Introduction

Earth seen from the moon.

Through scientific study and space exploration, we have learned that Earth exists as a part of a larger system called the *solar system*. Within our solar system, the moon and Earth have a very important relationship. The relationship between sun, Earth, and moon affects many of the everyday occurrences that we take for granted—the **tides**, the amount of solar energy, the length of our days and nights, and the **seasons**. Learning about this relationship helps us to understand these daily occurrences and to understand our need for future exploration of the world beyond our Earth.

The Relationship of the Earth and the Moon

Earth has one moon. The moon **revolves** around Earth about once a month. The moon also turns, or **rotates**, on its axis one time per month. Because of this, we only see one side of the moon. The moon does not give off light of its own. It reflects the light of the sun.

Earth has a blanket of air surrounding it called an *atmosphere*. The moon does not have an atmosphere because it does not have a strong enough gravitational force to hold a blanket of air around it. Since there is no atmosphere on the moon, there is no water. Without an atmosphere and water, the moon is unable to support life.

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Earth is the third planet from the sun. Earth's atmosphere is different from the other planets. It contains oxygen and water vapor and thus can support life. The atmosphere also protects Earth from extremes in

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temperatures. Without an atmosphere, the moon is subjected to very high and low temperatures. The dark side of the moon may get as cold as -175° Celsius, and the lighted side may reach temperatures of 130° Celsius.

When viewed from Earth, the surface of the moon has light and dark areas, which sometimes combine to look like a person's face. The light-colored areas are **highland areas**. The *highland areas* have mountains that are much higher than any found on Earth. The parts of the moon that appear dark are called **maria**. *Mare* (singular for maria) is the Latin word for *seas*. The maria are flat areas that look like seas, except that they do not have any water in them.

The surface of the moon also has many bowl-like depressions called **craters**. *Craters* vary in diameter from a few inches to over 500 miles. Most of the craters were produced long ago by the impact of **meteors**. In contrast, Earth has only about a dozen well-known craters. Although many *meteors* travel towards Earth, most of those meteors burn up in Earth's atmosphere. The moon, on the other hand, has no atmosphere to affect the meteors' impacts. Additional craters may have been on Earth in early geologic history, but these have been destroyed by erosion.

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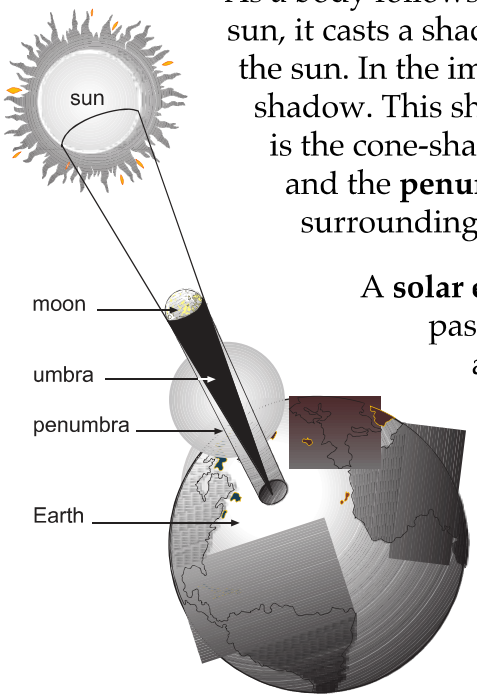
Solar Eclipse



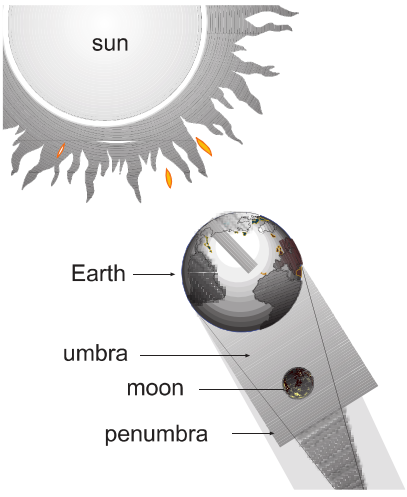
A solar eclipse takes place when the moon passes into a straight line between the sun and Earth.

As a body follows its **elliptical orbit**, or path, around the sun, it casts a shadow thousands of miles long away from the sun. In the image to the left, the moon is casting a shadow. This shadow has two parts—the **umbra**, which is the cone-shaped inner part that is completely dark, and the **penumbra**, which is the partly shaded region surrounding the *umbra*.

A **solar eclipse** takes place when the moon passes into a straight line between the sun and Earth. When the moon is in this position, its shadow moves onto a small area of Earth. During a **total eclipse** of the sun, the moon totally blocks out the sun and, for a short time, becomes dark. Only a halo of light from the sun's rim, called a **corona**, can be seen. Other parts of Earth that fall in the *penumbra* experience a **partial eclipse**, where only part of the sun is blocked by the moon. A *partial eclipse* is seen by many more people than a *total eclipse*.

Lunar Eclipse

When the moon moves into Earth's shadow, we have a **lunar eclipse**. During a *lunar eclipse*, hardly any sunlight reaches the moon and, consequently, it looks very dim. A lunar eclipse will last about three or four hours. It is longer than a *solar eclipse* because Earth's shadow is very wide, and it takes a long time to pass through it. A lunar eclipse can be seen from more areas of Earth than a solar eclipse. Also, there are many more lunar eclipses than solar eclipses.

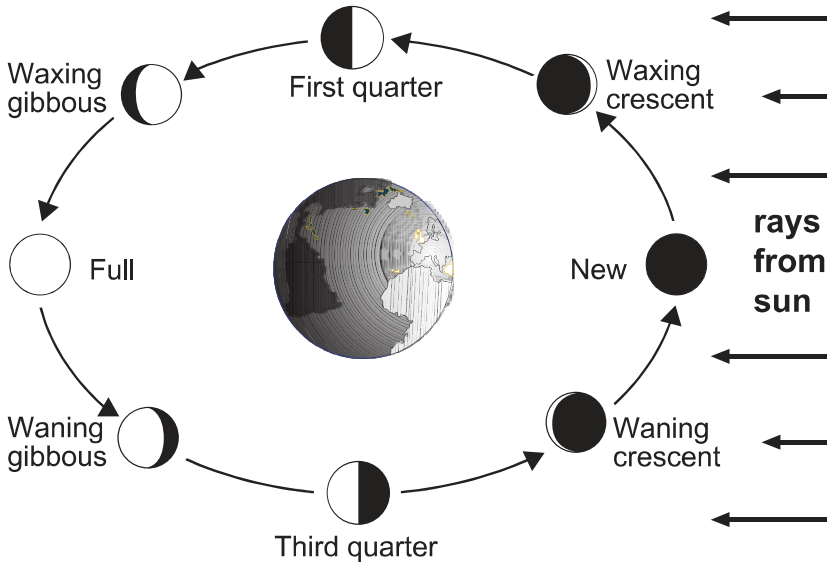


When the moon moves into Earth's shadow, we have a lunar eclipse.

Moon Phases

The moon moves around Earth in exactly the same way that the planets *revolve* around the sun. It takes the moon 27⅓ days to make one trip around Earth. The moon also *rotates* or spins on its axis one time as it revolves around Earth. While the moon is moving around Earth, Earth is also moving around the sun. Therefore, it takes about two more days for the moon to return to its original position in relation to the sun and Earth. It takes a total of 29½ days for the moon to pass from one new moon to the next new moon. This period of time is called a **lunar month**.

As the moon *orbits* Earth, sometimes the side that is lighted by the sun is facing Earth, and at other times part or all of the lighted side is facing away from Earth. The different portions of the lighted side of the moon that are visible as the moon revolves around Earth are known as **moon phases**.



The circle shows the phases of the moon as seen from Earth.

- New Moon—when the moon is in between Earth and the sun, the unlighted side of the moon is facing Earth and cannot be seen
- Crescent Moon—just before and after the new moon; only a slice of the lighted side is seen
- Quarter Moon—halfway between the new moon and full moon; half the moon is dark and half is lighted
- Gibbous Moon—just before and just after a full moon; over half of the moon is lighted; it appears lopsided
- Full Moon—when the moon is on the opposite side of Earth from the sun; the entire lighted side is facing Earth

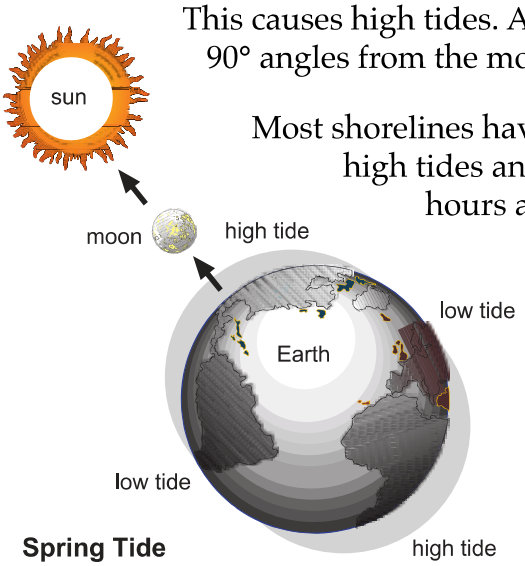
Tides

If you have gone to a beach and stayed a few hours, you probably have noticed that the ocean water does not stay at the same level. The water level of the ocean rises and falls at regular time periods. At certain times of the day the water is higher than at other times. This regular rise and fall of the ocean water is called *tides*.

The moon effects the tide more than the sun because it is so much closer to the Earth.

Tides are the movements of the ocean water caused by the gravitational attraction among the sun, Earth, and moon. Both the moon and sun affect the tides, but the moon's effect is greater than the sun's effect because it is so much closer.

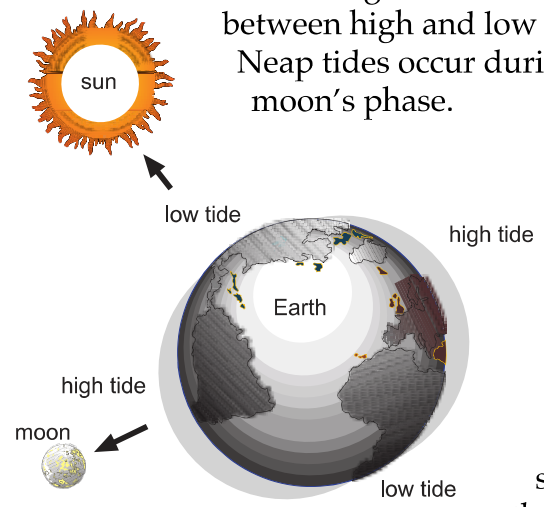
There are high tides and low tides. Tides do not change suddenly. High tides move in slowly. When the water reaches its highest level, it is called *high tide* or **flood tide**. Then, it slowly moves out until it reaches its lowest point called *low tide* or **ebb tide**. A low tide or *ebb* always follows a high tide or *flood tide*. The pull of the moon draws the water to the side of Earth closest to the moon and pushes it to the side of Earth opposite the moon. This causes high tides. At the same time, the side of Earth at 90° angles from the moon will have low tides.



Spring Tide

Most shorelines have four tides every day. There are two high tides and two low tides. There are about six hours and 12 minutes between a high tide and a low tide. Twice every month the sun, moon, and Earth are all in a straight line. The combined gravitational pull of the sun and moon causes higher than average high tides and lower than average low tides. These are called **spring tides**. *Spring tides* occur during a full moon and a new moon.

The moon, Earth, and sun are also at right angles (90°) twice a month. During this time, the gravity forces work against each other creating **neap tides**. During *neap tides*, the high tides are lower than normal and the low tides are higher than normal. Therefore, the difference between high and low tides is less during a neap tide. Neap tides occur during the first and third quarter of the moon's phase.



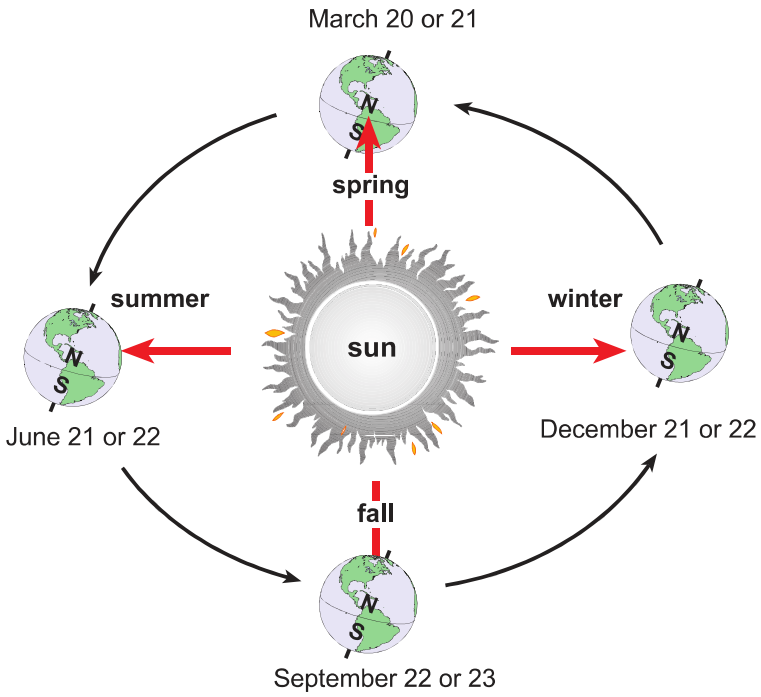
Neap Tide

There are usually two high tides and two low tides every 24 hours. Earth makes one turn on its axis in 24 hours. Meanwhile, the moon is also moving in its orbit around Earth. Earth must rotate 24 hours and 50 minutes before the moon returns to the same position overhead. The moon, then, has also moved. This results in the tides being 50 minutes later each day. For example, if it is high tide at 9:00 a.m. on Monday, the high tide will be at 9:50 a.m. on Tuesday. Low tides and high tides are about six hours apart. As Earth rotates, different locations on Earth pass through high and low tides.

Most locations in Florida experience two high tides and two low tides during a 24-hour period. This is called a *semidiurnal tide*. The heights of the high tides and low tides are about the same. Some places only experience a single high tide and a single low tide a day due to their location. This is a *diurnal tide*. Other places may experience mixed tides with varying heights of high and low tides during a 24-hour period.

Seasons

The *seasons* are the four divisions of the year characterized by differences in temperature, weather, and the number of hours of daylight. Seasons are caused by the tilt of Earth on its axis. Earth's tilt causes the duration of daylight hours to vary and the angle at which the sun's rays strike a given location to change as Earth makes its yearly revolution around the sun.



Seasons

Summer begins on June 21 or 22 in the Northern Hemisphere. During summer, the Northern Hemisphere is tilted toward the sun, and thus receives more direct rays. At the same time, the Southern Hemisphere is pointed away from the sun and receives the indirect rays of the sun. Therefore, it is winter in the Southern Hemisphere and summer in the Northern Hemisphere.

Winter begins on December 21 or 22 in the Northern Hemisphere, when it is tilted away from the sun. At the same time, the Southern Hemisphere is tilted towards the sun and is having summer.

Two times a year neither pole leans towards the sun. During these times Earth is in such a position in its orbit that its axis is neither tilted toward nor away from the sun. The vertical rays of the sun strike the equator. On these two days, called the *spring* or *fall* **equinox**, daylight and night hours are the same in both hemispheres. Day and night are 12 hours long everywhere on Earth.

On March 20 or 21, the spring equinox begins in the Northern Hemisphere. September 22 or 23, the fall *equinox*, is the beginning of fall. Again, the seasons are opposite in the Southern Hemisphere.

As the seasons change, the number of hours of daylight and darkness also changes. The first day of summer, June 21 or 22, has the greatest number of daylight hours and is called the *summer* **solstice**. The sun is the farthest north of the equator on this day because the North Pole is tilted most directly toward the sun.

After the summer *solstice*, daylight hours begin to decrease in the Northern Hemisphere until the winter solstice. Three months after the summer solstice comes the fall equinox. At that time, September 22 or 23, daylight and darkness are equal. Fall begins in the Northern Hemisphere, and spring begins in the Southern Hemisphere.

Daylight hours continue to decrease above the equator and increase below the equator until December 21 or 22, the winter solstice. The solstice has the least amount of daylight of the year and marks the beginning of winter in the Northern Hemisphere. At this time, the sun is the farthest south of the equator.

After the spring equinox, daylight hours continue to increase in the Northern Hemisphere until the summer solstice—the longest day.

After the winter solstice, days continue to grow longer in the Northern Hemisphere until the summer solstice. Three months after the winter solstice comes the spring equinox. On that day, Earth's axis leans neither toward nor away from the sun, and day and night are equal in both hemispheres. March 20 or 21 is the beginning of spring north of the equator and the beginning of fall in the Southern Hemisphere.

After the spring equinox, daylight hours continue to increase in the Northern Hemisphere until the summer solstice—the longest day. At this time, the cycle of the seasons begins again.

At the equator, the number of hours of daylight is always the same as the number of hours of darkness. As you move towards the poles, the hours become more uneven. The tilt of Earth on its axis causes the polar areas to have uneven hours of daylight and darkness. The poles have 24 hours of daylight in summer and 24 hours of darkness during the winter.

Summary

Our moon is very different from Earth. While the moon rotates on its axis and revolves around Earth, Earth revolves around the sun. These three heavenly bodies create different shadows as they change positions. At certain times these shadows result in eclipses—lunar, solar, or total. As the moon rotates and revolves, different portions of the lighted side are visible from Earth. As a result, the moon appears to change its shape, or go through phases. The moon's gravitational pull on Earth (as well as the sun's) causes our changing ocean tides.

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