Change Through Time

Unit Overview

In this unit, students will study the concepts and principles of evolution and classification. Chapter 14 deals with the history of life on Earth, and some hypotheses about how life began. Students will learn about fossils—what they are, how they are formed, and how they can be used to reconstruct the history of life on Earth. In Chapter 15, Darwin's theory of evolution by natural selection is discussed. The role of natural selection in the evolution of new species is presented. In Chapter 16, evidence of the ancestry of humans is explored. Chapter 17 introduces taxonomy and the diversity of organisms.

Introducing the Unit

Have students look at the birds in the photo and describe their successful adaptations. Tell students that they will learn in this unit why the ancestors of modern birds may be a group of extinct dinosaurs. Explain to students that as the environment changes populations may adapt, migrate, or become extinct.

Unit 5

Change Through Time

Life on Earth has a history of change that is called evolution. An enormous variety of fossils, such as those of early birds, provide evidence of evolution. Genetic studies of populations of bacteria, protists, plants, insects, and even humans provide further evidence of the history of change among organisms that live or have lived on Earth.

Unit Contents

Unit Project

internet CONNECTION Use the Glencoe Science Web Site for more project activities that are connected to this unit. www.glencoe.com/sec/science

Unit 5

Advance Planning

Chapter 14

- Order diatomaceous earth for MiniLab 14-1.
- Order the chemicals for the Alternative Lab.
- Order a live culture or preserved slides of *Oscillatoria* for the Quick Demo.
- Order live cultures or preserved slides of bacteria and cyanobacteria for the Biology Journal.

Chapter 15

- Order bacterial cultures, nutrient agar, and other materials for the Alternative Lab.

Chapter 16

- Obtain casts of various fossil hominids and ape skulls for the BioLab.

Chapter 17

- Obtain guidebooks that have dichotomous keys for local trees and shrubs, perhaps from your state's Bureau of Forestry, for MiniLab 17-1.
- Obtain identification guides to insects and other organisms for the Biolab.

Unit Projects

Diversity of Organisms

Have students do one of the projects for this unit as described on the Glencoe Science Web Site. As an alternative, students can do one of the projects described on these two pages.

Display

Visual-Spatial Students can use photographs or illustrations from magazines and science journals to make a collage showing different living things. L1 ELL

Making a Collection

Naturalist Have student groups study leaves or insects in your area and add them to the school collection. Students should identify differences in habitats, behaviors, and needs that contribute to the diversity among the organisms. L2 ELL

Interview

Linguistic Students can interview professionals at nature preserves, parks, or local environmental departments to find out how they care for the diverse life forms under their protection. Have students prepare their interview questions in advance. L1

Using the Library

Intrapersonal Students can read Chapter 17, which is "Galapagos Archipelago," of *Voyage of the Beagle* by Charles Darwin to find out about the diversity of birds and reptiles in the Galapagos. L3

Final Report

Have students present oral reports of their findings about the diversity of organisms. P COOP LEARN

Chapter 14 Organizer

Refer to pages 4T-5T of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section	Objectives	Activities/Features
Section 14.1 **The Record of Life** National Science Education Standards UCP.2-4; A.1, A.2; C.3, C.6; D.3; G.1-3 (2 sessions, 1 block)	1. **Identify** the different types of fossils and how they are formed. 2. **Summarize** the major events of the Geologic Time Scale.	**MiniLab 14-1:** Marine Fossils, p. 379 **Problem-Solving Lab 14-1:** p. 380 **Inside Story:** The Fossilization Process, p. 381 **Careers in Biology:** Animal Keeper, p. 382 **MiniLab 14-2:** A Time Line, p. 384 **Investigate BioLab:** Determining a Fossil's Age, p. 394
Section 14.2 **The Origin of Life** National Science Education Standards UCP.2-5; A.1, A.2; B.2, B.3; C.1, C.3, C.6; D.2; F.3, F.4; G.1-3 (2 sessions, 1 block)	3. **Analyze** early experiments that support the concept of biogenesis. 4. **Compare and contrast** modern theories of the origin of life. 5. **Relate** hypotheses about the origin of cells to the environmental conditions of early Earth.	**Problem-Solving Lab 14-2:** p. 392 **Biology & Society:** How Did Life Begin: Different Viewpoints, p. 396

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at **http://www.carolina.com**

MATERIALS LIST

BioLab
p. 394 shoebox with lid, pennies, graph paper

MiniLabs
p. 379 microscope, microscope slide, coverslip, diatomaceous earth, water
p. 384 meterstick, adding machine tape

Alternative Lab
p. 390 gelatin solution, droppers (3), gum arabic solution, pH paper, microscope, microscope slides, coverslips, hydrochloric acid, test tube, stirring rod

Quick Demos
p. 381 igneous rock, sedimentary rock, metamorphic rock
p. 385 microscope, prepared slide of *Oscillatoria*
p. 389 beef bouillon cube (2), flasks (2), water, rubber stopper

Key to Teaching Strategies

- **L1** Level 1 activities should be appropriate for students with learning difficulties.
- **L2** Level 2 activities should be within the ability range of all students.
- **L3** Level 3 activities are designed for above-average students.
- **ELL** ELL activities should be within the ability range of English Language Learners.
- **COOP LEARN** Cooperative Learning activities are designed for small group work.
- **P** These strategies represent student products that can be placed into a best-work portfolio.
- These strategies are useful in a block scheduling format.

The History of Life

Teacher Classroom Resources

Section	Reproducible Masters	Transparencies
Section 14.1 **The Record of Life**	**Reinforcement and Study Guide,** pp. 61-62 L2 **Concept Mapping,** p. 14 L3 ELL **Critical Thinking/Problem Solving,** p. 14 L3 **BioLab and MiniLab Worksheets,** pp. 67-68 L2 **Laboratory Manual,** pp. 99-102 L2 **Content Mastery,** pp. 69-70, 72 L1	Section Focus Transparency 35 L1 ELL Reteaching Skills Transparency 23 L1 ELL
Section 14.2 **The Origin of Life**	**Reinforcement and Study Guide,** pp. 63-64 L2 **BioLab and MiniLab Worksheets,** pp. 69-70 L2 **Content Mastery,** pp. 69, 71-72 L1	Section Focus Transparency 36 L1 ELL Basic Concepts Transparency 20 L2 ELL

Assessment Resources

Chapter Assessment, pp. 79-84
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 14 quiz

Additional Resources

Spanish Resources ELL
English/Spanish Audiocassettes ELL
Cooperative Learning in the Science Classroom COOP LEARN
Lesson Plans/Block Scheduling

NATIONAL GEOGRAPHIC Teacher's Corner

Products Available From Glencoe
To order the following products, call Glencoe at 1-800-334-7344:
CD-ROM
NGS PictureShow: Age of Dinosaurs
Curriculum Kit
GeoKit: Earth's History

Products Available From National Geographic Society
To order the following products, call National Geographic Society at 1-800-368-2728:
Video
Dinosaurs: Then and Now

GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life
CD-ROM ELL
Video: *Discovering Dinosaurs*
Exploration: *The Record of Life*
Videodisc Program
Discovering Dinosaurs
Plate Tectonics

The Infinite Voyage
The Dawn of Humankind
The Great Dinosaur Hunt

The Secret of Life Series
Diatom
Layers in Time
Plate Tectonics
Archaebacteria
What's in Stetter's Pond: *The Basics of Life*

Getting Started Demo

Visual-Spatial Have students examine the volcano in the photograph. Ask them to compare the events in the existence of a volcano with the events on the time line they made in Getting Started. Point out that events that take either long or short periods of time may be shown on such time lines. L2

Theme Development

In this chapter, the themes of **unity within diversity** and **evolution** are interwoven in a discussion of today's diversity among organisms and how diversity results from the evolution of unicellular organisms that lived billions of years ago.

0:00 Out of Time?

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

Chapter 14 The History of Life

What You'll Learn

- You will examine how rocks and fossils provide evidence of changes in Earth's organisms.
- You will correlate the Geologic Time Scale with biological events.
- You will sequence the steps by which small molecules may have produced living cells.

Why It's Important

Knowing the geological history of Earth and understanding ideas about how life began provide background for an understanding of the theory of evolution.

Getting Started

Making a Record of Life

Make a record of your life. Draw a line to represent a time line. Starting with your birth, record the major events of your life on the time line. *How many major events have you experienced?*

interNET CONNECTION To find out more about fossils and early Earth's history, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science**

Erupting lava fountains such as this one in Hawaii indicate what Earth may have been like soon after it formed. Scientists discover that living things change over time.

Section 14.1 The Record of Life

Section Preview

Objectives

Identify the different types of fossils and how they are formed.

Summarize the major events of the Geologic Time Scale.

Vocabulary

fossil
plate tectonics

You may have seen thrilling movies and read books that described travel in time machines. The characters in such stories speed forward or backward through time, often encountering unusual organisms and strange environments. The differences you saw and read about probably didn't surprise you. After all, everything changes over time. Even Earth has changed considerably during the estimated 4.6 billion years it has existed. It's difficult to imagine what Earth might have been like that long ago.

A model of a velociraptor

Early History of Earth

To learn more about ancient Earth, step into an imaginary time machine and punch a few buttons. Get ready to visit a place to which you might never want to return—primitive Earth.

Early Earth was inhospitable

What was early Earth like? Some scientists suggest that it was probably very hot. The friction of colliding meteorites could have heated its surface, while both the compression of minerals and the decay of radioactive materials heated its interior. Volcanoes might have frequently spewed lava and gases, relieving some of the pressure in Earth's hot interior. These gases helped form Earth's ancient atmosphere, which probably contained little free oxygen, but a lot of water vapor and other gases, such as carbon dioxide, and nitrogen. If ancient Earth's atmosphere was like this, you would not have survived in it.

By about 3.9 billion years ago, Earth might have cooled enough for the water in its atmosphere to condense. This might have led to millions of years of rainstorms with lightning—enough rain to fill Earth's oceans. It is in the oceans, probably between 3.9 and 3.5 billion years ago, some scientists propose, that the first organisms appeared.

Prepare

Key Concepts

Students will explore different types of fossils and their scientific value. They will learn how scientists use the fossil record to reconstruct the history of life on Earth.

Planning

- Gather meter sticks and rolls of adding machine tape for MiniLab 14-2.
- Gather shoe boxes, pennies, and graph paper for the BioLab.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 35** on the overhead projector and have students answer the accompanying questions. L1 ELL


Transparency 35 Inferring from Fossils

Section Focus
Use with Chapter 14, Section 14.1

1. The diagram shows a set of fossilized footprints. What observations can you make about the footprints?
2. What can you infer from the observations?

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BIOLOGY: The Dynamics of Life — SECTION FOCUS TRANSPARENCIES

Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

Kinesthetic Meeting Individual Needs, p. 380; Project, p. 381; Quick Demo, p. 389

Visual-Spatial Getting Started Demo, p. 376; Biology Journal, pp. 383, 392; Meeting Individual Needs, pp. 386, 389; Tech Prep, p. 390

Interpersonal Check for Understanding, p. 386; Project, p. 386

Intrapersonal Extension, pp. 387, 393; Going Further, p. 395

Linguistic Biology Journal, pp. 384, 396; Portfolio, p. 389; Meeting Individual Needs, p. 396

Logical-Mathematical Quick Demo, p. 381; Portfolio, p. 382

Naturalist Display, p. 378; Tech Prep, p. 378

Assessment Planner

Portfolio Assessment
BioLab, TWE, p. 395

Performance Assessment
MiniLabs, TWE, p. 379, 384
MiniLabs, SE, pp. 379, 384
Performance Assessment, TWE, p. 387
Alternative Lab, TWE, p. 390-391
BioLab, SE, pp. 394-395

Knowledge Assessment
Section Assessments, SE, pp. 387, 393
Knowledge Assessments, TWE, p. 390, 393
Alternative Lab, TWE, p. 390-391
Problem-Solving Lab 14-2, TWE, p. 392
Chapter Assessment, SE, pp. 397-399

Skill Assessment
Problem-Solving Lab 14-1, TWE, p. 380
Skill Assessment, TWE, p. 385

Resource Manager

Section Focus Transparency 35 and Master L1 ELL

2 Teach

Brainstorming

Ask students to brainstorm a list of questions they must answer in order to gain a more accurate picture of ancient life.

Visual Learning

Figure 14.1 Ask students to list the information scientists can obtain about each type of fossil. Responses may include how the fossil compares with a modern-day organism.

Display

Naturalist Obtain samples of the types of fossils in Figure 14.1. Have students try to identify the fossils on display and explain how each may have formed. L2 ELL

TECHPREP

Comparing Fossils

Naturalist Have students prepare a chart that compares fossils. The chart should have at least three column heads: Type of Fossil; Production of Fossil; and Example. L3

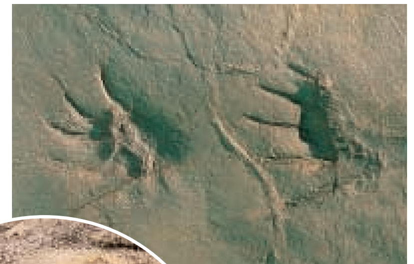
GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Video: *Discovering Dinosaurs*
Disc 2

History in Rocks

Can scientists be sure the Earth formed in this way? No, they cannot. There is no direct evidence of the earliest years of Earth's history. The physical processes of Earth constantly destroy and reform rock. The oldest rocks that have been found on Earth formed only about 3.9 billion years ago. Although rocks cannot provide information about Earth's infancy, they are an important source of information about the diversity of life that has existed on the planet.

Figure 14.1
There are many types of fossils that provide clues about ancient organisms.



A Trace fossils A trace fossil is the marking left by an animal and may include a footprint, a trail, and a burrow.

B Casts When minerals in rocks fill a space left by a decayed organism, they make a replica, or cast, of the organism.

C Petrified fossils Minerals sometimes penetrate and replace the hard parts of an organism, producing copies of them.

F Molds A mold forms when an organism is buried in sediment and then decays, leaving an empty space.

D Imprints A thin object, such as a leaf, that falls into sediment can leave an imprint when the sediment hardens into rock.

E Amber-preserved and frozen fossils At times, an entire organism was quickly trapped in ice or tree sap that hardened into amber.

Fossils—Clues to the past

If you've ever visited a zoo or botanical garden, you've seen evidence of the diversity of life. But the millions of species living today are probably only a small fraction of all the species that ever existed. About 99 percent of species are extinct—they no longer live on Earth. Among other techniques, scientists study fossils to learn about the ancient species. A **fossil** is evidence of an organism that lived long ago.

Because fossils can form in many different ways, there are many types of fossils, as you can see in ***Figure 14.1.*** Use the *MiniLab* on the next page to observe some marine fossils under your microscope.

Paleontologists—Detectives to the past

The study of fossils is a lot like solving a mystery. Paleontologists (pay lee ahn TAHL uh justs), scientists who study ancient life, are like detectives who use fossils to understand events that happened long ago. They use fossils to determine the kinds of organisms that lived in the past and sometimes to learn about their behavior. For example, fossil bones and teeth can indicate the size of animals, how they moved, and what they ate.

Paleontologists also study fossils to gain knowledge about ancient climate and geography. For example, when scientists find a fossil like the one in ***Figure 14.2,*** which resembles a present-day plant that lives in a mild climate, they may reason that the ancient environment was also mild.

By studying the condition, position, and location of rocks and fossils, geologists and paleontologists can make deductions about the geography of past environments. For example, if only the heaviest bones of an animal's skeleton are found in an area, it might mean that a river once ran through the area and carried

MiniLab 14-1 Observing and Inferring

Marine Fossils Certain sedimentary rocks are formed totally from the fossils of once-living ocean organisms called diatoms. The diatom fossils are often 1000 meters thick. These sedimentary rocks were at one time in the past under ocean water and were then lifted above sea level during periods of geological change.

Present-day diatoms

Procedure

1. Prepare a wet mount of a small amount of diatomaceous earth. **CAUTION:** ***Use care in handling microscope slides and coverslips.***
2. Examine the material under low-power magnification.
3. Draw several of the different shapes you see.
4. Compare the shapes of the fossils you observe to present-day diatoms shown in the photograph. Remember, however, that the fossils you observe are probably only pieces of the whole organism.

Analysis

1. Describe the appearance of fossil diatoms.
2. How are fossil diatoms similar to and different from the diatoms in the photo? Can you use these similarities and differences to predict how diatoms have changed over time? Explain your answer.
3. What part of the original diatom did you observe under the microscope? How did this part survive millions of years? Why were the fossils you observed in pieces?

Figure 14.2
These fossil leaves are from rocks about 200 million years old. They are remarkably similar to the leaves of *Ginkgo biloba,* trees that are planted as ornamentals throughout the United States.

MiniLab 14-1

Purpose
Students will observe fossil diatoms and compare them with modern species of diatoms.

Process Skills
observe and infer, compare and contrast, apply concepts

Teaching Strategies

- Remind students to handle glass microscope slides carefully and place broken slides in the container for broken glass.
- Remind students that they are looking at fragments of the silica-containing cell walls of diatoms.
- Have students use a very small amount of the diatomaceous earth for better viewing.

Expected Results
Students should see broken cell walls of many different shapes.

Analysis

1. Answers will vary—rod-shaped, glasslike, circular, boatlike, needle-shaped, ridged or scored surface
2. Although broken, the fossil diatoms look similar and therefore have probably changed little over time.
3. The cell walls were visible because they did not decompose. The weight of water and sediments crushed them.

Assessment

Performance Have students determine the shapes and sizes of the diatoms in the sample they observed. Use the Performance Task Assessment List for Making Observations and Inferences in **PASC**, p. 17. L1 ELL

Cultural Diversity

Motonori Matuyama and Paleomagnetism

For unexplained reasons, Earth's polarity has reversed at times so that the magnetic north pole became the south pole and vice versa. Scientists assess volcanic rocks to study polarity changes and use the data they gather to date rocks. The Japanese geologist, Motonori Matuyama (1884-1956) discovered the magnetic reversals. Discuss some examples of how paleomagnetic studies have been important in understanding the evolution of some organisms.

Internet Address Book

interNET CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Diatom

Resource Manager

BioLab and MiniLab Worksheets, p. 67 L2

Problem-Solving Lab 14-1

Purpose
Students will analyze a situation and evaluate its explanations.

Process Skills
analyze information, draw a conclusion, judge, think critically

Teaching Strategies
■ Review the appearance of Gondwanaland.

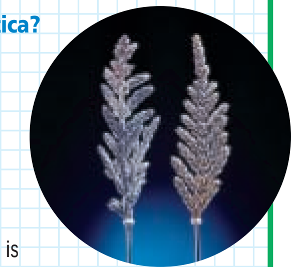
Thinking Critically
1. It's unlikely that ferns could grow in cold temperatures.
2. Not reasonable; it's unlikely that mutations could result in ferns adapted to extreme cold.
3. Reasonable; areas near the poles would have been warmer.

Assessment
Skill Ask students to suggest other reasons why fern fossils are in Antarctica. Use the Performance Task Assessment List for Design-ing an Experiment in **PASC**, p. 33. L2

Resource Manager
Critical Thinking/Problem Solving, p. 14 L3
Laboratory Manual, pp. 99-100 L2

Problem-Solving Lab 14-1 — Thinking Critically

Could ferns have lived in Antarctica?
Scientists have discovered fossil remains of ferns in the rocks of Antarctica. These fern fossils are related to ferns that grow in temperate climates on Earth today.


Fern Fossil from Antarctica

Analysis
Read each statement below and judge whether or not the statement is reasonable. Explain the reason for each of your judgments.

Thinking Critically
1. Fern fossils in Antarctica are of plants that could withstand freezing temperatures.
2. The ferns in Antarctica may have been mutated forms of ferns that grew in warm climates.
3. The temperature of Earth may have been much warmer millions of years ago than it is today.

away the lighter bones. You can use the *Problem-Solving Lab* on this page to try to solve a fossil mystery.

Fossils occur in sedimentary rocks

For fossils to form, organisms usually have to be buried in small particles of mud, sand, or clay soon after they die. These particles are compressed over time and harden into a type of rock called sedimentary rock. Today, fossils still form at the bottoms of lakes, streams, and oceans.

Most fossils are found in sedimentary rocks. Layers of these rocks form by processes that prevent damage to the organism. How do these fossils become visible millions of years later? To answer the question, look at the *Inside Story*. Fossils are not usually found in other types of rock because of the ways those rocks form. For example, metamorphic rocks form when heat, pressure, and chemical reactions change other rocks. The conditions under which metamorphic rocks form would destroy any fossils that were in the sedimentary rock.

Figure 14.3
Most sedimentary rocks form in horizontal layers with the younger layers closer to the surface.

The Age of a Fossil

The fossils in different layers of sedimentary rock vary in age. Scientists use a variety of methods to determine the age of fossils.

Relative dating

One method is a technique called relative dating. To understand relative dating, imagine yourself stacking newspapers at home. As each day's newspaper is added to the stack, the stack becomes taller. If the stack is left undisturbed, the newspapers at the bottom are older than ones at the top.

The relative dating of rock layers uses the same principle. In *Figure 14.3*, you see fossils in different layers of rock. If the rock layers have not been disturbed, the layers at the surface must be younger than the deeper layers. The fossils in the top layer must also be younger than those in deeper layers. This principle is a geological law. Using this law, scientists can determine the order of appearance and extinction of the species that formed fossils in the layers.

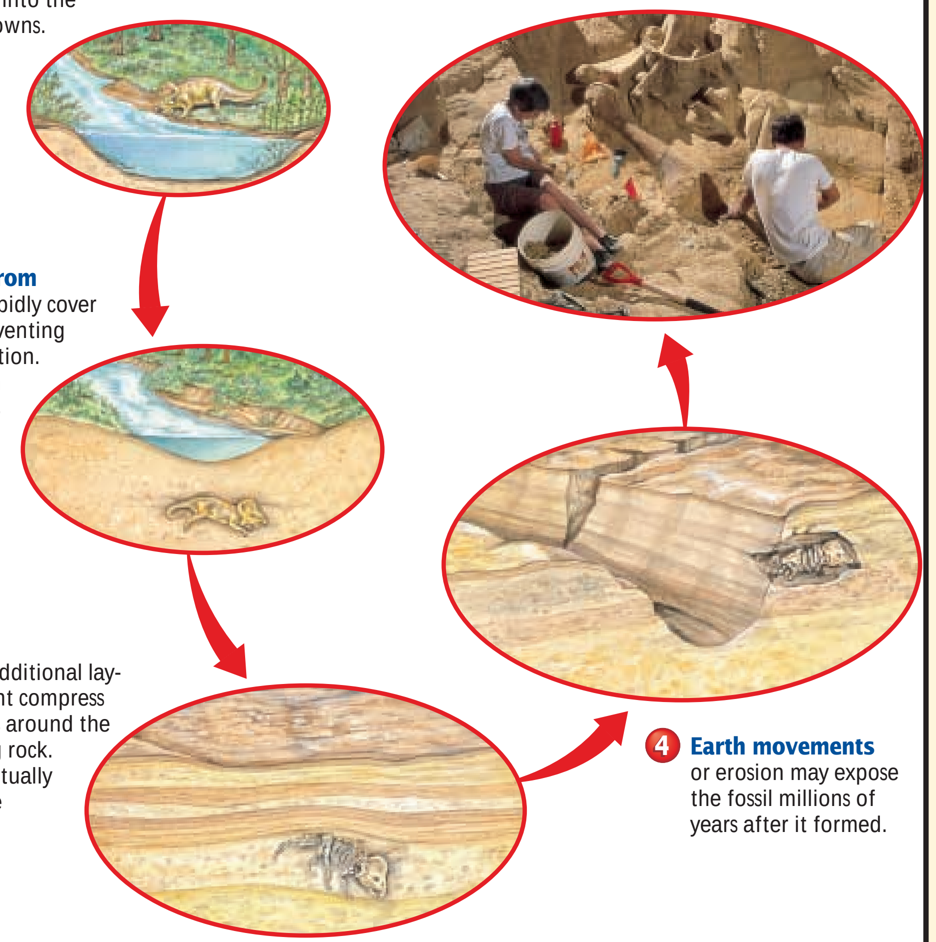
INSIDE STORY

The Fossilization Process

Few organisms become fossilized because, without burial, bacteria and fungi immediately decompose their dead bodies. Occasionally, however, organisms do become fossils in a process that usually takes many years. Most fossils are found in sedimentary rocks.

Critical Thinking *Describe how the movements of Earth might expose a fossil.*


A Protoceratops



INSIDE STORY

Purpose
Students will understand the geological and biological processes involved in how fossils form.

Teaching Strategies
■ Point out that an organism's remains are subjected to destructive environmental factors, such as heat, cold, and pressure. Therefore, the number and quality of fossils is limited.
■ Have students make a flowchart of the events that lead to the formation of fossils. L2

Visual Learning
Visual-Spatial Sedimentation allows fossils to form. Model the process using objects and sediments of various sizes and weights placed in a 2L plastic container three-quarters full of water. Shake the container. Have students observe what occurs. Explain that under pressure the objects may be fossilized. L2 ELL

Critical Thinking
The Earth's surface can rupture during earthquakes and some rock layers can fold over others. The slow erosion of rock may uncover fossils.

Quick Demo
Logical-Mathematical Show students pieces of igneous, metamorphic, and sedimentary rocks. Explain how each is formed. Ask students to explain why fossils in metamorphic rocks are rare.
L2 ELL

Meeting Individual Needs

Learning Disabled
Kinesthetic Have students obtain a small leaf and a dead insect. Place each into its own small plastic container that is half-filled with water. Place the containers in a freezer. After 24 hours, remove them. Describe how the leaf and the insect look. Compare frozen fossils to molds or casts.
L1 ELL

Glencoe Technology

VIDEODISC
The Secret of Life
Layers in Time

PROJECT

Fossil Preservation
Kinesthetic Student groups can carry out the following activity to learn more about the preservation of fossils.
1. Place fresh fruit, such as strawberries or orange slices, in an open plastic container. Cover the fruit with water and place the container in a freezer.
2. Put the same amount and types of fruit in a similar container. Leave the container undisturbed at room temperature.
3. After three days, observe all the fruit. Summarize your observations and draw a conclusion about any differences you observe between the containers. L1
ELL COOP LEARN

Concept Development

Explain to students that radioactive dating is an accurate technique for geological timekeeping because the decay rate of a radioactive element is constant.

Enrichment

Visual-Spatial If possible, schedule a visit to a local museum of natural history. Most have displays of the Geological Time Scale. L2 ELL

GLENCOE TECHNOLOGY

VIDEODISC

The Infinite Voyage

The Dawn of Humankind, Dating Fossils: Effects of Dating Methods and Interbreeding (Ch. 5)
4 min.

CAREERS IN BIOLOGY

Career Path

Courses in high school: biology, mathematics, and English
College: degree in biology or zoology for zoo/aquarium work
Other educational sources: on-the-job-training; two-year program in animal health

Career Issue

Ask students whether they think a person can love animals so much that he or she is unable to care for them effectively. Have them explain their answers.

For More Information

For more information, write to:

American Association of Zoo Keepers
635 Gage Boulevard
Topeka, Kansas 66606-2066

or

Animal Caretakers Information
Humane Society of the United States
Companion Animals Division
2100 L Street NW
Washington, DC 20037

CAREERS IN BIOLOGY

Animal Keeper

Would you like to make a career out of caring for animals? There are many opportunities if you love animals.

Skills for the Job

Animal keepers or caretakers give animals food and water, exercise them, clean their cages, groom them, monitor their health, and sometimes administer medicines. Keepers must finish high school. Many pet shops, kennels, shelters, and stables provide on-the-job training. Humane societies, veterinarians, and research laboratories hire graduates of two-year programs in animal health. Most zoos and aquariums employ keepers with four-year degrees in zoology or biology. Taking care of animals often means working weekends and holidays, so keepers must care about their work.

interNET CONNECTION For more careers in related fields, be sure to check the Glencoe Science Web Site.
www.glencoe.com/sec/science

Radiometric dating

Just as you cannot tell the actual age of a specific newspaper in the stack by just glancing at the stack, you cannot determine the actual age of a fossil by using relative dating techniques. To find the specific ages of fossils, scientists use radiometric dating techniques utilizing the radioactive isotopes in rocks or fossils. Recall that radioactive isotopes are atoms with unstable nuclei that break down, or decay, over time, giving off radiation. A radioactive isotope forms a new element after it decays. Because every radioactive isotope has a characteristic decay rate, scientists use the rate of decay as a type of clock. The decay rate of a radioactive isotope is called its half-life.

Just as you can judge how long ago an hourglass was turned by comparing the amounts of sand in the top and bottom containers, scientists try to determine the approximate ages of rocks by comparing the amount of a radioactive isotope and the new element into which it decays. For example, suppose that when a rock forms it contains a radioactive isotope that decays to half its original amount in one million years. Today, if the rock contains equal amounts of the radioactive isotope and the element into which it decays, then the rock must be about 1 million years old.

Scientists use potassium-40, a radioactive isotope that decays to argon-40, to date rocks containing very old fossils. Based on chemical analysis, chemists have determined that potassium-40 decays to half its original amount in 1.3 billion years. Scientists use carbon-14 to date fossils less than 50 000 years old. Again, based on chemical analysis, they know that carbon-14 decays to half its original amount in 5730 years.

In the *BioLab* at the end of this chapter, you can simulate this dating technique. Keep in mind, however, that this dating technique frequently produces inconsistent dates because the initial amount of radioisotope in the rock can never be known with certainty. For this reason, scientists always analyze many samples of a rock using as many methods as possible to obtain reasonably consistent results about the rock's age.

A Trip Through Geologic Time

By examining layers of sedimentary rock and dating the fossils that are found in the layers, scientists have been able to put together a chronology, or calendar, of Earth's history. This chronology, called the Geologic Time Scale, is based on evidence from Earth's rocks.

The Geologic Time Scale

Rather than being based on months or even years, the Geologic Time Scale is divided into the four eras that you see in ***Figure 14.4:*** the Precambrian (pree KAM bree un) era, the Paleozoic (pay lee uh ZOH ihk) era, the Mesozoic (mez uh ZOH ihk) era, and the Cenozoic (sen uh ZOH ihk) era. An era is the largest division in the scale, and each represents a very long period of time. Each era is subdivided into periods.

The divisions in the Geologic Time Scale are distinguished by the organisms that lived during the time period. The fossil record indicates that there were several occurrences of mass extinction that fall between time divisions. A mass extinction is an event that occurs when entire groups of organisms disappear from the fossil record almost at once.

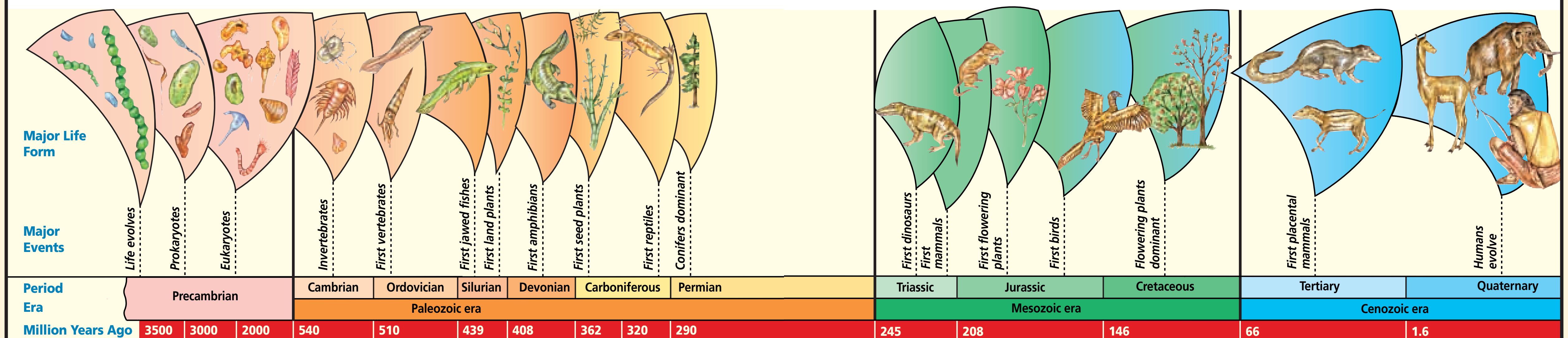


Figure 14.4
The Geologic Time Scale is a calendar of Earth's history based on evidence found in rocks. Life probably first appeared on Earth between 3.9 and 3.5 billion years ago.

The BioLab at the end of the chapter can be used at this point in the lesson. INVESTIGATE BioLab

Chalkboard Example

To illustrate the concept of geological time, reproduce on the chalkboard or an overhead transparency a page from a monthly calendar. Remind students that the total area of the page represents a unit of time equal to one month. Divide the calendar into four (or five) horizontal strips. Ask students what amount of time each strip represents. *one week* Cut one of the strips into seven pieces and ask students what each square represents. *one day* Then, ask students how minutes and seconds could be shown. Elicit from students how geologic time, like calendars, is also divided into units.

GLENCOE TECHNOLOGY

CD-ROM

Biology: The Dynamics of Life

Exploration: *The Record of Life*
Disc 2

Resource Manager

Concept Mapping, p. 14 L3 ELL
Laboratory Manual, pp. 101-102 L2

Portfolio

Calculating Age Using Half-Lives

Logical-Mathematical Have students solve the following problems by drawing a bar graph. Have them place their graphs in their portfolios.

- A radioactive element has a known half-life of 20 days. How much of a 16-g sample of the radioactive element will remain unchanged after 80 days? *1 g*
- A fossil contains a radioactive element with a half-life of 10 000 years. If the ratio of radioactive element to decay element is 1:3, how old is the fossil? *20 000 years or two half-lives* L3 P

BIOLOGY JOURNAL

Summarizing Geologic Time

Visual-Spatial Have students draw a large box on a sheet of paper in their journals. Then, have them divide the box into four smaller boxes with the first box occupying about one-third of the total area and the last box occupying about one-eighth of the total. Have students label each box with the name of one of the eras of geologic time, placing the Precambrian in the largest box and the Cenozoic in the smallest. As students read about these eras, have them write terms or phrases inside the box that describe that era. Students can use their sheets as study tools. L1 ELL

MiniLab 14-2

Purpose
Students will model the Geologic Time Scale.

Process Skills
use a table, sequence, measure in SI

Teaching Strategies
- Review how to relate distance to a time scale.
- Review the Geologic Time Scale's two major divisions.

Expected Results
Students perform the calculations that establish their scales. They plot major events on the scale.

Analysis
1. the longest era—Paleozoic the shortest era—Cenozoic
2. Mesozoic era
3. primates

Assessment
Performance Have student groups collect pictures of 15-20 organisms. Ask them to illustrate the Geologic Time Scale on poster board, and glue each picture where the organism first appeared in the fossil record. Use the Performance Task Assessment List for Poster in **PASC**, p. 73. L1 ELL COOP LEARN

Resource Manager
BioLab and MiniLab Worksheets, p. 68 L2

MiniLab 14-2 Organizing Data

A Time Line In this activity, you will construct a time line that is a scale model of the Geologic Time Scale. Use a scale in which 1 meter equals 1 billion years. Each millimeter then represents 1 million years.

Procedure
1. Use a meterstick to draw a continuous line down the middle of a 5 m strip of adding-machine tape.
2. At one end of the tape, draw a vertical line and label it "The Present."
3. Measure off the distance that represents 4.6 billion years ago. Draw a vertical line at that point and label it "Earth's Beginning."
4. Using the table at right, plot the location of each event on your time line. Label the event and the number of years ago it occurred.

Geologic Time Scale

Event	Estimated years ago
Earliest evidence of life	3.5 billion
Paleozoic era begins	540 million
First land plants	430 million
Mesozoic era begins	245 million
Triassic period begins	245 million
Jurassic period begins	208 million
First dinosaurs	225 million
First birds	150 million
Cretaceous period begins	146 million
Dinosaurs become extinct	66 million
Cenozoic era begins	66 million
Primates appear	60 million
Humans appear	200 000

Analysis
1. Which era is the longest? The shortest?
2. In which eras did dinosaurs and birds appear on Earth?
3. What major group first appeared after dinosaurs became extinct?

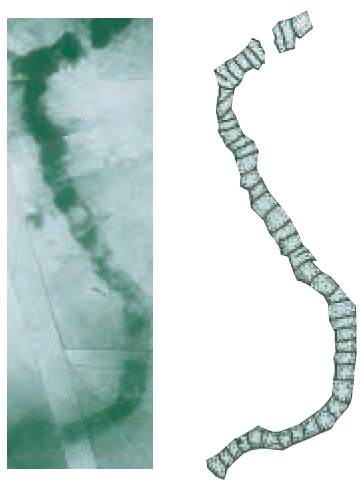


Figure 14.5
The filamentous fossils of these ancient organisms resemble some modern organisms.

The Geologic Time Scale begins with the formation of Earth about 4.6 billion years ago. To understand the large size of this number, try the *MiniLab* and also try scaling down the history of Earth into a familiar, but hypothetical, calendar year.

Life in the Precambrian

In your hypothetical calendar year, the first day of January becomes the date on which Earth formed. The oldest fossils are found in Precambrian rocks that are about 3.5 billion years old—near the end of March on the hypothetical calendar. Scientists found these fossils, which are shown in ***Figure 14.5***, in rocks found in the deserts of western Australia. They have found more examples of similar types of fossils on other continents. The fossils resemble the forms of modern species of photosynthetic bacteria called cyanobacteria (si a noh bak TIHR ee uh). You will read more about cyanobacteria in a later chapter.

Scientists have also found fossils of dome-shaped structures called stromatolites (stroh MAT ul ites) in Australia and on other continents. Stromatolites still form today in Australia from mats of cyanobacteria, ***Figure 14.6***. Thus, the stromatolite fossils are evidence of the existence of photosynthetic bacteria on Earth about 3.5 billion years ago.

The Precambrian era accounts for about 87 percent of Earth's history—until about the middle of October in the hypothetical calendar year. At the beginning of the Precambrian era, unicellular prokaryotes—cells that do not have a membrane-bound nucleus—appear to have been the only life forms on Earth. Then, about 1.8 billion years ago, the fossil record shows that more complex eukaryotic organisms, living things with membrane-bound nuclei in their cells, appeared. The eukaryotes flourished. By the end of the Precambrian, about 544 million years ago, multicellular eukaryotes, such as sponges and jellyfishes, filled the oceans.

Diversity in the Paleozoic

In the Paleozoic era, which lasted until 245 million years ago, many more types of animals and plants appeared on Earth, and some were embedded in the fossil record. The earliest part of the Paleozoic era is called the Cambrian period. Paleontologists often refer to a Cambrian explosion of life because the fossil record shows an enormous increase in the diversity of life forms at this time. During the Cambrian period, the oceans teemed with many types of animals, including worms, sea stars, and unusual arthropods, such as the one shown in ***Figure 14.7***.

During the first half of the Paleozoic, fishes, the oldest animals with backbones, appeared in Earth's waters. There is also fossil evidence of ferns and early seed plants existing on land about 400 million years ago. Around the middle of the Paleozoic, four-legged animals such as amphibians appeared on Earth. During the last half of the era, the fossil record shows that reptiles appeared and began to flourish on land.

The largest mass extinction recorded by the fossil record marked the end of the Paleozoic. About 90 percent of Earth's marine species and 70 percent of the land species disappeared at this time.

Life in the Mesozoic

The Mesozoic era began about 245 million years ago, which would be about December 10 on the hypothetical one-year calendar. Many changes, in both Earth's organisms and its geology, occurred over the span of this era.

The Mesozoic era is divided into three periods. Fossils from the Triassic period, the oldest period, show that mammals appeared on Earth at this time. These fossils of mammals indicate that early mammals were small and mouselike. They probably scurried around in the shadows of huge fern forests, trying to avoid dinosaurs, reptiles that also appeared during this time.

Figure 14.6
Fossils of stromatolites, like the modern Australian specimens shown here, provide evidence that photosynthetic bacteria lived on Earth 3.5 billion years ago.

Figure 14.7
Arthropods, such as this trilobite, were among the many groups of animals that appeared during the Cambrian explosion.

Quick Demo

Set up a microscope with a living culture or prepared slide of *Oscillatoria.* Point out that early cyanobacteria are hypothesized to have produced much of the oxygen that changed the initial composition of Earth's atmosphere.

Enrichment
Some students may comment on the smooth gliding movement of *Oscillatoria.* Explain that these organisms expel jets of slime through holes in their cell walls. This pushes the cells through their environment.

Visual Learning
Ask students what living group of animals the trilobite in Figure 14.7 most resembles. *arthropods or insects*

Assessment
Skill Assess the students' understanding of geologic time by having them sequence some of the major events of the Geologic Time Scale with the era in which they occurred. L2

GLENCOE TECHNOLOGY

VIDEOTAPE
The Secret of Life
Gone Before You Know It: The Biodiversity Crisis

VIDEODISC
The Infinite Voyage
The Great Dinosaur Hunt, The Evolution of Extinction (Ch. 2) 3 min.

The Great American Bone Rush (Ch. 3) 2 min.

Biology Journal

Extinct Animals
Linguistic Ask students to research an extinct animal, such as a woolly mammoth, brachiosaur, pterodactyl, or saber-toothed cat. Have them describe in their journals what foods, environments, enclosures, or other factors might be required to keep the animal alive in a zoo. L2

Internet Address Book

interNET CONNECTION
Note Internet addresses that you find useful in the space below for quick reference.

Visual Learning

Figure 14.8 Have students compare the Archaeopteryx and Hoatzin. Discuss the characteristics that the animals share and do not share. L2

3 Assess

Check for Understanding

Interpersonal Prepare an in-class "game show" to check student understanding of the topics in this section. Prepare questions on index cards in a variety of categories, such as types of fossils, fossil formation, dating techniques, and the Geologic Time Scale. Have students work in teams to answer the questions. L2 ELL COOP LEARN

Reteach

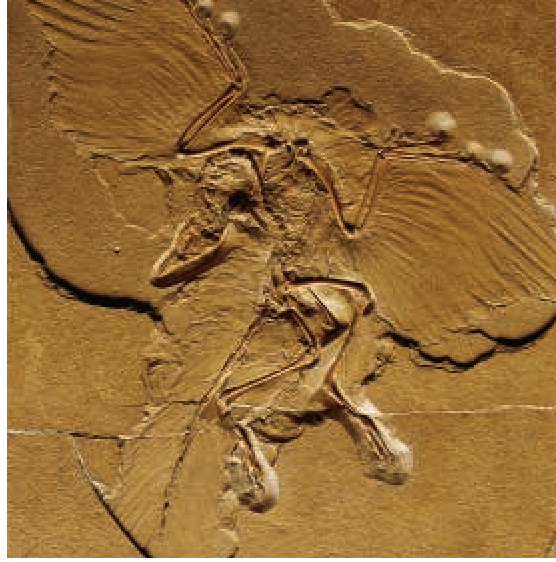
Visual-Spatial Have students demonstrate the concept of radiometric dating using balls of clay or other materials to represent radioactive materials. L1

GLENCOE TECHNOLOGY

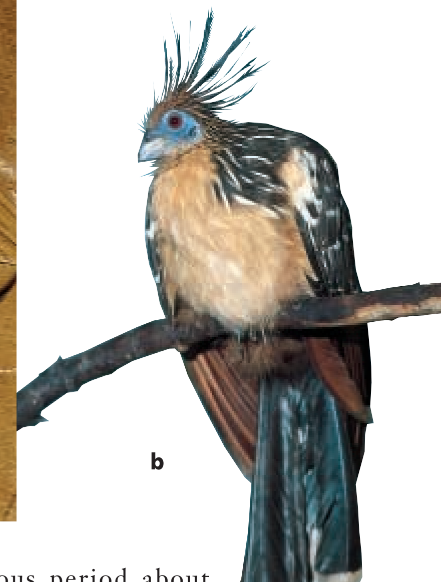
VIDEODISC
Biology: The Dynamics of Life, *Discovering Dinosaurs* (Ch. 2)
Disc 1, Side 2, 40 sec.

The Infinite Voyage: *The Great Dinosaur Hunt, New Dinosaur Discoveries and Their Link With Today* (Ch. 10) 8 min.

Theories of Extinction (Ch. 11) 3 min. 30 sec.



a



b

Figure 14.8
Both fossil evidence like this *Archaeopteryx* **(a)** and some characteristics of present-day birds like this hoatzin **(b)** suggest that dinosaurs might have been the ancestors of today's birds.

WORD *Origin*
tectonics
From the Greek word *tecton,* meaning "builder." Plate tectonics can build mountains.

The middle of the Mesozoic is called the Jurassic period, which began about 208 million years ago, or mid-December on the hypothetical calendar. The Jurassic period is often referred to as the Age of the Dinosaurs.

Recent fossil discoveries support the idea that modern birds evolved from some of these dinosaurs toward the end of this period. For example in ***Figure 14.8,*** you see the fossil of *Archaeopteryx,* a small dinosaur discovered in Germany. The fossil reveals that *Archaeopteryx* had feathers, a birdlike feature. You also see a present-day bird, the hoatzin, in ***Figure 14.8.*** This bird has a reptilian feature, claws on its wings, for its first few weeks of life. It also flies poorly, as the earliest birds probably did. Paleontologists suggest that such evidence supports the idea that modern birds evolved from dinosaurs.

A mass extinction

The last period in the Mesozoic, the Cretaceous, began about 144 million years ago. During this period, many new types of mammals and the first flowering plants appeared on Earth. The mass extinction of the dinosaurs marked the end of the Cretaceous period about 66 million years ago. Scientists estimate that not only dinosaurs but almost two-thirds of all living species at the time became extinct. Based on geological evidence of a large crater in the waters off eastern Mexico, some scientists propose that a large meteorite collision caused this mass extinction. Such a collision could have filled the atmosphere with thick, toxic dust that, in turn, changed the climate to one in which many species could no longer survive.

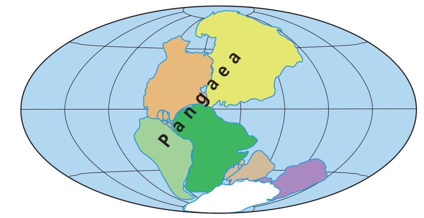
Changes during the Mesozoic

Geological events during the Mesozoic changed the places in which species lived and affected their distribution on Earth. The theory of continental drift, which is illustrated in ***Figure 14.9,*** suggests that Earth's continents have moved during Earth's history and are still moving today at a rate of about six centimeters per year. This is about the same rate at which your hair grows. Early in the Mesozoic, the continents were merged into one large land mass. During the era the continent broke up and the pieces drifted.

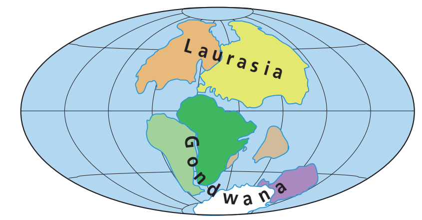
The geological explanation for how the continents move is called **plate tectonics** (tek TAHN ihks). According to this idea, Earth's crust consists of several rigid plates that drift on top of molten rock. These plates are continually moving—spreading apart, sliding by, or pushing against each other. The movements affect organisms. For example, after a long time, the descendants of organisms living on plates that are moving apart may be living in areas with very different climates.

The Cenozoic era

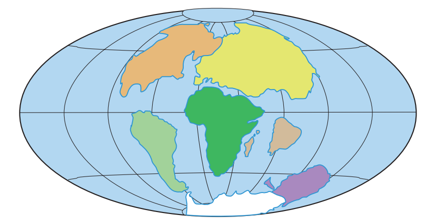
The Cenozoic began about 66 million years ago—around December 26 on the hypothetical calendar of Earth's history. It is the era in which you now live. Mammals began to flourish during the early part of this era. Among the mammals that appeared was a group of animals to which you belong, the primates. Primates first appeared approximately 30 million years ago and have diversified greatly. The modern human species appeared perhaps as recently as 200 000 years ago. On the hypothetical calendar of Earth's history, 200 000 years ago is late in the evening of December 31.



A About 245 million years ago, the continents were joined in a landmass known as Pangaea.



B By 135 million years ago, Pangaea broke apart resulting in two large landmasses.



C By 66 million years ago, the end of the Mesozoic, most of the continents had taken on their modern shapes.

Figure 14.9
The theory of continental drift describes the movement of the land masses over geological time. The modern continents are shown in different colors.

CD-ROM
View an animation of Plate Tectonics located in the Presentation Builder of the Interactive CD-ROM.

Section Assessment

Understanding Main Ideas

1. Describe what some scientists propose Earth was like before life arose.
2. Why are most fossils found in sedimentary rocks?
3. What do paleontologists learn from fossils?
4. Explain the difference between relative dating and radiometric dating.

Thinking Critically

5. Suppose you are examining layers of sedimentary rock. In one layer, you discover the remains of an extinct relative of the polar bear. In a deeper layer, you discover the fossil of an extinct alligator. What can you hypothesize about changes over time in this area's environment?

SKILL REVIEW

6. **Making and Using Tables** Construct a table listing the four geologic eras, their time spans, and the major forms of life that appeared during each era. Use the information in the table to construct a time line based on the face of a clock. For more help, refer to *Organizing Information* in the **Skill Handbook.**

Extension

Intrapersonal Students can research local geological history to determine what organisms previously might have lived there. If available, exhibit some local fossils. L2

Assessment

Performance Ask groups of students to pick one era of the Geologic Time Scale and show on a bulletin board all the kinds of life that existed then. L1 ELL COOP LEARN

4 Close

Discussion

Ask students to summarize the trend of how organisms developed during Earth's history. Discuss each response. *Organisms became more complex, larger, and more diverse.* L2

GLENCOE TECHNOLOGY

VIDEODISC
Biology: The Dynamics of Life Disc 1, Side 2, 45 sec. *Plate Tectonics* (Ch. 3)

The Secret of Life: *Plate Tectonics*

MEETING INDIVIDUAL NEEDS

Learning Disabled

Visual-Spatial Have students compare illustrations or models of bird and dinosaur skeletons. Have them record their observations of similar bones in a data table with the two headings, Bird and Dinosaur. Structure the process by having students look at the skeletal parts one-by-one. L1 ELL

PROJECT

Evidence of Pangaea

Interpersonal Have student groups report about a type of fossil animal that has modern descendants distributed in a way that supports the existence of Pangaea. Ask students to use maps and drawings to show how plate tectonics affected the animal. L3 ELL P COOP LEARN

Section Assessment

1. Earth was hot; meteors bombarded its surface, and volcanoes erupted. As Earth cooled, it rained constantly.
2. Sedimentary rocks form slowly, preventing damage to a fossilizing organism.
3. Paleontologists can infer diet, size, habitat, and other information from fossils.
4. Relative dating relies on the position of rock layers and results in relative date. Radiometric dating relies on half-lives of radioactive elements.
5. The region may have changed from a warm to a cold climate.
6. Student tables should be constructed from the information in Figure 14.4 and under the heading A Trip Through Geologic Time in the text. Check tables and student time lines for accuracy.

Resource Manager

Reteaching Skills Transparency 23 and Master L1 ELL
Reinforcement and Study Guide, pp. 61-62 L2
Content Mastery, p. 70 L1

Prepare

Key Concepts

Students will learn about scientific hypotheses of the origin of life. They will read about some classic experiments designed to prove biogenesis. Then, they will study modern hypotheses about the origin of cells.

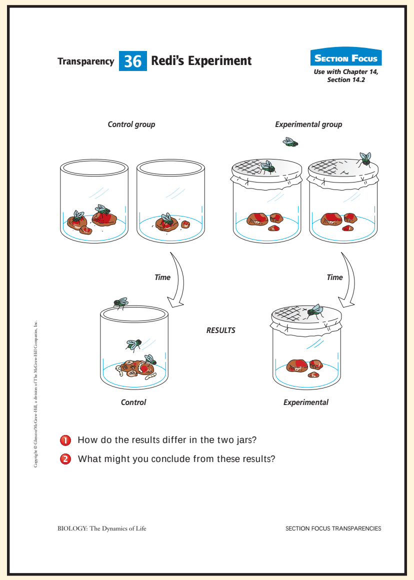
Planning

- Obtain beef bouillon cubes for the Quick Demo.
- Collect the materials needed for the Alternative Lab.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 36** on the overhead projector and have students answer the accompanying questions. L1 ELL



SECTION PREVIEW

Objectives

Analyze early experiments that support the concept of biogenesis.

Compare and contrast modern theories of the origin of life.

Relate hypotheses about the origin of cells to the environmental conditions of early Earth.

Vocabulary

spontaneous generation
biogenesis
protocell
archaebacteria

Section

14.2 The Origin of Life

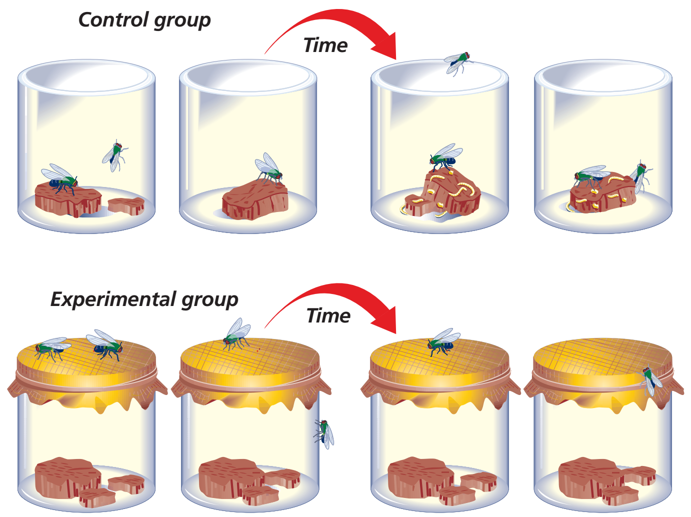
Will rotting meat give rise to maggots? Can mud produce live fish like the ones shown here? Will a bag of wheat give birth to mice? You'd probably answer all these questions with a no. But not too long ago, people did not know how life begins. However, evidence provided by scientists such as Louis Pasteur finally solved the mystery. To obtain the evidence, scientists relied on the scientific methods of observation, hypothesis, and controlled experimentation.

Mudskippers

Origins: The Early Ideas

In the past, the ideas that decaying meat produced maggots, mud produced fish, and grain produced mice were reasonable explanations for what people observed occuring in their environment. After all, they saw maggots appear on meat and young mice just appear in sacks of grain. Such observations led people to believe in **spontaneous generation**—the idea that nonliving material can produce life.

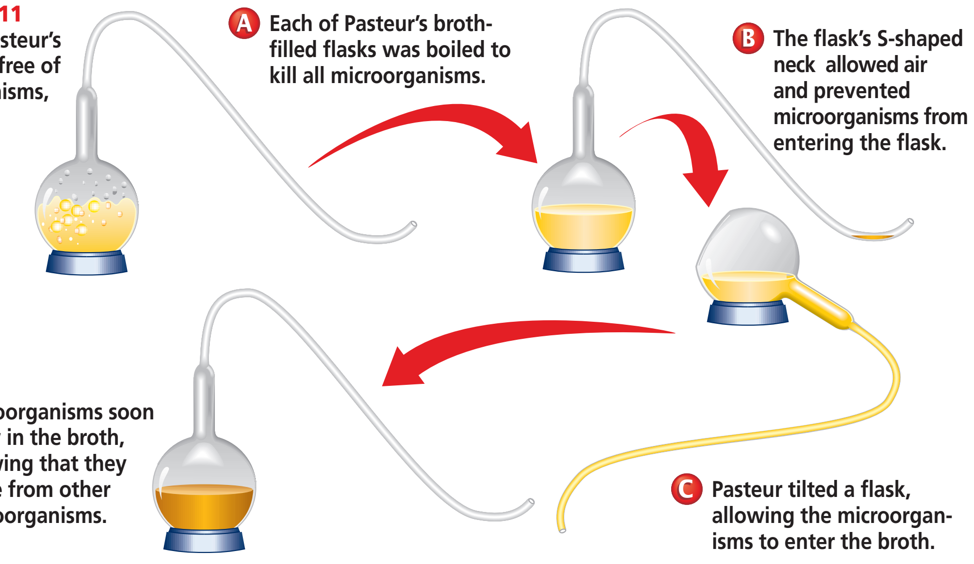
Figure 14.10 Francesco Redi's controlled experiment tested the spontaneous generation of maggots from decaying meat.



A Redi placed decaying meat in several uncovered control jars and in covered experimental jars. The covers prevented flies from landing on the meat.

B In time, maggots and flies filled the open jars, but not the covered jars, showing that only flies produce flies.

Figure 14.11 Some of Pasteur's flasks, still free of microorganisms, are at the Pasteur Institute in Paris.



Spontaneous generation is disproved

In 1668, an Italian physician, Francesco Redi, disproved a commonly held belief at the time—the idea that decaying meat produced maggots, which are immature flies. You can follow the steps of Redi's experiment in *Figure 14.10.* Redi's well-designed, controlled experiment successfully convinced many scientists that maggots, and probably most large organisms, did not arise by spontaneous generation.

However, during Redi's time, scientists began to use the latest tool in biology—the microscope. With the microscope, they saw that microorganisms live everywhere. Although Redi had disproved the spontaneous generation of large organisms, many scientists thought that microorganisms were so numerous and widespread that they must arise spontaneously—probably from a vital force in the air.

Pasteur's experiments

Disproving the existence of a vital force in air proved difficult. Finally, in the mid-1800s, Louis Pasteur designed an experiment that disproved the spontaneous generation of microorganisms. Pasteur set up an experiment in which air, but no microorganisms, was allowed to contact a broth that contained nutrients. You can see how Pasteur carried out his experiment in *Figure 14.11.*

Pasteur's experiment showed that microorganisms do not simply arise in broth, even in the presence of air. From that time on, **biogenesis** (bi oh JEN uh sus), the idea that living organisms come only from other living organisms, became a cornerstone of biology.

Word Origin

biogenesis
From the Greek word *bios*, meaning "life," and the Latin word *genesis*, meaning "birth." Biogenesis proposes that living organisms come only from other living organisms.

Origins: The Modern Ideas

Biologists have accepted the concept of biogenesis for more than 100 years. However, biogenesis does not answer the question: How did life begin on Earth? No one will ever know for certain how life began on Earth. However, many scientists have developed theories about the origin

2 Teach

Quick Demo

Kinesthetic Explain that people once believed that life spontaneously arose from nonliving matter, such as broth. Dissolve two bouillon cubes in separate flasks of hot water. Boil the bouillon for several minutes. After the broth cools, seal one flask with a rubber stopper and label it "boiled." Leave the second flask open. Set the flasks on a shelf in the classroom. Have students observe the flasks every day and record their observations in their portfolios. L2 ELL P

Visual Learning

Figures 14.10 and 14.11 The experiments by Redi, Pasteur, and others to disprove spontaneous generation are examples of the application of scientific methods. Use the illustrations to reinforce students' understanding of scientific methods. Discuss the purpose of each step of the procedures with students.

Concept Development

Point out that the spontaneous generation of cells was harder to disprove than the spontaneous generation of whole organisms because microscopes were not powerful enough to show cells dividing until 1875.

Resource Manager

Section Focus Transparency 36 and Master L1 ELL
Basic Concepts Transparency 20 and Master L2 ELL

Meeting Individual Needs

Gifted

Intrapersonal Have interested students prepare a report or poster presentation about the work of Italian scientist Lazzaro Spallanzani in the debate over spontaneous generation. L3

Meeting Individual Needs

English Language Learners

Visual-Spatial Have students use block diagrams on paper to model how the experiments of Redi or Pasteur demonstrate the scientific method. Have students record their procedures and observations. L1 ELL

Portfolio

Evaluating Pasteur's Experiment

Linguistic After setting up the Quick Demo using broth, have students predict what will happen in each flask, observe the flasks for a week, and then evaluate their prediction. Have them write their conclusions and put them in their portfolios. L2 P

Tying to Previous Knowledge

Review the chemistry concepts that students studied previously, particularly the role of carbon in organic molecules. Review the general structure of proteins and nucleic acids. Relate this information to the hypotheses about the origin of life.

Using Science Terms

Have students list synonyms and antonyms for primordial. *first, original, early; last, final, ultimate* Ask them to explain why Oparin suggested that molecules in the oceans formed "primordial soup." *They were in a liquid medium.*

TECHPREP

Primordial Soup

Visual-Spatial Have students design a can and label for "Primordial Soup." The student design should have a creative graphic and a section of contents. L2

ELL

Assessment

Knowledge Have students compare the early ideas of biogenesis and Oparin's hypothesis in an essay. L2

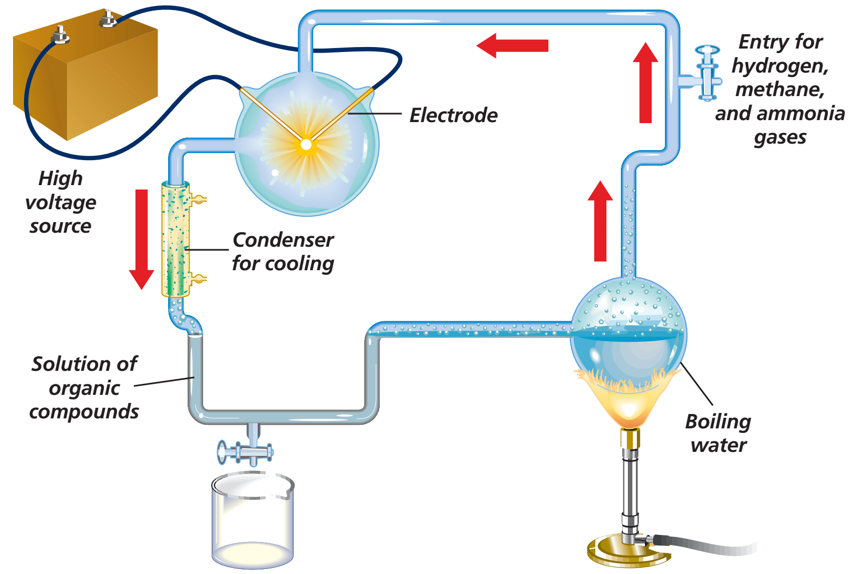


Figure 14.12 Miller and Urey's experiments showed that under the proposed conditions on early Earth, small organic molecules, such as amino acids, could form.

WORD Origin

primordial
From the Latin word *primordium,* meaning "origin." The origin of life may have been in the primordial soup.

of life on Earth from testing scientific hypotheses about conditions on early Earth. The *Biology & Society* at the end of this chapter summarizes some important viewpoints about the origin of life on Earth.

Simple organic molecules formed

Scientists hypothesize that two developments must have preceded the appearance of life on Earth. First, simple organic molecules, or molecules that contain carbon, must have formed. Then these molecules must have become organized into complex organic molecules such as proteins, carbohydrates, and nucleic acids that are essential to life.

Remember that Earth's early atmosphere probably contained little free oxygen. Instead, the atmosphere was probably composed of water vapor, carbon dioxide, nitrogen, and perhaps methane and ammonia. Many scientists have tried to explain how these substances could have joined together and formed the simple organic molecules that are found in all organisms today.

In the 1930s, a Russian scientist, Alexander Oparin, hypothesized that life began in the oceans that formed on early Earth. He suggested that energy from the sun, lightning, and Earth's heat triggered chemical reactions to produce small organic molecules from the substances present in the atmosphere. Then, rain probably washed the molecules into the oceans to form what is often called a primordial soup.

In 1953, two American scientists, Stanley Miller and Harold Urey, tested Oparin's hypothesis by simulating the conditions of early Earth in the laboratory. In an experiment similar to the one shown in ***Figure 14.12,*** Miller and Urey mixed water vapor (steam) with ammonia, methane, and hydrogen gases. They then sent an electric current that simulated lightning through the mixture. Then, they cooled the mixture of gases, produced a liquid that simulated rain, and collected the liquid in a flask. After a week, they analyzed the chemicals in the flask and found several kinds of amino acids, sugars, and other small organic molecules, providing evidence that supported Oparin's hypothesis.

The formation of protocells

The next step in the origin of life, as proposed by some scientists, was the formation of complex organic compounds. In the 1950s, various experiments were performed and showed that, if the amino acids are heated without oxygen, they link and form complex molecules called proteins. A similar process produces ATP and nucleic acids from small molecules. These experiments convinced many scientists that complex organic molecules might have originated in pools of water where small molecules had concentrated and been warmed.

How did these complex chemicals combine to form the first cells? The work of American biochemist Sidney Fox showed how the first cells may have occurred. As you can see in ***Figure 14.13,*** Fox produced protocells by heating solutions of amino acids. A **protocell** is a large, ordered structure, enclosed by a membrane, that carries out some life activities, such as growth and division.

The Evolution of Cells

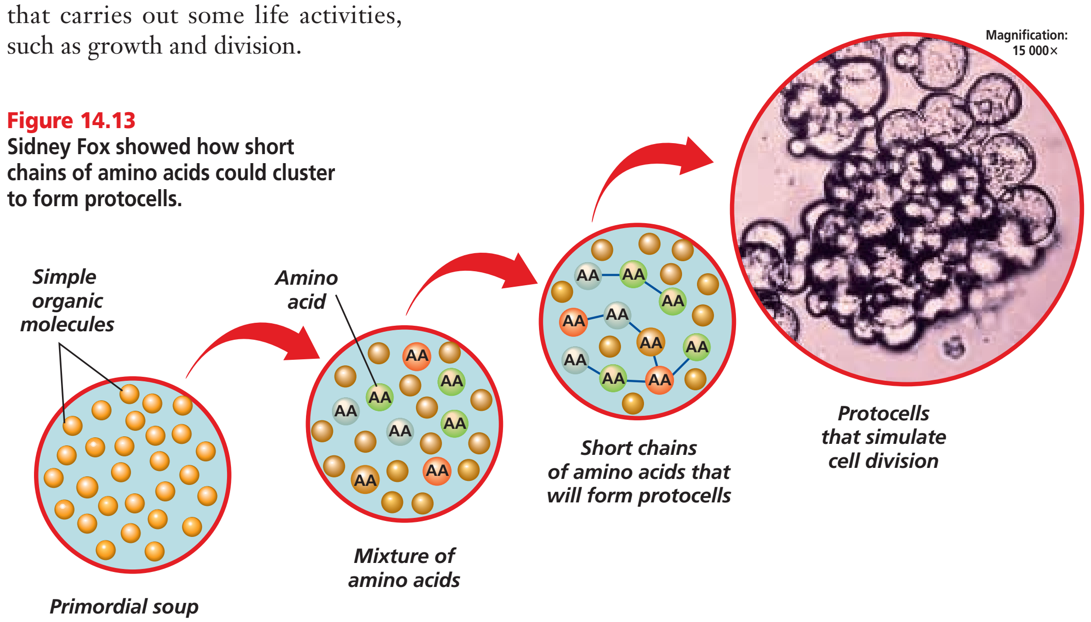
Although the origin of life may always be a mystery, fossils indicate that by about 3.5 billion years ago, photosynthetic prokaryotic cells existed on Earth. But these were probably not the earliest cells. What were the earliest cells like, and how did they evolve?

The first true cells

The first forms of life may have been prokaryotes that evolved from a protocell. Because Earth's atmosphere lacked oxygen, scientists have proposed that these organisms were most likely anaerobic. For food, the first prokaryotes probably used some of the organic molecules that were abundant in Earth's early oceans. Because they obtained food rather than making it themselves, they would have been heterotrophs.

Over time, these heterotrophs would have used up the food supply. However, organisms that could make food had probably evolved by the

Figure 14.13 Sidney Fox showed how short chains of amino acids could cluster to form protocells.



Visual Learning

Figure 14.13 Have students study the illustration of Fox's experiment. Discuss how Fox's experiment relates to Oparin's hypothesis and the Miller-Urey experiment.

Tying to Previous Knowledge

Review the basic structure and function of cells. Emphasize the substances cells need to live and the different ways cells release energy. Relate this information to the evolution of cells.

Discussion

Ask students why studying modern archaebacteria and cyanobacteria is important for determining the origin of life. *Such bacteria resemble the earliest known living things and indicate the conditions required to support life then.*

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Archaebacteria

Alternative Lab

Making Coacervates

Purpose
Students will investigate the conditions under which the first cells may have evolved.

Materials
1% gelatin solution, droppers (3), 1% gum arabic solution, pH papers, microscopes, microscope slides, coverslips, 0.1*M* hydrochloric acid (HCl), test tubes, stirring rods. For preparation instructions, see page 40T of the Teacher Guide.

Procedure
Give the following directions.

1. Remind students to wear safety goggles, a lab apron, and disposable gloves. Remind them to use care when working with a microscope and glass slides.
2. Measure 5 mL of 1% gelatin solution. Pour it into the test tube. Add 3 mL of 1% gum arabic solution. Mix gently.
3. Record the pH of the mixture.
4. Make a wet mount of the mixture. Observe under high power and record your observations.
5. Stir one drop of 0.1*M* HCl solution into the mixture. Record the mixture's pH.
6. Repeat step 4 for the HCl mixture.
7. Repeat steps 5 and 6 until you see coacervates, clumps that look like cells. Record the mixture's pH and describe the appearance of the coacervates.
8. Repeat steps 5 and 6 until the coacervates disappear.

Analysis

1. What living things do coacervates resemble? *cells*
2. Around what pH did you observe coacervates? *pH 5*
3. What conditions of early Earth does the mixture of gelatin (a protein) and gum arabic (a carbohydrate) simulate? *the amino acids and simple sugars in the "primordial soup"*

Assessment

Knowledge Have students present an oral report of the investigation. Ask: What was the role of hydrochloric acid? How does this investigation relate to hypotheses about the origin of life? Use the Performance Task Assessment List for Oral Presentation in **PASC,** p. 71. L1

Problem Solving Lab 14-2

Purpose

Students will use a model to show events on the Geologic Time Scale.

Process Skills

observe and infer, sequence, use an illustration

Teaching Strategies

■ Question students about the history of life to assess their knowledge before they start.

Thinking Critically

Prokaryotes appeared around 4:00 to 4:30 a.m. and eukaryotes around 10:00 a.m.

Assessment

Knowledge Have students approximate the time of evolution of three other groups of organisms by finding out when they appear in the fossil record. L1

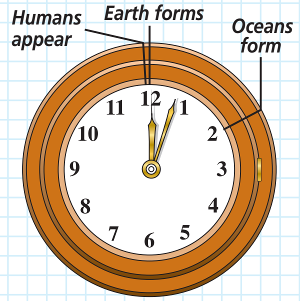
3 Assess

Check for Understanding

Have students list the three main conclusions of this section in their journals. *Life comes from existing life; life probably originated on Earth through the reaction of chemicals in Earth's atmosphere and their further reaction on Earth's surface; and cells probably evolved as the chemicals on early Earth became more organized.* Ask students to list the scientific evidence that supports each conclusion. L2

Problem-Solving Lab 14-2 — Interpreting Data

Can a clock model Earth's history? As a result of studying fossils and analyzing geological events, scientists have been able to construct the Geologic Time Scale, a timetable that shows the appearance of organisms during the history of Earth.



Analysis

The diagram shown here compresses the history of Earth into a 12-hour clock face. On the clock, assume that the formation of Earth occurred at midnight. The oceans formed at 2:00 A.M. Use this information to help you answer the following questions.

Thinking Critically

Based on fossil evidence, at what time on the face of the clock did prokaryotes evolve? At what time did the first eukaryotes appear?

Figure 14.14
Present-day archaebacteria live in places like this hot spring in Yellowstone National Park.

time the food was gone. These first autotrophs were probably similar to present-day archaebacteria. **Archaebacteria** (ar kee bac TIHR ee uh) are prokaryotes that live in harsh environments, such as deep-sea vents and hot springs like the one shown in *Figure 14.14*. The earliest autotrophs probably made glucose by chemosynthesis rather than by photosynthesis, which requires light-trapping pigments. In chemosynthesis, autotrophs release the energy of inorganic compounds in their environment to make their food.

Photosynthesizing prokaryotes

Photosynthesizing prokaryotes might have been the next type of organism to evolve. Recall that the process of photosynthesis produces oxygen. As the first photosynthetic organisms increased in number, the concentration of oxygen in Earth's atmosphere began to increase. Organisms that could respire aerobically would have evolved and thrived. In fact, the fossil record indicates that there was a very large increase in the diversity of prokaryotes about 2.8 billion years ago.

The presence of oxygen in Earth's atmosphere probably affected life on Earth in another important way. Lightning would have converted much of the oxygen into ozone molecules that would then have formed the thick layer of gas that now exists 10 to 15 miles above Earth's surface. The ozone layer probably shielded organisms from the harmful effects of ultraviolet radiation and enabled the evolution of more complex organisms, the eukaryotes.

The endosymbiont theory

The complex cells of eukaryotes probably evolved from prokaryote cells. Use the *Problem-Solving Lab* to determine how long the event might have taken. The endosymbiont theory, proposed by American biologist Lynn Margulis in the early 1960s, explains how eukaryote cells may have arisen.

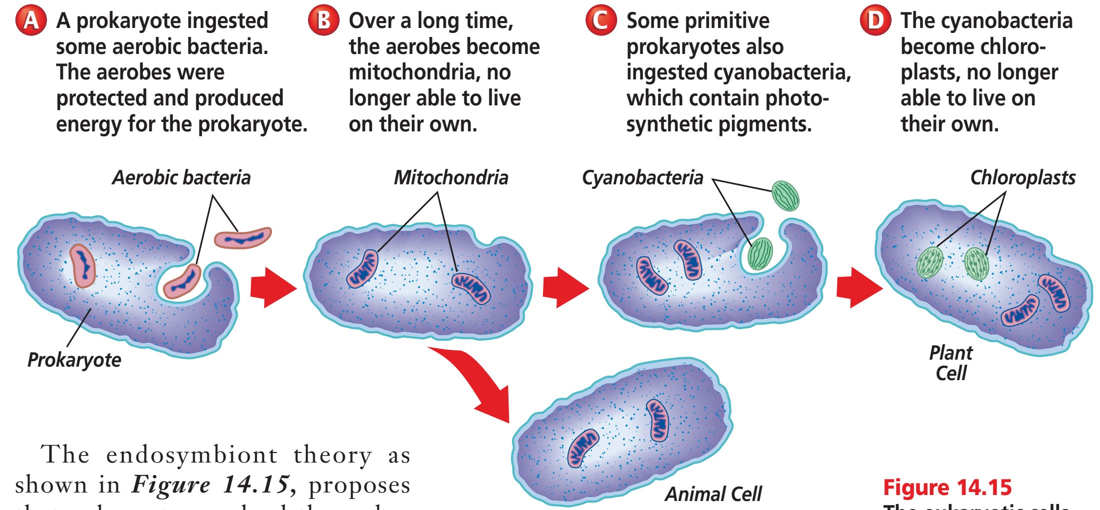


Figure 14.15
The eukaryotic cells of plants and animals probably evolved by endosymbiosis.

The endosymbiont theory as shown in *Figure 14.15*, proposes that eukaryotes evolved through a symbiotic relationship between ancient prokaryotes. Margulis based her hypothesis on observations and experimental evidence of present-day unicellular organisms. For example, some bacteria that are similar to cyanobacteria and chloroplasts resemble each other in size and in the ability to photosynthesize. Likewise, mitochondria and some other bacteria look similar. Experimental evidence revealed that both chloroplasts and mitochondria contain DNA that is very similar to the DNA in prokaryotes and very unlike the DNA in eukaryotic nuclei.

Since Margulis first proposed the endosymbiont theory, new evidence has been found to support it. For example, scientific research has shown that chloroplasts and mitochondria have their own ribosomes that are similar to the ribosomes in prokaryotes. In addition, both chloroplasts and mitochondria reproduce independently of the cells that contain them. The fact that some modern prokaryotes live in close association with eukaryotes, a relationship from which the endosymbiont theory stems, also supports the theory.

Section Assessment

Understanding Main Ideas

1. How did Pasteur's experiment finally disprove spontaneous generation?
2. What was Oparin's hypothesis, and how was it tested experimentally?
3. Why do scientists think the first living cells to appear on Earth were probably anaerobic heterotrophs?
4. How would the increasing number of photosynthesizing organisms on Earth have affected both Earth and its other organisms?

Thinking Critically

5. Some scientists speculate that lightning was not present on early Earth. How could you modify the Miller-Urey experiment to reflect this new idea? What energy source would you use to replace lightning?

Skill Review

6. **Sequencing** Make a flow chart sequencing the evolution of life from protocells to eukaryotes. For more help, refer to *Organizing Information* in the **Skill Handbook**.

Reteach

Ask students to list the scientists who experimented about the origin of life and their conclusions. Have them use their lists to quiz each other. L1 COOP LEARN

Extension

Intrapersonal Ask students who have mastered this section to find out how scientists think that nucleic acids may have developed from elements already present on Earth. L3

Assessment

Knowledge Ask each student to give an oral report about how life originated. L2

4 Close

Discussion

Have students discuss whether new life could originate on Earth today. They should consider how modern Earth differs from early Earth, including having an atmosphere rich in oxygen. L2

GLENCOE TECHNOLOGY

VIDEOTAPE
The Secret of Life
What's in Stetter's Pond: The Basics of Life

Resource Manager

Reinforcement and Study Guide, pp. 63-64 L2
Content Mastery, pp. 69, 71-72 L1

Biology Journal

Photosynthetic Prokaryotes

Visual-Spatial Have students compare slides or living cultures of both bacteria and cyanobacteria to photographs of stromatolite sections and early cells, such as those discovered in western Australia. Have students record their observations in their journals. L3 ELL

Section Assessment

1. Life would not appear in sterile broth unless previously existing organisms entered the broth.
2. Life began in Earth's oceans after organic molecules formed from ocean chemicals. Miller and Urey tested the hypothesis.
3. There was no oxygen in the atmosphere and there were food molecules in the "organic soup" of the ocean.
4. They eventually created an oxygen-rich atmosphere. Organisms evolved that could use the oxygen.
5. Possible answers include sunlight, radioactivity, or heat from volcanoes.
6. protocells ⇒ anaerobic prokaryotes ⇒ chemosynthetic prokaryotes ⇒ photosynthetic prokaryotes ⇒ eukaryotes.

INVESTIGATE BioLab

Time Allotment
One class period

Process Skills
make and use graphs, collect data, define operationally, formulate models, interpret data, use numbers

Preparation

- Any box large enough to hold the 100 pennies may be used.
- Provide graph paper.

Internet Address Book

interNET CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

Resource Manager

BioLab and MiniLab Worksheets, p. 69 L2

INVESTIGATE BioLab

Determining a Fossil's Age

Radioactive isotopes are used to date fossils and rocks. The dating is based on knowing four things: the amount of the radioactive isotope in the rock when it formed; the element into which the isotope decays; the rate of decay; and the amounts of isotope and new element in a rock or fossil. It takes 1.3 billion years for half of the radioactive isotope K 40 in a sample to decay—change into Ar 40. This time is K 40's half-life. When a rock such as volcanic lava forms, it is assumed that the amount of K 40 in the rock is 100 percent and the amount of Ar 40 is 0 percent.

Preparation

Problem
How can you simulate radioactive half-life?

Objectives
In this BioLab you will:
- **Formulate models** Simulate the radioactive decay of K 40 into Ar 40 with pennies.
- **Collect data** Collect data to determine the amount of K 40 present after several half-lives.
- **Make and use a graph** Graph your data and use its values to determine the age of rocks.

Materials
shoe box with lid
100 pennies
graph paper

Skill Handbook
Use the **Skill Handbook** if you need additional help with this lab.

Procedure

1. Copy the data table.
2. Place 100 pennies in a shoe box.
3. Arrange the pennies so that their "head" sides are facing up. Each "head" represent an atom of K 40, and each "tail" an atom of Ar 40.
4. Record the number of "heads" and "tails" present at the start of the experiment. Use the row marked "0" in the data table.
5. Cover the box. Then shake the box well. Let the shake represent one half-life of K 40, which is 1.3 billion years.

Data Table

Number of Shakes (half lives)	Number of Heads (K 40 atoms left)				
	Trial 1	Trial 2	Trial 3	Totals	Average
0					
1					
2					
3					
4					
5					

6. Remove the lid and record the number of "heads" you see facing up. Remove all the "tail" pennies.
7. To complete the first trial, repeat steps 5 and 6 four more times.
8. Run two more trials and determine an average for the number of "heads" present at each half-life.
9. Draw a full-page graph. Plot your average values on the graph. Plot the number of half-lives for K 40 on the x axis and the number of "heads" on the y axis. Connect the points with a line. Remember, each half-life mark on the graph axis for K 40 represents 1.3 billion years.

Analyze and Conclude

1. **Applying Concepts** What symbol represented an atom of K 40 in this experiment? What symbol represented an atom of Ar 40?
2. **Thinking Critically** Compare the numbers of protons and neutrons of K 40 and Ar 40. (Consult the Periodic Chart in the Appendix for help.) Can Ar 40 change back to K 40? Explain your answer, pointing out what procedural part of the experiment supports your answer.
3. **Defining Operationally** Define the term half-life. What procedural part of the simulation represented a half-life period of time in the experiment?
4. **Communicating** Explain how scientists use radioactive dating to approximate a fossil's age.
5. **Making and Using Graphs** You are attempting to determine the age of a rock sample. Use your graph to read the rock's age if it has:
   a. 70% of its original K 40 amount.
   b. 35% of its original K 40 amount.
   c. 10% of its original K 40 amount.

Going Further

Application Suppose you had calculated the same data for an element with a half-life of 5000 years rather than 1.3 billion years. Plot a graph for the hypothetical isotope. How do the graphs compare?

interNET CONNECTION To find out more about radioactive dating, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Procedure

Teaching Strategies

- Have students work in groups to reduce the quantity of materials needed.
- Be sure that students understand the value of a simulation experiment such as this one. You may want to discuss with students why this particular lab would have to be run as a simulation.
- Remind students not to return the "tail" pennies to the box.
- Review the experimental need for several trials to collect data.
- Review how to determine an average.
- Review the meaning of a symbol such as K40 and how to determine the number of protons in an element.

Data and Observations

Half-life	Average number of K40
0	100
1	50
2	25
3	12
4	6
5	3

INVESTIGATE BioLab

Analyze and Conclude

1. K-40—penny with "head" side up; Ar-40—penny with "tail" side up
2. Potassium has 19 protons and 21 neutrons, and Argon has 18 protons and 22 neutrons; No. K40 decays or changes into Ar-40. Remove "tail" pennies.
3. A half-life is the time needed for half the number of atoms of a radioactive element to change into atoms of a different element. Shaking the box represented a half-life.
4. They compare the amount of a radioactive element present now in a fossil or rock to the amount originally present, and use the element's half-life to calculate the sample's age.
5. a. 650 000 000
   b. 1 950 000 000
   c. 4 550 000 000

Assessment

Portfolio Have students write a summary of this experiment in their portfolios that emphasizes the value of using the simulation to illustrate the concept of radioactive decay. Use the Performance Task Assessment List for Lab report in **PASC**, p. 47. L1 P

Going Further

Intrapersonal The graphs will appear the same. Ask students to research how a radioactive element decays to form a different element. L2

Biology & SOCIETY

Purpose

Students will explore a variety of ideas about the origin of life.

Teaching Strategies

- Organize students into teams for a debate on the origins of life. Have each team defend one point of view. Ask students to research the strengths of their viewpoint and the weaknesses of the opposing viewpoints. L2 COOP LEARN
- Review the chemical composition of nucleic acids, amino acids, lipids, carbohydrates, and other organic molecules in cells.

Investigating the Issue

The views assume the conditions and substances found on early Earth are the same. It could more directly lead to an explanation of a DNA world.

Going Further

Linguistic Have students research and report to the class about organic molecules on planets, meteors, and comets. Students may also research current technology in SETI (search for extraterrestrial intelligence) projects. Have students prepare models, videos, or posters for a class presentation. L3 ELL

Biology & SOCIETY

How Did Life Begin: Different Viewpoints

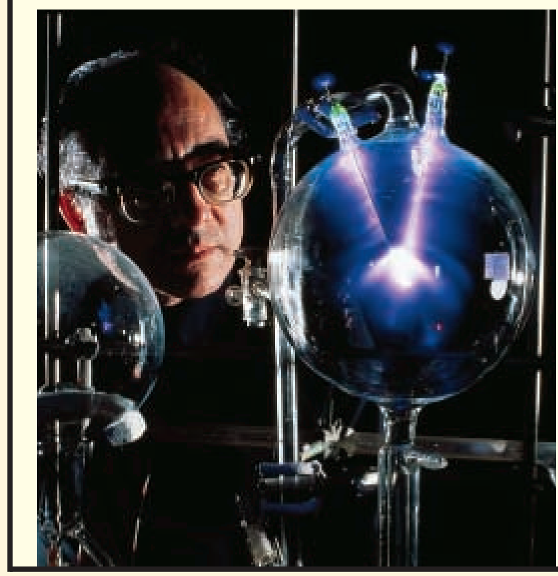
How life originated on Earth is a fascinating and challenging question. Many have proposed answers, but the mystery remains unsolved.

Because it is impossible to travel in time, the question of how life originated on Earth may never be answered. However, many ideas and beliefs have been proposed.

Divine origins Common to human cultures throughout history is the belief that life on Earth did not arise spontaneously but was placed here by a creator. Many major religions teach that life was created by a supreme being. Many people believe that life could only have arisen with the intervention of a divine force.

Meteorites One scientific idea about life's origin on Earth proposes that life arrived here on meteorites, space-borne rocks that may collide with Earth's surface. Many meteorites contain some organic matter, which could help explain how organic molecules considered necessary for the formation of cells might have arrived on Earth and entered its oceans.

Primordial soup A. I. Oparin proposed that Earth's ancient atmosphere probably contained the gases nitrogen, methane, and ammonia, but little free oxygen. Energy from the sun, volcanoes, and lightning fueled chemical reactions among these gases, which eventually combined into small organic molecules such as amino acids. Rain trapped and then washed these molecules into the oceans, making a primordial soup of organic molecules. In this soup, proteins, lipids, and other complex organic molecules found in present-day cells formed. Harold Urey and Stanley Miller provided the first experimental evidence to support this idea.



Stanley Miller

Bubbles In 1986, Louis Lerman proposed that the chemical reactions of the primordial soup took place inside tiny bubbles of lipid molecules, where they occurred more quickly. Wind, waves, and rainfall created the bubbles.

An RNA world Some scientists propose that the formation of self-replicating molecules preceded the formation of cells. Today's self-replicating molecules, DNA and RNA, provide clues about the earliest self-replicating molecules. Scientists propose that RNA, which is central to the functioning of a cell, probably predated DNA on Earth. However, because RNA is a more complex molecule than protein, it is not easy to obtain data that supports the idea that RNA could have been formed on early Earth.

Investigating the Issue

Thinking Critically How do the primordial soup and the bubble views of life's origin on Earth support each other? What is the strength of the RNA world hypothesis?

interNET CONNECTION To find out more about the origin of life, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Biology Journal

Exploring Life's Origins

Linguistic Have students record their opinions on research about the origin of life. Ask if the research of Oparin, Miller and Urey, Fox, and others is conclusive, or should more work be done in this area? Students can use evidence discussed in the text or in class to support their arguments. L2

Meeting Individual Needs

Gifted

Linguistic Have students research other experiments about the origin of life. Have them summarize in their journals the experiments they research. Ask them to evaluate the evidence from each experiment in light of other research findings. L3

Chapter 14 Assessment

Summary

Section 14.1 The Record of Life

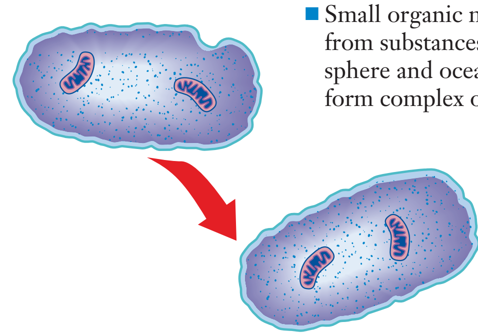
Main Ideas

- Fossils provide a record of life on Earth. Fossils come in many forms, such as the imprint of a leaf, the burrow of a worm, or an actual bone.
- By studying fossils, scientists learn about the diversity of life and about the behavior of ancient organisms and their environments.
- Earth's history is divided into the four eras of the Geologic Time Scale, a calendar of Earth's history based on evidence in rocks and fossils.

Vocabulary

fossil (p. 378)
plate tectonics (p. 387)

Section 14.2 The Origin of Life



Main Ideas

- Francesco Redi and Louis Pasteur designed controlled experiments to disprove spontaneous generation. Their experiments and others like them convinced scientists to accept biogenesis.
- Small organic molecules might have formed from substances present in Earth's early atmosphere and oceans. Small organic molecules can form complex organic molecules.
- The earliest organisms were probably anaerobic, heterotrophic prokaryotes. Over time, chemosynthetic prokaryotes evolved and then photosynthetic prokaryotes that produced oxygen, changing the atmosphere and triggering the evolution of aerobic cells and eukaryotes.
- The endosymbiont hypothesis proposes that eukaryotes evolved through a symbiotic relationship between prokaryotes.

Vocabulary

archaebacteria (p. 392)
biogenesis (p. 389)
protocell (p. 391)
spontaneous generation (p. 388)

Understanding Main Ideas

1. About how many years ago do scientists suggest that Earth cooled enough for water vapor to condense?
   a. 20 million years
   b. 4.6 billion years
   c. 3.9 billion years
   d. 5.5 billion years
2. Most fossils occur in layers of _______ rocks.
   a. sedimentary
   b. metamorphic
   c. igneous
   d. volcanic
3. The endosymbiont theory suggests how _______ evolved from _______.
   a. protocells—organelles
   b. eukaryotes—prokaryotes
   c. archaebacteria—eubacteria
   d. prokaryotes—protocells
4. Who was the scientist who showed that microscopic life is not produced by spontaneous generation?
   a. Francesco Redi
   b. Stanley Miller
   c. Louis Pasteur
   d. Harold Urey

Main Ideas

Summary statements can be used by students to review the major concepts of the chapter.

Using the Vocabulary

To reinforce chapter vocabulary, use the Content Mastery Booklet and the activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web Site.

THE PRINCETON REVIEW *All Chapter Assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.*

Understanding Main Ideas

1. c
2. a
3. b
4. c

Glencoe Technology

VIDEOTAPE
MindJogger Videoquizzes
Chapter 14: *The History of Life*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

Resource Manager

Chapter Assessment, pp. 79-84
MindJogger Videoquizzes
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 14 quiz

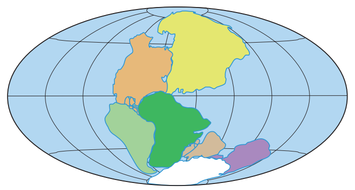
5. a
6. b
7. c
8. d
9. b
10. b
11. trace fossils
12. archaebacteria
13. unicellular prokaryotes
14. Mesozoic
15. protocell
16. spontaneous generation
17. fossil
18. Precambrian
19. plate tectonics
20. biogenesis

Applying Main Ideas

21. Because fossils are found in sedimentary rock, paleontologists need to know the rock's history.
22. From fossils, scientists may be able to determine whether animals lived in large groups, what they ate, how they obtained their food, and what their home ranges were.

Chapter 14 Assessment

5. The Geologic Time Scale is based on _______.
   a. different organisms that appeared during Earth's history
   b. various rock layers that occur in Europe and Canada
   c. landforms such as mountains and faults in California
   d. when oceans and seas formed
6. Shallow seas that teemed with life could first be found _______.
   a. in the Precambrian era
   b. in the Paleozoic era
   c. in the Mesozoic era
   d. 6.5 billion years ago
7. The mass of continents in the diagram shown here is called _______.

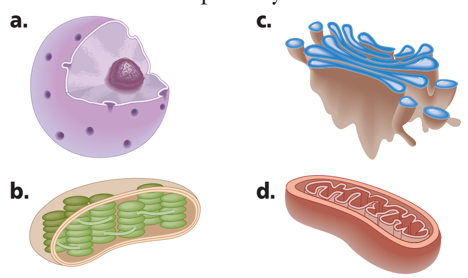


   a. Laurasia c. Pangaea
   b. Gondwana d. North America
8. An entire, intact organism may be preserved in _______ and _______.
   a. casts—trace fossils
   b. molds—casts
   c. imprints—petrified fossils
   d. amber—ice
9. Scientists theorize that oxygen buildup in the atmosphere resulted from _______.
   a. respiration c. chemosynthesis
   b. photosynthesis d. rock weathering

The Princeton Review — Test-Taking Tip

Do Some Reconnaissance
Find out what the conditions will be for taking the test. Is it timed? Will you be allowed a break? Know these things in advance so that you can practice taking tests under the same conditions.

10. Which of the following cell organelles may have evolved from a plant cell's symbiotic association with a photosynthetic bacterium?



11. Fossil markings such as footprints or animal burrows are called _______.
12. The group of prokaryotes that live in harsh conditions, such as the near-boiling water in hot springs, is _______.
13. Fossils of organisms found in the early Precambriam are all of _______.
14. Dinosaurs, mammals, and flowering plants appeared during the _______ era.
15. Sidney Fox showed that heating solutions of amino acids can produce a large, associated structure called a _______.
16. The idea of _______ suggests that nonliving matter can produce living things.
17. Any evidence of an organism that lived long ago is a(n) _______.
18. The earliest evidence of life so far recorded is found in rocks dated to the _______ era.
19. The geological explanation for how continents move is _______.
20. The idea that life comes only from preexisting life is _______.

Applying Main Ideas

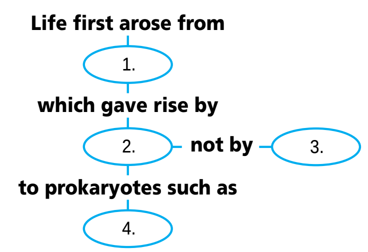
21. Why is knowledge of geology important to paleontologists?
22. Explain how fossils might help paleontologists to learn about the important behaviors of different types of animals. Which social behaviors might they provide information about?

Chapter 14 Assessment

23. How might the way organisms obtain energy have evolved over time?
24. Explain why there might be similar fossils on the east coast of South America and the west coast of Africa.

Thinking Critically

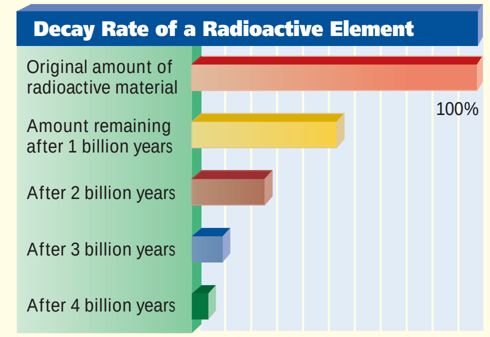
25. **Observing and Inferring** Why are amber-preserved and frozen fossils of great value to scientists?
26. **Comparing and Contrasting** What details about an organism might casts show that are not displayed in molds?
27. **Formulating Hypotheses** Why do scientists propose that the 3.5 billion-year-old fossils of cyanobacteria-like prokaryotic cells found in Australia, were not the first species to have evolved on Earth?
28. **Measuring in SI** Assume that a particular radioactive element has a half-life of 1 year. If 1000.0 g of the radioactive element are present in a sample today, how much will be in the sample after 10 years?
29. **Concept Mapping** Complete the concept map by using the following vocabulary terms: archaebacteria, biogenesis, spontaneous generation, protocells.



CD-ROM
For additional review, use the assessment options for this chapter found on the ***Biology: The Dynamics of Life Interactive CD-ROM*** and on the Glencoe Science Web Site.
www.glencoe.com/sec/science

Assessing Knowledge & Skills

The following graph illustrates the decay rate of a particular radioactive element.



Interpreting Data Study the graph and answer the following questions.

1. How long does it take for half of the element to decay?
   a. 1 billion years c. 3 billion years
   b. 2 billion years d. 4 billion years
2. How much of the original material is left after 2 billion years?
   a. 100% c. 25%
   b. 50% d. 12.5%
3. How much of the original material is left after 4 billion years?
   a. 50% c. 12.5%
   b. 25% d. less than 10%
4. This element would best be used to date fossils that are __________ years old.
   a. a few thousand c. a few million
   b. less than a million d. a billion
5. **Interpreting Scientific Illustrations** Use both ***Figure 14.4*** and the above graph to identify the era in which this radioactive element would be the most useful in dating fossils.

Chapter 14 Assessment

23. The earliest organisms probably were heterotrophic, obtaining energy through anaerobic processes. Some later anaerobic organisms may have been autotrophic, increasing the amount of oxygen in the atmosphere. The presence of oxygen in the atmosphere and the evolution of cells with mitochondria allowed organisms to use oxygen in aerobic respiration.
24. The theory of plate tectonics explains that the two continents were once joined.

Thinking Critically

25. The entire organism is preserved, including its soft tissues.
26. Casts are three-dimensional representations of molds and show more details, such as surface texture, than do molds.
27. The earliest organisms were probably anaerobic heterotrophs, not autotrophs.
28. 0.9766 grams
29. 1. Protocells; 2. Spontaneous generation; 3. Biogenesis; 4. Archaebacteria

Assessing Knowledge & Skills

1. a
2. c
3. d
4. d
5. the Precambrian era