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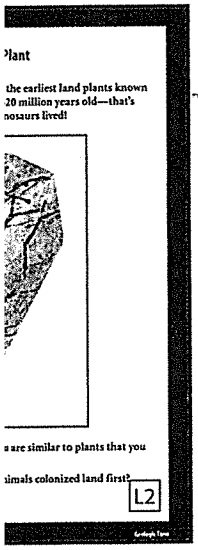


Knowledge

Ask students to ce they have been in a photo that is ith no plant or ani- may want to show aphs. Explain that ve looked like this d more than 4 bil-

section 2

Early Earth History

as you read

What You'll Learn

- **Identify** characteristic Precambrian and Paleozoic life-forms.
- **Draw** conclusions about how species adapted to changing environments in Precambrian time and the Paleozoic Era.
- **Describe** changes in Earth and its life-forms at the end of the Paleozoic Era.

Why It's Important

The Precambrian includes most of Earth's history.

Review Vocabulary

life: state of being in which one grows, reproduces, and maintains a constant internal environment

New Vocabulary

- Precambrian time
- cyanobacteria
- Paleozoic Era

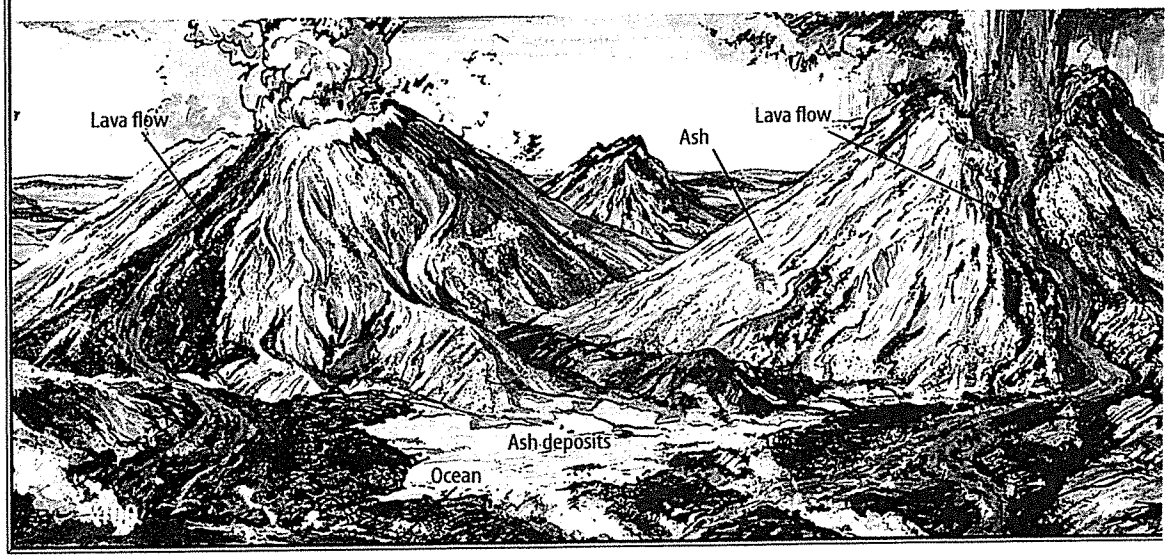
Precambrian Time

It may seem strange, but **Figure 12** is probably an accurate picture of Earth's first billion years. Over the next 3 billion years, simple life-forms began to colonize the oceans.

Look again at the geologic time scale shown in **Figure 2. Precambrian** (pree KAM bree un) **time** is the longest part of Earth's history and includes the Hadean, Archean, and Proterozoic Eons. Precambrian time lasted from about 4.5 billion years ago to about 544 million years ago. The oldest rocks that have been found on Earth are about 4 billion years old. However, rocks older than about 3.5 billion years are rare. This probably is due to remelting and erosion.

Although the Precambrian was the longest interval of geologic time, relatively little is known about the organisms that lived during this time. One reason is that many Precambrian rocks have been so deeply buried that they have been changed by heat and pressure. Many fossils can't withstand these conditions. In addition, most Precambrian organisms didn't have hard parts that otherwise would have increased their chances to be preserved as fossils.

Figure 12 During the early Precambrian, Earth was a lifeless planet with many volcanoes.



Section 2 Resource Manager

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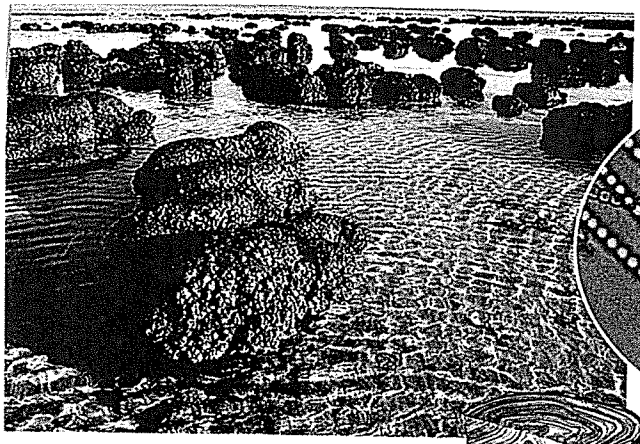
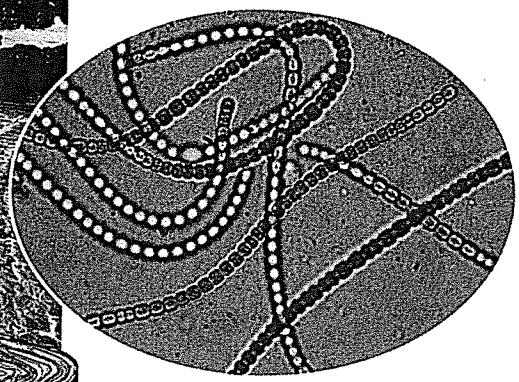
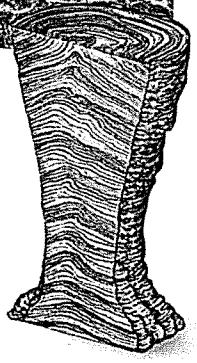


Stromatolites have changed little throughout geologic time. These modern ones in Australia look much like ancient stromatolites.



This is a microscopic view of cyanobacteria.



This cross section of a stromatolite head shows its layered appearance.

Figure 13 Cyanobacteria can produce layered mounds of sediment called stromatolites. The sticky surface of the cyanobacteria colony traps grains of sediment. The surface of the sediment then becomes colonized with cyanobacteria again, and the cycle repeats, producing the layers inside the stromatolite.

Early Life Many studies of the early history of life involve ancient stromatolites (stroh MA tuh lites). **Figure 13** shows stromatolites, which are layered mats formed by cyanobacteria colonies. **Cyanobacteria** are blue-green algae thought to be one of the earliest forms of life on Earth. Cyanobacteria first appeared about 3.5 billion years ago. They contained chlorophyll and used photosynthesis. This is important because during photosynthesis, they produced oxygen, which helped change Earth's atmosphere. Following the appearance of cyanobacteria, oxygen became a major atmospheric gas. Also of importance was that the ozone layer in the atmosphere began to develop, shielding Earth from ultraviolet rays. It is hypothesized that these changes allowed species of single-celled organisms to evolve into more complex organisms.

Reading Check *What atmospheric gas is produced by photosynthesis?*

Animals without backbones, called invertebrates (ihn VUR tuh brayts), appeared toward the end of Precambrian time. Imprints of invertebrates have been found in late Precambrian rocks, but because these early invertebrates were soft bodied, they weren't often preserved as fossils. Because of this, many Precambrian fossils are trace fossils.

INTEGRATE Chemistry

Earth's First Air Cyanobacteria are thought to have been one of the mechanisms by which Earth's early atmosphere became richer in oxygen. Research the composition of Earth's early atmosphere and where these gases probably came from. Record your findings in your Science Journal.

2 Teach

Discussion

Cyanobacteria How Earth be differe cyanobacteria had r oxygen for the pla phere? Animals as v would not have evolv depend on oxygen to li without the protection of it is likely that organisr them would not have evc

Reading Che

Answer oxygen

INTEGR Chemis

Earth's First Air Before to accumulate, Earth's at probably composed of w bon dioxide, and nitroge might have been in the o that formed Earth and I into the atmosphere d eruptions. They might a brought to Earth by com

P

Research Investigate Urey experiment. W phere did they assur Earth, and what wer to show? Miller and Ure methane, ammonia, and spark to produce amino advances have occ that experiment? Si ments with a more acc gases for early Earth have results. L2

LAB DEMONSTRATION

Purpose to show the importance of hard parts to fossil preservation

Materials flat pan, gelatin dessert, small seashells, board that fits inside the pan, clay

Procedure Place a layer of clay in the bottom of a flat pan. Sprinkle pieces of the gelatin dessert and the shells on top of the clay. Cover with a second clay layer. Apply pressure to the top layer of clay with the board. Peel away the top clay layer to expose the shell layer.

Expected Outcome Students observe that hard parts (shells) retain their shape and leave an imprint, but the soft gelatin is smashed and leaves no recognizab

Assessment

Compare what you observed in th ity with the formation of fossils. M form from hard parts of living organisms. parts do not become fossilized. L2

ng Check

aran organisms had
r to modern jellyfish,
t corals.

Mini LAB

lents use fossils to
ıe age of rock lay-
Visual-Spatial
tegy Suggest that
ce a chart that lists
during which each
ıuld have formed.

ıntains fossils A and B.
organisms lived
ring the Ordovician

/ one fossil in each
ıat fossil existed during
ıt periods.

nt
ıich rock layer is
Which is the
xplain. Layer 1 is old-
youngest; unless they
ırbed, the oldest layer is
ottom and the youngest
Use Performance
t in the Science
p. 89.

Mini LAB

Dating Rock Layers with Fossils

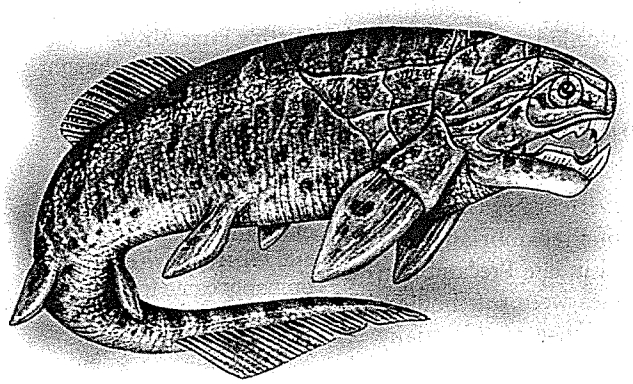
Procedure

1. Draw three rock layers.
2. Number the layers 1 to 3, bottom to top.
3. Layer 1 contains fossil A. Layer 2 contains fossils A and B. Layer 3 contains fossil C.
4. Fossil A lived from the Cambrian through the Ordovician. Fossil B lived from the Ordovician through the Silurian. Fossil C lived in the Silurian and Devonian.

Analysis

1. Which layers were you able to date to a specific period?
2. Why isn't it possible to determine during which specific period the other layers formed?

Figure 14 This giant predatory fish lived in seas that were present in North America during the Devonian Period. It grew to about 6 m in length.



Unusual Life-Forms A group of animals with shapes similar to modern jellyfish, worms, and soft corals was living late in Precambrian time. Fossils of these organisms were first found in the Ediacara Hills in southern Australia. This group of organisms has become known as the Ediacaran (ee dee uh KAR un) fauna. **Figure 15** shows some of these fossils.

Reading Check *What modern organisms do some Ediacaran organisms resemble?*

Ediacaran animals were bottom dwellers and might have had tough outer coverings like air mattresses. Trilobites and other invertebrates might have outcompeted the Ediacarans and caused their extinction, but nobody knows for sure why these creatures disappeared.

The Paleozoic Era

As you have learned, fossils are unlikely to form if organisms have only soft parts. An abundance of organisms with hard parts, such as shells, marks the beginning of the Paleozoic (pay lee uh ZOH ihk) Era. The **Paleozoic Era,** or era of ancient life, began about 544 million years ago and ended about 248 million years ago. Traces of life are much easier to find in Paleozoic rocks than in Precambrian rocks.

Paleozoic Life Because warm, shallow seas covered large parts of the continents during much of the Paleozoic Era, many of the life-forms scientists know about were marine, meaning they lived in the ocean. Trilobites were common, especially early in the Paleozoic. Other organisms developed shells that were easily preserved as fossils. Therefore, the fossil record of this era contains abundant shells. However, invertebrates were not the only animals to live in the shallow, Paleozoic seas.

Vertebrates, or animals with backbones, also evolved during this era. The first vertebrates were fishlike creatures without jaws. Armoured fish with jaws such as the one shown in **Figure 14** lived during the Devonian Period. Some of these fish were so huge that they could eat large sharks with their powerful jaws. By the Devonian Period, forests had appeared and vertebrates began to adapt to land environments, as well.

Differentiated Instruction

Learning Disabled and Visually Impaired Provide plastic, plaster, or clay models of important fossils of animals and plants that lived during the Paleozoic Era. Handling the fossils will help students picture these organisms' shapes, sizes, and external features. L1

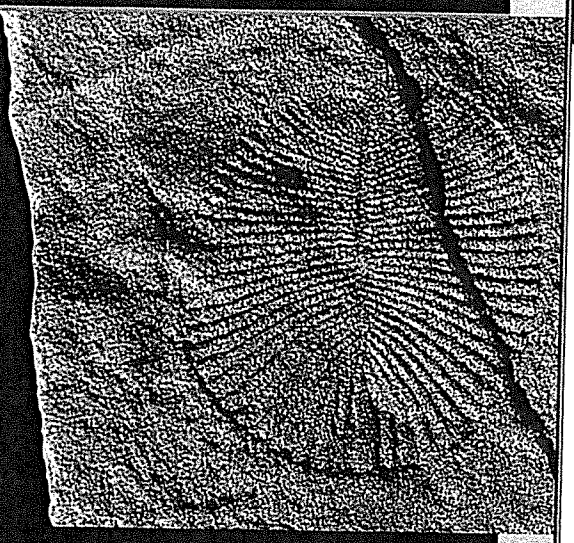
Teacher FYI

Ediacaran Fossils Fossils of Ediacaran organisms are so different from later organisms that the time when these organisms lived can be thought of as a distinct period, the Vendian. This period is the latest part of the Proterozoic Eon and occurred before the Cambrian Period of the Paleozoic Era.

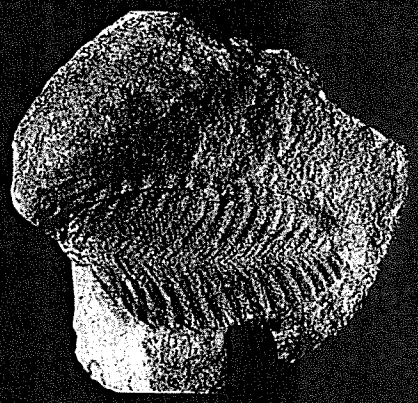
NATIONAL GEOGRAPHIC VISUALIZING UNUSUAL LIFE-FORMS

Figure 15

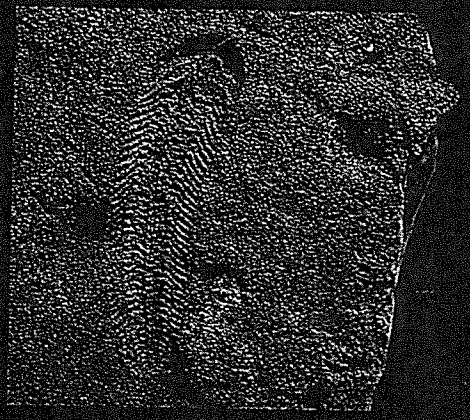
A variety of 600-million-year-old fossils—known as Ediacaran (eed ee uh KAR un) fauna—have been found on every continent except Antarctica. These unusual organisms were originally thought to be descendants of early animals such as jellyfish, worms, and coral. Today, paleontologists debate whether these organisms were part of the animal kingdom or belonged to an entirely new kingdom whose members became extinct about 545 million years ago.



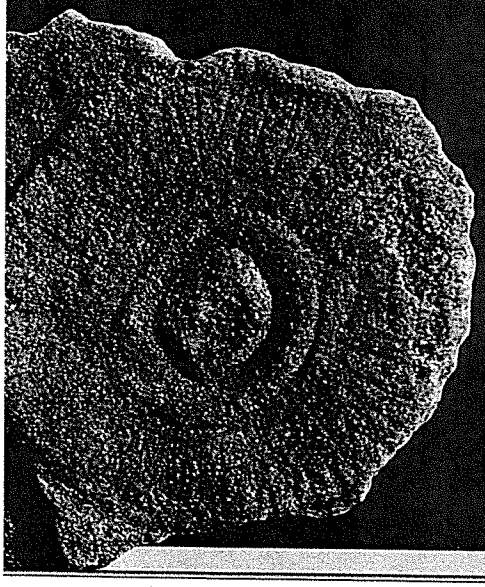
DICKENSONIA (dihk un suh NEE uh) Impressions of *Dickensonia,* a bottom-dwelling wormlike creature, have been discovered. Some are nearly one meter long.



RANGEA (rayn JEE uh) As it lay rooted in sea-bottom sediments, *Rangea* may have snagged tiny bits of food by filtering water through its body.



SPRIGGINA (sprih GIHN uh) Some scientists hypothesize that the four-centimeter-long *Spriggina* was a type of crawling, segmented organism. Others suggest that it sat upright while attached to the seafloor.



CYCLOMEDUSA (si kloh muh DEW suh) Although it looks a lot like a jellyfish, *Cyclomedusa* may have had more in common with modern sea anemones. Some paleontologists, however, hypothesize that it is unrelated to any living organism.

NATION GEOGRA

Visualizing U Life Forms

Have students e pictures and read t Then ask the followi

If Ediacaran faun bodied and did no skeletons or shells, they have been foss body shapes were probab quick burial by sand or o on the sea floor. L2

Activity

Ediacaran Fossils H groups of students r locations around where Ediacaran f been found and mark tions on a world ma group to select one l make an oral present the fossils found ther

ENTIFYING nceptions

ion Some students of sharks as having te recently because ring today. Explain nany other animals ıy, fossil evidence hat sharks evolved harks evolved dur- vonian Period, over ı years ago.

ng Check

s and leglike fins

tiry Lab

later

hat materials could design an egg that out of water?

terials clay, paper, aluminum foil, cloth,

me 1 class period

tegies

ıust retain water and exchange. Students to solve both prob- courage them to use a erials.

ents how this activity ıe evolution of eggs.

al inquiry activities, see *ry Labs.* L2

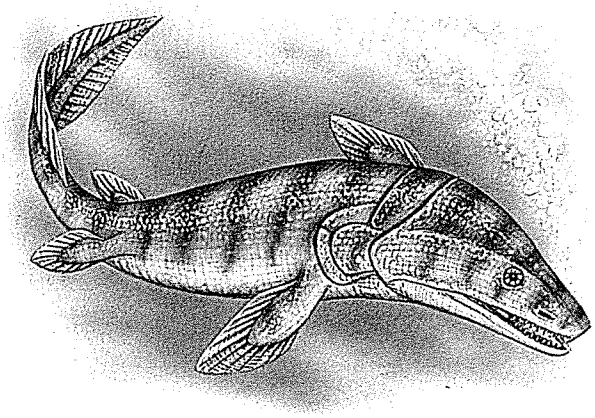


Figure 16 Amphibians probably evolved from fish like *Panderichthys* (pan dur IHK theez), which had leglike fins and lungs.

Life on Land Based on their structure, paleontologists know that many ancient fish had lungs as well as gills. Lungs enabled these fish to live in water with low oxygen levels—when needed they could swim to the surface and breathe air. Today's lungfish also can get oxygen from the water through gills and from the air through lungs.

One kind of ancient fish had lungs and leglike fins, which were used to swim and crawl around on the ocean bottom. Paleontologists hypothesize that amphibians might have evolved from this kind of fish, shown in **Figure 16.** The characteristics that helped animals survive in oxygen-poor waters also made living on land possible. Today, amphibians live in a variety of habitats in water and on land. They all have at least one thing in common, though. They must lay their eggs in water or moist places.

Reading Check ***What are some characteristics of the fish from which amphibians might have evolved?***

By the Pennsylvanian Period, some amphibians evolved an egg with a membrane that protected it from drying out. Because of this, these animals, called reptiles, no longer needed to lay eggs in water. Reptiles also have skin with hard scales that prevent loss of body fluids. This adaptation enables them to survive farther from water and in relatively dry climates, as shown in **Figure 17,** where many amphibians cannot live.

ScienceOnline

Topic: Paleozoic Life

Visit earth.msscience.com for Web links to information about Paleozoic life.

Activity Prepare a presentation on the organisms of one period of the Paleozoic Era. Describe a few animals from different groups, including how and where they lived. Are any of these creatures alive today, and if not, when did they become extinct?

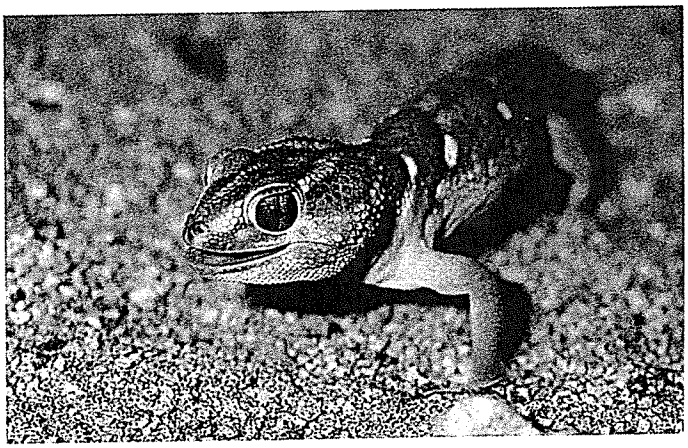


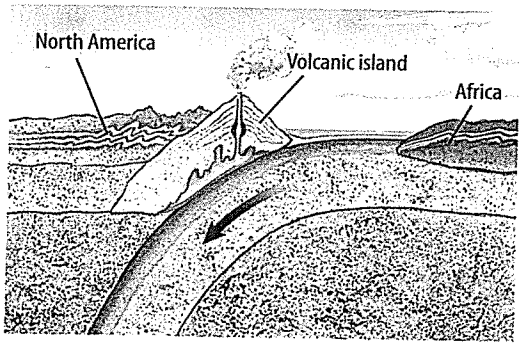
Figure 17 Reptiles have scaly skins that allow them to live in dry places.

Visual Learning

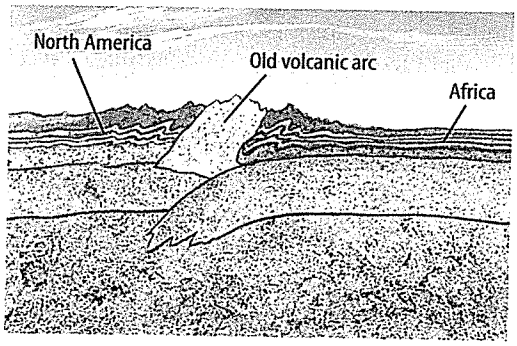
Figure 17 Have students list another characteristic of reptiles that allows them to live on land. Students should cite eggs with a membrane that keeps it from drying out. This membrane allows eggs to be laid on land instead of in the water. L2 **Linguistic**

Science Journal

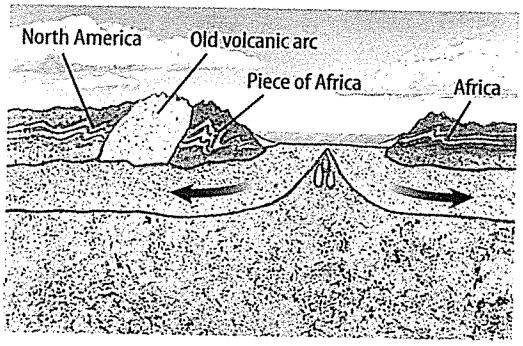
Extinctions Have students write reports on species that became extinct and causes of the extinctions that occurred at the ends of the Ordovician and Permian periods. Possible answers: Ordovician: species of graptolites, trilobites, brachiopods due to global cooling; Permian: >90% of marine species and 70% of land species due to several factors. L2



More than 375 million years ago, volcanic island chains formed in the ocean and were pushed against the coast as Africa moved toward North America.



About 375 million years ago, the African plate collided with the North American plate, forming mountains on both continents.



About 200 million years ago, the Atlantic Ocean opened up, separating the two continents.

Mountain Building Several mountain-building episodes occurred during the Paleozoic Era. The Appalachian Mountains, for example, formed during this time. This happened in several stages, as shown in **Figure 18.** The first mountain-building episode occurred as the ocean separating North America from Europe and Africa closed. Several volcanic island chains that had formed in the ocean collided with the North American Plate, as shown in the top picture of **Figure 18.** The collision of the island chains generated high mountains.

The next mountain-building episode was a result of the African Plate colliding with the North American Plate, as shown in the left picture of **Figure 18.** When Africa and North America collided, rock layers were folded and faulted. Some rocks originally deposited near the eastern coast of the North American Plate were pushed along faults as much as 65 km westward by the collision. Sediments were uplifted to form an immense mountain belt, part of which still remains today.

Figure 18 The Appalachian Mountains formed in several stages.
Infer *how these movements affected species in the Appalachians.*

Differentiated Instruction

Challenge Have students research the Pennsylvanian Period's swamps, where much of the coal used today was formed. Have students describe the process that must occur for plant remains to change into coal. Plant material must collect under water or be buried quickly in the absence of air so that the material's carbon content is not lost. Over time, with pressure and heat, the material increases in hardness, and carbon is concentrated. Plant material changes from peat to lignite to bituminous coal and finally to anthracite coal. L2 L3

Discussion

Mountain Formation ical-features map students. Remind the Appalachians the east coast of N Why aren't they today? Possible answ deposition have extend the mountains and the sea level has uncovere once sea bottom. L2

Activity

Fossil Field Trip Tak a field trip to an Paleozoic Era roc school. Show the where to look for students take pho sketches of the fos the classroom, have to identify the fossil If no exposure exis of Paleozoic age or science supply ho the labeled fossils in **Visual-Spatial**

Caption Answer

Figure 18 Local climate causing the extinction species that were not ada

Quick Demo

Soft-bodied Fossils

Materials gummi v clay, plaster of paris

Estimated Time 10 m

Procedure Place a l clay in a shallow gummi worms into an impression. Co layer of plaster of p plaster dries, it sh behind impressions c Compare this to the Ediacaran fauna. P second tray with beforehand will allo to proceed without w to dry.

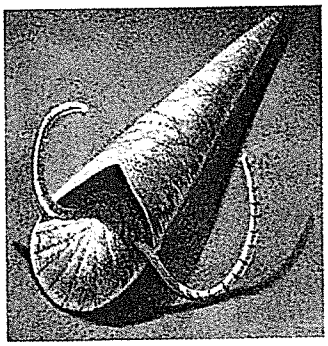


Figure 19 Hyoliths were organisms that became extinct at the end of the Paleozoic Era.

End of an Era At the end of the Paleozoic Era, more than 90 percent of all marine species and 70 percent of all land species died off. **Figure 19** shows one such animal. The cause of these extinctions might have been changes in climate and a lowering of sea level.

Near the end of the Permian Period, the continental plates came together and formed the supercontinent Pangaea. Glaciers formed over most of its southern part. The slow, gradual collision of continental plates caused mountain building. Mountain-building processes caused seas to close and deserts to spread over North America and Europe. Many species, especially marine organisms, couldn't adapt to these changes, and became extinct.

Other Hypotheses Other explanations also have been proposed for this mass extinction. During the late Paleozoic Era, volcanoes were extremely active. If the volcanic activity was great enough, it could have affected the entire globe. Another recent theory is similar to the one proposed to explain the extinction of dinosaurs. Perhaps a large asteroid or comet collided with Earth some 248 million years ago. This event could have caused widespread extinctions just as many paleontologists suggest happened at the end of the Mesozoic Era, 65 million years ago. Perhaps the extinction at the end of the Paleozoic Era was caused by several or all of these events happening at about the same time.

section 2 review

Summary

Precambrian Time

- Precambrian time covers almost 4 billion years of Earth history, but little is known about the organisms of this time.
- Cyanobacteria were among the earliest life-forms.

The Paleozoic Era

- Invertebrates developed shells and other hard parts, leaving a rich fossil record.
- Vertebrates—animals with backbones—appeared during this era.
- Plants and amphibians first moved to land during the Paleozoic Era.
- Adaptations in reptiles allow them to move away from water for reproduction.
- Geologic events at the end of the Paleozoic Era led to a mass extinction.

Self Check

1. **List** the geologic events that ended the Paleozoic Era.
2. **Infer** how geologic events at the end of the Paleozoic Era might have caused extinctions.
3. **Discuss** the advance that allowed reptiles to reproduce away from water. Why was this an advantage?
4. **Identify** the major change in life-forms that occurred at the end of Precambrian time.
5. **Think Critically** How did cyanobacteria aid the evolution of complex life on land? Do you think cyanobacteria are as significant to this process today as they were during Precambrian time?

Applying Skills

6. **Use a Database** Research trilobites and describe these organisms and their habitats in your Science Journal. Include hand-drawn illustrations and compare them with the illustrations in your references.

Science Online earth.msscience.com/self_check_quiz

section 2 review

1. mountain building, continental movement, closure of seas, spread of deserts
2. Mountain building caused seas to close and deserts to spread over wide areas. Many species, especially marine organisms, could not adapt to these changes.
3. The development of a membrane-encased egg allowed reptiles to reproduce away from water. This allowed these animals to live in a greater variety of habitats than their amphibian ancestors.
4. The first invertebrates appeared in Earth's oceans.
5. They produced oxygen, which helped make Earth's atmosphere suitable for most animal life and helped develop Earth's protective ozone shield; no.
6. Trilobites are marine invertebrates. Descriptions should provide basic information about the appearance, habitat, and habits of these animals.