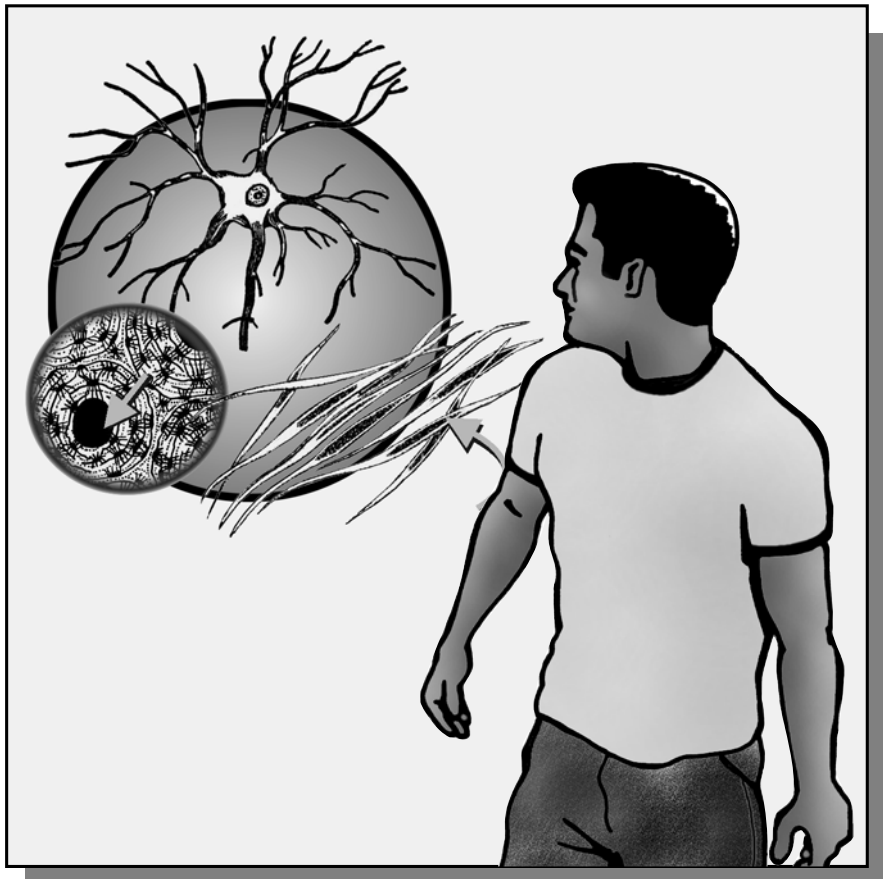
Basic Science Mysteries



Chapter 5

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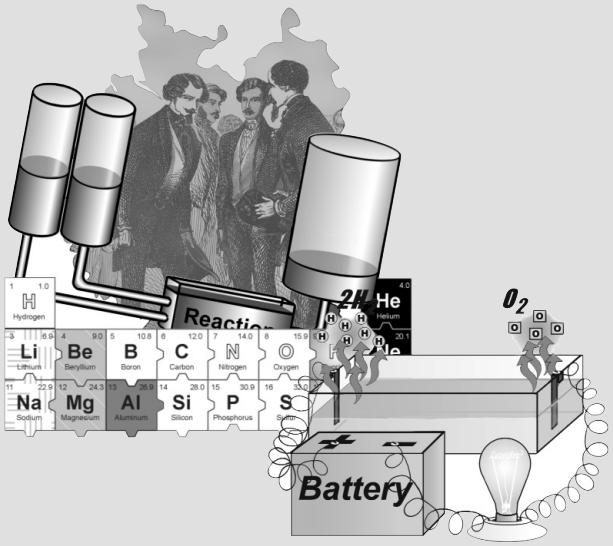
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"By knowledge, understanding and wisdom the true mysteries of life unfold as they are studied line by line and precept upon precept." —Ronald E. Johnson, C.Ph.D.



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Lesson 1
Meteorology

Chapter 5

Meteorologists, Humidity and Precipitation

Section 1

Lessons 1-5

THE WEATHER





You and LaToya were sitting in your backyard eating a snack and listening to the radio. The weather was beautiful. The Sun was shining and the temperature was perfect, not too hot or too cold. It was just right!

LaToya told you that she had some exciting news. Her parents had bought a tent and some camping equipment at a garage sale. They were in the process of planning a camping trip to the mountains the next weekend and told LaToya that she could invite a girlfriend. LaToya wanted you to go with them.

That was exciting news. You had never been camping, but the idea was exciting. You were sure that your parents would let you go. You and LaToya were on the same girl's soccer team, had most of your classes together at school, and were in the same youth group at church. Even your families were friends. Both of your mothers were cashiers at a grocery store and usually ate lunch together every day.

Your mom brought more soft drinks outside for you and LaToya. You asked permission to go on the trip. Your mom smiled and said she had already heard about the trip from LaToya's mom. Your mom said that camping was a wonderful idea and that you would have a great time!

LaToya told you that everything was all planned for rock climbing and hiking. You could even fish in a stream. The only thing that could change the plans was bad weather. If bad weather was forecasted, then the trip would have to be postponed. You looked around at the beautiful, sunny skies and hoped that the nice weather would last through the weekend.

VOCABULARY

Humidity: a measure of the amount of water vapor in the air
Precipitation: water that falls as rain, snow, sleet, or hail
Meteorologists: persons who study the weather
Radar: a device which uses radio waves for detecting distant objects

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Weather affects people's lives whether they are involved in recreational activities like camping or occupational activities like farming or outdoor construction work. Farmers depend on the weather for good crops. Construction workers depend on the weather to know when to pour concrete, or paint a house or work on a roof. Finances are affected by the weather. A farmer can lose an entire peach crop exposed to a late freeze. A construction foreman can lose a contract if a building is not finished on time due to rain delays or other weather complications.

Rain or snow can cause frustration when parades, picnics, ball games and other events are spoiled by bad weather. As a result, much time, effort, and money is put into trying to forecast, or predict, what the weather will be like on certain days. Accurate forecasts could mean that problems caused by the weather would be less frustrating, damaging or even deadly. *Weather* is the condition of the atmosphere at a given time and place. The elements of weather include temperature, ***humidity***, cloudiness, ***precipitation***, wind and pressure. These elements are organized into various weather systems. All weather systems have well-defined cycles and are governed by laws of heat and motion.

The basis of weather is the unequal heating of the atmosphere-ocean system of Earth. Tropical regions near the equator receive more heat from the Sun than do polar regions. When air is heated, it circulates upward. This heated air circulates toward the poles. Cold air from the poles is pushed along the surface of the Earth toward the equator. As these masses of air move, changes in weather occur.

You can tell what current weather conditions are simply by making observations. You can see the Sun shining. You can see clouds forming in the sky. You can notice when rain begins to fall. You can feel the temperature as you step outside and determine whether it feels hot or cold. However, the weather is constantly changing because the air is constantly moving. You cannot always rely on your own observations to predict what the weather will be like later.

Meteorologists, people who study weather, have many tools and instruments to help them make accurate predictions about the weather. Meteorologists start by gathering data to give them a complete picture of conditions in the atmosphere. These conditions include wind speed and direction, air pressure and how it is changing, temperature, precipitation and humidity.

Many meteorologists get data from the National Weather Service, which has a network of weather stations throughout the United States. Meteorologists also use weather balloons to study conditions in the upper atmosphere. As the balloons drift upward, they relay data about temperatures, winds, and other conditions that affect large areas of the Earth.

Radar is used to locate and track the presence of storms. Radar uses radio waves, bouncing them like an echo off objects. By measuring the time a signal takes to return, the distance to the object can be calculated. Doppler radar is an advanced kind of radar that can show the direction in which a storm is moving.


Doppler Radar Tower

Satellites orbiting the Earth keep track of worldwide weather patterns. Satellites can take pictures of the cloud patterns that occur during storms and monitor the temperature of the water near the surface of the oceans. Satellites collect information from their own instruments and relay it to ground stations for analysis.

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In the study of meteorology, scientists continue to learn about the interaction of air with land and oceans. They are able to see a relationship between the global water cycle and the weather. Accurate weather forecasting and tracking of worldwide weather conditions can help prevent disasters and save lives. In addition, knowing what the weather will be helps in planning daily events such as what to wear and what activities to schedule. Everyone is affected by the weather. In the future, patterns of weather behavior will be better understood and weather prediction should become more reliable.

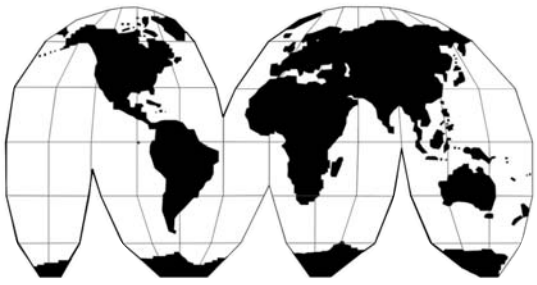
You and LaToya began to plan for the weekend camping trip. You made a list of the clothing, equipment, and supplies you would need. Of course, all of this depended on the weather. What you did not realize was how unpredictable the weather can be. What may start out as a beautiful day can suddenly change, so you should have been prepared for anything! However, no forecast could have possibly predicted what was ahead for you that weekend!



"The Sun is always shining above the storms of life to give us the rainbow—a promise of better times ahead."

—Nancy Sarada Johnson

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Lesson 2
Meteorology

Chapter 5

Latitudes and Climate Zones

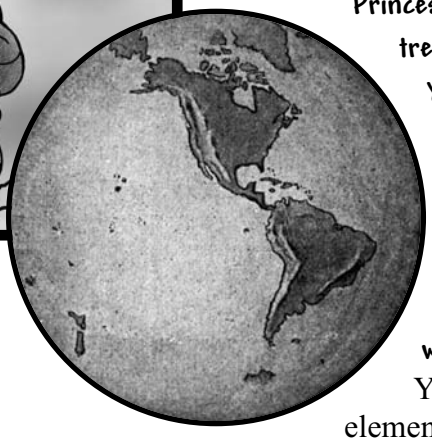
Section 1

Lessons 1-5

HOT AND HUMID



You pushed your hair out of your face as you wiped away the ***perspiration*** collecting on your forehead. Your clothes were sticking to your body as you worked in your backyard. Only a few days remained before you were to leave on your camping trip, and your mother had asked you to clean out Princess' doghouse and change her bedding before you left. Princess was lying in the shade under a tree watching you as you worked. You probably should have picked a cooler day to work, but the temperature did not seem so hot when you started. You wished it were not so hot and humid. You could not imagine any worse weather!



VOCABULARY

Perspiration: sweat
Latitude: imaginary lines designating distance, parallel to and north or south of the equator, measured in degrees
Elevation: a high place with reference to sea level
Fronts: the boundary between two air masses
Evaporate: to change from liquid into a vapor
Water vapor: a gaseous form of water, often invisible
Condenses: process of causing a gas or a vapor to change into a liquid

You feel the effects of two of the elements of weather: temperature and humidity. When you step outdoors, the air temperature may be the first weather condition you notice. *Temperature* is a measure of the degree of hotness of the air. The United States uses the Fahrenheit scale to measure temperature. Two other scales are also used for measuring temperature. Scientists use the Kelvin, or absolute, scale and the Celsius, or centigrade, scale. Most nations use the Celsius scale. Most people agree that a temperature reading of 72 degrees Fahrenheit is considered the "perfect" or "most comfortable" temperature.

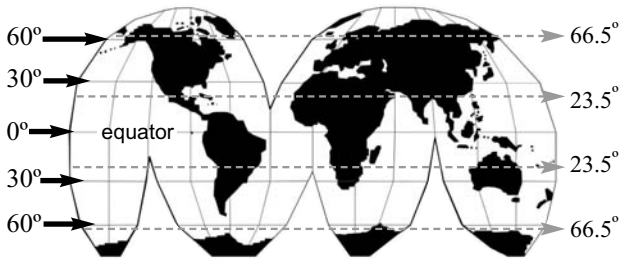
When you average the temperature readings from all points of Earth, you will get an average of 59 degrees Fahrenheit (15°C). That average includes temperatures from the deserts to the polar regions. Temperatures on Earth range from a record high of 140°F (58°C) to a record low of −130°F

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(−88°C). This range varies according to ***latitude***, ***elevation***, season and time of day.

Earth's surface can be divided into three major climate zones: tropical, temperate and polar. These zone differences are based mainly on temperatures.

The *tropical climate* zone is the warmest region and is located 23.5° north and south of the equator. A tropical climate has an average temperature higher than 64°F



during the coldest month. Hawaii and parts of Florida are in the tropical climate zone.

Most regions with a *temperate climate* lie between latitudes 23.5° and 66.5° north and south of the equator. Most of the United States lies within the temperate climate zone. The average summer temperature in a temperate climate is above 64°F and the average winter temperature is below 50°F.

The *polar climate* zone is the coldest region and is located at north and south latitudes greater than 66.5°. A polar climate has an average temperature lower than 50°F during the warmest month. Alaska is in the polar climate zone.

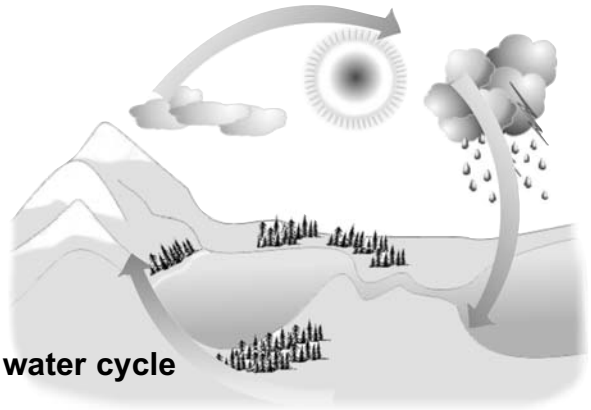
Temperature is generally highest in the tropics and lowest near the poles. Along the equator, all months are equally warm. Seasonal variations of temperature are generally more pronounced at higher latitudes.

Temperature ranges tend to be consistent within a given climate zone during a particular season, although temperatures can change abruptly when ***fronts*** or thunderstorms pass overhead.

The thermal energy of the Sun is a major factor affecting the weather, but so is the amount of moisture in the air. Weather is also greatly affected by water, one of Earth's most abundant substances.

The Sun provides the energy to ***evaporate*** water from the oceans and other bodies of water. When water evaporates, it becomes ***water vapor***. As it cools in the upper atmosphere, water vapor ***condenses*** and forms clouds. The water eventually falls back to Earth as precipitation such as rain or snow. This water cycle forms the basis of Earth's weather.

The amount of water vapor in the air is called *humidity*. The spaces between the



water cycle

water vapor molecules are filled with air. The temperature of the air affects how much water vapor it can hold. The warmer the air, the more water vapor the air can hold. Reduce the temperature of the air, and you reduce the amount of water vapor the air can hold. Thus, humidity is reduced.

Relative humidity is a ratio that compares the amount of water vapor in air to the amount of water vapor the air can hold at a given temperature. When the temperature changes, the relative humidity also changes. Relative humidity is most often given as a percent.

When the relative humidity of air reaches 100 percent, the air contains all the

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moisture it can possibly hold at that temperature. When this happens, the air is saturated. When air near the ground is cooled to a point at which the air is saturated with water, the vapor condenses and forms droplets on the grass. The temperature at which air is saturated and condensation takes place is called the *dew point*.

As the relative humidity approaches a high percentage, people often describe the condition by using words such as "muggy or sultry." Their hair sticks to their faces, and they perspire heavily. Most people are uncomfortable in hot, humid weather.

You became more and more uncomfortable as you worked in the backyard, so you decided to take a break and join Princess in the shade of the tree. You drank a big glass of water and wiped your face with a cool, damp cloth. You started to feel better. Clouds were starting to form overhead, blocking the Sun. The temperature dropped slightly. You thought about the weekend and wondered if the tent would provide adequate shelter against rain. Maybe being hot and humid was not so bad. Actually, the weather could be much worse.

Princess wagged her tail as you patted her head. You would miss her over the weekend. You loved animals and seemed to know instinctively how to work with them. That was a good thing for you. The weather was not the only problem you would have to face on your campout!

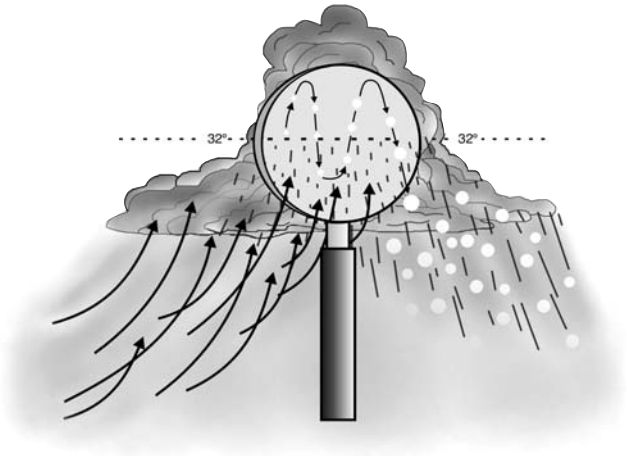
Life Principle



"Contentment does not come from possessions—rather from within."

—Anonymous

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Lesson 3
Meteorology

Chapter 5

Clouds and Coalescence

Section 1

Lessons 1-5

RAINY DAYS





As you watched the skies, clouds continued to develop. Sensing that rain was approaching, you hurried to finish cleaning Princess' doghouse. The temperature continued to drop as the clouds turned dark. You and Princess dashed inside just as the first raindrops fell.

You knew the rain was needed. Area farmers had been concerned about getting enough water for their crops. Even the area forestry service was concerned about the dry conditions. Forest fires start easily when an area receives little rainfall. The mountains where you planned to go camping over the weekend were located along the edge of a national forest. The trees there were some of the oldest and tallest in that part of the United States. Parts of the mountains were only accessible by horseback. If you were skillful enough to follow one of the trails through the ***dense*** forest, you would find some odd ***granite*** clusters that resembled villages. A river cut through the cliffs, exposing extraordinary ***fossil beds***. Perhaps you and LaToya would be able to go to that area. You had never ridden a horse, but you would like to try.

The rain pelted the windowpane as you looked into the backyard. You had hoped the sky would clear before the weekend arrived. However, the sky was filled with dark clouds, and you realized that the rain might last for a while.

Clouds are really collections of tiny water droplets or ice crystals that vary in size from 0.002 to 0.1 millimeters in diameter. Clouds form when water vapor in the air condenses. The condensing vapor forms tiny drops of water around dust

VOCABULARY

Dense: crowded together; thick
Granite: a hard igneous rock used especially for building
Fossil beds: places where remnants or traces of organisms of past ages, such as skeletons or leaf imprints, are embedded in the Earth's crust
Latin: the language of the ancient Romans
Coalescence: the process in which water droplets collide in clouds and form bigger droplets

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particles in the atmosphere. These cloud droplets and ice crystals are so small that they stay suspended in the air.

A system for naming and identifying clouds was proposed by English naturalist Luke Howard in 1803 and, with slight modification, is still in use today. Howard's system uses ***Latin*** words to describe clouds as they appear to an observer on the ground.



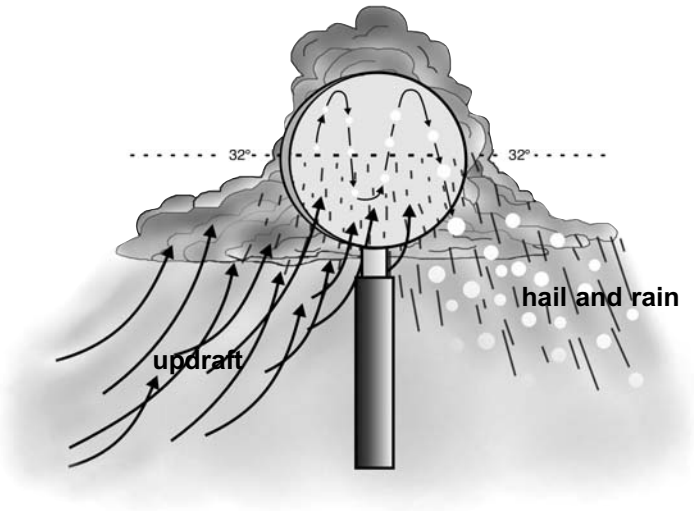




Cirrus clouds are wispy and are usually found at very high altitudes. *Stratus* clouds form near the ground and are gray and sheet-like. Those which produce rain are called *nimbo-stratus* clouds. *Cumulus* clouds are puffy. While smaller cumulus clouds can be associated with fair weather, the giant cumulus clouds often produce thunderstorms and are called *cumulo-nimbus* clouds ("nimbus" means *rain*).

Water droplets in a cloud swirl around and bump into each other. Cloud droplets may grow bigger as large droplets collide and merge with smaller drops. This process is called ***coalescence***. When these droplets become too heavy to remain suspended in the atmosphere, they fall out of the clouds as precipitation. *Precipitation* is any form of water, either solid or liquid, that falls from the atmosphere and reaches the ground. Precipitation can take several different forms.

The rapid upward movement of warm, moist air forms thunderstorms. They form when the air near to the ground is warm and humid. When this warm air lifts, it becomes cooler. The water vapor in the air condenses, forming cumulus clouds that can reach heights of five miles. Within cumulus clouds, the air and water vapors begin to move up and down very rapidly. The greater the temperature difference between the relatively warm cloud and its surrounding air, the more vigorous the thunderstorm will be. The falling droplets of water coming from the tall, cumulo-nimbus clouds create a downward motion of air that spreads out at Earth's surface, which can cause some of the strong winds associated with thunderstorms. If the cloud stretches into cold, upper-air layers, hail can form as raindrops begin to fall and are blown upward into



freezing temperatures. In some situations the process happens several times, allowing the hail stones to increase in size.

Heavy rains from thunderstorms sometimes cause flooding and mudslides. Strong winds and hail can also cause damage. Lightning occurs because an attraction exists between positive and negative electrical charges. Lightning travels through the air from one charged region of a cloud to another charged region. The lightning can also occur between the cloud and the surrounding air, or between the cloud and the ground. Thunder results from the rapid heating of the air around a lightning bolt, forming a sound wave.

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The rain began to fall harder on the windowpane. You saw a flash of light followed by a clap of thunder. Princess put her head in your lap. She did not like thunder. Neither did you. You wondered if all animals reacted to thunder the way Princess did. Unfortunately, you would have the opportunity to find out over the coming weekend!

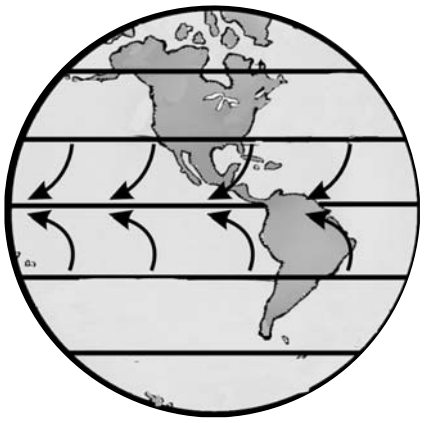
Life Principle



"Into each life some rain must fall."

—Henry W. Longfellow

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Lesson 4
Meteorology

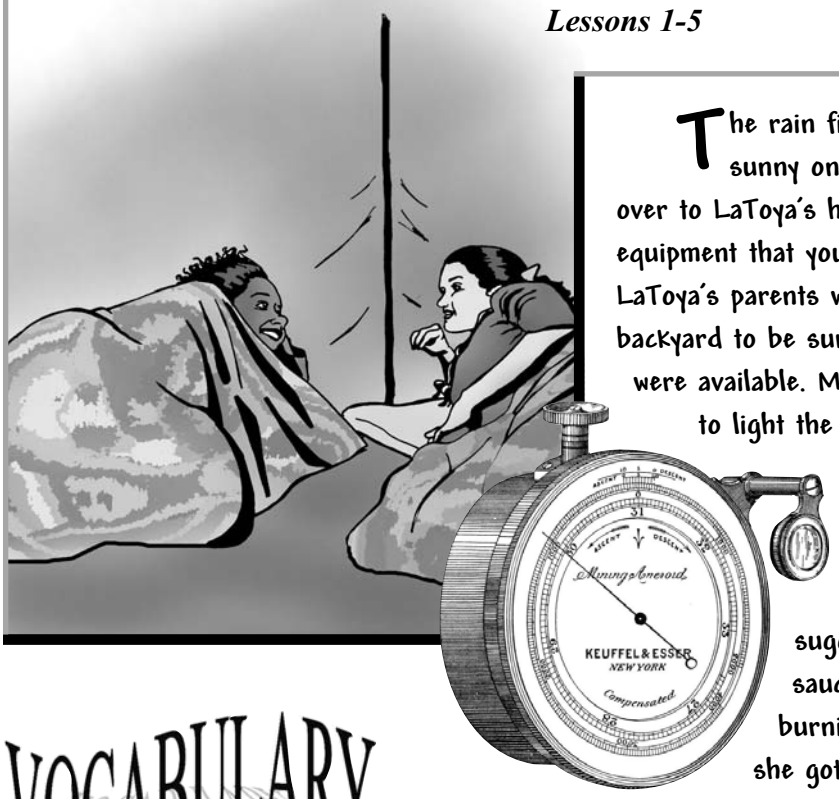
Chapter 5

High and Low Pressure Weather Systems

Section 1

Lessons 1-5

WIND AND PRESSURE



The rain finally stopped and the sky was sunny once again. You rode your bike over to LaToya's house to check out the camping equipment that you would be using that weekend. LaToya's parents were setting up the tent in their backyard to be sure all the ropes and tent pegs were available. Mrs. Clark asked you and LaToya to light the butane burner on the camp stove to try it out. LaToya showed you how to attach the butane container and get the flame started. Then she suggested heating some chocolate sauce while you had the flame burning. You heated the sauce while she got some ice cream from the freezer.

The Clarks were a nice family and you were glad to be included on that trip. They worked together quickly to get the tent erected. All the poles, stakes, and ropes were in place. Mr. Clark told you and LaToya that you could sleep outside in the tent that night if you wanted to. Then the next day, the tent had to be dismantled and packed so it would be ready for the weekend. The camp stove worked great with the chocolate sauce as proof. The four of you sat in lawn chairs by the tent as you ate.

When night arrived, you and LaToya crawled into your sleeping bags. After talking for a while, you fell asleep. Suddenly you awakened. The wind had increased, and the flap on the front of the tent had blown loose. You secured it and got back into your sleeping bag, only to have to get right back out again. The wind had blown over the lawn chairs, causing them to bang against the

VOCABULARY

Moist: slightly wet, damp
Matter: anything that has mass and takes up space
Air pressure: pressure at any one point on Earth's surface from the weight of the air above it
Weather system: the weather conditions of an air mass
Low pressure system: an area of air pressure less than the surrounding area
High pressure system: an area of air pressure greater than the surrounding area

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side of the tent. You folded the chairs and stacked them on the patio. You wondered what the wind would displace next.

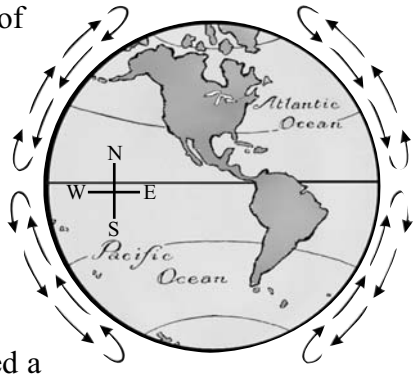
Wind is air in motion. The wind direction is the direction from which the wind is blowing. A north wind blows from the north and a south wind blows from the south.

Weather at the Earth's surface is closely related to moving bodies of air called *air masses*. An air mass is a large body of air whose properties are determined by the part of Earth's surface over which it develops. An air mass that develops over land is dry compared to an air mass that develops over the ocean. An air mass that develops over a polar region is cold compared to an air mass that develops over a tropical region. An air mass forms when a body of air stays over the same region for several days. The air takes on the properties of the surface beneath it, and is described by its temperature and its humidity. An air mass may be either cold or warm, and it may be either ***moist*** or dry.

The atmosphere transports warm air toward the poles and cold air toward the equator. The wind pattern generated by the unequal heating of the Earth's surface produces the major wind belts over the globe.

Air masses move over the surface of Earth. When an air mass moves and collides with another air mass, a boundary forms between the two air masses. This boundary is called a *front*. Many kinds of storms occur along fronts.

wind belts



A cold front marks the boundary where cold air is replacing warm air. Cold fronts often produce heavy rain or snow that lasts for a short time. When a warm air mass overtakes a cold air mass, a warm front forms. Warm fronts produce rain or snow that may fall for several days.

Meteorology, the study of weather, is subject to the same laws of science as other studies. You will remember that the definition of ***matter*** is anything that has mass and takes up space. Air molecules are composed of matter. They have mass. They take up space. The force of gravity pulls on air causing the gases to press on the Earth. That pressure is called ***air pressure***. The weight of the air molecules exerts a force upon the Earth and everything on it. Air pushes on all the surfaces that it touches. The amount of force exerted on a unit surface area is called *atmospheric pressure* or *air pressure*. At higher levels of the atmosphere, fewer air molecules press down from above. As a result, air pressure always decreases with increasing height above sea level.

When a gas is heated, the molecules move farther apart. When a gas is cooled, the molecules move closer together. Molecules of gases in the atmosphere also move farther apart or closer together as heating and cooling occur.

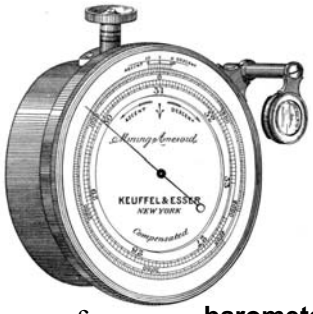
When air is warmed, gas molecules move farther apart, the gases become less dense, and air pressure lowers. Warm air rises. When air is cooled, gas molecules move closer together, the gases become denser, and the air pressure increases. Cool air sinks.

An air mass and its weather conditions are called a ***weather system***. An area of air pressure less than the surrounding area is called a ***low pressure system***. Since the molecules of warm air are spread farther apart, they exert less pressure. A low pressure system contains warm air. An area of air pressure greater than the surrounding area is called a ***high pressure system***. A high pressure

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system results from the denser cold air pressing on the Earth's surface.

When meteorologists know the air pressure of a region, they are able to make a more accurate forecast. *High pressure* means sinking, stable air. *Low pressure* means rising, unstable air. Meteorologists use an instrument called a *barometer* to measure air pressure.

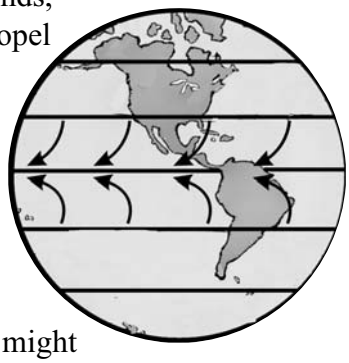


barometer

Air, like other gases, moves from an area of greater density to an area of lesser density. Therefore, winds blow out of a high pressure system. The greater the difference in pressure, the stronger the winds will be.

Centuries ago when the world's trade depended on sailing ships, sailors counted on favorable "trade winds," such as prevailing winds, to propel ships to their destinations. Winds that blow from the same direction over long distances are called *prevailing winds*. However, two areas on Earth's surface experience little or no wind. Sailors feared crossing these areas because their ships might become stranded for long periods of time. The *doldrums* and the *horse latitudes* are regions of the Earth's surface where little or no wind blows. The doldrums lie roughly between latitudes 10° South and 10° North. This is a low pressure belt near the equator where the air is hot and sultry. At about 30° from the equator in both hemispheres are the horse latitudes, a belt of high pressure. The region's name was created when Spanish sailing vessels carrying horses to the New World were stranded due to lack of wind. Stories are told of sailors who had to throw the horses overboard to conserve food and water.

trade winds



The winds in your neighborhood seemed to be getting stronger. You got up and checked each tent peg. So far, everything was staying in place. You looked at LaToya. She was still asleep. If that wind did not awaken her, you wondered what kind of weather would arouse her from sleep. You should have been glad she was sleeping. She would need lots of energy that weekend. You thought you had better get back to sleep. You would need your energy, too!

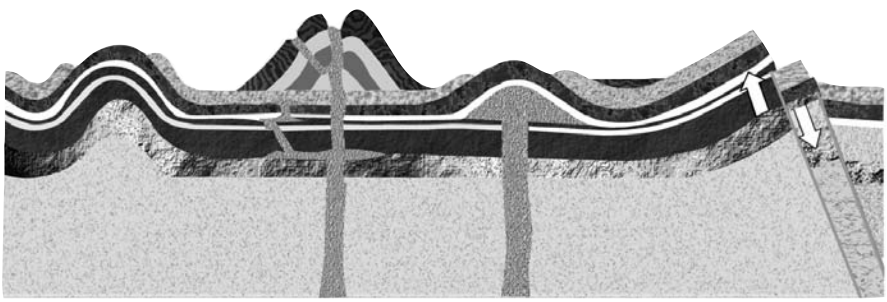
Life Principle

"If one does not know to which port one is sailing, no wind is favorable."

—Seneca



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Lesson 5
Geology

Chapter 5

Mountain Formations

Section 1

Lessons 1-5

THE MOUNTAINS



A "mountain" of camping equipment and supplies was piled beside the Clarks' car. You wondered how everything would fit. Fortunately, the Clarks had one of those older cars, the kind with a large trunk. You helped them load the tent, camp stove, lawn chairs, lanterns, flashlights, fishing gear, food and clothing into the trunk. Amazingly, everything fit.

You would be camping in a national forest at a campsite operated by park rangers. Your destination was located in the mountains, about a three-hour drive from your neighborhood. Your campsite was equipped with running water and picnic tables but no electricity.

Weather is always cooler in mountain regions because of the higher ***elevation***. Even though the temperature was rather warm in your neighborhood, you brought a jacket and sweatshirt with you.

Mountains affect the local climate in a region because mountainous ***terrain*** changes the movement of air masses and patterns of precipitation. Especially high mountain ranges affect climate and weather patterns over vast areas, because they stand as barriers to regularly circulating air masses. When air rises to get over the top of a mountain, the air cools because of the higher elevation. As the air cools, its water vapor condenses and forms clouds. Precipitation in the form of rain or snow, depending on the air temperature, falls on the side of the mountain where the air is rising. The air descending down the other side is usually dry, having lost most of its moisture. As a result, the side of the mountain where the air is rising usually receives more precipitation than the side of the mountain where the air descends.

VOCABULARY

Elevation: the height of something in reference to a fixed point, such as sea level
Terrain: an area of land
Altitude: the height of a thing above a reference level
Mountain range: a group of mountains in the same region with similar shape and structure
Lithosphere: outer crust of the Earth
Faulting: movement of rock along a fault in the Earth's crust
Faults: the boundary between two rock sections of the Earth's crust that move during earthquakes
Crustal strata: horizontal layers of Earth's crust

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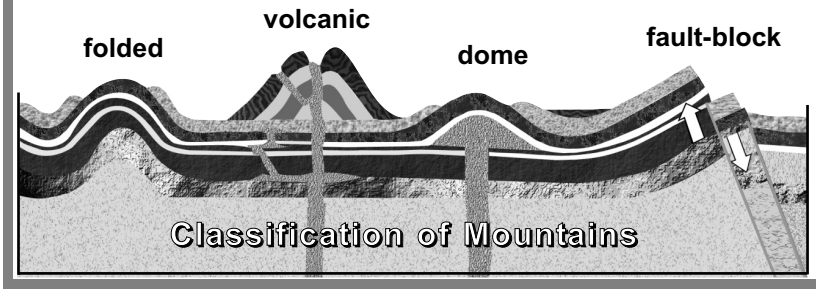
Mountain ranges are found on nearly all Earth's continents and on the ocean floor. A *mountain* is a region of land that is raised rather steeply above the surrounding terrain. A mountain is higher than a hill, and much narrower at the top than at the base. The elevation, or ***altitude***, of a mountain is given as the height of the summit above sea level.

A group of mountains that are in the same region and have similar shape and structure are called a ***mountain range***. Mountains are normally found in groups or ranges.

Scientists who study land formations are called *geologists*. Geologists believe that movements in the Earth's crust form most mountains. Canadian geologist J. Tuzo Wilson suggested that the outer crust of the Earth, called the ***lithosphere***, is broken up into many large rigid plates and several smaller ones that move at a slow rate. Movements that result in collisions between plates tend to raise the crust by ***faulting***, folding, or arching up layers of rock. This is one theory as to how some of the mountains were formed. Evidence of folds and ***faults*** in rock suggests that tremendous forces must exist beneath the ground for folds and faults to result in mountains.

Mountains can be formed and shaped in a variety of ways. Erosion, for example, wears away softer rock and leaves the harder rock. Wind and water are agents of erosion that wear away layers of the Earth. Mountains are also formed as a result of the action of volcanoes and earthquakes.

Mountains can be classified into four groups according to shape and structure:



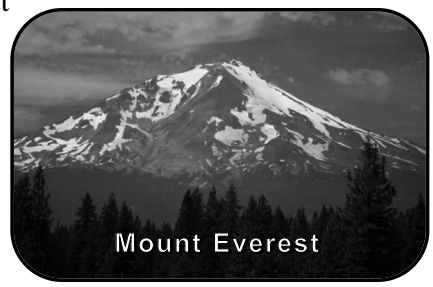
Classification of Mountains

fault-block, folded, volcanic and dome. Each kind of mountain has its own characteristics.

A *fault-block* mountain is the result of movement of rock along faults, or major deep cracks, in Earth's crust. This type of movement is called *faulting* and causes rock bordering on faults to be lifted vertically in great rugged blocks. The raised edges of the blocks then appear as mountains. The lowered edges appear as valleys. The Sierra Nevada Range in California is a fault-block mountain range.


Sierra Nevada Range

A *folded* mountain is produced by horizontal compression of the ***crustal strata*** into what looks like folds or wrinkles. The thick sheets of rock appear to fold over one another. Geologists think that most folded mountains form at boundaries where plates collide. Mount Everest, a folded mountain in the Himalayas, is in the highest mountain range on Earth. With an elevation of 8,848 meters (29,021 feet), Mount Everest is the tallest mountain on Earth. Mt. McKinley (it's original name was *Denali*) is the highest mountain in the United States and all of North America.


Mount Everest

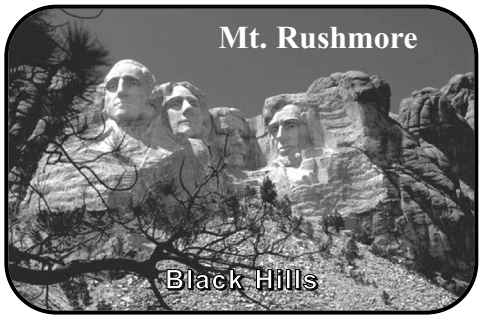
Volcanic mountains are formed from molten rock material that reaches Earth's surface and falls back on itself. Kilauea, the world's most active volcano, is located on the central Hawaiian Island, Hawaii.

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Kilauea's current eruption cycle began on January 3, 1983. The volcano spews an estimated average of 400,000 cubic meters of lava a day. By 1995, the accumulation of lava had added about 500 acres of new land to the island. Like the other islands of the Hawaiian chain, Hawaii was formed by volcanic action and is extremely mountainous. The dominant feature of the terrain is a series of volcanoes, linked by lava ridges.


Kilauea Lava Flow

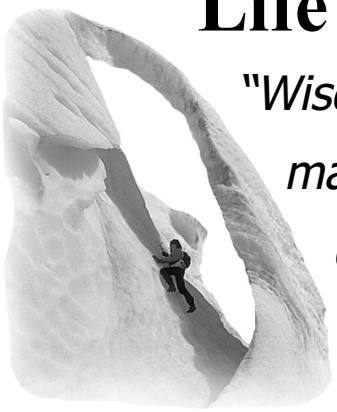
A *dome* mountain is formed when a large area of the Earth's surface is slowly bent upward. Molten rocks deep below Earth's surface arch the rocks at the surface but do not break through. This gradual uplifting of the Earth's surface, causes dome mountains to form, such as the Black Hills of South Dakota. These hills (mountains) are world famous because of the stone faces of four outstanding American presidents (Washington, Jefferson, T. Roosevelt, Lincoln) carved in the solid granite rock of Mt. Rushmore.



Mountains are valuable resources. They provide a rich abundance of mineral, forest, and agricultural resources. In addition, they are a significant recreational source, offering many opportunities for camping, hiking, fishing, mountain climbing, and other activities.

During the drive to the mountains you listened to the car radio. The regular program was interrupted by a news bulletin. Apparently, a bear had ripped through several tents during the night at a campsite near yours. No one was injured. The bear was after food. Campers were warned to keep all food in their vehicles, not in their tents, at night.

You and LaToya were frightened that a bear might rip through your tent. Mr. Clark told you not to make a big issue of the radio report. He cautioned you and LaToya to use common sense and to follow the park rangers' directions. You were supposed to have a weekend filled with fun, not with fear! Mr. Clark was right. You decided not to make a big deal of it. You purposed not to let some story about a bear spoil your weekend!

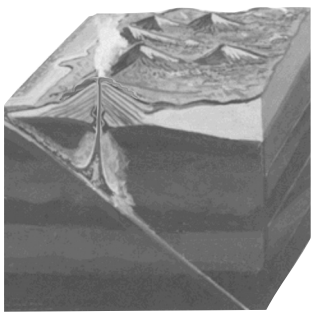


Life Principle

"Wisdom is not to make mountains out of molehills."

—Anonymous

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Lesson 6
Geology

Chapter 5

Formation and Characteristics of Volcanoes

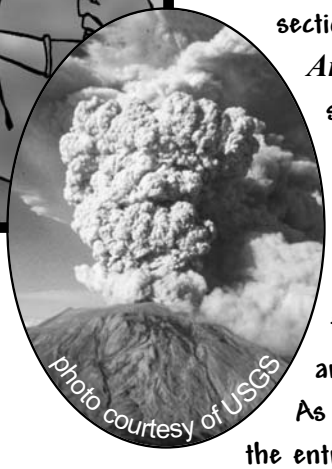
Section 2

Lessons 6-10

VOLCANOES



The drive to your camping area took you through a wooded region. As you followed the curve of the road, you were aware that you were climbing in altitude. Looking back out the rear-view window, you saw the valley below you. Ahead, all you could see was more trees. As you rounded a curve, you spotted a river. Boulders lined the riverbed. Mr. Clark explained that a section of that area was rich in fossils. ***Archaeologists*** had found remains of several small dinosaurs there. Scientists hoped to locate a complete skeleton of one of the larger ones. That would be a rare and valuable find. Mr. Clark suggested that you and LaToya take the guided horseback ride to watch the archaeologists at work.

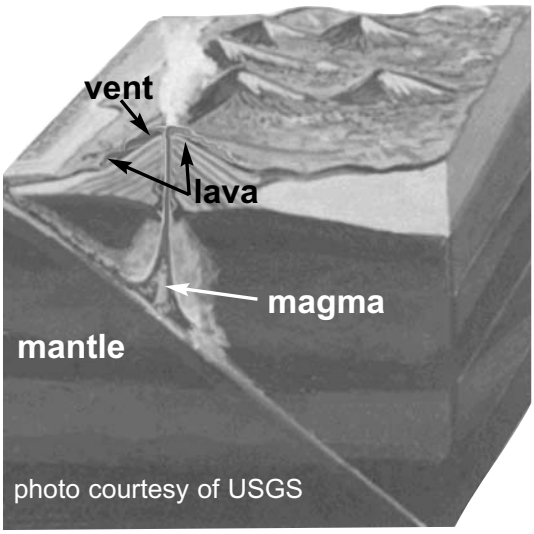


As you continued your ascent, you passed the entrance to a campsite. That was where most of the archeologists stayed along with others who were interested in digging for fossils. You recognized the campsite's name as the location mentioned in the news report where the campers were having a problem with bears. You were glad that was not your campsite!

Within a few miles, you saw a steep cliff rising above the trees. Judging from the shape and structure, you recognized this as a fault-block mountain. The entrance to your campsite was just ahead. You were thankful for several things. One, you were glad to be included on this trip. Two, you were glad your campsite was not the one where the bears were spotted. Three, you were glad this mountain was not a volcanic mountain.

VOCABULARY

Archaeologists: those who study bones, artifacts and ruins of past cultures
Molten: melted by heat
Magma: the molten rock material under the Earth's crust
Mantle: the layer of the Earth between the crust and the core
Lava: molten rock (magma) that reaches the Earth's surface through a volcano
Silica: a crystalline compound
Vent: opening of the volcano in the Earth's surface



A *volcano* is a geological landform that consists of an opening in the Earth's crust through which ***molten*** rock material reaches the surface. All volcanoes originate when hot, melted rock material mixed with gas is forced upward through denser, surrounding rock. This molten rock material is called ***magma***. It is formed in the middle layer of the Earth, the ***mantle***, and works its way toward the Earth's surface. Once magma reaches the surface, it is called ***lava***.

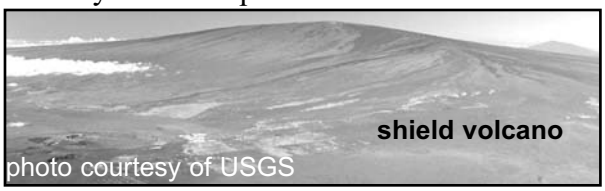
An eruption occurs any time the volcanic material reaches the surface of the Earth. Gases are trapped in magma. Surrounding rock puts pressure on magma when it is deep underground. As the gas in the magma comes near the Earth's surface, the pressure on the magma is reduced, and the gases begin to escape.

Volcanic eruptions vary according to the thickness of the magma and the types of gases that are trapped inside. Some volcanic eruptions are explosive. Other eruptions are quiet and nonexplosive.

Magma contains many different elements and compounds. Magma that contains more of the compound ***silica*** tends to be very thick. This type of magma can even clog the ***vent***, or opening, of the volcano, building up increased pressure. When the magma does escape, this type of eruption is usually violently explosive. Ash, steam and rocks are projected high into the air, accompanied by thunderous noise.

Magma containing less silica is thinner, producing a quiet eruption. There is no explosive discharge of dust, ash, or gas because these gases are generally released gradually before a significant amount of pressure builds up. The lava tends to flow from the vent like a river.

The form of a volcano is produced by the nature of its eruption. If the eruption is quiet, a gently sloping *shield* volcano is produced. The lava flows onto Earth's surface and spreads out over a large area in flat layers. Over time, these layers build up to form a shield volcano.



If the eruption is explosive, a *cinder cone* volcano forms. Gases and rock fragments are hurled high into the air. Then, they fall to the ground and form a steep-sided, loosely packed mountain.



Some volcanoes produce alternating quiet and explosive eruptions. These are called *composite* volcanoes. Their sides are formed of layers of lava alternated with layers of cinders and ash.



photo courtesy of USGS

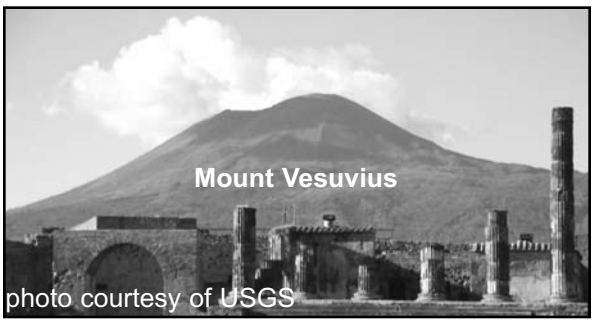
Volcanoes with a high silica content produce explosive eruptions with a high force. This results in the formation of a

cinder volcano. Those with a low silicone content produce quiet eruptions with a low force, which results in the formation of a shield volcano. Composite volcanoes are characterized by a moderate force and have both quiet and explosive eruptions. The silica content can be either high or low depending on which type of explosion occurred.

Volcanoes are common at plate boundaries. Because Earth's crust is made up of large pieces or plates, volcanoes are found on continents as well as the ocean floor. Sometimes enough lava builds up to reach above the surface of the water, forming a volcanic island.

Most of the volcanoes on Earth today are *dormant*, which means that they are not currently active. However, a dormant volcano could erupt in the future. If a volcano is releasing materials or has recently released materials, such as smoke, gas, dust, ash, cinders, or lava, the volcano is considered *active*. Currently, more than 600 volcanoes on Earth are classified as active. An *extinct* volcano is one that has not erupted during recorded history and is not expected to erupt in the future.

In 1943, geologists had an opportunity to see how a volcano formed when a farmer discovered hot smoke and ash rising from an opening in the ground of his cornfield, located in central Mexico. The area had been shaken previously by earthquakes over a two-week period. In less than 24 hours from the time the farmer noticed the opening, a hill 8 meters (25 feet) high stood where the ground had once been flat. The vent began releasing hot fragments and molten rock. By the end of a week, the hill was 168 meters (550 feet) high. After eight months, the cone stood about 457 meters (1500 feet) high. The volcano of Paricutin continued to erupt and grow taller for nine years, reaching a final height of 518 meters (1700 feet) above the ground, or about 9,200 feet above sea level. However, it has been inactive since 1952.



One of the best-known volcanoes in the world is Mount Vesuvius, located in Italy. In the year 79 A.D. this volcano erupted, burying the city of Pompeii. An estimated 2,000 people were trapped and killed. In 1748, archaeologists began to excavate the remains of Pompeii, covered in ash and cinder. Many of the buildings had been left intact. Remnants of some of the victims of the disaster were located. Ashes, mixed with rain, had settled around the bodies in fossil-type molds that remained after the bodies themselves had disintegrated. These molds were filled with liquid plaster by the archaeologists, preserving the forms of the bodies. Some of these figures are part of an exhibit in the museum erected at Pompeii.

The world's most active volcano, Kilauea, is located in Hawaii, and is situated on the southeastern slope of the volcanic mountain, Mauna Loa. The current eruption cycle began on January 3, 1983. The volcano spews an estimated average of 400,000 cubic meters of lava a day.





photos courtesy of USGS

Mount St. Helens is an active volcano located in

southwestern Washington. The volcano had been dormant since 1857. However, in early 1980, it began to show signs of activity. Then May 18, 1980, Mount St. Helens erupted with a tremendous explosion. It released about 20,000 times the energy of each atomic



bomb used in World War II. Much of the mountain was blown away. The blast hurled over 275 trillion tons of ash and rock into the air and killed 57 people. The eruption also triggered land/mud slides and ash falls and emptied a huge lake. The resulting tidal wave wiped out millions of trees and caused serious erosion. Later, the volcano erupted again, this time producing a massive mud slide, which carved out a wide canyon about 100 feet deep in just one or two days time. This led some geologists to re-evaluate their theories that canyons require millions of years to form. Layered sediment was also previously theorized to have required millions of years to form, but 600 feet of such sediment has built up around Mount St. Helens since the eruption, with 25 feet of it being "created" in just one day.

The people who stayed on or near Mount St. Helens ignored the warnings of scientists who predicted that the volcano was about to erupt. Mount St. Helens had been dormant for over 120 years. Apparently campers and nature lovers thought it would remain dormant.

In 2002, Mount Nyiragongo in the Democratic Republic of Congo, Africa erupted suddenly and violently. Rivers of red lava flowed down the mountain and through the main streets of Goma, the nation's largest city. More than 350,000 people were displaced from their homes, businesses, schools and farms.

Your campsite was just great. You helped the Clarks erect the tent, unroll the sleeping bags and put all the supplies in place. Mrs. Clark told you and LaToya that you could hike, fish or ride horses to the fossil beds. She also reminded you to follow the warnings of the park ranger to stay on marked trails. That's one warning you would wish you had followed!

Life Principle

"*A wise person follows good advice.*"



—Israeli proverb



Lesson 7
Geology

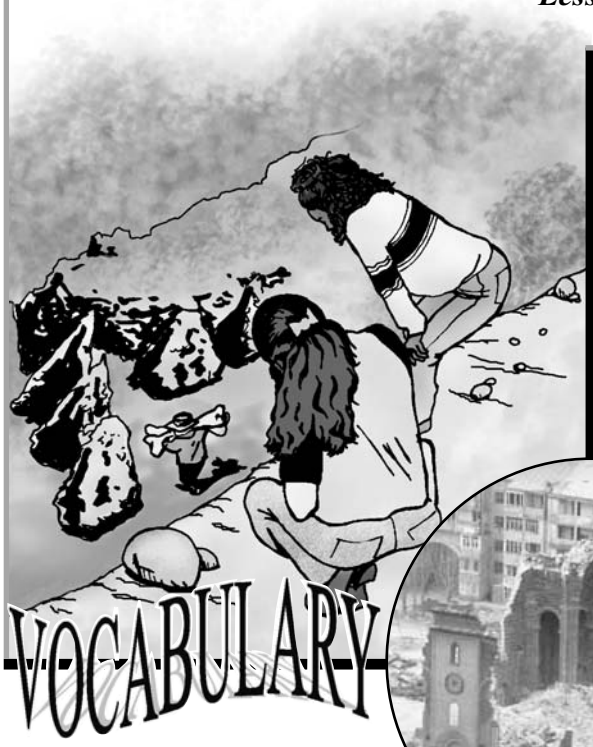
Chapter 5

Characteristics and Measurement of Earthquakes

Section 2

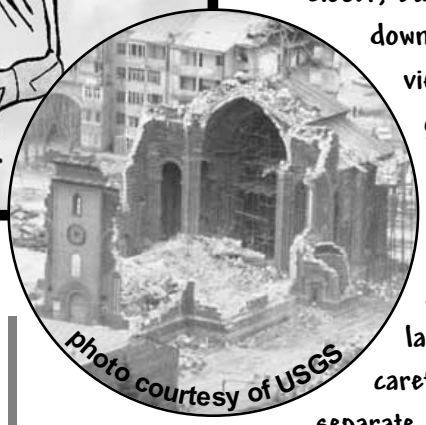
Lessons 6-15

EARTHQUAKES



VOCABULARY

Earthquake: a shaking and trembling of Earth's crust
Plates: gigantic sections of Earth's crust
Seismic wave: a wave produced by an earthquake
Focus: the point in Earth's interior where seismic waves originate
Epicenter: the point on Earth's surface directly above the focus
Seismograph: an instrument that measures and records earthquake waves
Magnitude: the strength of an earthquake



You and LaToya decided to hike along a trail that led close to the fossil beds. A horseback tour to the area left just minutes before you arrived, so you had to find the trail yourself or wait for the tour group to return. The park ranger showed you a pathway that would take you along a cliff just above where the archaeologists were working. The horseback tour would get you closer, but you decided not to wait. Looking down from the cliff, you had a good view of the fossil bed area. Several groups of people were carefully chipping the rock along the riverbed. Others were sorting items into piles. Even from a distance away, you could tell that several large fossilized bones were being carefully dusted and placed into a separate stack.

From your vantage point, you could see something moving in the wooded area near the river where the larger bones were stacked. You look closely to see if the object was a bear. You were relieved to see that it was only a man wearing dark clothes and a hat. He walked to the pile of bones, selected two large ones and struggled to carry them back into the woods. You thought it strange that no one was there to help him carry his heavy load, but everyone else was at the river's edge.

You and LaToya decided to get a closer look at the place from where the man took the two bones. You left the pathway and attempted to take a shortcut through a section of the woods; but the trees were so dense that you had trouble getting any closer.

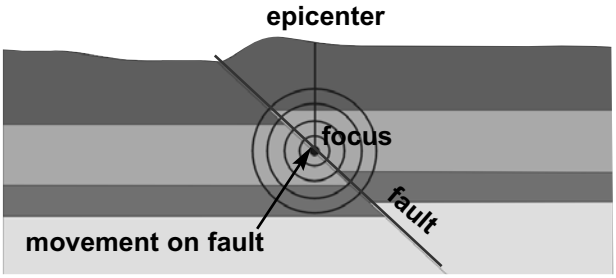
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Walking on the path was much easier than climbing over roots and brushing tree limbs out of your face. Suddenly the ground beneath you started to tremble, and you felt a slight shaking. Within a few seconds, the shaking stopped. You realized that something was not exactly right, but you were not sure what. LaToya suggested that the best thing to do was to return to the pathway and head back to the campsite. The only problem was, you could not find the pathway.

You felt a slight ***earthquake***. Earthquakes can be caused by a sudden shifting of rocks below the surface of the Earth. Many earthquakes are not even felt at the surface. Other earthquakes are so strong that they cause widespread destruction.

A *fault* is a fracture in the Earth's crust. On both sides of the fault are gigantic sections, or ***plates***, of the Earth's crust. The Earth is slowly moving as parts of the Earth's crust shift and slide past one another. Usually this movement is gradual. Most earthquakes occur at the boundaries of plates. As the plates move, they slide against each other or push into one another. Moving plates have great amounts of energy. In time, enough force develops to cause a sudden and violent movement.

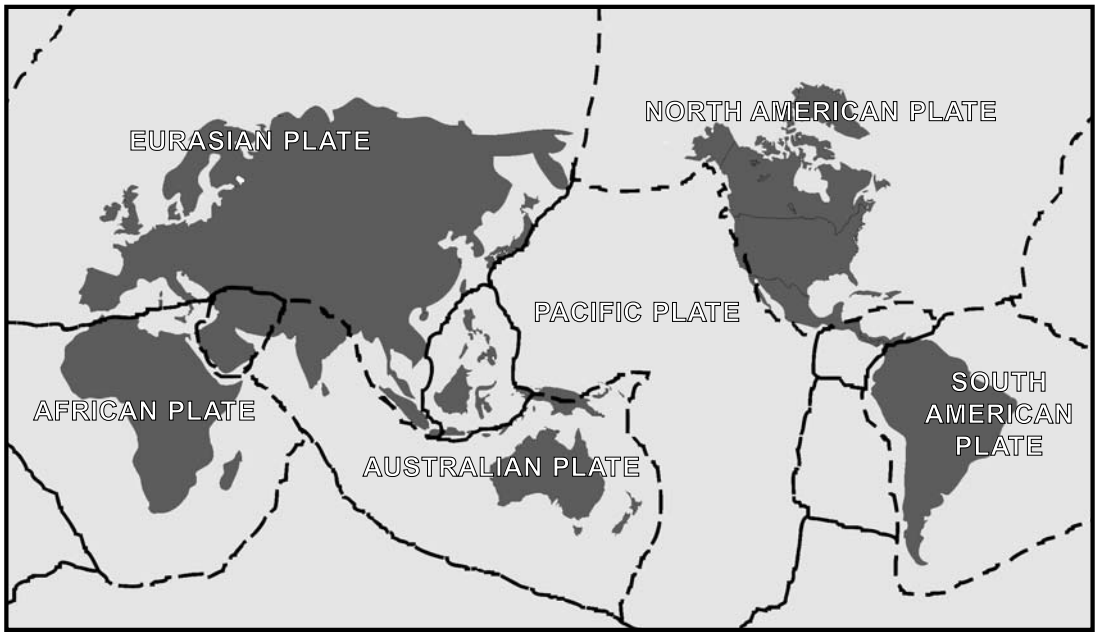
The sudden shifting causes rocks and soil at the surface to vibrate. This action produces a type of wave called a ***seismic wave***. The point in the Earth's interior where seismic waves originate is the ***focus*** of the earthquake. The point on Earth's surface directly above the focus is the ***epicenter***.



Seismic waves travel outward in all directions from the focus and can be detected, measured and recorded with an instrument called a ***seismograph***.

The height of the wavy lines recorded on the seismograph are related to numbers on

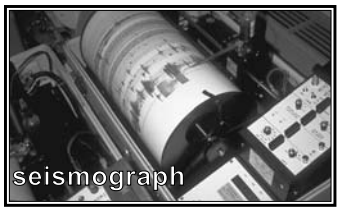
Plates of the Earth



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a scale used to measure the strength of an earthquake. The ***magnitude*** of an earthquake is a measure of the earthquake's strength. The Richter scale assigns a number from one to ten determined by the height of the wave. The higher the number, the stronger the earthquake. This scale was devised in 1935 by the American seismologist, Charles F. Richter.

The amount of damage caused by an earthquake depends on the strength of the quake, its distance from inhabited areas, the design of buildings and the type of ground on which the buildings are constructed. Scientists are trying to design earthquake-proof buildings. Extending a building's foundation well below ground level can help a building withstand an earthquake. Steel-framed buildings and concrete buildings with few doors or windows hold up better than buildings with a lot of glass or brick. Architects designing buildings for communities located on or near a fault line are continuously studying data to help engineers design safer and stronger structures.


seismograph

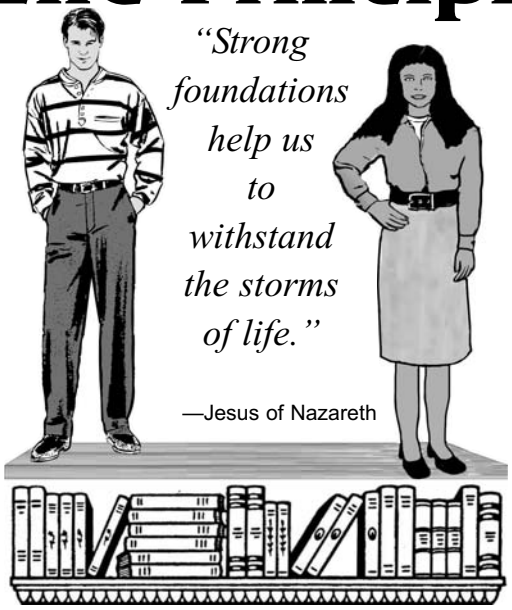
Almost one million earthquakes take place each year around the world. Most of these earthquakes are not felt by anyone. Most earthquakes felt in the United States measure less than 3.5 on the Richter scale. These earthquakes are strong enough to shake buildings, but not strong enough to cause extensive damage.


earthquake destruction

On January 26, 2001, an earthquake registering 7.7 on the Richter scale occurred in India, killing at least 20,085 people and injuring about 166,836 people. The earthquake was felt throughout northern India, Pakistan, Bangladesh and western Nepal.

The people along the river also felt the earthquake. They stopped their digging activities and started to pack up their supplies. Some confusion was evident about where the large bones were stacked. Several men appeared to be looking for something. You could not stop to worry about that now. Your primary goal was to find that pathway, which you thought must be on the other side of a row of pine trees, blocking your view. You had not wandered too far away from the path, but at that moment you were lost! Your panic increased when a little vine caught your sock. You must have tripped over it in your confusion during the earthquake. Your ankle was really itching where the vine touched your skin. You began to wish you had never left the path.

Life Principle



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Lesson 8
Meteorology

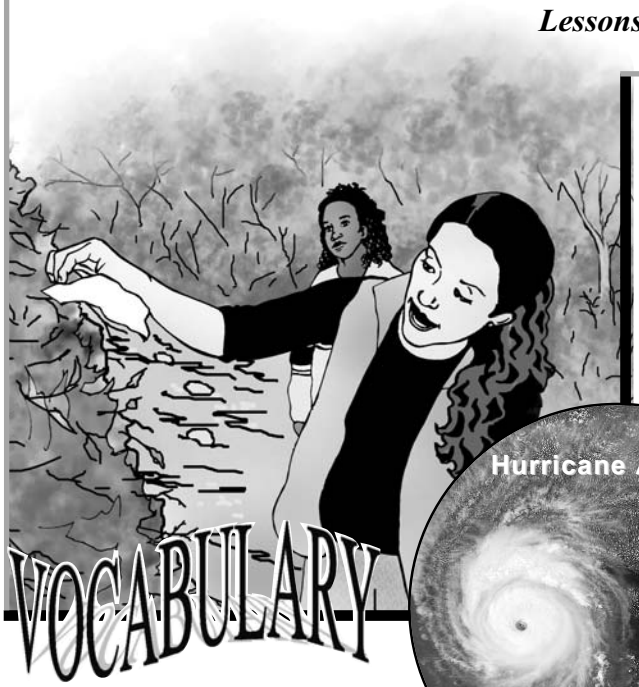
Chapter 5

Formation, Characteristics and Comparisons

Section 2

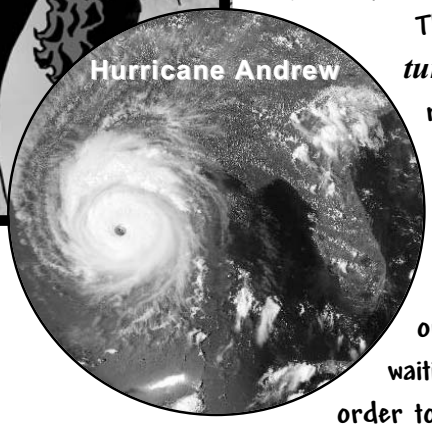
Lessons 6-10

HURRICANES



Your ankle was really itching. You pulled away the vine caught in your sock. The vine had leaves with jagged edges on it. The leaves were grouped in clusters of three. Your fingers suddenly began to itch where you had touched the vine. You wished you could find that pathway!

Things appeared to be a bit ***turbulent*** in your life at that moment. You figured out that you had stepped in poison ivy. You would feel the effects of a severe rash and itching for a couple of weeks. You had impatiently set out to find the fossil bed without waiting for the guided tour. Then, in order to get a closer look at the archaeologists, you had ignored the ranger's warning and left the pathway. You were certain you had experienced a slight earthquake and only hoped that no damage had been done to the campsite. You thought something suspicious might be going on at the fossil bed, but you were not sure what. To make matters worse, you were the one who encouraged LaToya to disregard her parents' advice as well as the ranger's instructions!

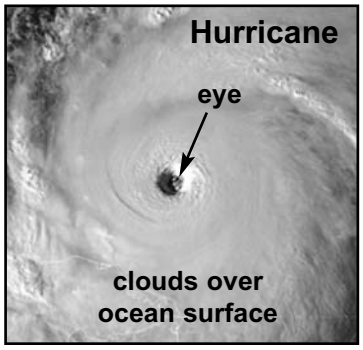


VOCABULARY

Turbulent: violently agitated or disturbed
Hurricane: a tropical storm involving heavy rains and winds exceeding 74 mph
Eye: center of a swirling storm such as a tornado or hurricane
Spirals: three-dimensional curves that turn a round a fixed point
Swells: large water waves
Swirl: to move with a spinning or whirling motion
Typhoons: hurricane systems that develop in the Western/ Northern Pacific Ocean and Philippines
Cyclones: hurricane systems that develop in the Indian and South Pacific Oceans

Things can get a bit turbulent in weather situations, as well. However, weather turbulence is not a result of poor choices, but is a result of scientific laws as they affect meteorology.

A ***hurricane*** consists of high-velocity winds blowing around a low-pressure center. Clouds form a circular



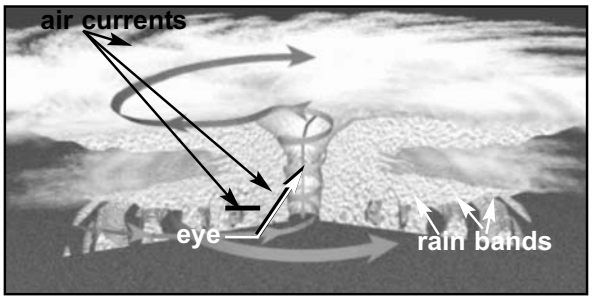
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pattern around the ***eye***, or center, of the hurricane. The largest type of storm that occurs on Earth is the hurricane. For a storm to be called a hurricane, it must form over water and have winds that blow at least 120 kilometers (74 miles) per hour.

A hurricane is a large tropical storm that forms over warm oceans. The warm, moist ocean air ***spirals*** upward around the low-pressure system. Friction between the winds and the ocean surface creates very large waves or ***swells***.

Hurricanes form where two opposing winds meet and begin to ***swirl***. A low-pressure area forms in the middle of the swirl and begins rotating. Warm, moist air is forced up into the middle of the low pressure area. Because of the circulating pattern of the winds, few clouds appear in the eye. As the air rises, it cools and moisture starts to condense. The rising, warm, moist air forms cumulus clouds. This condensing water vapor creates clouds with very heavy precipitation.

Hurricane Structure



Heat energy from warm, moist air at the surface of an ocean fuels a hurricane. As long as the hurricane remains over a warm ocean, more heat energy in the form of water vapor is taken up by the hurricane. This condition allows more condensation to occur, making the hurricane stronger and more powerful. Hurricane strength is rated on a scale from one to five, with five being the strongest.

Hurricanes can cover areas as large as 480 kilometers (300 miles) across and usually weaken when they strike land. However, even though weaker over land than water, they still are violent storms causing great loss of life and damage to personal property. Meteorologists track hurricanes over water or land using radar and satellites. Early warning is the only way to save lives and prevent even greater property damage.

Hurricane Andrew was the costliest hurricane ever to hit the United States. Hurricanes have also devastated other areas. In 1998 Hurricane Georges took its toll on the Caribbean, the Florida Keys and the Gulf Coast with 600 deaths and five billion dollars worth of damage. That same year, Hurricane Mitch hit Central America, claiming 9,000 lives and causing five billion dollars worth of damage.



Several names are used for the word hurricane, depending on its location of origin. A system that develops over the Atlantic or Eastern Pacific Oceans is called a hurricane. These systems are called ***typhoons*** if they develop in the Western/Northern Pacific Oceans and Philippines. In the Indian and South Pacific Oceans they are called ***cyclones***.

Assigning personal names to hurricanes was chosen to provide ease of communication between forecasters and the general public. Sometimes hurricanes can last for a week or

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more. Several can be in the same ocean at the same time. Using names creates less confusion about hurricanes as information about their predicted pathway is relayed. At one time, only women's names were used for hurricanes. However in 1970, the U.S. National Weather Service added men's names. The hurricanes are named alphabetically as they occur. The following table identifies the names selected for the year 2000.

Atlantic Storm Names for 2000		
Alberto	Helene	Oscar
Beryl	Isaac	Patty
Chris	Joyce	Rafael
Debby	Keith	Sandy
Ernesto	Leslie	Tony
Florence	Michael	Valerie
Gordon	Nadine	William

Hurricane warnings should be taken very seriously. People must plan for high water as well as high wind. Most people nail boards or plywood over large windows to protect glass from being broken. Many people along coastlines have to be evacuated from their homes.

You wished you had listened to the warnings given to you before you took the hike. You promised LaToya that you would follow directions next time. You were sorry you had convinced her that you knew what you were doing, when you really did not know. LaToya said not to worry. As you had walked into the dense forest, she had marked the trail with some of the tissues she had in her pocket. You were so busy leading the way, you didn't see what she was doing. She spotted one of the tissues on a bush just ahead. Beyond that, was another one. LaToya's plan worked well. As you retrieved the dropped tissues, you were led out of the woods into a clearing. You found yourselves back on the path and decided to head back to the campsite before anything else negative could happen.

Life Principle

"In times of turbulence, hold tight to what you know is right."

—Anonymous



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Lesson 9
Meteorology

Chapter 5

Formation, Characteristics and Precautions

Section 2

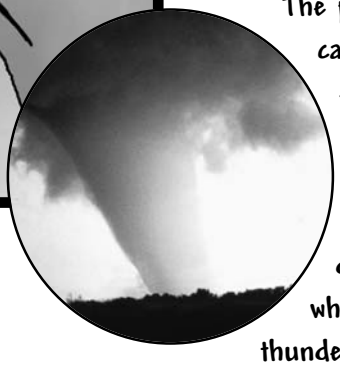
Lessons 6-10

TORNADOES



When you arrived at the campsite, Mrs. Clark put some medicated lotion on your poison ivy rash. You admitted what had happened when you missed the guided horseback tour. The Clarks were not pleased that you ignored the ranger's warning to stay on the pathway, but they said the poison ivy had probably taught you a valuable lesson. You assured them that it had!

The park ranger came by to check on your campsite and told you that small earthquakes were quite common in that area, but no damage was ever done. All that ever happened was a little excitement among the campers. He did warn you about the day's forecast, which called for late afternoon thunderstorms, and that you should seek shelter if you saw any lightning. Just then, however, the skies were clear and the Sun was shining.



You and LaToya returned to the stables and waited for the next guided tour. The itching had subsided and you felt better. You were glad you admitted your mistake to the Clarks. You made up your mind to learn from it. You were not going to make the same mistake twice! Your forecast for the afternoon called for a fun adventure!

Unfortunately, the weather forecast called for thunderstorms. ***Tornadoes*** can form from severe thunderstorms. Fortunately, your afternoon thunderstorm would not be severe enough to produce a tornado. However, as with all thunderstorms which include lightning, thunder, heavy rain, and high wind, you should have remembered to take certain ***precautions***.

VOCABULARY

Tornados: violent funnel-shaped storms whose whirling winds move in narrow paths over land
Precautions: actions taken to protect against possible danger or failure
Updraft: an upward current of air
Vortex: a spiral motion of fluid, especially a whirling mass of water or air
Debris (de-bree): the scattered remains of something broken or destroyed

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Thunderstorms can produce a great deal of damage. Lightning strikes Earth about



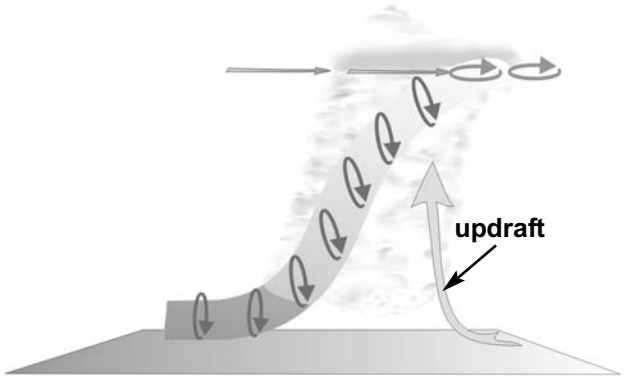
100 times each second. In the United States about 100 persons are killed, and many injured, each year. Lightning starts approximately 75,000 forest fires and forty percent of all farm fires each year. However, lightning is also beneficial, because it produces nitrogen needed by the soil and is carried there by nitrogen-charged rainwater during a storm. During a storm that produces lightning, your best place for safety is indoors. If that is not possible, find a low-lying area and stay there, as flat to the ground as possible. Standing under a tree is very dangerous because it is more likely to be struck by lightning, due to its height.

A tornado is a violent, funnel-shaped storm whose whirling winds move in a narrow path over land. The funnels are always associated with violent motions in the atmosphere involving the rapid, upward movement of warm, moist air. Scientists are not exactly sure what causes this upward-moving air to rotate. They know that tornadoes develop with low-pressure areas of high winds.

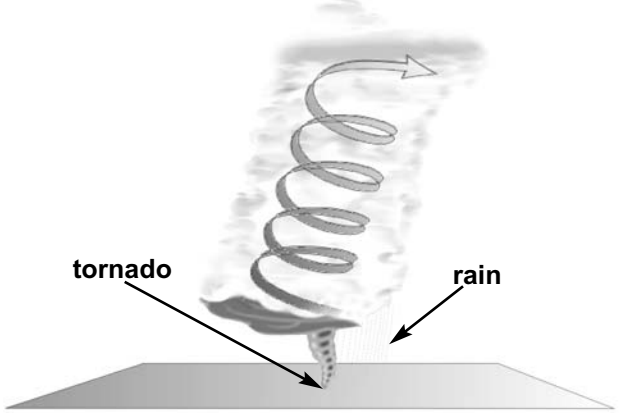
Meteorologists believe that the upward-moving air is twisted when it comes in contact with the cooler winds moving in a different direction at the top of the cloud. Rising air within the thunderstorm ***updraft*** tilts the rotating air from horizontal to vertical. Most tornadoes form within this area of strong rotation, producing a funnel-shaped cloud that extends from the storm clouds to the ground.



low-pressure areas of high winds



upward-moving air is twisted when it comes in contact with the cooler winds.



Rising air within the thunderstorm updraft tilts the rotating air from horizontal to vertical

The term *tornado* comes from the Spanish words, “Tronada” meaning *thunderstorm* and “tornar” meaning *to turn*. A tornado is a powerful ***vortex*** that can spin faster than 300 mph. A tornado produces the strongest, fastest winds to develop over land.

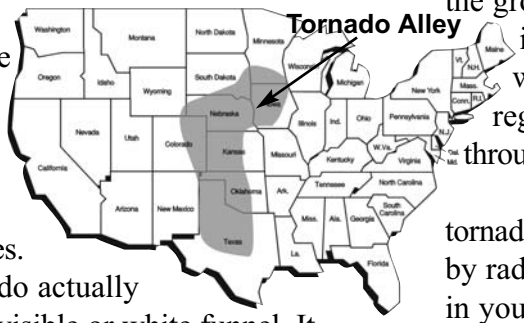
VOCABULARY

Waterspout: a funnel that develops over water
Dust devil: a funnel that develops over the desert

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Professor Fujita of the University of Chicago developed a scale to indicate the power of a tornado. The Fujita Scale is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure. That scale is in widespread use today to describe the strength of tornadoes. This scale ranks tornadoes from F-0 (least destructive) to F-5 (most destructive). Most tornadoes have a ranking of F-0 or F-1. Most tornadoes form in the spring and summer months.

Conditions are more favorable for tornado formation in the Midwestern section of the United States, called "tornado alley." The states ranked according to the number of killer tornadoes lists Texas as first, Oklahoma as second, and Arkansas as third. Each year the National Weather Service documents about 1,000 tornado touchdowns in the United States.



A tornado actually begins as an invisible or white funnel. It quickly turns dark because of the dust and ***debris*** picked up as the tornado travels over land. When a funnel forms over water, it is called a ***waterspout***. When it forms over the desert, it is called a ***dust devil***. Neither is as strong as a tornado.

The average forward speed of a tornado is 30 to 40 miles per hour, but it can go as fast as 70 miles per hour. A tornado does not travel in a straight line. The funnel may suddenly change direction at any given moment.

The twisting motions of the winds within a tornado have definite patterns. In the Northern Hemisphere (above the equator), tornadoes usually turn counter-clockwise. In the Southern Hemisphere, tornadoes usually turn clockwise. Exceptions to this rule are rare.

Tornado Destruction



Tornadoes can cause widespread damage, destruction and loss of lives. The National Weather Service's warnings regarding tornadoes should be taken very seriously.

A *Tornado Watch* means that conditions in the atmosphere are suitable for the formation of tornadoes, but that a tornado is not yet on the ground. When such a watch has been issued, you should pay attention to weather reports to keep informed regarding the formation of tornadoes throughout the day.

A *Tornado Warning* means that a tornado is on the ground or has been indicated by radar, or a funnel cloud has been sighted in your area! This is a very serious situation. You should take cover immediately below ground level or in a closet or bathroom in the middle of your house.

The first horseback tour returned and the horses were watered. The guide helped you and LaToya select gentle horses, since both of you were inexperienced at horseback riding. You patted your horse, Star, and talked to him by whispering in his ear. He nuzzled you with his nose. The guide gave you some grain to place in your palm. Holding your hand open, you offered it to Star who willingly ate it. The guide told you that you related well with horses.

The descent down the mountain to the river was easy on horseback. Star was sure-footed and steady, even when the path took you

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near the edge of a cliff. You continued to talk to him and pat him on the neck as you were riding. You were so happy and having so much fun that you did not notice the sky turning dark in the distance. Maybe the storm would miss your area. Maybe not. You would soon find out.

Life Principle

"A wise person recognizes danger and takes proper precautions."



—Hebrew proverb

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Lesson 10
Paleontology

Chapter 5

Theories of Formation,
Transitional Forms and Discoveries

Section 2

Lessons 6-10

FOSSILS



The guide led you and LaToya to the river. He told you that you could stay for two hours. You had to return the horses to the stable at the conclusion of that time. Trails wound in and out of the wooded areas that you could explore, or you could follow the river's edge until you came to the area where the scientists were digging for fossils.

You and LaToya rode Star and Paint along the river for a few miles. A number of families were fishing for trout. LaToya suggested that the two of you try that tomorrow. You passed a dock where canoes were tied for the campers to use. That looked like fun, too!



When you reached the fossil bed area, you tied Star and Paint to a ***hitching post***. The scientists were at work, but were not too busy to talk about what they were finding. One of them, Professor Parker, was assisted by his teenage daughters, Diane and Dana. The girls took a break to show you what their father had discovered and to answer your questions.

Fossils are the mineralized remains or traces of plants or animals that were once alive. The organic matter was replaced by inorganic mineral substances so that the shape of the ***organism*** has been preserved in rock. A fossil can give us an idea of what an organism looked like when it was alive. Most fossils are the remains or traces of the hard parts of organisms, such as bones, shells, teeth or wood. When an organism dies, its soft tissues usually either ***decay*** or are eaten by scavengers. The parts that do not decay or are not eaten by something else can become fossils.

VOCABULARY

Hitching post: a post or rail to which horses can be tied
Fossils: remains of once-living organisms
Organism: a living thing
Decay: to decompose or rot
Sediment: material that settles to the bottom
Invertebrates: animals without backbones
Sedimentary rock: rock formed from sediment
Retrieve: to find and bring back

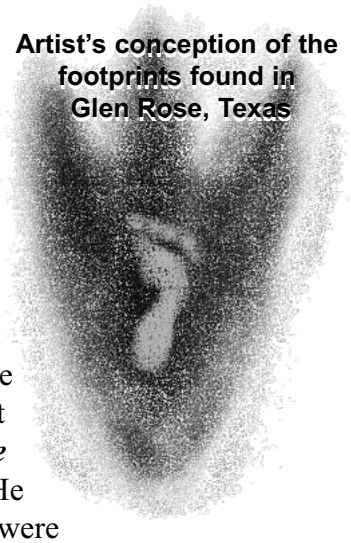
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Fossils, such as bones, are the remains of once-living things. Fossils may be only traces, such as imprints in rocks of leaves or footprints of once living-things. Most fossils are found in rock.

A fossil usually forms when the hard part that has not decayed or been eaten is buried in ***sediment***. That can occur in several ways. Wind can blow dust or sand over the dead organism. Earthquakes or volcanoes can bury the dead organism under rocks, mud, gravel, lava or other solid matter. A flood or other catastrophe can quickly bury whole organisms under layers of mud and water. As the weight and pressure of the matter presses on the dead organism, it is trapped and squeezed together, forming rock. Even soft tissues can be fossilized by this means.

Most animal fossils are shells, casts, molds, and other remains of ***invertebrates***. Snails, sea urchins, corals, and sponges fall within this category. Millions of these fossils from thousands of tons of rock have been collected from around the world. Fossils are most commonly found in ***sedimentary rock*** such as limestone, sandstone and shale. The shells or hard skeletons and the woody material of plants are usually preserved best. Fossils are found in all parts of the world. They are found on the tops of the highest mountains and even ***retrieved*** from under the ocean floor. The bottoms of many creeks and rivers are covered with fossils.

Several types of scientists are interested in recovering fossils. ***Paleontology*** is the study of the forms of life preserved in fossils. A ***paleontologist*** studies fossils to try to understand how and when organisms lived. ***Archaeology*** is the systematic recovery and study of material evidence (artifacts) remaining from past human cultures. An ***archaeologist*** is interested in how and when humans lived in ancient times. Paleontologists and archaeologists often work together at fossil-bed sites but do not always agree on what the fossils actually reveal, such as human footprints unearthed beside and inside dinosaur footprints in Texas.



Artist's conception of the footprints found in Glen Rose, Texas

English naturalist Robert Hooke began in the late 17th century to collect and study fossils of ***marine creatures*** from England. He realized that these fossils were from animals that lived under different conditions, in a different climate, and were ***extinct***. Other scientists began to hunt for and collect fossils from around the world. Englishman Charles Darwin, in the early to mid 1800s, was influenced by Hooke's observations of animal life and similarities among some fossils. Darwin's beliefs about those observations developed the foundation of modern evolutionary theory.

Prior to Darwin's time, most scientists accepted the Biblical account that Earth and all of its life forms had been divinely created

VOCABULARY

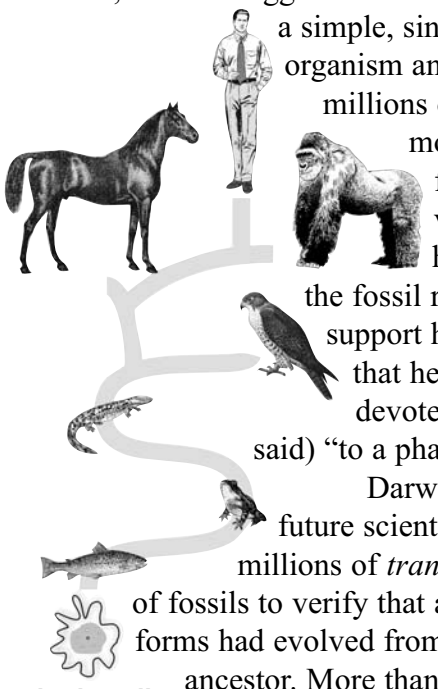
Paleontology: the study of the forms of life existing in prehistoric or geologic times
Paleontologist: one who studies paleontology
Archaeology: the systematic recovery and study of material evidence (artifacts) remaining from past human cultures
Archaeologist: one who studies archaeology
Marine creatures: creatures that live in the ocean or sea
Extinct: no longer exists
Vertebrate: an animal with a backbone

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in complete form at a specific point in time. Most scientists also believed the Biblical account that life had been destroyed around 4000 B.C. by a sudden catastrophe, namely Noah's flood. Only water creatures plus the people and land animals taken into Noah's ship survived. The remains of pre-flood life on Earth are visible only as fossils and artifacts.

Darwin challenged the creationist concept and offered an evolutionary theory. In it, Darwin suggested that all life began as a simple, single-celled organism and evolved over millions of years into more complex life forms. Darwin voiced concern, however, that the fossil record did not support his theory and that he may have devoted himself (as he said) "to a phantasy."



single cell organism

Darwin hoped that future scientists would find millions of *transitional* forms of fossils to verify that all present life forms had evolved from a common ancestor. More than 140 years later, though diligently searched for, those transitional forms, or "missing links" in the chain of evolutionary theory, have not been found. Millions of unearthed fossils have been studied, yet provide no verifiable evidence of evolution as a fact.

Many scientists support the concept that a sudden worldwide catastrophe in the ancient world, such as a universal flood, buried most then-living things. Most scientists agree that flood conditions are best for fossil formation due to the rapid means by which plants and animals are covered by sediment, away from animals that would eat them or elements that would decompose the dead organisms. Huge fossil graveyards that may best be explained by massive flooding have been discovered throughout the world. Some graveyards cover many square miles. Some are in mountain areas, thousands of feet above sea level. Numerous graveyards variously contain a mixture of fossils: sea creatures, human bones, dinosaurs, whales, elephants, 3-toed horses, mastodons, and many other creatures that were supposed to be separated in time by millions of years, or by geography and climate.

Some evolution scientists claim that a few transitional forms of ***vertebrate*** fossils have been found. Although only a relatively small amount of such fossils have been located, much dissension exists even among evolutionists as to whether those fossils are actually transitional forms or just some type of mutation or malformed organism. Many evolutionists still hope to find numerous transitioned fossils showing that some fish gradually changed into amphibians, some amphibians into reptiles, some reptiles into birds and other reptiles into mammals. Such proof has not been located. In addition, no fossils have ever been found to show how the first *vertebrates*, the fishes, could have evolved from *invertebrate* ancestors. As one modern evolutionist scientist wrote, "The known fossil record fails to document a single example of . . . evolution accomplishing a major morphologic transition and hence offers no evidence that a gradual model (of change) can be valid."

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Scientists are still studying the fossil record to try to answer questions about the origin of life. Evolutionists think fossils are similar because they believe all forms of life evolved from a common ancestor. Scientists who embrace the concept of intelligent design claim that, like an artist or musician with a recognizable style, similarities of fossils and other life forms exist because the same intelligence designed all lifeforms.

You and LaToya were told by Dana and Diane that their father believed the scientific data found in the fossil record raised many questions which the Theory of Evolution could not answer satisfactorily.

Professor Parker located one set of dinosaur tracks right beside some human footprints. This discovery persuaded the professor to believe that dinosaurs and man lived at the same time. The professor had hoped to find more of these fossilized footprints side by side before he had to return to the University the following week. An evolutionist would say that the dinosaurs became extinct millions of years before man ever existed. Professor Parker reasoned that man and dinosaurs must have existed together before the dinosaurs became extinct, probably due to major climatic changes in the ancient world.

Dana told you that if you would return tomorrow, she would show you and LaToya how to dig for fossils. Who could tell, maybe you would make an important discovery!

Life Principle

"A look to the past can help give meaning for today."

—Anonymous



Dinosaur footprints in rock bed of Paluxy River in Texas (used by permission of CEM).

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Lesson 11
Geology

Chapter 5

Geologic Column, Law of Superposition

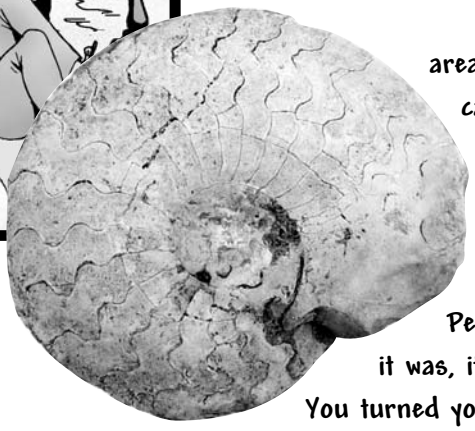
Section 3

Lessons 11-15

LAYERS



You and LaToya rode Star and Paint along the river's edge. You passed beside the place where the large fossils had been stacked. No one was there, and the fossils had been removed. You imagined they had been taken back to the scientists' camp for identification and analysis. You wondered if they were dinosaur bones.



Looking toward the wooded area where you saw the man carrying two of the larger fossils, you began to shiver. You thought you detected some movement in the woods. Perhaps it was that same man. Perhaps it was a bear. Whatever it was, it did not want to be seen. You turned your attention back to the river.

All the canoes had been returned to the dock. No one was fishing, either. Suddenly, you realized why. Dark clouds were quickly approaching. A thunderstorm was ***imminent***. The horses seemed to sense the change in the weather and started to trot. They wanted to get back to the stable.

The horses seemed sure-footed and steady on the riverbank even though most of it was composed of a rock layer. In the area where the fossils were located, the riverbank was composed of several layers of rock. That was especially evident in the cliffs that formed one side of the bank. The layers seemed to form a pattern of horizontal stripes.

Scientists study such rock layers to try to determine which events in Earth's past occurred before other events, and how or why those events occurred. That the layers were laid

VOCABULARY

Imminent: about to occur
Geologic column: a suggested vertical arrangement of rock layers determined in part by the fossils they contain
Geologic time scale: organizes geologic column into four divisions, called eras
Amphibians: animals that hatch as aquatic larvae with gills, then develop into adults having air-breathing lungs; a frog is an example

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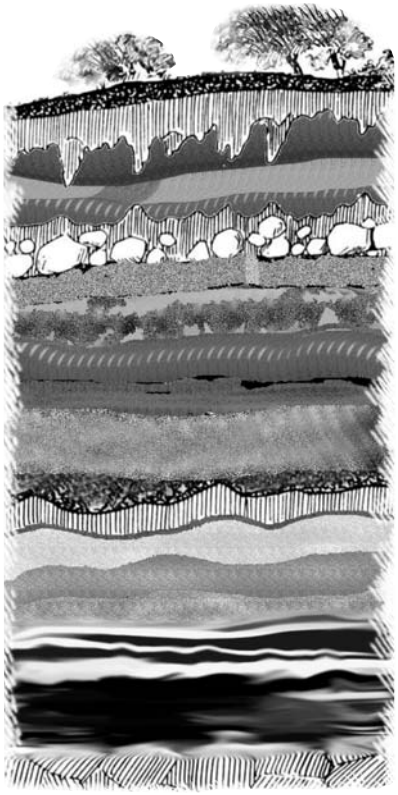
down in some type of pattern is obvious. But exactly what that pattern means may not be as obvious.

Scientists disagree regarding what the layers of the Earth tell us. Some scientists believe that clues in the rock layers can be used to determine the relative ages of the rocks in those layers. One such clue, they say, are fossils. Some scientists believe that the age of the fossils within each layer is a clue to the age of the rock layer surrounding the fossils. By assuming to know the relative ages of fossils, scientists believe they can determine relative ages of rock layers that contain those fossils. Such scientists conclude that the rock layers must be approximately the same age as the fossils.

The theory that Earth is approximately 4.6 billion years old is strongly supported by most evolutionists. They believe that as the layers of the Earth were laid down, the oldest layer was laid first, the next layer was laid second, and so forth, until the most recent layer, which was the last to fall into place. Man supposedly appeared during the most recent layer.

With that premise in mind, evolutionists expect to find fossils of simple life forms buried deep in the earliest layers, and fossils of more complex organisms in the top layers. As scientists dig through these layers known as the ***geologic column***, the rocks lowest in the column should have only fossils of very simple life forms. Fossils higher in the column should be different. They should show a gradual change from these simple forms into more complicated forms of life.

geologic layers



Scientists who support this theory have developed a ***geologic time scale*** that organizes the geologic column into four divisions of time, called *eras*: precambrian, paleozoic, mesozoic and cenozoic. Each era is subdivided into periods which theoretically cover millions and millions of years. The terms *geologic column* and *geologic time scale* are used interchangeably. Evolutionists claim that simple living things developed into complex living things within each era. For example, during one time period, some fish theoretically gradually evolved into ***amphibians*** and some amphibians developed into reptiles. In the next era, some reptiles evolved into birds, and other reptiles into mammals. Finally, some mammals evolved into humans. Weaker organisms died out along the way and became extinct.

According to this theory, fossils are assigned to particular eras, depending on their

VOCABULARY

Artifacts: objects made by humans, such as tools, pottery or jewelry from an earlier civilization

Law of Superposition: in layers of rock, the oldest layers are at the bottom, and the youngest layers are at the top if the layers have not been disturbed

Cataclysmic: description of violent, physical action producing changes in Earth's surface

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levels of development on the evolutionary ladder. Fish should be found in a layer lower than mammals. As an evolutionist finds fossils, he or she dates the rock layer which contains the fossils. Evolutionists who date the fossils by the age of the rock layers are criticized for using *circular reasoning:* also dating the rock layers by the fossils.

Many scientists have found a major problem with this type of dating process. As they dig for fossils, paleontologists find fossils of fish, amphibians, reptiles, birds, and mammals in the same layer. They also find mammals in the deepest layers, but according to evolutionary theory, mammals should not be found there if mammals evolved last; they should be only in the top layers. More doubt is being cast on evolution as more human ***artifacts*** are found in "out of order" places in all layers of the geologic column. Findings from Mesozoic/Paleozoic eras include: foot, sandle and hand prints, fossilized human skeletal remains, a gold chain embedded in coal and metal tools and implements, such as an iron pot and an iron hammer embedded in rock. Scientists who question the geologic time scale sequence claim that fossils are buried *where* they lived, not necessarily *when* they may have lived. For example, fossils of clams and sea creatures are discovered in deep rock layers because the water creatures lived deep in the ocean before experiencing fossilization.

Many scientists believe that all the different, basic kinds of plants and animals appeared on Earth complex and fully grown. Each basic kind would then appear complete in the fossil record. According to this idea, scientists would expect to find fossils of various basic types, similar to creatures in existence today. Scientists would expect to find fossils of reptiles and fossils of birds, but would not expect to find fossils showing reptiles gradually changing into birds. The fossil record casts much doubt on evolutionary development of Earth and its creatures.

When evolutionists find fossils of simple organisms in the same rock layer with fossils of complex organisms, they employ a concept called the ***Law of Superposition*** to explain why the evidence seems to contradict their theory. The Law of Superposition states that, in rock layers, the oldest layers are at the bottom, and the youngest layers are at the top, if the layers have not been disturbed. If the fossil evidence does not support the Law of Superposition, scientists assume that the layers have been disturbed by something ***cataclysmic*** such as an earthquake, a volcano, or a flood.

The geological column, or time scale, shown below does not represent an actual series of rock layers. The chart was designed to help scientists classify fossils, based on the Theory of Evolution. The chart depicts eons of time in descending order from most recent to most ancient and lists the major groups of organisms thought to have evolved in those time periods. The time scale is only hypothetical —the Theory of Evolution in chart form. Nowhere on Earth does this complete sequence exist. In fact discoveries by archaeologists and paleontologists more often discredit the

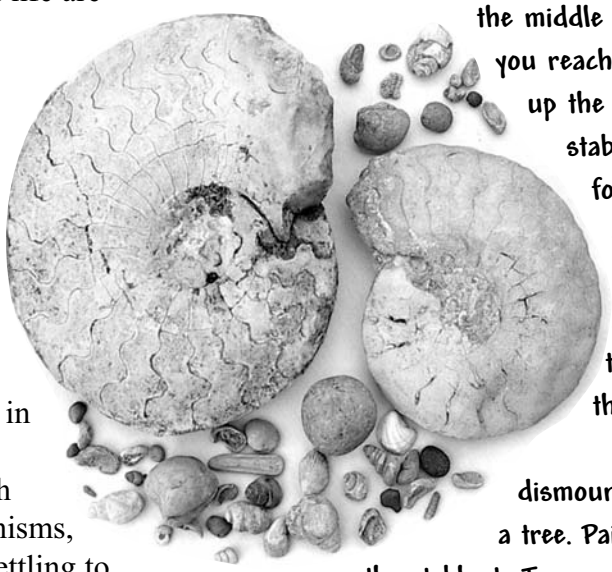
Geologic Column/Time Scale

Name/Timespan of Eras	Basic Life Forms
Cenozoic Era (up to 975,000 years ago)	mammals, man, complex plants
Mesozoic Era (70 million to 2 million years ago)	dinosaurs, birds
Paleozoic Era (200 million to 500 million years ago)	all invertebrates, earliest vertebrates, primitive land plants, amphibians, reptiles
Pre-Cambrian Era (500 million to 2 billion years ago)	"Big Bang" (formation of Earth) primitive water organisms (algae, bacteria)

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chart than validate it. This is why most explanations of the origin of life are *theories*.

Many scientists who support the Young Earth Theory believe that Earth is only about 6,000 to 10,000 years old, and that thick layers of sediment were laid down suddenly following a worldwide catastrophe, such as Noah's flood. In this view, material in Earth's surface would have accumulated into layers with the heaviest items and organisms, not necessarily the oldest, settling to the bottom first. Perhaps this is why dinosaur fossils are often found many feet below ground level, while fossilized sea shells rest on mountain tops.



You hoped you would not be caught in the middle of a flood. Just as you reached the trail that led up the mountain back to the stable, lightning flashed, followed by a loud clap of thunder. Paint was startled by the noise and reared back, throwing LaToya to the ground.

You quickly dismounted and tied Star to a tree. Paint ran back toward the stable. LaToya was bruised, but (thankfully) not hurt. You encouraged her to rest for a few minutes as you sat beside her on the ground. Fortunately, her head had just missed a layer of rock and she had landed on the softer ground. Something about the rock caught your attention, but just as you were about to get a closer look, you heard a growling noise. Whatever it was, it was too close. You forgot about the rock and quickly helped LaToya up onto Star. Climbing up behind her, you both rode back to the stables as fast as Star could gallop!

Life Principle

"Truth is always strange; stranger than fiction."

—Lord Byron in *Don Juan*



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Lesson 12
Paleontology

Chapter 5

Early Fossil Finds, How Named, Theories on Extinction

Section 3

Lessons 11-15

DINOSAURS



You made it back to the stable just as the first drops of rain hit your area. When Paint arrived without a rider, the guide knew that something must have happened. He was about to start looking for you when you both showed up on Star. The guide told you that Star must like you to let you ride double.

Because of the rain, you and LaToya stayed in the stable area protected from the weather. The guide showed you how to unsaddle Star and to brush him. You asked permission to ride Star back to the river the next day. The guide agreed.

The thunderstorm passed quickly, so you and LaToya returned to the campsite. Mr. and Mrs. Clark had stayed in their car during the storm. That was much safer than standing under a tree. The tent and other equipment had survived the earthquake and the thunderstorm without any damage. That had been some day!

You helped Mrs. Clark and LaToya prepare dinner by using the camp stove. After you finished eating, Mr. Clark carefully put all the food in the ice chest and locked it in the car trunk. He reminded you of the ranger's warning to keep food out of the tent at night. You certainly did not need a bear ripping through your tent during the night trying to find food!

Suddenly, you remembered about the rock where LaToya was thrown from her horse. You were about to get a closer look at it before you heard something making a growling noise. That area is where the bears had been reported. You would have to get a closer look at the rock the next day, when you could do so

VOCABULARY

Dinosaurs: extinct, often gigantic, reptiles
Iguana: a large tropical lizard
Iguanodon: large dinosaur that probably stood upright, ranging up to 33 feet in length
Reconstructed: to construct again, rebuilt
Protoceratops: a small dinosaur about six feet long
Maiasaura: dinosaur whose name means "good mother lizard"
Mesozoic Era: one of four divisions of the Geologic Column, or Time Scale
Archaeopteryx: an extinct bird

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safely. You thought you saw something that resembled a huge footprint, but you could not be sure.

Fossils of ***dinosaurs*** have been found in just about every place in the world, including the United States. Scientists have been analyzing dinosaur fossils for more than 150 years. The earliest fossil finds were in Europe. In 1822, Mary Anne Mantell, wife of a British, fossil-collecting physician, discovered a rock which contained a fossilized tooth that looked like a tooth of an ***iguana***, a lizard that lives in Mexico and South America. However, the fossilized tooth was much, much larger. Dr. Mantell concluded that the animal from which the fossilized tooth came must have been a giant, plant-eating, reptilian animal and named it ***Iguanodon*** (iguana tooth).



The mystery was not solved until some miners found the fossilized skeletons of more than 30 Iguanodons buried and piled together about 1,000 feet down in a coal mine in southwest Belgium. From these fossil finds, scientists were able to discern the size and distinctive parts of Iguanodons. They varied in size from one and one-half tons to five tons and ranged in size from 14 to 33 feet in length. They may have stood as tall as 17 feet. They probably stood upright on their two strong hind legs and feet, but could run on all four legs when necessary. Sir Richard Owen, British anatomist and superintendent of the famous British Museum noted that Iguanodon fossils represented a category of reptiles that had not yet been classified. In 1841, he gave them the name *dinosaur*, which means "terrible lizard."Since that time, many dinosaur fossils have been discovered and identified.

Great care is taken with dinosaur fossils. When significant fossils are located, an exact diagram of the fossil location is made. Each fossil is numbered, measured and photographed, and careful notes are recorded. Each fossil is cautiously dusted and placed in a special container to protect it. The fossils are then taken to a museum where the skeletons are ***reconstructed***, sometimes mistakenly. For example, the "discoverer" of *Brontosaurus* placed the wrong dinosaur head on *Apatosaurus*, thereby creating Brontosaurus. New dinosaur dictionaries do not feature Brontosaurus, who was a mistake.

Finding a complete dinosaur skeleton is rare. Sometimes bones have to be made from plaster to fill in missing parts. Months may be required for scientists to reconstruct a large dinosaur skeleton. Many prehistoric reconstruction displays in museums and textbooks represent skilled artwork of scientific suppositions.

Much has been discovered about dinosaurs since Sir Richard Owen gave them their name. In 1922, fossilized dinosaur eggs were found in the Gobi Desert of Mongolia. Over 30 eggs were found in each of several nests. The mother was a relatively small dinosaur, called ***Protoceratops***, that was about six feet long.

In 1978, in Montana, a dinosaur's nest was discovered that not only had fossil eggs in it, but also the bones of fossilized babies. The dinosaur that laid these eggs was given the name ***Maiasaura*** which means "good mother lizard." The Maiasauras were duck-billed dinosaurs that grew up to 30 feet long. They laid their eggs in nests that were made from mounds of dirt six feet across.

Dinosaurs were huge or small, tall or short, fast runners or slow movers. Scientists agree that great variety existed among dinosaurs. However, not all scientists agree as to when dinosaurs lived or what happened

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to them. They disappeared mysteriously from Earth.

Some scientists believe that dinosaurs appeared during the ***Mesozoic Era***, which is one of the four basic divisions of the Geologic Column. These scientists believe that dinosaurs lived from about 230 million to about 65 million years ago. Evolutionary theory contends that the ancestors of dinosaurs were crocodile-like creatures called *Archosaurs*. Evolutionists believe some Archosaurs became crocodiles while others became *Pterosaurs*, a type of flying reptile. Evolutionists think other Archosaurs adopted a two-legged posture, s-shaped necks and evolved into dinosaurs.

The fossil record reveals no evidence of dinosaurs that are part crocodile on the way to becoming full dinosaurs. About 300 different varieties of dinosaurs have been discovered in the fossil record. Each one is a distinct type of dinosaur. Some evolutionists believe that ***Archaeopteryx*** was a cross between a reptile and a bird. However, the evidence indicates that the ancient creature was very much a bird. It had perching feet, feathered wings, a bird-like skull and a wishbone. Birds are the only creatures with feathers. Other evolutionists claim archaeopteryx was clearly a bird. Intelligent design scientists believe that dinosaurs did not evolve at all, that they always have been dinosaurs, just as people always have been people.



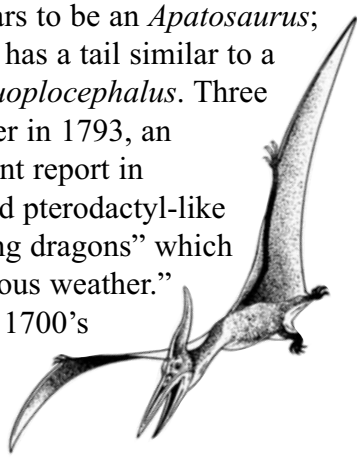
Archaeopteryx

Many scientists think that the Bible records dinosaurs in the Book of Job. There, a huge animal with a tail the size of a large tree trunk is described and is named "behemoth." Scholars estimate that this description was made about 2000 B.C. The word "dinosaur" did not come into existence until 1841.

That dinosaurs or "dragons" may have lived during man's time is reflected in numerous written accounts of sightings and encounters of them by people, in petroglyphs (pictures carved in rock by humans) and in fossilized human footprints, both inside and alongside dinosaur tracks.

Some scientists think the data from historical references along with other evidence such as the fossilized footprints indicate that dinosaurs may have lived up until at least about 4,000 years ago and reportedly into more modern times. In 330 B.C., soldiers of Alexander the Great in their conquest of India, reported finding natives there who worshiped huge, hissing reptiles that lived in caves. An Irishman in the 900s recorded his encounter with a creature that looked like a *Stegosaurus*. In 1572, an Italian peasant killed a "dragon" that fit the description of *Tanystropheus*, one of the smaller dinosaurs.

The tombstone for the Bishop of Carlisle (in the United Kingdom), who died in 1496, bears various animal carvings around its brass border. One image depicts two sauropod-type creatures engaged in combat. On appears to be an *Apatosaurus*; the other creature has a tail similar to a *Stegosaurus* or *Euoplocephalus*. Three hundred years later in 1793, an official government report in Scotland described pterodactyl-like creatures as "flying dragons" which preceded "boisterous weather." In the 1400's and 1700's public records consisted of events which people or their ancestors had either personally



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witnessed or recorded. Numerous, early, detailed drawings, as well as later, written descriptions of dinosaur-type creatures preceded discoveries of their fossilized skeletons.

Since the mid 1800's, scientists have discovered numerous ancient petroglyphs, artifacts, documents and art forms on nearly every continent, depicting many different types of dinosaurs and "sea monsters." Such discoveries cause some scientists to question unproven theories that man evolved millions of years later in time than dinosaurs.

In the Indian Ocean in 1938 and again in 1952, fishermen caught live *coelacanth* fish. Such "prehistoric" fish were claimed to have become extinct 200 million years ago. Unfossilized bones of a *Tyrannosaurus Rex* were found and studied by University of Montana scientists in 1990. They reported discovery of what appeared to be red blood cells that could not possibly be millions of years old. The cells would either have decayed or fossilized.

Scientists not only disagree on when dinosaurs lived, but also on what caused them to become extinct. Evolutionists present several hypotheses. One idea is that an enormous meteorite collided with Earth. Theoretically, this collision threw so much dust into the upper atmosphere that light and heat from the Sun were blocked out for several years. Lack of sunlight would have killed vegetation, and the dinosaurs would have perished for lack of food. Some scientists disagree with this theory due to survival of other reptiles: snakes, turtles, and crocodiles.

Other scientists suggest that dinosaurs had such tiny brains, they could not compete with more intelligent animals for survival. Another theory is that egg-eating mammals ate so many dinosaur eggs that some species became extinct.

Many archaeological sites give evidence that a great, catastrophic flood occurred over the entire world, which changed Earth's climate and landforms and affected everything, including the dinosaurs. The pre-catastrophic Earth would have had warm temperatures (comfortable for reptiles) and would have been filled with lush, green plants.

The climatic changes caused by the catastrophe could have killed many of the surviving animals including Mastodons and dinosaurs, which needed a warm climate to survive. Food, once abundant in a lush tropical climate, would have been hard to find in the frigid temperatures of a harsh Ice Age. During this time, glaciers and great sheets of ice could have covered about a third of the world. The dinosaurs in these land areas simply could not have survived in such hostile weather conditions. They did, however, leave footprints and fossils to remind us of their existence.

When you awoke the next morning, the weather conditions were great! It was a beautiful, sunny day. Mr. and Mrs. Clark said they would join you and LaToya on your horseback ride to the river. They planned to fish and take a canoe ride. You and LaToya were going to check on that intriguing rock before you did anything else!

LIFE PRINCIPLE



"Self-discipline keeps good habits in your life from becoming extinct."

—Dennie Lindsey

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Lesson 13
Biology

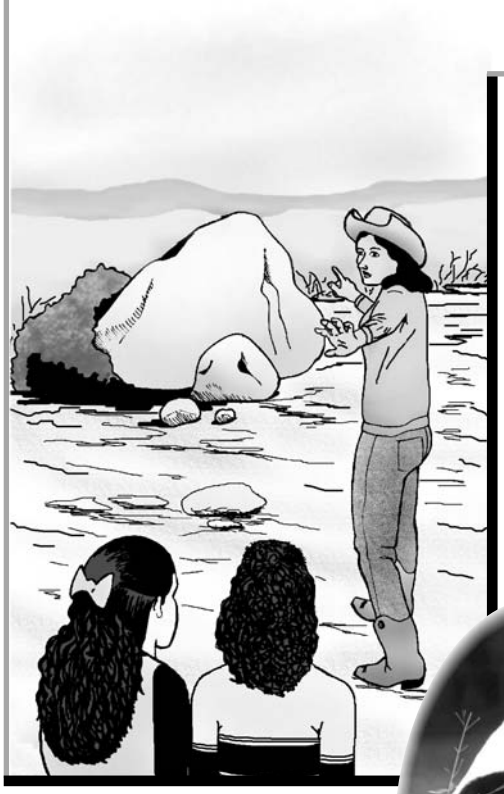
Chapter 5

Types and Rates of Extinction, Contributing Factors, Legislation

Section 3

Lessons 11-15

EXTINCT AND ENDANGERED SPECIES



The trip to the river on horseback was fun. You and Star led the way, LaToya and her mom and her dad followed. At the river, the four of you tied your horses to a hitching post. Mr. and Mrs. Clark selected a canoe to use. You and LaToya looked for Diane and Dana. LaToya spotted them working beside Professor Parker at a new site very close to the spot where LaToya was thrown from her horse.

Diane and Dana had scary news. Apparently the night before, three tents were ripped apart by bears. The interesting thing was that no one saw the bears. They just heard the growling and tearing noises. By the time anyone could get a flashlight or a lantern, the bears were gone. Some of the paleontologists were packing up to leave because of fear. Another strange circumstance was that the tents that were attacked did not have any food in them. The park rangers were surprised at the behavior of the bears. This had not happened before.



You told your story about hearing some growling noises yesterday as you tried to get a closer look at a rock. The bears seemed to be everywhere, at least in the fossil bed area. You hoped the bears were asleep somewhere that morning. You asked the girls to take a look at the rock because you thought it might contain fossils.

As you walked towards the rock, you tried to ***clarify*** that you had just gotten a quick glance at it before you were scared away. Diane and Dana were not afraid. They explained that their dad taught them to use common sense when approaching a new

VOCABULARY

Clarify: to explain or make clear
Species: the smallest group into which living things are classified
Endangered species: those organisms that are in danger of becoming extinct
Poachers: people who hunt or fish illegally
Pollution: harmful chemicals entering water, air or soil

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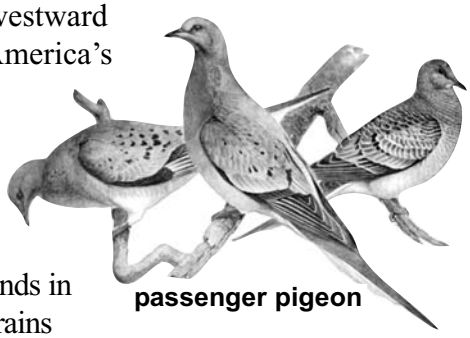
situation. They would approach the area cautiously and leave at the first sign of danger. That plan helped you and LaToya to be brave. However, you secretly wished that bears had joined dinosaurs on the extinct list. That would have suited you just fine!

Dinosaurs are the best known organisms thought to be extinct. However, fossil records have shown that many other ***species*** have also become extinct. Usually, extinction is a natural process that takes place as human and animal populations die because of changes in climate, lack of food, war or through disease.


dodo bird

In recent times, people have caused the extinction of several animal species. The dodo bird and the passenger pigeon were hunted until they became extinct. The dodo was a large bird, about the size of a turkey, which could run but not fly. These birds once inhabited the forests of the island of Mauritius in the Indian Ocean. The dodo was first reported by Dutch colonizers in 1598. Dodos became extinct in less than 100 years because they were exploited by hunters. In addition, domestic animals such as hogs, destroyed many dodo eggs in their nests.

At one time, an estimated three to five billion passenger pigeons occupied the Earth. In the United States, the first settlers to move west in the 1880s found the passenger pigeons a convenient source of meat, fat and feathers. The westward expansion of America's railroads encouraged professional hunters to kill pigeons to meet restaurant demands in eastern cities. Trains shipped thousands of pigeons directly to city markets. Within a short time, the supply was exhausted. In 1914, the last remaining passenger pigeon died in a zoo.


passenger pigeon

The current global extinction rate of both plants and animals is estimated at about 20,000 species per year. Since the 1700s, over 60 animal species have disappeared from the United States alone.

Nothing can be done to save species that are already extinct, but something can be done to protect the plants and animals whose populations are dwindling in size. ***Endangered species*** are those organisms that are in danger of becoming extinct. Some animals considered endangered include the California condor, whooping crane, the giant panda, the brown pelican, and the peregrine falcon.


giant panda

To protect endangered species in the United States, the Endangered Species Act was passed in 1973. This legislation makes illegal the harming of animals considered to be endangered species. Several worldwide conservation organizations maintain a global list called the "red list" of endangered and vulnerable animal species. Many countries

VOCABULARY

Food chain: the path by which energy is transferred from one organism to another
Ecosystem: all the living and nonliving things in an environment and the ways that they affect one another

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regulate and restrict trade involving species on the "red list." For example, many countries banned the sale or trade of elephant-tusk ivory in an attempt to prevent widespread slaughter of elephants just for their tusks.



Sadly, human activities account for many of the animals being placed on the list of endangered species. Loss of habitat, or habitat destruction, is a major cause of placing a species in danger. As the human population increases, so does the need for places for humans to live, shop, go to schools, enjoy recreation and farm. To make room for these activities, the areas where plants and animals live are cleared. When that happens, many native plants do not reproduce and animals which cannot relocate, die.

Unfortunately, some people hunt illegally and kill endangered animals just for their fur or other body parts. These people are called ***poachers***. Poachers illegally kill elephants for their ivory tusks. In recent years, the African elephant population has dropped from an estimated one million to only five hundred thousand. Much of that drop is because of poachers and their activities. The number of black rhinoceroses has fallen from 60,000 to about 3,500 today. The animal is slaughtered for its horn, which is used in Asian ceremonies.

The large majority of sporting hunters obey hunting laws, including those that put a limit on the number of animals that can be killed. Limits on animals taken by hunters are usually assigned on a daily or seasonal basis. The quotas can change as game populations increase or decrease. Hunting for sport within the limits of the law is an activity many people enjoy. When done correctly, hunting actually helps maintain healthy populations of game animals. Controlled hunting prevents endangered wildlife from starvation or death on roadways.

Human activities that involve ***pollution*** can endanger living things. Polluting the water, air or soil with harmful chemicals can change the natural environment; thus can cause both plants and animals to sicken and die.

Humans should be concerned about species becoming extinct or endangered. If a species is eliminated, a break occurs in the ***food chain***. Plants, animals and humans are all valuable parts of an ***ecosystem***. Each part occupies a specific place in the design of nature, on which other living creatures depend. Balancing human need for activities with the needs of plants and animals is not easy, but it is necessary for Earth's ecosystem to be maintained.

As the four of you approached the rock, you detected that same rustling sound. Within a few seconds, the growling started. Dana motioned for the three of you to slowly back away. She stood still, listening. Then she backed away, also.

LIFE PRINCIPLE



"Your talents and abilities become endangered or extinct if they are not used."

—Anonymous

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Lesson 14
Health

Chapter 5

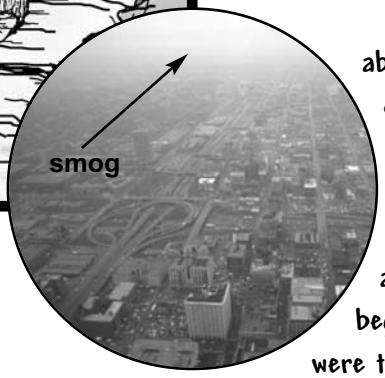
Smog, Acid Rain, Dumping Hazzardous Materials and Recycling

Section 3

Lessons 11-15

POLLUTION PROBLEMS





Dana joined the three of you at the river's edge. She told you that something about the growling did not sound right. However, until she was sure, Dana did not want to take any chances. She could only get a glimpse of the rock because she could not get very close to it. However, Dana thought she saw enough to know that it might very well contain a fossilized footprint. She was certain that Professor Parker would want to examine it.

Dana thought something was phony about the growling sound, so she developed a plan to trick whatever or whoever was making the noise. She instructed the three of you to return to the rock. She told you to scream and act scared when the growling noise began. Then you were to say that you were too afraid to stay any longer and you were going to find your parents and go home.

The three of you carried out Dana's plan while she hid in the bushes. As you ran away screaming, she remained hidden. You, Diane, and LaToya ran back to the dock as if you were waiting for your parents to return from their canoe trip. Within a few minutes, Dana signaled for you to return to her hiding place.

The four of you cautiously approached the rock. There was definitely a part of a huge footprint showing. The rest of the rock was buried beneath a mixture of pebbles and dirt. Just beyond that rock were two others with the same type of footprints. Diane and Dana were thrilled. They recognized that as a major fossil find. But, before they notified Professor Parker, Dana said to follow her.

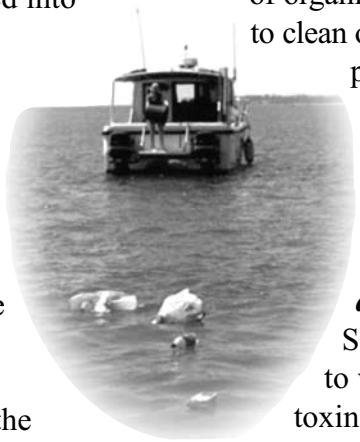
VOCABULARY

Environment: the conditions that surround you
Microorganisms: organisms of tiny size, such as germs
Deteriorate: to diminish in quality, decay or fall apart
Fertilizers: chemicals added to soil to help plants grow
Smog: air pollution produced from chemicals and automobile exhaust combined
Acid rain: rain having an unusually high acid content as a result of pollutants

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In the wooded area where the growling noises originated, Dana told you to look for anything unusual. Behind a large tree, LaToya found a candy bar wrapper. Just past that, you found two batteries. Diane discovered a soda can beside a bush, but no signs of a bear were anywhere. Dana remarked that bears did not pollute the environment like that. Only inconsiderate humans did!

The ***environment*** is everything around us. It includes living things and nonliving things. It also includes the air we breathe, the water we drink and the soil in which we grow our food. We are affected in many ways when harmful substances are released into the environment.



Ocean pollution is the dumping of harmful materials into the ocean. For years, people legally dumped waste products into the ocean. Such actions were justified with the reasoning that the oceans were so large that waste products would not be harmful. As scientists learned more about the delicate balance of life within the oceans and its effect on humans, this type of careless activity was declared illegal.

For example, years ago, some people thought mercury could be safely dumped on the ocean floor. Since the mercury would not dissolve in seawater, the action was considered harmless. However, scientists have learned that chemical processes in the ocean changes the mercury so that it is absorbed by fish, shrimp, oysters and other sea life. Since mercury is poisonous, people become ill when they eat mercury-contaminated sea food.



Oil spills also create an environmental hazard for ocean life. Plants and animals covered by oil can die. Oil affects the ability of organisms to feed and breathe. Birds that try to clean oil from their feathers can die from oil poisoning.

Rivers, lakes, streams, and ponds are also recipients of pollutants. Foreign matter such as certain ***microorganisms***, chemicals, industrial wastes or sewage will ***deteriorate*** the quality of water. Sewage can add bacteria and viruses to water supplies. Another source of toxins is poisonous chemicals used to control pests on crops and lawns. For example, sediments consisting of soil particles with chemical ***fertilizers*** and pesticides can be washed by storms into nearby rivers or lakes. These chemicals are harmful to fish and to humans who eat the fish or drink the water.

The Clean Water Act of 1977, as well as other pieces of legislation, established rigorous controls and cleanup guidelines for industrial and public pollution. Citizens and officials have an obligation to make sure rivers, lakes, streams and oceans are protected from harmful substances.

The air we breathe is made up of a number of gases. Atmospheric gases are essential to living things. Without air, we

VOCABULARY

Incineration: burning a substance to ashes
Composting: a mixture of decaying organic matter using as fertilizer
Recycling: to reprocess a thing and using it again

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would die within minutes. Individuals might not contribute much to air pollution, but collectively a nation can pollute the environment. A significant portion of industry and transportation is based on burning gasoline, coal and oil. These fuels release chemicals that are discharged into the atmosphere. ***Smog*** is usually found in urban areas because of automobiles and industry. Smog can cause serious health problems related to lung disease. Nations throughout the world are constantly attempting to strike a balance between convenient use of vehicles and prevention of pollution.

Acid rain forms when sulfur dioxide and nitrogen oxide, from industry and car exhausts, react with water droplets in the air. The precipitation returns to Earth in the form of acid rain which harms wildlife, plant life, and deteriorates stone buildings. The Clean Air Act was enacted to keep air free from pollution.

The land can be polluted by any number of materials including garbage, sewage, trash, litter and industrial wastes. Solid wastes are unwanted materials such as garbage, paper, plastics and other synthetic items, metals and wood. A typical American generates an average of four pounds of solid waste each day.

Until the mid 1960s, trash dumps in open fields and ditches were common places for communities to dump garbage and trash. Such places were infested with rats and insects. Since the 1960s, *sanitary landfills* have taken the place of the town dumps. Landfills are large, unlined dirt pits into which solid wastes are placed. When a pit is filled, it is covered over with dirt and another pit is dug. This process allows communities to maintain safer environments and to reclaim land for future use as places of recreation, residences or industry.

Incineration, or burning, of waste reduces the volume of solid waste, but can produce concentrations of toxic fumes or hazardous materials that become airborne. ***Composting*** uses natural biological processes to break down organic wastes. This is an effective way of dealing with organic garbage, but not man-made materials such as plastics or glass.

Recycling has become an important part of disposing of waste products. Recycling involves reusing certain waste materials and helps reduce solid waste pollution.



Any place with human activity produces items which need to be thrown away. Each person can help maintain a safe environment by disposing of trash in an appropriate container, not littering, and by recycling waste products whenever possible.

Dana and Diane picked up the discarded batteries, soda pop can and candy wrapper. Before they put this litter in one of the trash containers placed throughout the campsite, the girls showed it to Professor Parker. Dana explained her theory about the bears to her dad. She thought that the batteries were from a tape recorder that had a recording of a bear growling. She believed that someone was using that growling noise to scare away campers and scientists.

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Professor Parker agreed. Some of the paleontologists and archaeologists had been scared away by what they thought were bears. As a result, most of the excavation work had stopped. It was as if someone did not want the project to go forward.

You led Professor Parker to the rock you had found. Suddenly, he became quite excited and called for the other scientists to join him. Working carefully and meticulously, they uncovered several sets of dinosaur tracks along side human tracks. That was a rare find! Professor Parker said he might have missed finding it, had it not been for you and LaToya. He thought he knew the reason someone had tried to scare him away. Those tracks could be excavated and sold for a significant amount of money to any one of many museums in other countries that would gladly pay to have them. However, Professor Parker and the scientists with him planned to take some of the tracks back to the university for science students to see and appreciate. The rest of the tracks would be donated to a local museum.

Dana was probably right. Someone had used those batteries in a tape recorder. When the batteries began wearing down, the bear's growl began to slow down in an unnatural way. Dana had listened carefully and had heard a whirring noise behind the sound of the bear's growl, made by the tape itself. Apparently, the person had changed the batteries and had simply thrown the old ones on the ground.

You and LaToya helped with the excavation efforts because, after all, you were responsible for discovering the fossils. But first, you went to the canoe dock to tell LaToya's parents. There, as you looked at the people in the canoes, you saw a clue to the mystery. Suddenly, you recognized the thief and where the missing dinosaur bones were!

Life Principle



"An unpolluted mind is a valuable asset."

—Anonymous

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Lesson 15
Physics

Chapter 5

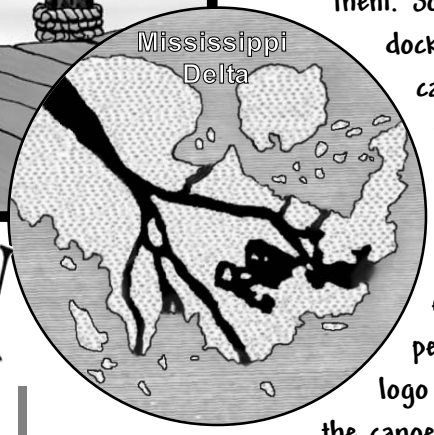
Drainage Basins, Sediment Deposition and Deltas

Section 3

Lessons 11-15

RUNNING WATER





Standing on the dock, you watched as Mr. and Mrs. Clark paddled their canoe toward you. Other families were also enjoying canoe rides. The maximum number of persons these canoes could hold was four. You noticed that the canoes with four people aboard sank lower in the water than the canoes with just one or two people in them. Some empty canoes were tied to the dock, waiting to be used. The unoccupied canoes were riding highest on the water. Each canoe was inscribed with the logo, Running River Canoe Company.

The water level was high enough on the canoes holding four persons to touch the logo. The entire logo was clearly above the water level on the canoes holding one or two people. The logo on the empty canoes sat highest above the water level.

Only one canoe was occupied by one person. That person was a man wearing a familiar looking hat. He was paddling quickly away from the dock. All the rest of the canoes had several passengers in them. Strangely, the canoe with only one person was riding lower in the water than any of the others. That canoe was sitting so low in the water that the entire logo was covered!

A climb up the lifeguard tower at the end of the dock gave you a better vantage point to observe that particular canoe. You noticed the bottom of the canoe was filled with long cases. At first glance, anyone would have thought those cases were filled with fishing rods. However, you suspected otherwise!

VOCABULARY

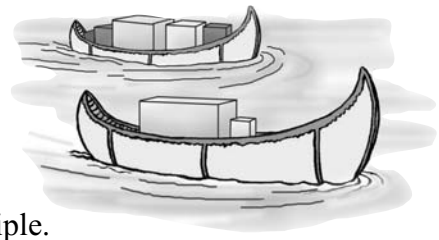
Buoyancy (boý-ancy): the tendency of an object to float in liquid
Archimedes' Principle: documents that a submerged object is subject to a buoyancy force that is equal to the weight of the fluid displaced by that object
Submerged: placed under water
Displaced: one thing having taken the place of another
Sediment: small rocks, gravel or sand that are carried by a river from one place and deposited in another location

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You were actually using the scientific process of observation to help you solve a mystery. By observing the water level on the canoes, you noticed that the heavier the load, the lower the canoe rested in the water. The scientific word for what you were observing is ***buoyancy***, which is the tendency of an object to float in a liquid. The lighter the object, the higher it floats in the liquid. The heavier the object, the lower it floats in the liquid. Therefore, the heavier canoes rode lower in the water than the lighter canoes.

Objects in those cases were so heavy that they caused the canoe with only one person to ride lower in the water than a canoe with four occupants. Application of ***Archimedes' Principle*** convinced you that the canoe carried objects much heavier than one man.

Archimedes was a Greek mathematician and philosopher who lived in the third century, B.C. He documented that a ***submerged*** body is subject to a buoyancy force that is equal to the weight of the fluid ***displaced*** by that body. The mysterious canoe represented the submerged body. The fluid was the water in the river. The displacement was how high or low the canoe floated in the water. The relationship between an object and the water it displaces is called Archimedes' Principle.



Rivers flow to the ocean under the influence of gravity. Most rivers travel a long way before reaching the ocean, but that is the final destination of most streams and rivers. As rivers make their journeys, earth materials erode and are transported elsewhere. This material is called ***sediment*** and is composed of fine rocks, gravel, and sand that, along with the water carrying them, wears away at the banks of the rivers. This determines the rivers' courses with bends and canyons created either by a little water over a long time period or a great deal of water in a short time period.

Rivers develop as water that drains from land surfaces and streams come together. Every stream, no matter how large or small, has a ***drainage basin***. This is the land area out of which water flows that contributes water to streams. In mountainous areas the drainage basin for rivers includes the snow at the tops of the mountains. As the snow melts, runoff water produces small streams. Other forms of precipitation contribute to this process. Small streams come together to form bigger streams. Bigger streams eventually merge to form rivers.

A drainage basin can be as small as the top of a mountain, or as large as a region of the United States. The largest drainage basin in the United States is the Mississippi River Drainage Basin. This is the area that contributes water drainage that forms the Mississippi River. That basin covers about one-third of the United States.

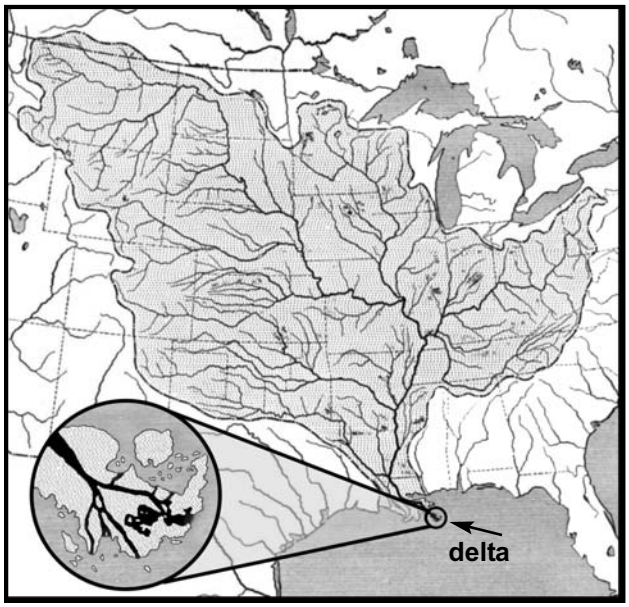
Rivers eventually drop or deposit their sediments in a process called ***deposition***. As the rivers slow down, larger particles of sediment drop out first. As these depositions

VOCABULARY

Drainage basin: the land area that contributes water to a stream by the water draining off the land
Deposition: the process in which rivers eventually deposit their sediments
Fertile: rich in material needed to sustain plant growth
Delta: a somewhat triangular-shaped flat deposit of sediment between river branches at the mouth of a river

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Mississippi Basin



collect, rich land forms "grow" and provide ***fertile*** ground for natural vegetation and wildlife. As a river enters a lake or an ocean, it slows down and deposits a large amount of sediment. This forms a ***delta***. Many large rivers have deltas extending over thousands of square miles. The Mississippi River delta is one of the largest deltas. The city of New Orleans is built on this delta, where once only ocean existed. The age of the Mississippi Delta is calculated to be about 4,000 years old.

As soon as the man in the canoe rounded the river bend, you found Professor Parker to explain what you suspected. He believed you, because he knew that Archimedes' Principle supported your data. He notified the park manager, who alerted park rangers located down river. Using a park patrol boat, the rangers stopped the man in the canoe before he could get away.

The man reluctantly admitted to the thefts of the dinosaur bones, which were hidden in cases labeled "fishing rods." This was the man (dressed in dark clothing, wearing a hat) you had seen drag some of the fossils into the woods. He had hoped to scare everyone away from the fossil bed so he could recover the fossils himself. His plan was to sell them to a museum in a foreign country. A tape recorder with new batteries was also found in his possession. The recorder contained a tape of growling noises the man had made of bears at a local zoo.

The Clarks were proud of you and LaToya for your quick thinking, common sense and careful observations! Professor Parker and the other scientists from the university acknowledged both of you as the ones who made the discovery of this latest set of dinosaur tracks and human footprints. Both of your names would be inscribed on a plaque at the university and at the museum where the prints would be exhibited.

Professor Parker talked to you and LaToya about enrolling in the university when you finished high school. He believed that you both could become outstanding science majors. He also felt certain that your accomplishments would earn you some type of scholarship.

You did not know what your future held, but college enrollment was an exciting possibility! As for the present, you wanted to take a canoe ride and demonstrate Archimedes' Principle yourself. You thought it would be a fun way to end the camping trip!

Life Principle



" When you feel yourself sinking, call for help."

—Anonymous

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