The Movement of the Earth, Moon, & Sun

Measuring Time on Earth

People can determine the approximate time of day by determining where the Sun is in the sky. If the Sun is near an imaginary line drawn from due north to due south, it is about 12:00 noon. Humans have used movements of Earth, the Moon, and the Sun to measure time for thousands of years.

Earth Movements Measure Time

Earth spins and makes one complete turn in about 24 hours. This spinning causes the Sun to appear to move across the sky from east to west. It takes 24 hours from when the Sun is highest in the sky (noon) until it is highest in the sky again (noon the next day).

Rotation Measures Days

The spinning motion of Earth enables you to measure the passing hours of the day. **Rotation** is the spinning of Earth on its axis, an imaginary line drawn through Earth from its north pole to its south pole.

Revolution Measures Years

The motion of Earth around the Sun enables you to measure the passing of years. **Revolution** is the motion of Earth in its orbit around the Sun. As Earth revolves in its orbit, the Sun appears to move through the skies compared to the seemingly fixed positions of the stars.

Why do seasons change?

Recall that Earth's orbit around the Sun is an ellipse. This means that Earth is closer to the Sun at one time than it is at other times. Is this the cause of seasonal changes on Earth? Because Earth is closest to the Sun in January, you would expect this to be the warmest month. However, you know this isn't true in the northern hemisphere; something else must be causing the change.



These seasonal changes are caused by

- 1. Earth's rotation The number of daylight hours determines how long the sun is hitting the Earth. The more sun, the warmer it is. The less sun, the colder it is.
- 2. Earth's revolution During the summer, the sun is higher in the sky and hits Earth's surface at a higher angle. These rays are more intense and warms the earth more than when the sun is lower





in the sky. As the year progresses, the sun hits the Earth at a lower angle. These lower angle rays are less intense and not as warm.

3. The tilt of its axis - Earth remains tilted in the same direction as it revolves, so different hemispheres are tilted toward the Sun at different times of the year. The hemisphere tilted toward the Sun receives sunlight at higher angles than the hemisphere tilted away from the Sun. The greater intensity of sunlight is one reason why summer is warmer than winter. When it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere. When it is winter in the Northern Hemisphere, it is summer in the Southern Hemisphere. Therefore, children in Australia celebrate Christmas in the summer.

Equinoxes and Solstices

Because of the tilt of Earth's axis, the Sun's position relative to Earth's equator constantly changes. Most of the time, the Sun is north or south of the equator, but two times during the year, the Sun is directly over the equator. An **equinox** is when the sun is directly above Earth's equator, and the number of daylight hours equals the number of nighttime hours all over the world. The term *equinox* is derived from two words meaning "equal" and "night." At that time, neither the northern nor the southern hemisphere is tilted toward the Sun. In the northern hemisphere, the Sun reaches the spring equinox on March 20 or 21, and the fall equinox on September 22 or 23.

The **solstice** is the point at which the Sun reaches its greatest distance north or south of the equator. The term *solstice* is derived from the Sun's name, *Sol*, and a Latin word meaning "standing"; that is, it appears to stand, or stop moving, north or south in the sky. In the northern hemisphere, the Sun reaches the summer solstice on June 21 or 22, and it reaches the winter solstice on December 21 or 22. When the Sun is at the summer solstice, there are more hours of daylight than during any other day of the year, and the Sun's rays strike at a higher angle. When it's at the winter solstice, on the shortest day of the year, the most nighttime hours occur and the Sun's rays strike at the lowest angle.

The Moon

The moon is the earth's only natural satellite. Its average distance from the earth is 384,403 km. Its revolution period around the earth is the same length and direction as its rotation period, which results in the moon always keeping one side turned toward the earth and the other side turned away from the earth. The side turned away from the earth is called the moon's dark side, even though it is lit half of the time. The moon's period of revolution is about 29.5 days long.

Movement of the Moon

You have seen the Moon move across the sky from east to west, just like the Sun. This is an apparent movement like the Sun's, caused by Earth's rotation. But, the Moon actually does

move in another way. If you look at the Moon each day at the same time over a period of a few days, you will see that it moves toward the east.

Rotation and Revolution

This eastward movement of the Moon is an actual movement that is caused by the Moon's revolution in its orbit. A complete lunar phase cycle takes 29.5 days. Many people think the Moon does not rotate because it always keeps the same side facing Earth. This is not true. The Moon keeps the same side facing Earth because it takes the same length of time to rotate once on its axis — the same amount of time that it takes to revolve once around Earth. You can observe this by having a friend move the ball around you while keeping the same side of it facing you. You will see only one side.

Phases of the Moon

A new moon occurs when the Moon is between Earth and the Sun. During a new moon, the side of the Moon facing away from Earth is lighted and the side of the Moon facing Earth receives no light from the Sun. The Moon is in the sky, but it cannot be seen.

Waxing Phases

After a new moon, the moon's phases are said to be waxing — the lighted portion that we see appears larger each night. The first phase we see after a new moon is

called the waxing crescent. About a week after a new

moon, we see one-half of the Moon's lighted side, or one-quarter of the Moon's surface. This phase is the first-quarter.

The moon is in the waxing gibbous phase from the first quarter up until full moon. A full moon occurs when we see all of the Moon's lighted side. At this time, the Moon is on the side of Earth opposite from the Sun.

Waning Phases

After a full moon, the lighted portion that we see begins to appear smaller. The phases are said to be waning. When only half of the side of the Moon facing Earth is lighted, the third-quarter phase occurs. The waning crescent occurs before another new moon. Only a small slice of the side of the Moon facing Earth is lighted. The word *month* is derived from the same root word as *Moon*. The complete cycle of the Moon's phases takes about 29.5 days.

Eclipses

Eclipses occur when Earth or the Moon temporarily blocks sunlight from reaching the other object. Sometimes, during a new moon, a shadow cast by the Moon falls on Earth,



causing a solar eclipse. During a full moon, a shadow of Earth can be cast on the Moon, resulting in a lunar eclipse. Eclipses can occur only when the Sun, the Moon, and Earth are lined up perfectly.

Solar Eclipses

A **solar eclipse** occurs when the Moon moves directly between the Sun and Earth and casts a shadow on part of Earth. The darkest portion of the Moon's shadow is called the umbra. A person standing within the umbra experiences a total solar eclipse. The only portion of the Sun that is visible during a total eclipse is part of its atmosphere, which appears as a pearly white glow around the edge of the eclipsing Moon. This is the only time the entire disk of the new moon phase can be photographed – it appears black against the Sun. The next solar eclipse in the United States will be August 21, 2017. A total solar eclipse can occur as often as twice a year, yet most people live their entire lives without witnessing one. The reason why it is so rare to view a total solar eclipse is that only those people in the small region where the Moon's umbra strikes Earth can see one and, even then, there must be clear skies.

WARNING: *Regardless of where you are standing, never look directly at a solar eclipse. The light can permanently damage your eyes*



Lunar Eclipses

When Earth's shadow falls on the Moon, a **lunar eclipse** occurs. A lunar eclipse begins when the Moon moves into Earth's penumbra, or the shadow cast by the earth or moon over an area experiencing a partial eclipse. As the Moon continues to move, it enters Earth's umbra, and you see a curved shadow on the Moon's surface. When the Moon moves completely into Earth's umbra, a total lunar eclipse occurs. The Moon sometimes becomes red during an eclipse because light from the Sun is scattered and refracted by Earth's atmosphere. Longer wavelength red light is affected less than shorter wavelengths, so more red light falls on the Moon.

A partial lunar eclipse occurs when only a portion of the Moon moves into Earth's umbra, or the fully shaded inner region of a shadow. The next partial lunar eclipse will be March 23, 2016. You may never see a total solar eclipse, but it is almost certain you will have a chance to see a total lunar eclipse. The next total lunar eclipse will be January 31, 2018. The opportunities to witness lunar eclipses are much more frequent than solar eclipses, and anyone on the night side of Earth can see them.



The Moon's Surface

When you look at the Moon, you can see many of its larger surface features. Craters, rays, mountains, and maria can easily be seen through a small telescope or a pair of binoculars. What are these different features, how did they form, and what do they tell us about the Moon's history and interior?

Craters, Maria, and Mountains

Many depressions on the Moon were formed by meteorites, asteroids, and comets, which strike the surfaces of planets and their satellites. These depressions, which are called **craters**, formed early in the Moon's history.

Surrounding many craters are ray patterns produced by lighter-colored material from just below the lunar surface that was blasted out on impact and settled on top of the darker surface material around the craters. During the impact, when these large basins formed, cracks may have formed in the Moon's crust, allowing lava from the still-molten interior to reach the surface and fill in the basins, forming maria. **Maria** are the dark-colored, relatively flat regions on the Moon's surface.

Surrounding the large depressions that later filled with lava are areas that were thrown upward in the original collision and formed mountains. The largest mountain ranges on the Moon surround the large, flat, dark-colored maria.

Regolith

When NASA scientists started to plan for crewed spacecraft to land on the Moon, they were concerned about whether the lunar surface would be able to support the craft? To find out, unmanned *Surveyor* spacecraft were landed on its surface. One *Surveyor* craft actually bounced a few times as it landed on the side of a crater. What was this material that the spacecraft had landed on? Impacts on the Moon throughout its history led to the accumulation of debris known as **regolith.** On some areas of the Moon, this regolith is almost 40 m thick, while in other locations, it is only a few centimeters thick. Some regolith is coarse, but some is a fine dust. If you watch astronauts walking on the Moon, you will notice that they often kick up a lot of dust.

Why Do We Study the Sun?

We look at the sun rising every day. It's bright, it's big and it warms us up. Our sun happens to be the brightest object in our universe and naturally we are really curious to know more about it.

Our sun gives us light, heat and energy. It may seem that energy comes from other sources such as gasoline and electricity but the ultimate source of energy for the Earth is nothing else but the sun. Without the sun life on Earth would not exist. It would be so cold that no living thing would be able to survive and our planet would be completely frozen.

It defines the seasons, the harvests, and even the sleep patterns of all living creatures on Earth.

The sun is a normal star. It is much closer to us than any other star, and by studying the sun, we can therefore learn more about other stars. The better we understand other stars, the more we know about the Milky Way. From there we know more about other galaxies and in the end we learn more about the universe.

The sun also plays the role of a big anchor, which creates gravity that keeps our planet and the other planets of the solar system in a small space. If it weren't for the sun, our planet would simply fly off loose into the universe.

Our sun is very dynamic and it changes constantly. It has the largest eruptions in the solar system. These eruptions can be so large that they can reach our planet and cause serious damage by disrupting satellites and other communication devices. Our TV may not work, our cell phones will be down, a high speed train may run loose and if an astronaut happens to be on the moon at the time when the sun erupts, he or she would be in great danger.

The sun is way bigger than the Earth. In fact its radius is 109 times bigger than the radius of the Earth. For those of you who are curious, the sun's Radius is 696,000km and the Earth's radius is 6, 376km. The sun's average surface temperature is 5700 C. Compare that to the Earth's average temperature, which is 20 C. The sun is 150 million km (93 million miles) away from the Earth. We know that the Earth's structure consists of different layers. The sun also has layers but unlike the Earth, the sun is entirely gaseous; there is no solid surface.

Words to Know

- **1. axis** imaginary line that extends from pole to pole through the center of the earth
- 2. rotation movement of an object in a circular motion (The Earth rotates on its axis.)
- **3. revolution** the orbiting of one heavenly body around another (The Earth **revolves** around the sun.)
- **4. solstice** when the sun is furthest from the equator and the day is either the shortest or longest of the year
- **5. equinox** when the sun is directly above the equator the day has equal light and dark (March 21 and September 21)
- 6. winter solstice the shortest day of the year (December 21)
- 7. summer solstice the longest day of the year (June 21)