

13.2 Paleozoic Era: Life Explodes



Section 13.2

1 FOCUS

Section Objectives

- 13.4** List the periods that make up the Paleozoic era.
- 13.5** Explain how tectonic movements affected the locations of the continents during the Paleozoic era.
- 13.6** Describe some of the life-forms that existed in the early Paleozoic era.
- 13.7** Explain how life evolved during the Paleozoic era.

Reading Focus

Key Concepts

- When was the Paleozoic era?
- How did tectonic movements affect the locations and formations of the continents during the Paleozoic era?
- What kind of life existed in the early Paleozoic?
- How did life evolve during the Paleozoic era?

Vocabulary

- ◆ Gondwana
- ◆ Laurasia

Reading Strategy

Identifying Details Copy the table below. As you read the section, fill out the table with notes.

	Continental positions	Plant life	Animal life
Early Paleozoic			
Middle Paleozoic			
Late Paleozoic			

Reading Focus

Build Vocabulary L2

Graphic Organizers As they read this section, have students create a concept map or flowchart that includes the vocabulary terms and major concepts for this section.

Reading Strategy L2

Sample answers: Early Paleozoic—Gondwana at the South Pole, other landmasses near the equator; confined to the sea; marine invertebrates such as trilobites, cephalopods, and brachiopods developed and animals with hard shells; Late Paleozoic—Pangaea formed; land plants developed from leafless spikes to full trees; fish developed scales, and amphibians became dominant

As the Precambrian came to a close, the fossil record disclosed diverse and complete multicelled organisms. This set the stage for more complex plants and animals to evolve at the dawn of the Paleozoic era.

➤ **Following the long Precambrian, the most recent 540 million years of Earth's history are divided into three eras: Paleozoic, Mesozoic, and Cenozoic.** The Paleozoic era encompasses about 292 million years and is by far the longest of the three.

Before the Paleozoic, life forms possessed no hard parts, such as shells, scales, bones, or teeth. Hard parts greatly enhanced a life form's chance of being preserved as part of the fossil record. The Paleozoic era contains many more diverse fossils due to the emergence of life forms with hard parts.

Abundant Paleozoic fossils have allowed geologists to construct a far more detailed time scale for the last one-eighth of geologic time than for the preceding seven-eighths, the Precambrian. Moreover, because every organism is associated with a particular environment, the greatly improved fossil record provided invaluable information for learning about ancient environments. For our brief tour of the Paleozoic, we divide it into Early Paleozoic (Cambrian, Ordovician, Silurian periods) and Late Paleozoic (Devonian, Mississippian, Pennsylvanian, Permian periods).

INSTRUCT

Early Paleozoic

Build Reading Literacy **L1**

Refer to p. 392D in Chapter 14, which provides guidelines for previewing.

Preview Have students scan the boldfaced material, topic headings, and graphics in this section to get an idea of how it is organized and what it is about. This preview of the section will help students know where to find the information needed to complete the table for this section's reading strategy.

Visual, Verbal

Early Paleozoic

The early Paleozoic consists of a 123-million-year span that includes the Cambrian, Ordovician, and Silurian periods. Looking at Earth from space at this time, you would have seen the familiar blue planet with many clouds, but the arrangement of the continents would be very different from today.

Early Paleozoic History 🌍 During the Cambrian, Ordovician, and Silurian periods, the vast southern continent of Gondwana encompassed five continents (South America, Africa, Australia, Antarctica, India, and perhaps China).

North America and several other landmasses were not part of Gondwana. Although the exact position of these northern continents is uncertain, they are thought to have been near the equator and separated by a narrow sea, as shown on the map in Figure 5.

At the beginning of the Paleozoic, North America was a land with no living things, plant or animal. Soon, a mountain-building event affected eastern North America. The final chapter in this story was the formation of the Appalachian Mountains, over 200 million years later.

During the Silurian period, much of North America was once again covered by shallow seas. This time, large barrier reefs restricted circulation between shallow marine basins and the open ocean. Water in these basins evaporated, depositing large quantities of rock salt and gypsum.

Figure 5 A landmass called Gondwana and the northern continental landmasses existed in early Paleozoic time.

Explaining *What continents made up Gondwana?*



Why are more fossils found from the Paleozoic era than Precambrian time?



370 Chapter 13

Customize for Inclusion Students

Learning Disabled Graphic organizers are essential to managing the large amount of information presented in this chapter. Help students who are learning disabled use the reading strategy for this section by having students complete this activity in heterogeneous

cooperative groups. Also, remind students to refer back to the geologic time scale on p. 365 if they get lost in what they are reading. Tell students to add details to their own version of the scale as they read. (See Reteach in Section 13.1.)



Integrate Biology L2

Trilobites Have students research the different varieties of trilobites. Students should then present their findings to the class, including pictures and a comparison of sizes and structures of the different varieties.

Verbal

Use Community Resources L2

If possible, bring students to a nearby museum to observe fossils and recreations of ancient environments.

Visual, Kinesthetic

Early Paleozoic Life 🌍 Life in early Paleozoic time was restricted to the seas. Vertebrates had not yet evolved, so life consisted of several invertebrate groups. The Cambrian period was the golden age of trilobites. More than 600 types of these mud-burrowing scavengers flourished worldwide. By Ordovician times, brachiopods outnumbered the trilobites. Brachiopods are among the most widespread Paleozoic fossils and, except for one modern group, are now extinct. The adult brachiopods lived attached to the seafloor, but the young larvae were free swimming. This mobility accounts for the group's wide geographic distribution.

The Ordovician also marked the appearance of cephalopods—mobile and highly developed mollusks that became the major predators of the time. Squid and octopus are descendents of these early cephalopods. Cephalopods were the first truly large organisms on Earth. Figure 6 shows some cephalopods and other organisms of the Ordovician.

The beginning of the Cambrian period marks an important event in animal evolution. For the first time, organisms appeared that secreted material that formed hard parts, such as shells. Hard parts clearly served many useful purposes and aided adaptations to new ways of life. Mollusks, such as clams and snails, secreted external shells that protected them and allowed body organs to function in a more controlled environment. The successful trilobites developed an exoskeleton of a protein called chitin, which permitted them to burrow through soft sediment in search of food. The fossil in Figure 7 shows the exoskeleton of a trilobite.

Figure 6 Cephalopods, trilobites, brachiopods, snails, and corals inhabited the waters of the Ordovician period.

Figure 7 Trilobite Fossil
Inferring When did trilobites live?



How did the formation of hard parts benefit animals?

Earth's History 371

Facts and Figures


The thick layers of rock salt and gypsum deposited during the early Paleozoic are called evaporite beds because they form as a result of water evaporating and leaving previously


dissolved materials behind. These beds are an important resource for the chemical, rubber, plasterboard, and photographic industries in Ohio, Michigan, and western New York State.

Answer to . . .

Figure 5 South America, Africa, Australia, Antarctica, India, and perhaps China

Figure 7 Trilobites lived during the Cambrian period.

 There were more organisms with hard parts, which greatly enhanced a life-form's chance of being preserved in the fossil record.

 Hard parts allowed animals to venture into different environments.

Late Paleozoic

Build Reading Literacy L1

Refer to p. 362D in Chapter 13, which provides guidelines for using prior knowledge.

Use Prior Knowledge Review the law of superposition with students. (The oldest rock layers will always be found on the bottom of an outcrop unless that outcrop has been overturned or intruded.) Ask students to apply this law during the Quick Lab.

Quick Lab

Relative Dating L2

Objective After completing this activity, students will be able to apply the law of superposition to put layers in a sequence.

Skills Focus **Observing, Inferring**



Prep Time none

Class Time 10 minutes

Teaching Tip Give students about 5 minutes to complete the activity, then spend a few minutes discussing the results with the class.

Expected Outcome Students will correctly apply the law of superposition to determine the sequence in which the cards were laid down.

Analyze and Conclude

- 8 of hearts, 6 of diamonds, 3 of diamonds, 7 of spades, 10 of hearts, 5 of spades, ace of clubs, 4 of hearts, 9 of clubs
- All the cards, except the 2 of clubs, could be put in sequence. The 2 of clubs was not in the stack, so it was not possible to determine where it would have gone in the sequence.
- An intrusion would be like slipping a card in from the side.

Visual, Logical

Quick Lab

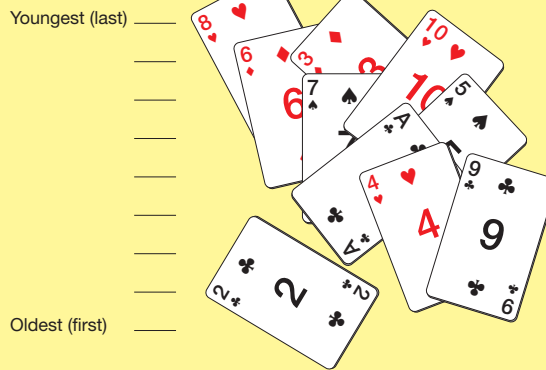
Relative Dating

Geologists can relatively date the fossils they uncover with respect to their positions in the ground. Assume the playing cards shown are layers of rocks viewed from above. Using the cards, answer the questions below.

Analyze and Conclude

- Observing** List the order, first (oldest) to last (youngest), that the cards were laid down.
- Inferring** Were you able to place all of the cards in sequence? If not, which one(s) could not be “relatively” dated and why not?
- Applying** What geologic process would be represented by slipping a card in from the side?

Youngest (last) _____



Late Paleozoic

The late Paleozoic consists of four periods—the Devonian, Mississippian, Pennsylvanian, and Permian—that span about 160 million years. Tectonic forces reorganized Earth’s landmasses during this time, creating the supercontinent Pangaea.

Late Paleozoic History As ancestral North America collided with Africa, the narrow sea that separated these landmasses began to close slowly, as compared in Figure 8B and 8C. Strong forces of compression from this collision deformed the rocks to produce the Appalachian Mountains of eastern North America.

During the union of North America and Africa, the other northern continents began to join, as shown in Figure 8. By the Permian period, this newly formed landmass had collided with western Asia and the Siberian landmass along the line of the Ural Mountains. Through this union, the northern continent of **Laurasia** was born, made up of present-day North America, Europe, western Asia.

As Laurasia was forming, Gondwana moved northward. By the Pennsylvanian period, Gondwana collided with Laurasia, forming a mountainous belt through central Europe. **By the end of the Paleozoic, all the continents had fused into the supercontinent of Pangaea.** With only a single vast continent, the world’s climate changed dramatically. The interior of this large continent, located far from a source of moisture became quite arid. In addition, these regions became very seasonal, having extremes far greater than those we experience today.

Facts and Figures

In the early Paleozoic, a mountain-building event affected eastern North America from the present-day Appalachians to Newfoundland. These mountains have since eroded away,

leaving behind deformed strata and a large volume of sedimentary rocks from the weathering of these mountains.

Late Paleozoic Plate Movements

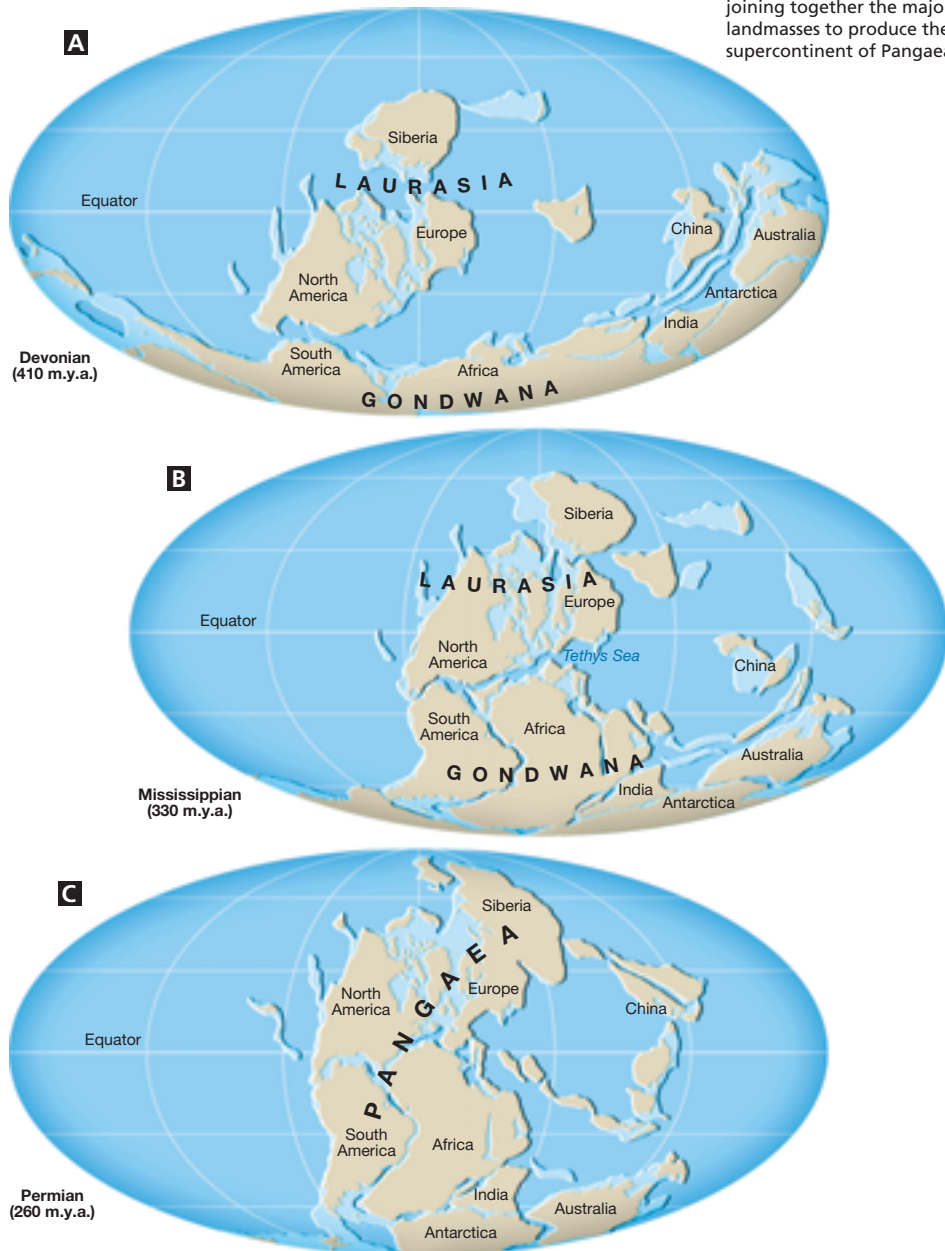


Figure 8 During the late Paleozoic, plate movements were joining together the major landmasses to produce the supercontinent of Pangaea.

Build Reading Literacy **L1**

Refer to p. 186D in Chapter 7, which provides guidelines for relating text and visuals.

Relate Text and Visuals Remind students to look back at the geologic time scale on p. 365 as they read to see when the major events happened and to review the sequence of epochs and periods.

Visual

Use Visuals **L1**

Figure 8 This diagram shows the movement of landmasses during the late Paleozoic. Ask: **During the late Paleozoic, how did Gondwana move relative to the equator?** (*toward the equator*) How would this movement have affected the climate of Gondwana? (*It would have gotten warmer.*) **During the late Paleozoic, how did Siberia move relative to the equator?** (*away from the equator*) How would this movement have affected the climate of Siberia? (*It would have gotten colder.*)

Visual

Earth's History 373

Facts and Figures

In the Mississippian period, when Laurasia and Gondwana were forming, ancestral North America and Africa collided, creating strong compressional forces that deformed rocks, producing the northern Appalachian Mountains of eastern North America. As

Pangaea was forming in the Pennsylvanian period, the African fragment of Gondwana and the southeastern edge of North America collided, creating the southern Appalachian Mountains.

Integrate Biology

L2

Survival of the Fittest Evolution is largely based on the idea of natural selection, or survival of the fittest. This idea states that any mutation that increases the chance of an organism's survival, and therefore reproductive success, would be passed along to future generations, making each successive generation more fit than the last. Have students consider why the following adaptations would be passed on. Ask: **Why would a fish with specialized organs for lungs be more fit than fish with gills?** (*The fish with lung structures could obtain oxygen from air. It could survive if the water dried up or the tide went out, leaving it on dry land.*) **Why would organisms able to reproduce on land be more fit than other organisms?** (*Organisms able to reproduce on land could survive in a more arid environment.*)

Verbal, Logical

Figure 9 Armor-plated fish were common during the Devonian period.

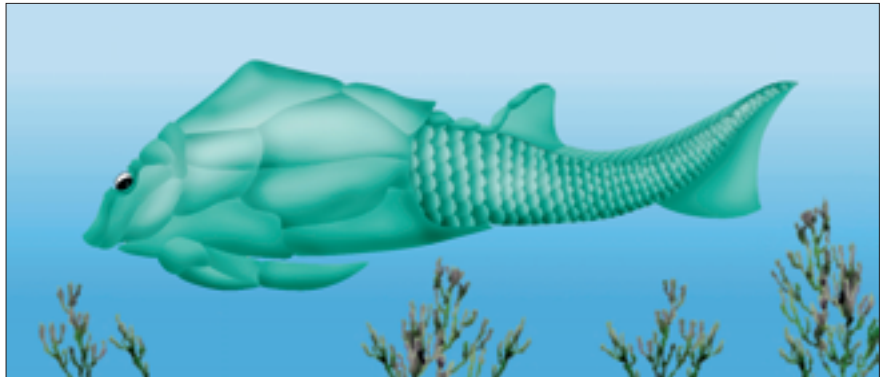
Inferring What steps were involved in the evolution of armor-plated fish into modern day fish?

Late Paleozoic Life During most of the late Paleozoic, organisms diversified dramatically. 🌱 **Some 400 million years ago, plants that had adapted to survive at the water's edge began to move inland, becoming land plants.** These earliest land plants were leafless vertical spikes about the size of your index finger. However, by the end of the Devonian, 40 million years later, the fossil record indicates the existence of forests with trees tens of meters high.

In the oceans, armor-plated fishes that had evolved during the Ordovician continued to adapt. Their armor plates thinned to lightweight scales that increased the organisms' speed and mobility, as shown in Figure 9. Other fishes evolved during the Devonian, including primitive sharks that had a skeleton made of cartilage and bony fishes—the groups to which virtually all modern fishes belong. Because of this, the Devonian period is often called the “age of fishes.”

By late Devonian time, several fish became adapted to land environments. The fishes had primitive lungs that supplemented their breathing through gills. Lobe-finned fish likely occupied tidal flats and small ponds. Through time, the lobe-finned fish began to use their lungs more than their gills. By the end of the Devonian period, they had developed lungs and eventually evolved into true air-breathing amphibians with fishlike heads and tails.

Modern amphibians, like frogs, toads, and salamanders, are small and occupy limited biological niches. However, conditions during the remainder of the Paleozoic were ideal for these newcomers to the land. Plants and insects, which were their main diet, already were very abundant and large. 🌱 **The amphibians rapidly diversified because they had minimal competition from other land dwellers.** Some groups took on roles and forms that were more similar to modern reptiles, such as crocodiles, than to modern amphibians.



374 Chapter 13

Facts and Figures

The lobe-finned fish that developed during the late Devonian may have used their bony fins to “walk” from dried-up pools in search of other ponds. As they moved farther across arid Pangaea to find water, a lobe-finned fish with an evolved lung structure would be more likely

to survive the trek. Eventually, these hardy survivors evolved into true amphibians. Some lobe-finned fish with only primitive lungs did manage to survive this difficult time, and these became today's fish. Today's fish still have primitive lungs in addition to gills.



The Great Paleozoic Extinction

Build Reading Literacy

L1

Refer to p. 446D in Chapter 16, which provides guidelines for sequencing.

Sequence As students read Late Paleozoic Life, ask them to create a flowchart showing how the “age of fishes” became the “age of amphibians.” (Sample answer: fish, the dominant life-form, developed primitive lungs and could stay on land longer → lobe-finned fish spent more and more time on land, so lobe-finned fish with stronger lungs were more likely to survive → lobe-finned fish lungs developed further, making them true air-breathing amphibians → with very little competition on land, amphibians took off as the dominant life-forms)

Visual, Verbal

By the Pennsylvanian period, large tropical swamps extended across North America, Europe, and Siberia. Trees approached 30 meters, with trunks over a meter across. The coal deposits that we use today for fuel originated in these swamps. See Figure 10. These lush swamps allowed the amphibians to evolve quickly into a variety of species.

The Great Paleozoic Extinction

The Paleozoic ended with the Permian period, a time when Earth’s major landmasses joined to form the supercontinent Pangaea. This redistribution of land and water and changes in the elevations of landmasses brought pronounced changes in world climates. Broad areas of the northern continents became elevated above sea level, and the climate became drier. These climate changes are believed to have triggered extinctions of many species on land and sea.

By the close of the Permian, 75 percent of the amphibian families had disappeared, and plants had declined in number and variety. Although many amphibian groups became extinct, their descendants, the reptiles, would become the most successful and advanced animals on Earth. Much of the marine life did not adapt and survive. At least 80 percent, and perhaps as much as 95 percent, of marine life disappeared. Many marine invertebrates that had been dominant during the Paleozoic, including all the remaining trilobites as well as some types of corals and brachiopods, could not adapt to the widespread environmental changes.

Figure 10 Model of a Pennsylvanian Coal Swamp
Shown are scale trees (left), seed ferns (lower left), and scouring rushes (right). Note the large dragonfly.

Earth’s History 375

Facts and Figures

Large bodies of water moderate the climate of nearby land areas. Since water heats and cools slower than land does, coastal areas that benefit from sea breezes are warmer in the winter and cooler in the summer. When all the continents merged to form Pangaea, many

areas that had been coastal became landlocked in the continent’s interior. Interior regions do not benefit from the moderating effects of large bodies of water. So these areas had much hotter summers and much colder winters.

Answer to . . .

Figure 9 The armor plates thinned and became light-weight scales, which increased the speed and mobility of the fish.

Section 13.2 (continued)

3 ASSESS

Evaluate Understanding

L2

Have students review with the class by putting them in cooperative groups to share the tables they created for the Reading Strategy in this section. Encourage students to modify their tables as needed based on discussion with their group.

Reteach

L1

Review the essential content of this section with students by using the geologic time scale on p. 365. This figure clearly shows the order of periods in the Paleozoic as well as the life-forms present during each period. Then use Figure 8 to review how landmasses moved during the late Paleozoic and how these movements would have affected life at that time.

Writing In Science

Answers should follow the logical progression of life described in the chapter, but should begin with late Paleozoic life (closer to the surface) and end with early Paleozoic life (deeper). Recommend that students use the geologic time scale on p. 365 or the table they created in this section to help them.

The late Paleozoic extinction was the greatest of at least five mass extinctions to occur over the past 500 million years. Each of the mass extinctions drastically changed the existing biosphere and wiped out large numbers of species. In each case, however, the survivors formed new biological communities that were more diverse than their predecessors. Thus, mass extinctions actually allowed life on Earth to flourish, as the few hardy survivors eventually filled more niches than the ones left by the victims.

The cause of the great Paleozoic extinction is uncertain. The climate changes from the formation of Pangaea and the associated drop in sea level undoubtedly stressed many species. In addition, at least 2 million cubic kilometers of lava flowed across Siberia to produce what is called the Siberian Traps. Perhaps debris from these volcanic eruptions blocked incoming sunlight, or perhaps enough sulfuric acid was emitted to make the seas virtually unfit to live in. Some recent research suggests that an impact with an extraterrestrial body may have contributed to the mass extinction. Whatever caused the late Paleozoic extinction, it is clear that without it a very different population of organisms would exist today.

Section 13.2 Assessment

Reviewing Concepts

1. 🗺️ What are the seven periods that make up the Paleozoic era?
2. 🗺️ Which present-day continents made up Gondwana, Laurasia, and Pangaea?
3. 🗺️ Which life forms dominated the early, middle, and late parts of the Paleozoic era?
4. 🗺️ What allowed amphibians to flourish on land?

Critical Thinking

5. **Comparing and Contrasting** Compare and contrast the life that existed at the beginning of the Paleozoic era with the life that existed at the end of the era.

6. **Applying Concepts** Explain how life made the transition from water to land.

Writing In Science

Descriptive Paragraph Imagine you are uncovering rocks and fossils from a site that was formed during the Paleozoic era. Write a paragraph describing what kinds of fossils you would expect to find as you dug from the surface and moved downward.

376 Chapter 13

Section 13.2 Assessment

1. Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, Permian
2. Gondwana—South America, Africa, Australia, Antarctica, India, and perhaps China; Laurasia—North America, Europe, western Asia; Pangaea—all the present-day continents
3. early—invertebrates; late—amphibians
4. Amphibians were able to colonize areas that other animals were not. The lack of competition for resources allowed amphibians to be successful.

5. Life at the beginning of the Paleozoic was mostly restricted to water. By the end of the Paleozoic, life had begun to inhabit land at a rapid pace.

6. Life moved onto land as plants developed seeds and other characteristics that allowed them to live without depending on water. Animals developed hard parts and ways to reproduce without standing water. Once some plants and animals were able to live on land, the lack of competition allowed them to grow and diversify rapidly.