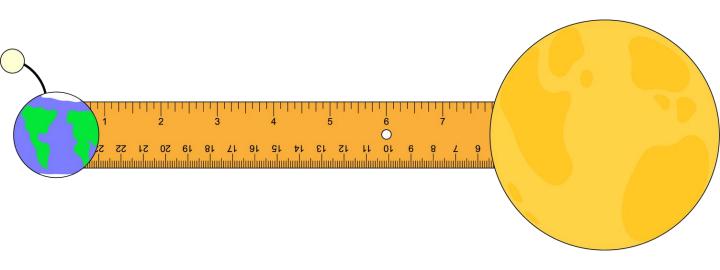


Accessing Prior Knowledge

Name:	Date:

Earth, Sun, and Moon System

Observe the model. Use what you know about the Earth, Sun, and Moon system to label this model. Use as many details as you can.



Use the Earth, Sun, and Moon model to explain what causes the seasons on Earth.				
	_			



Scope Phenomenon

Tides Are Changing

1. What do you notice happening to the water level throughout the time-lapse video?

2. Throughout the day, water levels in oceans rise and fall. What force do you think is responsible for this?

3. The Sun, the Moon, and Earth affect the ocean tides, day-and-night cycle, phases of the Moon, and seasons. How do you think this happens?



Name:	Date:

Moon Phases

Description

During the course of a month, we see many different faces of the Moon. Why do you think this happens?

These changing faces happen because the Sun illuminates the Moon's surface as the Moon revolves around Earth. This change in the illuminated surface of the Moon is called the lunar cycle.

The lunar cycle has eight different phases. The cycle takes 29 days, beginning with a new moon, going through the full moon, and then back to the new moon. The cyclical pattern of the lunar phases gives us evidence that motion is occurring.



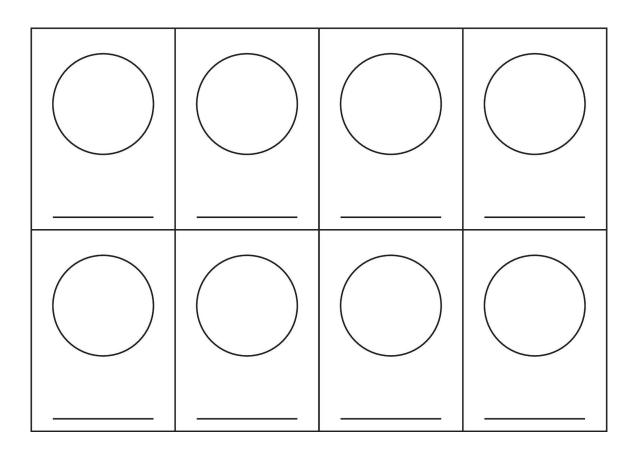
Procedure:

- 1. Take your Moon on a Stick and your pencil and stand in a large circle around the lamp so that no one is between you and the lamp.
- 2. Stand facing the lamp, and hold your Moon directly in front of you.
- 3. Keep your Moon in front of you and slowly rotate to your left, making a one-eighth turn.
- 4. Continue to keep your Moon in front of you and rotate your body to the left until your right shoulder is pointed toward the light source.
- 5. Keep your Moon in front of you and rotate to your left, again making a one-eighth turn.
- 6. Hold your Moon up so that your shadow does not fall on your Moon and rotate to your left until the light source is directly behind you.
- 7. Hold your Moon in front of you again while you rotate to your left, making a one-eighth turn.
- 8. Holding your Moon in front of you, rotate to your left until your left shoulder is pointed toward the light source.
- 9. Continue holding your Moon in front of you as you rotate to your left, making a one-eighth turn.
- 10. Return to facing the lamp. You have completed one lunar cycle.
- 11. Record your observations in the data chart on the next page.



Data

Complete the diagram below to record your observations. Title the chart "Moon Phases."

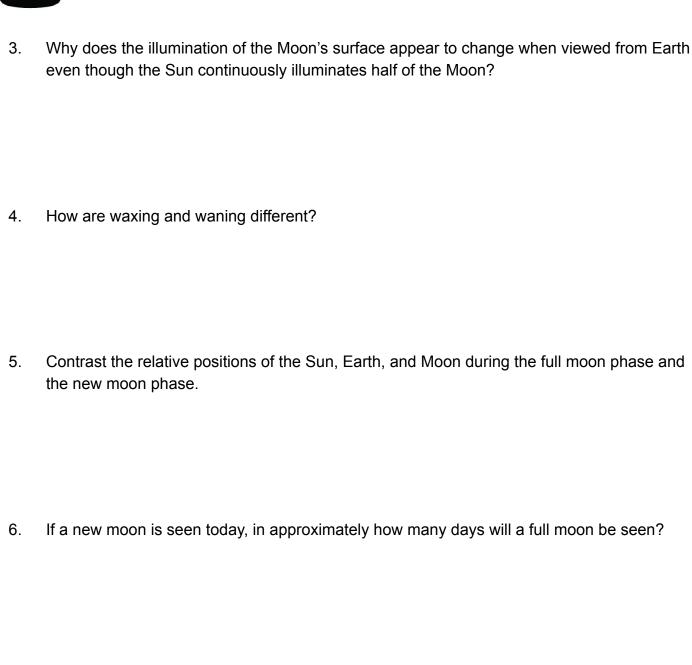


Answer the following questions in complete sentences.

1. How can you use the revolution motions within Earth, the Sun, and Moon system to explain the predictable pattern of the lunar cycle?

2. How is a full moon different from a new moon?





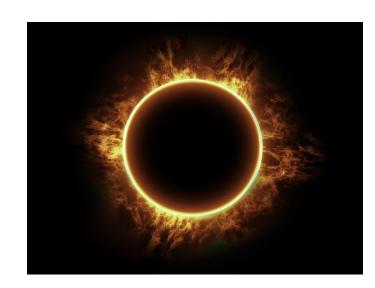


Name: _	Date:	

Eclipses

Description

Eclipses occur when one body of the Earth, Sun, and Moon system blocks the light by coming in between the other two bodies. Solar eclipses occur when the Moon is between Earth and the Sun (new moon) and is aligned to block the view of the Sun from Earth. Lunar eclipses occur when Earth is between the Moon and the Sun (full moon) and is aligned to block the light from the Sun to shine on the Moon as viewed from Earth.



Procedure:

Eclipse 1

- 1. Stand in a circle around the lamp. Hold your "Moon on a Stick" at arm's length. The lamp represents the Sun, your head represents Earth, and the ball on a stick represents the Moon. Stand facing the Sun (lamp).
- 2. Move the Moon (ball) around your head to model the revolution of the Moon around Earth. Move the Moon (ball) in orbit until it completely blocks your view of the Sun (lamp).
- 3. What type of eclipse is this?
- 4. When the Moon prevents the view of the Sun, a solar eclipse occurs. One way to remember the alignment of the planetary bodies for a solar eclipse is the sentence "Smart Susie Makes Eggs." (Smart = solar, Susie = Sun, Makes = Moon, and Eggs = Earth.)
- 5. Take turns looking at your lab partner's face during the solar eclipse. How much of his/her face is in shadow?
- 6. During a solar eclipse, the Moon makes a small shadow on Earth. This small size explains why a solar eclipse can't be seen from all locations on Earth.



7. Draw a diagram below to show the alignment of Earth, the Sun, and Moon system and the effect on Earth of a solar eclipse. Label your diagram "Solar Eclipse."

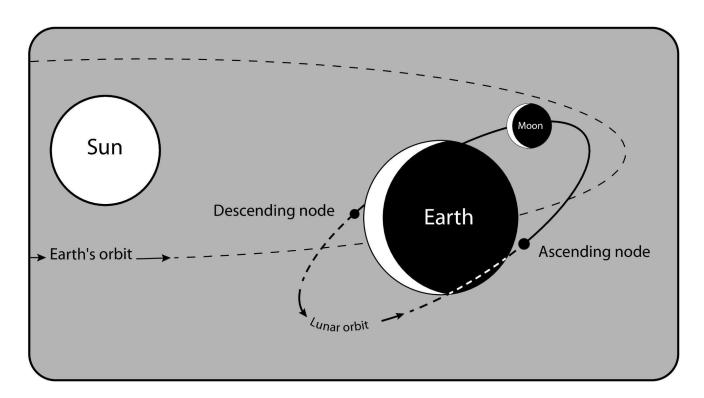
Eclipse 2

- 1. Stand so that the Sun (lamp) shines directly on the back of your head.
- 2. Move the Moon (ball) in orbit until Earth (your head) casts a complete shadow on the Moon.
- 3. What type of eclipse do you have now?
- 4. When the Moon passes into Earth's shadow, a lunar eclipse occurs. One way to remember the alignment of the planetary bodies for a lunar eclipse is the sentence "Lazy Susie Eats McDonaldsTM." (Lazy = lunar, Susie = Sun, Eats = Earth, and McDonaldsTM= Moon.)
- 5. Return to your seat to complete the rest of this task.
- 6. Draw a diagram below to show the alignment of Earth, the Sun, and Moon system and the effect on Earth of a lunar eclipse. Label your diagram "Lunar Eclipse."



Moon Movement

- 1. Look at the Moon Movement Diagram below. Are Earth's orbit around the Sun and the Moon's orbit around Earth in the same plane?
- 2. If the Moon revolved around Earth on the same plane that Earth revolves around the Sun, lunar and solar eclipses during each lunar cycle would be possible. However, the plane of the Moon's orbit (around Earth) and the plane of Earth's orbit (around the Sun) is slightly different and angled when compared to each other. This angle difference is 5 degrees. It is exaggerated in the diagram to clearly show where the two planes intersect.
- 3. How many places do the two planes of orbit intersect on the diagram?



Moon Movement Diagram

4. Try to create a model of the intersection of the orbital planes using two pieces of paper. Be sure to draw the orbits of the Earth and the Moon on the papers. You will most likely need scissors to cut into the planes to allow them to truly intersect!



Questions

Answer the following questions in complete sentences.

1. Do more people see a solar eclipse or a lunar eclipse?

2. What type of eclipse could we see during a full moon?

A new moon?

3. Why do we see a full moon more often than we see an eclipse?

Earth, Sun, and Moon System Picture Vocabulary

Axis



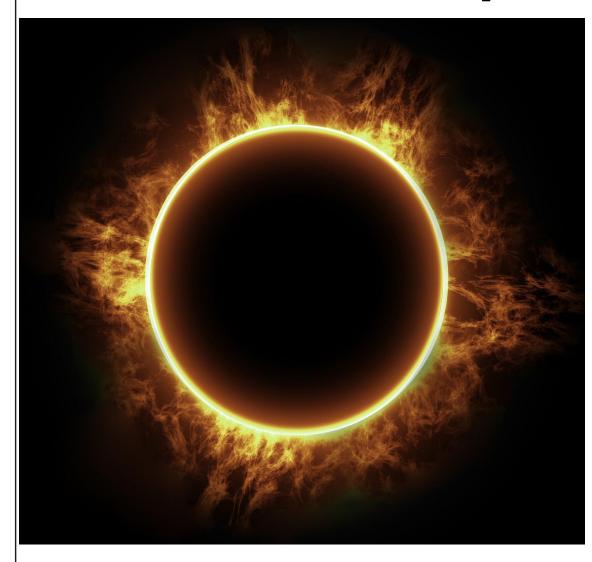
The imaginary line through Earth that extends from the North Pole to the South Pole and is the center of Earth's rotation

Cyclic Patterns



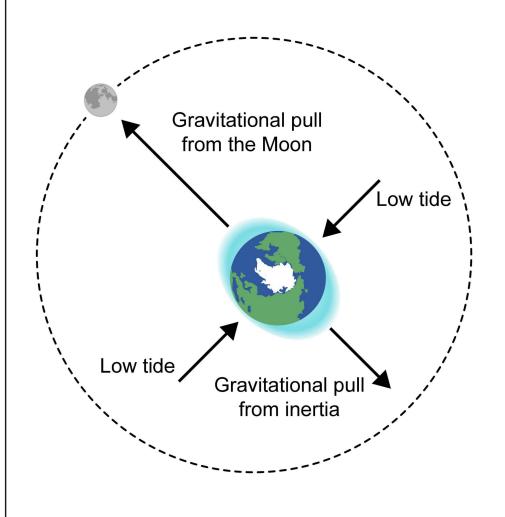
A phenomenon or process that involves multiple steps and repeats itself

Eclipse



An obscuring of the light from a celestial body by the passage of an object between the celestial body and the observer or between the celestial body and its source of illumination

Gravitational Pull



The attraction between two objects due to the invisible force of gravity; the gravitational pull from the Moon is primarily responsible for the tides that form on Earth

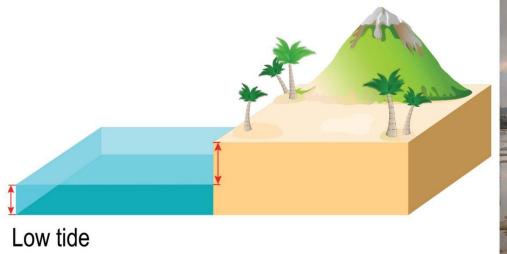
High Tide





When the tide is at its greatest elevation

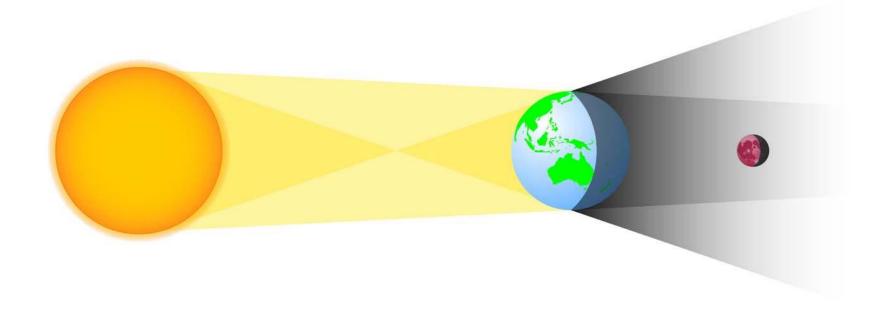
Low Tide





When the tide is at its lowest elevation

Lunar Eclipse



When the full moon passes into Earth's shadow, causing the Moon to appear reddish in color when the Sun, Earth, and the Moon directly line up; lasts 1–3½ hours

Lunar Phase



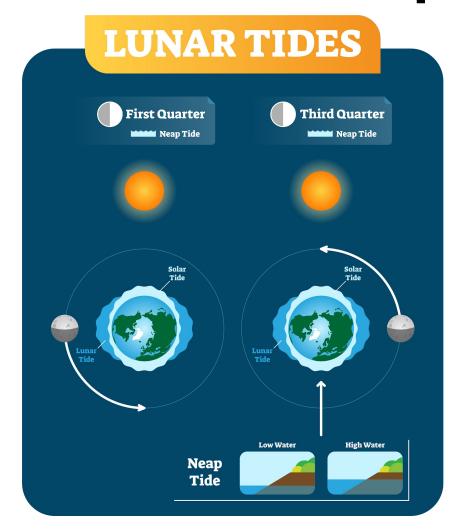
The shape of the illuminated portion of the Moon as seen by an observer, usually on Earth

Moon



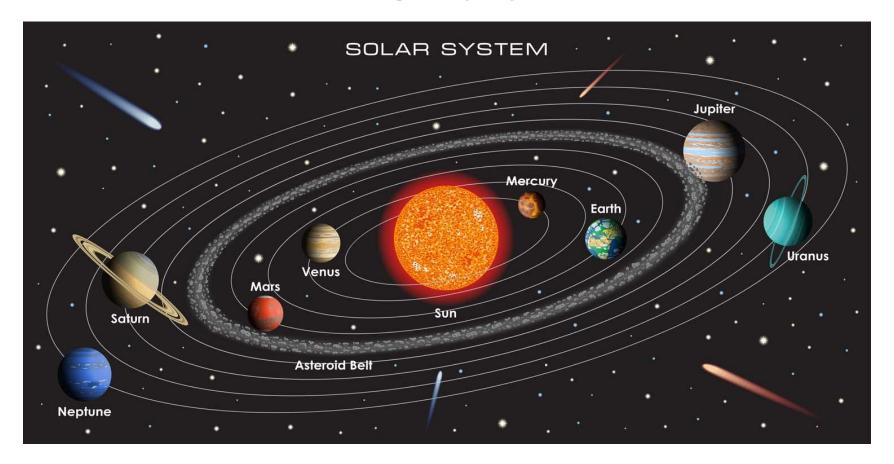
A celestial body that revolves around a planet

Neap Tide



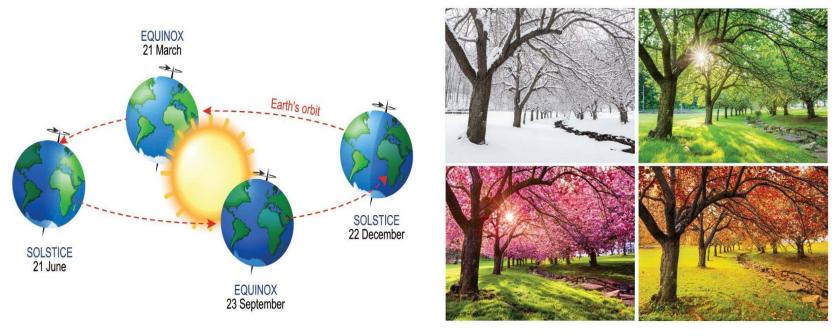
Tide with the smallest daily tidal range; occurs when the Sun, Earth, and the Moon form a 90-degree angle

Orbit



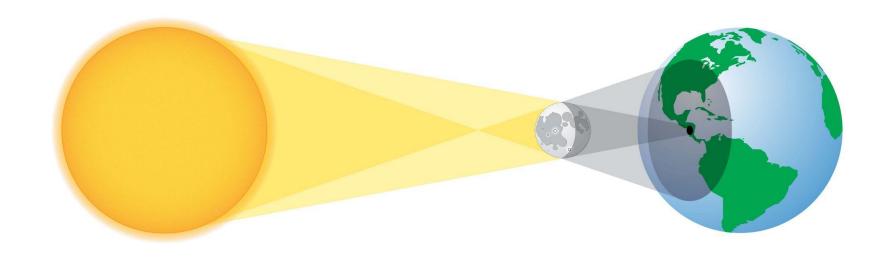
A curved path followed by a satellite as it revolves around an object

Seasons



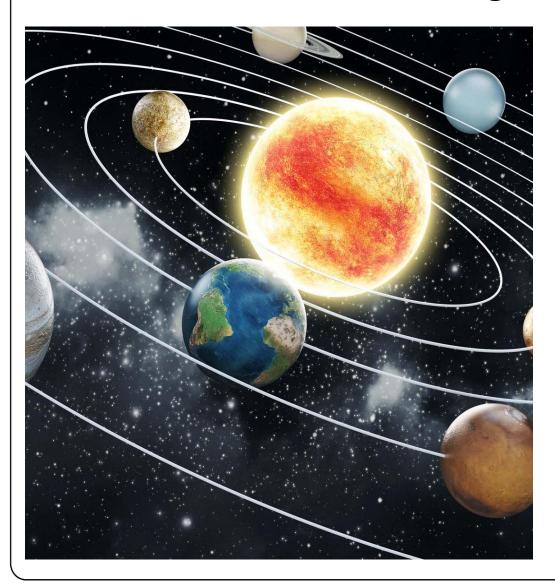
The four natural divisions of the year based on changes in temperature due to varying amounts of sunlight received (both intensity and number of daylight hours vary); caused by the tilt of Earth during its revolution

Solar Eclipse



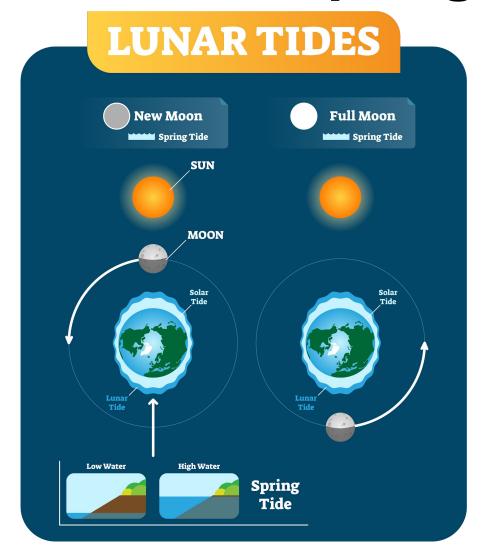
When the Moon passes between Earth and the Sun, covering all or part of the Sun; occurs when the Sun, the Moon, and Earth directly line up; lasts for less than 12 minutes

Solar System



A star and the group of planets and other celestial bodies that are held by its gravitational attraction and revolve around it

Spring Tide



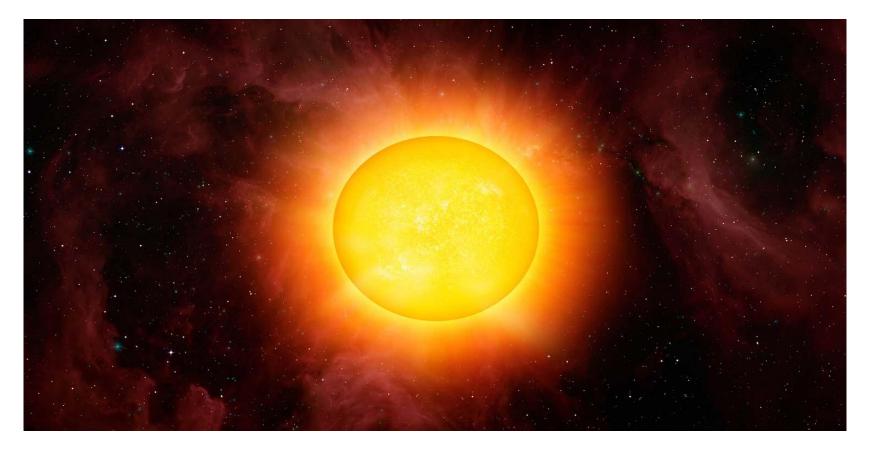
Tide with the largest daily tidal range, which occurs when the Sun, Earth, and the Moon line up with each other

Star



A celestial body consisting of a mass of gas held together by its own gravity in which the energy is generated by nuclear reactions in its interior

Sun



The luminous star around which Earth and other planets revolve; composed mainly of hydrogen and helium

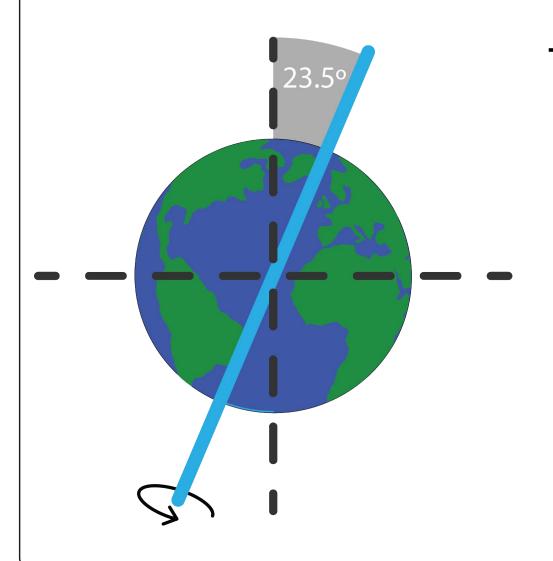
Tide





The rise and fall of sea levels caused by the gravitational attraction of the Moon and the Sun

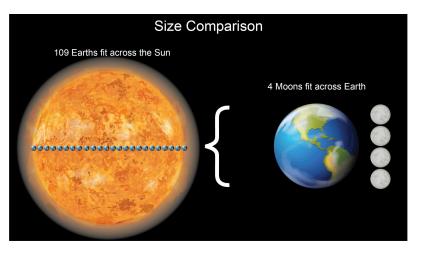
Tilt



The slant of Earth's axis, which is 23.5 degrees from vertical compared to Earth's orbital plane around the Sun; results in the North Pole always pointing toward the North Star

Reflect

In the image on the right, you see Earth in the foreground, the tiny Moon, and the Sun in the distance. The Moon orbits Earth, and the Earth-Moon system orbits the Sun. It is hard to imagine that the interactions of these three celestial objects, although so far away from each other, can cause day and night, seasons, moon phases, eclipses, and tides.



Earth, Moon, and Sun System Motions

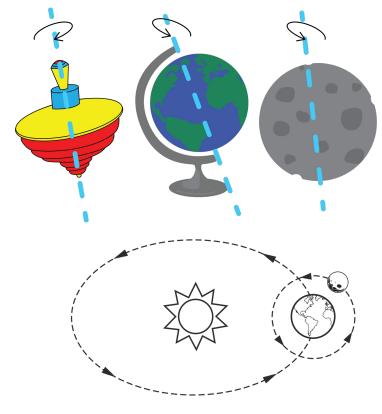
Rotation means the motion of a spinning object. The Sun and each of the planets and moons in our solar system rotate about their axes. An axis is an imaginary line about which each planet or moon spins. This imaginary line marks the center of a planet's or moon's rotation. Earth rotates on its axis about once every 24 hours. The Moon rotates very slowly over the course of a month.

A revolution is the orbiting of another body. Earth (with the Moon) revolves around the Sun in one year (365 ¼ days). The Moon revolves around Earth in one month (approximately 27.3 days). Because the Moon rotates once and revolves once a month, the same side always faces Earth.



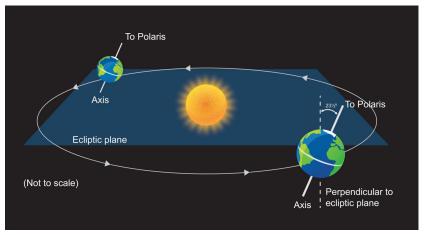
Understanding the size comparison of the Sun, Earth, and the Moon will help you understand their motion. Earth is much bigger than the Moon. About 50 Moons could fit inside Earth. To compare diameters, you could line up four Moons across Earth.

The Sun is even larger. About one million Earths could fit inside the Sun, and 109 Earths could fit across the face of the Sun.

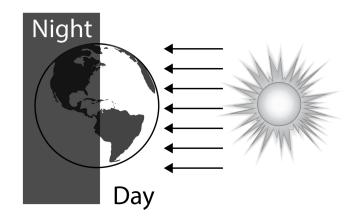


Look Out!

Earth does not tilt back and forth as it goes around the Sun. Earth revolves at a constant angle of 23.5° around the Sun. The northern end of Earth's axis, the geographic North Pole, always points to the North Star, Polaris.



What Do You Think?



Day and Night

What do you think causes day and night on Earth? Rotation! As Earth spins on its axis, the side facing the Sun experiences daytime (about 12 hours), while the side of Earth facing away from the Sun experiences night (about 12 hours). The same occurs on the Moon, except the Moon's slow rotation causes daytime to last about 2 weeks and night to last another 2 weeks. A full day on the Moon would last about one Earth month.

Reflect

Even though you can't feel it, Earth rotates very fast. Earth's rotation is so fast that it causes the planet to bulge out slightly at the equator and shrink slightly at the poles.

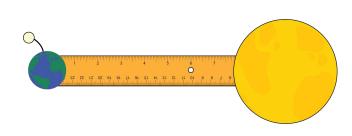
Therefore, Earth is not a perfect sphere. In most photographs and diagrams, Earth typically looks like a perfect sphere. Earth's circumference is slightly wider at the equator than it is across the poles. This shape is called an *oblate spheroid*. Because of this shape, solar energy travels in a straight line from the Sun and hits different parts of the curved Earth at different angles—more directly at the equator and less directly at the poles.



This clementine is an oblate spheroid. Earth is more rounded than this clementine.

Try Now

To make a good model of the Sun, Earth, and the Moon system, you need to either choose objects that show size and location or objects useful for showing their movements. Now, you need to consider distance. Even though your distances will not be exact, your model will still help show the patterns of how these objects move. The Moon revolves around Earth at a distance of about 30



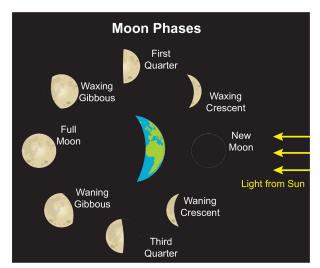
Earth diameters. The Moon is about one-quarter the diameter of Earth. Knowing those two dimensions should help you create a scale model inside the classroom. In the model above, the yellow balloon is the Sun and the table-tennis ball is Earth sitting on a golf tee poking through the hole in the ruler. The marshmallow is the Moon attached to Earth with a short straw.

Reflect

Although it appears to be glowing, the Moon does not produce its own light. Instead, the face of the Moon is illuminated by the Sun. Solar energy travels in a straight line from the Sun to Earth and the Moon so that the side of Earth or the Moon that faces the Sun is illuminated. Solar energy reflects off the side of the Moon that faces the Sun and can travel to Earth. As it revolves around Earth, the Moon reflects different amounts of sunlight. As a result, we see different amounts of the Moon at different times of the month.

The Lunar Cycle

Our view of the sunny side of the Moon depends on the relative positions of Earth, the Moon, and the Sun. This happens in a predictable pattern called the lunar cycle, in which we observe different phases of the Moon. This diagram shows the eight phases of the lunar cycle. For example, in the diagram you can see that the full moon phase occurs when the Moon, Earth, and the Sun are in a straight line, resulting in the full moon appearing all night. However, when the Moon comes between Earth and the Sun, as in the new moon phase, the Moon rises and sets during the day and is not visible. Each phase is described in greater detail on the next two pages.



The lunar cycle occurs because the Sun illuminates varying amounts of the Moon facing Earth observers.

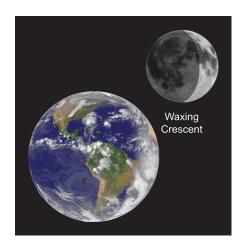
lunar cycle: the pattern that describes how the Moon's appearance in the sky changes over the course of a month

Look Out!

The Phases of the Moon

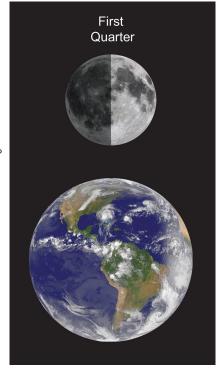
The new moon phase occurs when the Moon is located directly between Earth and the Sun. As a result of this alignment, the Sun illuminates the side of the Moon that faces away from Earth. The Moon is not visible from Earth at night during the new moon phase because it rises and sets during the day.





The waxing crescent phase occurs when the new moon begins to change to a first quarter moon. (*Waxing* describes the period when we see more and more of the Moon from Earth.) During this phase, the Sun illuminates less than half the side of the Moon facing Earth. As a result, the Moon appears as a crescent shape in the sky.

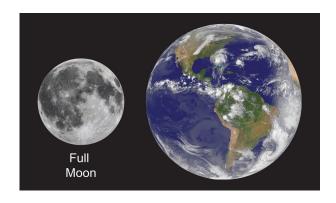
The first quarter phase occurs when the waxing moon is at a 90° angle relative to Earth and the Sun. During the first quarter phase, the Sun illuminates exactly half the side of the Moon facing Earth.





The waxing gibbous phase occurs as the first quarter moon changes to a full moon. During the waxing gibbous phase, the Sun illuminates more than half the side of the Moon facing Earth. As a result, the Moon appears nearly full in the sky.

The full moon occurs when Earth is located between the Moon and the Sun. During the full moon phase, the Sun illuminates the whole side of the Moon facing Earth. During this phase, the Moon appears as a full circle in the sky.

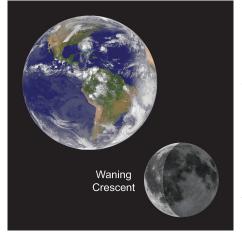




The waning gibbous phase occurs as the full moon changes to a last quarter moon. (*Waning* describes the period when we see less and less of the Moon from Earth.) The waning gibbous phase is the mirror image of the waxing gibbous phase.

The last (third) quarter phase occurs when the waning moon is at a 90° angle relative to Earth and the Sun. The last quarter phase (also called a half moon) is the mirror image of the first quarter phase.





The waning crescent phase occurs when the last quarter moon changes to a new moon. The waning crescent phase is the mirror image of the waxing crescent phase. A new moon follows the waning crescent phase, starting the cycle over again. The Moon takes approximately 28 days to complete one cycle.

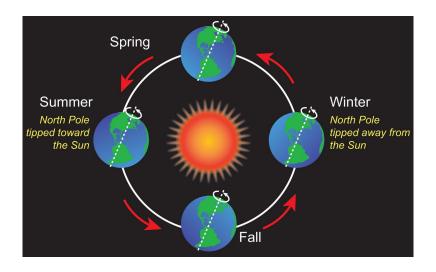
The fact that Earth's distance from the Sun changes throughout the year might seem like a good explanation for the seasons. You might think that Earth is colder when it is farther from the Sun and warmer when it is closer to the Sun; however, this explanation is incorrect. In fact, the distance between Earth and the Sun stays relatively constant throughout Earth's orbit. Also, not every part of Earth experiences the same seasons at the same time. When it is summer in the northern hemisphere, it is winter in the southern hemisphere. What, then, causes the seasons?



Reflect

Seasons

Earth's axis is tilted at a 23.5° angle. If Earth's axis were not tilted, we would not experience different seasons. As Earth revolves around the Sun, sometimes the northern hemisphere is tilted toward the Sun. When the northern hemisphere is tilted toward the Sun, it receives more direct rays of sunlight; it is summer. During summer, days are longer and weather is warmer in the northern hemisphere. Plants there have plenty of sunlight for photosynthesis, and animals have plenty to eat.



Earth's tilted axis and its revolution around the Sun—not Earth's distance from the Sun—cause the seasons. When the northern hemisphere is tilted toward the Sun, it receives more direct rays of sunlight than the southern hemisphere. During this time, the northern hemisphere experiences summer and the southern hemisphere experiences winter.

When Earth reaches the opposite side of its orbit—a process that takes about six months—the southern hemisphere is tilted toward the Sun. It will receive more direct and intense solar energy, and the northern hemisphere will receive less. As a result, the southern hemisphere will experience summer and the northern hemisphere will be in the middle of winter. The change in season at a given place on Earth is directly related to the orientation of tilted Earth and the position of Earth in its orbit around the Sun. This is due to the change in the directness and intensity of the solar energy at that place over the course of the year.

Reflect

Arriving at a sandy ocean beach early in the day, you set up a blanket and chairs within a few meters of the water. After a swim in the surf, you decide to go off the beach to a refreshment stand for a snack and to an amusement park to ride the roller coaster. You return to the beach later, only to discover the ocean has flooded your chairs and soaked your blanket. What force has moved the ocean-water level up the beach? What force will later move the ocean-water level back down?



Gravity in the Sun-Earth-Moon System

Throughout the day, water levels in oceans and lakes around the planet rise and fall. These regular movements, or tides, are produced by the motions and positions of three objects in space. These objects are Earth, the Moon, and the Sun.



The Moon revolves around Earth as Earth revolves around the Sun. Although the Sun is much bigger than the Moon, the Moon is nearly 400 times closer to Earth. (This diagram is not drawn to scale.)

As they move through space, the Moon, Earth, and the Sun exert gravitational forces on one another. The force of gravity is affected by two variables: the masses of the objects and the distances between them. Although the Moon is much less massive than the Sun, the Moon is much closer to Earth than Earth is to the Sun. As a result, the force of the Moon's gravity on Earth is more than double the force of the Sun's gravity on Earth. Substances that are free to move on Earth's surface, such as ocean water, are more greatly affected by the Moon's gravity than by the Sun's. This is particularly important for Earth's tides. As the Moon revolves around Earth, it pulls water in oceans and lakes toward it. This causes water levels to rise in some places and to fall in others.

Look Out!

All things in the universe that have mass also have gravity and pull on each other. We can see the effect of the Moon's gravity as tides rise and fall. As the Moon's gravity pulls on Earth, Earth pulls back on the Moon. If the Moon had any oceans or lakes, the water in those bodies would also experience tides.

Gravity and Ocean Tides

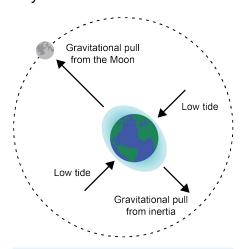
Each day, tides on Earth rise and fall between two extremes. A high tide is the highest point on a shore that water will reach, mainly due to the gravitational attraction of the Moon. At any given time of day, high tides are produced on whichever shores are facing the position of the Moon relative to Earth. At the same time, high tides are also produced on the shores opposite the position of the Moon relative to Earth. In other words, at any given time on Earth, one tidal bulge faces the Moon, and one tidal bulge faces the opposite direction.

What causes this second tidal bulge? A combination of gravity and inertia. Inertia is the tendency for something to remain at rest or in motion unless acted on by an unbalanced force. Water on Earth has inertia; it tends to stay in place unless acted on by an unbalanced force.

For example, forces from winds cause waves as air moves across the surfaces of oceans and lakes.

Another force that overcomes water's inertia is gravity.

Look at the diagram. On the side of Earth facing the Moon, the pull of the Moon's gravity is greater than the water's inertia—its tendency to stay in place. So the water on that shore bulges toward the Moon. At the same time, the Moon's gravity pulls Earth slightly toward the Moon. The Moon's gravity does not affect water on the side of Earth opposite the Moon. Therefore, as the planet is pulled in one direction toward the Moon, the water on the opposite side of the planet remains in place. The result is a second tidal bulge due to inertia. As Earth rotates under the Moon, the bulges move around the planet. However, they are always opposite each other.



The Moon's gravity and the inertia of water create two high tides on opposite sides of Earth. Two low tides happen at right angles to the tidal bulges.

A low tide is the lowest point on a shore that water will reach.

Low tides always happen at places on Earth that are at right angles to the tidal bulges. Like high tides, two low tides occur at the same time on opposite sides of Earth.

At any given place on Earth, high tides occur twice most days, and low tides occur twice most days. For example, suppose a beach in New Jersey faces the Moon at noon. That beach will experience a high tide at noon (as will a beach on the opposite side of the planet). Approximately 12 hours later, that beach will face away from the Moon. This will produce another high tide around midnight. Low tides on the same beach will occur at approximately 6 p.m. and 6 a.m.

Tides do not occur at the same times every day. At any beach, high tides are separated by approximately 12 hours and 25 minutes. The same is true of low tides. Therefore, each day, high tides and low tides happen slightly later than they happened the previous day.

What Do You Think?

Find the Virginia coast on a globe of Earth. (If you do not have a physical globe, you can find many globes online. Enter the terms *virtual globe* into a search engine.) When it is high tide in Virginia, where on Earth is also experiencing a high tide? Where is it low tide?

Choose one other location on another part of the globe. When it is high tide in this location, and where else on Earth is it also high tide? Where is it low tide?

Tidal Variations

If you measured high and low tides every day for a month, you would discover that some high tides are higher than others. You would also discover that some low tides are lower than others. If you did the same thing over the course of a year, you would discover that the range between high and low tides is greatest around January 2. You would also discover that the range between high and low tides is least around July 2.

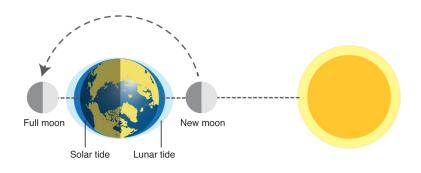
All of these variations are caused by three factors:

- How the Moon, Earth, and the Sun are aligned with each other
- Where the Moon is positioned relative to Earth
- Where Earth is positioned relative to the Sun

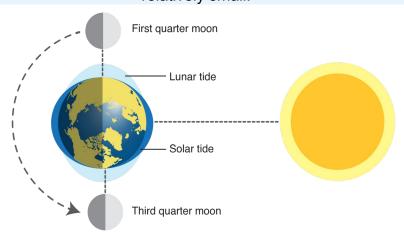
Let us examine these in order. As the Moon revolves around Earth, it reaches a point between Earth and the Sun. This happens once each month, during the new moon phase of the **lunar cycle**, when the side of the Moon facing Earth is dark. When Earth, the Moon, and the Sun are aligned like this, the effect of the Sun's gravity combines with the Moon's gravity.

The same thing happens about two weeks later when Earth is between the Moon and the Sun. (In this alignment, the side of the Moon facing Earth is completely bright—the full moon phase.) These two alignments produce higher than average high tides and lower than average low tides. We call these tides spring tides.

About one week after a new moon or a full moon, the Moon and the Sun form a right angle relative to Earth. In this position, the Sun's gravity works against the Moon's gravity. High tides are lower than average, and low tides are higher than average. We call these tides neap tides.



During a spring tide (above), the Moon, Earth, and the Sun are aligned. High tides are higher than average, and low tides are lower than average. During a neap tide (below), the Moon, Earth, and the Sun form a right angle. The difference between high and low tides is relatively small.



Why is the range between high and low tides greatest in early January and least in early July? Earth follows an elliptical, or oval-shaped, path around the Sun. Earth's path takes it closest to the Sun around January 2 of each year. On that date, called perihelion, the gravitational force between Earth and the Sun is strongest. This produces a greater than average range of tides. Earth's path takes it farthest from the Sun around July 2 of each year. On that date, called aphelion, the gravitational force between Earth and the Sun is weakest. This produces a lower than average range of tides.

Looking to the Future: Harnessing the Energy of Tides

To reduce our dependence on fossil fuels such as oil, coal, and natural gas, many countries have turned to alternative sources of energy. These include wind energy, solar energy, geothermal energy, and the energy of moving water. Another benefit of these alternative resources is they create less pollution than fossil fuels do.

Until recently, the energy of moving water has mainly been harnessed by damming rivers to produce electricity. Since the 1960s, some countries, such as France, have built tidal power plants. Other countries, including Canada and the United States, are investigating ways to transform the movements of tides into electrical energy.

Here is how a tidal power plant works: As tides rise and fall, they have kinetic energy—the energy of motion. This kinetic energy is used to turn the blades of a machine called a turbine. Gears and other devices transmit this motion to an electric generator. This machine transforms the tidal energy into electrical energy. The electrical energy is transmitted through cables to homes, factories, and communities.

Try Now

The relative positions of the Moon, Earth, and the Sun produce different kinds of tides. In the spaces below, draw the positions of the Moon, Earth, and the Sun that produce each kind of tide or condition.

NOTE: The same kind of tide may be produced by more than one set of positions of the Moon, Earth, and the Sun. In such cases, draw all sets of positions that produce the tide.

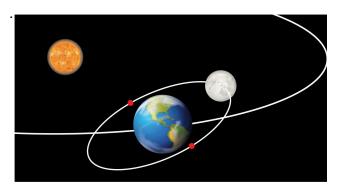
Tide or Condition	Relative Positions of the Moon, Earth, and the Sun
Spring Tide	
(above-average range of tides)	
Neap Tide	
(below-average range of tides)	
Earth at Perihelion	
(above-average range of tides)	
Earth at Aphelion	
(below-average range of tides)	

What Do You Think?

Eclipses

How do you think system of Earth, the Sun, and the Moon can explain eclipses of the Sun and the Moon? An eclipse occurs when one celestial object passes through the shadow of another celestial object.

- A solar eclipse is when the Moon blocks the Sun and the Moon's shadow falls along a small path on Earth.
- A lunar eclipse is when the Moon moves into Earth's shadow.

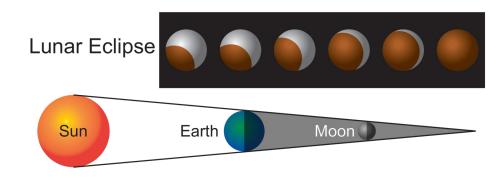


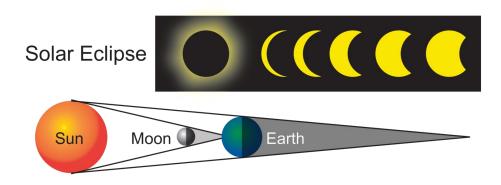
We do not see solar and lunar eclipses every month because the Moon's orbital path around Earth is tilted with respect to the plane of Earth's orbit. Eclipses only occur when all three celestial bodies line up in the same plane. The points in the Moon's orbit where this occurs are called nodes (shown on the left as red dots). Eclipses only occur at these nodes.

During a solar eclipse, sunlight is prevented from reaching only a very narrow path on Earth because the Moon casts a very small shadow.

During a lunar eclipse, Earth's shadow covers the entire Moon because Earth's shadow is much larger than the Moon.

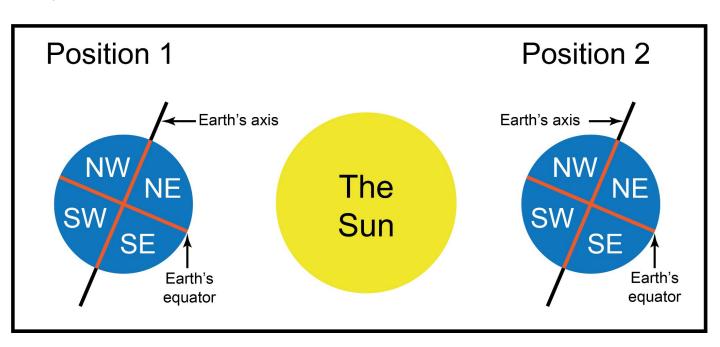
Often, the Moon will appear a copper-red color during a lunar eclipse because light is refracted or bent through Earth's atmosphere and appears red. This is called a blood moon.





Try Now

Earth's rotation and revolution affect day-and-night cycles as well as the seasons. The following diagram shows Earth at two positions in its orbit around the Sun. (This diagram is not drawn to scale.)



For each position, decide whether each section is experiencing day or night and winter or summer. Write your answers in the charts below.

	Position 1			Posi	tion 2			
Ī	NE Se	ection	NW S	ection	NE Se	ection	NW S	ection
Ī	Day or	Winter or	Day or	Winter or	Day or	Winter or	Day or	Winter or
	Night?	Summer?	Night?	Summer?	Night?	Summer?	Night?	Summer?
Ī								
l								
l								
-1								

Position 1			Posi	tion 2			
SE Se	ection	SW S	ection	SE Se	ection	SW S	ection
Day or	Winter or	Day or	Winter or	Day or	Winter or	Day or	Winter or
Night?	Summer?	Night?	Summer?	Night?	Summer?	Night?	Summer?

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Connecting With Your Child

Exploring Rotation and Revolution at Home

To help your child learn more about rotation and revolution, try a few simple experiments.

- 1. First, gather a flashlight and a round object such as a globe or ball (preferably about the size of a basketball or beach ball).
- Create an axis for the ball by taping two drinking straws, pencils, or similar objects to opposite ends of the ball.
- In a darkened room, hold the ball a few feet away from your child. Have your child shine the flashlight on the ball. Hold the ball so that the axis is pointing up and down at a slight tilt toward the flashlight.
- 4. Holding the ball steady at this tilt, walk in a circle around your child. Keep the flashlight aimed at the ball. As you revolve around your child, discuss how the ball represents Earth on its tilted axis and the flashlight represents the Sun.
- 5. Stop periodically at different points in the "orbit." Ask your child to explain which season each hemisphere is experiencing and where it is day and where it is night.
- 6. Try the exercise again. This time, hold the ball so that the axis is perfectly straight up and down, rather than at a tilt.
- 7. Ask your child how this changes the effect of Earth's orbit on each hemisphere. Earth will still experience day and night as it rotates. But without a tilted axis, Earth's different hemispheres will not experience different seasons.

Here are some questions to discuss with your child:

- How does Earth's tilted axis affect each hemisphere as the planet revolves?
- Point to different spots on the ball. What would people living here experience when Earth was at this point in its orbit?
- If Earth's axis weren't tilted, what would change?



Name:	Date:

Good to Go, Not So Sure

	,	
Earth, Sun, and Moon System	Good to Go: What I Know	Not So Sure: What I Hope to Discover
Rotation		
Revolution		
Seasons		
Eclipses		



Name:	Date:

Earth, Sun, and Moon System Outline

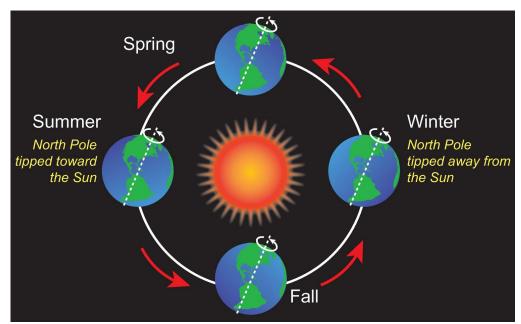
- 1. Rotation
 - a.
 - b.
 - C.
- 2. Revolution
 - a.
 - b.
 - C.
- 3. Lunar Phases
 - a.
 - b.
 - C.
- 4. Seasons
 - a.
 - b.
 - C.
- 5. Ocean Tides
 - a.
 - b.
 - C.
- 6. Eclipses
 - a.
 - b.
 - C.



Name:	Date:

The Reasons for the Seasons

Use the image in the STEMscopedia for this activity. Explain the reason for each season in the northern hemisphere. Then list the season the southern hemisphere would be experiencing.



Season in Northern Hemisphere	Explanation	Season in Southern Hemisphere
Winter		
Spring		
Summer		
Fall		



Name:	Date:

Use the following information to answer Questions 1–6.

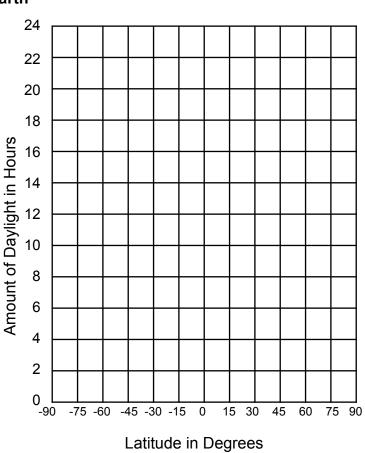
Due to the tilt of Earth and its orbit around the Sun, different locations on Earth receive different amounts of sunlight throughout the year, which affects the time of year that each location experiences the seasons. One implication is that the seasons in the northern and southern hemispheres are reversed.

The chart below compares the latitude on Earth to the amount of sunlight it receives at various times during the year.

1. Use the table on the left to plot the data on the right.

Hours of Daylight at Various Latitudes on Earth

Latitude	Daylight in March (hours)	Daylight in September (hours)
90°	0	24
75°	8.3	16.3
60°	10.3	13.9
45°	11.1	13.1
30°	11.5	12.6
15°	11.7	12.3
0°	12	12
-15°	12.3	11.7
-30°	12.5	11.4
-45°	12.9	10.9
-60°	13.7	10.1
-75°	15.7	7.7
-90°	24	0



- 2. Is the data proportional? How can you tell? Why do you think the graph is shaped this way
- 3. Label the graph with Spring in the Northern Hemisphere, Spring in the Southern Hemisphere, Fall in the Northern Hemisphere, Fall in the Southern Hemisphere.

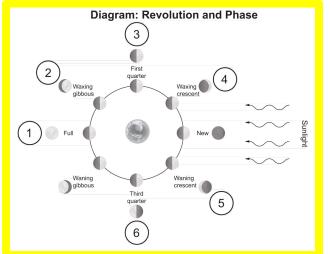


- 4. New York City is located at 40°N latitude. How much sunlight would you expect it to see in March? September?
- 5. Perth, Western Australia, is located at 31°S latitude. How much sunlight would you expect it to see in March? September?
- 6. What do you notice about the amount of daylight as you get closer to the North and South Poles?

Use the following information to answer Questions 7–11.

The diagram below shows the position of the Sun, the Moon, and Earth at different phases during

Earth's revolution around the Sun.



- 7. What is the ratio of full moons to the total number of moon phases?
- 8. What is the ratio of gibbous moons to non-gibbous moon phases?

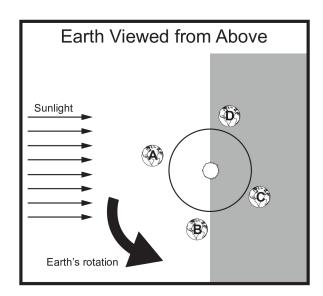
- 9. A synodic period is the time it takes for the Moon to move to the same *period as seen by an observer on Earth.* The Moon's synodic period is about 29.5 days. How many first and third quarter moons should you see in six synodic periods?
- 10. What is the ratio of days in one synodic period per quarter?
- 11. What is the ratio of days in a year to days in a synodic period? What is the unit rate? What does this number represent? Why do you think it's not a whole number?



Name:	Date:	

Rotation and Revolution

- Have you ever wondered what it was like on the other side of the world as you were getting ready for bed? Perhaps you have wondered what season it was in Australia as you were sweating on a hot summer day. The first question can be answered by examining the tilt of Earth on its axis. The second answer comes from understanding the position of Earth during its revolution around the Sun.
- First of all, let's discuss what an axis is. Picture an imaginary pole running from the North Pole through Earth's center all the way to the South Pole. This imaginary pole is called an axis. Earth rotates on its axis, taking about 24 hours to



complete one entire spin. Thus, one complete rotation cycle results in 12 hours of daylight and 12 hours of night, as different parts of Earth are rotated into the Sun's light. Have you ever stood outside and watched as the Sun sinks below the horizon? You have actually been witnessing Earth's rotation. The Sun is not moving, although it appears to be. Earth is moving! The rotating Earth also makes the other stars in the night sky seem to glide across the sky when, in fact, it is the rotation of Earth on its axis that makes them appear to move. At any given time during the 24-hour rotation, half of Earth is in sunlight and half of Earth is in darkness. This means as you get ready for bed, somewhere on the other side of Earth, someone is just getting up.

Think of Earth as a ball with a rod through it, representing the axis. This makes it easier to visualize Earth's orientation in space relative to other objects like the Sun. Now consider the Sun as another ball. Imagine the Sun located in the center of a disc, somewhat like a Frisbee. The planets in the solar system would be positioned on the Frisbee but at varying distances from the Sun. The area we are visualizing as a Frisbee is actually called the plane of the ecliptic. It is the plane of Earth's orbit around the Sun. Earth's axis is not oriented perpendicular to the plane of its orbit, but rather it is tilted at 23.5 degrees from the perpendicular. Why is this an important detail? This orientation in space, relative to the Sun, has great influence on Earth's seasonal changes.



- Now, to address our second question. What would cause it to be summer in North America and winter in Australia? We have just learned that rotation is the spinning of Earth on its axis that causes day and night. We also learned that the orientation of Earth's axis is tilted 23.5 degrees from the perpendicular of the plane of the ecliptic. Now picture this: While Earth is rotating, it is also revolving around the Sun in a nearly circular path called an orbit. This revolution takes one year, or 365 days, to complete. During this one year, Earth experiences four different seasons. The seasons are summer, fall, winter, and spring, but they do not happen at the same time in the northern and southern hemispheres. In June, July, and August, Earth's tilt positions the northern hemisphere so that sunlight hits it more directly. The northern hemisphere has a larger number of daylight hours, causing a summer season. During that period of time, the southern hemisphere is angled so the sunlight is not as direct. The number of daylight hours is smaller, causing the opposite winter season. This explains why the northern and southern hemispheres experience different seasons.
- The next time you watch a sunset or sunrise, think about the rotation of Earth. Remember that you are experiencing the same thing that is causing day and night. On the next scorching hot summer day or frigidly cold winter day, think about the tilt of Earth on its axis. Remember how its position in Earth's revolution around the Sun brings you the seasons.



Reading Science

1		In paragraph 3, what word or phrase gives you a clue to what the word perpendicula means?					
	A	"Somewhat like a Frisbee"					
	В	"Relative to the Sun"					
	С	"Instead, it is tilted"					
	D	"Orientation in space"					
2	Whi	ch of the following effectively summarizes paragraph 2?					
	A	The orientation in space, relative to the Sun, is the cause of Earth's seasonal changes.					
	В	There is an imaginary pole running through the center of Earth from the North Pole to the South Pole, which is called an axis.					
	С	We also learned that Earth's axis is tilted 23.5 degrees from the perpendicular of the plane of the ecliptic.					
	D	The northern hemisphere has more daylight hours.					
3	Ace	cording to this passage, what is rotation?					
	A	The constant spinning of Earth on its axis					
	В	The movement of Earth through space around the Sun					
	С	An orbital path shaped more like a circle than an oval					
	D	The four seasons: summer, fall, winter, and spring					



Reading Science

4	Which of the following statements best shows why it would be winter in the southern
	hemisphere and summer in the northern hemisphere?

Α	Earth's tilt positions the northern hemisphere to receive more of the Sun's direct
	rays.

- **B** Earth's tilt positions the southern hemisphere to receive more of the Sun's direct rays.
- **C** Earth's tilt exposes the northern hemisphere to longer periods of daylight.
- **D** Both A and C are correct.

The rotation of Earth takes approximately _____ to complete, and the revolution of Earth takes approximately _____ to complete.

- **A** 1 day, 30 days
- B 12 hours, 24 hours
- **C** 365 days, 24 hours
- **D** 24 hours, 365 days



Name: _	Date:

Engineering Design Process – Define the Problem, Brainstorm, and Plan

1. Define the Problem

The Problem

Monitoring and predicting tides are essential for shipping, commercial fishing, and the marine industry. Knowledge of the time and height of tides and the speed and direction of tidal currents is important information for ships trying to navigate through ports that have shallow waters. Numerous massive cranes on specially designed freighters have passed underneath the San Francisco-Oakland Bay Bridge, sometimes with only 25 inches to spare. Engineers in ferries and on top of the cranes themselves monitor the operation. After investigating tides, you are tasked with planning a test or model to predict the best time to maneuver the cranes under the Bay Bridge.

Criteria and Constraints

- Your model or test must show the tides at least four times during the day.
- Predict the best time to maneuver the cranes under the Bay Bridge, including the reasoning for your predictions.

2. Brainstorm



3.	Plan Evaluate the ideas you wrote down while brainstorming, and choose one. Draw your plan, and label the parts. Be sure to identify all materials needed to carry out the plan.



Engineering Design Process Student Rubric

Category	3	2	1	0
Brainstorm	The student listed multiple brainstormed ideas.	The student listed a couple brainstormed ideas.	The student listed only one brainstormed idea.	The student did not attempt to brainstorm a solution.
Plan	The plan could successfully solve the problem.	The plan has some issues that would make it unlikely to fully solve the problem.	The plan would not solve the problem at all.	No plan was created.
Criteria Expectations	All the criteria for the design were followed.	More than half of the criteria were followed.	Less than half of the criteria were followed.	None of the criteria were followed.
STEM Skill: Critical Thinking	The student presented an evidence-based solution to the posed problem or scenario.	The student presented a solution to the posed problem or scenario, but they did not include any evidence from research.	The student presented a solution that did not align with the posed problem or scenario.	The student did not present any solution to the posed problem or scenario.
STEM Skill: Adaptability and Resilience	The student was reflective and demonstrated a willingness to rework the task, ultimately leading to a better product.	The student overcame any frustrations and completed the task.	The student asked for help when needed and completed the task as a result.	The student struggled, did not seek out help, and as a result, did not complete the task.



Content Connection Video

	Name:	Date:
	Why Are There Seasons?	
1.	Why does Earth have seasons?	
2.	What is a year?	
3.	When the part of Earth that you're on is tilted toward the Sun, what sea	son is it?
4		0

4. How is Earth positioned in relation to the Sun during spring and autumn?

5. When the northern hemisphere is experiencing summer, what is happening in the southern hemisphere?



Claim-Evidence-Reasoning

Name:	Date:

External Data

Scenario: Justin lives in Evanston, Illinois, U.S.A. The following table shows the times of sunrise and sunset at his hometown for the past five days. He has a friend named Mateo on social media in Buenos Aires, Argentina.

Sunrise and Sunset Table				
Sunrise (am) Sunset (pn				
Day 1	5:45	8:59		
Day 2	5:46	8:58		
Day 3	5:47	8:56		
Day 4	5:48	8:55		
Day 5	5:49	8:54		



Prompt: Write a scientific explanation that justifies what season Mateo is experiencing in Argentina during the past five days.

PEER EVALUATION

Peer Name: Rebuttal:



Claim-Evidence-Reasoning

Earth, Sun, and Moon System

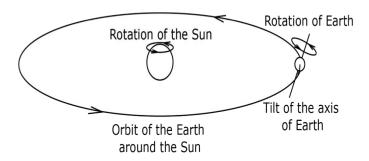
Rubric for Writing a Scientific Explanation

Points Awarded	2	1	0
Claim	Not applicable.	Answers the question and is accurate based on data.	No claim or does not answer the question.
Evidence	Cites data, patterns within the data, and uses labels accurately.	Cites data from the data source but not within the context of the prompt.	No evidence or cites changes but does not use data from the data source.
Reasoning	Cites the scientifically accurate reason using correct vocabulary and connects this to the claim. Shows accurate understanding of the concept.	Cites a reason, but it is inaccurate or does not support the claim. Reasoning does not use scientific terminology or uses it inaccurately.	No reasoning or restates the claim but offers no reasoning.
Rebuttal	Rebuttal provides reasons for different data or outliers in the data. Can also provide relevance to the real world or other uses for the findings.	Rebuttal is not connected to the data or is not accurate.	Does not offer a rebuttal.

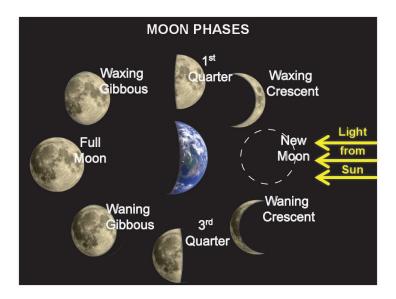


Name:	Date:

An illustration is provided showing the relative motions of Earth and the Sun. What effect would changing the angle of tilt of Earth's axis have?



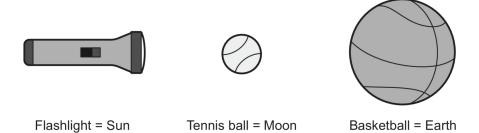
The diagram below shows the Moon's different phases depending on its position. Spring tides are the strongest tides and neap tides are the weakest tides. Based on this information and the relative positions of Earth, the Moon, and the Sun shown in the diagram, during which moon phases do spring and neap tides occur?





Open-Ended Response

3 Students use the materials pictured below to create a model of the lunar cycle. What action must the students perform to demonstrate what causes the changing appearance of the Moon from Earth?





Name:	Date:	Group:

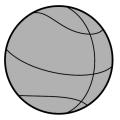
Students use the materials pictured here to create a model of the lunar cycle. 1







Tennis ball = Moon



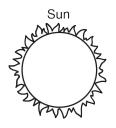
Basketball = Earth

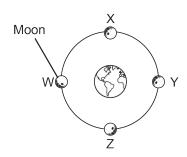
What should the students do to model the process that causes the changing appearance of the Moon in the lunar cycle?

- Move the tennis ball around the flashlight. Α
- Slightly cover up the flashlight with their hand. В
- C Move the tennis ball around the basketball.
- Spin the basketball on a tilted axis. D



2 Students were shown a diagram of the Sun, the Moon, and Earth with the Moon at four locations in its orbit around Earth (labeled W, X, Y and Z).





Student 1

The greatest tides occur when the moon is in the positions labeled W and Y.

Student 2

The greatest tides occur when the moon is in the positions labeled X and Z.

Student 3

The greatest tides occur when the moon is in the positions labeled

Student 4

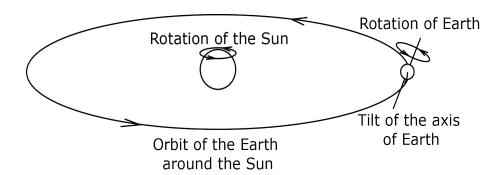
The greatest tides occur when the moon is in the positions labeled Z.

The students were asked to predict when tides would be the greatest. Which student made the most accurate prediction?

- A Student 1
- B Student 2
- C Student 3
- **D** Student 4



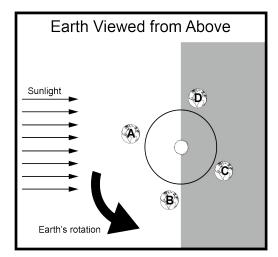
3 Which of the following is primarily responsible for the changing of seasons on Earth?



- A Orbit of Earth around the Sun
- **B** Rotation of the Sun
- **C** Rotation of Earth
- **D** Tilt of the axis of Earth



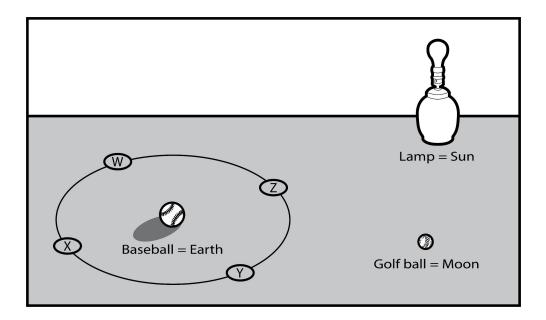
4 The diagram illustrates Earth rotating as well as how the Sun's light illuminates Earth.



According to the diagram, which point on Earth is about to experience sunset?

- **A** A
- **B** B
- **C** C
- **D** D

5 Some students are using objects to model Earth, the Moon, and the Sun. They wish to represent the positions of these objects during a solar eclipse.



To accurately model the solar eclipse, the golf ball should be placed in which labeled position?

- A Position W
- **B** Position X
- C Position Y
- **D** Position Z



Note: Due to the nature of this element, not all sections of the activity can be completed and submitted online by students.

Description

In this activity, students identify the importance of the tilt, revolution, and rotation of Earth; the causes of lunar and solar eclipses; and create three models. The first model will show how Earth's rotation causes day and night; the second will show how Earth's tilt and revolution around the Sun

cause the four seasons; the third model will show the positions of Earth, the Sun, and the Moon during each type of eclipse.

Materials

Printed Material

1 Student Handout (per student)

Reusable

- 1 Pair of scissors (per student)
- 1 Glue stick (per student)
- 1 Pencil (per student)

Consumable

- 1 Sheet of notebook paper (per student)
- 5 Pieces of construction paper, various colors (per student)

Procedure

- 1. Have students answer the first question on the Student Handout.
- 2. Have students describe in their own words how Earth's rotation causes us to experience night and day. Once the majority of students appear to have completed this, have a quick discussion of student answers, checking for comprehension.
- 3. Second question: Encourage students to draw a sketch illustrating their explanation of night and day. Remind students to label and identify any important aspects of their sketch.
- 4. Third question: Have students answer the following question in their own words. Describe how the 23.5° tilt of Earth on its axis results in the creation of seasons.
- 5. Once the majority of students appear to have completed this, have a quick discussion of student answers, checking for comprehension.
- 6. Fourth question: Encourage students to draw a sketch illustrating their explanation of the tilt of Earth and its effect on the seasons. Remind students to label and identify any important aspects of their sketch, such as the North Star; direction of Earth's rotation and revolution; and Earth's tilt, axis, and equator.
- 7. Fifth question: Have students answer the following question in their own words. Describe the positions of Earth, the Moon, and the Sun during a lunar and solar eclipse
- 8. Once the majority of students appear to have completed this, have a quick discussion of student answers, checking for comprehension.
- 9. Sixth question: Encourage students to draw a sketch illustrating the positions of Earth, the Moon, and the Sun during a lunar eclipse and during a solar eclipse. Remind students to draw in the shadow of Earth during a lunar eclipse and the shadow of the Moon on the solar

- eclipse. Have them be sure to label all parts.
- 10. Use construction paper to create a flat paper model from the sketches the students have made in questions 2, 6, and 7. Remember to label and identify any important aspects of the model such as the North Star; direction of Earth's rotation and revolution; Earth's tilt, axis, and equator; and the shadow of the Moon and the shadow of Earth.
- 11. Once students have completed their models, discuss as a class what students have created, identifying the important components of the model and the proper labeling. Example: the North Star; the direction of the rotation and revolution; the tilt of Earth; Earth's axis; the equator; and the shadow of the Moon and the shadow of Earth.
- 12. Students will complete the graphic organizer independently. Review as desired.
- 13. Have students answer the open response question on the Student Handout.
- 14. Once completed, discuss some of the students' answers to the big questions: Is there life? What is Earth like? What are the ecosystems like? Etc.

Guiding Questions

- 1. What are some key elements when discussing the rotation and revolution of the Moon and Earth?

 (Get students talking about the 23.5° tilt, the North Star, and the difference between rotating causing night and day and revolving causing the seasons.)
- 2. How are lunar eclipses different from solar eclipses?

 The Moon is between Earth and the Sun during a solar eclipse, and Earth is between the Sun and the Moon during a lunar eclipse.

Name:	Date:
2	

Check Understanding

Follow the instructions from your teacher to	complete th	ne following	activities.	Then a	answer	the
following questions with complete sentences	S.					

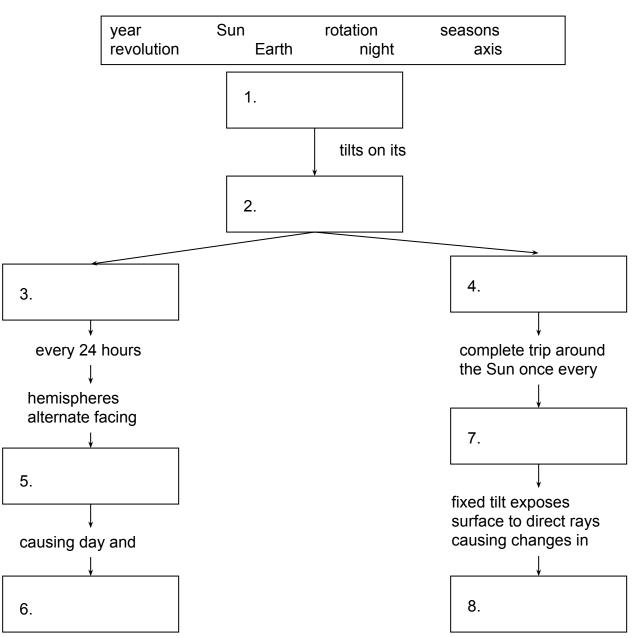
- 1. In your own words, describe how Earth's rotation causes us to experience night and day.
- 2. On another sheet of paper, create a sketch illustrating your answer to number 1. Make sure to label and identify any important factors such as Earth's axis, the North Star, and the direction Earth moves.
- 3. In your own words, describe how the 23.5° tilt of Earth results in the creation of seasons.

- 4. On another sheet of paper, create a sketch illustrating your answer to number 3. Make sure to label and identify any important factors such as the angle of the Earth's tilt, its approximate distance from the Sun, and where the Sun's rays are the strongest.
- 5. In your own words, describe the positions of Earth, the Moon, and the Sun during a lunar and solar eclipse.
- 6. On another sheet of paper, create a sketch illustrating your answer to number 5. Make sure to label Earth, the Sun, the Moon, Earth's shadow, and the Moon's shadow.

Check Understanding, Continued

Directions: Use the terms in the word bank to complete the graphic organizer below.

Word Bank





Check Understanding, Continued

Answer the following questions with complete sentences.

1. Explain what life on Earth would be like if it was not tilted and did not rotate or revolve. Do you think there would still be life? Where would you want to live on Earth in those conditions?