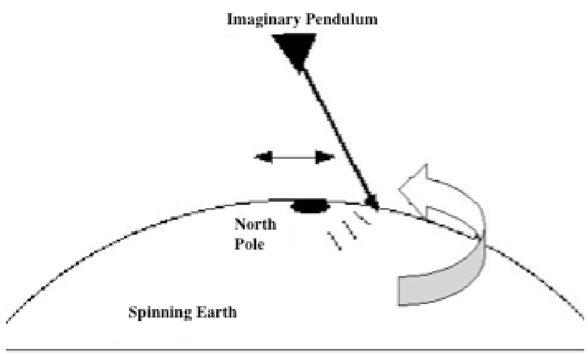
**Name:**

# *The Mystical Moon*

When we look up into the sky, we see the sun, moon, planets and stars going across the sky. We may think Earth is standing still and everything is going around us. Hundreds of years ago people saw the same thing and believed Earth was the center of the universe. It seemed Earth stood still and everything in the sky circled Earth.

In 1852, a French scientist, Jean Bernard Foucault, did an experiment to show that Earth spins. He built a pendulum by attaching an iron ball with a pointer on it to a 200-foot wire hanging from a dome ceiling. After putting the ball into motion, it scratched a mark in sand spread out below it, each time it swung across. Throughout the day the scratch lines slowly and evenly shifted to the right. Foucault's swinging iron ball offered



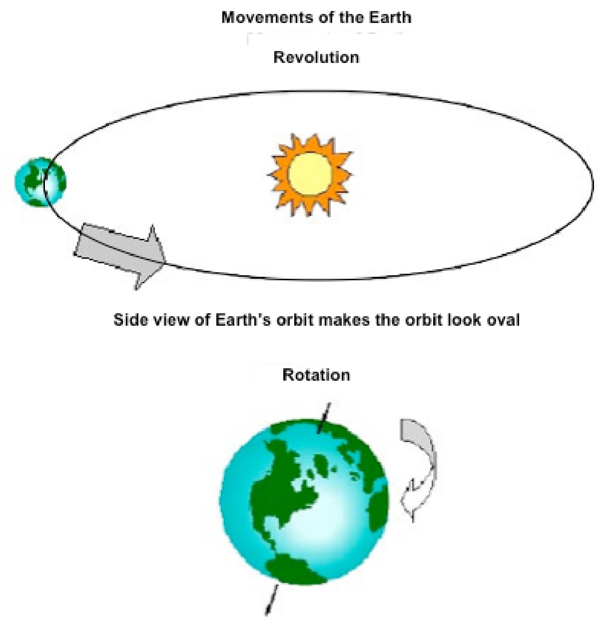

proof of the Earth's **axis of rotation**, *the spinning of objects around an imaginary centerline*. Since a pendulum does not change course, it had to be Earth that was rotating beneath the pendulum. The North and South Poles mark Earth's axis. It is easiest to understand a pendulum at the North Pole. The pendulum would swing in the same path all day scratching marks in a complete circle as Earth rotated under it.

When we see the sun move across the sky, it is the rotation of Earth that gives the sun this appearance. The sun is actually in the same place in the sky. As Earth rotates, it brings the sun in and out of view giving us daylight and darkness. Like the sun, the stars stay in the same place. As Earth rotates, all stars, except the North Star, appear to change their positions. Some stars will come into view or go out of view. Others will follow a circular pattern in the sky. Some night, pick a star in the eastern horizon to observe. During the night, it will appear to be moving across the sky just like the sun. It is the



rotation of Earth that changes the star's positions during the night. On another night, pick a star near the North Star. It will appear to be circling around the North Star. Earth's axis is pointing directly at the North Star, so the star doesn't appear to move. The stars near the North Star seem to be circling it because of the rotation of Earth.

Earth rotates on its axis every 24 hours. Another major movement of planets and moons is **revolution**, *the circling of an object in space around another object in space*. It takes a year for Earth to revolve around the sun. It takes the moon about 29 days to revolve around Earth. *The path a planet or a moon takes during its revolution* is called an **orbit**.




Not only were early astronomers very interested in the sun and stars in the sky, they were also fascinated by the changing moon. It appeared to change size from day to day. This strange occurrence captivated people's imaginations for hundreds of years. There have been many stories, legends and myths written to explain why the moon changes shape. One story claims the moon is a cookie that is nibbled on each night by

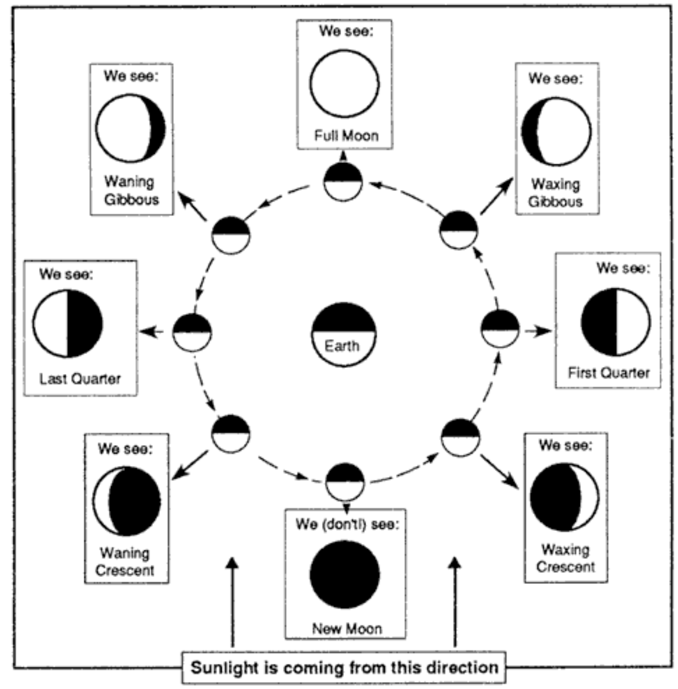
some mysterious creature, then magically reappears whole in a few days. Another story tells that Earth's shadow falls on the moon causing the light to gradually disappear then gradually reappear. Today we know these ideas are incorrect. In the next few pages, you will read why the moon appears to change and grow in the sky each month.

To understand this we need to know where the moon gets its light. The moon does not produce its own light. As the sun's rays shine on the moon, they are **reflected**, *bounced off*. This reflection lets us see the moon. Just like Earth, half of the moon is always exposed to light, and the other half is dark. But, why don't we see the full reflection of the moon each time we see the moon?

Remember, it takes the moon about twenty-nine days to revolve around Earth. The lunar cycle takes place during the revolution. During the lunar cycle the sun rises twenty-nine times. You have probably noticed that the moon doesn't always rise and set at the same time each day. Sometimes it rises with the sun, after the sun has been up a while or when the sun is setting. Sometimes it rises after the sun has gone down or in the middle of the night. The moon doesn't revolve around Earth as fast as the Earth rotates. Because of Earth's faster rotation, the moon rises about fifty minutes later each day.

You have probably noticed that each time the moon rises it appears to have a different shape. The shape of the moon seems to grow for a while and then shrink for a while. The **phases of the moon** are *the different shapes of the moon during a lunar cycle*. So, not only is the moon rising at different times each day, it also has a different shape each day.






The lunar cycle begins with the New Moon-one that is not visible to our eyes. During his phase the moon is between the sun and Earth. The moon and sun rise and move across the sky together. (Remember, the sun is not moving. It is the rotation of Earth that brings the sun into view.) Since sunlight is hitting the part of the moon that is facing away from Earth, we see only the dark side of the moon. We cannot see any part of the moon's lighted reflection, so the moon is invisible. We call it a New Moon. The New Moon phase only takes place during daylight hours. As Earth rotates to nighttime, the New Moon is no longer in view, having disappeared behind the horizon.

Since the moon rises later each day during the lunar cycle, we see more of the lighted side of the moon each time it rises. On the eighth or ninth day, the moon is in the First Quarter phase. It has traveled one-quarter of the way through its orbit. From Earth we can now see one half of the lighted side.

**Figure 1: New Moon to First Quarter**

On the fifteenth or sixteenth day of the lunar cycle, the moon has orbited behind Earth, putting Earth between the sun and moon. The moon has traveled half way in its orbit. Each night we see more of the lighted side appear. The positioning of these three bodies lets us see the complete lighted side of the moon called the Full Moon.

**Figure 2: First Quarter to Full Moon**

On the twenty-second or twenty-third day of the lunar cycle, the moon has orbited to the other side of Earth, opposite the First Quarter Moon's position. The moon now looks smaller as we see less and less of the lighted side. It appears as a half moon just as it did at the First Quarter Moon. But what is different about the Last Quarter Moon compared to the First Quarter Moon? You are right if you guessed that the lighted side is on the left or east side instead of the right or west side of the moon. This is called the Last Quarter Moon because the moon has traveled three-quarters of the way through its orbit.

**Figure 3: Full Moon to Last Quarter**

Finally as the moon approaches the last phase of the lunar cycle, the moon and sun are rising just about the same time. The reflected light we see from the moon has shrunk to a small sliver. The next day the moon will be positioned between the sun and Earth creating a New Moon. The lunar cycle starts over again.



**Figure 4: Last Quarter to New Moon**

Scientists can predict very accurately where the moon will be and what phase the moon will be in on any given day in the future. Because the sun, Earth, and moon are so reliable, we have based calendars and measured time on their motions. We also have the beautiful phases of the moon for our enjoyment and curiosity.

# *The Mysterious Change of the Seasons*

Imagine you are a person living a long time ago, and winter is coming. The length of the day is getting shorter and the weather is getting colder. What if the days get shorter and shorter and the sun disappears entirely? Earth would be cold and dark. This is a frightening idea. The ancient Native Americans in Utah drew rock art symbols to help them know when the sun's light would start shining longer during the winter days. This gave them comfort that the sun would once again return to warm them. The reason for the changing of the seasons was a mystery.

Other ancient people told stories to explain the seasons. One tells of how an evil person took one of the daughters of the sun as prisoner. In the sun's anger, he withdrew more of his light each day until she was returned. This made everything cold, dark, and stormy. Finally, there was a brave person who had enough courage to save the sun's daughter. On her return, the sun started to shine its light longer each day to bring back the warm, fair days.

Another story is told about people in the northern countries who tried to stop winter from coming. As the days became shorter, they built huge fires and performed ceremonies to convince the sun to come out for more hours each day. They found that after a few months, the sun would stay up long enough for them to plant crops and have time to grow.

Today, we know these stories are myths. This unit will help you understand why we have seasons.

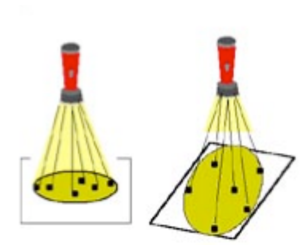
## The Seasons

The changing of Earth's seasons depends on two important facts: (1) Earth revolves, or makes one revolution around the sun every 365 days and (2) Earth is on an angle in relation to the sun. This knowledge of Earth hasn't always been known. In 1742, an English astronomer named James Bradley was one of the first to prove Earth's repeated revolution around the sun. Bradley kept track of the position of the stars each night. He noticed many stars disappeared from the horizon and weren't seen for many months. Then they reappeared in the opposite horizon. After one year they would be back in their same positions in the sky. These observations of the changing positions of the stars showed that Earth revolves around the sun.

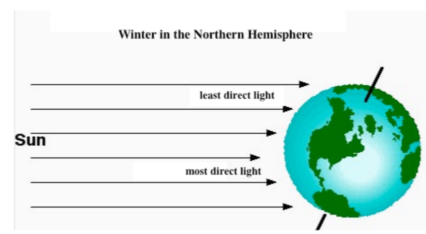


Earth revolves in an **orbit**, *the path a planet takes during its revolution*. The orbit of Earth around the sun is nearly circular. People incorrectly believed the seasons were caused by changes in Earth's distance from the sun during its yearly revolution. Today we know this is not the reason for the changing seasons. In fact, we are closest to the sun during our winter. The distance from the sun doesn't have much affect on the heating and cooling of Earth. So what causes the seasons each year?

The second important fact that helps us understand Earth's seasons is **Earth's tilt**, a *23.5 degree angle*. **Earth's axis of rotation**, *imaginary poles on which Earth spins*, are at a 23.5 degree angle tilt relative to the sun. As Earth revolves around the sun, it maintains this tilt, and always points in the same direction, toward the North Star. The combination of the Earth's revolution around the sun, and Earth's 23.50angle tilt are the reasons we have seasons.



Why does tilt make a difference? Think of a sunburn you may have received during a day playing outdoors. Which part of you got the worst burn? Was it the top of your shoulders or your legs? Chances are, it was your shoulders. The angle of your shoulders caused them to receive the most direct rays of the sun. Your legs were angled away from the sun and absorbed less of the sun's energy. The diagram to the side shows another way to think of the sun's light and tilt. Notice that the space between the rays in diagram A is much closer than diagram B. The heat that is produced by the light in diagram A will be greater than in diagram B.

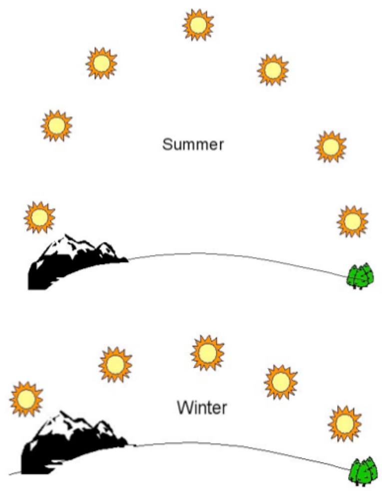



As Earth revolves around the sun, Earth's tilt never changes, yet Earth's tilt changes in relation to the sun. When Earth's North Pole points away from the sun, the Northern Hemisphere has winter. When this happens, the Southern Hemisphere gets more sunlight and is warmer. People in Australia go swimming in the ocean in December because it is their summer. Six months later, Earth's North Pole is pointing towards the sun and receives the most direct rays and warmth from the sun. That is when the United States has summer and the Southern Hemisphere enjoys winter.

There are two times during the year when the Northern and Southern Hemisphere have the same amount of daylight. They are March 21st and September 21st. These mark the first official days of spring and fall.

The tilt of Earth affects the height of the sun in the sky and the length of daylight. During summer, the sun stays out longer during the day and is higher overhead at noon. During the winter, the days are short because the sun never gets very high in the sky.

Think about the season you are currently enjoying. Are the days getting longer or shorter? Is the sun higher or lower in the sky each day? If you can answer these questions, you have learned a lot about seasons!

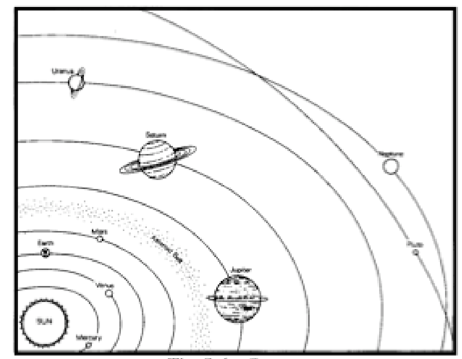





## *Earth is Not the Center of the Universe*

Have you ever looked up at the night sky and wondered about all the pinpoint lights? People through the ages have wondered about these points too. With the use of telescopes, artificial satellites, binoculars, and even observations with the naked eye, men and women have discovered many different **celestial objects**, *all of the different objects in space that make up our universe*.

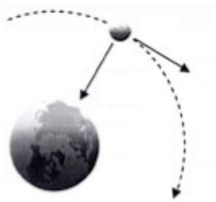
Even though all these celestial objects are very far away, astronomers have discovered that some celestial objects are closer to us than others. **Stars** *are celestial objects that consist of gases which generate light and heat*. They are very far away from us. (Plan to learn about stars in our next unit.) The celestial objects in this unit are those that are within our **solar system**, *the system made up of the nine unique planets and many smaller objects that orbit the sun*. Our solar system consists of nine planets and their moons, asteroids, comets, and a **sun**, *the star that is the basis of our solar system and sustains life on Earth as the source of heat and light.*



The Solar System

Most of the celestial objects that are part of our solar system are constantly circling our sun. These circling paths are called orbits. All celestial objects have some amount of **gravity**, *the attraction of one mass to another mass*. **Gravitational force** is a *measurement of the pull of gravity*. Large masses have a stronger gravitational force than small ones. If a small object is trapped by the gravity of a larger object, it must move fast enough not to be "captured" by the gravity of the larger object. If it slowed down enough, it would fall into the larger object. For example, the moon moves around Earth in an orbit. If the moon moved more slowly, Earth's gravity would pull it into Earth. If the moon moved more rapidly, it would escape into space. Since the sun is the largest mass in our solar system, it creates the gravitational force needed to hold Earth and other planets in orbit around the sun.

A **planet** is *a celestial body that revolves around a star, does not give off its own light, and is larger than asteroids or comets*. The planets of our solar system, in order from the sun, are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. Mercury, Venus, Earth, and Mars, the inner planets, are made up of rocky, solid matter. The outer planets, Jupiter, Saturn, Uranus, Neptune, are made up of gasses. The farthest out planet, Pluto is made up of rocky, solid matter. The chart below shows the **distance***, a measure of the amount of space between objects*, of planets from the sun. Can you figure out how far some planets are from other planets?



**Distance from the Sun:**

| *Name of the Planet:* | *Miles:* | *Kilometers:* |
|---|---|---|
| Mercury | 36,000,000 | 58,000,000 |
| Venus | 67,000,000 | 108,000,000 |
| Earth | 93,000,000 | 150,000,000 |
| Mars | 141,000,000 | 228,000,000 |
| Jupiter | 484,000,000 | 778,000,000 |
| Saturn | 888,000,000 | 1,429,000,000 |
| Uranus | 1,786,000,000 | 2,875,000,000 |
| Neptune | 2,799,000,000 | 4,504,000,000 |
| Pluto | 3,666,000,000 | 5,900,000,000 |

**Below are data that can be used to compare the planets:**

| *Planet:* | *Facts:* |
|---|---|
| Mercury | • It is the nearest planet to our sun<br>• Our moon and Mercury's surface look similar<br>• It has no atmosphere<br>• It has no moons<br>• Mercury revolves around the sun with the same side always facing the sun<br>• It has the greatest range of temperature—662˚ F (day) to -274˚ F (night) = 936˚ F |
| Venus | • It is the second planet from the sun<br>• It spins slowly backwards as it orbits the sun<br>• Its atmosphere is mostly made up of carbon dioxide<br>• The atmosphere traps heat making Venus the hottest planet (860˚ F).<br>• Its surface is mostly craters, mountains, and volcanic lava flows<br>• It has no moons |
| Earth | • It is the third planet from the sun<br>• It is covered by 70% water and 30% land<br>• It has one moon<br>• It has the conditions necessary for life as we know it<br>• It has volcanoes and earthquakes |

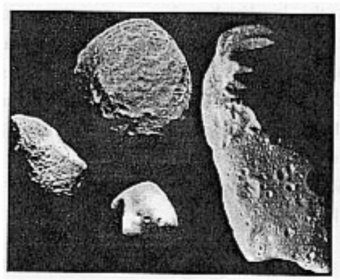


| | |
|---|---|
| Mars | • It is the fourth planet from the sun<br>• Iron oxides (rust) cause its surface to have a red glow<br>• It has polar ice caps made of frozen carbon dioxide and water<br>• It has two small moons<br>• It has a thin atmosphere<br>• Huge dust storms sometimes cover the surface |
| Jupiter | • It is the fifth planet from the sun<br>• Its atmosphere is made mostly of hydrogen, helium, methane, and ammonia<br>• Its Great Red Spot is a storm, which has lasted for millions of years<br>• It has a ring system<br>• It has four large and twenty-four small moons<br>• It is the largest planet in our solar system |
| Saturn | • It is the sixth planet from the sun<br>• It is the second largest planet<br>• It has an atmosphere of hydrogen, helium, methane, and ammonia<br>• It has at least thirty moons<br>• The largest moon, Titan, is larger than Mercury<br>• If it were set upon Earth's oceans, it would float<br>• It has a ring system |
| Uranus | • It is the seventh planet from the sun<br>• It is the third largest planet in our solar system<br>• It has a ring system<br>• Its axis points toward the sun<br>• It has 21 moons<br>• It has an atmosphere of hydrogen, helium, methane, and ammonia<br>• Methane causes Uranus to appear blue in color |
| Neptune | • It is the eight planet from the sun<br>• It has a Great Dark Spot that is a huge storm system as large as Earth<br>• It has high altitude winds<br>• Its atmosphere is made of hydrogen, helium, methane, and ammonia<br>• Methane causes Neptune to appear blue in color<br>• It has eight moons<br>• Its moon, Triton, has an atmosphere<br>• It has a ring system |
| Pluto | • It is the ninth planet from the sun<br>• Its atmosphere is nitrogen, carbon monoxide, and methane<br>• Its moon, Charon, is half the size of Pluto<br>• It is the outermost known planet<br>• Its oval orbit sometimes puts it closer to the sun than Neptune |

It can be difficult to understand how big and how small the planets are. We have some ideas of how large Earth is because we live and travel on it. We get a sense of how vast it is as we travel to distant cities around the country and the world. It may take many hours or even many days to reach a destination depending on the type of transportation we use. Our knowledge of Earth will help us understand the sizes of the planets. The sizes of the planets on the previous pages are drawn to scale, comparisons of objects to a standard, showing how big and how small the planets are compared to Earth.

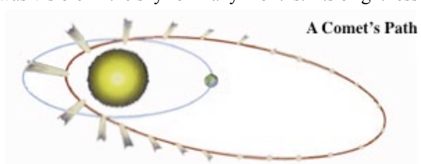
**Asteroids** are *irregular pieces of rock that move through space.* Their mass, the amount of matter in something, can be as small as tiny particles or as large as 1000 km in diameter. Most of the asteroids of our solar system are found in the asteroid belt between Mars and Jupiter. Most asteroids in this belt revolve around the sun. Other asteroids are scattered throughout our solar system.

**Comets** are *composed of dust, ice and gasses which orbit the sun in a large, oval course*. They are often described as "dirty snowballs." As comets approach the sun, the ice vaporizes, releasing dust and gasses that follow behind, creating tails. The tail may reflect enough of the sun's light to be visible without a telescope. The tails always stretch away from the sun hundreds of millions of kilometers. Each time they orbit the sun, comets get smaller and smaller. After orbiting the sun many times, the comets will eventually disappear.



Comets are usually named after the people who first discover them. In 1705, Edmund Halley predicted that a comet everyone had seen many years before, would reappear in 1758. When his prediction came true, the comet was named after him. Halley's Comet passes by Earth every 76 years. It was last seen in 1986. When will people be able to see it again?

A new comet was discovered on July 23, 1995, by two young amateur astronomers. Hale-Bopp Comet was visible in the sky for many months. Its brightness peaked in March and April of 1997.



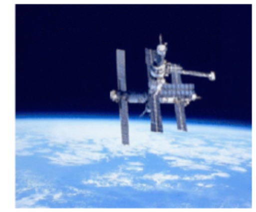
A Comet's Path

Oftentimes, when you are looking out at space on a clear night, you may suddenly see a streak of light flash across the sky. You have just seen a **meteor**, *a small particle of matter that is seen when it falls into Earth's atmosphere*. Sometimes we call them shooting stars. Meteors form from small rocks and dust clouds floating in space. Sometimes meteors will cross Earth's path. When they hit Earth's atmosphere, friction makes them burn up and produce a streak of light. Sometimes the rock chunk is so large that it won't burn completely, so it strikes Earth. These are called meteorites. Some meteorites can create large holes on Earth's surface, but most meteors are very small. When a group of small meteors enter Earth's atmosphere, we enjoy a special light show for an hour or so.

A Meteor Crater



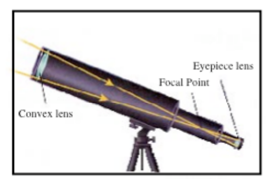
**Satellites** are natural or man-made objects that revolve around a larger object in space. The moon is considered a natural satellite because it revolves around Earth. Scientists use rockets to place man-made satellites in space to orbit Earth. Man-made satellites are lifted high into space, above the atmosphere. They can gather scientific data about Earth that can't be obtained from Earth's surface. They take photographs of large areas of Earth and huge weather systems. The satellites measure Earth's atmosphere and the military uses satellites to photograph buildings and troop movement all over the world.



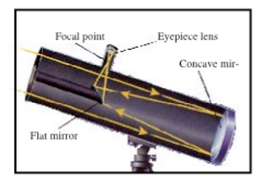
Man-made satellites also help with communications by relaying telephone calls and e-mail messages anywhere in the world. We can hear radio and see television programs that keep us current on world events. Satellites have brought people in the world closer together.

We have launched satellites that orbit Mars and Venus taking pictures of them. These pictures are used to learn more about the surface of Mars and Venus and to determine if there has ever been life on these planets. So far, there is no evidence of life ever existing on them. Man-made satellites are now carrying telescopes into space.

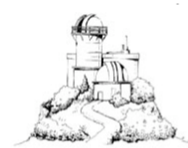
Galileo was one of the first scientists to observe objects in the sky using a **telescope**, *an instrument that magnifies or makes distant objects appear larger*. His observation led to the understanding that we do not live in an Earth-centered universe. Galileo's telescope had a curved lens at each end. He observed the moon's mountains, valleys, and craters. He was also able to observe nearby planets and their moons. In 1668, Sir Isaac Newton improved on Galileo's telescope. Newton's telescope used mirrors and only one lens to sharpen the images. However, even though the telescope had been improved, many early observations were not very detailed.




A Telescope with Lenses



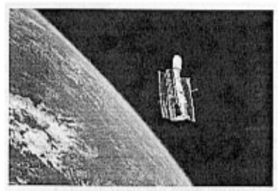

A Telescope with a Lens and Mirrors



Since the time of Sir Isaac Newton, telescopes have improved. Modern observers see objects more clearly and at greater distances. Telescopes are often housed in observatories. Observatories are placed on top of mountains where the air is thin and fewer city lights exist. Air makes objects in space

look blurry, and surrounding lights take away the brightness of objects being observed.

As technology has improved and aided in space exploration, NASA has launched satellites that contain telescopes. Images observed from space are seven times clearer than the strongest telescopes on Earth. One such satellite-telescope, the Hubble Space Telescope, was launched in 1990. If the Hubble Telescope needs adjustment or repair, we send astronauts in a space shuttle to resolve the problem.



**Hubble Telescope in Orbit Around Earth**

Another type of space exploration takes place here on Earth. Scientists have found that celestial objects give off energy in the form of radio waves. Radio Telescopes use that technology to create different pictures of the universe. They can show energy-producing objects that do not give off light. Huge dish-shaped structures have been made to collect radio sounds generated from space. By listening to radio waves, scientists are making new maps of the universe and listening for signals from space that might indicate the existence of life elsewhere.

**Radio Telescope**

Another type of space exploration takes place here on Earth. Scientists have found that celestial objects give off energy in the form of radio waves. Radio Telescopes use that technology to create different pictures of the universe. They can show energy-producing objects that do not give off light. Huge dish-shaped structures have been made to collect radio sounds generated from space. By listening to radio waves, scientists are making new maps of the universe and listening for signals from space that might indicate the existence of life elsewhere.

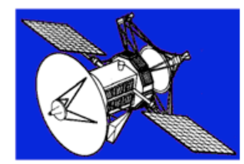
One way scientists have been able to learn more about space is by working in a space shuttle. A space shuttle takes off like a rocket with large fuel tanks supplying the energy. After launch, the tanks eject and the shuttle flies like an airplane in space. While in space, scientific experiments are performed by the astronauts. Most astronauts have scientific training but others are needed to fly the shuttle or make repairs.



The space shuttle does not stay in space more than a short period. For long-term experiments, a space station is used. In 1973, the United States launched the Sky Lab Space Station where astronauts lived and worked for 84 days. The former Soviet Union space station, Mir, supported astronauts for 438 days. One of the interesting findings is that people can live in space and be weightless for long periods of time without harmful side effects.

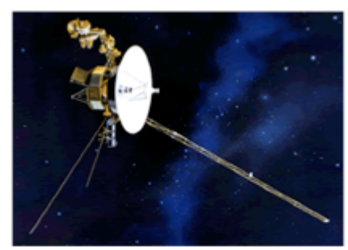
**International Space Station**

One of NASA's most exciting projects is the International Space station (ISS). The station is being built in space with resources from sixteen nations. Each nation is building a section. The parts are lifted into space by American and Russian rockets. The parts are assembled in space and the station should be completed by 2006. The ISS is designed as a permanent laboratory for long-term research projects. When this space station is finished, scientists from all over the world will be able to live and work in space. While only seven scientists can live on the ISS at a time, future space stations will be built to house thousands of people to continue this research. Someday, you might live on a space station and conduct experiments that will benefit the whole world!



**Magellan Space Probe**

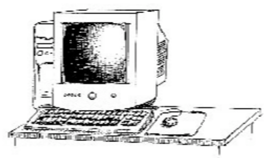
We have talked about objects on Earth and objects that orbit Earth that are used to gather information about our solar system. Another way to collect information requires the use of space probes that are sent to celestial objects we want to know more about. Space probes carry cameras, radio transmitters and receivers, and other instruments. Scientists use radios to communicate with space probes. Programmers tell probes what to do as they pass selected celestial objects. If a probe were passing Venus, the programmers could command it to take pictures or the temperature of the atmosphere.



**Voyager Space Probe**

The probe, Galileo, launched in 1989, reached Jupiter in 1995. It returned some of the most exciting photographs of Jupiter and its moons ever seen. Some probes such as Pioneer 10, Voyager 1, and Voyager 2, have been launched to fly past the outer planets and venture into outer space. These probes have traveled past the asteroid belt and have taken pictures of Jupiter, Saturn, Uranus and Neptune. As the probes travel toward the edge of our solar system, they continue to transmit data to Earth for a few years. By the year 2000, the space probe, Pioneer 10, had traveled more than 11 billion km. On board is a metal plate with an engraving of a man, a woman, and Earth's position in the Milky Way Galaxy.

Computers have made a huge difference in our ability to organize, compute and analyze information received from space. You may think the only computers astronauts and scientists use are those that are on their desks. All the satellites and probes that we previously talked about have computers placed in them. The scientists use the computers on their desks to communicate with the satellites and probes. Commands are given to satellites to position telescopes. Commands are given to probes to tell them where to journey and how to position cameras for taking pictures. The computers on Earth decode these pictures and interpret their finding for scientists. When samples of gasses or material are taken by a probe, their computers analyze and interpret the gasses or materials of celestial objects and send the information back to Earth. Computers are also helpful in predicting the motion of planets, the phases of the moon, and tracking the course of comets and asteroids.

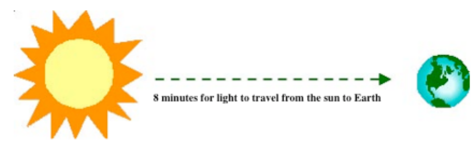


Technology, and space exploration have made it possible for astronomers and scientists to gather more accurate information about our solar system than we can ever imagine. We can answer questions people have asked for centuries. However, many more questions have been generated because of the information gathered. When you grow up, you may be the scientist who finds answers to these questions.



# *Stargazing*

You have probably wondered how far away from Earth are the celestial bodies you see in the **universe**, *the space that consists of all matter, all light and all forms of radiation and energy*. Stars are so far away that our present mode of space travel would take more than a lifetime to reach the nearest star. Planets in our solar system would take a varied number of years to reach, depending on the planet you wanted to visit. Rockets can travel through space at about 75,000 mph or 121,000 kph. If we wanted to visit Venus, our closest planet, we would have to travel about 14.5 days. Pluto, our furthest planet, would take us about 5.5 years to reach.




Since celestial bodies are so far away from each other, our present system of miles and years make it difficult for our minds to comprehend because the numbers are so large. Scientists and astronomers use the **light-year**, *the distance light travels in one year,* to help us understand these distances.

Let's use the sun and Earth to see how this works. Earth is about 93,000,000 miles or 150,000,000 kilometers away from the sun. A beam of light from the sun takes about 8 minutes or 500 seconds to reach us. The **speed of light** *travels at a rate of 186,000 miles per second or 300,000 kilometers per second*. This is much faster than our rockets can travel today.

To find the distance light travels in a year, we need to determine how many seconds are in a year, then multiply it by the speed of light. To begin, multiply 60 seconds in a minute times 60 minutes in an hour. This equals 3,600 seconds in an hour. Next, multiply 3,600 seconds in an hour times 24 hours in a day. This equals 86,400 seconds in a day. Now, multiply 86,400 seconds in a day times 365 days in a year. This equals 31,536,000 seconds in a year. Finally, by multiplying 31,536,000 seconds in a year with 186,000 miles per second, we find that a **light-year in miles** is about *5,865,696,000,000 (five trillion, eight hundred sixty-five billion, six hundred ninety-six million) miles*.

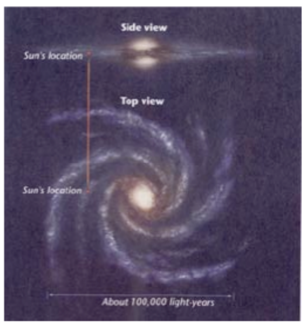
By multiplying 31,536,000 seconds in a year with 300,000 kilometers per second, we find a **light-year in kilometers** is about *9,469,800,000,000 (nine trillion, four hundred sixty-nine billion, eight hundred million) kilometers*.

**Light-year Calculation**

60 seconds per minute x 60 minutes per hour = 3,600 seconds per hour
3,600 seconds per hour x 24 hours per day = 86,400 seconds per day
86,400 seconds per day x 365 days a year = 31,536,000 seconds per year
31,536,000 seconds per year x 186,00 miles per second =
5,865,696,000,000 miles per year = **1 light-year in miles**

Scientists measure the approximate distance of one celestial body to another in miles or kilometers and divide by the speed of light to determine the light-years. The closest star, other than our sun, is Alpha Centauri. It is 4.3 light-years away. This means it would take about 4 years and 4 months to reach it from Earth traveling at the speed of light.

| **Distance from the Sun in Light Years to the Planets** | |
|---|---|
| *Planet* | *Light Years* |
| Mercury | 0.000006 (3 light minutes) |
| Venus | 0.000011 (6 light minutes) |
| Earth | 0.000016 (8 light minutes) |
| Mars | 0.000024 (12.5 light minutes) |
| Jupiter | 0.000082 (43 light minutes) |
| Saturn | 0.000151 (79 light minutes) |
| Uranus | 0.000304 (160 light minutes) |
| Neptune | 0.000476 (250 light minutes) |
| Pluto | 0.000624 (327 light minutes) |
| Alpha Centauri (nearest star) | 4.3 |



Milky Way Galaxy

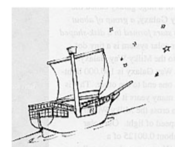
Most stars belong to a **galaxy**, *a group of billions of stars held together by gravity*. Our solar system lies on the outer edge of a huge galaxy called the **Milky Way Galaxy**, *a group of about 200 billion stars formed in a disk-shaped spiral*. Our solar system is a tiny dot compared to the Milky Way Galaxy. The Milky Way Galaxy is 100,000 light-years from one end to the other. This is about how many years it would take someone to cross the Milky Way traveling at the speed of light. Our solar system is about 0.00125 of a light-year. You can see how small our solar system is compared to the Milky Way. In the picture, most of the celestial bodies you see in the sky are in the Milky Way Galaxy.

The Milky Way Galaxy is only one galaxy. There are billions of galaxies that span the universe. One of the Milky Way's neighboring galaxies is Andromeda. It is 2 million light years away. It is so far away that you can't see its individual stars. You can only see a hazy spot in the night sky produced by the combined light of the stars. The pictures below were taken by the Hubble Space Telescope. There are many galaxies within the view of the Hubble Telescope. Even though our world seems big to us, in the universe we are very, very small.




Other Galaxies

Stars in the sky have fascinated people throughout the ages. Many years ago when people were out tending their flocks, sailing their ships, traveling or just star gazing, they noticed how some stars were always visible at night. Other stars were only visible during certain months of the year. People charted when these stars appeared and how they were positioned. They depended on these stars and star patterns for direction. Skywatchers noticed that during the spring, summer, fall and winter, there would be certain stars and star formations in the sky for each season. They began to make calendars of the months based on star formations.



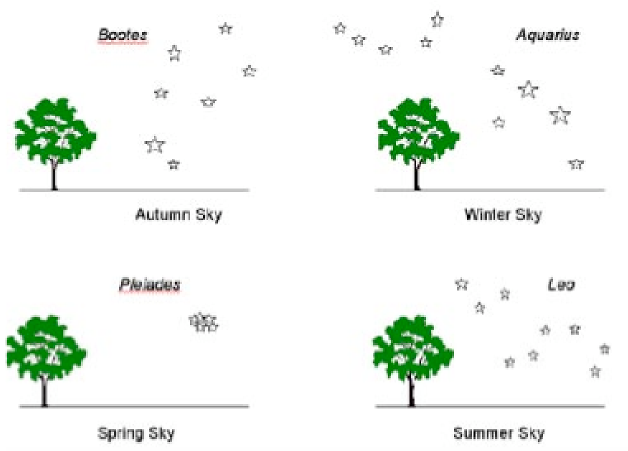
Ancient Arabs, Egyptians, Babylonians and Greeks were well aware of the different stars. Many varied interpretations were written and reported by those different populations. They had observed that some stars could be connected like a dot-to-dot picture. Depending on what they thought the picture looked like, ancient people associated them with objects, beasts or people. They wrote stories about stars related to heroes, heroines and beasts of their time and culture. Since those ancient times, people have continued to make up stories, develop religious practices and grow crops based on groups of stars.

Groups of stars are called **constellations**, *patterns of stars in the sky that have been identified and named*. Some constellations can be seen all year. These are stars that are close to the North Star. The North Star is directly above the North Pole and does not appear to move. The other stars seem to move around it at night because of Earth rotating on its axis.

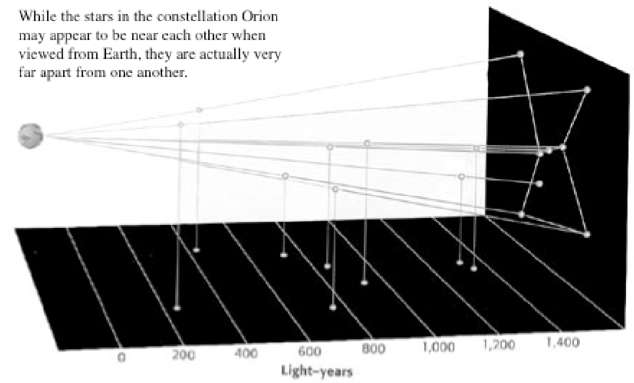

There are other constellations that are seen only during certain seasons. The positions of these constellations have shown stargazers for thousands of years what time of year it is. The pictures below show constellations seen in the western sky at about 10:00 P.M. in North America at the beginning of the different seasons. You can see how

people of ancient times were able to tell what season it was just by looking west in the evening.

Stars in a constellation may look like they are close together. Actually, stars that make up constellations may be very far apart. Look at the picture below to see how the stars of Orion appear close together when viewed from Earth, but they are many light-years apart.



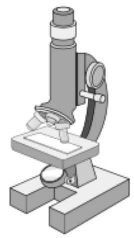



People of all ages have discovered that constellations can be used as reference points. Sailors used them to help guide their ships at night. African-Americans fleeing slavery sought what they called the Drinking Gourd, or Big Dipper, found near the North Star, as a guide to freedom. Pioneers migrating west used constellations as a guide while traveling on the Oregon Trail. Constellations have been important, not only in the development of ancient civilizations, but in the development of modern ones as well.

# *The Good and Bad of Microorganisms*

It happens every year, sometimes two or three times. It happens to almost everyone in every city, state, town and country around the world. When was the last time it happened to you? What? Oh, sorry! When was the last time you were sick? Did you have a fever, scratchy throat, headache, body aches or several of these symptoms? A **microorganism**, *a living thing that can only be seen with the aid of magnification*, was probably the cause of whatever sickness you had. You may have called it a germ, but this term only describes relatively few microorganisms.



**Microscope**

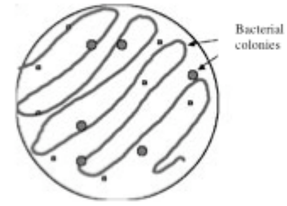
All microorganisms are *living things* or **organisms**. Microorganisms may be unicellular or **single-celled**, *any living thing that has only one cell, the smallest unit of life.* Some microorganisms are multicellular, having more than one cell. Microorganisms require food, air, water, ways to dispose of waste and an environment in which they can live. Some microorganisms are **producers**, *living things that make their own food from simple substances usually using sunlight*, as plants do. Some microorganisms eat other organisms to get their food. Most microorganisms do not cause disease and many are helpful. There are many different kinds of microorganisms. Scientists observe and classify microorganisms just as they do plants and animals. These classifications are determined by the microorganisms' shape, structure, how they get food, where they live and how they move. The microorganisms you will study in this unit include bacteria, fungi, and protist. Let's look at the characteristics of each.

**Bacteria** are *microscopic, single-celled organisms that exist all around you and inside you*. Although they can cause sickness and disease, they are very important to life on Earth. We depend on bacteria to help in the digestion of food, for plant growth, and to help us make foods and medicines. Bacteria are an important part of the soil. They are able to capture some nutrients that plants cannot. When living things die, bacteria play a very important role as **decomposers**, *bacteria and fungi feeding on and breaking down plant and animal matter*. Without these decomposers, the bodies of all organisms that have ever lived would still remain. This would be messy. When bacteria break down the dead organisms, they release substances that can be used by other organisms in the ecosystem.

Bacteria can affect our bodies in several ways. Harmful bacteria can make us sick, but fortunately, our bodies will fight back. When streptococcus bacteria give us strep throat we can take medicine to help us get well faster. Some bacteria always live in our bodies. They are found in digestive systems and help digest food. Other bacteria are in our food. When you eat yogurt or cheese, you eat bacteria.



Bacteria are the smallest microorganisms. You can see them when there are thousands of them growing together in a colony. To see bacteria as a single organism requires a microscope with very high magnification. Bacteria live in almost every place on Earth. Scientists can **culture**, *grow microorganisms in a specially prepared nutrient medium*. The drawing shows how colonies of bacteria look when cultured on a plate. The colonies vary in size and color depending on the type of bacteria.

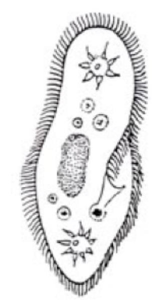



**Bacterial Colonies on a Plate**

**Fungi** *are organisms that are neither plant nor animal, yet have characteristics of both, and absorb food from whatever source they are growing on*. A common fungus is a mushroom. It looks like a plant but is not green. Mushrooms cannot make their own food and must live on a food source. Some are poisonous, and only an expert can identify them. Another fungus, yeast, is used to make bread rise and give it flavor. Athlete's foot is caused by a fungus. Some types of fungi rot wood in homes. Fungi also like warm moist places to grow. A good way to prevent fungus is to keep things, like your toes, dry.

**Fungi**

**Protozoans** *are microscopic organisms that usually live in water*. They move through the water with tiny hair-like arms called cilia. The cilia are located all around the sack-like body of the protozoa and wave back and forth to move the protozoa through the water. Some protists are producers like plants. Others must eat smaller things like bacteria or molds. Protozoa are an important food source for many pond creatures. Some protozoans are harmful to people. You may have heard that it is not a good idea to drink water from a stream. Streams sometimes contain a protozoan called Giardia that can make you sick.



**Algae** *are a type of protist that usually live in water and can produce their own food*. Some algae are very large, while others are microscopic. Algae can be red, brown, yellow or green. Some of the largest algae are kelp. They can grow to be 60 meters long. Algae are an important part of the ocean's ecosystem. They provide food for fish, whales and many other sea animals. Phyloplaukton provide over half of oxygen on Earth. Algae are also eaten by people. In fact, algae are in ice cream.

There are many important discoveries that scientists have made concerning microorganisms. The next two stories describe how two of the discoveries were made.

## Important Discoveries

<u>Louis Pasteur</u>

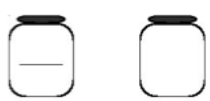
Louis Pasteur was a French chemist. He is sometimes known as the father of modern bacteriology because he was able to show that bacteria exist, grow and can be controlled. Pasteur is credited with developing the process of pasteurization. He developed an **investigation**, *a process designed to answer a question*, and used an **experiment**, *a series of steps to find the answer to a question*. These are the steps of his experiment:

Step one: Pasteur developed a **hypothesis**, *an idea made into a statement that can be tested*. Pasteur proposed that if bacteria were heated, they would die.

Step two: Two jars with a culture of bacteria were covered.

Step three: Jar A was heated and Jar B was not. Jar A is testing the heat experimental **variable**, *a part of an experiment that is changed in order to find out the effects of that change*. Jar B is not testing the heat variable. It is called the **control**, *a part or variable of an experiment that is kept the same to be used for comparison*. A control is needed to compare results when the experiment is done.

Step four: After some time had passed, Pasteur observed that Jar A had no bacterial growth and Jar B had bacterial growth.



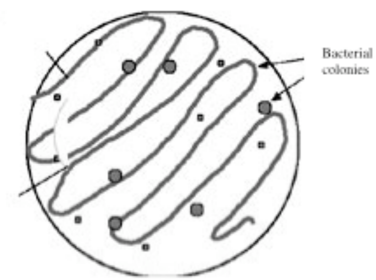


Step five: Pasteur came to the **conclusion**, *a summary based on data related to a hypothesis*, that heating kills bacteria.

<u>Alexander Fleming</u>

It was a warm September day in 1928. Alexander Fleming was working with bacterial cultures in a London hospital. He left the windows of the lab open. After studying some laboratory plates of staphylococci bacteria, he accidentally left a plate by the open window and forgot about it. A few days went by. He returned and found that the plate by the window was contaminated. Was his experiment ruined?

Fleming didn't throw the plate away. He re-examined it under a microscope and found mold growing on the staphylococci. He noticed a clear zone that existed all around the mold. The mold was killing the deadly bacteria. Penicillin was the mold that killed bacteria.




**Fleming's Bacterial Plate**

It was Alexander Fleming's mistake that gave the world penicillin. This is now considered one of the greatest discoveries of the 20th century. Fleming received the Nobel Prize in 1945, and millions of people worldwide have survived disease because of his discovery.

# *Energy – Heat, Light, and Sound*

A two-year-old has plenty of it, and the sun has a bunch of it. Do you know what it is? If not, let me give you a definition. "A source of usable power." By now most of you have probably guessed the answer. It's energy. The sun definitely qualifies. What about a two-year-old's energy? Is it "a source of usable power" as the definition states? As you may know, two-year-olds are usually bundles of energy, but their energy cannot be used by others.

This unit is going to discuss three types of energy: heat, light, and sound. As we discuss them, be sure to watch for similarities as you learn some background on each. So, if you're ready, here we go.

## Heat

If you go camping, you usually build a fire to sit around at night. You may make S'mores, have hot chocolate and stay warm. Have you ever wondered why a marshmallow cooks without touching the flame, why the smoke rises, or why water in a pan boils? Heat can move from one object to another in three different ways: conduction, convection and radiation.

**Conduction** *is the heat transfer through a substance or from a substance to another by direct contact*. Everything is made up of small particles. When the particles are moving faster, there is more energy and the temperature is higher. As fast-moving particles touch slow-moving particles, the energy is transferred. This causes slower particles to speed up and the faster particles to slow down. You can demonstrate this by rubbing your hands together very fast for 30 seconds. Now touch them to your ears. Can you feel the heat transfer from your hands to your ears? As your ears warm, your hands will cool until the particles in each are moving at the same speed.

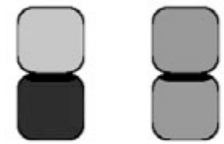
**Conduction**

Another example of conduction is a pan on the stove. The stove is heated by gas or electricity. Then the pan gets hot. *Substances that transfer heat better than others* are **conductors**. Can you think of other examples of conductors? Insulators are substances that do not conduct heat easily. Glass, wood, plastic and rubber are all insulators. Pans have plastic or wood handles to keep the pan from conducting heat to your hand and burning it. Can you think of other examples of insulators?

**Convection** *is the heat transfer in liquids and gases as particles circulate in currents*. This transfer of energy causes warm substances to rise and cool ones to sink. In heat transfer by convection, the particles in a liquid or gas speed up as they are heated. This causes the particles to move apart and the substance becomes lighter. As the heated substance rises, the cooler, heavier substance moves down. These currents exchange heat through this movement.



You can observe convection in a simple experiment. Get two baby food jars. Fill one with hot water and a drop of red food color. Fill the other with cold water and a drop of blue food coloring. Place a card over the mouth of the cold water jar and turn it upside down on top of the warm water. Carefully pull out the card. You should see warm, red water rising and cold water sinking.



**Radiation** is *the transfer of heat through space in the form of waves*. The heat we receive from the sun is radiant heat. Radiant heat travels as waves through space. Heat waves hit Earth and cause warming. Our atmosphere traps the warmth. Your house gets warm when the sun's waves or rays travel through a window and are trapped in your house, warming it. Heat waves are invisible. All warm objects radiate or give off heat waves. Some other examples of radiation are the heat surrounding a fire, the heat given off by an electric heater, and the heat near a hot oven.

## Light

If you were asked to make a list of all the things that give us light, what would you write? Light bulbs, candles or campfires may be on your list. The sun is an important source, also. Light is energy that travels in waves and is produced by hot, energetic objects.

Light bulbs are hot, energetic objects. If you have ever touched a light bulb while it is on, you know it is hot. You know the light bulb needs energy because you have to turn the light switch on to provide electricity for it. The electricity flows through either a thin metal wire or a gas. The wire or gas glows and gives off light when heated.

## Sound

If a tree falls in the forest and no one is there, does it make any sound? **Sound** is *a form of energy that causes particles to vibrate back and forth*. How would you answer the question about the tree falling in the forest?

When the tree hits the ground it causes the particles in the air to vibrate. **Vibration** is *a rapid movement back and forth*. The tree creates vibrations in the air as it falls. The vibrations spread out in all directions. If the vibrations in the air reach you, your eardrum will vibrate and you will hear the sound of the tree falling.

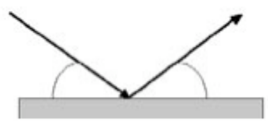
Have you ever placed your hands over your ears because someone was yelling? The loudness or intensity of a sound depends on the energy used. The more energy used,

the louder the sound. You use a lot more energy to yell than you do to whisper. The same is true with all sounds: the more energy expended, the louder the sound.

Do you sing or play a musical instrument? If you do, you understand **pitch**, *how high or low a sound is*. The pitch of an instrument changes by adjusting its length or width. A trombone's sound changes from low to high as the slide is moved in. The pitch of musical instruments can also be changed by tightening the strings which increases the speed of vibration. The picture below shows glasses filled with water. The glass on the left will have the lowest pitch when tapped. It has the greatest length of air space to vibrate, thus creating a low sound.

To keep areas quiet, such as libraries, there are materials placed in the rooms such as carpet and upholstered chairs to absorb noise. The **absorption***, the ability to take in or dampen*, soaks up any noise so people can study in quiet surroundings.

One way the three forms of energy are alike is that they can be reflected. Think back to the last time you looked in a mirror. You saw a **reflection**, *the bouncing back of light waves from a surface*. If light wasn't reflected, you wouldn't have seen anything. *Light strikes the mirror* at an **angle of incidence**. *It bounces off at the same angle*, the **angle of reflection**.



We are very familiar with reflection when it comes to mirrors and other items that reflect images. Did you know that everything reflects light? When we look at things, the color that we see is light that is reflected from the object. For example, if we look at a red apple it reflects red and **absorbs** or *takes in all the colors* but red. What color is reflected when you look at a banana? What colors are absorbed when you look at a banana? All colors are reflected if an object appears white. All colors are absorbed if an object appears black. Most objects reflect more than one color, creating a vast number of color combinations. Sound waves are reflected from canyon walls if you shout loudly. You may have enjoyed hearing the echo of your voice. Heat waves are reflected from windows by aluminum foil placed over them. This keeps houses cooler in the summer.

Energy waves can also be **refracted**, *bent*. Light is easiest to observe as it is refracted. Light always travels in a straight line when going through a single **medium**, *any substance through which a light wave can travel*. In some mediums, such as air, light travels quickly. In other mediums, such as water and glass, light travels more slowly. When light travels from one type of medium to another, the light changes speed and is refracted. Look at the picture of the pencil in the glass of water. The light rays bend as the light rays pass from the water to the air, making the pencil look bent. This is also seen in a rainbow. To get the same effect, shine a light through a **prism***, a medium*



*that breaks up light*. You will create the same rainbow spectrum as seen in a rainbow made by nature. As you can see in the picture below, white light is actually made up of seven different colors.

Heat, light and sound are similar to each other. They are forms of energy and they travel in waves.