Chapter 3

Introducing Earth

Earth is an enormous system. Studying such a large system can be difficult. Through observations, scientists have come up with techniques to make the study of Earth easier. A couple of techniques that you will learn about in this chapter are relative dating and tree-ring dating. Scientists also use maps to study Earth. Look at a map of your town. What conclusions can you draw about Earth's surface and geology from that map?

? Key Questions

1. *How is the Grand Canyon like a history book?*
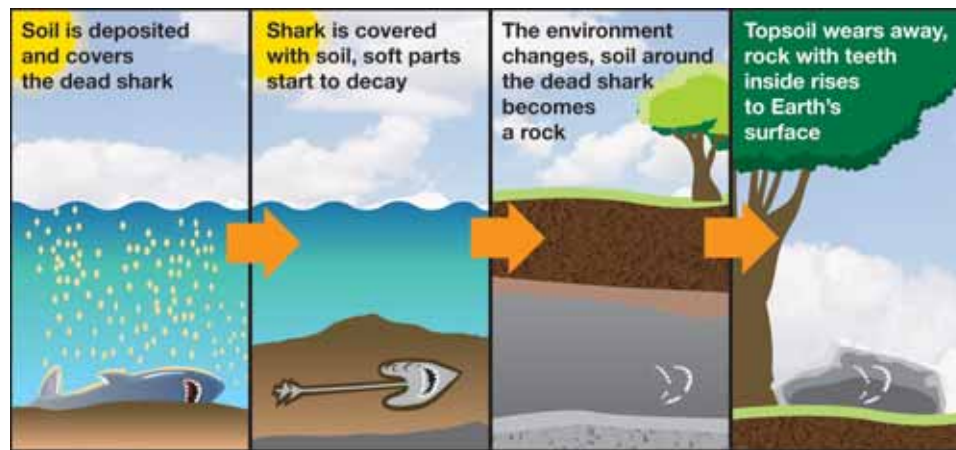
2. *How old is Earth?*

3. *What is a topographic map?*

3.1 Observing Earth

You have learned about systems and how they are used in experiments. In this book you will learn about Earth, a huge system! Earth science is a large field of science that includes **geology**, the study of rocks and rock formations (Figure 3.1). This section is about geology and the scientific methods used to study it.
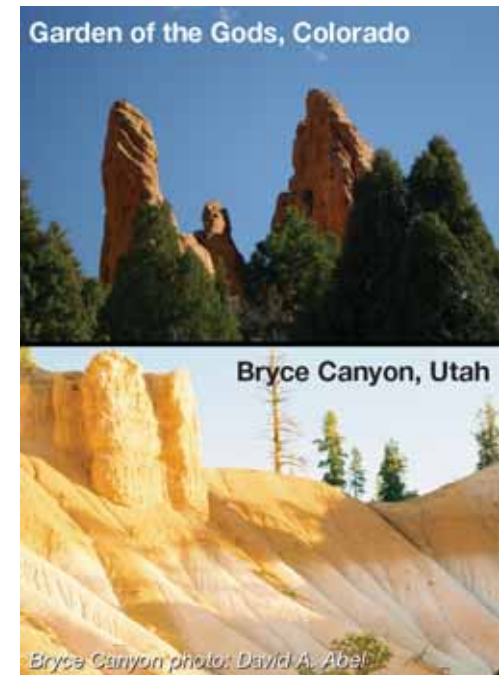
The beginnings of geology

Shark's teeth In 1666, Nicolas Steno, a Danish anatomist, studied a shark's head and noticed that the shark's teeth resembled mysterious stones called "tonguestones" that were found inside of local rocks. At that time, people believed that tonguestones had either fallen from the moon, or that they grew inside the rocks. Steno theorized that tonguestones looked like shark's teeth because they actually *were* shark's teeth that had been buried and became fossils!

How did teeth get inside a rock? Steno realized that when an animal dies it is eventually covered by layers of soil. The animal's soft parts decay quickly, but bones and teeth do not. Over a long period of time, the soil around the dead animal becomes rock with the bones and teeth inside.

Figure 3.1: *Examples of rock formations*

Relative dating

What is relative dating?

Steno's thoughts and observations helped him develop ideas about how rocks and fossils form. His ideas are used today in the study of geology as a technique called relative dating. **Relative dating** is a method of putting events in the order in which they happened.

Relative dating is used by geologists as they study rock formations, and also by scientists called *paleontologists* who study and identify fossils. A **fossil** is a part of a dead animal or plant that has been preserved for a long time.

How is relative dating used?

Relative dating can be used to determine the general age of a rock, rock formation, or fossil. Relative dating does not try to determine the exact age of an object, but instead uses clues to figure out the order of events over time. A simple example of relative dating is presented in Figure 3.2. Which event occurred first?

The present explains the past

Like Steno, Scottish geologist James Hutton (1726–1797) was an important figure in the development of modern geology. Hutton believed that if you understand processes that are happening now, you can use that knowledge to explain what happened a long time ago. The short form of his idea is: *The present explains the past.*

For example, think of the last time it rained really hard. What happened to the ground? You might have seen small rivers of water washing away soil. When the rain stopped, there may have been grooves left behind by the rivers of rain. The way water affects the land is seen every time it rains. We can use the observations that we make in the present to figure out how the Grand Canyon was formed in the past! The Grand Canyon was formed by the Colorado River (see next page).

VOCABULARY

relative dating - a method of putting events in the order in which they happened.

fossil - a part of a dead animal or plant that has been preserved for a long time.
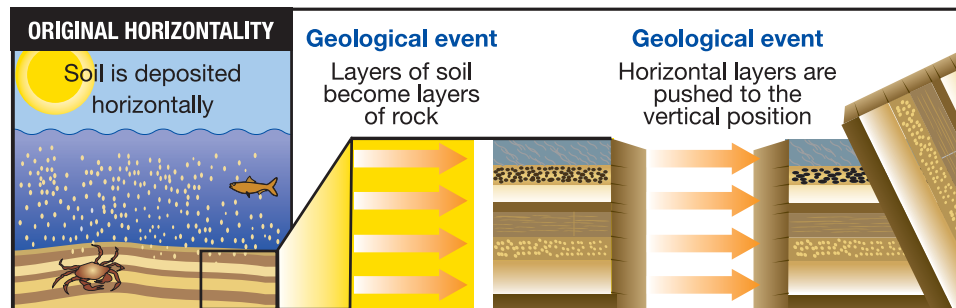
Snow depth
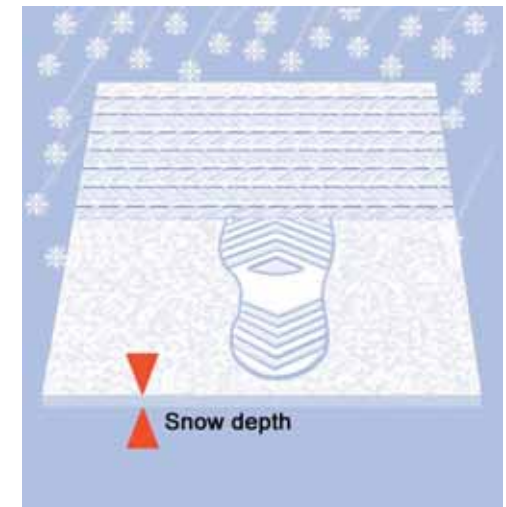
Figure 3.2: *This graphic illustrates three events: a footstep, a tire track, and snowfall. Which event happened first? Sequencing these events in the correct order is a form of relative dating.*
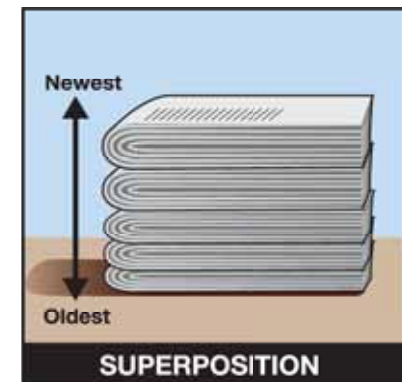
Steno's ideas

Steno's ideas for relative dating include superposition, original horizontality, and lateral continuity. These ideas help identify the clues you need to put events in the order in which they happened.

What is superposition? *Superposition* means that the bottom layer of a rock formation is older than the layer on top, because the bottom layer formed first. A stack of old newspapers illustrates superposition (Figure 3.3).
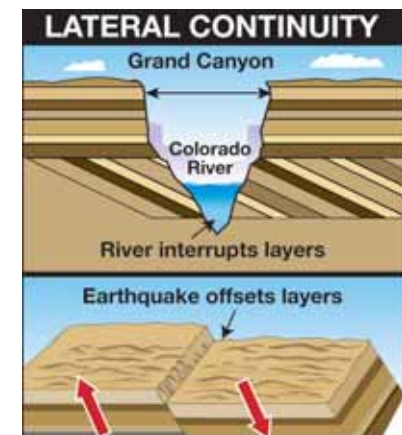
Original horizontality Sediment particles fall to the bottom of a body of water, such as a riverbed, in response to gravity. The result is horizontal layers of sediment. Over time, these layers can become layers of rock. Sometimes rock layers are found in a vertical position. Steno realized that movements of the Earth could slowly move horizontal rock layers into a vertical position. This theory is called *original horizontality*.

Figure 3.3: *A stack of old newspapers illustrates superposition. The oldest newspaper is usually on the bottom of the stack.*

Lateral continuity *Lateral continuity* is the idea that when layers of sediment are formed, they extend in all directions horizontally. Subsequently, a separation may be caused by erosion or an earthquake. The Colorado River created the gap that is now the Grand Canyon. If you were to compare rock layers in the Grand Canyon, you would find that the layers on one side of the canyon match up with the layers on the other side (Figure 3.4).

**Figure 3.4:** *Layers of rock are continuous unless a river interrupts the layers or an earthquake moves them.*

More relative dating

Cross-cutting relationships
The theory of *cross-cutting relationships* states that a vein of rock that cuts across a rock's layers is younger than the layers. Figure 3.5 shows a rock formation with three layers and a cross-cutting vein. The rock layers formed first. The vein formed when melted rock oozed into a crack in the original rock, cutting across the layers. Then the melted rock solidified. The bottom layer is the oldest part of the rock formation and the vein is the youngest. The middle and top layers formed after the bottom layer but before the vein.

Inclusions
Sometimes rock pieces called *inclusions* are found inside another rock. During the formation of a rock with inclusions, sediments or melted rock surrounded the inclusion and then solidified. Therefore, the inclusions are older than the surrounding rock (Figure 3.5). A rock with inclusions is like a chocolate chip cookie. The chocolate chips (inclusions) are made first. Then they are added to the batter (melted rock or sediment) before being baked (hardened) into a cookie (rock).

Faunal succession
Faunal succession means that fossils can be used to identify the relative age of the layers of a rock formation (Figure 3.6). For example, dinosaur fossils are found in rock that is about 65 to 200 million years old because these animals lived that long ago. The fossils of modern human beings (*Homo sapiens*) are found in rock that is about 40,000 years old, but not in rock that is 65 to 251 million years old. And dinosaur fossils are not found in rock that is 40,000 years old. This means that human beings did not live at the same time as the dinosaurs. How might you learn which plants and animals *did* live at the same time as the dinosaurs?
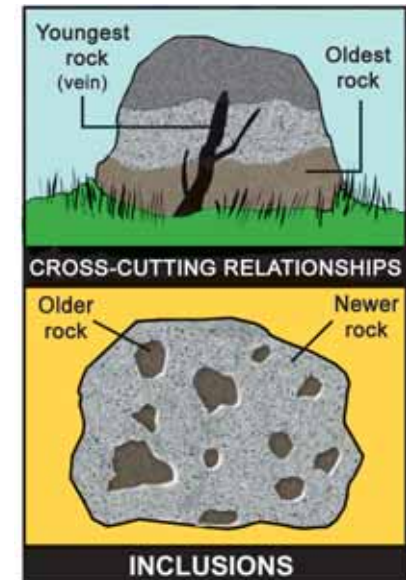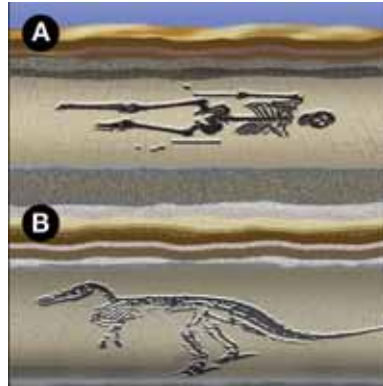

Figure 3.5: *Cross-cutting relationships and inclusions.*
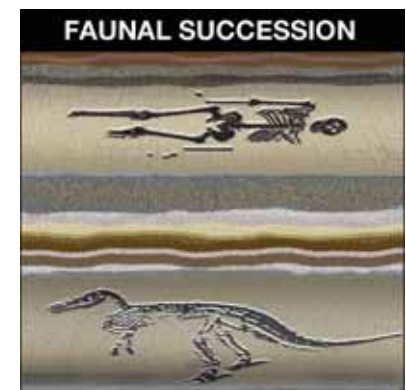
Figure 3.6: *Faunal succession.*

3.1 Section Review

1. Who is Nicolas Steno? What ideas did he come up with that have contributed to modern geology?

2. How are a vein of rock and an inclusion similar? How are they different? Describe a vein and an inclusion in your answer.

3. What idea is represented in the figure at the right? Which organism is oldest? Which is youngest? How can you tell?

4. True or False: Superposition states that rock layers near the surface of Earth are younger than rock layers further from the surface. Explain your reasoning.

5. How is the Grand Canyon like a history book?

6. Study the following picture. Which is the oldest layer of rock? Which layer is the youngest?

3.2 Geologic Time

When we talk about Earth's history, we use the term "geologic." The geologic time scale is a model of Earth's history. In this model, time is divided into eras and periods. Figure 3.7 includes pictures of organisms and events that characterize the periods. How old do you think Earth is? In this section you will learn about Earth's age and how it was determined.

The geologic time scale

Precambrian era The Precambrian era lasted from 4,570 to 542 million years ago (mya). During this earliest time, layers of rock formed the Grand Canyon and only single-celled organisms lived on Earth.

Paleozoic era The Paleozoic era lasted from 542 to 251 mya. During the Cambrian period many new, complex life forms developed, but glaciers covered the Earth in the Ordovician period, causing many of these new organisms to become extinct. Fish, reptiles, and amphibians developed during the rest of the Paleozoic era.

Mesozoic era The Mesozoic era lasted from 251 to 65 mya. At the beginning of this era, Earth's continents were connected in one "supercontinent" called *Pangaea*. During the Triassic period, pieces of Pangaea moved apart. The Jurassic period was marked by the dinosaurs and the appearance of the first birds. During the Cretaceous period, the Rocky Mountains in the western part of the United States formed. Flowering plants also evolved during the Cretaceous period.

Cenozoic era The Cenozoic era began 65 mya and is still going on. A giant meteor hit Earth at the beginning of the Tertiary period. Scientists believe this event may have ended the existence of the dinosaurs. Modern humans appeared 40,000 years ago during the Quanternary period.
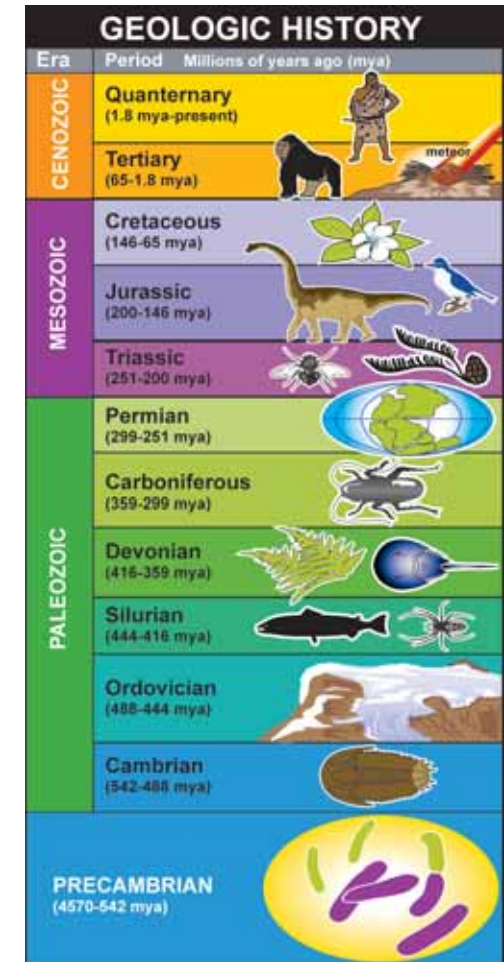
Figure 3.7: *Earth's geologic history.*

The age of Earth

An early calculation William Thomson Kelvin (1824–1907), was a physicist who did important work in the study of temperature. In 1862, Kelvin calculated Earth's age to be between 10 million and 100 million years. His calculations were based on his belief that Earth was once a "red-hot globe" and his prediction of how long it took for the Earth to cool enough to sustain life as we know it.

Radioactive decay Lord Kelvin's calculations were proven incorrect in the early 1900s, when the concept of radioactive decay was discovered. **Radioactive decay** refers to how unstable atoms lose energy and matter over time. As a result of radioactive decay, an element turns into another element over a period of time. An **element** is a substance composed of only one kind of atom. For example, uranium is a radioactive element that decays in several steps, eventually becoming lead, a stable, nonradioactive element.
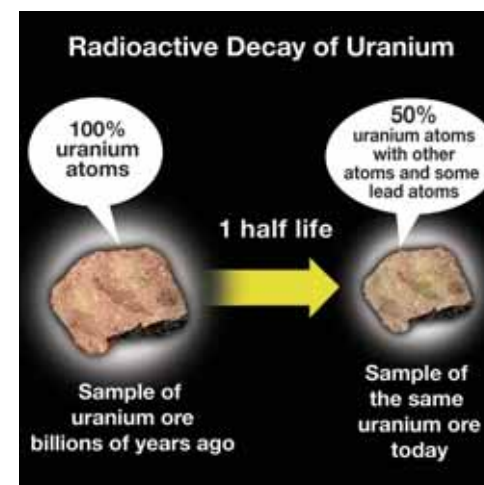
The half-life of uranium Scientists know that it takes 4.5 billion years for one half of the uranium atoms in a specimen to turn into lead. We say that 4.5 billion years is the *half-life* for the radioactive decay of uranium (Figure 3.8).When scientists study rocks that contain uranium, they can determine a rock's age by the ratio of uranium to lead atoms found in the sample. Understanding radioactive decay has allowed scientists to accurately determine the age of rocks and fossils found on Earth.

Earth is around 4.6 billion years old The oldest rocks found on Earth so far are around 4 billion years old. Scientists can't determine Earth's exact age by dating Earth's rocks because the oldest rocks have been destroyed. But scientists have found moon rocks and meteorites that are around 4.6 billion years old, and since it is believed Earth was formed at the same time as the rest of the solar system, that would make Earth around 4.6 billion years old as well.

Figure 3.8: *The radioactive decay of uranium to lead. Radioactive decay is measured in half-lives. After one half-life, 50% of the atoms have decayed.*
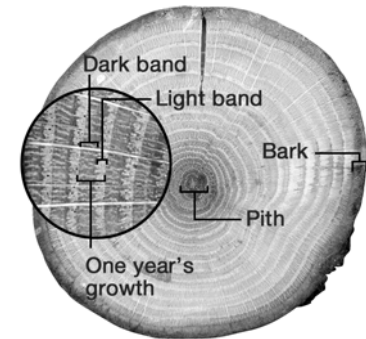
Learning from trees

One tree ring equals one year

Have you ever looked at a tree stump or a log of wood? You may have noticed that the wood forms circular layers. These layers are called *tree rings*. For pine trees, one tree ring includes two bands—one light and one dark. A tree grows one tree ring for every year that it is alive (Figure 3.9).
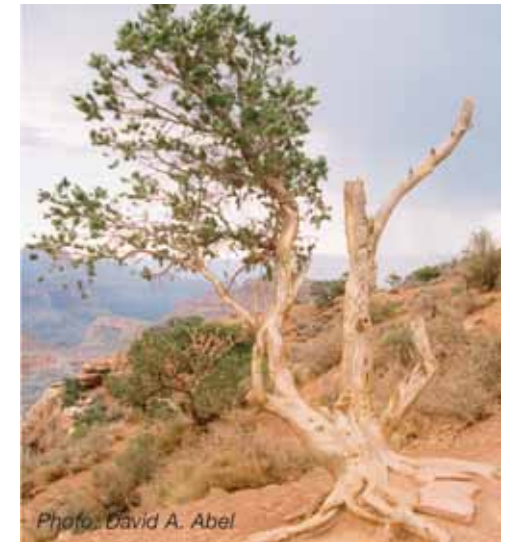

Figure 3.9: *A cross-section of a tree shows tree rings. Each ring is composed of two bands—a dark and a light band. One tree ring equals one year's growth.*

Very old trees

The oldest tree that we know about, a bristlecone pine called "Methuselah," is 4,765 years old. It is located in the White Mountains of California. A bristlecone pine is pictured in Figure 3.10. Redwood trees, the world's tallest trees at about 300 feet tall, are found in California and can live to be 2,000 years old. This means that there are some trees that have been living on Earth for longer than any human being or animal!

Trees are like history books. Each tree ring is a record of what the environment was like that year. For example, even though no one living today was around in the 1800s, we can guess what the environment might have been like back then by studying a 200-year-old tree.

Tree-ring dating

Andrew Douglass (1867–1962) was an astronomer who discovered the significance of tree rings. In the early 1900s, Douglass hypothesized that trees might record what Earth's climate was like in the past. He began to test his hypothesis by recording the tree rings of pines and Douglas firs and eventually sequoia trees. By 1911, he had proven that trees within a similar area had matching tree ring patterns. Wide tree rings indicated a very wet year and narrow rings indicated a dry year. Douglass named this new field of science *dendrochronology* (tree-ring dating). Douglass founded the Tree-Ring Research Laboratory at the University of Arizona in 1937.

**Figure 3.10:** *A bristlecone pine.*

3.2 Section Review

1. How old is Earth? What methods have scientists used to determine this?

2. Which answer is correct? During the Precambrian era:

   a. Human beings lived and thrived.

   b. Dinosaurs became extinct.

   c. Only single-celled organisms lived.

   d. Flowering plants evolved.

3. List two events of the Mesozoic era.

4. How much uranium is left if a solid piece goes through:

   a. one half-life?

   b. two half-lives?

5. If a tree has 25 rings, how old is it?

6. Figure 3.11 shows cross-sections from two trees that grew in different environments.

   a. The trees were the same age when they were cut. How old are these trees?

   b. Write a description that explains the wet and dry conditions for each tree during each year of its lifetime.

7. Research bristlecone pines. What kind of environment do they live in? Where do you find bristlecone pines? Are they all over the world or just in certain locations?

CHALLENGE

Earth has been in existence for 4.6 billion years. Many changes have occurred in its geology, climate, and in the organisms that have lived here during this time.

Since there have been so many changes, scientists have divided the 4.6 billion years of Earth's existence into 4 eras. Each era is different in length. Construct a timeline of Earth's history including all 4 eras. Your timeline must be drawn to scale, accurately representing the amount of time for each era. Use Figure 3.7 to help you make your timeline.

A)   B)
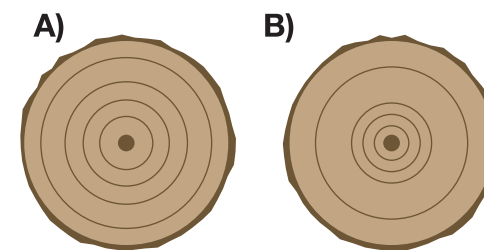
Figure 3.11: *Cross-sections of two trees.*

3.3 Mapping Earth

A **map** is a representational drawing of a location. You may be familiar with road maps or state maps. On a local weather report, you might see a map of the United States. There are also world maps. In this section, you will learn about two kinds of maps that represent the surface of the Earth: topographic and bathymetric maps.
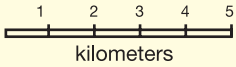
Elevation and depth

Mapping concepts

Before learning about topographic and bathymetric maps, we need to review a few concepts that are used to make these maps. These concepts are elevation, depth, and scale of maps.

Elevation

Elevation means the height of an object measured from a reference level. Usually the reference level that is used on maps is called sea level. **Sea level** is an average level of the ocean (Figure 3.12).

Depth

The depth of rivers, lakes, and oceans is important information for certain maps. The depth of these features is compared to sea level.

Scale of maps

The *scale* of a map helps you relate the small distances on the map to the larger real-life distances. There are three kinds of map scales. A *fractional scale* shows the ratio of the map distance to the real-life distance as a fraction. The scale 1/100,000 means that 1 unit on the map is equal to 100,000 units in real life. A *verbal scale* expresses the relationship in words, "1 centimeter is equal to 1 kilometer." A bar scale is simply a bar drawn on the map with the size of the bar equal to a distance in real life.

Types of map scales

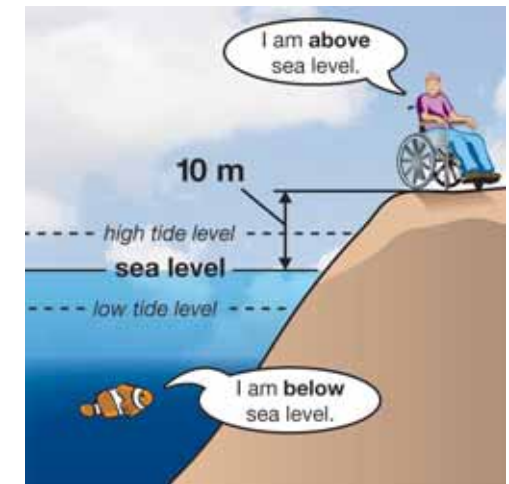| Fractional	Verbal	Bar
1/1,000,000	1 cm = 1 km	1 2 3 4 5 kilometers

Figure 3.12: *Elevation and sea level. You may know that oceans experience tides—sea level is the halfway point between high tide and low tide.*

Topographic maps

What is a topographic map?

A topographic map is a map that shows elevation. Since a map is often a flat piece of paper, you may wonder how you can show a mountain on a map. **Topographic maps** use special lines called contour lines to show mountains and other land features.

Contour lines

Contour lines indicate all points where the elevation is the same. The zero contour line on a topographic map indicates sea level (Figure 3.13). A 100-meter contour line indicates points that are 100 meters above sea level.

Direction and map symbols

Maps show direction—north, south, east, and west. An example of the direction symbol you might see on a map is shown at the left. A **legend** is a special area on the map that lists the symbols that are used. Topographic maps (and bathymetric maps) use a range of symbols to show contour lines, rivers and lakes, roads and train tracks, airports, types of plants, buildings, and many other things.

North

West ⊕ East

South
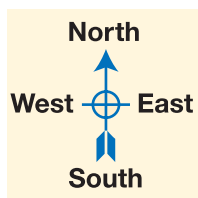
Topographic contour	6000	River	
Bathymetric contour		Lake	
Campground	▲	Highway	
Railroad track	—+——+——+—	Woodland	

National Map Accuracy Standards

The United States Geological Survey (USGS) publishes about 57,000 topographic maps of the United States. These maps are drawn according to the National Map Accuracy Standards. The standards define accurate measurements for map making so that any map you read can be compared to another map. The scales of most USGS topographic maps are 1:24,000, 1:100,000, 1:250,000, or 1:500,000.

Figure 3.13: *The 0 contour line is always at sea level.*

Making a topographic map

Drawing contour lines

To understand how to add contour lines to a topographic map, imagine you have a shape in a box that you will fill with water. The shape will represent an island. The starting level of water in the box equals zero or sea level. You will add water to the box four times. Each time will represent a water level increase of 10 meters.
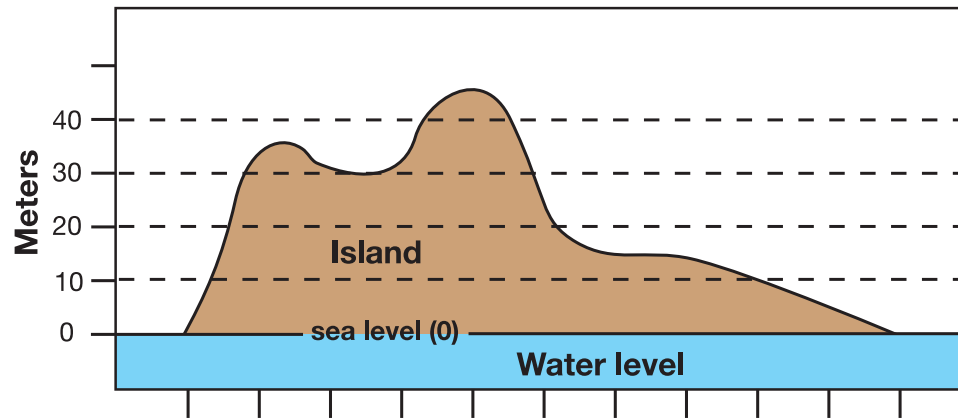

1

0 contour line

2

0 and 10 contour lines

What does the map look like?

Figure 3.14 illustrates how contour lines are used to make a topographic map. The first line—the 0 contour line—shows the outline of the island when the water is at sea level. At the 10-meter mark, the outline of the island is smaller and lies inside the 0-meter contour. On the right side of the map, the space between the 10- and 20-meter contour is wider than on the left. This shows that the right side of the island is not as steep as the left side. When contour lines are close together, you know that the land is steep. When contour lines are farther apart, the land is not as steep—it slopes gradually. Only the highest of the two peaks is shown on this topographic map. The second peak is less than 40 meters high but taller than 30 meters. We would need a contour line at 35 meters to see this peak.

3
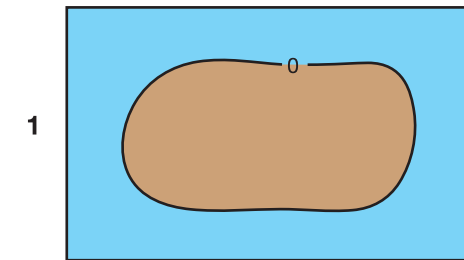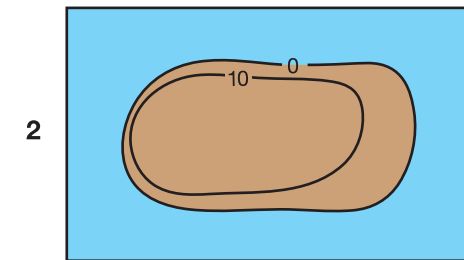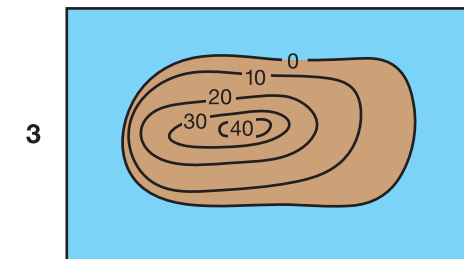
Topographic map of the island

Figure 3.14: *Drawing contour lines to make a topographic map. Note that the space between the 10- and 20-meter contour is narrower on the left than the right. This shows that the left side of the island is steeper.*

Bathymetric maps

What is a bathymetric map?

A **bathymetric map** shows the depths of a body of water such as a lake or an ocean. Bathymetric maps use contour lines to show depth (Figure 3.15). However, depth can also be shown using color. The map below shows land elevation and ocean depth using color.

Longitude and latitude

The bathymetric map below has numbers on the top, sides, and bottom. These numbers are part of a grid system that helps describe locations on Earth. There are two starting places for this grid. The **equator** is an imaginary line around Earth's middle and between the north and south poles. The **prime meridian** is an imaginary line that goes through Greenwich, England, and is perpendicular to the equator.

Latitude lines are north or south of the equator (the zero line) and run east-west (left to right on the map below). **Longitude** lines (or meridians) are east or west of the Prime meridian (the zero meridian) and run north-south (top to bottom on the map below). Both latitude and longitude lines are measured in degrees. The star on the map indicates the location of the Hawaiian volcano, Mauna Loa: Latitude 19.5° north, Longitude 155.5° west.
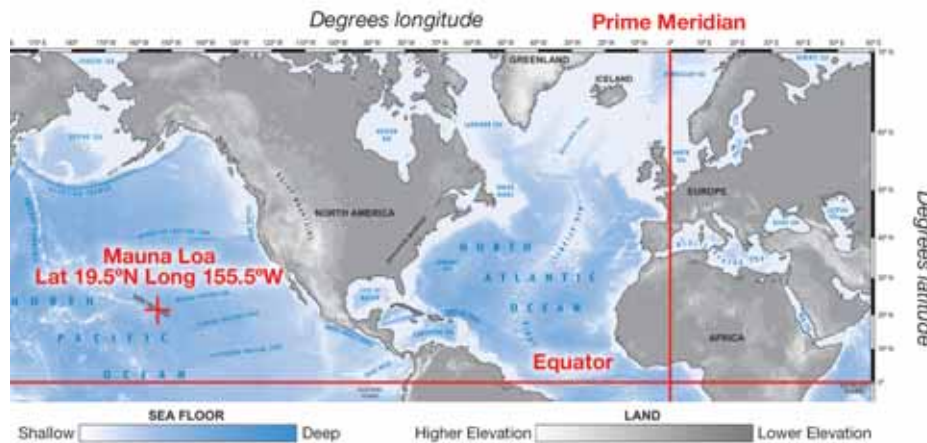
VOCABULARY

bathymetric map - a map that shows the depths of a body of water such as a lake or an ocean.

equator - an imaginary line around Earth's middle and between the north and south poles.

prime meridian - an imaginary line through Greenwich, England and perpendicular to the equator.

latitude - east-west lines that are north or south of the equator.

longitude - north-south lines that are east or west of the prime meridian.

Bathymetric map of a lake Depth in meters
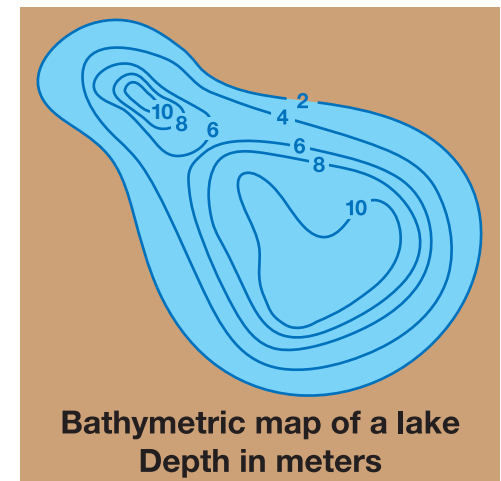
Figure 3.15: *A bathymetric map of a lake. Where is the lake the deepest? Where is the lake the shallowest?*

3.3 Section Review

1. Answer the following questions using the map below.
   a. Using the two-lane road, how many kilometers is it from point A to point B?
   b. Which point is the furthest east on the map?
   c. Which map location would have no cars?

Study your town's location on several maps. Use a world map, a country map, a state map, and a topographic map.

- In what hemisphere is your town?
- What is the latitude and longitude of the town in which you live?
- In what area of the state is your town located? (north, south, east, west, etc.)
- How far is your town from the nearest state border? What direction is this border from your town?
- What other towns are directly surrounding your town? What direction are each of these towns from your town?
- What is the elevation of the town in which you live?

1 cm = 1 km

• • • • • • • foot trail

━━━━ highway

──── two-lane road

2. On what kind of maps are contour lines found? What are contour lines?
3. What information does a map legend give you?
4. Match these islands (A, B, and C) with their topographic map.
5. Compare and contrast bathymetric and topographic maps.
6. The scale of a topographic map is 1:24,000 which means one centimeter on the map equals 24,000 centimeters on land. How many kilometers is 24,000 centimeters?
7. What is the difference between latitude and longitude lines?

A.   1.

B.   2.

C.   3.

It's All in the Rings

How old are you? Can you think of how you changed between your last two birthdays (other than to add a candle to your cake, that is)? As children grow, they get taller, or more muscular, or acquire other characteristics that indicate they are getting older. Trees get older and taller each year, too, and their years are marked by growth rings. *Dendrochronologists* are scientists who study tree rings to date past events. By studying the rings, they can tell how old the wood is to the exact year. Imagine finding trees that are 500, 1,000, or even more than 4,000 years old!

Tree rings

Generally, trees growing in mild climates produce one growth ring per year. Tree-ring growth is affected by rainfall, temperature, and nutrients in the soil. Trees that grow under good conditions have wide ring growth. Those growing under poor conditions produce narrow rings. Each tree ring typically represents an annual growth cycle.

One growth ring

However, counting tree rings to determine a tree's age is not enough. Occasionally, a tree may grow more than one ring or none at all over a year. Dendrochronologists use cross-dating (matching patterns among tree samples) to make sure dates are accurate. This means studying 20 or more trees of the same species growing under similar conditions.

Bristlecone pines—the oldest living trees

Conifers are cone-bearing, needle trees that are often chosen for research. Fir and pine trees are easy to work with because they have clear rings and they grow quite old. Some trees, such as maples and oaks, may live 250 years. But conifers may live thousands of years.

Bristlecone Pine

Bristlecone pines are the oldest living trees on Earth. People often think that big trees with big, wide trunks are old. But big does not necessarily mean old. Bristlecone pines grow slowly and are not that large. They are able to ward off insects and disease and that allows them to live a long, long time. A bristlecone pine named Methuselah is growing in the White Mountains of California and is the oldest living tree in the world. Discovered in 1953 by Edmund Schulman, this tree is more than 4,750 years old.

Clues from the past

We can learn a lot about the past from tree rings. Scientists use tree-ring data to understand past climates, glacier movements, fires, droughts, and insect outbreaks. This information can be used to solve problems in other areas of

science such as ecology, climatology, geology, and anthropology. For ecologists studying living things and their environment, tree-ring analysis provides information about insect outbreaks and fires. Climatologists (who study climates) learn about droughts and cold spells. Geologists studying Earth's structure use the data to learn about volcanic eruptions and earthquakes. Anthropologists studying human societies learn how they lived in the past, using tree-ring data to understand historical buildings and ruins. Scientists have used tree rings to date ruins from Ancestral Puebloans in the Southwest United States.

Laboratory of Tree-Ring Research: touchdown!

Who would expect to find scientific research going on under a football stadium? The Laboratory of Tree-Ring Research (LTRR) at the University of Arizona in Tucson has been exactly there for years. In 1937, Andrew Ellicott Douglass founded the lab—the first of its kind in the country—and became the father of dendrochronology. Douglass, an astronomer, hoped tree rings would provide records about past sunspot cycles. He found a link among the Sun, climate, and tree-ring growth.

Douglass needed space for his tree-ring samples and a sports stadium seemed to be the answer. Today, the lab occupies two floors under the stadium, and contains over 600,000 tree-ring samples.

At LTRR, researchers, professors, and students are involved in many projects. Rex Adams, senior research specialist (seen in this photo), takes field trips across the western United States for climate, fire, and ecology studies.

Photo - courtesy of Melanie Lenart, Laboratory of Tree Ring Research, University of Arizona

He studies the tree-ring samples he brings back to unlock past events. For Adams, the best part of his job is working in the field collecting samples. He compares his work to doing a crossword puzzle or solving a mystery. And, yes, if Adams or others work on a Saturday afternoon in the fall, the lab does rock a bit during a football game. But how much sturdier many of those old tree samples must seem compared even with a concrete stadium.

Questions:

1. What do wide and narrow tree rings mean?
2. Count the tree rings in the cross-section on the previous page. How old was this tree when it was cut down?
3. Why are fir and pine trees commonly used for tree-ring analysis?
4. How is tree-ring data used?
5. Who was Andrew Ellicott Douglass?

CHAPTER ACTIVITY — Trees and Maps

Activity 1—How tall is a tree?

You know that counting tree rings gives the age of a tree. Now, you will measure the height of a tree.

Materials

Thin cardboard; measuring tape; drinking straw; string; clay; tape; scissors, protractor, and T-square

What you will do

1. Use the T-square to mark out a right triangle on the cardboard. The triangle should have 2 equal sides that are each 20 cm long. Cut out the triangle.
2. Cut the straw to 10 cm long and tape it to the longest side of the triangle.
3. Tape a 30-cm piece of string to one of the 45 degree angles of the triangle. Fix a ball of clay to the other end of the string. The clay acts as a weight for the string.
4. Look through the straw to the top of the tree, and have someone check the position of the string.
5. Walk forward and backward until the string hangs in line with the side of the triangle and you can see the top of the tree through the straw.
6. When this happens, you can figure out the height of the tree. Take the distance you are away from the tree (in meters), and add it to the height of your eye from the ground (in meters). This gives you the height of the tree!

Activity 2—Making a land form

Elevation in cm
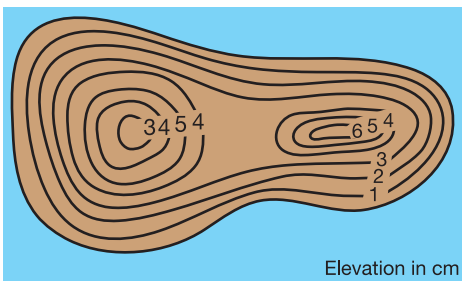
During this activity, you will create a land form that matches this topographic map.

Materials

The materials used for Investigation 3B; modeling clay and a rectangular piece of cardboard (with the same dimensions as the bottom of the GeoBox)

What you will do

1. Study the topographic map on this page. Each contour line represents an elevation of 1 centimeter.
2. Then, use the modeling clay to create a model land formation in the GeoBox that matches the topographic map.
3. To see if your land form matches the map, add water to the 0-cm mark on the GeoBox and trace the outline of your land formation on the lid. This is the 0-cm contour line and represents sea level.
4. Pour colored water into the tray until it reaches the 1-cm mark.
5. Now, trace the outline the water makes around the edges of the model land formation on the lid.
6. Repeat this procedure until you have poured 8 cm of water into the tray.
7. Finally, trace the outlines from the plastic sheet onto a piece of tracing paper.
8. Label the contour lines on your topographic map with the proper elevations.

Applying your knowledge

a. Activity 1: How high was the tree you measured?
b. Activity 2: Does your topographic map of your land formation match the topographic map on this page? Why or why not? If your map does not match the one on this page, make improvements to your model landform and try the activity again.

Chapter 3 Assessment

Vocabulary

Select the correct term to complete the sentences.

geology	relative dating	topographic map
legend	bathymetric map	radioactive decay
equator	contour line	elevation
latitude	map	sea level
longitude	prime meridian	element
fossil		

Section 3.1

1. Through their observations of rock formations, Nicholas Steno and James Hutton helped develop the field of _____.

2. _____ is a method that involves putting events in the order in which they happened.

3. An ancient shark tooth is an example of a(n) _____.

Section 3.2

4. Uranium is a(n) _____ that has a half-life of 4.5 billion years.

5. Uranium is an unstable element, which decays to a more stable element, lead. This process is an example of _____.

Section 3.3

6. A(n) _____ is a representational drawing of a location.

7. The average level of the ocean along a coastline is called _____.

8. On a mountain top, _____ is much higher than at sea level.

9. A(n) _____ is list of symbols used on a map.

10. A(n) _____ indicates the location on a map where elevation is the same.

11. A _____ is a map that shows the surface features of an area and shows elevation by using contour lines.

12. A _____ is a map that shows the depths of bodies of water.

13. _____ lines are imaginary lines on Earth's surface that run east-west and represent north and south locations.

14. _____ lines are imaginary lines on Earth's surface that run north-south and represent east and west locations.

15. The _____ is a line that falls between the north and south poles on Earth and that represents 0° latitude.

16. The _____ is a line that is perpendicular to the equator and that represents 0° longitude.

Concepts

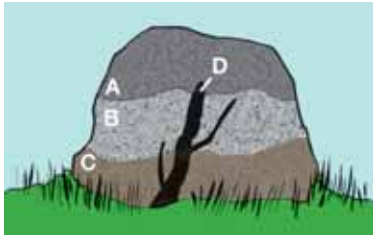### Section 3.1

1. Use relative dating to identify the order in which each line was drawn. Which line was drawn first? Which line was drawn last?
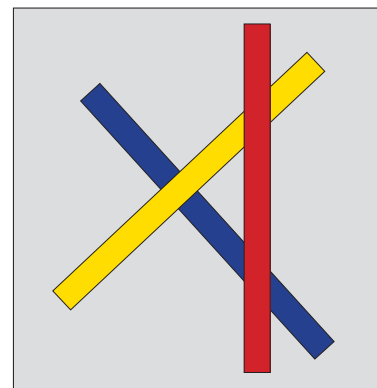
2. Define superposition and lateral continuity. Why are these ideas useful in interpreting how the Grand Canyon formed?

3. An inclusion is:
   a. younger than surrounding rock.
   b. the same age as surrounding rock.
   c. older than surrounding rock.

4. Put the rock bodies (A, B, C, and D) illustrated below in order from oldest (formed first) to youngest (formed last). Explain your reasoning.


5. How do scientists use the ideas of faunal succession to identify how long ago different animals lived?

Section 3.2

6. How old is Earth? How old is the solar system and the moon?

7. Uranium decays into a more stable element called:

> a. lead   c. carbon
>
> b. nitrogen   d. phosphorous

8. What range of time is known as the Precambrian Era? What kinds of organisms lived during this era?

9. During what era did humans first appear?

10. How might a tree fossil help a scientist understand the climate of certain places millions of years ago?

11. You notice that a tree cross section has very wide tree ring that occurred in 1985 and a very narrow tree ring that occurred in 1992.

    a. From this information, what can you infer about the tree's environment in 1985?

    b. What can you infer about the tree's environment in 1992?

Section 3.3

12. Why is a legend an important part of a map? What would happen if a map did not include a legend?

13. Look at the topographic map below.
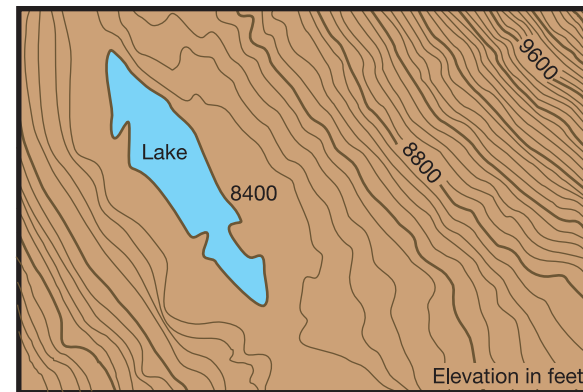
    a. Where are the steepest slopes on the map?

    b. Where is the lowest elevation shown on this map?

    c. What is the lowest elevation?

    d. Where are the gentlest slopes?

14. What do latitude and longitude lines represent?

Math and Writing Skills

Section 3.1

1. Both Nicolas Steno and James Hutton contributed to the development of modern geology. What important things did each scientist do? Through research, find a fact about each of these scientists that was not mentioned in the chapter.

2. Imagine you have to explain superposition to a group of second graders. Think of a creative model you could use that would help them understand this concept. Describe your model and how you would teach superposition in a paragraph.

3. How do scientists know which plants and animals lived at the same time as the dinosaurs?

Section 3.2

4. A scientist discovers that a certain rock is 25% uranium and 75% lead and other elements. If the rock started out as being 100% uranium, How many half-lives has the rock gone through?

5. A rock that is 100% uranium goes through three half-lives.

   a. How many years is three uranium half-lives?

   b. How much uranium is left after three half-lives: 2%, 10%, or 12.5%?

6. Which era took up the most time during geologic history?

7. Imagine you could go back in time and visit any period of Earth's geologic history. Which period would you want to visit? Why would you want to visit this time in geologic history?

Section 3.3

8. A map is drawn with 1 centimeter equal to 2 miles.

   a. How many centimeters equal 10 miles?

   b. How many miles does 4 centimeters represent?

9. The scale of a topographic map is 1:250,000 which means one centimeter on the map equals 250,000 centimeters on land. How many kilometers is 250,000 centimeters?

10. Choose an object in your classroom.

   a. Measure the dimensions of this object. Sketch the object and write its dimensions.

   b. Imagine that the dimensions of the object were half of what they are now. What would the dimensions be?

   c. Now, imagine that the dimensions of the object were twice as big. What would the dimensions be?

11. Look at the topographic map from Concepts question 13. How many feet does each contour line represent? (Hint: Subtract 8400 from 8800 and divide the answer by the number of lines between these two elevations.)

12. Below is a diagram of a tree core. Use this diagram to answer the following questions. Do not count the bark or the pith when figuring out how old the tree is. One tree ring equals a white area and one dark line.

Bark

1985

Center of tree
(pith)

   a. How old is this tree?

   b. What year was this tree cut down?

   c. Give an example of a year that was probably warm with a lot of rainfall.

   d. Name a year that was probably cool and dry.

Chapter Project—Making Maps

Now it's your turn to make maps.

   a. You want your friends to come to a party at your house after school. They have never been to your house before, so you have decided that the best way to give them directions is to create a map from school to your house. Include all important features along the route. Be sure your map is to scale, has a legend, symbols and other important map features. Remember, it must be accurate and easy to read!

   b. You decide that you want your party to have a pirate theme. You hide a treasure and draw a map for your friends to use to find it. Make your treasure map easy to follow.