

16.1 Darwin's Voyage of Discovery

Lesson Objectives

- State Charles Darwin's contribution to science.
- Describe the three patterns of biodiversity noted by Darwin.

Lesson Summary

Darwin's Epic Journey Darwin developed a scientific theory to explain how **evolution**, or change over time, occurs in living things. Darwin's theory explains how modern organisms have evolved over long periods of time through descent from common ancestors.

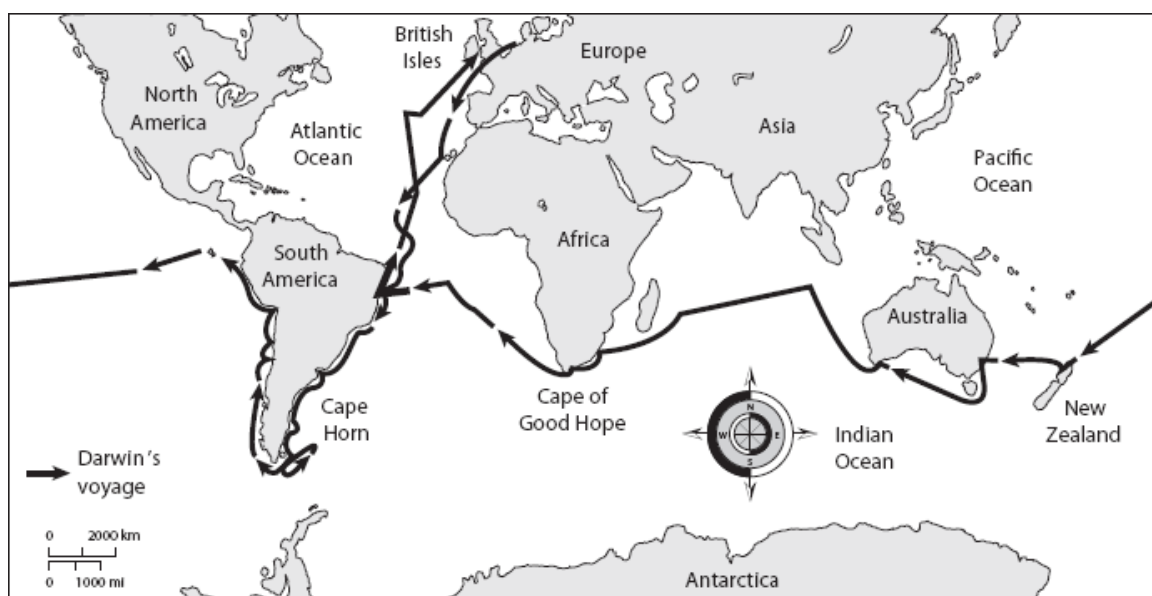
Observations Aboard the *Beagle* During his five-year trip on the *Beagle*, Darwin made many observations and collected a great deal of evidence.

- ▶ He noticed that many different, yet ecologically similar, animal and plant species occupied different, yet ecologically similar, habitats around the globe.
- ▶ On the Galápagos Islands, Darwin noticed that the traits of many organisms—such as the shell shapes of tortoises—varied from island to island. He noticed that different, yet related, animal and plant species occupied different habitats within a local area.
- ▶ Darwin collected **fossils**, the preserved remains of ancient organisms. He noticed that some fossils of extinct species resembled living species.

Darwin's findings led him to think that species are not fixed and that they could change by some natural process.

Darwin's Epic Journey

- THINK VISUALLY** On the map below, (1) find and label the Galápagos Islands (2) circle the names of three large land masses Darwin did not visit on his voyage.

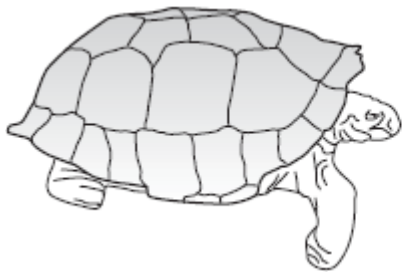


For Questions 2–4, complete each statement by writing the correct word or words. Refer to the map on the previous page as needed.

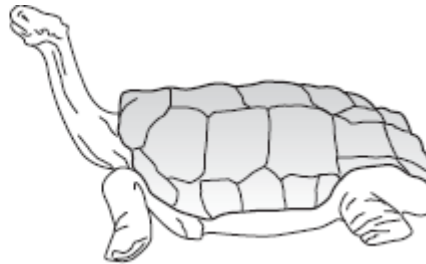
2. Darwin spent most of his time exploring the continent of _____; he did not visit _____, _____, or _____.
3. During Darwin's time, geologists were suggesting that Earth was _____.
4. Darwin's work offers insight into the living world by showing organisms are constantly _____.

Observations Aboard the *Beagle*

Use the drawings of the tortoises to answer Questions 5 and 6.



Isabela Island tortoise



Hood Island tortoise

5. What important information about the Galápagos Islands tortoises did Darwin learn?

6. Given its body structure, which tortoise above would require a habitat where food is easy to reach?

Use the map on the previous page to answer Questions 7 and 8.

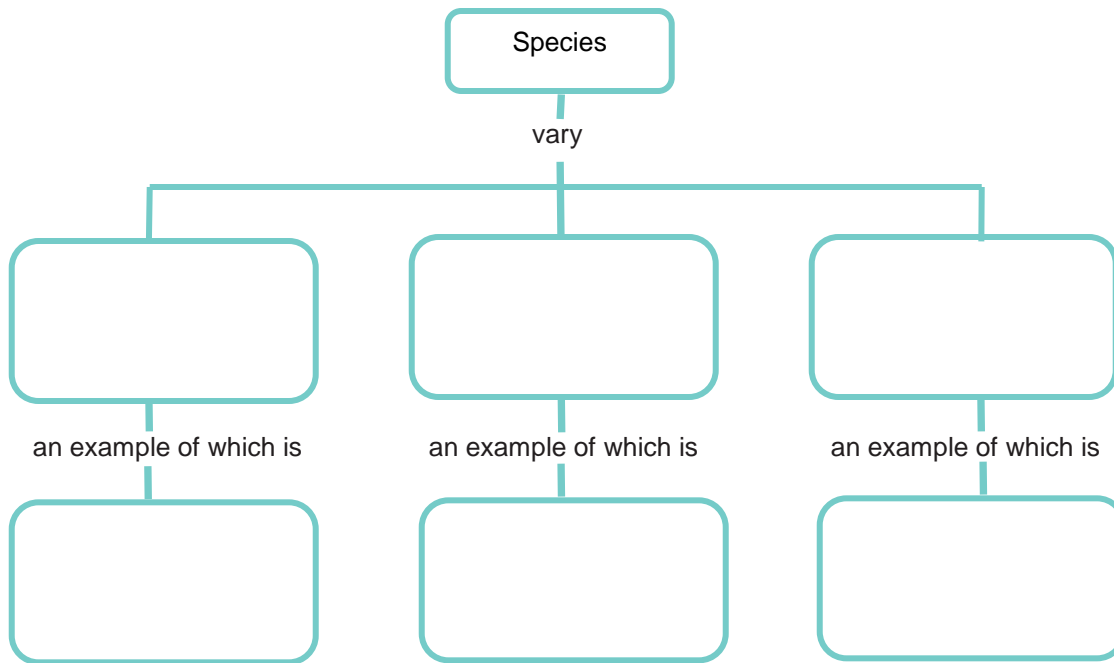
7. On the map, place the labels Rheas, Emus, and Ostriches on the continents where they are found. Why were the similarities among rheas, ostriches, and emus surprising to Darwin?

8. Why might Darwin come to think that the finches of the Galápagos Islands might be related to the finches of South America, despite how different the birds were in appearance?

9. Darwin observed that the birds he would eventually discover were finches had differently shaped beaks. What might this suggest about the eating habits of the birds? Explain.

10. What did the similarities between fossil animals and modern animals, like the glyptodont and armadillo, suggest to Darwin?

11. Complete the graphic organizer by listing three ways that species vary. For each pattern of biodiversity, list an example that Darwin observed.







Apply the Big idea

12. When Darwin returned to England, he learned that the small brown birds he observed on the Galápagos Islands were all finches. They resembled South American finches. What hypothesis does this observation support?

16.2 Ideas That Shaped Darwin's Thinking

Lesson Objectives

-  Identify the conclusions drawn by Hutton and Lyell about Earth's history.
-  Describe Lamarck's hypothesis of evolution.
-  Describe Malthus's view of population growth.
-  Explain the role of inherited variation in artificial selection.

Lesson Summary

An Ancient, Changing Earth In Darwin's day, most Europeans believed that Earth and all its life forms were only a few thousand years old and had not changed very much in that time. Several scientists who lived around the same time as Darwin began to challenge these ideas. These scientists had an important influence on the development of Darwin's theory of evolution.

- ▶ Geologists James Hutton and Charles Lyell argued that Earth is many millions of years old.
- ▶ They also argued that the processes changing Earth today, like volcanism and erosion, are the same ones that changed Earth in the past.

Knowing that Earth could change over time helped Darwin realize that species might change as well. Knowing that Earth was very old convinced Darwin that there had been enough time for life to evolve.

Lamarck's Evolutionary Hypothesis Jean-Baptiste Lamarck was one of the first scientists to propose hypotheses about how evolution occurred.

- ▶ To explain evolution, Lamarck hypothesized that all organisms have an inborn drive to become more complex and perfect. According to Lamarck, an organism could gain or lose traits during its lifetime by using or not using certain organs.
- ▶ Lamarck also hypothesized that acquired characteristics could be passed on to an organism's offspring leading to evolution of the species.

Scientists now know that most of Lamarck's ideas about evolution are incorrect. However, he correctly suggested that life is not fixed and was the first to offer a natural and scientific explanation for evolution. Further, he recognized that an organism's traits are linked to its environment.

Population Growth Thomas Malthus thought that if the human population continued to grow unchecked, it would run out of living space and food. Darwin realized that this was true of all organisms, not just humans.

Artificial Selection Plant and animal breeders in Darwin's time used a process now known as artificial selection to improve their crops and livestock. In **artificial selection**, nature provides the variations, and humans select those they find desirable. Darwin experimented with artificial selection. The results from his experiments indicated natural variation was very important because it provided the raw material for evolution.

An Ancient, Changing Earth

1. In what two ways did an understanding of geology influence Darwin?

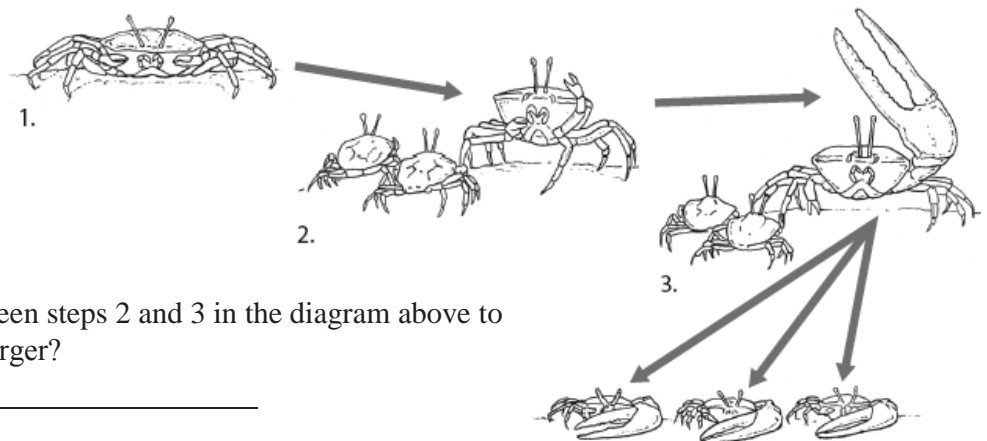
For Questions 2–5, write *True* if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

- _____ 2. Hutton realized that Earth was much younger than previously believed.
- _____ 3. Lyell thought most geological processes operated extremely quickly.
- _____ 4. The processes that changed Earth in the past are different from the processes that operate in the present.
- _____ 5. Lyell's work explained how large geological features could be built up or torn down over long periods of time.

Lamarck's Evolutionary Hypotheses

6. How did Lamarck propose that species change over time?

Use the diagram to answer Questions 7–8.



7. According to Lamarck's hypothesis, what occurs between steps 2 and 3 in the diagram above to make the crab's claw grow larger?

8. Which step in the diagram above shows the inheritance of acquired traits as proposed by Lamarck?

9. How did Lamarck pave the way for the work of later biologists?

10. Which of Lamarck's ideas turned out to be true? Which turned out to be false?

11. How would Lamarck have explained the length of a giraffe's neck?

Population Growth

For Questions 12–14, write the letter of the correct answer on the line at the left.

_____ 12. Which observation caused Thomas Malthus to form his theory about population growth?

- A. Human birth rate was higher than the death rate.
- B. War caused the death of thousands of people.
- C. Famines were common in England in the 1800s.
- D. The offspring of most species survived into adulthood.

_____ 13. Which of the following is an idea attributed to Malthus?

- A. As a population decreases in size, warfare and famine become more common.
- B. As a population increases in size, the percentage of offspring that survive also increases.
- C. If the human population grew unchecked, its rate of evolution would increase geometrically.
- D. If the human population grew unchecked, there wouldn't be enough living space and food for everyone.

_____ 14. Malthus's ideas led Darwin to conclude that

- A. Earth is much older than previously thought.
- B. the size of the human population can grow indefinitely.
- C. many more organisms are born than will survive and reproduce.
- D. organisms are able to evolve through a process known as artificial selection.

Name _____ Class _____ Date _____

Artificial Selection

15. How do humans affect artificial selection? What role does nature play?

16. What is another name for artificial selection?

17. Describe how you could use artificial selection to breed pigeons with large beaks.



Apply the Big idea

18. Complete the table about scientists who contributed to the development of the theory of evolution.

Scientists Who Contributed to Darwin's Theory of Evolution	
Scientist	Contribution to Darwin's Theory
James Hutton	
Charles Lyell	
Jean-Baptiste Lamarck	
Thomas Malthus	

16.3 Darwin Presents His Case

Lesson Objectives

-  Describe the conditions under which natural selection occurs.
-  Explain the principle of common descent.

Lesson Summary

Evolution by Natural Selection Darwin published *On the Origin of Species* in 1859. In the book, Darwin describes and provides evidence for his explanation of how evolution occurs. He called this process **natural selection** because of its similarities to artificial selection. Darwin's theory of evolution by natural selection can be summed up as follows:

- ▶ More offspring are produced than can survive to reproduce. There is competition for limited resources, or a struggle for existence.
- ▶ Individuals exhibit variation in their traits and some of these differences can be passed on to their offspring.
- ▶ Inherited traits that increase an organism's ability to survive and reproduce are called **adaptations**.
- ▶ Differences among adaptations affect an individual's **fitness**—the ability to survive and reproduce in a specific environment.
- ▶ Only the fittest organisms live to reproduce and pass on their adaptive traits to offspring. This is known as the survival of the fittest.

From generation to generation, populations continue to evolve as they become better adapted, or as their environment changes.

Common Descent Darwin argued that all species are descended, with modification, from common ancestors. Through descent with modification, all organisms—living and extinct—are linked on a single tree of life.

Evolution by Natural Selection

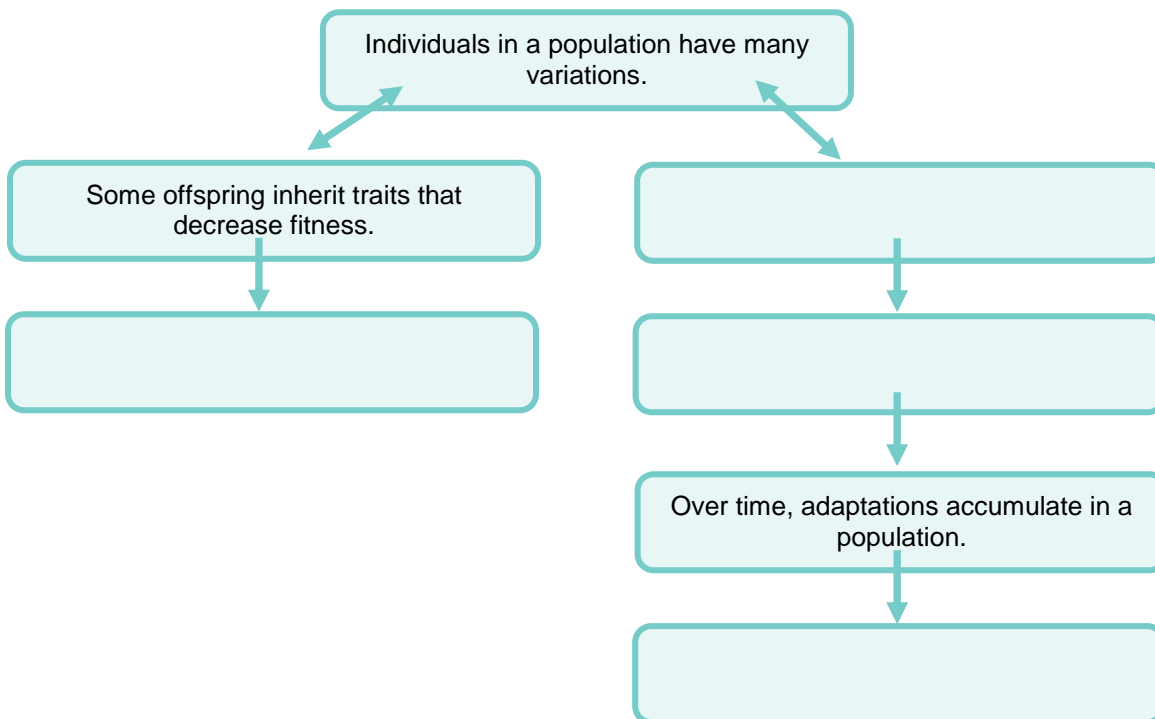
1. What does the phrase *struggle for existence* mean?

2. Why is camouflage considered an adaptation?

3. How does an animal's level of fitness relate to its chances of survival and reproduction?

For Questions 4–6, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

- _____ 4. Natural selection acts on acquired traits.
- _____ 5. Any inherited characteristic that increases an organism's chance of survival is considered an adaptation.
- _____ 6. Natural selection is the ability of an individual to survive and reproduce in its specific environment.
7. Below is a partially completed flowchart that models how natural selection drives evolution. The missing steps are listed below, out of order, and lettered A–D. Write the letter of the missing step in a blank box in the flowchart.
- A. Adaptations are passed on to the next generation.
 - B. The accumulation of adaptations may lead to the evolution of a new species.
 - C. These offspring have few or no offspring of their own.
 - D. Some offspring inherit traits that increase fitness (adaptations).



Common Descent

For Questions 8–13, complete each statement by writing the correct word or words.

8. Natural selection depends on the ability of organisms to _____, which means to leave descendants.
9. Every organism alive today _____ from ancestors who survived and reproduced.
10. Over many generations, adaptation could cause successful species to _____ into new species.
11. Common descent suggests that all species, living and extinct, are _____.
12. The principle that living species descend, with changes, from other species over time is referred to as _____.
13. The _____ provides physical evidence of descent with modification over long periods of time.

Apply the Big idea

14. In the three boxes on the left, draw an example of natural selection that might occur in a population of frogs. Then, on the lines at right, describe each stage.






The Struggle for Existence

Variation and Adaptation /Survival of the Fittest

Natural Selection

16.4 Evidence of Evolution

Lesson Objectives

-  Explain how geologic distribution of species relates to their evolutionary history.
-  Explain how fossils and the fossil record document the descent of modern species from ancient ancestors.
-  Describe what homologous structures and embryology suggest about the process of evolutionary change.
-  Explain how molecular evidence can be used to trace the process of evolution.
-  Explain the results of the Grants' investigation of adaptation in Galápagos finches.

Lesson Summary

Biogeography **Biogeography** is the study of where organisms live now and where they and their ancestors lived in the past. Two biogeographical patterns are significant to Darwin's theory:

- ▶ The first is a pattern in which closely related species differentiate in slightly different climates. The Galápagos tortoises and finches follow this pattern.
- ▶ The second is a pattern in which very distantly related species develop similarities in similar environments. The rheas, ostriches, and emus fall into this pattern.

The Age of Earth and Fossils

- ▶ Radioactive dating techniques have confirmed that Earth is ancient—approximately 4.5 billion years old. Recent fossil finds document intermediate stages in the evolution of many groups including whales, birds, and mammals.

Comparing Anatomy and Embryology

- ▶ **Homologous structures** are shared by related species and have been inherited from a common ancestor. Similarities and differences among homologous structures help determine how recently two groups shared a common ancestor.
 - Body parts that share a common function, but neither structure nor common ancestry, are called **analogous structures**. Analogous structures do not provide any evidence for evolutionary descent.
 - Homologous structures that are greatly reduced in size or have little to no function are called **vestigial structures**.
 - Many homologous structures develop in the same order and in similar patterns during the embryonic, or pre-birth, stages of related groups. These similarities provide further evidence that the animals share common ancestors.

Genetics and Molecular Biology At the molecular level, the universal genetic code and homologous molecules such as genes and proteins provide evidence of common descent.

Testing Natural Selection Scientists have designed experiments to test natural selection. Observations of Galápagos finches confirm that competition and environmental change drive natural selection.

Biogeography

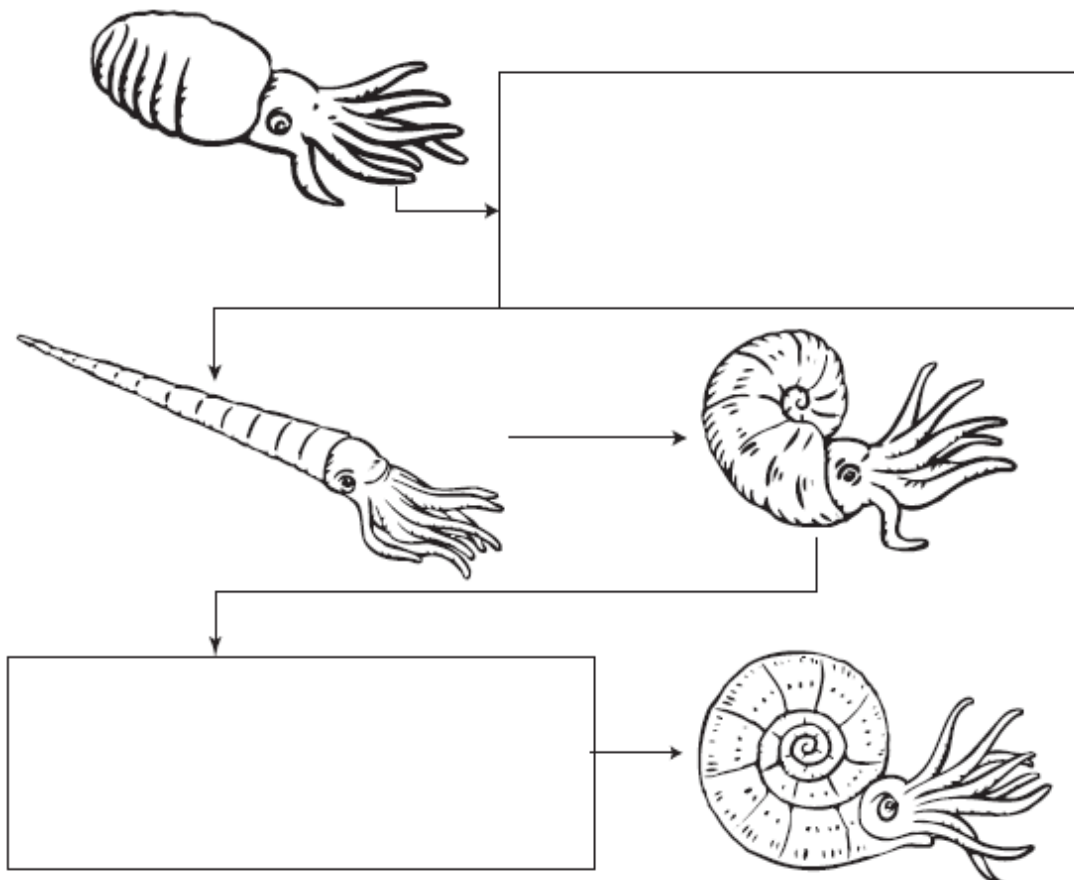
For Questions 1–3, complete each statement by writing the correct word or words.

1. Biogeographers study where organisms live now and where they and their _____ lived in the past.
2. When individuals from a mainland bird population immigrate to various islands, natural selection may result in _____, but different, island species.
3. Distantly related organisms may be similar if they live in _____.
4. What explains the distribution of finch species on the Galápagos Islands?

5. What explains the existence of similar but unrelated species?

The Age of Earth and Fossils

6. **THINK VISUALLY** The illustrations below show organisms whose fossils make up part of the fossil record. The organisms are in order from oldest to most recent. In the boxes, draw an animal that might have been an intermediate form between the shown organisms.



Use the illustrations of the marine organisms on the previous page to answer Questions 7–8.

7. Describe a situation in which organism 3 might have had an advantage over organism 2?

8. How might these fossils provide evidence for evolution?

Comparing Anatomy and Embryology

9. Complete the table about types of anatomical structures.

Types of Anatomical Structures		
Structure Type	Description	Example
	Structures that are shared by related species and that have been inherited from a common ancestor	
	Body parts that share common function, but not structure	
	Body parts in animals that are so reduced in size that they are just vestiges, or traces, of homologous structures in other species	

For Questions 10–14, match the structure with the correct type. A structure type may be used

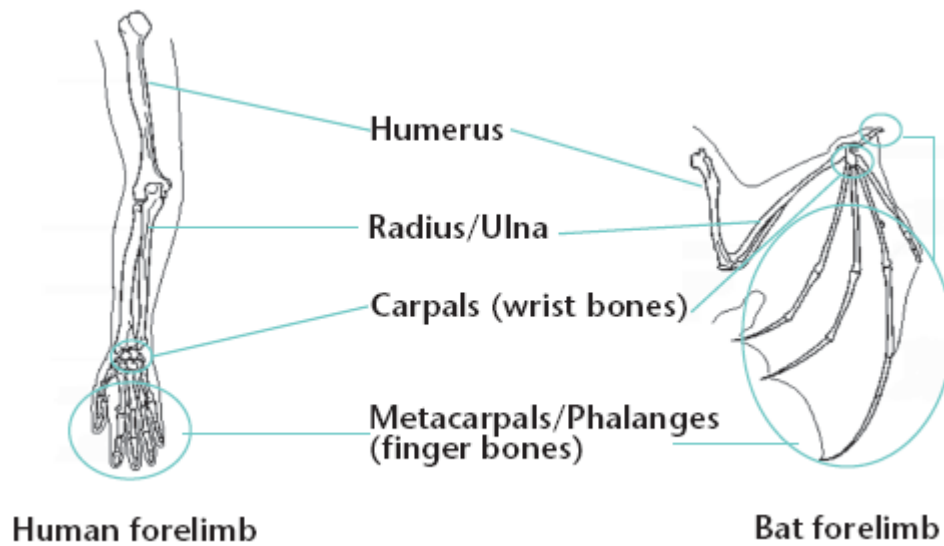
Anatomical Structure

- _____ 10. bat wing and mouse arm
 _____ 11. reptile foot and bird foot
 _____ 12. dolphin fin and fish tail
 _____ 13. eyes on a blind cave fish
 _____ 14. snake tongue and dog nose

Structure Type

- A. homologous structure
 B. analogous structure
 C. vestigial structure

Use the illustrated homologous structures to answer Questions 15–17.



15. How are the forelimbs similar?

16. How are the forelimbs different?

17. How are homologous structures such as forelimbs evidence for common descent?

18. How does the pattern of embryological development provide further evidence that organisms have descended from a common ancestor?

Genetics and Molecular Biology

For Questions 19–25, complete each statement by writing the correct word or words.

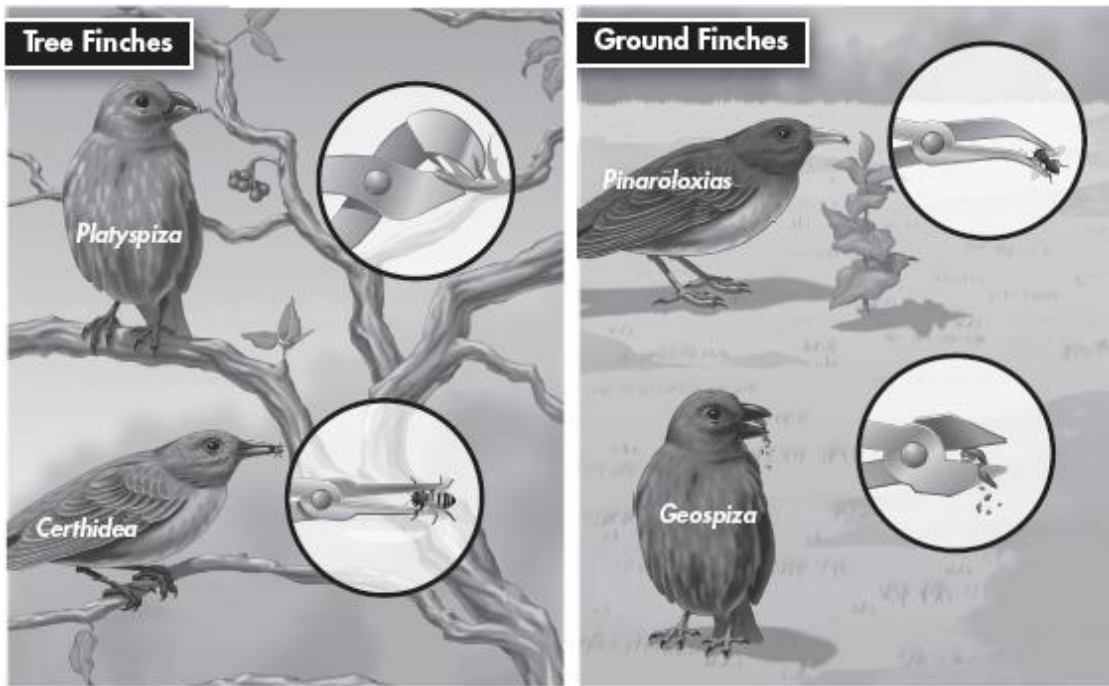
19. The science of _____ provides molecular evidence that supports evolutionary theory.
20. All living cells use _____ and _____ to code heritable information.
21. The universal genetic code is used by almost all organisms to _____.
22. Proteins that are _____ share extensive structural and chemical similarities.
23. Cytochrome c is a protein used for _____ in almost every living cell.
24. Homologous genes called Hox genes control timing and growth in _____.
25. Relatively minor changes in an organism's genome can produce major changes in an organism's _.

Testing Natural Selection

Write the letter of the correct answer on the line at the left.

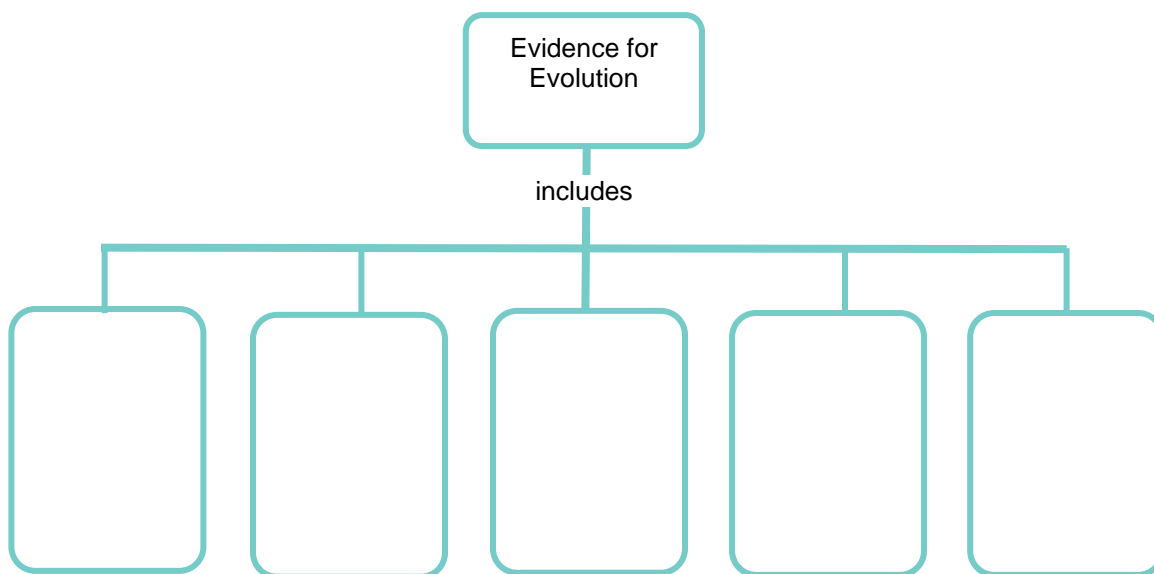
- _____ 26. Which of the following hypotheses did the Grants test?
 - A. Differences in beak size and shape produce differences in fitness.
 - B. For beak size and shape to evolve, the birds must leave the islands.
 - C. For beak size and shape to evolve, the climate must change radically.
 - D. Differences in beak size and shape are not determined by genetic mutations.
- _____ 27. The data that the Grants collected proved that there is
 - A. no link between the environment and the shape of finch feet.
 - B. no link between the environment and the shape of finch beaks.
 - C. great variation of heritable traits among Galápagos finches.
 - D. very little variation of heritable traits among Galápagos finches.
- _____ 28. The Grants conducted their experiment to test which of the following processes?
 - A. Natural selection
 - B. Genetic mutation
 - C. Artificial selection
 - D. Sexual reproduction

29. **VISUAL ANALOGY** The art shows how finch beaks are similar to certain kinds of hand tools. Suppose a finch fed on insects that burrowed into small holes on tree trunks. What type of tool do you think this finch's beak would resemble? Explain your answer.



Apply the Big idea

30. Complete the concept map.



Chapter Vocabulary Review

Match the term with its definition

Term

- _____ 1. evolution
- _____ 2. fossil
- _____ 3. fitness
- _____ 4. adaptation
- _____ 5. natural selection
- _____ 6. homologous structures
- _____ 7. vestigial structures

Definition

- A. Change over time
- B. Inherited characteristic that increases an organism's chance of survival
- C. Preserved remains of an ancient organism
- D. The process by which organisms with variations most suited to their environment survive and leave more offspring than others
- E. Small structures with little or no function
- F. Structures that develop from the same embryonic tissues but have different mature forms
- G. Ability of an individual to survive and reproduce in a specific environment

For Questions 8–10, write a definition for the vocabulary term.

8. biogeography

9. artificial selection

10. analogous structures

11. Does the illustration below show analogous or homologous structures? Explain.



Turtle



Alligator



Bird



Mammals
