17–3 Evolution of Multicellular Life

Although the fossil record has missing pieces, paleontologists have assembled good evolutionary histories for many groups of organisms. Furthermore, the fossil record indicates that major changes occurred in Earth’s climate, geography, and life-forms. In this section, you will get an overview of how multicellular life evolved from its earliest forms to its present-day diversity.

Precambrian Time
Recall that almost 90 percent of Earth’s history occurred during the Precambrian. During this time, simple anaerobic forms of life appeared and were followed by photosynthetic forms, which added oxygen to the atmosphere. Aerobic forms of life evolved, and eukaryotes appeared. Some of those organisms gave rise to multicellular forms that continued to increase in complexity. Few fossils exist from this time because the animals were all soft-bodied. Life existed only in the sea.

Paleozoic Era
Rich fossil evidence shows that early in the Paleozoic Era, there was a diversity of marine life. Scientists once thought that those different forms of life evolved rapidly at the beginning of the Paleozoic, but increasing evidence from Precambrian fossils and DNA studies suggests that life began to diversify much earlier. Regardless of when these forms evolved, fossil evidence shows that life was highly diverse by the first part of the Paleozoic Era, the Cambrian Period. An artist’s portrayal of Cambrian life, which included many kinds of invertebrate animals, is shown in Figure 17–14.

Vocabulary Preview
Read the names of the periods aloud and encourage students to repeat them after you. Knowing how to pronounce the words correctly will help students remember them.

Reading Strategy
Depending on the amount of detail you expect students to learn, you might want to suggest that they make a separate row in their table for each period.

Figure 17–14 The fossil record shows evidence of many types of marine life early in the Paleozoic Era. These and other unfamiliar organisms dwelt in the sea during the Cambrian Period, a time when animals with hard parts evolved.
Cambrian Period
Paleontologists call the diversification of life during the early Cambrian Period the “Cambrian Explosion.” For the first time, many organisms had hard parts, including shells and outer skeletons. During the Cambrian Period, the first known representatives of most animal phyla evolved. Invertebrates—such as jellyfishes, worms, and sponges—drifted through the water, crawled along the sandy bottom, or attached themselves to the ocean floors. Brachiopods, which were small animals with two shells, were especially common. They resembled—but were unrelated to—modern clams. Trilobites were also common. Trilobites were arthropods, which are invertebrates with segmented bodies, jointed limbs, and an external skeleton.

Point out that the first organisms with shells and outer skeletons evolved during the Cambrian Period. Then, ask: Why would having hard parts such as shells be an advantage to organisms? (The hard body parts would help protect the organisms from predators.)

**17–3 (continued)**

**Build Science Skills**

**Inferencing** Point out that the first land-dwelling organisms, which occurred during the Ordovician Period, was an important evolutionary event. Point out how the earliest terrestrial organisms would have had virtually no competitors for the diversity of potential niches available on land.

**Make Connections**

**Environmental Science** Help students appreciate why the evolution of the first land-dwelling organisms, which occurred during the Ordovician Period, was an important evolutionary event. Point out how the earliest terrestrial organisms would have had virtually no competitors for the diversity of potential niches available on land.

**Build Science Skills**

**Drawing Conclusions** Ask: How did life on Earth differ before and after the Permian extinction? (Most marine life and many land vertebrates—particularly large ones—were lost. Small reptiles and land plants were less affected.)

1. Why is it important for the first land-dwelling organisms to develop hard parts such as shells?

2. What evidence suggests that hard parts were an advantage for organisms on land?

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**ESL SUPPORT FOR ENGLISH LANGUAGE LEARNERS**

**Vocabulary: Writing**

**Beginning** On the board, make a box labeled *Paleozoic Era*. Write several words or simple phrases describing the life-forms of Precambrian time in the box. To clarify the descriptions, call students’ attention to the organisms in Figure 17–14. Then, have the students draw two boxes, one labeled *Mesozoic Era* and another labeled *Cenozoic Era*. Have pairs of students work together to draw a picture or write a word or phrase describing the dominant life-forms of that era.

**Intermediate** Extend the beginning-level activity by writing a complete sentence on the board to describe the life-forms present in the *Paleozoic Era*. Then, ask students to fill in their labeled boxes using complete sentences. If an ESL student needs assistance, pair him or her with a student who is proficient in English.

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**ESL**

**Comparing and Contrasting** Which of today’s animals do eurypterids resemble? (The hard body parts would help protect the organisms from predators.)

**Ordivician and Silurian Periods**

During the Ordovician (awr-duh-VISH-un) and Silurian (sih-LOOR-ee-un) periods, the ancestors of the modern octopi and squid appeared, as did aquatic arthropods like the one shown in Figure 17–15. Some arthropods became the first animals to live on land. Among the first vertebrates (animals with backbones) to appear were jawless fishes, which had suckerlike mouths. The first land plants evolved from aquatic ancestors. These simple plants grew low to the ground in damp areas.

**Devonian Period**

By the Devonian (dih-VOH-nee-un) Period, some plants, such as ferns, had adapted to drier areas, allowing them to invade more habitats. Insects, which are arthropods, appeared on land. In the seas, both invertebrates and vertebrates thrived. Even though the invertebrates were far more numerous, the Devonian is often called the Age of Fishes because many groups of fishes were present in the oceans. Most fishes of this time had jaws, bony skeletons, and scales on their bodies. Sharks appeared in the late Devonian.

**Carboniferous and Permian Periods**

Throughout the rest of the Paleozoic Era, life expanded over Earth’s continents. Other groups of vertebrates, such as reptiles, evolved from certain amphibians. Reptiles are animals that have scaly skin and lay eggs with tough, leathery shells. Winged insects evolved into many forms, including huge dragonflies and cockroaches. Giant ferns and other plants formed vast swampy forests, shown in Figure 17–16. The remains of those ancient plants formed thick deposits of sediment that changed into coal over millions of years, giving the Carboniferous its name.
At the end of the Paleozoic, many organisms died out. This was a mass extinction, in which many types of living things became extinct at the same time. The mass extinction at the end of the Paleozoic affected both plants and animals on land and in the seas. As much as 95 percent of the complex life in the oceans disappeared. For example, trilobites, which had existed since early in the Paleozoic, suddenly became extinct. Many amphibians also became extinct. Not all organisms disappeared, however. The mass extinction did not affect many fishes. Numerous reptiles also survived.

Mesozoic Era

The Mesozoic Era lasted approximately 180 million years. Events during the Mesozoic include the increasing dominance of dinosaurs. The Mesozoic is marked by the appearance of flowering plants.

Triassic Period

Those organisms that survived the Permian mass extinction became the main forms of life early in the Triassic (try-AIS-ik) Period. Important organisms in this new ecosystem were fishes, insects, reptiles, and cone-bearing plants like the one in Figure 17–17. Reptiles were so successful during the Mesozoic Era that this time is often called the Age of Reptiles.

About 225 million years ago, the first dinosaurs appeared. One of the earliest dinosaurs, Coelophysis, was a meat-eater that had light, hollow bones and ran swiftly on its hind legs. Mammals also first appeared during the late Triassic Period, probably evolving from mammal-like reptiles. Mammals of the Triassic were very small, about the size of a mouse or shrew.

Answers to . . .

Checkpoint The diversification of life during the early Cambrian Period

Figure 17–15 Possible answers include a crab, a scorpion, and a lobster.

Figure 17–17 Fishes, insects, and reptiles
17–3 (continued)

Address Misconceptions

Some students might think that dinosaurs were not very successful in evolutionary terms because, with the possible exception of the ancestors of modern birds, dinosaurs became extinct at the end of the Cretaceous Period. Point out that dinosaurs “ruled” Earth for a total period of about 150 million years. Put this time span in perspective by comparing it with the length of time that the human family, the hominids, has been in existence, which is less than 10 million years.

Use Visuals

Figure 17–18 Call on students to describe the environment that is depicted in the figure. (They may say it is hot and wet or tropical.) Explain that, during the Mesozoic, many places on Earth, including much of North America, had this type of environment. Remind students that dinosaurs were reptiles and probably could not internally regulate their body temperature. Ask: What would happen to dinosaurs if they were in North America today? (It might be difficult for them to survive because of the cold and other differences in environment.)

Jurassic Period

During the Jurassic (joo-RAS-ik) Period, dinosaurs became the dominant animals on land. Dinosaurs “ruled” Earth for about 150 million years, but different types lived at different times. At 20 meters long, Dicraeosaurus, shown in Figure 17–18, was one of the larger dinosaurs of the Jurassic Period. One of the first birds, called Archaeopteryx, appeared during this time. Many paleontologists now think that birds are close relatives of dinosaurs. Since the 1990s, scientists working in China have found evidence for this hypothesis in other fossils that have the skulls and teeth of dinosaurs but the body structure and feathers of birds.

Cretaceous Period

Reptiles were still the dominant vertebrates throughout the Cretaceous (krih-TAY-shus) Period. Dinosaurs such as the meat-eating Tyrannosaurus rex dominated land ecosystems, while flying reptiles and birds soared in the sky. Flying reptiles, however, became extinct during the Cretaceous. In the seas, turtles, crocodiles, and extinct reptiles such as pleiosaurs swam among fishes and marine invertebrates.

FACTS AND FIGURES

**How sweet it is**

Fruits and seeds were a major evolutionary advance in the reproduction of plants. However, if animals eat unripe fruits, the immature seeds in them are not capable of sprouting and growing. As a result, natural selection led to plants that have ways to discourage animals from eating their unripe fruits. Many unripe fruits are green and contain bitter-tasting chemical compounds. The green color of the unripe fruits makes them more difficult to see among a plant’s leaves, and the bitter taste helps discourage animals from eating them. As the seeds mature, the bitter-tasting chemical compounds break down, and the fruits become laden with sugars. While this process occurs, the fruits also change color from green to red, orange, purple, or whatever color indicates ripeness in that species. These colors are more easily seen by animals against the background of green leaves, and the fruits’ sweet taste reinforces the eating response.
**Cenozoic Era**

During the Mesozoic, early mammals competed with dinosaurs for food and places to live. The extinction of dinosaurs at the end of the Mesozoic, however, created a different world. During the Cenozoic, mammals evolved adaptations that allowed them to live in various environments—on land, in water, and even in the air. One land mammal from the early Cenozoic is shown in Figure 17–19. Paleontologists often call the Cenozoic the Age of Mammals.

**Tertiary Period**

During the Tertiary Period, Earth’s climates were generally warm and mild. In the oceans, marine mammals such as whales and dolphins evolved. On land, flowering plants and insects flourished. Grasses evolved, providing a food source that encouraged the evolution of grazing mammals, the ancestors of today’s cattle, deer, sheep, and other grass-eating mammals. Some mammals became very large, as did some birds.
Make Connections
Environmental Science Provide students with background information on the ice ages. Explain that over the past two million years, there were four major ice ages, each lasting at least 100,000 years or longer and between which were long periods of warmer climate. During the peak of the most recent ice age, which ended about 20,000 years ago, ice covered much of North America, reaching as far south as the present-day lower midwestern states. Scientists think the ice ages were caused by variations in the position of the Earth relative to the sun, changes in the sun’s energy output due to sunspots, and continental movement.

3 ASSESS
Evaluate Understanding
Read each of the Key Concepts in the section, leaving the name of the era or period blank. Call on students at random to fill in the blanks.

Reteach
Have pairs of students make and quiz each other with flashcards that each have an important evolutionary event on one side and the correct era and period on the other side.

If students have a hard time developing ideas for their stories, suggest that they brainstorm in small groups. Stories should include information from the text as well as additional reliable sources.

If your class subscribes to the iText, use it to review the Key Concepts in Section 17–3.

Answer to . . .
Figure 17–20 Organisms that could not migrate to a warmer climate or adapt to the change in climate would have gone extinct.

17–3 (continued)

Quaternary Period Mammals that had evolved during the Tertiary Period eventually faced a changing environment during the Quaternary Period. During this time, Earth’s climate cooled, causing a series of ice ages. Repeatedly, thick continental glaciers advanced and retreated over parts of Europe and North America. So much of Earth’s water was frozen in continental glaciers that the level of the oceans fell by more than 100 meters. Then, about 20,000 years ago, Earth’s climate began to warm. Over the course of thousands of years, the continental glaciers melted. This caused sea levels to rise again.

In the oceans, algae, coral, mollusks, fishes, and mammals thrived. Insects and birds shared the skies. On land, mammals—such as bats, cats, dogs, cattle, and the mammoths shown in Figure 17–20—became common. The fossil record suggests that the early ancestors of our species appeared about 4.5 million years ago but that they did not look entirely human. The first fossils assigned to our own species, Homo sapiens, may have appeared as early as 200,000 years ago in Africa. According to one hypothesis, members of our species began a series of migrations from Africa that ultimately colonized the world.

1. Key Concept Where did life exist during the early Paleozoic Era?
2. Key Concept What evolutionary milestone involving animals occurred during the Devonian Period?
3. Key Concept What are two key events from the Mesozoic Era?
4. Critical Thinking Inferring If you were a paleontologist investigating fossils from the Cenozoic Era, what fossils might you find?

Creative Writing
Choose one of the periods described in this section. Then, write a story about life during that time. Include information about the life-forms, weather, and other characteristics.

1. Early life existed in the sea.
2. During the Devonian Period, animals began to invade the land.
3. Events include the first appearance of dinosaurs and the appearance of seed plants, including cone-bearing and flowering types.
4. You might find fossils of flowering plants, insects, birds, and mammals, including humans.