Earth and the Moon

TIMES AND SEASONS

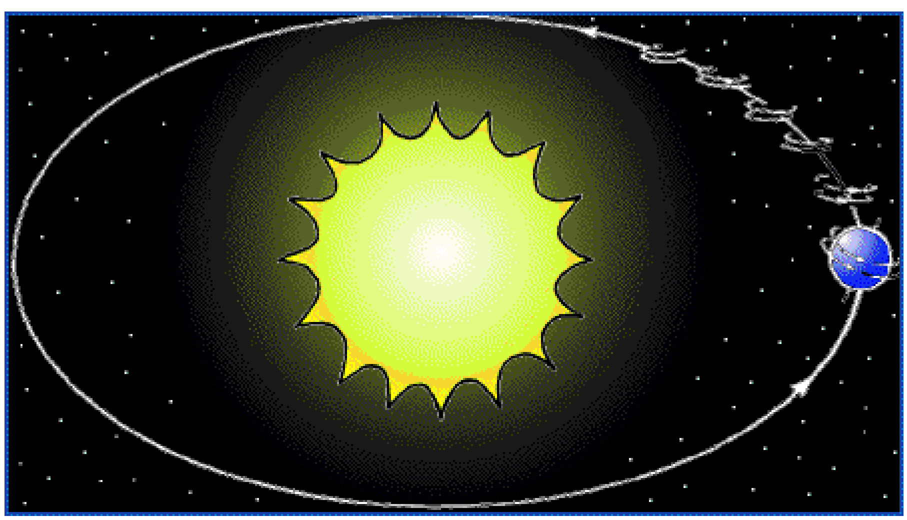
HOW THE EARTH MOVES

Have you ever looked at the sun when you get up in the morning? It looks low to the ground. Have you ever looked at the sun at lunch time? It looks high in the sky. What is happening? Is the sun moving? The answer may surprise you. The sun is not moving. It only looks like it is. In this lesson, you will learn why the sun looks like it moves through the sky.

The earth rotates. You may have used a *globe* to help you learn about the earth. A globe is a model of the earth. It spins on its *axis*, which runs through the North and South Poles. On the globe, the axis is a metal pole. On the real earth, the axis is an imaginary line. You can spin a globe around on its axis. The real earth moves this way, too. The earth spins, or *rotates* on its axis once a day.

It takes twenty-four hours for the earth to rotate once. The sun stays in the same place while the earth rotates. This makes the sun look like it is moving. You can see this for yourself by slowing turning in place. Stand in the middle of the room. Slowly spin around in a circle. You can see how objects in the room look like they are moving.

The rotation of the earth makes day and night. When your side of the earth is facing the sun, you have day. When your side of the earth is away from the sun, you have night. The earth's rotation keeps the sun from shining on all parts of the earth at the same time.



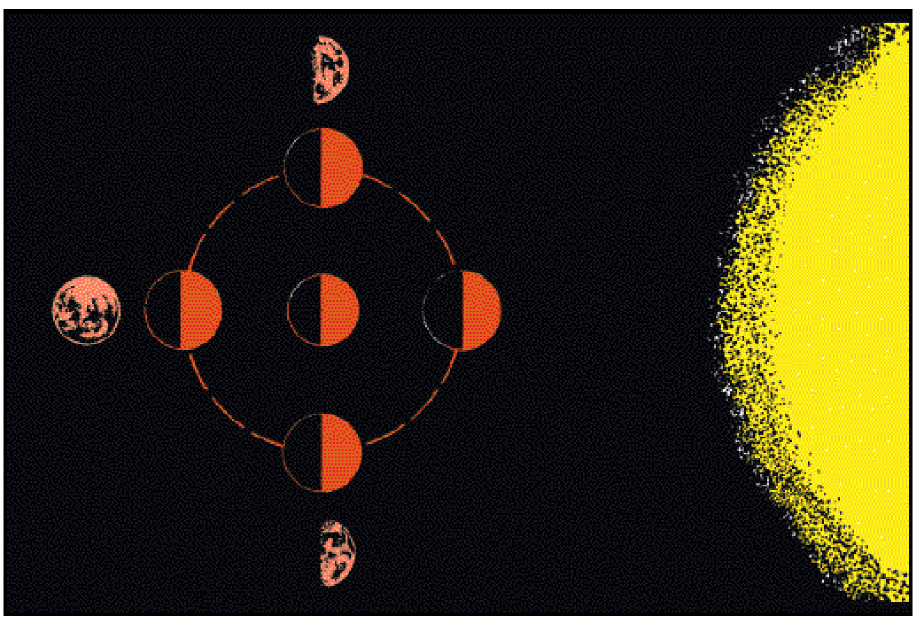
The earth revolves. The earth moves in another way. As the earth spins on its axis, it also *revolves* around the sun. The earth always travels in the same path. That path is called the earth's *orbit.* The orbit is almost a circle. The sun is almost in the center of the orbit. It takes one year, or 365 days, for the earth to revolve once around the sun. The earth's orbit around the sun makes seasons.

WHY TIME CHANGES

You look at a clock when you want to know the time. You look at a *calendar* when you want to know the day, week, or month. All these things help you to know about time. Long ago, people did not have clocks and calendars to help them. They had to look at the sun in the day to know the time of day. At night, they looked at the moon to know about the day of the month. In this lesson, you will learn more about what causes time to change.

Day and night. A day is the time that it takes the earth to turn around once on its axis. One rotation of the earth is one day. Each day is twenty-four hours long. You may think of a day only when you see the sun. You may think of night as the time when it is dark. The dark and the light together make one day. Each twenty-four hours of time is one day because that's how long it takes the earth to turn completely around.

Months and years. As the earth rotates on its axis, day turns to night and again to day. The earth also revolves around the sun. The earth takes one year to revolve around the sun. A year is divided into twelve months. About every thirty days, the moon revolves around the earth. That's how we determine our months. The picture below shows the four different phases of the moon during a one-month cycle.



You have found that the world turns around each day. As the world turns, the time changes. The world is divided into twenty-four time zones. The time zones help people to tell time in the entire world. As the world rotates, the time changes.

The United States has five time zones. The names are Eastern, Central, Mountain, Pacific and Alaska/Hawaii Time Zones. The time changes one hour from one time zone to another. When it is 5:00 am in New York City in the Eastern time zone, it is 4:00 am in Chicago in the Central time zone. When it is 4:00 pm in the Central time zone, it is 5:00 pm in the Eastern time zone. Alaska and Hawaii's time zone is two hours behind the Pacific Time Zone.

http://www.worldtimezone.com/

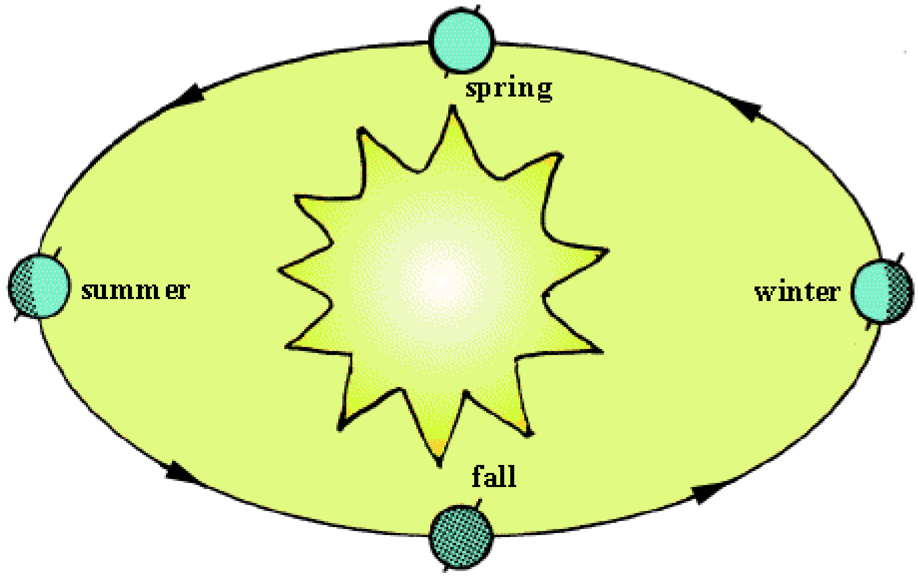
WHY SEASONS CHANGE

You have learned how the earth rotates, making day and night. You have learned how the earth revolves in an orbit around the sun, making a year. Now you are going learn what causes the different seasons of the year.

The earth's tilt. If you look carefully at a globe, you will see that the earth's axis does not point straight up. The axis *tilts* to one side. It always tilts the same direction. The earth is never straight up and down but always tilted a little.

As the earth revolves around the sun, the axis is tilted. First the axis points toward the sun, but as the earth travels around the sun, the axis points away from the sun. The way the axis points as the earth is traveling around the sun makes the seasons.

Winter and summer. Winter and summer happen because the earth is tilted as it revolves around the sun. The northern end of the earth's axis points toward the sun in summer months. These months are June, July, and August for the north end of the earth. You have more hours of light in summer. Your part of the earth is toward the sun for more hours each day. When the part of the earth where you live is toward the sun, you have hotter days. The southern end of the earth has its summer when the northern end is having its winter. These months are December, January, and February. When your part of the earth is having winter, it is pointing away from the sun, and the days are colder.



The earth is divided into two hemispheres, or halves. The top half is called the Northern Hemisphere. The bottom half is called the Southern Hemisphere. Seasons in the Northern and Southern Hemispheres are opposites of each other. When the Northern Hemisphere is having warm weather, the Southern Hemisphere is having cold weather. When the Northern Hemisphere is having cold weather, the Southern Hemisphere is having warm weather.

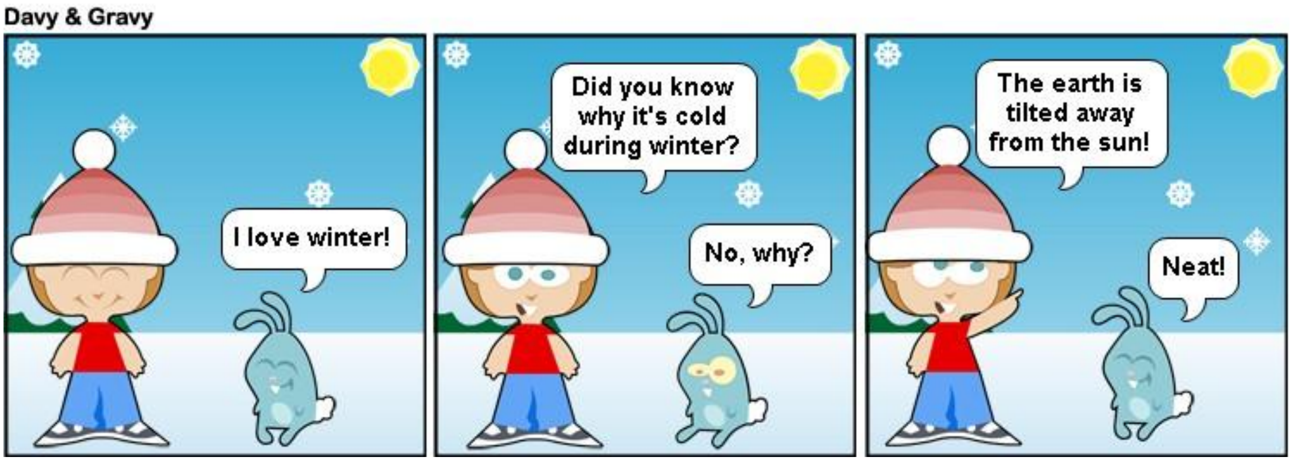
When your town has winter, the earth's axis is pointed away from the sun. Your town does not get as much light or heat from the sun. The days are shorter and colder.

Spring and fall. We have learned about winter and summer. There are two more seasons in the year. One comes after winter and before summer. The other season comes after summer and before winter. Can you name them? That's right. Spring comes between winter and summer and fall comes after summer but before winter.

The four seasons are spring, summer, fall, and winter. Spring and fall are opposite seasons. Which one do you like best?

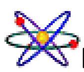
You have thought about the four seasons of the year. Each season is different. The seasons are made by the north end of the axis pointing toward or away from the sun.

Your part of the world gets more heat from the sun when the north end of the axis points to the sun. When the axis points away from the sun, you get less heat. Now you know why winter is colder than summer. The axis is pointing away from the sun in winter. It is pointing toward

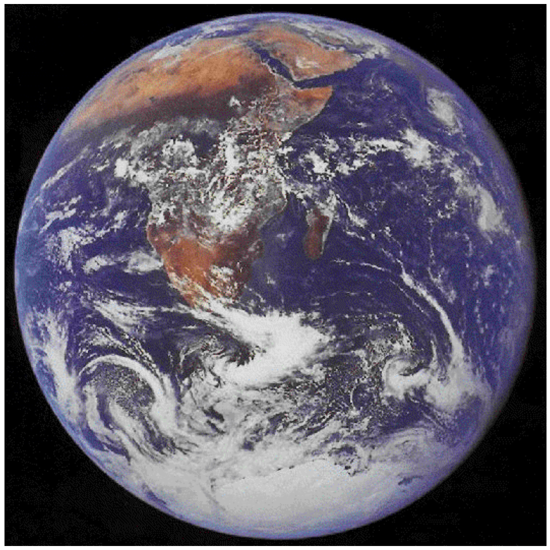


the sun in summer.

EARTH'S SHAPE

Earth is very special among all the planets. Earth is special because of certain things that make it suitable for life. It is the only planet we know of that is capable of supporting life. Some things that make Earth special are its distance from the sun, its oxygen that we breathe, and its tilt on its axis, the speed that it moves through space, and the amount of water present on it. All of these things, especially air, water, and sunlight, make life possible for us on planet Earth. In this lesson you will learn about Earth's shape.

Many ancient civilizations believed the Earth was flat. Over time, philosophers and scientists began questioning the shape of the Earth. The Greek philosopher Aristotle proposed a spherical shape for the Earth when he observed the Earth's shadow on the moon during an *eclipse*. Aristotle logically assumed that the shape of the Earth must be round since its shadow was curved. He also used differences in star constellations seen by people in the North and South to support his theory. Today, extensive exploration and satellite images have proven the spherical shape of the Earth.



About two thousand years after Aristotle, another great scientist named Sir Isaac Newton suggested that the Earth was not a perfect sphere. Using mathematical calculations, Newton determined that the Earth was flatter at the poles than around the middle. Newton called the Earth's shape an oblate spheroid. In fact, the Earth is not a perfect sphere. It bulges around the equator. The diameter of the Earth at the equator is approximately 7,926 miles (12,756 km), while its diameter at the poles is approximately 7,900 miles (12,714 km). The difference is only about 26 miles, but it is significant enough to contribute to climatic variations. Most globes and models show the Earth as a perfect sphere for the sake of simplicity.

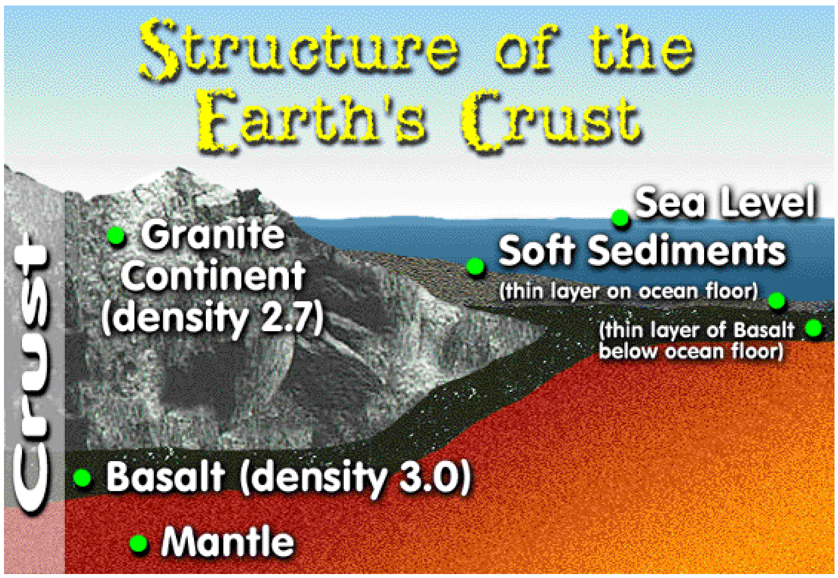
The equator divides the Earth into two halves, called *hemispheres*. The hemisphere north of the equator is the northern hemisphere, and the one south of the equator is the southern hemisphere. The Earth can also be divided into eastern and western hemispheres by the Prime Meridian. This imaginary line runs through Greenwich, England at 0° longitude.

Recent scientific studies have indicated that the shape of the Earth may be changing. Satellite images and mathematical calculations have suggested significant changes to the Earth's bulge at the equator. Scientists believe that this change is due to climate and weather related events. Over the past two decades, water and soil have been redistributed around the Earth through melting ice caps and severe weather. This redistribution may have affected the Earth's gravity field, causing it to bulge even more at the equator.

EARTH'S SURFACE

The Earth's surface is usually covered by a thin layer of soil or by a body of water such as a lake or ocean. Below these uppermost materials is the crust of the Earth. The crust consists of bedrock. *Geology* is the scientific study of the history of the Earth's crustal rocks and the natural forces which produced the surface landforms. In this lesson you will learn about the Earth's surface.

Crust. The outermost layer of the Earth is called crust. Most of the crust is made of granite or basalt. The oceans rest on a thin crust which is only about 5 km thick. The crust below the oceans consists of basalt covered in most places with a very thin layer of salt sediments. The continents consist primarily of granite or similar rock. The continents are thicker than the ocean basin crust, ranging up to 50 km thick. Granite is less dense (lighter) than basalt and so it appears to rise to higher elevations. It appears to "float" upon the softer, hotter rocks of the underlying mantle. This is why the waters of the ocean basins are contained below the shorelines of the continents.



Granite continents floating in Earth's mantle. Note the thin basalt crust below the oceans and thin layer of sediments covering ocean basin.

Plate tectonics. The average thickness of continental crust is 20 miles. The crust may seem like a deep layer to us. When compared to the whole Earth, the crust is very thin. Image the Earth as an egg. The crust is the relative thickness of the egg's shell. The crust is also fragile, like an egg shell. Although the ground beneath our feet feels very solid, it is cracked in many places. Large pieces of crust, called tectonic plates, float on top of the upper mantle. There are seven large plates and many smaller ones. They large plates are the African, Antarctic, Australian, Eurasian, North American, Pacific, and South American plates. Some of the smaller plates are the Arabian, Caribbean, and Indian plates.

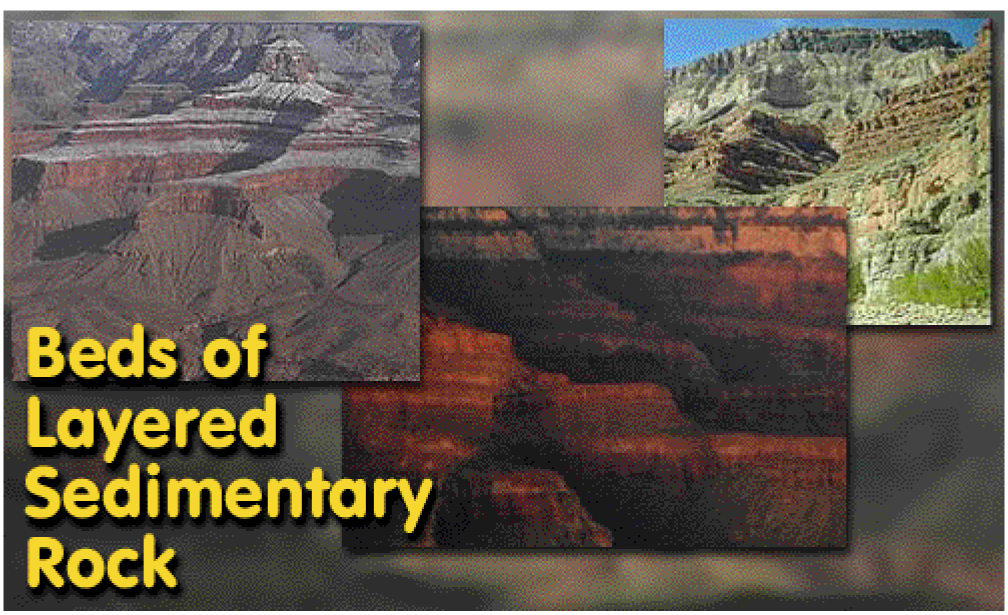
Many geologists believe that all the land masses of the present Earth were at one time joined together as a single continent. It is further assumed from geologic evidence that this original mega-continent began to break apart into smaller land masses. These smaller subcontinents eventually drifted to their present positions. There is strong evidence to support this conclusion. It also appears that the present-day continents are part of larger crustal plates which include portions of both ocean basin and continental crust. The world-wide distribution of moving plates is known as plate *tectonics.* You yourself may have noticed when looking at a world globe that the outline of some continents appear to fit together. In addition, some mountain chains and other geological features on various continents will line up when the continents are placed back together.

EARTH'S ROCKS

Have you ever seen the Grand Canyon? Maybe you have been to California and seen Half Dome. Maybe you have been to Arizona and seen the spectacular red rock formations. The Earth's surface is covered with extraordinary landforms. Many of these landforms are made from rocks. Geologists categorize the rocks on the Earth's surface into three main types. In this lesson you will learn about each type.

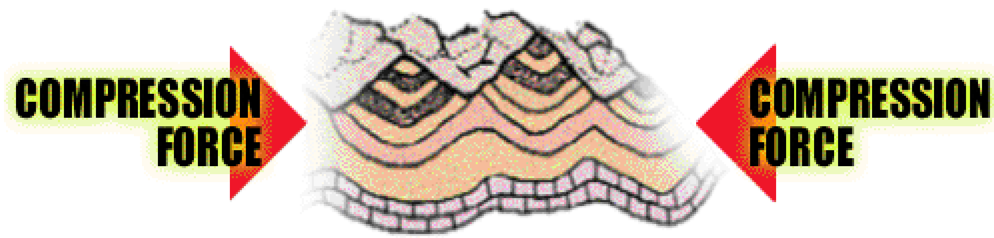
Sedimentary rock. One type of rock is called *sedimentary rock.* It is formed from rock fragments and other *sediments.* Sediments are the product of erosion from pre-existing rock. The rock fragments have a large range in size; therefore sedimentary rock may have large pieces of rock or small grains of sand. The rock becomes hard when the sediment becomes compacted and cemented together by minerals in water. Common rock-forming minerals which cement sediments together are calcium carbonate (calcite), iron oxide (limonite) and silica (quartz).

Sedimentary rocks are usually deposited in horizontal layers. The layers are usually easy to see. Each one was formed at a different time during the Earth's history. When the rocks are eroded by wind, water, and other forces, the horizontal rock beds are revealed. Harder sedimentary rock will erode to form steep, near vertical slopes. Softer rocks will erode to form more shallow slopes. Many beautiful landforms on Earth are made from eroded sedimentary rock.



Sedimentary rock layers range in thickness from only a few inches to many feet. Some layers in the Grand Canyon are 100 feet thick. The Grand Canyon also contains many different layers of rock. Each layer tells a different story about the climate conditions and life on Earth at the time the bed was created.

Another typical landform which results from sedimentary rocks are folded mountain ranges. Many high mountain ranges such as the Appalachian mountains of the eastern United States have been formed by the folding of original flat lying beds of sedimentary rock. Within some mountains, the original beds are only slightly folded. Other mountains, however, have been deformed into very tight folds in which the original layers are now nearly vertical.

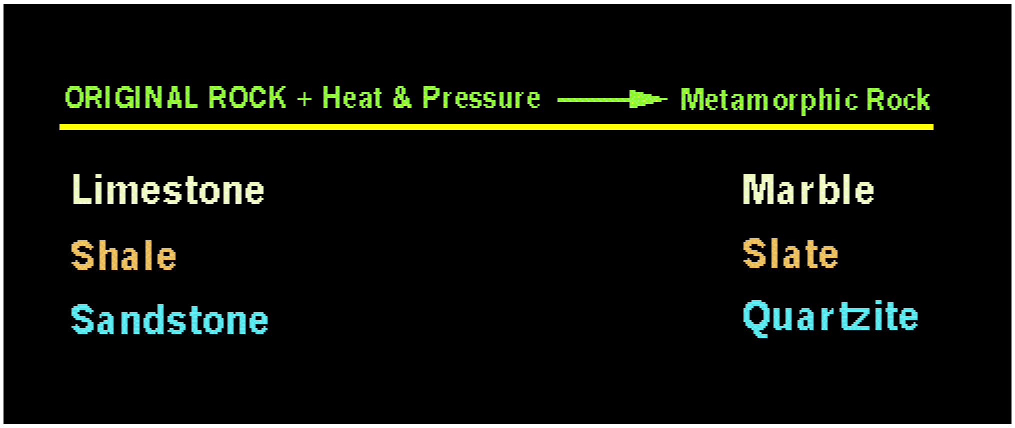


Igneous rock. Another category of rock is called *igneous rock.* This type of rock is formed from the cooling of magma. Magma is an extremely hot liquid melt of natural minerals. Magma forms from the melting of rock below the Earth's surface. Sometimes the magma cools below the Earth's surface. Granite is formed when magma cools this way. Most mountains are made from granite. Other times, magma escapes through volcanoes and breaks in the Earth's crust. Magma on the Earth's surface is called lava. When lava cools it forms different types of igneous rocks, such as obsidian and pumices.

The type of igneous rock formed depends on the minerals in the magma, whether it cools above or below the Earth's surface, and how fast it cools. Slow cooling forms igneous rock with large crystals. Quick cooling forms igneous rock with small crystals. Obsidian is cooled so quickly that it has very few crystals. This gives it a shiny, glassy appearance.

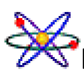
Metamorphic rock. The word, "metamorphic" means, "to change form." *Metamorphic rocks* are those which have gone through a physical and chemical change. These rocks are formed when igneous or sedimentary rocks are changed by heat and pressure. Squeeze your hands together as hard as you can. You should feel heat and pressure. Movements in the Earth's crust can squeeze and heat rocks until their elements rearrange into new minerals. Marble is an example of a metamorphic rock formed from a sedimentary rock called limestone. Metamorphic rocks may also be exposed at the Earth's surface in canyons, mountains or steep sided hills.

The table below lists some sedimentary rocks and their metamorphic change.



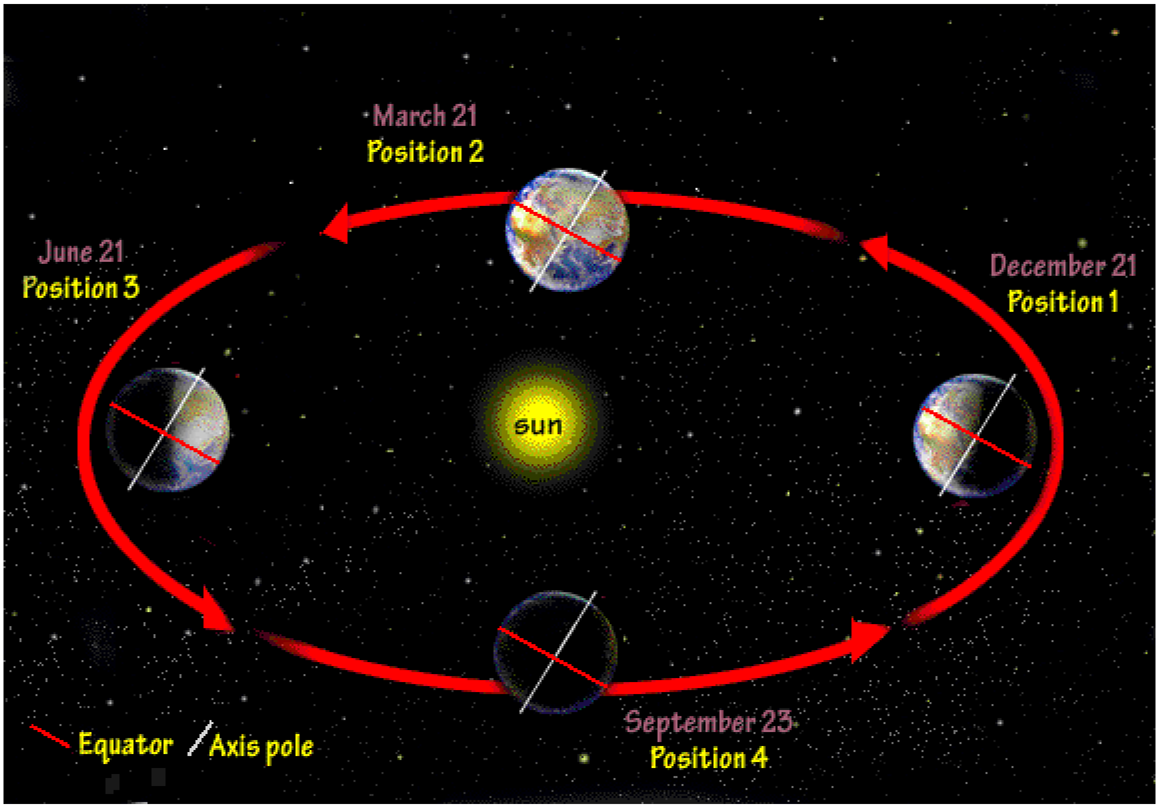
The rock cycle. The relationship of the three basic types of rocks can be visualized as a cycle. A cycle has no beginning or end. So it is with the formation of igneous, sedimentary, or metamorphic rocks. It can begin with any type of rock. For example, the igneous rock granite could be pressed below the Earth's surface until it changes into the metamorphic rock gneiss. Alternately, the granite could be exposed as hills on the surface. Eventually weathering and erosion could break down granite hills into numerous small fragments. The fragments could be carried away by streams and be deposited in layers after the sediments settle out from the running water. If conditions cause the sediment to harden into rock, a sedimentary rock called arkose will form. If a geologist identifies a rock as arkose, she can assume that it was originally derived from a granite hill or mountain.

EARTH'S ROTATION

Have you ever heard that saying "The sun rises in the east and sets in the west"? Although it seems like the sun moves across the sky from east to west, the sun is actually not moving. The "movement" of the sun is caused by the Earth's rotation. In this lesson you will learn about the earth's rotation.

The Earth *rotates* on its axis once every 24 hours. The direction of the Earth's rotation is from west to east, or counterclockwise. This rotation causes the sun to appear as if it is rising and setting. The speed of the Earth's rotation is about 1100 miles per hour (1700 kilometers per hour). The speed is slightly faster at the poles because the Earth's diameter is smaller at the poles than at the equator.

The Earth rotates on an imaginary line running through the poles. This line is called an axis. The Earth's axis is tilted 23 $_{1/2}$ degrees. If it were not tilted, night and day would always be twelve hours each. The tilting of the Earth on its axis affects the length of day and night. It also causes the seasons. The actual length of day or night varies with the seasons and the distance of a particular location above or below the equator. At the equator day and night are each twelve hours long. At the North Pole one daylight period may last several months depending on the season of the year.



During the summer people who live near the North Pole will not enter the shadow of the Earth. The sun will remain above the horizon and shine for 24 hours each day. This condition whereby the sun never sets may last for several months or longer depending on how close the location is to the North Pole. At the North Pole the length of day will last six months followed by a long night of equal time. As the Earth continues to move to the position indicated as September 23, the sun appears lower on the horizon each day if you were right at the North Pole. Night and day become like twilight. The sky is never very bright or completely dark. As the Earth moves toward the winter position, each night becomes longer; nighttime exceeds daylight hours until the sun no longer rises above the horizon. The duration of this long winter night depends on how close the location is to the North Pole.

Similar conditions of darkness will occur at the South Pole at the opposite seasons of the year. No permanent residents live in the Antarctic but scientist and explorers at the South Pole will experience up to six months of continuous darkness from March through September. This period would occur when the northern hemisphere is experiencing summer weather. The length of day and night changes because the axis on which the Earth rotates is tilted.

Take a minute to think about Earth and the moon. What do they have in common? The Earth and moon are the only two objects in space which have been walked on by humans. Humans have been walking on Earth's surface for millions of years, but the moon had to wait until 1969 and the *Apollo 11* space mission. On July 20 of that year, Neil Armstrong became the first person to set foot on the moon. In this lesson, you will learn about the basic characteristics and patterns of the Earth and its moon.

Earth's Movement

EARTH'S REVOLUTION

Early scientists and philosophers believed that the Earth was the center of the solar system. They believe that the sun moved around the Earth. Today, we know that the opposite is true. The Earth *revolves* around the sun. In this lesson you will learn about the Earth's revolution.

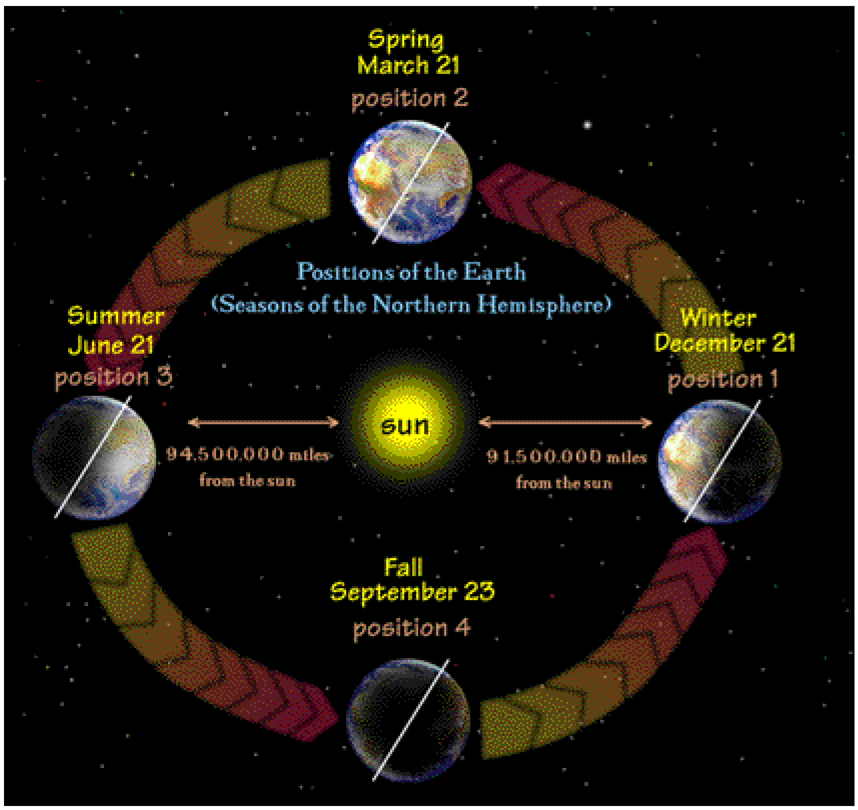
Earth's orbit. The Earth revolves around the sun in a curved path called an *orbit.* You might expect Earth's orbit to be circular, but it is not. Earth's revolves is an egg-shaped orbit called an *ellipse.* All other planets in our solar system have elliptical orbits. Even spacecrafts that circle the Earth have orbits that are ellipses. Earlier astronomers thought that the planets revolved around the sun in perfect circles. However, around 1618 a scientist named Johannes Kepler discovered the laws which explain the true elliptical motion of the planets.

The interaction of two laws helps to explain the Earth's orbit. These two laws were proposed by Sir Isaac Newton. They are *the Law of Inertia* (Newton's 1st Law) and *the Universal Law of Gravitation.* The Law of Inertia states that an object at rest tends to remain at rest, and an object in motion tends to continue in motion in a straight line, unless acted on by a force. Since the Earth is in motion around the sun, it will stay in motion unless an outside force stops its movement. The Universal Law of Gravitation states that all objects (masses) in the universe pull or attract one another. The larger the object or mass, the greater the pull. The sun pulls on Earth and the Earth pulls on the sun. The sun's much larger mass creates a much stronger gravitational pull than the Earth's.

Earth continues to move around the sun because of the combined effects of inertia and gravity. The Earth does not travel in a straight line because the continuous pull of gravity curves its movement toward the sun. Why doesn't the Earth just keep moving toward the sun? The Earth's revolution speed keeps it in orbit around the sun. For example, when a satellite is launched to orbit the Earth, it must be propelled to a precise speed before being "released" to the gravitational attraction of the Earth. If this was not planned and executed exactly, the satellite would merely be pulled to the Earth by gravity or if it moved too fast it would escape from the Earth and travel into space.

Years and seasons. Earth revolves around the sun once every 365 $_{1/4}$, or 365.242, days. In other words, the Earth revolves around the sun once a year. Since the Earth does not make a complete journey in exactly 365 days, one full day must be added to the calendar every fourth year. Every fourth year has one full day added to February to make 29 days. The year with the extra day added to the calendar (366) is called *leap year.*

The Earth's revolution and tilted axis work together to cause the seasons. During the summer months, the Northern Hemisphere receives more light that the Southern Hemisphere. The South Pole is dark and cold during this time. In winter, the tilt of the Earth causes the Southern Hemisphere to receive more sun. During this time the South Pole has light. The Northern Hemisphere has shorter days and the North Pole is dark.



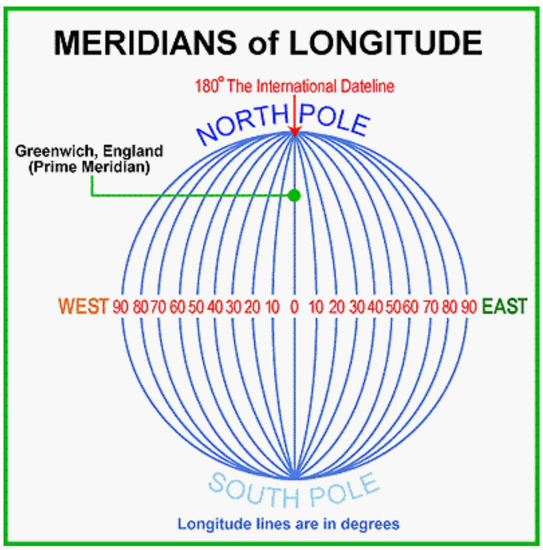
Around March 21, days and nights are of equal length. This period is called the *vernal equinox.* The word equinox means equal nights. It refers to the fact that the days and nights are of equal length during this time. During summer, the days become longer. Around September 22 the days and nights again become equal. This period is called the *autumnal equinox.* The longest day (daylight hours) of the year is June 21, and the shortest is December 22 in the northern hemisphere.

The sun is closer to the Earth in winter than in summer in the Northern Hemisphere. This fact is the opposite of what you might expect. Nearness is not the most important factor in producing heat. The sun's rays do not hit the Earth directly during the winter months. Although the sun is closer to Earth in winter, temperatures are colder. The sun's rays hit the Earth more directly during the summer. These direct rays produce more heat, even though the sun is not as close to the Earth. The opposite is true in the Southern Hemisphere. The sun is closer during its summer, but the rays do not hit as directly. Thus, seasons are not caused by the Earth's distance to the sun, but the Earth's tilt relative to the sun.

TIME

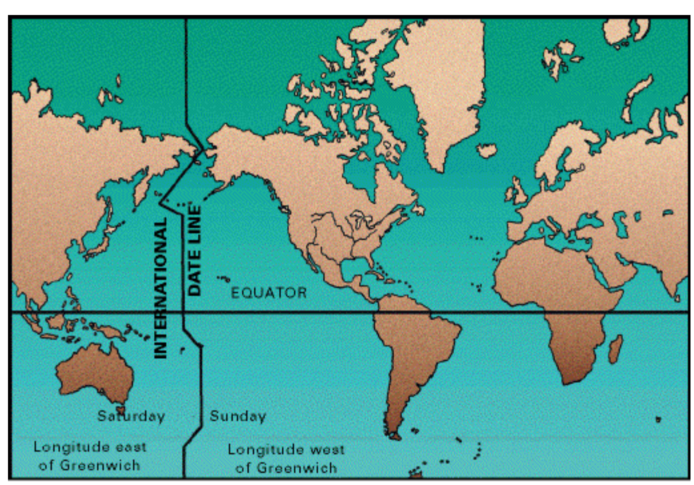
Do you have family or friends who live in another part of the country? Maybe you know someone who lives in another country altogether. Have you ever tried to call someone who lives in another part of the world? Since it is not the same time all over the world, you need to pay attention to time differences. It may be 9:00 a.m. in New York, but it is only 6:00 a.m. in California. In this lesson you will learn more about the Earth's time.

The Earth's daily rotation is what determines the world's time zones. A circle has 360 degrees. The Earth completes a 360° rotation, or circle, within each twenty-four-hour period. This means that a point on the Earth's surface rotates 15° per hour. The Earth is divided into twenty-four time zones. Each time zone is 15°. Division into twenty-four time zones is called Standard Time.



Longitude. To conveniently divide the globe, imaginary lines are drawn from the North Pole to the South Pole. These imaginary lines are *meridians* of *longitude.* Each of the Earth's time zones is 15° longitude. The *prime meridian* is at 0° and passes through Greenwich, England. As you have learned, a circle has 360°. By dividing the circle into halves, 180° falls halfway around the world from Greenwich (half of 360° = 180°). The 180° meridian is called the *International Date Line.* This imaginary line does not follow the 180° meridian exactly. It zigzags through the Pacific Ocean to avoid dividing an island or land area into two different time zones. By agreement with other nations, the 180° meridian is the line where the new calendar day begins.

Time zones. Standard time in time zones across the United States was put in place by railroads on November 18, 1883. Before then, time of day was kept by a well-known clock in each town or city. Thus, it could be 12:02 p.m. in one town, but 12:10 p.m. in another. In order to keep the railroads running on time, a standard time was needed. In 1918, standard time became a law.

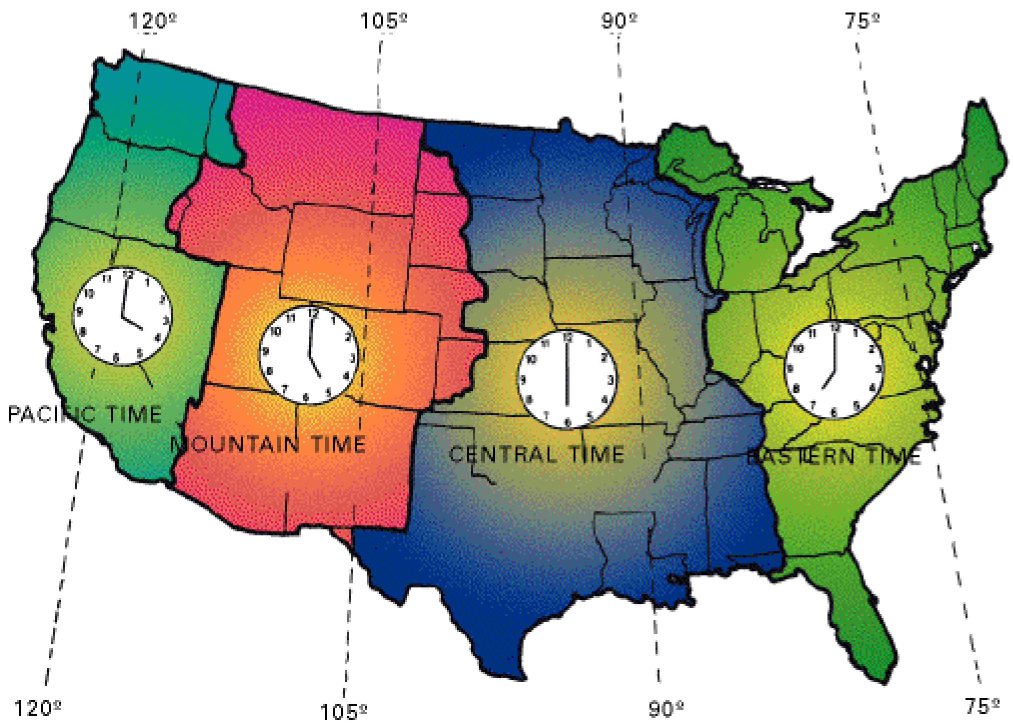


The International Date Line

The United States as a nation has six different time zones. These six time zones are: Aleutian/Hawaii time, Alaska time, Pacific time, Mountain time, Central time, and Eastern time. Four of these time zones apply to the 48 states of the continental United States. These time zones are Eastern, Central, Mountain, and Pacific. Like the International Date Line, these zones do not follow specific lines of longitude. They zigzag through the United States to avoid dividing cities. If the time zones were set exactly at every 15° longitude across the United States, they would run on the lines 75°, 90°, 105°, and 120°. Instead, the time zones zig zag to avoid dividing heavily-populated areas.

Aleutian-Hawaii	Alaska	Pacific	Mountain	Central	Eastern
9:30 a.m	10:30 a.m	11:30 a.m	12:30 p.m	1:30 p.m	2:30 p.m.

When time changes from one zone to the very next zone, the time will be different by one hour. However, when the time is 7:00 in New York City, it is 4:00 in Los Angeles, California. If the time is 7:00 in New York City, it is 5:00 in Salt Lake City, Utah.



Time Zones of the United States

You probably know more about the Earth's movement than you think. How many hours are in a day? The answer, 24, is the length of Earth's rotation. How many days are in a regular year? The answer, 365, is the approximate length of Earth's revolution. The actual length is 365.242 or 365 ¼, days, which is why *leap years* were invented. Using a calendar with only 365 days would result in an error of 0.242 days, roughly six hours, per year. It may not seem like much, but over the course of 100 years, the calendar would be ahead by almost a month. After another 100 years, the seasons would stop making sense. Leap years make up for the extra ¼ days by adding a full day to February every four years. During a leap year, February has 29 days and a year is 366 days long.

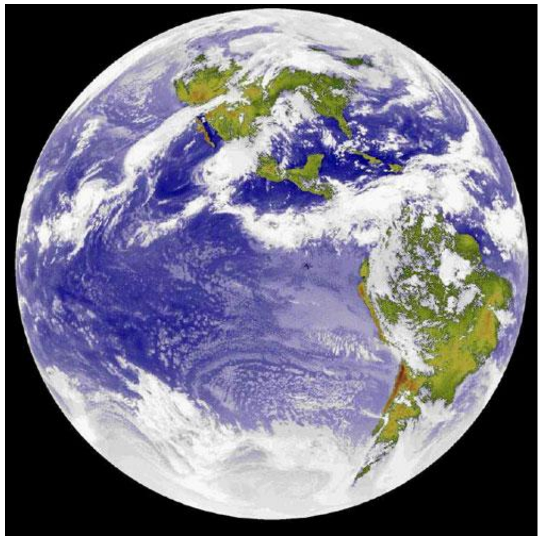
Leap years help keep the seasons in line with the calendar, but why do seasons happen in the first place? Earth's *axis* is tilted about 23°. This causes parts of the Earth's surface to receive more sunlight than other parts during certain times of the year. When the Northern Hemisphere is tilted toward the sun, temperatures are warmer and the days are longer. The Southern Hemisphere experiences colder temperatures and shorter days because it is tilted away from the sun. The opposite happens when the Northern Hemisphere is tilted away from the sun and the Southern Hemisphere is tilted toward it. Seasons are reversed in the two hemispheres. Winter in Canada is summer in Brazil and vice versa.

Although seasons are caused by the Earth's tilt, scientists believe their intensity may be affected by the Earth's orbit. Like other planets, Earth's orbit is not a circle, but an ellipse. Its perihelion is 147 million km (91 million miles) and its aphelion is 152 million km (94 million miles) away from the sun. Earth's eccentricity, or the degree to which the orbit is an ellipse, is fairly small. There is less than a two percent difference between the aphelion and perihelion, but the Earth is still closer to the sun during parts of the year than it is during other parts. When temperatures around the globe are averaged, sunlight falling on the Earth during its aphelion is about seven percent less intense than during its perihelion.

Reminder
The aphelion of a planet's orbit is the point during which it is the farthest away from the sun. The perihelion is the opposite, during which the planet is the closest to the sun. An old astronomer's trick is to remember that "away" and "aphelion" both begin with the letter A.

Earth's Structure

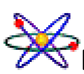
Like the other terrestrial planets, Earth is made of rock. Its crust is made mostly of silicon and oxygen, while its core is made of nickel and iron. Unlike the other terrestrial planets, Earth's crust is not a solid, single layer. Instead, it is made of several plates which move atop the molten rock of the mantle. Earth is also unique in that it is the only known planet with liquid water. The abundance of water, which covers about 71 percent of the planet, gives Earth its nickname - the Blue Planet. Earth's atmosphere is made of mostly nitrogen and oxygen. It protects the surface from meteoroids, traps heat energy from the sun, and recycles surface water. The atmosphere contains a special area called the ozone layer, which absorbs harmful radiation from the sun.



If you look at a globe or another model of the Earth, it will usually show the planet as a perfect circle. The Earth is round, but it has a squashed appearance, like a grape being squeezed between two fingers. The diameter between the poles is approximately 7,900 miles (12,714 km), while the diameter around the equator is about 7,926 miles (12,756 km). The difference between the two diameters is less than 30 miles, but it is large enough to cause variations in climate. Recent scientific studies have indicated that Earth's equator may be bulging even more because of the redistribution of water from melting polar ice caps.

THE MOON

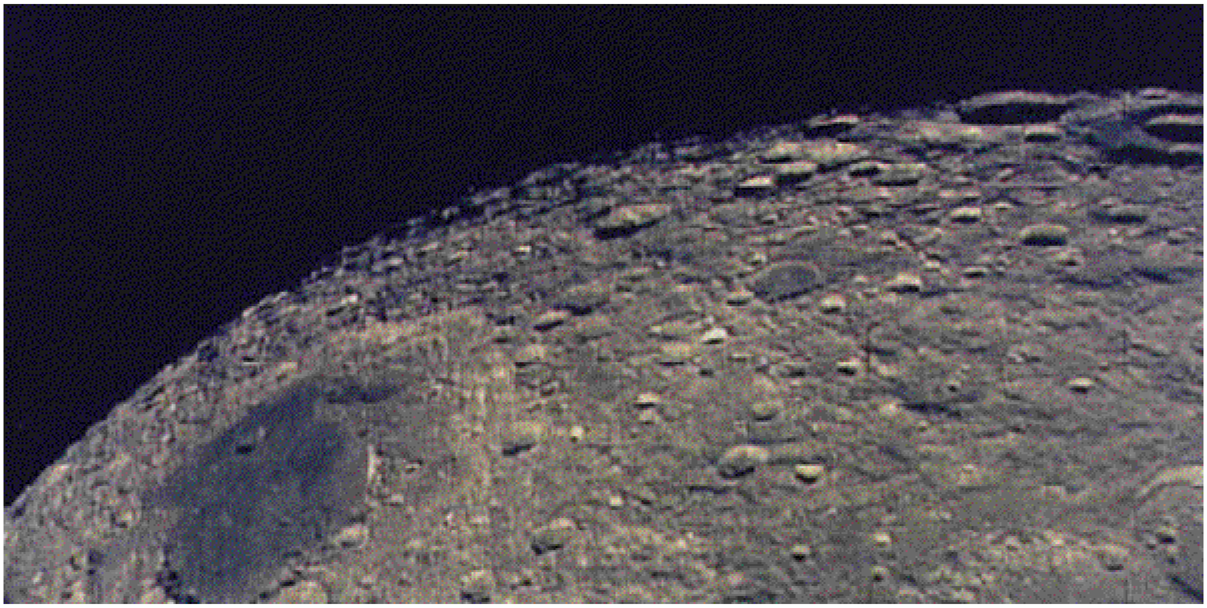
OUR MOON

Earth has one natural satellite called the moon. The moon is our nearest neighbor in space, making it the easiest to study. In this lesson, you will learn about the moon.

Size and distance. The moon is much smaller than the earth. Its gravitational is only one-sixth that of the earth. This means that if a person weighs 120 lb. on the earth, he would only weigh 20 lb. on the moon! The moon revolves around the earth in an elliptical orbit. This means that it is sometimes closer to the earth than other times. The moon's average distance from the earth is about 240,000 miles (386,160 kilometers).

Landscape. The moon's surface is covered with craters and waterless "seas." The Sea of Showers, the largest, is 750 miles wide. The Sea of Serenity is 430 miles wide. Both "seas" are round. They were originally called "seas" because ancient scientists thought these dark areas on the moon must be filled with water. Water is not present on the moon. Near the south pole of the moon, two high mountain ranges can be seen. These mountains are named Leibnitz and Doerfel.

The moon has a special rotation. It rotates just once on its axis each time it orbits around the earth. This means that from the earth, we see the same side of the moon all the time. The side of the moon that we cannot see from the earth is sometimes called the dark side of the moon.



Rare picture of back side of moon taken by the astronauts of the Apollo 13 mission.
Courtesy of NASA

Phases. Sometimes the moon is a full circle and other times it is a small sliver in the night sky. This change is caused by the moon's revolution around the earth and the sun's position in space. The moon revolves around the earth once every 29 1/2 days.

The moon's orbit around the earth causes it to appear differently in the sky at different times in its monthly orbit. You may be familiar with terms like full moon, half moon, and crescent moon. Sometimes the earth casts a shadow on the moon and blocks our view of it. This is called a lunar eclipse. These occur on a fairly regular basis.

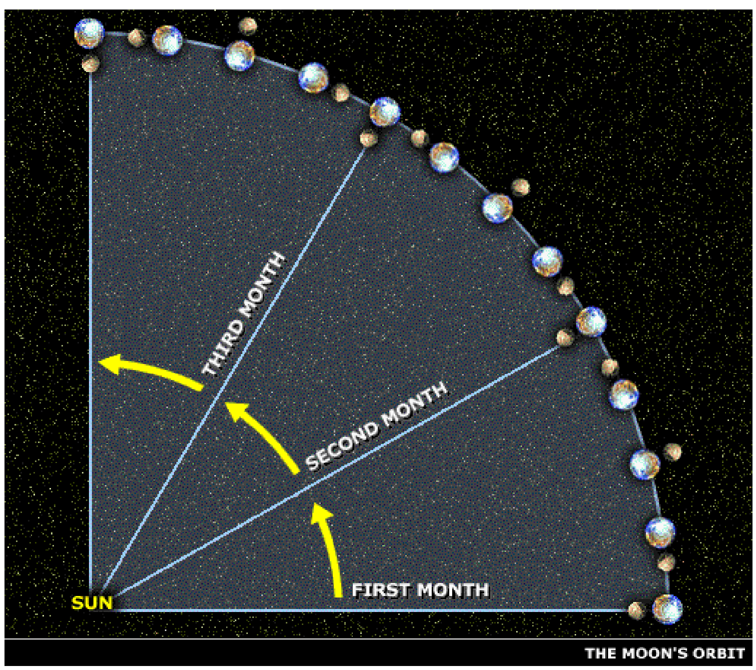
For a long time, people had wanted to go to the moon, but there had been no way he could get there. Finally, in 1969, after years of scientific research and planning, NASA sent astronauts to the moon. The Apollo 11 mission, manned by Neil Armstrong, Edwin "Buzz" Aldrin, and Mike Collins, became the first successful moon mission. Neil Armstrong became the first man to set foot on the moon on July 20, 1969. He was joined fifteen minutes later by Buzz Aldrin. While on the moon the astronauts took samples of soil and rocks to bring back to earth.

The moon, the earth's closest neighbor, is an average of 384,403 kilometers (238,857 miles) from the earth. The moon's diameter is 3,476 kilometers, and its surface gravity is 0.16 times that of the earth.

The moon is a satellite of earth and revolves around the earth counterclockwise--the same direction the planets revolve around the sun. Earth is located at one focus of the moon's elliptical orbit. The moon makes one complete revolution around earth every 27 1/3 days. Each night it is in a different part of the sky. Only one side of the moon faces earth, but the moon looks different each night because of the way sunlight reflects from it.

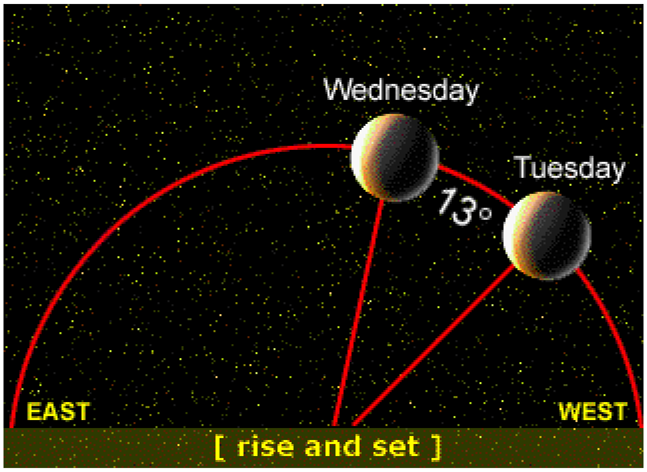
The moon has had a great impact on mankind. The moon's gravitational attraction is the main cause of tides. The calendar is modeled more or less after the moon's cycles. Many folk stories are related to the full or new moon. And, though there are many other moons in this solar system, the earth's moon is named The Moon (proper name).

Orbit. Paths of planets and satellites are elliptical. The moon revolves around the earth in an elliptical path. While it revolves around the earth, the moon revolves with the earth around the sun. The path of the moon in space is not the path that we see from the earth. Is the moon's path around the sun an ellipse?

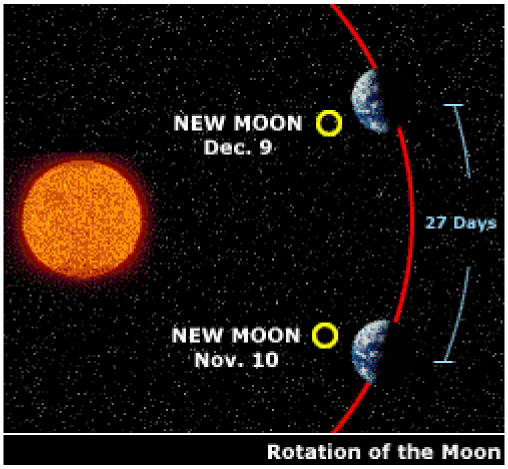


The earth's orbit is an ellipse, and the moon and earth travel around the sun together. However, most descriptions, pictures, and activities involving the moon and earth show their orbits as circular. The reason is that they have a *nearly circular* elliptical orbit. For convenience, then, the moon's orbit around the earth--and the earth's orbit around the sun--are treated as circles.

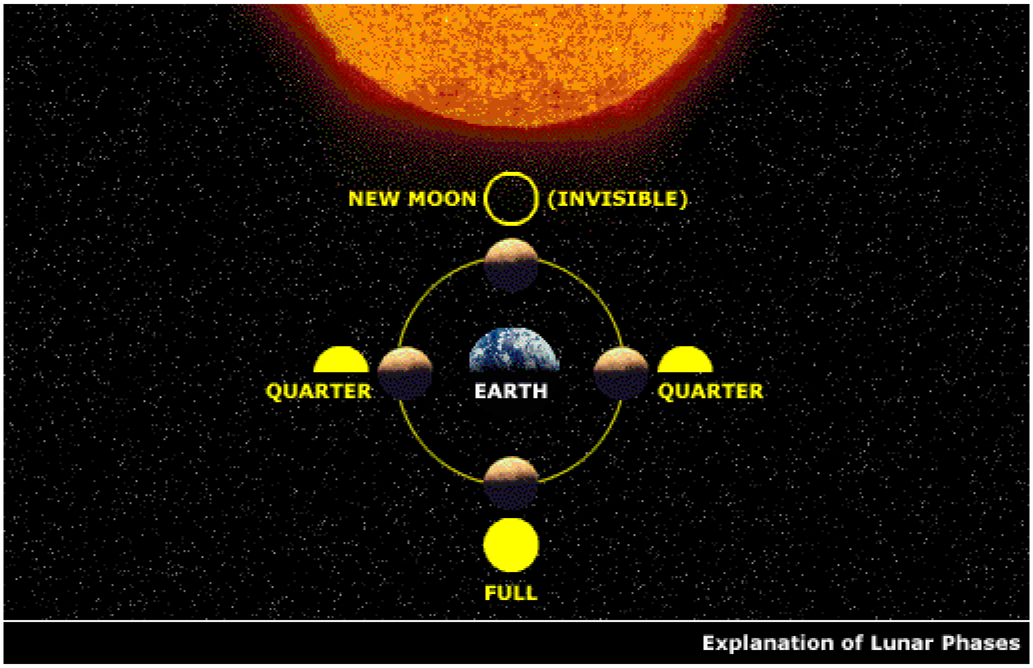
Rise and Set. Because the earth rotates on its axis counterclockwise when viewed from the northern hemisphere, the moon rises in the east and sets in the west. While the earth is making one complete rotation of 360° on its axis every 24 hours (15°/hr.), the moon revolves about 13° in its orbit around the earth. Therefore, the earth must rotate an *additional* 13° on its axis to catch up to the moon's revolution. The time required for the additional 13° is about 50 minutes; therefore, the moon rises 50 minutes later and sets 50 minutes later each night.



Rotation. The moon rotates on its axis counterclockwise in 27 1/3 days--the same time it takes to make one revolution. Because of this, the moon displays the same side toward the earth at all times. While the moon is revolving around the earth, however, the earth is also moving around the sun at the rate of approximately 1° each day. The moon requires additional time--about two extra days--to return to its original position in relation to the sun. Thus, the moon takes 29½ days to pass from new moon to new moon, or to make one revolution. This interval of time is called a *lunar month.*



Phases. The moon has four phases: new moon, first quarter, full moon, and last, or third quarter. The new moon cannot be seen because the moon is between the earth and the sun, so the lighted surface is not visible from the earth. At first and third quarters, the moon is at rightangles to the earth, so earth sees one-half the lighted side. When the moon is full, the earth is almost between the sun and the moon, and as a result observers from the earth see a fully lighted surface.



Phases of the Moon

Phase	Description
New Moon	Moon cannot be seen from earth because illuminated part faces away from earth. The new moon rises at sunrise and sets at sunset.
First Quarter	One-half of the illuminated part of the moon can be seen from earth. The moon rises at noon and sets at midnight.
Full Moon	The entire illuminated half of the moon can be seen from earth. The full moon rises at sunset and sets at sunrise.
Third Quarter	One-half the illuminated half of the moon rises at midnight and sets at noon.

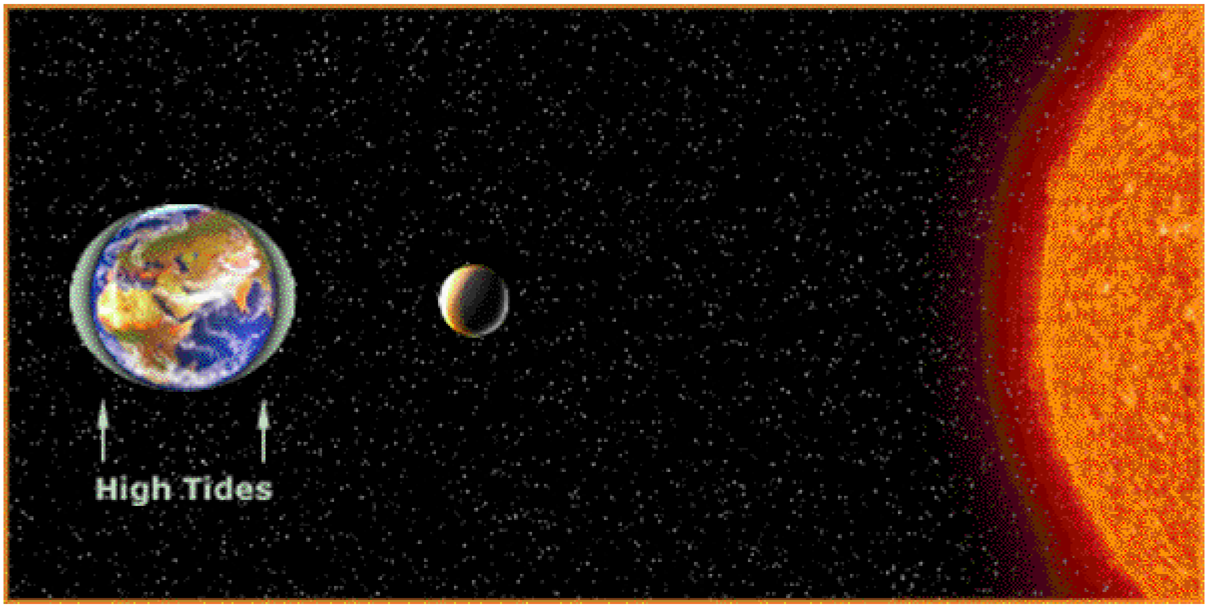
Tides. The rise and fall of the level of the oceans are called *tides.* Tides are caused by the gravitational pull of the moon and the sun on the earth.

The moon has a greater effect than the sun in producing tides. Although the ocean waters and continents are pulled toward the moon, only the oceans respond in an observable manner to this pull.

This phenomenon was discovered by Sir Isaac Newton. He said that the ocean waters on the side of the earth near the moon were attracted more strongly than the solid portions of the earth. Thus, waters rise as a direct high tide. An indirect high tide occurs on the opposite side of the earth. This indirect high tide is caused by a somewhat complex combination of forces.

Between direct and indirect high tides, two low tides occur. Since the earth must rotate in 24 hours, the tides rise about every 12 hours. The time between a high tide and a low tide is about six hours.

At the new-moon and full-moon phases, when the sun and moon are lined up, the tides are unusually high. These tides are called *spring* tides. During the quarter-moon phases, high tides are relatively low and are called *neap* tides. The difference in the level of water between high tide and low tide is called the *tidal range.*



How much do you weigh? Do you think you would weigh more or less on the moon? Gravity on the moon is about one-sixth the gravity on Earth. Since weight is a measure of gravity's pull on a mass, you would weigh less on the moon because there is less gravity. The moon is Earth's only satellite. It is unique in that it is the largest satellite compared to its planet. Most moons are much smaller than their planets, but our moon is almost one-fourth the size of Earth.

Like other satellites, the moon revolves around the Earth in an elliptical orbit. The moon has a synchronous rotation, when means its rotation and revolution periods are the same length. Every 28 days, the moon makes one trip around the Earth and spins once on its axis. The synchronous rotation causes the moon to appear locked in position, forcing us to always see the same side of the moon from Earth. The side we see is called the near side, while the side we cannot see is called the far side. The phases of the moon are caused by the moon's orbit. When the moon and the sun are on opposite sides of the Earth, sunlight shines on the moon's near side and it appears "full". During a new moon, the moon is between the Earth and the sun. Sunlight shines on the far side, making the moon appear a dark. In between, the moon's illuminated surface appears to wax (grow), then wane (shrink).

The moon has a rocky surface full of craters. It once had active volcanoes which formed large areas of basalt when erupting lava cooled. These areas look like dark spots on the moon's surface. Ancient astronomers believed these areas were large oceans, which is why they are called Maria, the Latin word for "seas". Since the moon has no atmosphere, it has suffered damage from meteoroids, asteroids, and comets. The South Pole-Aitken basin is the largest crater on the moon, and also the largest in the solar system. It is nearly 2,300 km (1300 miles) in diameter and 13 km (8 miles) deep. Unfortunately for us, the crater is located on the far side of the moon, which means only astronauts are able to see it in person.

The Moon's Effects

Most people know that the moon is not made of green cheese, as a popular myth would have us believe, but they do not know that the moon may be responsible for life as we know it on Earth. Since the Earth's axis is tilted, and it is not a perfect sphere, the planet wobbles a little as it rotates. Although the wobble is slight, it periodically causes parts of the Earth to be closer or father away from the sun, which creates variations in solar radiation. Scientists believe these changes could cause dramatic climatic changes which could wipe out entire species. The moon's gravitational pull is too weak to pull Earth into its orbit, but it is strong enough slightly slow down the Earth's rotation. This helps decrease the Earth's wobble and stabilizes our climate.

The moon also controls the Earth's tides. Since the behavior and life cycles of many species, including fish, sea turtles, and penguins, are closely related to the tides, scientists believe life on Earth would be drastically different without the moon. How do tides happen? The moon's gravity pulls water on Earth to one side, causing low tide in one hemisphere and high tide in the other. As the Earth rotates, water is pulled in the opposite direction, switching high and low tides. Since the Earth rotates faster than the moon, tides occur twice a day.

Let's Review

- Earth's axis is tilted about 23°, which causes seasons.
- Earth's revolves around the sun once every 365 ¼ days and rotates on its axis once every 24 hours.
- Earth's atmosphere is made mostly of nitrogen. It protects the surface from meteoroids and harmful solar radiation.
- The moon has a synchronous rotation. It rotates and revolves around the Earth once every 28 days.
- Phases of the moon are caused by the moon's orbit around Earth.
- The moon's gravitational pull helps stabilize Earth's wobble and causes ocean tides.