

Life over Time

Roseate Spoonbills thrive in shallow waters with muddy bottoms



Diversity and Evolution of Living Organisms

What Do You Think?

Over time, different life forms change as the environment changes. This happened a number of times in Florida's prehistory. What kinds of organisms do you think lived in prehistoric Florida? As you explore this unit, gather evidence to help you state and support a claim.

Life over Time

LESSON 1

Theory of Evolution by Natural Selection 414

SC.7.L.15.1, SC.7.L.15.2, SC.7.L.15.3

THINK SCIENCE..... 426

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Evidence of Evolution 428

SC.7.N.1.5, SC.7.L.15.1

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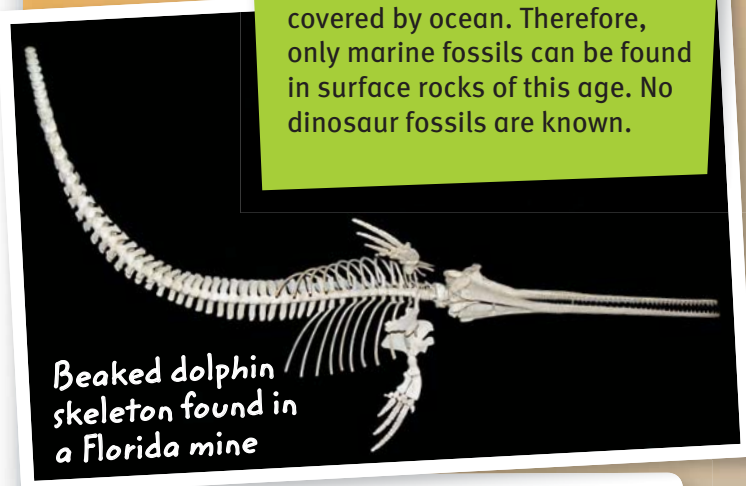
CITIZEN SCIENCE

Prehistoric Florida

Fossils of land animals in Florida rocks and sediments date back to about 25 million years ago. The fossil record indicates that most of these land animals became extinct in Florida around 10,000 years ago. What do we know about fossils in Florida that are even older than these?

Age of the Dinosaurs, (245 million years ago to 65 million years ago)

The Florida peninsula was covered by ocean. Therefore, only marine fossils can be found in surface rocks of this age. No dinosaur fossils are known.



In parts of Florida, the fossils of marine organisms and land animals are found in the same sediment. Why do you think that both types of fossils are found together?

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Fossil of a shark's jaw

Late Cenozoic Era (5 million years ago to Recent)

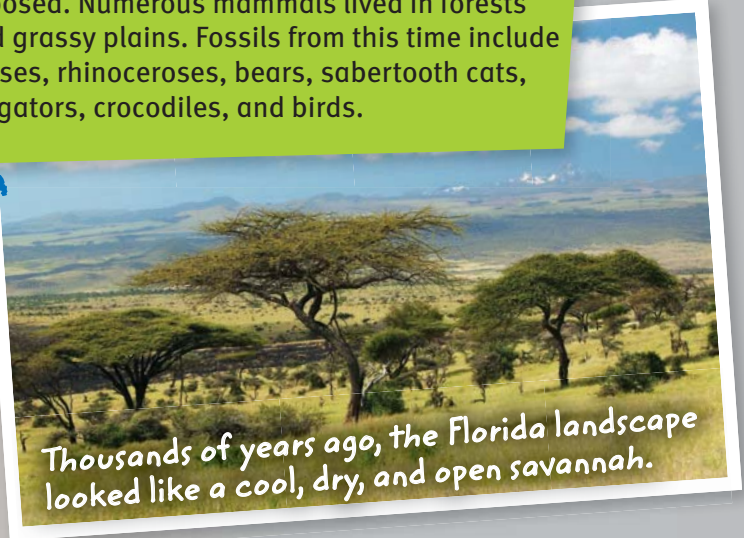
During the Ice Age, sea level rose and fell. Coral reefs formed in the warm waters off of the southeastern part of the peninsula. Fossils from this time include giant sloths, armadillos, bears, lions, sabertooth cats, and horses. Most of these animals became extinct around 10,000 years ago.

Middle Cenozoic Era (24.5 million years ago to 5 million years ago)

During this time, sea level generally dropped, and more of the Florida peninsula became exposed. Numerous mammals lived in forests and grassy plains. Fossils from this time include horses, rhinoceroses, bears, sabertooth cats, alligators, crocodiles, and birds.

Early Cenozoic Era (65 million years ago to 24.5 million years ago)

Most fossils from this time are marine organisms. These include fossils of shells, corals, sea urchins, sharks, sea turtles, and a very early whale.

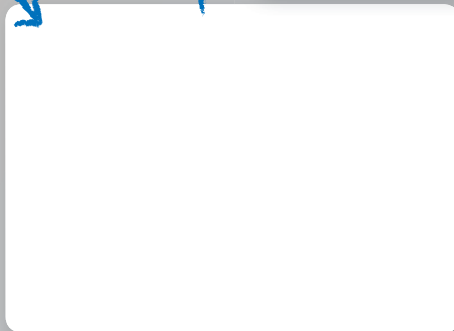


Thousands of years ago, the Florida landscape looked like a cool, dry, and open savannah.

Take It Home!

Your Neighborhood Through Time

Your neighborhood probably hasn't been around since the age of the dinosaurs but it has also changed over time. Do some research to find out when your town was founded. Create a timeline similar to the one above that shows the details of what changes your neighborhood and town might have experienced over time.



Theory of Evolution

by Natural Selection

ESSENTIAL QUESTION

What is the theory of evolution by natural selection?

By the end of this lesson, you should be able to describe the role of genetic and environmental factors in the theory of evolution by natural selection.

Because this grass snake's skin color looks like the plant stalk, it is able to hide from predators! This form of camouflage is the result of natural selection.



SC.7.L.15.1 Recognize that fossil evidence is consistent with the scientific theory of evolution that living things evolved from earlier species.

SC.7.L.15.2 Explore the scientific theory of evolution by recognizing and explaining ways in which genetic variation and environmental factors contribute to evolution by natural selection and diversity of organisms. **SC.7.L.15.3** Explore the scientific theory of evolution by relating how the inability of a species to adapt within a changing environment may contribute to the extinction of that species.

Lesson Labs

Quick Labs

- Analyzing Survival Adaptations
- Survive or Go Extinct
- Modeling Natural Selection

Exploration Lab

- Environmental Change and Evolution

Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false.

- | T | F | |
|--------------------------|--------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | Fur color can help prevent an animal from being eaten. |
| <input type="checkbox"/> | <input type="checkbox"/> | The amount of available food can affect an organism's survival. |
| <input type="checkbox"/> | <input type="checkbox"/> | Your parents' characteristics are not passed on to you. |
| <input type="checkbox"/> | <input type="checkbox"/> | A species can go extinct if its habitat is destroyed. |

2 Infer How do you think this bird and this flower are related? Explain your answer.



ACTIVE READING

3 Synthesize You can often define an unknown word by clues provided in the sentence. Use the sentence below to make an educated guess about the meaning of the word *artificial*.

Example sentence:

Many people prefer real sugar to artificial sweeteners made by humans.

artificial:

Vocabulary Terms

- evolution
- mutation
- artificial selection
- adaptation
- natural selection
- extinction
- variation

4 Apply As you learn the definition of each vocabulary term in this lesson, create your own definition or sketch to help you remember the meaning of the term.

Darwin's Voyage

What did Darwin observe?

Charles Darwin was born in England in 1809. When he was 22 years old, Darwin graduated from college with a degree in theology. But he was also interested in plants and animals. Darwin became the naturalist—a scientist who studies nature—on the British ship *HMS Beagle*.

During his voyage, Darwin observed and collected many living and fossil specimens. He made some of his most important observations on the Galápagos Islands of South America. He kept a log that was later published as *The Voyage of the Beagle*. With the observations he made on this almost five-year journey, Darwin formed his idea about how biological evolution could happen.

In biology, **evolution** refers to the process by which populations change over time. A population is all of the individuals of a species that live in an area at the same time. A species is a group of closely related organisms that can mate to produce fertile offspring. Darwin developed a hypothesis, which eventually became a theory, of how evolution takes place.

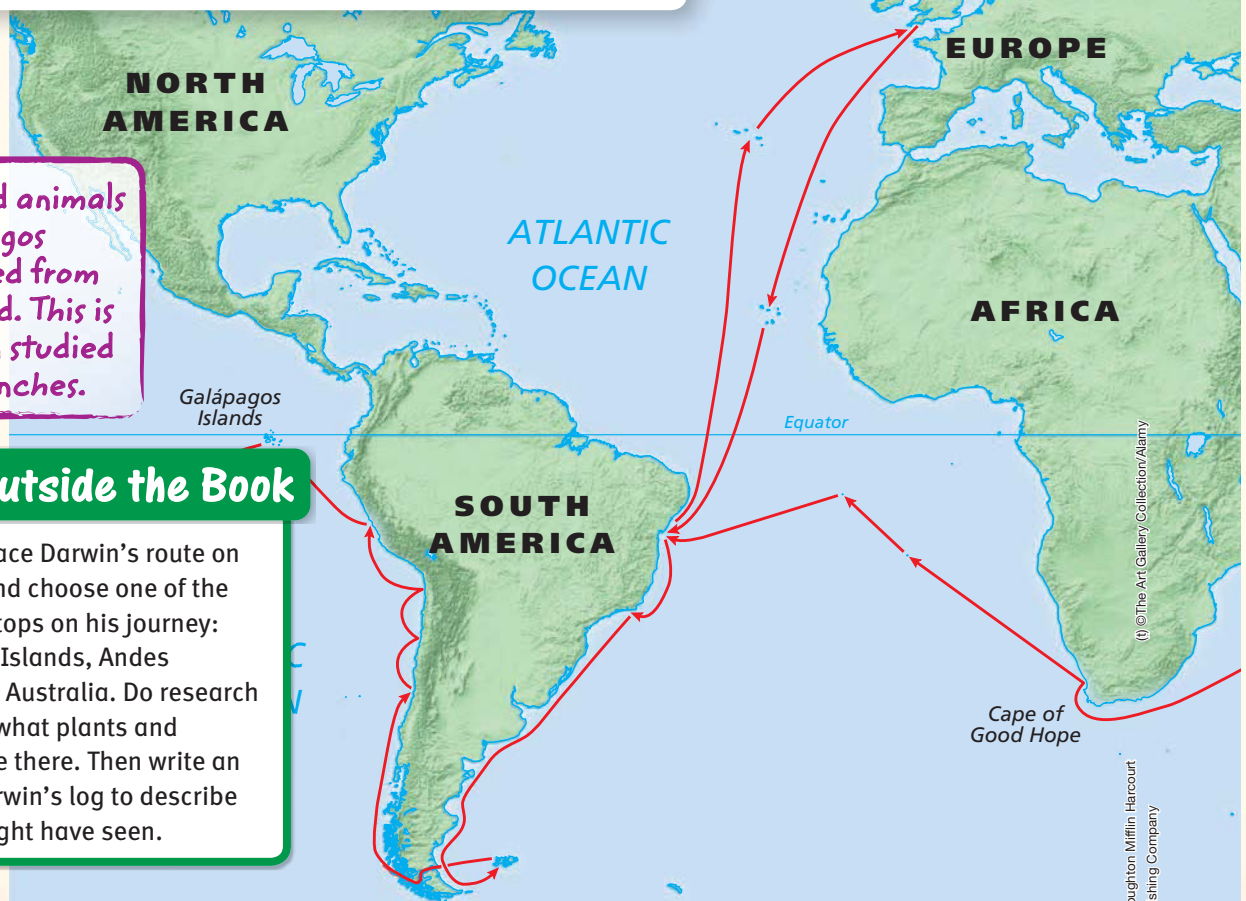


Darwin left England on December 27, 1831. He returned 5 years later.

The plants and animals on the Galápagos Islands differed from island to island. This is where Darwin studied birds called finches.

Think Outside the Book

5 Explore Trace Darwin's route on the map, and choose one of the following stops on his journey: Galápagos Islands, Andes Mountains, Australia. Do research to find out what plants and animals live there. Then write an entry in Darwin's log to describe what he might have seen.



Differences among Species

Darwin collected birds from the Galápagos Islands and nearby islands. He observed that these birds differed slightly from those on the nearby mainland of South America. And the birds on each island were different from the birds on the other islands. Careful analysis back in England revealed that they were all finches! Eventually, Darwin suggested that these birds may have evolved from one species of finch.

Darwin observed differences in beak size among finches from different islands. Many years later, scientists confirmed that these differences related to the birds' diets. Birds with shorter, heavier beaks could eat harder foods than those with thinner beaks.



This cactus finch has a narrow beak that it can use in many ways, including to pull grubs and insects from holes in the cactus.



This vegetarian finch has a curved beak, ideal for taking large berries from a branch.



Woodpecker finch

Visualize It!

6 Claims • Evidence • Reasoning

Make a claim about how the pointed beak of this woodpecker finch helps it to get food. Summarize evidence to support the claim and explain your reasoning.



Darwin saw many plants and animals that were found only on certain continents such as Australia.

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Darwin's Homework

What other ideas influenced Darwin?

The ideas of many scientists and observations of the natural world influenced Darwin's thinking. Darwin drew on ideas about Earth's history, the growth of populations, and observations of how traits are passed on in selective breeding. All of these pieces helped him develop his ideas about how populations could change over time.

Organisms Pass Traits On to Offspring

Farmers and breeders have been producing many kinds of domestic animals and plants for thousands of years. These plants and animals have traits that the farmers and breeders desire. A *trait* is a form of an inherited characteristic. For example, the length of tail feathers is an inherited characteristic, and short or long tail feathers are the corresponding traits. The practice by which humans select plants or animals for breeding based on desired traits is **artificial selection**. Artificial selection shows that traits can change. Traits can also spread through populations.

7 List Darwin studied artificial selection in the pigeons that he bred. List three other domestic animals that have many different breeds.

This chicken has been bred to have large tail feathers and a big red comb.



This chicken has been bred to have large head feathers.



This chicken has been bred to have feathers on its feet.



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(b) ©P.urestock/Getty Images

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ACTIVE READING

8 Identify As you read, underline the names of other important thinkers who influenced Darwin's ideas.

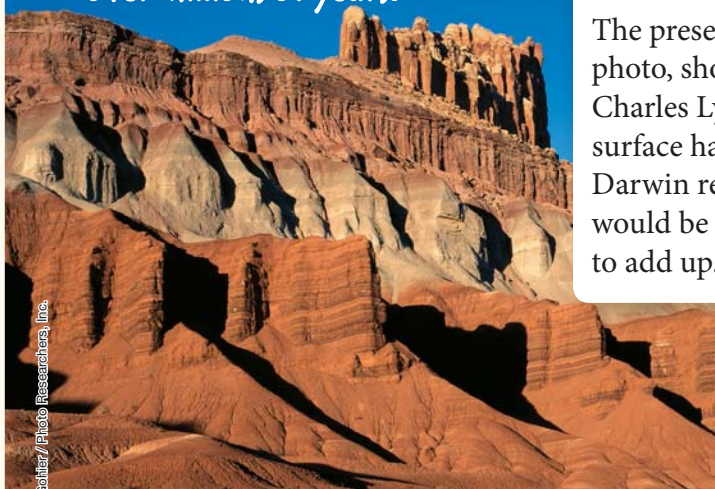
Organisms Acquire Traits

Scientist Jean-Baptiste Lamarck thought that organisms could acquire and pass on traits they needed to survive. For example, a man could develop stronger muscles over time. If the muscles were an advantage in his environment, Lamarck thought the man would pass on this trait to his offspring. Now we know that acquired traits are not passed on to offspring because these traits do not become part of an organism's DNA. But the fact that species change, and the idea that an organism's traits help it survive, shaped Darwin's ideas.



9 Claims • Evidence • Reasoning Make a claim about how the strength of your muscles is partly an acquired trait and partly dependent on DNA. Summarize evidence to support the claim and explain your reasoning.

These rock layers formed over millions of years.

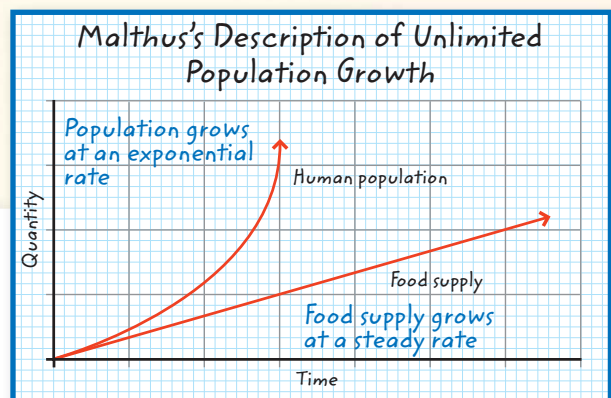


Earth Changes over Time

The presence of different rock layers, such as those in the photo, show that Earth has changed over time. Geologist Charles Lyell hypothesized that small changes in Earth's surface have occurred over hundreds of millions of years. Darwin reasoned that if Earth were very old, then there would be enough time for very small changes in life forms to add up.

A Struggle for Survival Exists

After his journey, Darwin read an essay about population growth by economist Thomas Malthus. The essay helped Darwin understand how the environment could influence which organisms survive and which organisms die. All populations are affected by factors that limit population growth, such as disease, predation, and competition for food. Darwin reasoned that the survivors probably have traits that help them survive and that some of these traits could be passed on from parent to offspring.



Visualize It!

10 Claims • Evidence • Reasoning Make a claim about population growth. Use evidence from the graph to support the claim and explain your reasoning.

Natural Selection

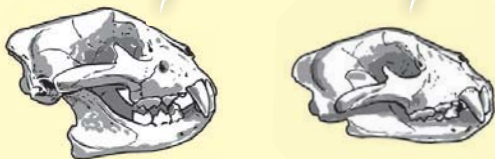
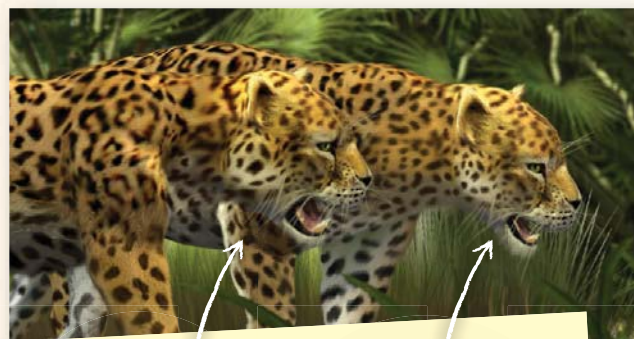
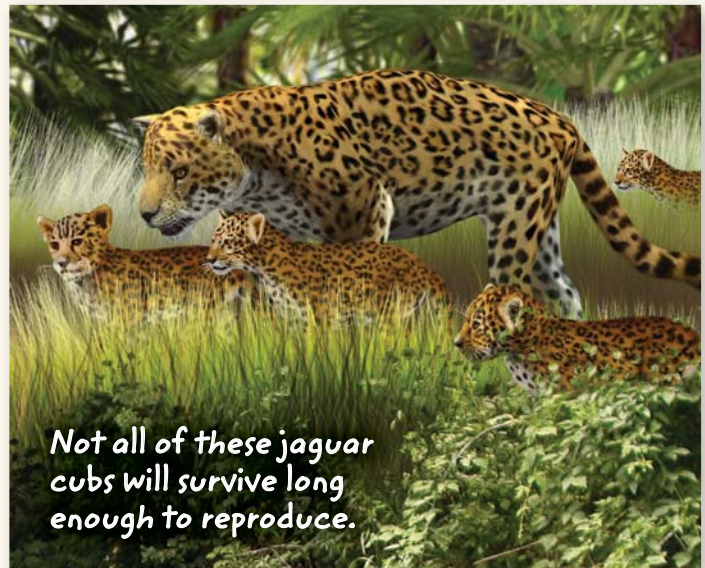
What are the four parts of natural selection?

Darwin proposed that most evolution happens through the natural selection of advantageous traits. **Natural selection** is the process by which organisms that inherit advantageous traits tend to reproduce more successfully than other organisms do. There are four parts that contribute to the process of evolution by natural selection—overproduction, genetic variation, selection, and adaptation.

Overproduction

When a plant or animal reproduces, it usually makes more offspring than the environment can support. For example, a female jaguar may have up to four pups at a time. Only some of them will survive to adulthood, and a smaller number of them will successfully reproduce.

11 Claims • Evidence • Reasoning Make a claim about a natural reason for low survival rates of jaguar cubs. Summarize evidence to support the claim and explain your reasoning.



Variation exists in the jaw sizes of these two jaguars. This variation will be passed on to the next generation.

Genetic Variation

Within a population there are natural differences, or variations, in traits. For example, in the two jaguar skulls to the left, one has a larger jaw than the other. This difference results from a difference in the genetic material of the jaguars. Genetic variations can be passed on from parent to offspring. An important source of variation is a mutation, or change in genetic material.

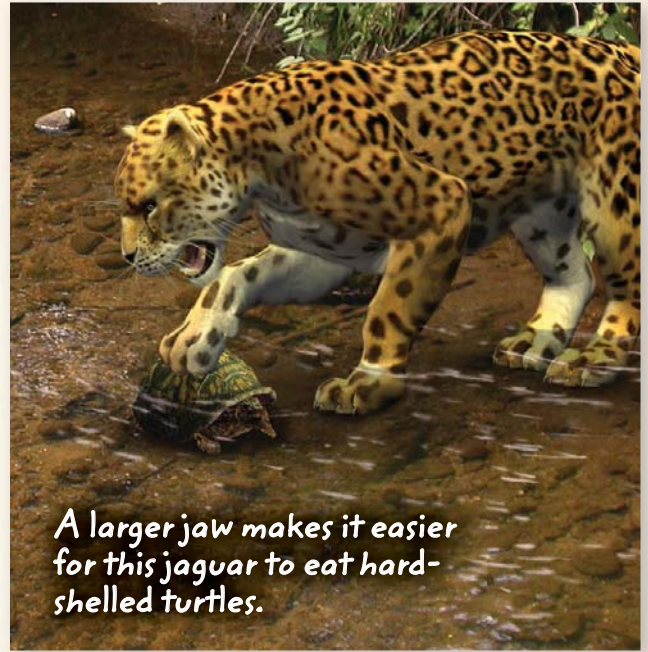
With each new generation, genetic variation introduces changes to the traits of a population. Greater genetic variation in a population increases the chance that some individuals will have traits that can help them survive environmental changes or diseases. Traits that enhance an individual's ability to reproduce will also increase the chance of survival of a species.

Selection

Individuals try to get the resources they need to survive. These resources include food, water, space and, in most cases, mates for reproduction. About 11,000 years ago, jaguars faced a shortage of food because the climate changed and many prey species died out. A genetic variation in jaw size then became important for survival. Jaguars with larger jaws could eat hard-shelled reptiles when other prey were hard to find.

Individuals with a particular trait, such as a large jaw, are more likely to survive long enough to reproduce. As a result, the trait is “selected” for becoming more common in the next generation of offspring.

12 Summarize How did large jaws and teeth become typical traits of jaguars?



Adaptation

An inherited trait that helps an organism survive and reproduce in its environment is an **adaptation**. Adaptation is the selection of naturally occurring trait variations in populations. Jaguars with larger jaws were able to survive and reproduce when food was hard to find. As natural selection continues, adaptations grow more common in the population with each new generation, and new adaptations may arise. Over time, the population becomes better adapted to the environment.



13 Explain In the table below, explain how each part of natural selection works.

Principle of natural selection	How it works
overproduction	
genetic variation	
selection	
adaptation	

Well-adapted

How do species change over time?

In order for a population to change, some individuals have to be genetically different from other members of the population.

Mutations are one of the main sources of genetic variation.

Offspring sometimes inherit a gene that has a slight mutation, or change, from the gene the parent has. Mutations can be harmful, helpful, or have no effect. Beneficial mutations help individuals survive and reproduce.

Over Generations, Adaptations Become More Common

ACTIVE READING

14 Identify Underline examples of adaptations.

Adaptations are inherited traits that help organisms survive and reproduce. At first, an adaptation is rare. For example, imagine a population of birds in which some birds have shorter beaks. If more birds with shorter beaks survive and reproduce than birds with longer beaks, more birds in the next generation will probably have short beaks. The number of individuals with the adaptation would continue to increase. Some adaptations, such as a duck's webbed feet, are physical. Other adaptations are inherited behaviors that help an organism find food, protect itself, or reproduce.



The male frigate bird uses his red throat pouch to attract a female, which could lead to reproduction.



Visualize It!

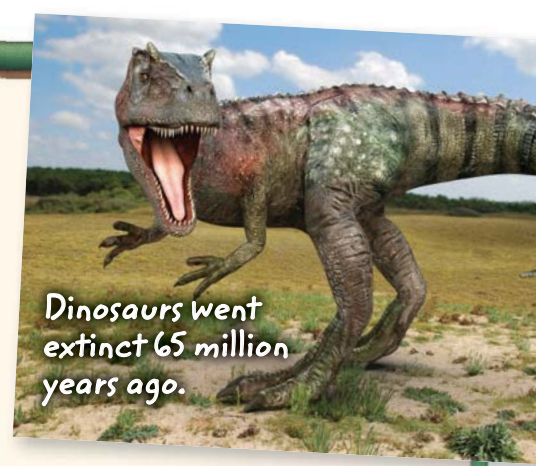
15 Claims • Evidence • Reasoning Write a claim about how this butterfly's long mouth part helps it to survive. Summarize evidence to support the claim and explain your reasoning.

Genetic Differences Add Up

Parents and offspring often have small genetic differences between them. Over many generations, the small differences can add up. These differences accumulate so that organisms alive now are often very different from their ancestors. As a result, there is great diversity among organisms. For example, the antibiotic penicillin was able to kill many types of bacteria in the 1950s. Today, some of those species of bacteria are now completely resistant to penicillin. The genetic makeup of these bacterial populations has changed. New fossil discoveries and new information about genes add to scientists' understanding of natural selection and evolution.

What happens to species as the environment changes?

Certain environments favor certain traits. Consider a snake population with either brown- or green-colored snakes. In a forest that has many dead leaves on the ground, brown snakes will blend in better than green snakes will. But in an area with more grass, the green snakes may be better at hiding from predators. Changes in environmental conditions can affect the survival of organisms with a particular trait. Environmental changes can also lead to diversity of organisms by increasing the number of species.



Adaptations Can Allow a Species to Survive

All organisms have traits that allow them to survive in specific environments. For example, plants have xylem tissue that carries water up from the roots to the rest of the plant.

If the environment changes, a species is more likely to survive if it has genetic variation. For example, imagine a species of grass in which some plants need less water than others. If the environment became drier, many grass plants would die, but the plants that needed less water might survive. These plants might eventually become a new species if they cannot reproduce with the plants that needed more water.

Some Species May Become Extinct

If no individuals have traits that help them to survive and reproduce in the changed environment, a species will become extinct.

Extinction occurs when all members of a species have died. Greater competition, new predators, and the loss of habitat are examples of environmental changes that can lead to extinction. Some extinctions are caused by natural disasters. Because a natural disaster can destroy resources quickly, organisms may die no matter what adaptations they have. The fossil record shows that many species have become extinct in the history of life on Earth.

Visualize It!

Environmental change has affected the environmental conditions near the North Pole.

16 Claims • Evidence • Reasoning

How has ice cover near the North Pole changed in the last few decades? Use evidence from the image to support your claim and explain your reasoning.

17 Claims • Evidence • Reasoning

Make a claim about how you think environmental change will affect species that live in the surrounding area. Use evidence to support the claim and explain your reasoning.



Visual Summary

To complete this summary, circle the correct word. You can use this page to review the main concepts of the lesson.

Darwin's theory of natural selection was influenced by his own observations and the work of other scientists.



18 Through *natural / artificial* selection, breeders choose the traits that are passed on to the next generation.

Evolution is Change over Time



Many extinctions have occurred over the course of Earth's history.

20 Because of environmental change, dinosaurs eventually became *mutated / extinct*.

The theory of evolution by natural selection states that organisms with advantageous traits produce more offspring.

19 Natural selection can act only on *acquired traits / inherited variation*.



21 Claims • Evidence • Reasoning Make a claim about how the environment influences natural selection. Summarize evidence to support the claim and explain your reasoning.

(l) ©The Art Gallery Collection/Alamy; (tr) ©Roger Harris/Photo Researchers.

Vocabulary

Use a term from the lesson to complete the sentences below.

- 1 The four parts of natural selection are overproduction, _____, selection, and adaptation.
- 2 _____ is the process by which populations change over time.
- 3 The hollow bones of birds, which keep birds lightweight for flying, is an example of a(n) _____.

Key Concepts

- 4 **Summarize** Describe Darwin's observations on the Galápagos islands during his voyage on the HMS *Beagle*.

- 5 **Claims • Evidence • Reasoning** How does environmental change affect the survival of a species? Summarize evidence to support your claim and explain your reasoning.

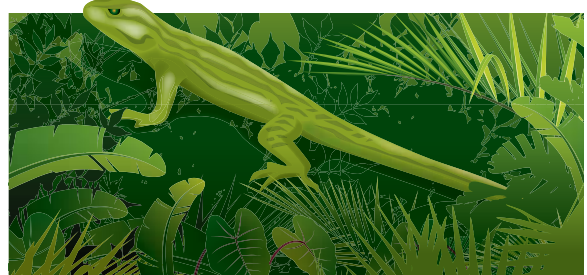
- 6 **Compare** Why are only inherited traits, not acquired ones, involved in the process of natural selection?

- 7 **Describe** What is the relationship between mutation, natural selection, and adaptation?

Critical Thinking

Use the diagram to answer the following question.

- 8 **Apply** How is each of these lizards adapted to its environment?



- 9 **Claims • Evidence • Reasoning** Make a claim about what might happen to a population of rabbits in a forest if a new predator moved to the forest. Cite evidence to support the claim and explain your reasoning.



Scientific Debate

Not all scientific knowledge is gained through experimentation. It is also the result of a great deal of debate and confirmation.

Tutorial

As you prepare for a debate, look for information from the following sources.

Controlled Experiments Consider the following points when planning or examining the results of a controlled experiment.

- Only one factor should be tested at a time. A factor is anything in the experiment that can influence the outcome.
- Samples are divided into experimental group(s) and a control group. All of the factors of the experimental group(s) and the control group are the same except for one variable.
- A variable is a factor that can be changed. If there are multiple variables, only one variable should be changed at a time.

Independent Studies The results of a different group may provide stronger support for your argument than your own results. And using someone else’s results helps to avoid the claim that your results are biased. Bias is the tendency to think about something from only one point of view. The claim of bias can be used to argue against your point.

Comparison with Similar Objects or Events If you cannot gather data from an experiment to help support your position, finding a similar object or event might help. The better your example is understood, the stronger your argument will be.

Read the passage below and answer the questions.

Many people want to protect endangered species but do not agree on the best methods to use. Incubating, or heating eggs to ensure hatching, is commonly used with bird eggs. It was logical to apply the same technique to turtle eggs. The Barbour’s map turtle is found in Florida, Georgia, and Alabama. To help more turtles hatch, people would gather eggs and incubate them. However, debate really began when mostly female turtles hatched. Were efforts to help the turtles really harming them? Scientists learned that incubating eggs at 25°C (77°F) produces males and at 30°C (86°F) produces females. As a result, conservation programs have stopped artificially heating the eggs.



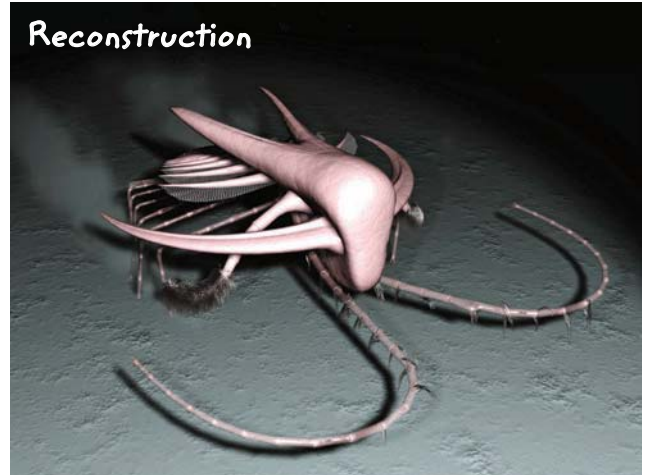
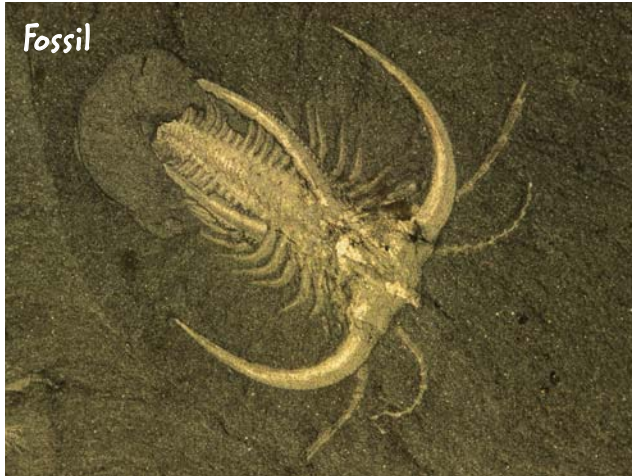
1 What is the variable described in the article about Barbour’s map turtles?

2 Write a list of factors that were likely kept the same between the sample groups described in the article.

3 What argument could people have used who first suggested incubating the turtle eggs?

You Try It!

Fossils from the Burgess Shale Formation in Canada include many strange creatures that lived over 500 million years ago. The fossils are special because the soft parts of the creatures were preserved. Examine the fossil of the creature *Marrella* and the reconstruction of what it might have looked like.



1 Recognizing Relationships Find four features on the reconstruction that you can also identify in the fossil. Write a brief description of each feature.

2 Claims • Evidence • Reasoning *Marrella* is extinct. How do you think *Marrella* behaved when it was alive? What did it eat? How did it move? Summarize evidence you can use to support your claim and explain your reasoning.

3 Communicating Ideas Share your description with a classmate. Discuss and debate your positions. Complete the table to show the points on which you agree and disagree.

Agree	Disagree

Take It Home!


Research more about the creatures of the Burgess Shale Formation. Find at least one other fossil creature and its reconstruction. What do you think the creature was like?

Evidence of Evolution

ESSENTIAL QUESTION

What evidence supports the theory of evolution?

By the end of this lesson, you should be able to describe the evidence that supports the theory of evolution by natural selection.

 **SC.7.N.1.5** Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics. **SC.7.L.15.1** Recognize that fossil evidence is consistent with the scientific theory of evolution that living things evolved from earlier species.

Fossils show us what a dinosaur looks like. This dinosaur lived millions of years ago!

Lesson Labs

Quick Labs

- How Do We Know What Happened When?
- Comparing Anatomy
- The Opposable Thumb

Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false.

- | T | F | |
|--------------------------|--------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | Fossils provide evidence of organisms that lived in the past. |
| <input type="checkbox"/> | <input type="checkbox"/> | The wing of a bat has similar bones to those in a human arm. |
| <input type="checkbox"/> | <input type="checkbox"/> | DNA can tell us how closely related two organisms are. |
| <input type="checkbox"/> | <input type="checkbox"/> | Whales are descended from land-dwelling mammals. |

2 Infer This is a Petoskey stone, which is made up of tiny coral fossils. What can you infer if you find a coral fossil on land?



ACTIVE READING

3 Synthesize You can often define an unknown word if you understand the parts of the word. Use the words below to make an educated guess about the meaning of the word *fossil record*.

Word	Meaning
fossil	the remains or trace of once-living organisms
record	an account that preserves information about facts or events

fossil record:

Vocabulary Terms

- fossil
- fossil record

4 Apply As you learn the definition of each vocabulary term in this lesson, create your own definition or sketch to help you remember the meaning of the term.

Fossil Hunt

How do fossils form?

Evidence that organisms have changed over time can be found in amber, ice, or sedimentary rock. Sedimentary rock is formed when particles of sand or soil are deposited in horizontal layers. Often this occurs as mud or silt hardens. After one rock layer forms, newer rock layers form on top of it. So, older layers are found below or underneath younger rock layers. The most basic principle of dating such rocks and the remains of organisms inside is “the deeper it is, the older it is.”

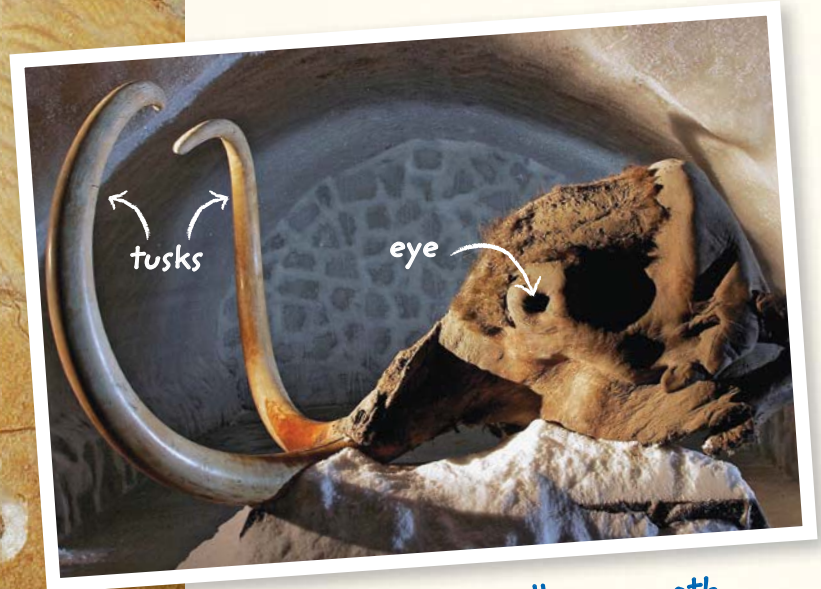


Amber fossils form when small creatures are trapped in tree sap and the sap hardens.

5 Examine What features of the organism are preserved in amber?



This flying dinosaur is an example of a cast fossil.



Because this woolly mammoth was frozen in ice, its skin and hair were preserved.

Many Fossils Form in Sedimentary Rock

Rock layers preserve evidence of organisms that were once alive. The remains or imprints of once-living organisms are called **fossils**. Fossils commonly form when a dead organism is covered by a layer of sediment or mud. Over time, more sediment settles on top of the organism. Minerals in the sediment may seep into the organism and replace the body's material with minerals that harden over time. This process produces a cast fossil. Many familiar fossils are casts of hard parts, such as shells and bones. If the organism rots away completely after being covered, it may leave an imprint of itself in the rock. Despite all of the fossils that have been found, it is rare for an organism to become a fossil. Most often, the dead organism is recycled back into the biological world by scavengers, decomposers, or the process of weathering.

How do fossils show change over time?

All of the fossils that have been discovered make up the **fossil record**. The fossil record provides evidence about the order in which species have existed through time, and how they have changed over time. By examining the fossil record, scientists can learn about the history of life on Earth.

Despite all the fossils that have been found, there are gaps in the fossil record. These gaps represent chunks of geologic time for which a fossil has not been discovered. Also, the transition between two groups of organisms may not be well understood. Fossils that help fill in these gaps are *transitional fossils*. The illustration on the right is based on a transitional fossil.

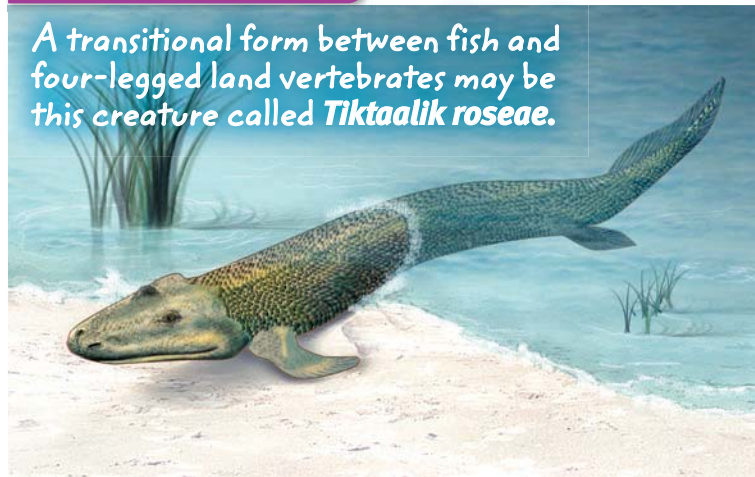
Fossils found in newer layers of Earth's crust tend to have physical or molecular similarities to present-day organisms. These similarities indicate that the fossilized organisms were close relatives of the present-day organisms. Fossils from older layers are less similar to present-day organisms than fossils from newer layers are. Most older fossils are of earlier life-forms such as dinosaurs, which don't exist anymore.

ACTIVE READING

6 Identify As you read, underline the steps that describe how a cast fossil forms.

Visualize It!

A transitional form between fish and four-legged land vertebrates may be this creature called *Tiktaalik roseae*.



7 Claims • Evidence • Reasoning Make a claim about the environment in which this organism lived. Summarize evidence to support the claim and explain your reasoning.

8 Explain Your Reasoning How is this organism like both a fish and a four-legged vertebrate, such as an amphibian? Explain your reasoning.

More clues . . .

What other evidence supports evolution?

Many fields of study provide evidence that modern species and extinct species share an ancestor. A *common ancestor* is the most recent species from which two different species have evolved. Structural data, DNA, developmental patterns, and fossils all support the theory that populations change over time. Sometimes these populations become new species. Biologists observe that all living organisms have some traits in common and inherit traits in similar ways. Evidence of when and where those ancestors lived and what they looked like is found in the fossil record.

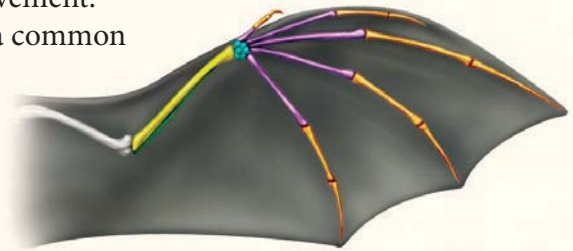
Common Structures

Scientists have found that related organisms share structural traits. Structures reduced in size or function may have been complete and functional in the organism's ancestor. For example, snakes have traces of leglike structures that are not used for movement. These unused structures are evidence that snakes share a common ancestor with animals like lizards and dogs.

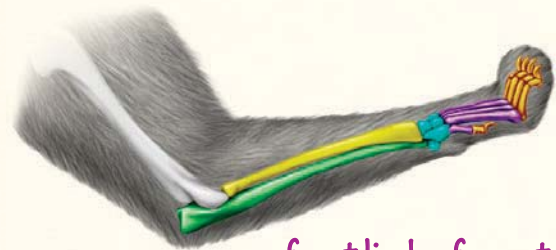
Scientists also consider similar structures with different functions. The arm of a human, the front leg of a cat, and the wing of a bat do not look alike and are not used in the same way. But as you can see, they are similar in structure. The bones of a human arm are similar in structure to the bones in the front limbs of a cat and a bat. These similarities suggest that cats, bats, and humans had a common ancestor. Over millions of years, changes occurred. Now, these bones perform different functions in each type of animal.

ACTIVE READING

9 List What is a common ancestor?



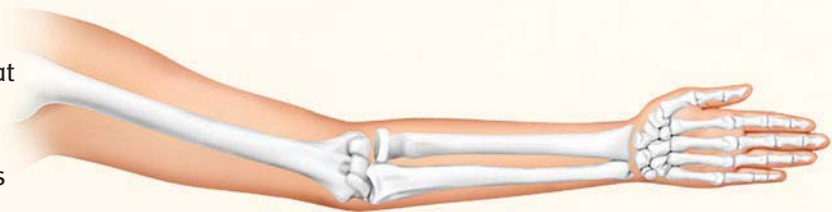
front limb of a bat



front limb of a cat

Visualize It!

10 Relate Do you see any similarities between the bones of the bat and cat limbs and the bones of the human arm? If so, use the colors of the bat and cat bones to color similar bones in the human arm. If you don't have colored pencils, label the bones with the correct color names.



Similar DNA

The genetic information stored in an organism's DNA determines the organism's traits. Because an organism's DNA stays almost exactly the same throughout its entire lifetime, scientists can compare the DNA from many organisms. The greater the number of similarities between the molecules of any two species, the more recently the two species most likely shared a common ancestor.

Recall that DNA determines which amino acids make up a protein. Scientists have compared the amino acids that make up cytochrome c proteins in many species. Cytochrome c is involved in cellular respiration. Organisms that have fewer amino acid differences are more likely to be closely related.

Frogs also have cytochrome c proteins, but they're a little different from yours.



Cytochrome C Comparison	
Organism	Number of amino acid differences from human cytochrome c
Chimpanzee	0
Rhesus monkey	1
Whale	10
Turtle	15
Bullfrog	18
Lamprey	20

Source: M. Dayhoff, *Atlas of Protein Sequence and Structure*

Visualize It!

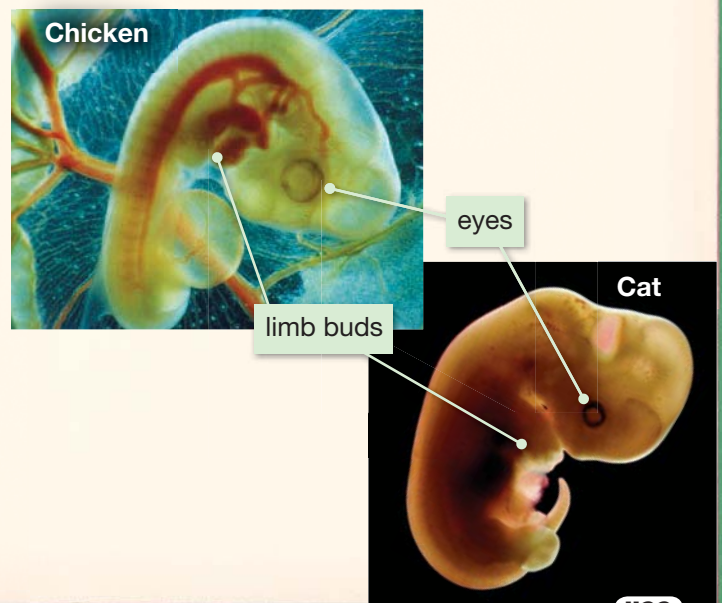
11 Claims • Evidence • Reasoning The number of amino acids in human cytochrome c differs between humans and the species at left. Make a claim about which two species are the least closely related to humans. Cite evidence to support the claim and explain your reasoning.

Developmental Similarities

The study of development is called *embryology*. Embryos undergo many physical and functional changes as they grow and develop. If organisms develop in similar ways, they also likely share a common ancestor.

Scientists have compared the development of different species to look for similar patterns and structures. Scientists think that such similarities come from an ancestor that the species have in common. For example, at some time during development, all animals with backbones have a tail. This observation suggests that they shared a common ancestor.

These embryos are at a similar stage of development.



Visualize It!

How do we know organisms are related?

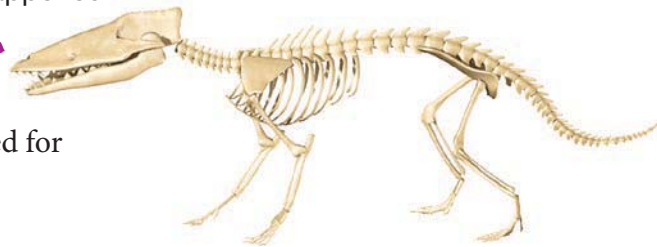
Scientists examine organisms carefully for clues about their ancestors. In a well-studied example, scientists looked at the characteristics of whales that made them different from other ocean animals. Unlike fish and sharks, whales breathe air, give birth to live young, and produce milk. Fossil and DNA evidence support the hypothesis that modern whales evolved from hoofed mammals that lived on land.

Fossil Evidence

Scientists have examined fossils of extinct species that have features in between whales and land mammals. These features are called *transitional characters*. None of these species are directly related to modern whales. But their skeletons suggest how a gradual transition from land mammal to aquatic whale could have happened.

A *Pakicetus* 52 million years ago

- whale-shaped skull and teeth adapted for hunting fish
- ran on four legs
- ear bones in between those of land and aquatic mammals



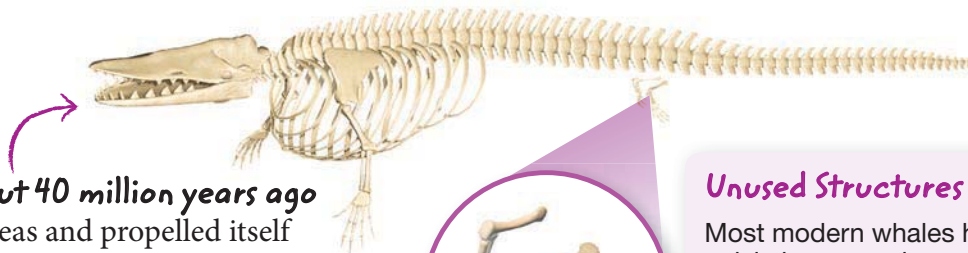
B *Ambulocetus natans* 50 million years ago

- name means “the walking whale that swims”
- hind limbs that were adapted for swimming
- a fish eater that lived on water and on land



C *Dorudon* About 40 million years ago

- lived in warm seas and propelled itself with a long tail
- tiny hind legs could not be used for swimming
- pelvis and hind limbs not connected to spine, could not support weight for walking



Unused Structures

Most modern whales have pelvic bones and some have leg bones. These bones do not help the animal move.

Molecular Evidence

The DNA of whales is very similar to the DNA of hoofed mammals. Below are some DNA fragments of a gene that makes a type of milk protein.

Hippopotamus TCC TGGCA GTCCA GTGGT

Humpback whale CCC TGGCA GTGCA GTGCT

12 Identify Circle the pairs of nitrogen bases (G, T, C, or A) that differ between the hippopotamus and humpback whale DNA.

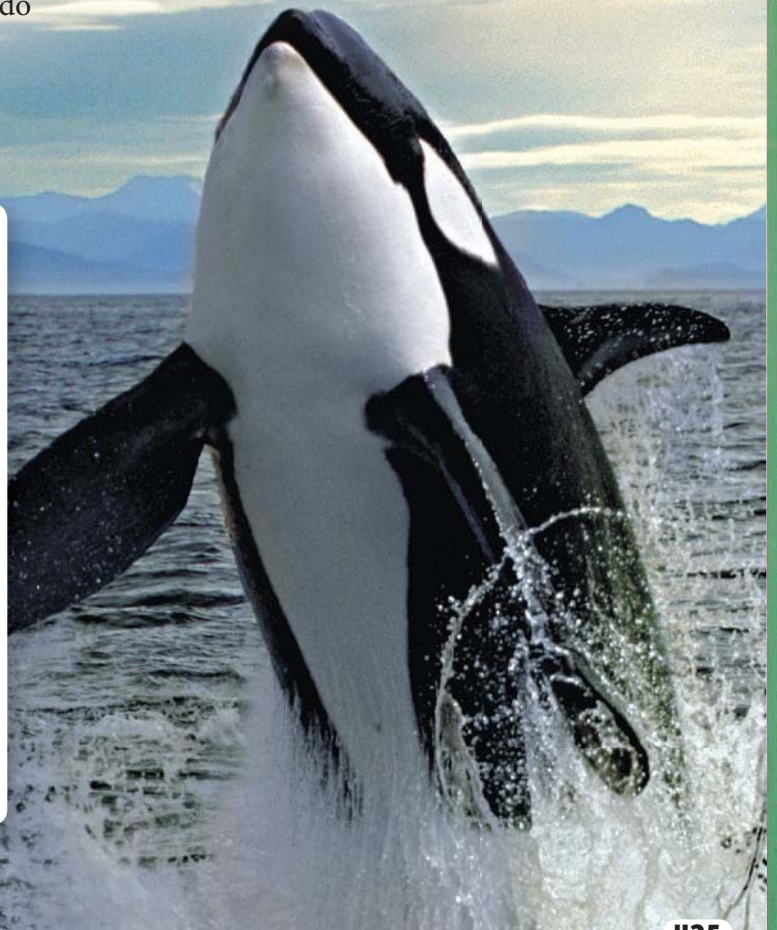
13 Infer How do you think these bones are involved in a whale's movement?



Modern Whale Present day

- no hind limbs, front limbs are flippers
- some whales have tiny hip bones left over from their hoofed-mammal ancestors
- breathe air with lungs like other mammals do

14 Claims • Evidence • Reasoning Examine the four skeletons for evidence to make a claim about which species appears to be the best adapted for swimming underwater for a long time. Summarize evidence to support the claim and explain your reasoning.



Visual Summary

To complete this summary, circle the correct word. You can use this page to review the main concepts of the lesson.

Evidence of Evolution

Fossil evidence shows that life on Earth has changed over time.



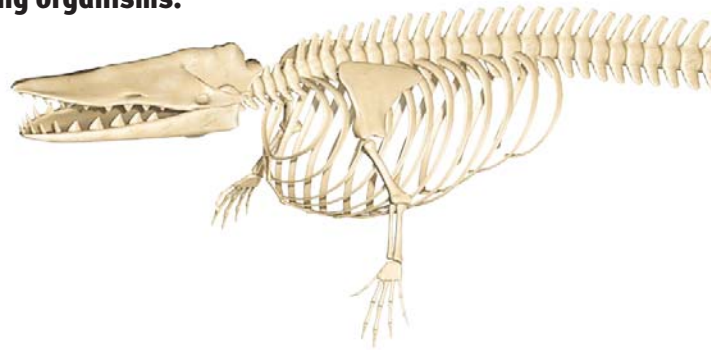
15 The remains of once-living organisms are called *fossils* / *ancestors*.

Evolutionary theory is also supported by structural, genetic, and developmental evidence.



16 *Similarities* / *Differences* in internal structures support evidence of common ancestry.

Scientists use evidence from many fields of research to study the common ancestors of living organisms.



17 The *tiny leg bones* / *large dorsal fins* of modern whales are an example of unused structures.

18 Claims • Evidence • Reasoning How does the fossil record provide evidence of the diversity of life? Summarize evidence to support the claim and explain your reasoning.

Vocabulary

1 Which word means “the remains or imprints of once-living organisms found in layers of rock?”

2 Which word means “the history of life in the geologic past as indicated by the imprints or remains of living things?”

Key Concepts

3 **Identify** What are two types of evidence that suggest that evolution has occurred?

4 **Explain** How do fossils provide evidence that evolution has taken place?

5 **Apply** What is the significance of the similar number and arrangement of bones in a human arm and a bat wing?

Critical Thinking

6 **Imagine** If you were a scientist examining the DNA sequence of two unknown organisms that you hypothesize share a common ancestor, what evidence would you expect to find?

Use this table to answer the following questions.

Cytochrome C Comparison	
Organism	Number of amino acid differences from human cytochrome c
Chimpanzee	0
Turtle	15
Tuna	21

Source: M. Dayhoff, *Atlas of Protein Sequence and Structure*

7 **Claims • Evidence • Reasoning** Make a claim about how related tuna, turtles, and chimpanzees are to humans. Use evidence to support the claim and explain your reasoning.

8 **Explain Your Reasoning** If there are no differences between the amino acid sequences in the cytochrome c protein of humans and chimpanzees, why aren't we the same species? Explain your reasoning.

9 **Explain Your Reasoning** Explain why the pattern of differences that exists from earlier to later fossils in the fossil record supports the claim that evolution has taken place on Earth.



Life over Time

is described by

Evidence of Evolution

supports the

Theory of Evolution

1 Support Your Claim The Graphic Organizer above shows that life over time is described by evidence of evolution. Name two types of evidence that support evolution.

2 Claims • Evidence • Reasoning Make a claim about how the finches that Darwin observed of the Galápagos Islands show evidence of evolution. Summarize evidence to support the claim and explain your reasoning.

3 Compare How is natural selection different from evolution?

4 Explain The fossil record reveals changes over time in the environment. Why might a scientist studying evolution be interested in how the environment has changed over time?



Name _____

Vocabulary

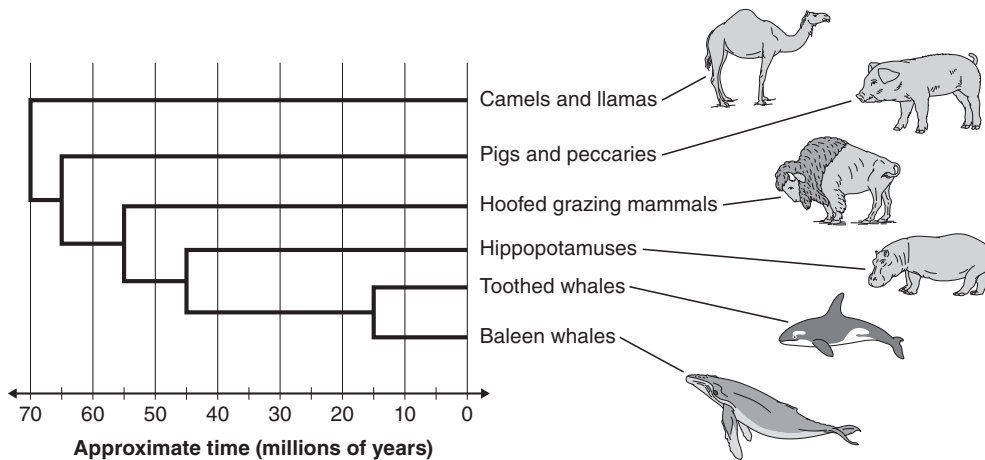
Fill in each blank with the term that best completes the following sentences.

- _____ is the difference in inherited traits an organism has from others of the same species.
- The _____ is made up of fossils that have been discovered around the world.

Key Concepts

Identify the choice that best completes the statement or answers the question.

- While exploring a rock formation, Hiroto finds a rock that has footprints pressed into it. A geologist tells Hiroto that the rock is millions of years old. Which of these statements is **correct** about Hiroto's find?
 - It is not a fossil because footprints are not fossils.
 - It is not a fossil because only whole organisms are fossils.
 - It is a fossil only if Hiroto finds actual parts of the organism in rocks nearby.
 - It is a fossil because footprints of organisms from million of years ago are considered to be fossils.
- The diagram below shows a model of the proposed relationships between some groups of ancient and modern mammals. Branch points represent when two species diverged from the proposed common ancestor.



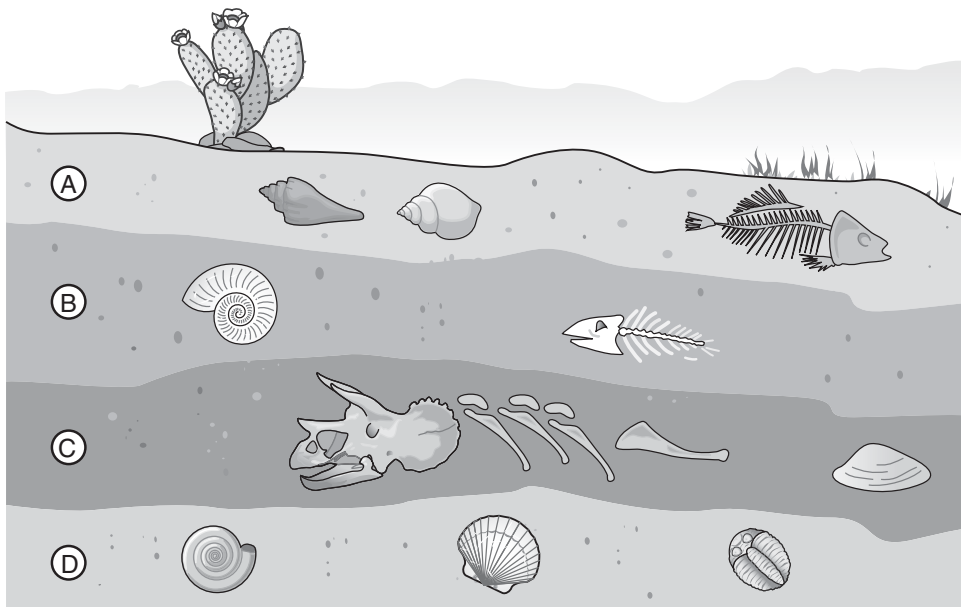
Which of these organisms is **most closely** related to whales?

- | | |
|----------------|----------------|
| F bison | H hippo |
| G camel | I pig |

5 Which of these conditions is **least likely** to cause a species to become extinct due to environmental changes?

- A less genetic variation
- B more genetic variation
- C specific food preferences
- D more competition for food

6 The diagram below shows a portion of the fossil record in sedimentary rock. Different rock layers and fossils are clearly visible.



Which of these statements is **true** of the fossils and rock layers shown in the diagram?

- F Layer B contains the second-oldest fossils.
- G Layer A contains the most recently formed fossils.
- H The fossils in layer B are older than those in layer D.
- I The fossils in layer D are the most recently formed.

7 When farmers want two desirable traits in cows, they often breed individuals that have those traits in the hopes that the offspring will have both desirable traits. What is this practice called?

- A variation
- B adaptation
- C natural selection
- D artificial selection

Name _____

- 8** Ronald observes a sparrow's nest in a shrub outside his home. The table below describes his findings.

Week	Observations
1	Six eggs were laid in the nest.
3	Five eggs hatched, and one egg did not hatch.
4	One of the chicks disappeared.
7	Three of the chicks learned to fly, and another one disappeared.

What part of natural selection did Ronald observe?

- F** adaptation **H** selection
G overproduction **I** variation
- 9** Environmental changes may lead to the evolution of a species. Polar bears live in the Arctic. Ice in the Arctic is melting fast, reducing the range where the polar bear can live. If polar bears do not have adaptations that allow them to survive these changes, what may happen to them?
- A** They may become extinct.
B They may overpopulate.
C They may change the environment.
D They may become another species.
- 10** Juan is studying fossils. His teacher wrote the following statements on the board and asked the students to put them in the correct order to describe how fossils are formed.

1. Minerals seep into the organism's body and replace it with stone.
2. The organism completely decomposes, leaving behind an imprint.
3. An organism dies, and its body is covered with a layer of sediment.
4. Time passes, and sediment layers continue to build up on the organism.

Which is the correct order of events for fossil formation?

- F** 3, 4, 1, 2 **H** 1, 3, 2, 4
G 2, 3, 4, 1 **I** 3, 2, 1, 4

11 At the zoo, Anya observes that the red kangaroos are of several sizes and colors. What characteristic of populations is Anya observing?

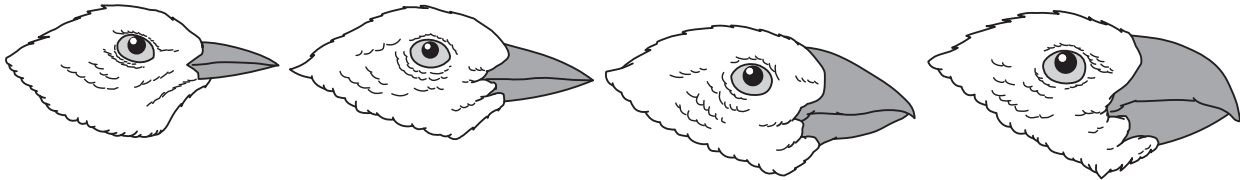
- A adaptation
- B evolution
- C selection
- D variation

Critical Thinking

Answer the following questions in the space provided.

12 Darwin's theory of natural selection consists of four important parts. Describe the four essential parts of natural selection.

13 Charles Darwin studied the finches of the Galápagos Islands and found that their beaks vary in shape and size.



Darwin found that the finches that ate mostly insects had long, narrow beaks. Finches that ate mostly seeds had shorter, broad beaks to crush seeds. Are the four types of finches shown above the result of natural selection? Use specific evidence to support your claim and explain your reasoning.
