

Chapter 17 The History of Life**Summary****17-1 The Fossil Record**

Fossils are preserved traces and remains of ancient life. Scientists who study fossils are called paleontologists. They use fossils to infer what past life-forms were like. All the information about past life provided by fossils is called the fossil record. The fossil record shows how life has changed over time. It shows that more than 99 percent of all species that ever lived on Earth have become extinct, or died out.

Few organisms are actually preserved as fossils. Most fossils that do form are found in sedimentary rock. As sediments build up in layers over time, they sometimes bury the remains of dead organisms. These dead organisms eventually turn into fossils.

Relative dating and radioactive dating are used to determine the age of fossils. Relative dating determines whether a fossil is older or younger than other fossils. It is based on where fossils are found in rock layers. Fossils from deeper rock layers are assumed to be older than fossils from rock layers closer to the surface. Index fossils represent species that lived for a short period of time but over a wide geographic range. Index fossils can help determine the relative age of fossils from different places. Radioactive dating determines a fossil's age in years. Radioactive elements in fossils decay, or break down, at a steady rate, called a half-life. A half-life is the length of time needed for half of the radioactive atoms in a sample to decay. A fossil's age is calculated from the half-life and the amount of remaining radioactive atoms the fossil contains.

The geologic time scale is used for evolutionary time. The scale begins with Precambrian Time. Following Precambrian Time, the scale is divided into three eras: the Paleozoic, Mesozoic, and Cenozoic eras. Each era is further divided into smaller lengths of time, called periods.

17-2 Earth's Early History

Earth is about 4.6 billion years old. At first, Earth was very hot and the atmosphere contained toxic gases. The atmosphere also contained water vapor but no oxygen. About 3.8 billion years ago, Earth's surface cooled and water vapor condensed. Thunderstorms soaked the surface, and oceans formed.

In the 1950s, Stanley Miller and Harold Urey simulated conditions on early Earth. They filled a container with water and gases found in Earth's early atmosphere. They passed electric sparks through the mixture to simulate lightning. Soon, organic compounds formed. The experiment showed that molecules needed for life could have evolved under conditions on early Earth. Sometimes large organic molecules form tiny bubbles called proteinoid microspheres. Structures similar to proteinoid microspheres might have become the first living cells. RNA and DNA also could have evolved from simple organic molecules.

The first known life-forms evolved about 3.5 billion years ago. They were single celled and looked like modern bacteria. Some were preserved as microscopic fossils, or microfossils. Eventually, photosynthetic bacteria became common. During photosynthesis, the bacteria produced oxygen. The oxygen accumulated in the atmosphere. The rise of oxygen drove some life-forms to extinction. At the same time, other life-forms evolved that depended on oxygen.

The first eukaryotes, or organisms with nuclei, evolved about 2 billion years ago. One explanation for how eukaryotes evolved is the endosymbiotic theory. This theory proposes that smaller prokaryotes began living inside larger cells and evolved a symbiotic relationship with the larger cells.

Later, sexual reproduction evolved. Sexual reproduction increased genetic variation, so evolution could occur more quickly.

17-3 Evolution of Multicellular Life

During Precambrian Time, life arose and evolved into multicellular forms. However, life still existed only in the oceans. Few fossils exist from the Precambrian, because the animals did not yet have any hard parts.

There is much more fossil evidence from the Paleozoic Era. Animals with hard parts, such as trilobites, evolved then. Other important evolutionary events of the Paleozoic include the evolution of land plants, insects, amphibians, and reptiles. At the end of the Paleozoic, there was a mass extinction, in which many types of organisms became extinct at once.

Important evolutionary events in the Mesozoic Era include the appearance of flowering plants and the dominance of dinosaurs. Reptiles, in general, were so successful during the era that the Mesozoic is called the Age of Reptiles. At the close of the Mesozoic, another mass extinction occurred.

The Cenozoic Era is called the Age of Mammals. During the Cenozoic, mammals evolved adaptations that allowed them to live on land, in water, and in air. The first human fossils may have appeared about 200,000 years ago in Africa.

17-4 Patterns of Evolution

Macroevolution means large-scale evolution, or evolution above the level of the species. Six patterns of macroevolution are extinction, adaptive radiation, convergent evolution, coevolution, punctuated equilibrium, and changes in developmental genes.

Most of the time, extinctions have occurred because species could not compete for resources or adapt to gradually changing environments. Several times, however, mass extinctions have occurred. During these mass extinctions, huge numbers of species became extinct at once. This may have occurred because of a combination of events, such as volcanoes erupting and asteroids striking Earth.

Adaptive radiation is the process in which a single species evolves into diverse species that live in different ways. Convergent evolution is the process in which unrelated species come to look alike because they have evolved similar adaptations to similar environments. Coevolution is the process by which two species evolve in response to changes in each other over time. For example, plants evolved poisons that protected them from insects. In response, insects evolved ways of protecting themselves from the poisons.

Darwin thought evolution occurred slowly and gradually. The fossil record sometimes shows a different pattern of evolution, called punctuated equilibrium. In this pattern, long periods of little or no change are interrupted by short periods of rapid change.

Some genes, called hox genes, control the actions of many other genes. Small changes in hox genes can produce major differences in adult organisms. Some scientists think that changes in hox genes may contribute to major evolutionary changes.

Chapter 17 The History of Life

Section 17-1 The Fossil Record (pages 417-422)



Key Concepts

- What is the fossil record?
- What information do relative dating and radioactive dating provide about fossils?
- What are the main divisions of the geologic time scale?

Fossils and Ancient Life (page 417)

1. Scientists who study fossils are called _____.
2. What is the fossil record? _____

3. What evidence does the fossil record provide? _____

4. Species that died out are said to be _____.
5. Is the following sentence true or false? About half of all species that have ever lived on Earth have become extinct. _____

How Fossils Form (page 418)

6. Circle the letter of each sentence that is true about fossils.
 - a. Most organisms that die are preserved as fossils.
 - b. Fossils can include footprints, eggs, or other traces of organisms.
 - c. Most fossils form in metamorphic rock.
 - d. The quality of fossil preservation varies.
7. How do fossils form in sedimentary rock? _____

Interpreting Fossil Evidence (pages 418-420)

8. List the two techniques paleontologists use to determine the age of fossils.
 - a. _____
 - b. _____

9. Circle the letter of each sentence that is true about relative dating.
 - a. It determines the age of a fossil by comparing its placement with that of fossils in other layers of rock.
 - b. It uses index fossils.
 - c. It allows paleontologists to estimate a fossil's age in years.
 - d. It provides no information about absolute age.
10. Is the following sentence true or false? Older rock layers are usually closer to Earth's surface than more recent rock layers. _____
11. Is the following sentence true or false? Scientists use radioactive decay to assign absolute ages to rocks. _____
12. The length of time required for half of the radioactive atoms in a sample to decay is called a(an) _____.
13. The use of half-lives to determine the age of a sample is called _____.
14. How do scientists calculate the age of a sample using radioactive dating?

15. Is the following sentence true or false? All radioactive elements have the same half-life.

Geologic Time Scale (pages 421–422)

16. Fill in the missing eras and periods in the geologic time scale below.

GEOLOGIC TIME SCALE

Time (millions of years ago)	Period		Era											
	Quaternary		Cretaceous		Triassic	Paleozoic				Vendian				
1.8 – present														
65 – 1.8														
145 – 65														
208 – 145														
245 – 208														
290 – 245														
363 – 290														
410 – 363														
440 – 410														
505 – 440														
544 – 505														
650 – 544														

17. Circle the letter of the choice that lists the eras of the geologic time scale in order from the most recent to oldest.
- a. Mesozoic, Paleozoic, Cenozoic
 - b. Cenozoic, Paleozoic, Mesozoic
 - c. Cenozoic, Mesozoic, Paleozoic
 - d. Paleozoic, Mesozoic, Cenozoic
18. Circle the letter of each sentence that is true about the geologic time scale.
- a. The scale is used to represent evolutionary time.
 - b. Major changes in fossil organisms separate segments of geologic time.
 - c. Divisions of the scale cover standard lengths of 100 million years.
 - d. Geologic time begins with the Cambrian Period.
19. After Precambrian time, what are the two basic divisions of the geologic time scale?

20. During which era did dinosaurs roam the Earth? _____
21. During which era did mammals become common? _____

Reading Skill Practice

Writing a summary can help you remember the information you have read. When you write a summary, write only the important points. Write a summary of the information in Section 17-1. Your summary should be shorter than the text on which it is based.

Section 17-2 Earth's Early History (pages 423-428)

Key Concepts

- What substances made up Earth's early atmosphere?
- What did Miller and Urey's experiments show?
- What occurred when oxygen was added to Earth's atmosphere?
- What hypothesis explains the origin of eukaryotic cells?

Formation of Earth (pages 423-424)

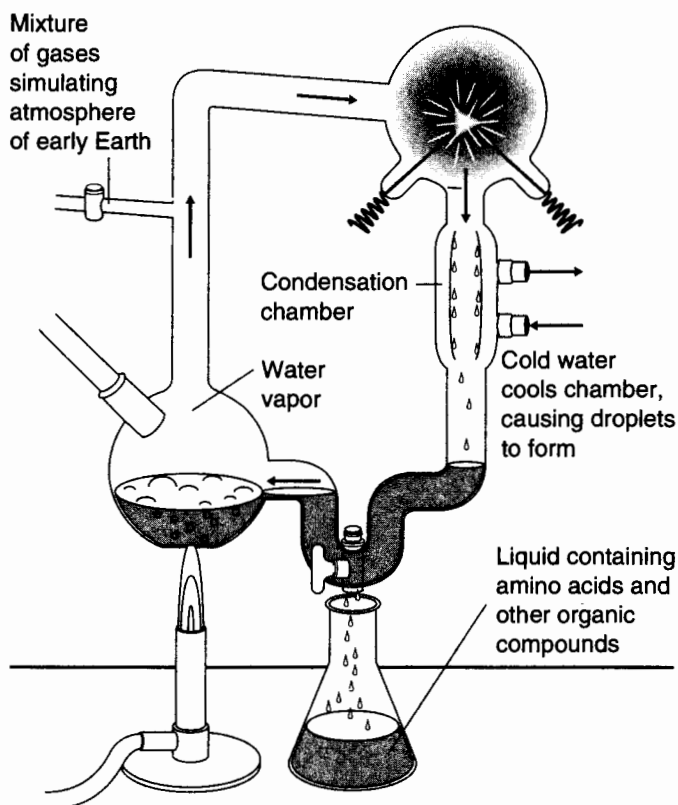
1. List six components of Earth's early atmosphere.

- a. _____ c. _____ e. _____
 b. _____ d. _____ f. _____

2. Is the following sentence true or false? Liquid water first occurred on Earth more than 4 billion years ago. _____

The First Organic Molecules (page 424)

3. Label the diagram to show which part of Miller and Urey's apparatus simulated lightning storms on early Earth.



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4. Circle the letter of each sentence that is true about Miller and Urey's experiments.
- a. Their purpose was to determine how the first organic molecules evolved.
 - b. They led to the formation of several amino acids.
 - c. They accurately simulated conditions in Earth's early atmosphere.
 - d. The results were never duplicated in experiments by other scientists.

The Puzzle of Life's Origins (page 425)

5. What are proteinoid microspheres? _____

6. Is the following sentence true or false? Scientists know how DNA and RNA evolved.

7. Why do scientists think that RNA may have evolved before DNA? _____

8. Once DNA evolved, why would it have become the primary means of transmitting genetic information? _____

Free Oxygen (page 426)

9. Microscopic fossils are called _____.
10. Circle the letter of each sentence that is true about the earliest life forms on Earth.
- a. They resembled modern bacteria.
 - b. They were eukaryotes.
 - c. They relied on oxygen.
 - d. They were not preserved as fossils.
11. How did early photosynthetic bacteria change Earth? _____

12. Is the following sentence true or false? The rise of oxygen in the atmosphere drove some life forms to extinction. _____

Origin of Eukaryotic Cells (pages 427-428)

13. Is the following sentence true or false? The ancestor of all eukaryotic cells evolved about 2 billion years ago. _____

14. What was the first step in the evolution of eukaryotic cells? _____

15. What does the endosymbiotic theory propose? _____

16. Circle the letter of each choice that provides support for the endosymbiotic theory.
- a. The membranes of mitochondria and chloroplasts resemble the plasma membranes of free-living prokaryotes.
 - b. Mitochondria and chloroplasts do not have DNA.
 - c. Mitochondria and chloroplasts have ribosomes that are similar in size and structure to those of bacteria.
 - d. Mitochondria and chloroplasts reproduce by binary fission as bacteria do.

Sexual Reproduction and Multicellularity (page 428)

17. How did sexual reproduction speed up the evolutionary process? _____

18. Is the following sentence true or false? Sexual reproduction evolved after the first multicellular organisms appeared. _____

Reading Skill Practice

When you read a section that contains new or difficult material, identifying the sentence that best expresses the main topic under each heading can help you focus on the most important points. For each heading in Section 17-2, identify and copy the sentence that best expresses the main topic under that heading. Do your work on a separate sheet of paper.

Section 17-3 Evolution of Multicellular Life

(pages 429-434)

Key Concepts

- What were the characteristic forms of life in the Paleozoic, Mesozoic, and Cenozoic eras?

Precambrian Time (page 429)

1. Is the following sentence true or false? Almost 90 percent of Earth's history occurred during the Precambrian. _____
2. Circle the letter of each sentence that is true about life in the Precambrian.
 - a. Anaerobic and photosynthetic forms of life appeared.
 - b. Aerobic forms of life evolved, and eukaryotes appeared.
 - c. Multicellular life-forms evolved.
 - d. Life existed on the land and in the sea.
3. Why do few fossils exist from the Precambrian? _____

Paleozoic Era (pages 429-431)

4. The first part of the Paleozoic Era is the _____ Period.
5. Is the following sentence true or false? Life was not very diverse during the Cambrian Period. _____
6. Circle the letter of each sentence that is true about the Cambrian Period.
 - a. Organisms with hard parts first appeared.
 - b. Most animal phyla first evolved.
 - c. Many animals lived on the land.
 - d. Brachiopods and trilobites were common.

Match the periods of the Paleozoic Era with the evolutionary events that occurred during them.

Periods	Events
_____ 7. Ordovician and Silurian	a. Reptiles evolved from amphibians, and winged insects evolved into many forms.
_____ 8. Devonian	b. The first vertebrates evolved, and insects first appeared.
_____ 9. Carboniferous and Permian	c. Many groups of fishes were present in the oceans, and the first amphibians evolved.

10. Animals first begin to invade the land during the _____ Period.
11. Where does the Carboniferous Period get its name? _____

12. When many types of living things become extinct at the same time, it is called a(an) _____.
13. Is the following sentence true or false? The mass extinction at the end of the Paleozoic affected only land animals. _____

Mesozoic Era (pages 431–432)

14. Complete the following table.

PERIODS OF THE MESOZOIC ERA

Period	Evolutionary Event
	First mammals
	First birds
	First flowering plants

15. The Mesozoic Era is called the Age of _____.
16. The first dinosaurs appeared in the _____ Period.
17. Is the following sentence true or false? The mammals of the Triassic Period were very small. _____
18. Is the following sentence true or false? Many paleontologists think that birds are close relatives of dinosaurs. _____
19. The dominant vertebrates throughout the Cretaceous Period were _____.
20. What advantage do flowering plants have over conifers? _____

21. Describe the mass extinction that occurred at the end of the Cretaceous Period.

Cenozoic Era (pages 433–434)

22. Is the following sentence true or false? During the Cenozoic Era, mammals evolved adaptations that allowed them to live on land, in water, and in the air.

23. The Cenozoic Era is called the Age of _____.

24. What were Earth's climates like during the Tertiary Period? _____

25. How did Earth's climate change during the Quaternary Period? _____

26. Is the following sentence true or false? The very earliest ancestors of our species appeared about 100,000 years ago. _____

Reading Skill Practice

When you read a section with many details, writing an outline may help you organize and remember the material. Outline Section 17–3 by first writing the section headings as major topics in the order in which they appear in the book. Then, beneath each major topic, list important details about it.

Section 17-4 Patterns of Evolution (pages 435-440)

Key Concepts

- What are six important patterns of macroevolution?

Introduction (page 435)

1. The large-scale evolutionary changes that take place over long periods of time are referred to as _____.
2. What are six patterns of macroevolution?
 - a. _____
 - b. _____
 - c. _____
 - d. _____
 - e. _____
 - f. _____

Extinction (page 435)

3. What are possible causes of mass extinctions? _____

4. What effects have mass extinctions had on the history of life? _____

Adaptive Radiation (page 436)

5. The process of a single species or a small group of species evolving into diverse forms that live in different ways is called _____.
6. What led to the adaptive radiation of mammals? _____

Convergent Evolution (pages 436-437)

7. The process by which unrelated organisms come to resemble one another is called _____.
8. Circle the letter of each choice that is an example of convergent evolution.
 - a. Bird's wing and fish's fin
 - b. Shark's fin and dolphin's limb
 - c. Human's arm and bird's wing
 - d. Human's leg and dolphin's limb

Coevolution (pages 437–438)

9. The process by which two species evolve in response to changes in each other over time is called _____.
10. How have plants and plant-eating insects coevolved? _____

Punctuated Equilibrium (page 439)

11. The idea that evolution occurs at a slow, steady rate is called _____.
12. What are some reasons rapid evolution may occur after long periods of equilibrium?

13. The pattern of long, stable periods interrupted by brief periods of more rapid change is called _____.
14. Is the following sentence true or false? Evolution has often proceeded at different rates for different organisms. _____

Developmental Genes and Body Plans (page 440)

15. How can hox genes help reveal how evolution occurred? _____

16. Is the following sentence true or false? Changes in the timing of genetic control during embryonic development can contribute to the variation involved in natural selection.

Chapter 17 The History of Life

Vocabulary Review

Multiple Choice *In the space provided, write the letter of the answer that best completes each sentence.*

- _____ 1. Index fossils are used in the type of dating called
 - a. radioactive dating.
 - b. periodic dating.
 - c. relative dating.
 - d. absolute dating.
- _____ 2. Oxygen was added to Earth's atmosphere by the process of
 - a. macroevolution.
 - b. endosymbiosis.
 - c. coevolution.
 - d. photosynthesis.
- _____ 3. Sexual reproduction evolved before the evolution of
 - a. multicellular organisms.
 - b. photosynthetic bacteria.
 - c. eukaryotes.
 - d. the earliest life forms.
- _____ 4. The Age of Mammals occurred during the
 - a. Mesozoic Era.
 - b. Paleozoic Era.
 - c. Cenozoic Era.
 - d. Precambrian.
- _____ 5. Dinosaurs were dominant during the
 - a. Precambrian.
 - b. Mesozoic Era.
 - c. Paleozoic Era.
 - d. Cenozoic Era.

Writing Descriptions *Describe each pattern of macroevolution.*

- 6. coevolution _____

- 7. convergent evolution _____

- 8. mass extinction _____

- 9. punctuated equilibrium _____

- 10. adaptive radiation _____

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