

A. Charles Darwin

1. Charles Darwin was a(n) naturalist, a person who studies plants and animals by observing them.

2. Darwin was not the first to develop a theory of evolution, but his theory is the one best supported by evidence today.

3. The type of tortoise, mockingbird, and finch that live on each of the Galápagos Islands was slightly different; Darwin later figured out that some varieties were different enough to be classified as different species.

B. Darwin’s Theory

1. Darwin noticed that there was a relationship between each species and the food sources of the island it lived on.

2. The species of tortoise that lived on an island with tall cacti had long necks; the species of tortoise that lived on an island with lots of short grass had short necks.

3. Darwin thought all the Galápagos tortoises shared a common ancestor that came to one of the islands millions of years ago.

4. Darwin knew that in any species, members of the same species each have slight differences, called variations.

5. Darwin didn’t know about genes, but he realized that variations in populations could help explain how the different species of Galápagos tortoises and other organisms evolved.

   a. Darwin knew that food is a(n) limiting resource, so members of a species that live in the same area compete for food.

   b. If a variation benefited a tortoise, allowing it to compete for food better than other tortoises, the tortoise lived longer, reproduced more, and passed on its variations to its offspring.

6. Natural selection is the process by which populations of organisms with variations that help them survive in their environments live longer, compete better, and reproduce more than populations that do not have the variations.

C. Adaptations

1. A(n) adaptation is a characteristic of a species that enables the species to survive in its environment.

2. Scientists classify adaptations into three categories.

   a. Structural adaptations involve shape, size, color, and other physical features; the length of a Galápagos tortoise species’ neck is an example of this type of adaptation.
Lesson Outline continued

b. Behavioral adaptations involve the way organisms act; hunting at night is an example of this type of adaptation.

c. Functional adaptations involve internal body systems that affect organisms’ biochemistry; expanding blood vessels that cool a jackrabbit’s blood is an example of this type of adaptation.

3. A structural adaptation that aids members of a species in blending in with their environment is called camouflage.

4. An adaptation in which one species resembles another species is called mimicry.

5. The living and the nonliving parts of the environment are always changing; species that cannot adapt to such changes will become extinct.

D. Artificial Selection

1. Darwin’s theory of evolution by natural selection predicts that species will develop adaptations and, therefore, eventually closely match Earth’s changing environments.

2. Selective breeding is the breeding of organisms for desired characteristics.

3. Darwin realized that natural selection and selective breeding are similar processes.

   a. In natural selection, nature causes the changes in the species; in selective breeding, humans cause the changes in the species.

   b. For this reason, Darwin called selective breeding artificial selection.

4. Artificial selection explains and supports Darwin’s theory.

Discussion Question

Describe some adaptations that common animals you observe or know about have. Explain what might happen to each species if its environment changed in a significant way.

Possible answers: a bird’s beak, which helps it get a particular food; a mammal’s or an insect’s coloration, which helps it hide in a particular environment; a mammal’s or bird’s claws, which help it capture a particular prey. After describing an adaptation, students should explain that a significant change in the environment could cause the species to become extinct unless offspring of that population developed variations leading to new adaptations that allowed them to survive and reproduce in the changed environment. If this happened, the species might evolve into a new species.
Lesson Outline for Teaching

Lesson 3: Biological Evidence of Evolution

A. Evidence for Evolution

1. Evolution does not occur in a straight line with one species replacing another in a series of orderly steps.
   a. Living species that are closely related share a common ancestor.
   b. How closely related two species are depends when they diverged, or split, from their common ancestor.

2. The study of similarities and differences among structures of living species is called comparative anatomy.
   a. Body parts of organisms that are similar in position but different in function are called homologous structures. The forelimbs of different mammals are examples.
   b. If species have homologous structures, this suggests that the species are related.
   c. The more similar two structures are to each other, the more likely it is that the species have evolved from a recent common ancestor.
   d. Analogous structures are body parts that perform a similar function but differ in structure. The wings of flies and birds are examples.
   e. The existence of analogous structures indicates that the species are not closely related.

3. Body parts that have lost their original function through evolution are called vestigial structures. The wings of flightless birds are an example.
   a. The best explanation for vestigial structures is that the species that have vestigial structures are related to ancestral species that still use the structures for a specific purpose.
   b. Whales have a tiny pelvic bone, which is a vestigial structure for walking on land.

4. Studying the development of embryos can also provide scientists with evidence that certain species are related.
   a. Embryology is the study of the development of embryos from fertilization to birth.
   b. All species of vertebrates have pharyngeal pouches at some stage during their development.
   c. The similarities in location and function of the pharyngeal pouches is a sign that the vertebrate species share a common ancestor.
Lesson Outline continued

5. The study of gene structure and function is called molecular biology.
   a. The existence of genes provides evidence of evolution because they have been shown to be the source of variation upon which natural selection acts.
   b. The more closely related two species are, the more similar their genes and proteins are.
   c. Studies in molecular biology have shown that some stretches of DNA that are common to many species change through time at steady, predictable rates like a kind of molecular clock.
   d. Scientists use this molecular clock to estimate the time in the past when living species diverged from common ancestors.

B. The Study of Evolution Today
   1. Since the publication of Darwin's theory, scientists have confirmed, refined, and extended his work.
   2. Scientific studies of fossils, anatomy, embryology, and molecular biology have provided evidence of relatedness among living and extinct species.
   3. The continuous discovery of new fossils that have features of species that lived before and after them is strong evidence of evolution of species.
   4. Scientists today are studying how genes can be reorganized in simple ways that cause dramatic changes in organisms.
   5. Though scientists now study evolution at the molecular level, the basic principles of Darwin's theory of evolution by natural selection have remained unchanged for more than 150 years.

Discussion Question
How could studying the genetic sequence of a dinosaur's DNA provide further evidence of biological evolution?

It might give clues about the ancestor of that species of dinosaur or about the ancestor of dinosaurs in general; it might give clues about which species, if any, arose directly from that dinosaur species or which modern species are most closely related to that dinosaur species.
Answers

What do you think? (page 1)

1. Agree; on rare occasions, tissues such as skin, muscles, leaves, bones, shells, and teeth become fossils.

2. Disagree; the fossil record contains many examples of extinction on local scales.

3. Disagree; variations are caused by random mutations in genes.

4. Agree; over time, the accumulation of many similar variations can lead to an adaptation.

5. Disagree; there is much evidence from comparative anatomy, embryology, and molecular biology to suggest that living species are all related.

6. Agree; some genes are found in plants as well as animals, although they are not identical in structure.

Lesson 1

Launch Lab (page 8)

1. The shell left an impression of its shape.

2. The fossil would show the basic size and shape of the organism.

Content Vocabulary (page 9)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<td>12</td>
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</tr>
</tbody>
</table>

1. geologic time scale
2. biological evolution
3. trace fossil
4. extinction
5. isotopes
6. fossil record
7. mold
8. tissue
9. cast

MiniLab (page 12)

1. Answers will vary. An example would be: A scientist would consider the flatfish with eyes on both sides of its head as the oldest, because it lacked the more advanced adaptation—both eyes on one side of the head. That adaptation helped the flatfish population survive by giving it better vision while lying on its side on the seafloor.

2. Answers will vary. An example would be that the existence of flatfish fossils of different ages with eyes (1) on the sides of the head, (2) at intermediate locations, and (3) on one side of the head provide evidence of biological change over time.

Content Practice A (page 13)

1. G
2. B
3. H
4. C
5. D
6. A
7. E
8. F

Content Practice B (page 14)

1. Sample answer: A fossil record is a record of all discovered species that lived on Earth, changes in those species, and when they became extinct.

2. Sample answer: Trace fossils are important in that they give evidence of an organism’s movement or behavior.

3. Sample answer: Absolute-age dating is more precise than relative-age dating because in absolute-age dating scientists measure radioactive decay to find the age of rock.

4. Sample answer: The geologic time scale divides time into units of time called eons, eras, and periods.

5. Sample answer: Scientists studying fossil records found evidence that species of related organisms changed over time. This information provides a record of biological evolution.

Language Arts Support (page 15)

1. Sample answer: First, carbonization may occur when a dead organism is compressed over time. Next, the pressure drives off the organism’s liquids and gases. As a result, all that remains is the carbon outline of the organism.

2. Sample answer: Before the formation of a mold and cast occurs, an organism dies and its hard body parts make an impression in soft sediment. As the sediment hardens, so does the impression, forming a mold. Then, sediments can later fill in the mold. Over time, these sediments might harden into a cast.

Language Arts Support (page 16)

Sample answer: When an environmental change occurs, extinctions can take place. After changes, such as volcanic eruptions, individuals of a species might not be able to obtain the resources they need to
Answers continued

survive. Then, if all organisms of a species die, the species becomes extinct. Some environmental changes, such as meteorite impacts, occur rapidly. Other environmental changes, such as the movement of tectonic plates or changes in sea level, occur gradually. As a result, rapid and gradual changes in the environment can lead to extinction.

Math Skills (page 17)
1. \(5.43 \times 10^8\)
2. \(3.4 \times 10^9\)
3. 4,000 (four thousand)
4. \(2.0 \times 10^8\)
5. \(1.8 \times 10^6\)
6. 65 million years ago

School to Home (page 18)
1. Students’ drawings should show a fossil in each of the following rock layers: B, C, E, and G.
2. The term younger should be written at the top of the arrow. The term older should be written at the bottom of the arrow.
3. a. The fossil in rock layer B is older; b. The fossils in rock layers E and G are younger.
4. The youngest fossil is the one in rock layer G.
5. This activity represents relative-age dating.
6. Rock layers B, C, E, and G are most likely sedimentary rock because most fossils are found in sedimentary rock.
7. If rock layers A, D, and F are igneous rock, absolute-age dating could be carried out. Absolute-age dating, which can determine a more precise age for fossils, is best performed using igneous rocks.

Key Concept Builder (page 19)
Accept information that appears in rows 1–5 presented in any order.
For completed table, see page T18.

Key Concept Builder (page 20)
1. E
2. C
3. A, C
4. B
5. D
6. C
7. E
8. D
9. A
10. B
11. C
12. A, C, D

13. E
14. C, D
15. A
16. A, E

Key Concept Builder (page 21)
1. F; are not able
2. F; absolute-age dating
3. T
4. F; relative-age dating
5. T
6. F; undisturbed
7. T
8. F; a more precise
9. T
10. T
11. F; absolute-age dating
12. T

Key Concept Builder (page 22)
1. The absence of fossils suggests some type of event that caused a mass extinction of organisms.
2. A mass extinction can occur within a few million years or less.
3. Extinctions take place when environments change quickly; gradual changes take place when environments slowly change.
4. There have been five major extinction events in Earth’s history.
5. The order of extinction events from the earliest time period to the most recent is Late Ordovician, Late Triassic, Late Permian, and Late Devonian.

Enrichment (page 23)
1. Possible answer: The Principle of Original Horizontality applies. When the strata were formed, they were horizontal. An upheaval caused by volcanic, earthquake, or tectonic activity caused the horizontal layers to tip up on the left side and down on the right (sloping down from left to right). One particular layer remains visible as a relatively unbroken stratum, but it is horizontally deformed.
2. Look for scenarios that include deformations of Earth’s crust by volcanic, earthquake, or tectonic forces causing strata to tip or fold. Students should indicate that if the samples are taken from the same depths, it does not mean that the fossils came from the same layer of sediment.
Answers continued

Challenge (page 24)
Students should have a copy of the geologic time scale for reference that provides information on the appearance of life-forms in the fossil record. Below is the list of fossils from the oldest at the bottom to the youngest at the top. All fossils are found within the five periods listed, though those within each layer are assumed to be of the same relative age. (All names of organisms are fictional.) Look for drawings that have the information in the correct order and that are associated with the correct period of geologic time. Students may be creative in the drawing of the rock strata, but they should not be assessed on creativity. The order can be quickly determined for most of the fossils by analyzing their names. For example, hint 3 should indicate to students that *Crawlitus fishensis* might be an early fish and, therefore, could not be in the fossil record before the Ordovician Period. Students may take a hint for drawing the fossils from their names.

The correct order and geological periods are as follows:

<table>
<thead>
<tr>
<th>Fossil</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Fernila treelinsis</em></td>
<td>(Carboniferous)</td>
</tr>
<tr>
<td><em>Fanlika devonensis</em></td>
<td></td>
</tr>
<tr>
<td><em>Spiralla fossilii</em></td>
<td>(Devonian)</td>
</tr>
<tr>
<td><em>Froggela slitherae</em></td>
<td></td>
</tr>
<tr>
<td><em>Dragona silurius</em></td>
<td>(Silurian)</td>
</tr>
<tr>
<td><em>Nautilius ordovician</em></td>
<td></td>
</tr>
<tr>
<td><em>Crawlitus fishensis</em></td>
<td>(Ordovician)</td>
</tr>
<tr>
<td><em>Bottelinia cambriae</em></td>
<td>(Cambrian)</td>
</tr>
</tbody>
</table>

Skill Practice (pages 25–26)
5. Answers will vary depending on the presentation form chosen. Encourage groups to use their own ideas, if feasible.
6. Answers will vary. Have student groups present their products to the class for discussion. Class members can offer constructive criticism, vote, or otherwise judge whether evidence exists that changes in common items over time have had an affect on their safety and efficiency.

Lesson Quiz A (page 27)
Multiple Choice
1. B
2. B

Matching Set 1
3. D
4. A
5. C
6. B

Matching Set 2
7. F
8. E
9. G

Lesson Quiz B (page 28)
Matching
1. G
2. A
3. F
4. C
5. B
6. I
7. D

Short Answer
8. Relative age dating is less precise than absolute-age dating. Relative-age dating uses the relative order in which rock layers were deposited to determine the relative order in which fossils, and the organisms they represent, appeared on Earth over time. Absolute-age dating uses radioactive decay to find the age of igneous rock layers, and then estimates the age of fossils embedded in sedimentary layers between them.
9. Answers will vary but should contain the idea that environmental change, whether it occurs suddenly or gradually, can have the effect of causing the extinction of species.

Lesson 2
Launch Lab (page 30)
1. Answers will vary.
2. Answers will vary.
3. The graph of measurements provides evidence that the length from the elbow to the tip of the middle finger varies within the class.

Content Vocabulary (page 31)
1. Camouflage is an adaptation that enables individuals of a species to blend in with their environments. Mimicry is another adaptation, whereby one species resembles another. Both adaptations help species avoid being eaten.
2. The term *scientist* is a general term. Scientists study and work with many different aspects of science. The term *naturalist* identifies a specific type of scientist. Naturalists study plants and animals through observation.
3. A variation is a slight difference in the appearance of individual members of a species. A particular variation might become
Answers continued

more common through natural selection and lead to an adaptation, or a characteristic, of a species that enables the species to survive in its environment.

4. Natural selection explains how populations change as their environments change. The process of selective breeding is similar to natural selection, but with important differences. Changes caused by selective breeding are due to human choice, while changes caused by natural selection are due to environmental changes.

5. If a person suspects something, the person thinks something is possible. If a person is convinced of something, the person has become certain of it as a result of argument or other support.

MiniLab (page 34)

1. Answers will vary but should include descriptions of how the moths that were discovered did not blend into their background environment as well as the moths that were better camouflaged.

2. Camouflage enables an organism to blend in with its environment. This can help it avoid predators or surprise prey.

Content Practice A (page 35)

1. variations
2. extinction
3, 4, 5. (any order) behavioral, structural, functional

Content Practice B (page 36)

1. D
2. A
3. K
4. L
5. B
6. F
7. J
8. H
9. C
10. I

School to Home (page 37)

a. Reproduction is the process of producing offspring. Reproduction enables organisms to pass their characteristics on to offspring; b. A variation is a slight difference in the appearance of a member of a species. Beneficial variations make it easier for individuals to compete in an environment; c. Competition occurs when individuals in a population must share the same limited resources. Through competition, individuals with beneficial variations get more food and other resources than individuals without them; d. Selection occurs when individuals in a population with helpful variations survive longer and produce more offspring with the same helpful variations. Natural selection results in helpful variations becoming more common within a population, eventually becoming adaptations.

Key Concept Builder (page 38)

1. naturalist
2. animals
3. HMS Beagle
4. Galápagos Islands
5. South America
6. dry
7. tortoises
8. mockingbirds
9. species
10. relationship
11. ancestor
12. short
13. long
14. variations
15. natural selection
16. variations
17. reproduce
18. populations

Key Concept Builder (page 39)

1. a process by which populations of organisms with variations that help them survive in their environments live longer, compete better, and reproduce.
2. The characteristics are inherited by the offspring.
3. a slight difference in the appearance of individual members of a species.
4. They occur naturally in populations as a result of random mutations, or changes in genes.
5. Helpful variations that help organisms survive are spread throughout the population as the organisms reproduce.
6. Through natural selection, tortoises, finches, and other diverse species became matched to their food sources.

Key Concept Builder (page 40)

1. A
2. V
3. A
4. A
5. V
Answers continued

6. V
7. V
8. A
9. A
10. V
11. A
12. A
13. V
14. A
15. V

Key Concept Builder (page 41)
1. Camouflage is an adaptation that enables species to blend in with their environments. Students’ drawings will vary and might include an insect or bird blending into its environment.

2. Mimicry is the resemblance of one species to another species. Students’ drawings will vary and might include two similar types of butterflies or a caterpillar that looks like a snake.

3. Selective breeding is the breeding of organisms for desired characteristics. Sample answer: This change is not caused by natural selection because each animal cannot naturally adapt to its environment for survival. However, characteristics are being selected for appearance or other reasons.

4. A mouth-shaped adaptation is the special mouth shape that a species has developed to obtain food and to survive. Students’ drawings might include the mouth shape of a pelican.

5. A species that is unable to adapt to environmental changes will become extinct. Students’ answers might include a volcano or flood as an example of a quick environmental change.

6. Artificial selection is changes in a species that are the result of selective breeding. Sample answer: Artificial selection supports Darwin’s theory because it shows that those with certain characteristics reproduce and survive.

Enrichment (page 42)
1. The goats that were raised to sell to the sailors and the rats from the ships are invasive and exotic species. (Others are the vermin from ships, such as insects, and some students might mention humans as invasive. These are reasonable answers.) Goats are grazers, much like the giant tortoises, but they are agile and able to reach food above and below the tortoise’s range. Goats outcompete tortoises and other slow grazers. Rats forage seeds and reproduce quickly. Neither animal has a natural predator on the Galápagos Islands. They outcompete the local animals for food and space.

2. Look for answers that show some insight into how Darwin thought about this very new theory and how it had to have time to grow and develop. He may have used most of that time working out the kinks. He also did not want to encounter the criticism of the clergy and, therefore, he postponed the publication of this work for years.

3. Although it is true that Darwin spent years trekking around South America and that he made some profound observations while he was there, the five weeks in the Galápagos revealed to him some of the most unusual examples of animal species he had ever seen. This visit is what caused Darwin to examine the reasons that some species could be so similar and yet so different. These questions helped him develop the foundation principle of biology, which is the theory of evolution by means of natural selection.

Challenge (page 43)
1. 2008

2. One likely reason is that the background color changed from grassland color to the deeper green of food crops. This gave the darker gray-colored variation a survival advantage. They were most likely better camouflaged from predators than the straw-colored variant in a field of green.

3. Possible Answer: The dominant color variation in the lizard population was not changed deliberately by humans to promote the gray color. Selective breeding is a technique that is used to emphasize and propagate specific traits or characteristics. In the case of the lizards, the color change was defensive and not purposeful.

Lesson Quiz A (page 44)
True or False
1. T
2. F; selective breeding or artificial selection
3. F; Mimicry

Multiple Choice
4. C
5. A
6. A
7. A

Lesson Quiz B (page 45)
Short Answer
1. A naturalist studies plants and animals by observing them in their natural habitat.
Answers continued

2. Answers will vary but should contain the idea that artificial selection demonstrates that the breeding of individuals with certain characteristics can cause a species to change over time.

3. Camouflage and mimicry are similar because both are a type of structural adaptation that helps organisms avoid being eaten by predators. However, camouflage is an adaptation that enables a species to blend in with its environment, but mimicry is an adaptation that causes one fairly harmless species to resemble another that predators avoid.

4. Answers will vary but should contain the idea that mutations are the cause of variation in populations.

5. Natural selection is the process that causes species to change when their environments change.

Completion
6. behavioral
7. structural
8. functional

Lesson 3
Launch Lab (page 47)

1. The spoons are similar in that each has a handle. They are different at the part of the spoon that picks up food.

2. Answers will vary. It might be a plain stick, a long wooden slat hollowed out on one end, or a seashell attached to a stick.

3. Answers will vary. Sample answer: A ladle is structured with a long handle and deep bowl for dipping out of a large container. A spoon with slots allows liquid to drain from food being lifted from a pot. A serving spoon is large enough to move serving-size amounts of food from a large serving dish to an individual plate. These spoons are related because they have handles connected to the functional part.

Content Vocabulary (page 48)
1. homologous structures
2. analogous structures
3. vestigial structures
4. embryology
5. Comparative anatomy

MiniLab (page 51)
1. rhesus monkey; yeast cell
2. A dog and a turtle are more closely related than a dog and a silkworm. The dog and the turtle have more amino acids in common for cytochrome c than the dog and the silkworm do.

3. The fewer the number of differences there are, the more closely related an organism is to a human.

Content Practice A (page 52)
1. vestigial structures
2. developmental biology
3, 4. (either order) homologous structures, analogous structures
5, 6. (either order) comparing sequences, divergence

Content Practice B (page 53)
1. B
2. J
3. I
4. G
5. A
6. C
7. F
8. B
9. I
10. D
11. C
12. F
13. G
14. D

School to Home (page 54)
1. Although the structures are often used differently, their placement and structure point to a common ancestor. For example, humans, cats, and birds have forelimbs with a similar structure, indicating that at some point they had the same ancestor with forelimbs.

2. In an ancestral species, the structure was used for a specific purpose. However, that purpose no longer exists. For example, a whale ancestor had pelvic bones that supported primitive rear legs. Because the animal spent most of its life in the water, whales evolved in a way that gradually eliminated the rear legs and the whale ancestor’s ability to walk on land. However, a primitive set of pelvic bones still exists in the whale’s skeleton, although they no longer have a function.

3. It indicates that there is a close evolutionary relationship between fish and other vertebrates.

4. Genes of two living species can be compared. The more similar they are, the more closely the two species are related.
Answers continued

5. The regular, predictable rate at which some stretches of DNA mutate can be used to measure the degree to which two species are related and how recently in the past the two species shared a common ancestor.

Key Concept Builder (page 55)
1. a common ancestor
2. how closely in time they split from a common ancestor
3. fossils/the fossil record
4. the study of what is the same and different among structures of living species
5. Sample answer: information about homologous structures and analogous structures
6. indicates body parts that are no longer functional as a result of evolution
7. Sample answer: information on pharyngeal pouches
8. Sample answer: an understanding that gene mutations result in variations

Key Concept Builder (page 56)
Sample answers:
1. Examples include forelimbs of humans, cats, and birds. The similarity of the structures indicates a common ancestor.
2. Examples include bird wings and fly wings. The difference in structure of these body parts indicates the organisms are not closely related.
3. Pharyngeal pouches are a type of pouch shared by all vertebrate embryos. The similarity in structure suggests an evolutionary relationship.
4. Vestigial structures have lost their original function but indicate a common ancestor with other animals.
5. The similarity in gene codes and proteins suggests a strong evolutionary relationship among all organisms.
6. Stretches of DNA mutate at predictable rates, indicating when past species diverged from common ancestors.

Key Concept Builder (page 57)
1. divergence
2. ancestors
3. natural selection
4. genes
5. species
6. natural selection
7. fossils
8. embryology
9. diversity
10. divergence, mammals

Key Concept Builder (page 58)
Sample answers:
1. Some scientists think new species evolve slowly as small variations are gradually selected. Other scientists think change occurs rapidly with long periods of time between variations.
2. Scientists think that DNA mutates, resulting in new species rising from a common ancestor.
3. Diversity results when genes reorganize in simple ways and give rise to dramatic changes in organisms.
4. The theory of evolution by natural selection says that new species evolved from changes that occurred gradually as variations increased an organism’s chances of survival.

Enrichment (page 59)
1. Students’ answers will vary but should show logical reasoning and be supported by facts. Students might choose some of the following criteria as a basis for classifying an animal as a bird: having wings, having a bone structure suitable for flight, being warm-blooded, or other traits common to birds.
2. Students’ answers will vary but should show logical reasoning. Possible answer: The fact that Microraptor was about the size of a crow, had bones similar in structure to bird bones, and had feathers and toes like birds means that it probably was an ancestor to modern birds. In addition, the fact that it had many dinosaurlike traits, such as the tail and teeth, means that it probably was a dinosaur. Therefore, birds and dinosaurs are closely related. The fact that the Microraptor had feathers even though it could not fly indicates that the feathers served another purpose than flight. If the feathers were for insulation, then Microraptor, and at least some dinosaurs, were warm-blooded. Finally, the fact that Microraptor had toes that could have grasped tree branches means that birds probably learned to fly from trees down.

Challenge (page 60)
Brochures should include information about why the structures are classified as homologous, analogous, or vestigial.

Homologous: your nose, a pig’s snout, and an elephant’s trunk

These structures have a different appearance. All are used for breathing, but each has other functions as well. For example, the elephant’s trunk can be used to grasp and manipulate objects. They are homologous because they arise from the same structure in a common ancestor.
Answers continued

Analogous: butterfly wing, airplane wing, bat wing

All three structures have the same function—flight. But each one arises separately from different origins, and one of them isn’t a living organism. Nevertheless, they are analogous.

Vestigial: cormorant wing, human tailbone, whale pelvic bone

These structures are vestigial because they no longer have any function in the modern animal. Each of the structures can be traced to the form of an ancestor, however. For example, the pelvic bones in a whale indicate that the whale was once a four-legged land dweller.

Lesson Quiz A (page 61)

Matching Set 1
1. C
2. A
3. B

Matching Set 2
4. F
5. E
6. D

Multiple Choice
7. C
8. B

Lesson Quiz B (page 62)

Completion
1. vestigial structures
2. Comparative anatomy
3. analogous structures
4. homologous structures
5. molecular biology
6. Embryology

Short Answer
7. Answers will vary but should include the fact that some scientists think change in species occurs at a slow, steady rate, but other scientists think change occurs in rapid bursts.
8. Answers will vary but should contain the ideas that species formation is difficult to study because the fossil record is incomplete and that species formation does not occur in time intervals that humans can easily observe.

Labs A and B (pages 63, 66)

9. Answers will vary. Descriptions may include different types of variations, such as spiky skin or foot modification for faster running.
10. Answers will vary. Examples might include height and/or strength to climb a tree out of a flooded area, running speed to escape volcanic emissions, and strong lungs to withstand toxic air.

Communicate Your Results  Groups can make oral presentations of their models or conduct a showing and review of the models for their classmates and/or external review judges.

B. Extension  Answers will vary. The events were presented in a different order, so the organisms might look completely different.

Lab C (page 69)

Please note:
- Students must complete Lab B before they are assigned Lab C.
- The procedure given below is just one possibility of many.
- If you have student perform the labs they design, make sure proper safety precautions are included before allowing them to proceed.

Sample procedure:

Ask a Question  How have different people contributed to our understanding of evolution today?

Form a Hypothesis  Student hypotheses will vary, but the following is an example: If the ideas came from different thinkers over a period of time, then the ideas built on one another to form and support a well-founded theory because more evidence supported past ideas.

Test Your Hypothesis  Testing procedures will vary, but the following is an example:
- Have students research the contributions of the individuals listed, noting important dates and their ideas on an index card.
- Have students arrange the index cards into a time line of the history of evolutionary thought.
- On the back of each card, have students write a statement inferring how that individual’s contribution relates to the ideas in the Inquiry Lab Model Adaptations in an Organism.
- Have students share their inferences as a class.

Analyze and Conclude  Students should present an analysis of their data and some conclusion.

Chapter Key Concepts Builder (page 70)

Students should present visually appealing and informative reports. Connections should be made between trilobites and other arthropods. Students should share that trilobites were marine arthropods that flourished in shallow salt water, but became extinct about 251 mya when almost all marine animals became extinct. Students should report on environmental changes that may have resulted in the mass extinction of marine life some 250 mya.

Chapter Test A (page 71)

Multiple Choice
1. C
2. A
Answers continued

3. B
4. A
5. C

Matching
6. B
7. C
8. A

Chapter Test A (page 72)
Interpreting a Diagram
9. variation
10. structural
11. behavioral
12. functional
13. camouflage

Chapter Test A (page 73)
Short Answer
14. Fossils can be dated by relative-age dating. Scientists can find the relative order in which species appeared on Earth by determining the order of the rock layers in which they are embedded. Absolute-age dating uses radioactive decay to determine the age of layers of igneous rock above and below the fossils, allowing scientists to estimate the age of the fossils embedded in sedimentary layers in between.

15. A molecular clock refers to the regular and predictable rate at which some stretches of DNA mutate. Knowing the rate at which the DNA changes, scientists can determine when two species diverged from a common ancestor.

16. Possible answer: Darwin observed the structural differences in tortoises and birds that lived in different types of environments on islands of the Galápagos chain. Darwin also observed that species could be changed by the process of selective breeding, or artificial selection.

Concept Application
17. A species that could not adapt to an environmental change would find it difficult, if not impossible, to survive in its environment. This inability to adapt would eventually lead to extinction.

18. Casts are fossil copies of an organism in rock. They often form when sediment fills a mold and hardens. Casts usually show hard, external features and form from organisms that leave behind shells or bones. A carbon film forms when an organism is compressed over time and its liquids and gases are pressed out. Only the black or brown carbon outline of the organism is left behind. Fish, plant leaves, and insects often become carbon films.

Chapter Test B (page 74)
Multiple Choice
1. C
2. B
3. C

Matching
4. B
5. C
6. A
7. B
8. A

Chapter Test B (page 75)
Interpreting a Diagram
9. natural selection
10. variation
11. structural
12. behavioral
13. camouflage

Chapter Test B (page 76)
Short Answer
14. Rock layers are laid down in sequence, with newer layers being laid down over older layers. Relative-age dating determines the comparative age of fossils based on their position in these rock layers. If the rock layers have been disturbed, their relative positions might be changed. It would no longer be possible to know whether the rock layers and the fossils they contain are in sequence from oldest at the bottom to newest at the top.

15. Possible answer: Patterns in the fossil record reveal that species change over time, that new species arise from existing species, and that many species that once existed have become extinct. Students can list any two answers.

16. Possible answer: Students might mention using evidence from comparative anatomy, such as homologous structures, or evidence from embryology. Students could also list the study of genes in molecular biology, as well as evidence from the fossil record.

17. Answers will vary but should describe Charles Darwin’s observation of the variations among the species of birds and tortoises in the Galápagos Islands. Students might also mention that Darwin observed that selective breeding can be used to change species. He used these observations to develop the theory that species change over time in response to their environment through a process called natural selection.
Answers continued

Concept Application
18. If the green grass in which a green insect was camouflaged turned brown, the insect’s green color would no longer be a useful adaptation. The green insect would be easier for predators to spot, so fewer green insects would survive to reproduce. The population of green insects might become extinct. If the population contained some individuals who had a variation in color that allowed them to hide in brown grass, those individuals might survive and pass on their color to their offspring, leading to a change in the color of the species.

Chapter Test C (page 77)
Multiple Choice
1. D
2. D
3. C

Completion
4. Embryology
5. comparative anatomy
6. molecular biology
7. Comparative anatomy
8. Molecular biology

Chapter Test C (page 78)
Interpreting a Diagram
9. variation
10. structural
11. behavioral
12. camouflage

Short Answer
13. Answers will vary but should reflect students’ knowledge that limited resources are a driving factor in natural selection. If every member of a population can obtain all the resources it needs, all the members of the population will be equally able to survive and reproduce. Under conditions in which resources are unlimited for each individual, there would be little reasons for natural selection to occur.

Chapter Test C (page 79)
14. Answers will vary but should contain the idea that absolute-age dating methods might have given scientists the ability to divide geologic time based upon intervals of set numbers of years, rather than intervals based on the appearance or disappearance of particular fossils. Students’ responses should reflect an understanding of the information provided by absolute-age dating.

15. Answers will vary but should include the idea that it was Darwin’s observation of animal and plant species and how their differences were linked to their environment that led him to his theory. These observations allowed him to infer that useful variations would become more prevalent in a species and would eventually lead to evolutionary change.

Concept Application
16. Answers will vary but should contain the idea that after an environmental change, previously useful adaptations might no longer be useful. For example, animals with thick fur would not survive well in a hotter climate. Through natural selection, the population would change, favoring individuals with less fur.

17. Answers will vary, but students’ plans can include the use of any type of fossil evidence. For example, a student could describe examining the mineralized skeletons of the species for homologous structures or attempting DNA analysis of original tissue of preserved organisms.

18. Biological evolution is the change in the population of related organisms over time. The fossil record shows that organisms have actually changed over long periods. For example, the fossil record shows that the horse had several ancestors with similar structures and body plans. Fossils show that some of these early forms of the horse became extinct, but others gradually evolved into the horse that is common today.
### Fossil Formation

<table>
<thead>
<tr>
<th>What are the different types of fossils?</th>
<th>What conditions existed for this type of fossil to form?</th>
<th>How did this type of fossil form?</th>
<th>Does this fossil show physical structure, movement, or behavior—or all three?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. mineralization</td>
<td>mud, sand, or other sediments in a stream or river</td>
<td>The remains of a dead organism are buried. Minerals in the water replace the organism’s original material and harden into rock.</td>
<td>physical structure</td>
</tr>
<tr>
<td>2. carbonization</td>
<td>compression over a long time</td>
<td>A dead organism is compressed over time. Pressure drives off the organism’s liquids and gases leaving only the carbon outline or film.</td>
<td>physical structure</td>
</tr>
<tr>
<td>3. molds and casts</td>
<td>mud or sand</td>
<td>The shell or bone of an organism leaves an impression (mold). Sediments later fill the mold and harden into a cast.</td>
<td>physical structure</td>
</tr>
<tr>
<td>4. trace fossils</td>
<td>mud [an example]</td>
<td>An organism walks across mud. The tracks fill in with sediment that hardens.</td>
<td>physical structure, movement, or behavior</td>
</tr>
<tr>
<td>5. original material</td>
<td>ice, tar pits, amber</td>
<td>The remains of an entire organism are found in ice, tar pits, or encased in amber.</td>
<td>physical structure and possibly movement or behavior</td>
</tr>
</tbody>
</table>