



# Evolution— Evidence of Change

## The BIG Idea

Evidence from biology and paleontology is best explained by the theory of evolution.

### LESSON 1 3.c, 4.c, 4.e, 7.d

#### Fossils and Evolution

**Main Idea** Fossils provide evidence of changes to species and the environment over time.

### LESSON 2 3.c

#### Biological Evidence

**Main Idea** Evidence from comparative anatomy and molecular biology are best explained by the theory of evolution by natural selection.

### LESSON 3 3.a, 4.f

#### Evolution and Plate Tectonics

**Main Idea** Over time, the movement of lithospheric plates has changed environments that led to changes in species.

### LESSON 4 3.d, 7.c, 7.d, 7.e

#### Classifying Organisms

**Main Idea** Scientists use traits and evolutionary history to classify species.



### Was it a plant or an animal?

This is a fossil of an ancient animal called a crinoid (KRI noyd). There were more crinoid species in Earth's ancient oceans than there are in present-day oceans. Sea lily and feather star are other names for crinoids. They are relatives of sea stars and sea urchins.

**Science Journal** Predict how this animal became a fossil. As you read this chapter, check whether the information presented supports your prediction.

# Start-Up Activities

## Launch Lab

00:20  
minutes

### Can you make an animal evolve?

Animals and plants living on Earth today evolved from simpler animals and plants. In fact, species on Earth are still evolving.



#### Procedure



1. Complete a lab safety form.
2. Create a primitive animal that evolves into a more complex animal over time. Make models from **materials provided** showing your animal at four different stages of its evolution.
3. Record descriptions of the changes your animal has gone through at each stage.

#### Think About This

- **List** specific adaptations that your animal has evolved to ensure its survival.
- **Describe** how these adaptations would help your animal survive through the process of natural selection.



Science online

Visit [ca7.msscience.com](http://ca7.msscience.com) to:

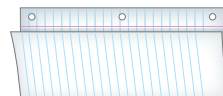
- ▶ view **Concepts in Motion**
- ▶ explore Virtual Labs
- ▶ access content-related Web links
- ▶ take the Standards Check

## FOLDABLES™ Study Organizer

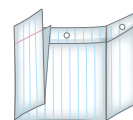
### Evidence of Evolution

Make the following Foldable to organize the evidence of evolution.

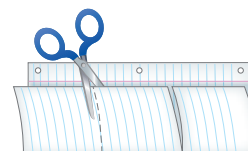
- ▶ **STEP 1 Fold** a sheet of paper in half lengthwise. Make the back about 3 cm longer than the front.



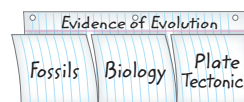
- ▶ **STEP 2 Fold** into thirds.



- ▶ **STEP 3 Unfold** and **cut** along the folds of the front flap to make three flaps.



- ▶ **STEP 4 Label** the flaps as shown.



### Reading Skill

#### Analyzing

As you read this chapter, you will learn about the evidence that supports evolution. List the evidence under the appropriate flap.

# Get Ready to Read

## Questioning

**1 Learn It!** Asking questions helps you to understand what you read. As you read, think about the questions you'd like answered. Often you can find the answer in the next paragraph or lesson. Learn to ask good questions by asking *who*, *what*, *when*, *where*, *why*, and *how*.

**2 Practice It!** Read the following passage from Lesson 1.

Did you see the movie in which an entire organism was preserved in amber—the fossilized sap of an ancient gymnosperm? A preserved organism in amber is a type of fossil called original material. Another example of original material is the head from a frozen woolly mammoth shown in **Figure 6**. An original material fossil is unique because none of the hard and soft structures of the original organism have been replaced or altered. The organism is preserved in its original form. It is rare to find original material, but when it happens, it provides much information to paleontologists. Most original material fossils are more recent than other fossil types.

—from page 248

Here are some questions you might ask about this paragraph:

- What is an original material fossil?
- Where can original material fossils be found?
- How often are original material fossils discovered?

**3 Apply It!** As you read the chapter, look for answers to lesson headings that are in the form of questions.



## Reading Tip

Test yourself. Create questions and then read to find answers to your own questions.

# Target Your Reading

Use this to focus on the main ideas as you read the chapter.

- 1 **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.
  - Write an **A** if you **agree** with the statement.
  - Write a **D** if you **disagree** with the statement.
- 2 **After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.
  - If any of your answers changed, explain why.
  - Change any false statements into true statements.
  - Use your revised statements as a study guide.

Before You Read A or D	Statement	After You Read A or D
	1 Fossils are the naturally preserved remains of ancient organisms.	
	2 Paleontologists study organisms living on Earth to learn more about fossils.	
	3 The fossil record is the only evidence for evolution by natural selection.	
	4 Some organisms have structures that have no function now but had a function in an ancient ancestor.	
	5 The moving lithospheric plates had no influence on the evolution of plants and animals.	
	6 Changes in landforms and in climate can result in the evolution of new species.	
	7 Present-day classification is based on the idea of common ancestors.	
	8 The classification of an organism remains the same even when scientists learn new information that contradicts its current classification.	



Print a worksheet of this page at [ca7.msscience.com](http://ca7.msscience.com).





# LESSON 1



## Science Content Standards

- 3.c** Students know how independent lines of evidence from geology, fossils, and comparative anatomy provide the bases for the theory of evolution.
- 4.c** Students know that the rock cycle includes the formation of new sediment and rocks and that rocks are often found in layers, with the oldest generally on the bottom.
- 4.e** Students know fossils provide evidence of how life and environmental conditions have changed.
- 7.d** Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

## Reading Guide

### What You'll Learn

- **Describe** the work of a paleontologist.
- **Compare and contrast** the processes that form different fossil types.
- **Explain** how fossils support evolution by natural selection.

### Why It's Important

Learning how fossils form helps you understand how Earth and organisms change over time.

### Vocabulary

fossil  
paleontologist  
permineralization  
mold  
cast  
fossil record

# Fossils and Evolution

**Main Idea** Fossils provide evidence of changes to species and the environment over time.

**Real-World Reading Connection** Do you watch television shows about forensic science? A show usually includes one or more forensic scientists who search for and analyze evidence to solve a mystery. Studying evolution is similar to solving a mystery. What evidence do scientists look for to determine the types of organisms that lived on Earth in the past?

## What are fossils?

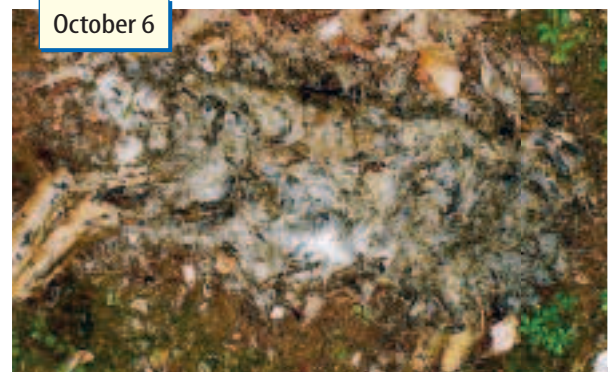
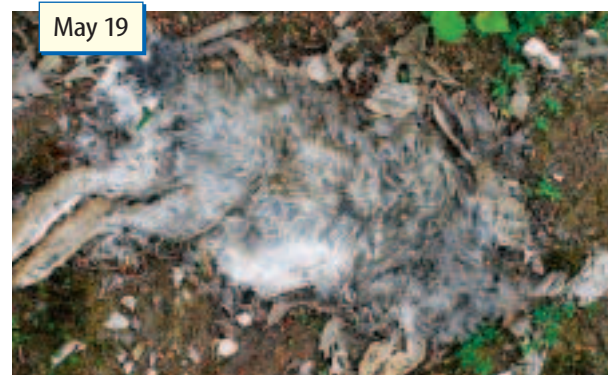
Organisms leave evidence of their existence on Earth. Much of this evidence lasts for only a short time, but occasionally it is preserved for a long time. **Fossils** are the naturally preserved remains, imprints, or traces of organisms that lived long ago. Fossils, as shown in **Figure 1**, can include bones, shells, and footprints of ancient life.

A **paleontologist** (pay lee ahn TAH luh just) is a scientist who studies fossils. Paleontologists study fossils to determine the relationships among organisms, the approximate times when life first appeared, when different organisms first lived on Earth, and when organisms became extinct. Some paleontologists work outside to discover and then carefully uncover fossils. Other paleontologists work in laboratories analyzing and learning about fossils.



**Figure 1** Some fossils, called microfossils, can only be seen under a microscope. Other fossils are larger than humans.





**Figure 2** As an organism decomposes, only hard body structures remain.

## When do fossils form?

Have you ever forgotten about a fruit in the refrigerator? When you discover it, the fruit might be soft and have mold growing on it. The fruit is decomposing—breaking down into substances that can be used by other organisms. The process of decomposition, as shown in **Figure 2**, is part of an organism's life cycle. In nature, organisms, such as insects, worms, bacteria, fungi, and others, consume and help break down dead organisms. These organisms are decomposers and help the decomposition process. Scavengers might eat part of a dead organism and then scatter the parts they cannot eat. What keeps decomposers and scavengers from destroying the remains of an organism before it is preserved as a fossil? What conditions provide for fossil formation?



What term describes the breakdown of a dead organism?

For a dead organism to become a fossil, it must be well protected from decomposers, scavengers, and environmental factors, such as heavy rains or acidic soils. Also, if a dead organism has hard structures such as teeth, bones, or a shell, it has a better chance of becoming a fossil than if it does not have hard structures. Hard structures decay more slowly than softer structures do, also shown in **Figure 2**, and scavengers are less likely to eat hard structures.

### WORD ORIGIN

#### paleontology

from Greek *palaaios* (means *old, ancient*) and *-ology* (means *study of*)



## How are fossils formed?

When the word *fossil* was first used, no one knew that fossils were from ancient organisms. In fact, some scholars argued that fossils could not be from ancient animals. They thought that the only way for fossils to have originated from once-living animals was for the bones and teeth to change magically to stone, which was impossible. It was not until the seventeenth century that scientists began to figure out how fossils form.

Fossils only form under certain conditions. This means that fossils are not commonly found in most rocks or in most locations. Usually, when we find a fossil, it is only part of a once-living organism. The most frequently found fossils are preserved hard **structures**, but occasionally soft structures are preserved. In rare instances, entire organisms are preserved. There are several different methods of preservation.

### Permineralization

A living organism's hard structures usually contain tiny spaces filled with air, blood, or other substances. After the organism dies, the substances inside the tiny spaces decompose leaving the spaces empty. If the hard structure is buried, layers of sediment slowly begin to compact and cement to form rock. During this process, **permineralization** (pur mihn ur ul i ZAY shun) can occur if water in the ground seeps into the tiny empty spaces and deposits minerals. Usually silica, calcite, or a similar mineral is left in the tiny spaces. This forms a strong, rocklike fossil. The details of the organism's original hard structure are often preserved. Most bones and trees become fossilized through permineralization, as shown in **Figure 3**. They have hard structures with small spaces where minerals can be deposited. When trees are fossilized through this process, they are often referred to as petrified wood.

### ACADEMIC VOCABULARY... structure (STRUHK cher)

(**noun**) any part of an organism *A plant has structures called roots that hold it in the ground.*

**Figure 3** This part of a dinosaur's leg bone and these tree trunks were preserved by permineralization.

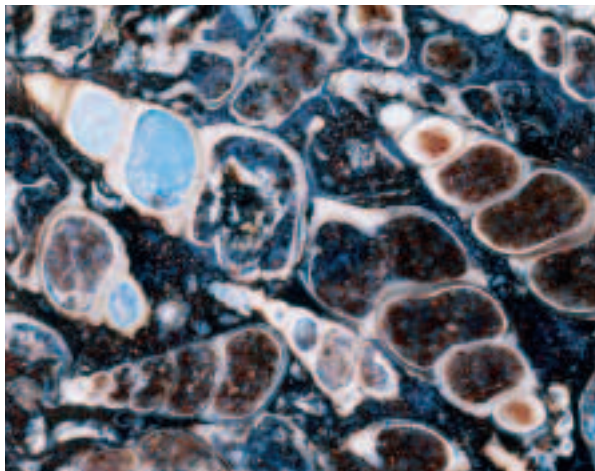
**Infer** what hard structures of the original tree are preserved.







**Figure 4** Mineral deposits have replaced the shells and filled the insides of these ancient snails. All that remains of this ancient fish is the carbon from the molecules that made up its body.



## Replacement

There are similarities between permineralization and replacement. Minerals such as silica, iron, and pyrite are critical for fossilization in both processes. However, in replacement, the hard structures of the organism dissolve and are replaced with minerals. During replacement, the original microscopic details, such as the inside of a bone, are partially or totally destroyed. Only the shape of the original organism remains. For example, a solution of water and dissolved silica might flow into and through the shell of a dead organism. If the water is acidic, it might dissolve the shell. Simultaneously, the dissolved silica in the water crystallizes and fills in the places where the shell had been and replaces the original shell. **Figure 4** shows an example of replacement.



What remains of the organism after replacement has occurred?

## Carbonization

If a dead organism is quickly buried under conditions without oxygen, elements that are normally found in the living tissue of the organism, such as hydrogen, oxygen, and nitrogen, are removed. A thin film of carbon is all that is left when these elements leave the organism's remains. As pressure from built-up sediment compresses the buried organism, a carbon film forms that preserves an image or shape of the original organism on a rock. Also, soft materials of animals, such as skin, fur, and feathers, can be preserved as carbon films, as shown in **Figure 4**. Countless plant fossils are preserved as carbon films and are the bases of present-day coalfields.

### SCIENCE USE V. COMMON USE: film

**Science Use** a thin coating or layer. *The oil formed a film on the water's surface.*

**Common Use** a motion picture. *The film about penguins received rave reviews.*



**Figure 5** This is a mold of the interior of an ancient snail shell. The shell was dissolved long ago. These casts are of ancient squidlike animals called ammonites.



**Mold**



**Cast**

## Molds and Casts

Preservation of an impression or indentation of an organism is a mold or cast, as shown in **Figure 5**. In these fossils, there are no remaining parts of the original organism. For example, **molds** can be the imprints from a shell or the skin of an animal. There are molds of bite marks, footprints, and eggs in a nest. If the mold is filled in with sediment that hardens into rock, a **cast** fossil forms.

## Original Material

Did you see the movie in which an entire organism was preserved in amber—the fossilized sap of an ancient gymnosperm? A preserved organism in amber is a type of fossil called original material. Another example of original material is the head from a frozen woolly mammoth shown in **Figure 6**. An original material fossil is unique because none of the hard and soft structures of the original organism have been replaced or altered. The organism is preserved in its original form. It is rare to find original material, but when it happens it provides much information to paleontologists. Most original-material fossils are more recent than other fossil types.

**Figure 6** Scientists discovered a woolly mammoth preserved in thick ice in Siberia. It still had hair on its head.



**Figure 6** What other body structures might have been preserved by freezing?

## What do fossils tell us?

Much of the evidence for the pattern of evolution and evolutionary relationships comes from fossils. Scientists also study fossils in order to understand some processes and rates of evolution. Recall from Chapter 5 that natural selection is the survival and reproduction of species with traits that enable them to survive under particular conditions. Over generations, species change due to the loss of organisms that did not have those traits that enabled them to survive. Fossils provide a record of different species that lived in the past.

### Relative Fossil Ages

Generally, the older the rock layer, the deeper it is in Earth. If a paleontologist finds fossils in a fairly shallow sedimentary rock layer and then finds others in a deeper sedimentary rock layer, the older fossils are usually those in the deeper sedimentary rock layer, as illustrated in **Figure 7**. This is true unless there has been an unusual disturbance to the area that has rearranged the rock layers. In this way, ages of the fossils can be compared by the relative ages of the rocks.



How can sedimentary rock layers indicate the relative age of fossils?

**Figure 7** Fossil-filled sedimentary rocks usually form horizontal layers. If undisturbed, sedimentary rock layers can provide evidence of the approximate ages of the fossils in them.



## MiniLab

00:45  
minutes

### How do fossils form?



Fossils form over time in several ways. Can you create a fossil?

#### Procedure



1. Complete a lab safety form.
2. Choose an **object** provided by your teacher to fossilize.
3. Make two **clay** pancakes. Rub **petroleum jelly** over one side of each pancake.
4. Press your object into the petroleum-covered side of one clay pancake. Cover the object with the other pancake (petroleum-jelly sides together). Press down lightly.
5. Carefully separate the two pancakes.

#### Analysis

1. **Identify** the type of fossil you made.
2. **Compare and contrast** your fossil with a real fossil.
3. **Analyze** any problems you had with this lab activity. How do you think you could improve it?







## Species and Environmental Changes

The **fossil record** is made of all known fossils and their placements in the formation of rocks and positions in time. It is evidence that supports the evolution of organisms. However, the fossil record has gaps, much like a story in a book that has missing pages. The gaps exist because most organisms decay before fossilization happens, geological processes destroy fossils, or fossils are undiscovered. Even with the gaps, the fossil record is evidence that most of the species that ever lived on Earth are now extinct.



Why are there gaps in the fossil record?

Fossils provide evidence of how life and environmental conditions have changed throughout time. By studying fossils, scientists have determined that during Earth's early history, life was not as complex as it is now. More complex organisms appeared later in Earth's history.

Scientists can use fossils to make models that show what an organism might have looked like, as shown in **Figure 8**. From fossils, scientists can sometimes determine whether an organism lived in family groups or alone, what types of food it ate, what kind of environment it lived in, and many other things about it.

**Figure 8** Paleontologists can reconstruct organisms from pieces of their fossilized remains. However, new evidence might require corrections to existing reconstructed organisms.





# How do fossils provide evidence of the past?

Most organisms decompose and leave no direct evidence of their existence. However, the parts of organisms that are preserved through permineralization, replacement, carbonization, or other methods can tell us much about when organisms lived, how they changed, and when they became extinct. Fossils provide clues that paleontologists can use to reconstruct extinct organisms.

The locations of fossils in sedimentary rock layers can indicate the relative ages of fossils. The pattern of when organisms appear in the fossil record and the structure of the organisms is best explained by the theory of evolution by natural selection.

## LESSON 1 Review

### Summarize

Create your own lesson summary as you design a **study web**.

1. **Write** the lesson title, number, and page numbers at the top of a sheet of paper.
2. **Scan** the lesson to find the **red** main headings.
3. **Organize** these headings clockwise on branches around the lesson title.
4. **Review** the information under each **red** heading to design a branch for each **blue** subheading.
5. **List** 2–3 details, key terms, and definitions from each **blue** subheading on branches extending from the main heading branches.



### Standards Check

#### Using Vocabulary

Write the vocabulary term defined below.

1. scientists who specialize in studying fossils **3.c**
2. naturally preserved remains of organisms that lived long ago **3.c**

#### Understanding Main Ideas

3. **Explain** why most plants and animals do not become fossils. **3.c**
4. **Give examples** of the types of fossils formed through permineralization and carbonization. **3.c**
5. **Describe** one method a paleontologist can use to approximate the age of fossils. **4.c**

#### Applying Science

6. **Evaluate** how fossils support the theory of evolution by natural selection. **4.e**
7. **Create** a map to show where fossils of different ages would be found along a cliff. **4.c**
8. **Identify** Copy and fill in the graphic organizer below to identify three fossilization processes. **3.c**



For more practice, visit **Standards Check** at [ca7.msscience.com](http://ca7.msscience.com).





## LESSON 2



### Science Content Standards

**3.c** Students know how independent lines of evidence from geology, fossils, and comparative anatomy provide the bases for the theory of evolution.

### Reading Guide

#### What You'll Learn

- **List** several sciences that have provided evidence for the theory of natural selection.
- **Describe** the study of embryology.
- **Summarize** how the study of DNA has affected the search for common ancestors.
- **Explain** how homologous structures provide evidence of evolution.

#### Why It's Important

Knowing how biological evidence supports the theory of evolution by natural selection will add to your understanding of how some species are related.

#### Vocabulary

comparative anatomy  
homologous structure  
embryology

#### Review Vocabulary

**adaptation:** inheritance of traits that allow an organism to survive in a particular environment (p. 216)

## Biological Evidence

**Main Idea** Evidence from comparative anatomy and molecular biology are best explained by the theory of evolution by natural selection.

**Real-World Reading Connection** At the zoo, there might be animals that appear similar. For example, different bears might have different colors of fur but you can easily recognize that they are bears. Are these similar animals related? Is it coincidence that they are similar? Scientists have wondered about the same things.

### Comparative Anatomy

Another form of evidence that supports the theory of evolution by natural selection is comparative anatomy. **Comparative anatomy** is the study of similarities and differences in the structures of organisms. By using comparative anatomy, scientists have made important scientific discoveries.

Scientists who study insects have known for years that two groups of insects—true flies and scorpionflies—are similar. A true fly, shown in **Figure 9**, has a pair of large, thin wings and a pair of small, knoblike appendages behind them. A scorpionfly has two pairs of large, thin wings. Scientists predicted that if these groups of insects had a common ancestor, a fossil existed of an ancestor of true flies with two pairs of wings. In 1976, scientists found fossils of four-winged true flies that confirmed their prediction of a common ancestor. The anatomy of the tiny insect fossils provided much evidence to support evolution. The combination of studying and comparing the structures of fossils and living organisms has supported the pattern of evolution.

**Figure 9** Although present-day true flies and scorpionflies appear different, they have a common ancestor.

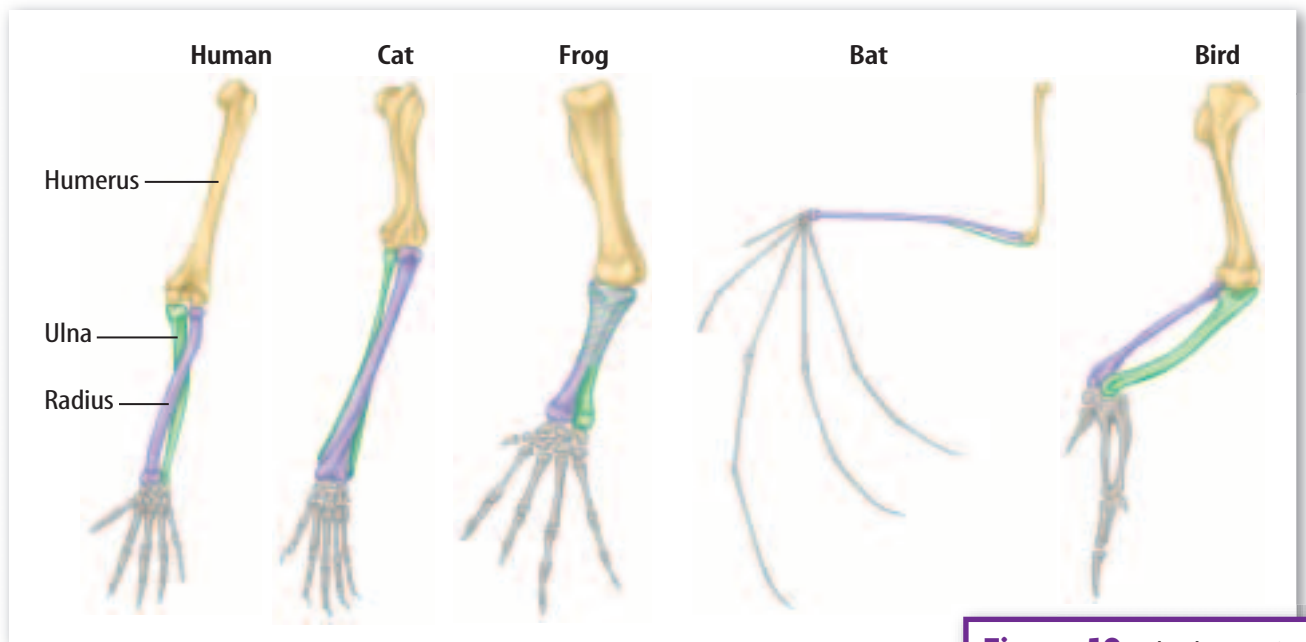


True Fly



Scorpionfly





**Figure 10** The bones in the upper limbs of these animals are homologous structures.

## Structures in Living Organisms

Humans, frogs, bats, birds, and cats all have a common set of three bones in their front or upper appendages, as shown in **Figure 10**. The sizes of the bones are different but their forms are similar. At some point in our past, we all shared a common ancestor, but some share more recent ancestors than others.

**Homologous Structures** In plants, many angiosperms have similar fruits. Recall from Chapter 3 that fruits develop mostly from flower ovaries and they protect the seeds. Angiosperms have a more recent common ancestor than gymnosperms—seed plants without fruits. Parts of organisms that are similar in origin and structure are called **homologous** (huh MAH luh gus) **structures**. Homologous structures are the result of evolution and can indicate how closely two or more species share common ancestors.



What can homologous structures in organisms indicate?

**Analogous Structures** The wings of birds and insects are examples of **analogous** (uh NAH luh gus) structures. They appear similar but have different ancestral origins. They resulted from similar environmental conditions that produced similar natural selection outcomes over time, but on distantly related organisms.

Scientists do not observe two organisms and decide that because they look alike, they share an ancestor. Instead, scientists consider geography, environmental conditions, fossil records, structures and functions of the body parts, and genetics when possible, in order to understand evolutionary relationships. The accumulation of evidence from these different sources supports evolutionary lines.

## WORD ORIGIN

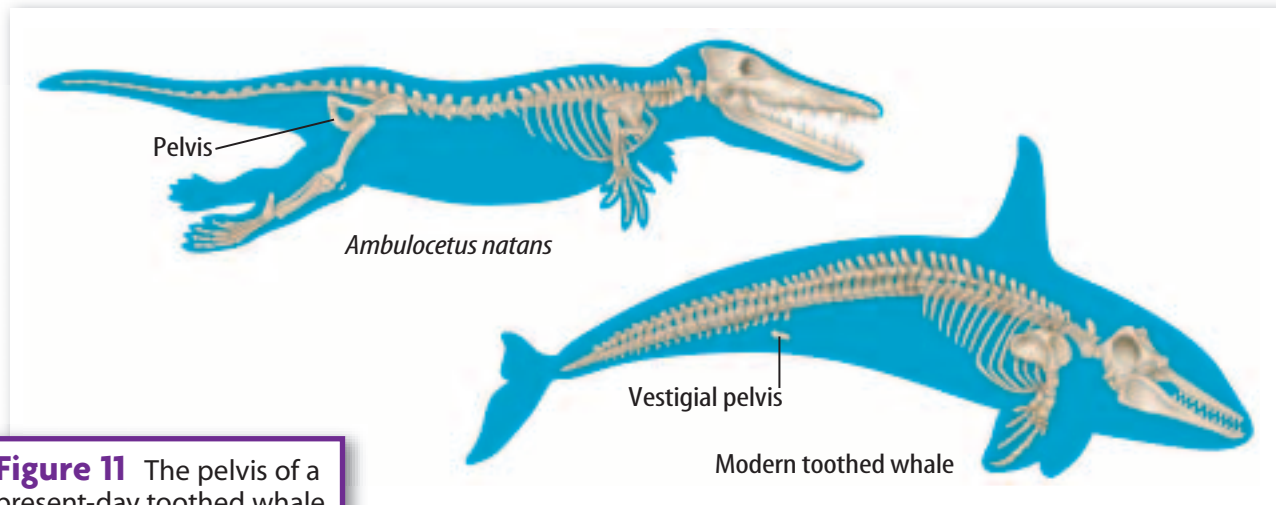
### homologous

from Greek *homologos*; means agreeing, of one mind

## ACADEMIC VOCABULARY

### analogous (uh NAHL uh gus)

(*adjective*) being or related to  
*Analogous animal behaviors include humans talking, frogs croaking, and birds singing.*



**Figure 11** The pelvis of a present-day toothed whale is just two small bones. In its ancient ancestors, the pelvis was larger and supported hind legs.

**Propose** an explanation as to why a toothed whale's pelvis is smaller today.

**Vestigial Structures** Another source of evidence for evolution are vestigial (veh STIH jee ul) structures. These structures have no function in their present-day form. However, scientists hypothesize that vestigial structures once functioned in an ancestor. For example, most mammals have pelvic bones that support a pair of legs. Present-day whales have pelvic bones but do not have leg bones like their ancestors, as shown in **Figure 11**. Some people question why vestigial structures would remain through natural selection if they have no function. It is because vestigial structures are genetically related to an advantageous trait of the species or because their absence would have harmful effects for the survival of the species.

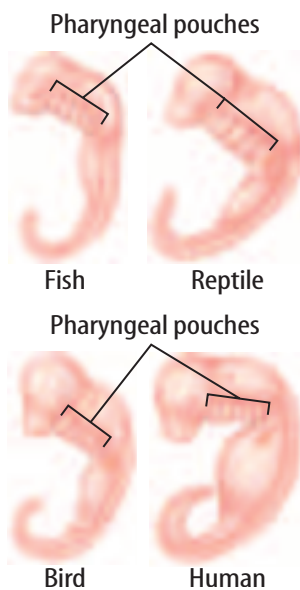
## Embryology

The science of the development of embryos from fertilization to birth is **embryology** (em bree AH luh jee). Scientists who study embryos of different animals often compare and contrast their patterns of development. Similar patterns can provide clues to the evolutionary relationships among organisms.

Embryos of different vertebrate animal species have similar early developmental stages during which they show common features. As the embryos grow and develop, those features become unique structures in different species. For example, embryos of vertebrate animals have bulges in the region of the neck called pharyngeal (fuh rihn JEE ul) pouches, as shown in **Figure 12**. They become facial and neck structures. In fish, they develop into structures called gill arches; in humans, one of the pharyngeal pouches develops into part of the ear.

It is important to remember that the more closely related species are, the more features they share during development. These shared similarities are best explained by the theory of common ancestors and evolution through natural selection. However, while developmental patterns indicate evolutionary history, they are not an historical journey through evolution.

**Figure 12** Similarities among vertebrate animal embryos provide evidence of evolution.



## Molecular Biology

What is known today about genetics, biochemistry, and molecular biology probably would have amazed Darwin. New technology provides the tools to continue making rapid discoveries in these areas. These molecular data also support the theory of evolution through natural selection.

The proteins in all organisms consist of countless arrangements of just 20 different molecules called amino acids. Recall from Chapter 1 that cellular respiration requires oxygen and releases energy. Organisms that use cellular respiration must have a protein called cytochrome *c* for this process to occur. Scientists have discovered slight differences in the cytochrome *c* molecules found in different organisms that use cellular respiration. It is unlikely that these differences developed independently from different ancestral lines. For example, this protein is more similar among mammals, such as a pig, a monkey, and a human, as shown in **Figure 13**, than are the forms of the protein found in other organisms. This supports the theory that different mammals have a more recent ancestor in common than do mammals and yeast.

Scientists also look at other proteins and at the sequences of DNA. Recent molecular data suggests that closest living relative of whales are hippopotamuses. This molecular evidence supports prior evidence from comparative anatomy about whales' relationships to even-toed hoofed animals, but offers specific information about the relationship than previously known.



What types of molecules provide evidence of evolution?

### DataLab

00:15  
minutes

#### What do proteins tell us about evolution?

##### Data

Use the graph in

**Figure 13** to compare cytochrome *c* of different organisms.

##### Data Analysis

1. **Name** the organism whose cytochrome *c* is most like human cytochrome *c*.
2. **Determine** if a dog or a turtle has a more recent common ancestor with a frog.

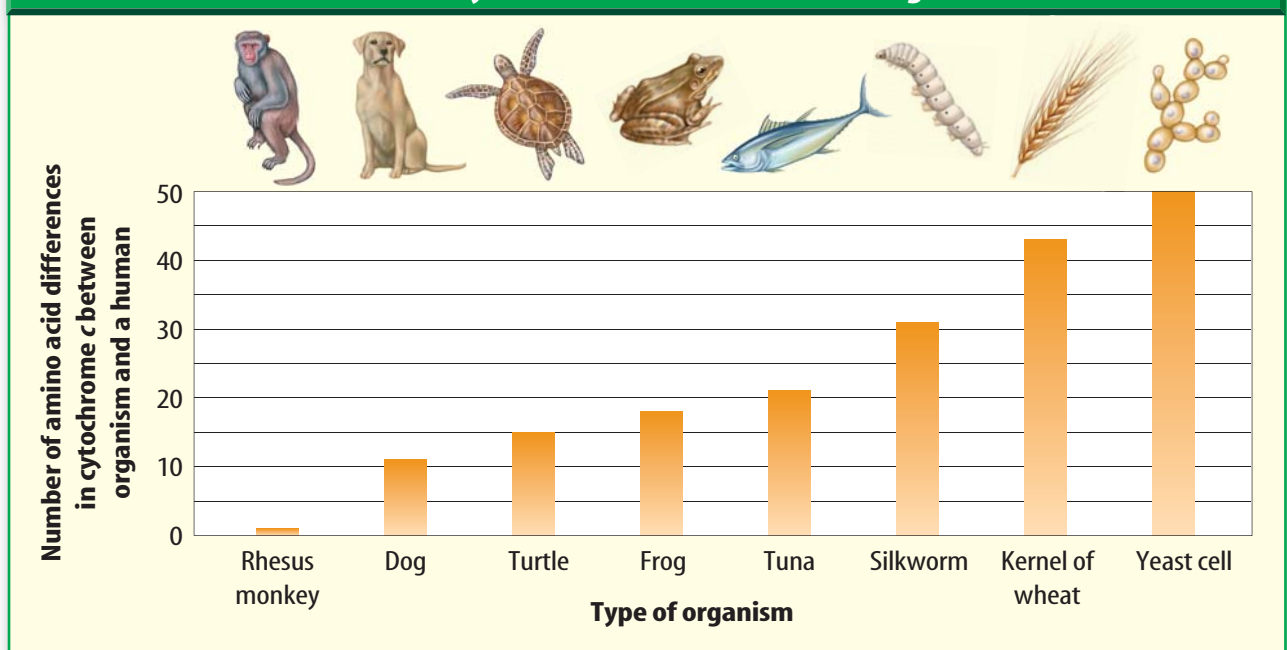


3.c



**Figure 13** Analysis of the protein—cytochrome *c*—can indicate common ancestors among organisms.

Differences in Cytochrome *c* Between Various Organisms







## How does biological evidence support the theory of evolution?

Evolution is also supported through different biological evidence. Scientists use homologous and analogous structures to determine possible relationships among modern organisms and their ancestors. Examining vestigial structures provides further understanding of the evolution of present-day organisms from ancient ancestors. Studying the embryology of different organisms provides supporting evidence for evolution from a common ancestor, but does not provide evidence of how evolution occurred. Recent technologies have enabled scientists to use molecular biology to search for common ancestors. The data from different branches of science are compared and used to build a better understanding of evolution.

### LESSON 2 Review

#### Summarize

Create your own lesson summary as you write a script for a **television news report**.

1. **Review** the text after the **red** main headings and write one sentence about each. These are the headlines of your broadcast.
2. **Review** the text and write 2–3 sentences about each **blue** subheading. These sentences should tell *who*, *what*, *when*, *where*, and *why* information about each **red** heading.
3. **Include** descriptive details in your report, such as names of reporters and local places and events.
4. **Present** your news report to other classmates alone or with a team.



ELA7: LS 2.2



#### Standards Check

##### Using Vocabulary

Complete each sentence using the correct term.

comparative anatomy  
homologous structure  
embryology

1. The femur bone in the upper appendages of birds, humans, and frogs is an example of a(n) \_\_\_\_\_. **3.c**
2. \_\_\_\_\_ provides evidence of evolution using structures of organisms. **3.c**
3. Pharyngeal pouches are an example of evidence of evolution based on \_\_\_\_\_. **3.c**

##### Understanding Main Ideas

4. **Explain** how DNA sequences can provide evidence of evolution. **3.c**

5. Which is most likely a vestigial structure?

- A. an ape's thumb **3.c**
- B. a dolphin's flipper
- C. a whale's pelvis
- D. a rabbit's fluffy tail

##### Applying Science

##### 6. Organize Information

Copy and fill in the graphic organizer below to describe the different examples of comparative anatomy as evidence of evolution. **3.c**

Comparative Anatomy	
Example	Description



For more practice, visit **Standards Check** at [ca7.msscience.com](http://ca7.msscience.com).



## LESSON 3



### Science Content Standards

**3.a** Students know both genetic variation and environmental factors are causes of evolution and diversity of organisms.

**4.f** Students know how movements of Earth's continental and oceanic plates through time, with associated changes in climate and geographic connections, have affected the past and present distribution of organisms.

### Reading Guide

#### What You'll Learn

- **Explain** how plate tectonics changes landforms and environments.
- **Discuss** how changes in landscapes and environments can lead to new species.
- **Describe** how plate tectonics relates to biogeography.

#### Why It's Important

Knowing that plate tectonics results in environmental and geological changes helps you understand how evolution can occur over time.

#### Vocabulary

geographic isolation  
convergent evolution

#### Review Vocabulary

**lithospheric plate:** large, brittle pieces of Earth's outer shell composed of crust and uppermost mantle (Grade 6)

# Evolution and Plate Tectonics

**Main Idea** Over time, the movement of lithospheric plates has changed environments that led to changes in species.

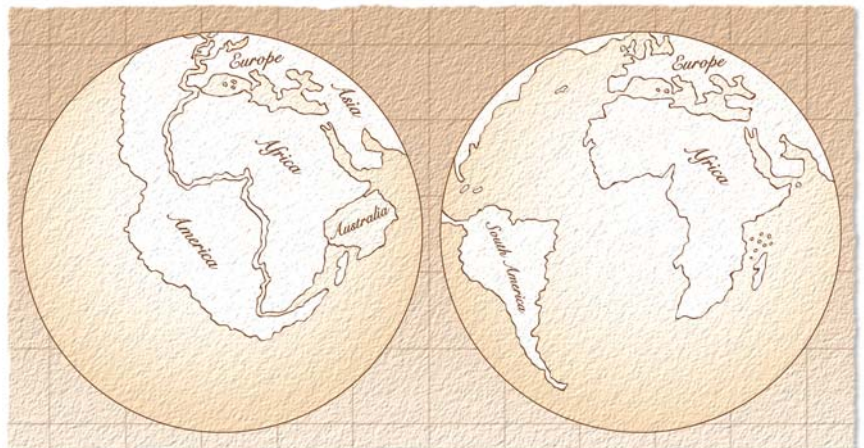
**Real-World Reading Connection** If you quickly glance at a clock, you probably notice the movement of the second hand but not the movement of the hour hand. Like the hour hand, the ground below you is slowly moving. Over time, the slow movement of Earth's plates has led to changes in species.

## Continental Drift

Earth's surface slowly changed over time, and it is hard to recognize the changes. However, earthquakes are evidence that changes to Earth's lithospheric plates are still occurring.

Recall that Alfred Wegener proposed the continental drift hypothesis in 1912. The most obvious evidence for his hypothesis included the fit of shorelines of Africa and South America, as shown in **Figure 14**. As lithospheric plates move, environmental changes result for the species that live on and near them. Natural selection acts upon species when there are environmental changes. Only individuals that are well-suited to the new conditions will be able to survive and pass their genes to offspring. Environmental changes can also lead to species extinctions.

**Figure 14** Because present-day continents can fit together like a jigsaw puzzle, Wegner proposed that they once were one large landmass.



# Visualizing Geographic Isolation

**Figure 15** The mountains, valleys, and coastal ranges of Oregon and California have geographic and geologic influences on species of salamanders.







## Geographic Isolation

Landforms are created when lithospheric plates move. Mountains and volcanoes form when lithospheric plates move together. Valleys form where lithospheric plates move apart. Sometimes, landforms become barriers between populations of species, and breeding between these populations is **prohibited**. When this happens, **geographic isolation** can occur. Once separated, the populations in different environments might follow different evolutionary paths over time. Other geographic features, such as rivers and large bodies of water, can lead to geographic isolation of species, also.

**Figure 15** illustrates geographic isolation in California. The geography of a location plays an important role in how organisms evolve.



How can geographic isolation occur?

### Darwin's Observations of Geographic Isolation

Geographic isolation was responsible for many of the organisms described in Darwin's journals. The results of geographic isolation puzzled Darwin and prompted much of his research. Imagine if you have two islands with very similar environmental conditions— island A and island B—but on different sides of Earth. Imagine that island A is near the mainland, but the environmental conditions on island A and those on the mainland are quite different. Obviously, you would expect the organisms on island A and island B to be more similar than those on island A and the mainland. In the Galápagos Islands and Ecuador, Darwin found just the opposite. Species on the Galápagos Islands were more similar to those on the Ecuador mainland even though the environments of the islands and the mainland were different. Yet, the similar organisms were clearly unique species. These observations led to the idea of evolution by natural selection.

### Geographic Isolation v. Convergent Evolution

Sometimes distant locations with similar environmental conditions have species with similar traits. These species have evolved independently but under similar conditions. This type of evolution is known as **convergent evolution** and results in structural and functional similarities. New research in genetics has supported the finding that although two species in similar environments can appear similar, they did not evolve from common ancestors.

**Figure 16** shows two plant species that have undergone convergent evolution. They appear similar, but they are from different branches of the evolutionary tree. Geographic isolation leads to closely related species that appear different while convergent evolution results in very distantly related species that appear similar.

### ACADEMIC VOCABULARY

**prohibit** (pro HIIH bit)

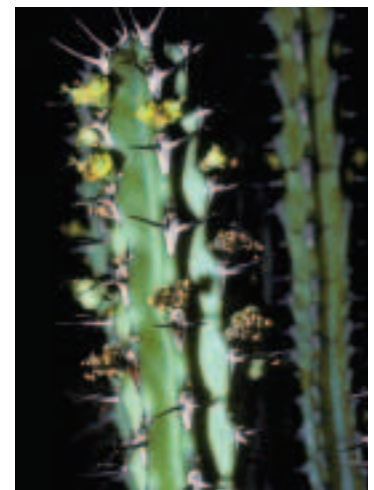
(*verb*) to prevent from doing something

*An automobile accident can prohibit other vehicles from moving on the freeway.*

**Figure 16** Cacti and euphorbias evolved in desert-like environments. But cacti evolved in the Americas and euphorbias evolved in Africa.



**Cactus**



**Euphorbia**



## How are plate tectonics and evolution related?

The moving lithospheric plates result in changes to Earth's surface, such as the formations of mountains, valleys, and bodies of water. These geographic barriers can result in the evolution of new species when populations become separated. Some related species are now separated because of plate tectonics. Widely separated species can evolve similar traits that ensure survival in similar environments.

Changes in climate, whether from plate tectonics or for other reasons, resulted in the evolution of new species by natural selection. Recall from Chapter 5 that environmental changes can cause species adaptations or extinctions. Only members of the species with traits that enable them to survive the new environmental conditions will survive, reproduce, and pass their genetic material to offspring.

### LESSON 3 Review

#### Summarize

Create your own lesson summary as you organize an **outline**.

1. **Scan** the lesson. Find and list the first **red** main heading.
2. **Review** the text after the heading and list 2–3 details about the heading.
3. **Find** and list each **blue** subheading that follows the **red** main heading.
4. **List** 2–3 details, key terms, and definitions under each **blue** subheading.
5. **Review** additional **red** main headings and their supporting **blue** subheadings. List 2–3 details about each.



ELA7: W 2.5



#### Standards Check

##### Using Vocabulary

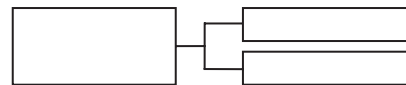
1. Define *geographic isolation* in your own words. **4.f**
2. Use *convergent evolution* correctly in a sentence. **3.a**

##### Understanding Main Ideas

3. **Describe** how the movement of lithospheric plates can lead to evolution in species. **4.f**
4. **Explain** how hummingbirds from North America and unrelated sunbirds from Africa could both evolve long beaks for reaching into flowers. **3.a**
5. **Show** how the formation of a valley could result in the evolution of new species. **4.f**

##### Applying Science

6. **Predict** what would happen to the plants in your neighborhood if Earth's climate cooled over the next century. **3.a**
7. **Infer** what might have happened to the South American population of beech trees if South America had drifted south instead of west. **4.f**
8. **Determine Cause and Effect** Draw a graphic organizer like the one below to list two ways evolution can occur because of plate tectonics. **4.f**



**Science**  **online**

For more practice, visit **Standards Check** at [ca7.msscience.com](http://ca7.msscience.com).

# Applying Math

## Converting Time Ranges of Fossils into Years



Fossil data span millions of years. These data are sometimes written in a decimal form of millions of years ago (mya). The data table for the time ranges of some fossil species is given below.

Fossil Species	Time Range (mya)
<i>Homo erectus javanicus</i>	1.6–0.6
<i>Homo erectus pekinensis</i>	0.7–0.5
Neanderthal	0.07–0.04
<i>Homo sapiens</i>	0.3–0.1
<i>Homo erectus soloensis</i>	0.8–0.46

### Example

Find how many years ago *Homo erectus soloensis* lived.

- 1 Use the data to find the beginning of the range and the end of the range for *Homo erectus soloensis*:

beginning: 0.8, end: 0.46

- 2 Multiply each number by 1,000,000 to find the range in years.


$$0.8 \times 1,000,000 = 800,000 \text{ years ago}$$

$$0.46 \times 1,000,000 = 460,000 \text{ years ago}$$

**Answer:** *Homo erectus soloensis* lived between 800,000 and 460,000 years ago.

### Practice Problems

1. In years, when was the first appearance of *Homo erectus javanicus* on Earth?
2. In years, when was the latest appearance of *Homo erectus javanicus* on Earth?
3. What is the time range for the existence of *Homo erectus javanicus* on Earth?

**Science**   
For more math practice,  
visit Math Practice at  
[ca7.msscience.com](http://ca7.msscience.com).





## LESSON 4



### Science Content Standards

**3.d** Students know how to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics and how to expand the diagram to include fossil organisms.

**Also covers:** 7.c, 7.d, 7.e

### Reading Guide

#### What You'll Learn

- ▶ **Describe** how people in the past classified organisms.
- ▶ **List** the hierarchical order of classifications for our current system.
- ▶ **Explain** how the recent advances in biotechnology have supported the theory of evolution through natural selection.

#### Why It's Important

Classification of organisms is a way to organize information about evolutionary relationships.

#### Vocabulary

systematics

#### Review Vocabulary

**species:** a group of organisms that share similar characteristics and can reproduce among themselves producing fertile offspring (Grade 6)

## Classifying Organisms

**Main Idea** Scientists use traits and evolutionary history to classify species.

**Real-World Reading Connection** How do you organize your clothes? Do you hang your T-shirts with your other shirts in your closet or put them in a drawer with other folded clothes? Do your friends organize their clothes in the same way? Scientists organize Earth's organisms into groups, but they do not always agree on the best system.

### Historic Classification Systems

The Greek philosopher Aristotle was one of the first people to classify organisms. He categorized things as animals, plants, or minerals. Aristotle also grouped living things by where they lived—in the air, on the land, or in the sea. Scholars used this system for hundreds of years. When Europeans began exploring new lands, they discovered many new plants and animals that could not be classified using Aristotle's system. A new classification system was needed.

In the mid-eighteenth century, Swedish botanist and explorer Carolus Linnaeus developed a classification system that grouped organisms based on similar physical structures. The Linnaeus classification system has many related levels. The largest group of organisms is a kingdom and the smallest group is a species. A species includes organisms that have the greatest number of traits in common and can breed and produce fertile offspring. Only species are subject to natural selection and evolution.

### Naming and Grouping Species

Linnaeus also developed a system for naming species that is still used. The two-word scientific name of an organism is its species name. For example, the species name for the California black oak is *Quercus kelloggii*.

Groups of similar living species belong to a genus (plural, genera). The first word of a species name identifies the genus to which the species belongs. All oaks have *Quercus* as the first word of their species name. Similar genera belong to a family, similar families belong to an order, similar orders belong to a class, similar classes belong to a phylum (plural, phyla), and similar phyla belong to a kingdom. **Table 1** shows these classifications levels for the western spotted skunk.



(t to b) Stephen L. Kossman/GPU Photo Researchers, Claus Meyer/Minuten Pictures, OSFS, Turner/Earth Science, Theo Allis/ORBIS, Kavika Chaiton/Codi Water Images, Esam/Arndt/Photo Communications

## Determining Kingdom

Cell type, the presence of a cell wall, or whether organisms are single-celled or multicellular, are used to define a kingdom. Scientists classify living organisms into one of six kingdoms—Kingdom Eubacteria, Kingdom Archeabacteria, Kingdom Protists, Kingdom Fungi, Kingdom Plantae, and Kingdom Animalia.









What are some traits that scientists use to classify organisms?

Concepts in Motion

**Interactive Table** To organize levels of classification, visit Tables at [ca7.msscience.com](http://ca7.msscience.com).

**Table 1** Classification of Living Things

Level	Example	Representative Organism	
Species	<i>Spilogale gracilis</i>		<b>Western spotted skunk</b>
Genus	<i>Spilogale</i> Spotted skunks (three species)		
Family	Mephitidae Skunks and stink badgers (four genera)		<b>Hog-nosed skunk</b>
Order	Carnivora All animals with large pointed teeth for tearing flesh (13 families)		<b>Mountain Lion</b>
Class	Mammalia Animals with mammary glands (26 orders)		<b>Mule deer</b>
Phylum	Chordata Animals with a spinal cord (11 families)		<b>Desert tortoise</b>
Kingdom	Animalia Multicellular eukaryotes whose cells do not have cell walls (32 phyla)		<b>Coral Reef at Anacapa Island, California</b>



## MiniLab

00:20  
minutes

### How can you create a dichotomous key?

In this lab, you'll create a dichotomous key to classify objects.

#### Procedure

1. Complete a lab safety form.
2. Obtain a **container of objects** from your teacher.
3. Examine the objects and then brainstorm a list of possible characteristics.
4. Choose a characteristic that separates the objects into two groups. Write a sentence to describe the characteristic. Write a sentence below it that has the word "not" in front of the characteristic. For example, if the characteristic is "round," then the second sentence would say "not round." At the end of the first sentence, write "Go to 1." At the end of the second sentence write "Go to 2."
5. Repeat step 4 for the two new groups. Sentences for new groups formed from the first group should have consecutive odd numbers. Sentences for groups formed from the second group should have consecutive even numbers. At the end of each new sentence, add the appropriate "Go to" directions.
6. Repeat steps 4 and 5 until there is one object in each group, then write the name of the object at the end of the sentence.

#### Analysis

**Compare** your key with at least three of your classmates' keys. Record differences and similarities.



## Modern Methods of Classification

The modern study of classification is called **systematics**. In systematics, mostly DNA and molecular biology are used to identify relationships between organisms.

Scientists can now determine the order or sequence of the molecules in an organism's DNA. The more DNA sequences two species have in common, the more likely it is that they share a recent ancestor. Such DNA evidence has confirmed many existing classifications. However, scientists have found that species established as close relatives, do not share as many DNA sequences as expected. When this occurs, scientists review existing evidence of evolution such as fossils and comparative anatomy data, and often reclassify organisms.



How can examining DNA sequences affect classification?

It is too expensive to find the complete DNA sequence for all organisms. However, scientists can determine the sequence of a sample of 1,000 molecule pairs in DNA called haplotype (HA ploh tipe). Scientists compare these small sequences of DNA between organisms to search for similarities. The more similar two halotypes are, the more closely the organisms are related.

DNA hybridization is another tool used in systematics. Scientists do not learn the actual sequences of DNA that two organisms share using DNA hybridization, but they can determine the percentage of DNA that is the same.

A new level of classification that developed because of molecular biology is domain. Domain is now the highest level instead of kingdom. Based on differences in a particular DNA sequence, organisms are separated into three domains—Bacteria, Archaea, or Eukarya. The Eukarya includes organisms that have cells with a nucleus. As other molecular biology techniques are developed, classification systems might change.



# How are classification of organisms and evolution related?

Classification is based on the idea of common ancestors, from the theory of natural selection. Aristotle developed the first classification system. Linnaeus used similar physical structures to place organisms into groups and developed the species naming system. The first word of a species name identifies the genus of the species. Molecular systematics is part of the classification process now. The new hierarchy of classification is domain, kingdom, phylum, class, order, family, genus, species. Classification is very useful for understanding and communicating evolutionary relationships.

## LESSON 4 Review

### Summarize

Create your own lesson summary as you write a **newsletter**.

1. **Write** this lesson title, number, and page numbers at the top of a sheet of paper.
2. **Review** the text after the **red** main headings and write one sentence about each. These will be the headlines of your newsletter.
3. **Review** the text and write 2–3 sentences about each **blue** subheading. These sentences should tell *who*, *what*, *when*, *where*, and *why* information about each headline.
4. **Illustrate** your newsletter with diagrams of important structures and processes next to each headline.



ELA7: W 2.5



### Standards Check

#### Using Vocabulary

1. Define *systematics* in your own words. **3.d**

#### Understanding Main Ideas

2. **Describe** how scientists use evolution to classify species. **3.d**
3. **Discuss** two advantages of the Linnean system over previous systems. **3.d**
4. **Sequence** the following classification categories from the one with the least number of organisms to the one with the greatest number of organisms: *family, domain, class, species, phylum, and order*. **3.d**

#### Applying Science

5. **Classify** a species of your choice. List all of the taxa in which it belongs, starting with its species name. **3.d**

6. **Develop** a classification tree for desserts. Be sure the most similar desserts are on the branches with the fewest divisions between them. The desserts that are less similar should branch farther back on the tree. **3.d**
7. **Take Notes** Copy the graphic organizer below and list methods of analyzing DNA mentioned in this lesson, and describe how each might affect modern classification. **3.d**

Method of DNA Analysis	Effect on Modern Classification

**Science**  **online**

For more practice, visit **Standards Check** at [ca7.mssscience.com](http://ca7.mssscience.com).

## Classifying the Students in Your Class

**Materials**  
paper and pencil



### Science Content Standards

**3.d** Students know how to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics and how to expand the diagram to include fossil organisms.

**7.c** Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.

**7.d** Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

**7.e** Communicate the steps and results from an investigation in written reports and oral presentations.

### Problem

If you had a dog, a cat, a mouse, and a gecko, how would you classify them? You could place them in the same group because they're all possible pets. Or, you might put the gecko in a different group because it doesn't have fur like the others. For any group of objects, there are several possible ways to classify them. Scientists create diagrams, called cladograms, like the one shown on the next page, to group organisms based on certain characteristics. A cladogram shows common ancestry and helps scientists to better understand evolution. What other uses might a cladogram have?

### Form a Hypothesis

Before you gather the data, propose a way to classify students in your class. Write a hypothesis.

### Collect Data and Make Observations

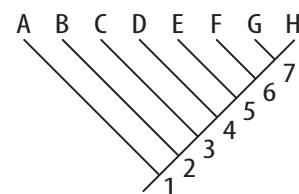
1. With other students in your class, brainstorm a list of characteristics about yourselves. Examples of characteristics might include:
  - number of pets
  - number of siblings
  - number of aunts or uncles or total family members
  - length of hair
  - height
  - hobbies
  - favorite school subject



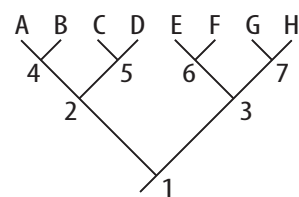
2. Make a questionnaire from the list of characteristics and distribute it to everyone in the class.
3. Complete your questionnaire as homework and bring it back to the class the next day. Do not put your name on your questionnaire.
4. Analyze the information about the characteristics of yourself and your classmates. How many different ways can you classify the members of your class?
5. Create a cladogram of your class using some or all of the characteristics from the questionnaire.

## Analyze and Conclude

1. **Explain** your choice of characteristic(s) used in making your cladogram.
2. **Describe** any difficulties you had in making your cladogram.
3. **Explain** what you like about this method of classification. Do you think it is useful?
4. **Identify** other sorting patterns you could use instead of producing a cladogram. What are the advantages and disadvantages of these other methods?
5. **Analyze** Is this a true cladogram? Explain.
6. **Infer** where a fossil of an ancient human might be on your cladogram.
7. **Error Analysis** Compare your cladogram to the cladograms of some of your other classmates. Write down advantages and disadvantages of each one. Would you do the activity differently next time? Explain.



Cladogram 1



Cladogram 2

## Communicate

### WRITING in Science

What did you learn from your experience of classifying a real set of data with multiple characteristics? Was it easy to identify individuals by their characteristics? Was this important? What might be the usefulness of the classifications? Summarize your findings in your Science Journal.



# Real World Science

## Science & Career



### Studying Bacteria Evolution

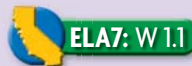
Since some bacteria reproduce quickly, scientists called microbiologists can observe many generations of these organisms within a few weeks. Often during that time, these organisms change or evolve. Some scientists study bacteria as they evolve to look for ways to control diseases in crops and humans. Others study bacteria to learn about their genetics and how to apply that knowledge to humans. Still others study these organisms to answer evolutionary questions.

Visit **Careers** at [ca7.msscience.com](http://ca7.msscience.com) to learn more about microbiologists. Create a list of interview questions that you might ask a microbiologist, such as questions about his or her background, current research and how it applies to the real world, and what a typical day is like.

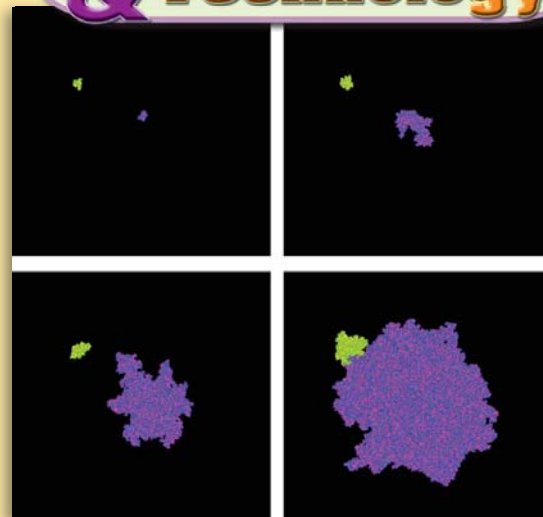
### Observe Evolution in Action

Scientists have created programs that can evolve digital organisms. These complex computer simulations can model real-life organisms, like ants, to study their behavior. Some programs allow the evolution of artificial brains to see if the animals can survive in specific environments. Other programs use artificial organisms only found within the computer world. This picture shows a digital form evolving.

Visit **Technology** at [ca7.msscience.com](http://ca7.msscience.com) to find out more. Write a short report describing one of the programs currently used.



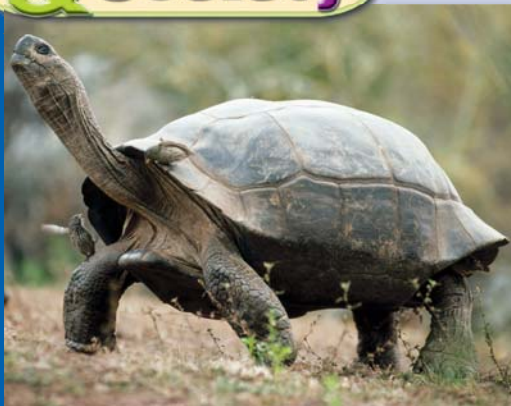
## Science & Technology



## Early Hypothesis of Evolution

In 1801, a French naturalist named Jean Baptiste Chevalier de Lamarck proposed that microscopic organisms appear spontaneously and then evolve into more complex life-forms. Eventually, perfection was reached when humans evolved. One of his ideas was that the long necks of giraffes evolved as giraffes stretched their necks to reach leaves on trees generation after generation. Today we know that his hypothesis about these processes was incorrect.

Visit **History** at [ca7.msscience.com](http://ca7.msscience.com) to find out more about Lamarck's ideas. Write a paragraph describing another of his incorrect hypotheses.



## The Galápagos Islands—An Evolution Museum

Until Darwin returned from his voyage, no one knew about these islands and their inhabitants. Today, the Galápagos Islands are known worldwide and recognized for their scientific importance. Visitors to the islands and the resident population are affecting native organisms, such as the Galápagos tortoises. However, conservation plans are underway to preserve this evolution museum.

Visit **Society** at [ca7.msscience.com](http://ca7.msscience.com) to learn about the plans to preserve life on the Galápagos Islands. Create a visual aid about one of the plans and share it with your class.



## The BIG Idea

Evidence from biology and paleontology is best explained by the theory of evolution.

### Lesson 1 Fossils and Evolution



3.c, 4.c, 4.e, 7.d

**Main Idea** Fossils provide evidence of changes to species and the environment over time.

- Paleontologists study fossils—the naturally preserved remains of ancient organisms—to learn more about these organisms.
- Permineralization and replacement are processes that result in dissolved minerals hardening and forming fossils of the remains of organisms.
- Molds and casts are preserved imprints and indentations that leave no part of the original organism.
- The fossil record provides evidence for evolution by natural selection.

- cast (p. 248)
- fossil (p. 244)
- fossil record (p. 250)
- mold (p. 248)
- paleontologist (p. 244)
- permineralization (p. 246)

### Lesson 2 Biological Evidence



3.c

**Main Idea** Evidence from comparative anatomy and molecular biology are best explained by the theory of evolution by natural selection.

- Scientists use homologous, analogous, and vestigial structures to determine possible relationships among organisms and their ancestors.
- Similarities and differences in development of embryos provide evidence of evolutionary relationships among different organisms.
- Scientists use molecular biology to search for common ancestors of organisms.

- comparative anatomy (p. 252)
- embryology (p. 254)
- homologous structure (p. 253)

### Lesson 3 Evolution and Plate Tectonics



3.a, 4.f

**Main Idea** Over time, the movement of lithospheric plates has changed environments that led to changes in species.

- The moving lithospheric plates can isolate populations and result in the development of new species.
- Changes in climate can also result in new species.

- convergent evolution (p. 259)
- geographic isolation (p. 259)

### Lesson 4 Classifying Organisms



3.d, 7.c, 7.d, 7.e

**Main Idea** Scientists use traits and evolutionary history to classify species.

- Early classification systems were based on the physical characteristics and where the organisms lived.
- Present-day classification is based on the idea of common ancestors.
- Molecular systematics is used to improve established classification.

- systematics (p. 264)



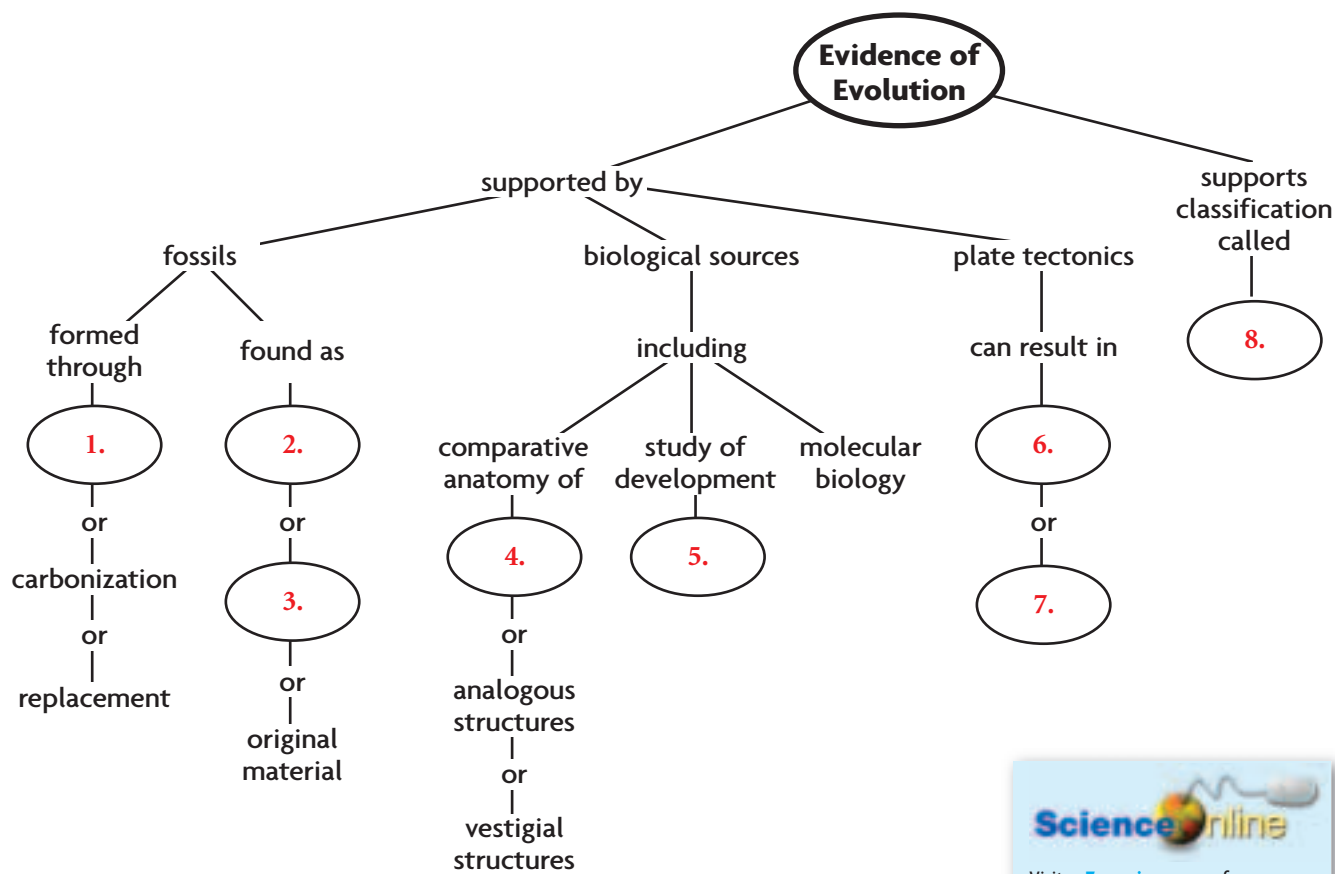
Download quizzes, key terms, and flash cards from [ca7.msscience.com](http://ca7.msscience.com).





## Linking Vocabulary and Main Ideas

Use the vocabulary terms on page 270 to complete this concept map.



## Using Vocabulary

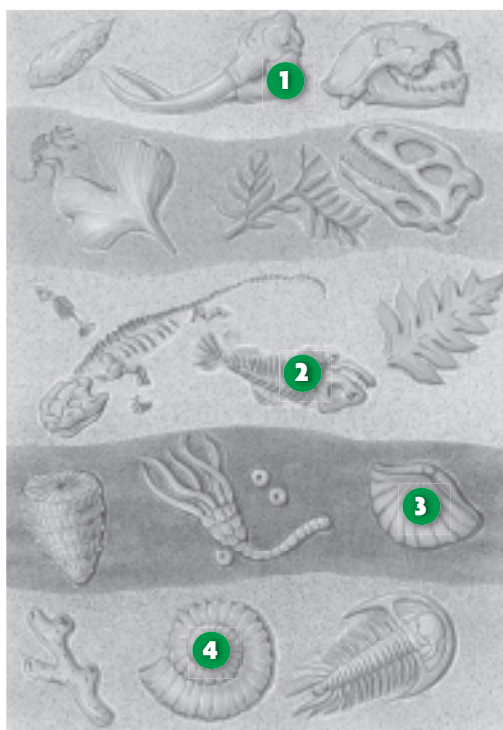
A(n) 9. is a scientist that researches, gathers, and examines evidence of evolution from the 10.. It includes all known 11. and their placements in the formation of rocks and positions in time. Through 12., the remains of trees become petrified wood. Over time, the imprint of a shell can be preserved as a 13.. If the imprint fills with sediment that hardens into rock, then a(n) 14. forms.



## Understanding Main Ideas

Choose the word or phrase that best answers the question.

- Which fossil formation process would most likely produce an image of an ancient fern leaf on a rock?
  - carbonization
  - cast
  - mold
  - permineralization
- The diagram below shows fossils in different, undisturbed rock layers.

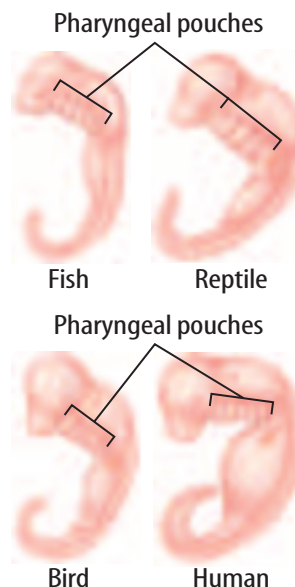


Which fossil would scientists predict to be the oldest?

- 1
- 2
- 3
- 4

4.c, 4.e

- What term describes a structure in an organism that has no function but might have had a function in an ancient ancestor?
  - analogous
  - convergent
  - homologous
  - vestigial
- Which would be considered homologous structures?
  - bones in a bird's arm and bones in a frog's arm
  - the cytochrome *c* in yeast and cytochrome *c* in rhesus monkeys
  - a permineralized bone of a woolly mammoth and original material of a woolly mammoth
  - the wing of bat and the wing of an insect
- Comparisons of these organisms provide evidence of evolution.



What type of scientist studies these organisms?

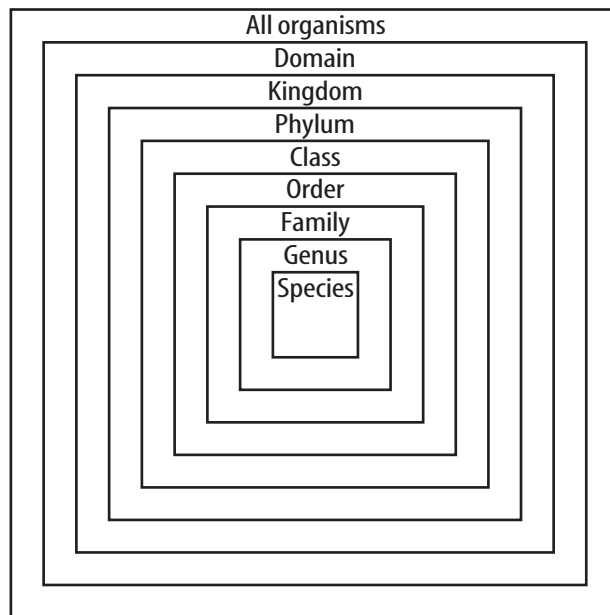
- embryologist
- entomologist
- microbiologist
- paleontologist

3.c



### Applying Science

6. **Explain** why the fossils shown in question 2 on the opposite page are in different layers. **4.c, 4.e**
7. **Compare and contrast** the processes of replacement and permineralization. **3.c**
8. **Evaluate** the benefits of DNA sequencing compared to DNA hybridization as a tool for classification. **3.d**
9. **Explain** why the classification of organisms can be diagrammed as shown below. **3.c**



10. **Discuss** why the fossil record for life on Earth has gaps.

### WRITING in Science

11. **Imagine** you are a paleontologist. A friend asks you, "How can finding a bunch of old bones support the theory of natural selection?" Write a response to explain the connections between fossils and the theory of evolution by natural selection. **ELA7: W 1.1**

### Cumulative Review

12. **Predict** Choose a present-day species and predict how it might leave fossil remains. Identify the type of fossil mostly likely to form from your species. Explain your choices. **3.c**
13. **Describe** the process of radioactive decay. Use the terms *isotope*, *nucleus*, and *half-life* in your answer. **3.c**

### Applying Math

Use the data table below to answer questions 14–17.

Fossil Species	Time Range (mya)
<i>Homo erectus javanicus</i>	1.6–0.6
<i>Homo erectus pekinensis</i>	0.7–0.5
Neanderthal	0.07–0.04
<i>Homo sapiens</i>	0.3–0.1
<i>Homo erectus soloensis</i>	0.8–0.46

14. In years, what was the first appearance of *Homo erectus pekinensis* on Earth? **MA7: NS 1.2**
15. In years, what was the last appearance of *Homo erectus pekinensis* on Earth? **MA7: NS 1.2**
16. In years, approximately how long did *Homo erectus pekinensis* exist on Earth? **MA7: NS 1.2**
17. Which species existed for the greatest number of years on Earth? **MA7: MR 1.1**





1 What is the study of fossils?

- A embryology
- B entomology
- C microbiology
- D paleontology

3.c

2 The table below shows some of the proteins in different species of organisms.

Proteins	
Species 1	A, G, T, C, L, E, S, H
Species 2	A, G, T, C, L, D, H
Species 3	A, G, T, C, L, D, P, U, S, R, I, V
Species 4	A, G, T, C, L, D, H

Which species are more closely related?

- A species 1 and species 2
- B species 3 and species 4
- C species 1 and species 3
- D species 2 and species 4

3.d

3 Which structure of an ancient organism is least likely to found as a fossil?

- A a clam shell
- B a tree trunk
- C a shark tooth
- D a dinosaur muscle

3.c

4 Which classification level includes the greatest number of species?

- A class
- B family
- C genus
- D kingdom

3.d

5 Below is an image of a type of fossil.



What type of fossil formation process created these tree fossils?

- A carbonization
- B cast
- C mold
- D permineralization

3.c

6 Which condition makes fossil formation of an organism's remains more likely?

- A attacked by scavengers
- B contains mostly hard structures
- C covered by acidic soils
- D decomposed by bacteria

3.c

7 Which is true for an original material fossil?

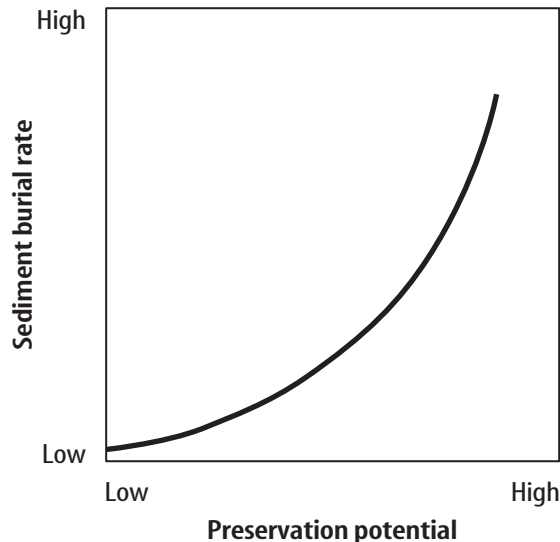
- A Minerals replaced hard structures.
- B Only carbon from molecules that made up its body remains.
- C No hard or soft structures have been altered.
- D An imprint of the material has been filled with sediment that hardened as rock.

3.c



- 8 The graph below shows the relationship between the rate at which an organism is buried in sediment and the potential for it to be preserved as a fossil.

**Relationship Between Sediment Burial Rate and Potential for Remains to Become Fossils**



**Which statement correctly describes the graph?**

- A The higher the rate of sediment burial, the lower the preservation potential.
- B The higher the rate of sediment burial, the higher the preservation potential.
- C The lower the rate of sediment burial, the higher the preservation potential.
- D The rate of sediment burial has no effect on the preservation potential.

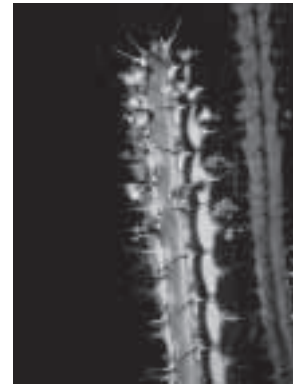
4.c, 4.e

- 9 What are cavities left in rocks when shells or bones dissolve?

- A casts
- B molds
- C original material
- D carbon films

3.c

- 10 These two plants evolved in similar environments but on two different continents.



**Which term describes this type of evolution?**

- A analogous
- B convergent
- C homologous
- D vestigial

4.f

- 11 Imagine that a river suddenly becomes wider and separates a population of a species of flightless birds. What is most likely to happen to the two populations of flightless birds over time?

- A One population will learn to fly and abandon the other population.
- B The two populations will become separate species because they cannot interbreed.
- C Both populations will become extinct because they cannot get across the river.
- D The two populations will remain unchanged.

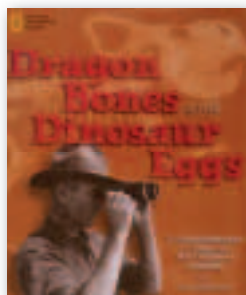
3.a

# Reading on Your Own...



## From the Recommended Literature for Science and Math

Are you interested in learning more about how species have changed over time? If so, check out these great books.



### Biography

#### **Dragon Bones and Dinosaur Eggs: A Photobiography of Explorer Roy Chapman Andrews**

by Ann Bausum, describes the life of explorer-adventurer Roy Chapman Andrews. He led five expeditions to the Gobi desert to study the ecosystem. This book contains photographs from his expeditions and quotations from his writings. *The content of this book is related to Science Standard 7.3.*

### Nonfiction

**Collision Course: Cosmic Impacts and Life on Earth**, by Fred Bortz, examines how comets or asteroids are formed and gives examples of the effects of asteroid impacts. Detailed photographs of the people, impacts, and equipment add interest. *The content of this book is related to Science Standard 7.3.*

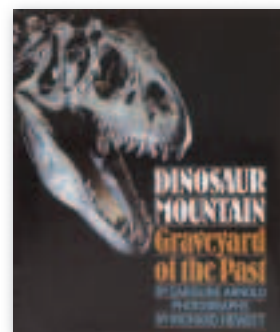


### Nonfiction

**Galapagos in 3-D**, by Mark Blum, presents up-close photos of and information about an amazing variety of animals found on Galapagos. This book is informative not only about the animals, but also about how our eyes see things. *The content of this book is related to Science Standard 7.3.*

### Nonfiction

**Dinosaur Mountain: Graveyard of the Past**, by Caroline Arnold, describes the discoveries made at the Dinosaur National Monument quarry in Utah. This book details the work of paleontologists and contains color photographs of the digs and the work of the scientists. *The content of this book is related to Science Standard 7.4.*

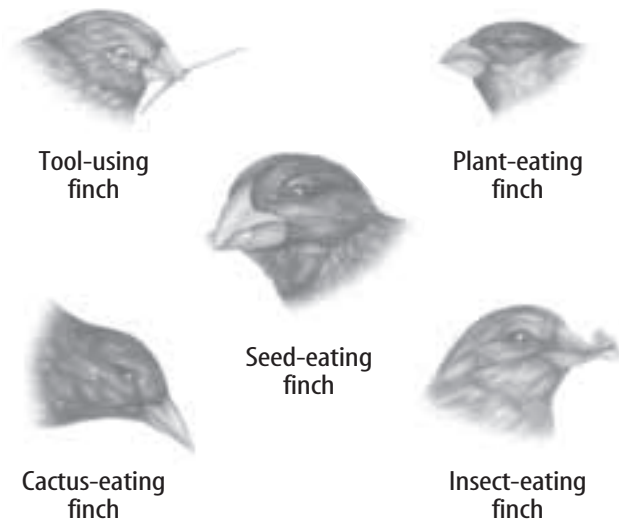






Choose the word or phrase that best answers the question and write your response on a sheet of paper.

- The figure below shows finches with different types of beaks.



Which, besides competition for food, contributed to the evolution of the species of Darwin's finches?

- predation
  - DNA
  - camouflage
  - variation in beak shape
- Some harmless species imitate or mimic a poisonous species which increases their survival. Which is this an example of?
    - acquired characteristics
    - adaptation
    - variation
    - geographic isolation
  - A series of helpful variations in a species results in which?
    - adaptation
    - fossils
    - gradualism
    - climate change

Write your responses to the following on a sheet of paper.

- Discuss** why trilobites are classified as index fossils.
- List** three examples of direct evidence for evolution.
- Describe** the typical conditions necessary for fossil formation.
- The photo below shows an albino lemur.



- Describe** an environment in which this albino lemur might not be at a disadvantage.
- Explain** how camouflage might benefit a species?
- Compare** Lamarck's and Darwin's ideas about how evolution occurs.
- Design a flow chart** to show how natural selection might cause a species to change through time.
- Discuss** Fossil remains of plants and animals that lived millions of years ago have been found on more than one continent. How are the locations of these fossil remains evidence that Earth's continental and oceanic plates have moved?