

# Moon Phases and Eclipses

**ESSENTIAL QUESTION**  
*How do Earth, the moon, and the sun affect each other?*

By the end of this lesson, you should be able to describe the effects the sun and the moon have on Earth, including gravitational attraction, moon phases, and eclipses.

Why is part of the moon orange? Because Earth is moving between the moon and the sun, casting a shadow on the moon.



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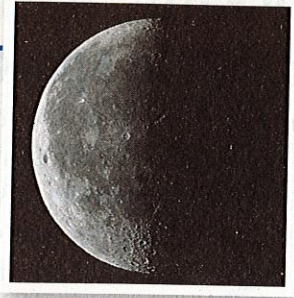
## Lesson Labs

### Quick Labs

- Moon Phases
- Lunar Eclipse

### S.T.E.M. Lab

- What the Moon Orbits



## Engage Your Brain

**1 Identify** Fill in the blanks with the word or phrase you think correctly completes the following sentences.

We can see the moon because it \_\_\_\_\_ the light from the sun.

The moon's \_\_\_\_\_ affects the oceans' tides on Earth.

The impact craters on the moon were created by collisions with \_\_\_\_\_, meteorites, and asteroids.

**2 Describe** Write your own caption for this photo in the space below.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## Active Reading

**3 Synthesize** You can often define an unknown word if you know the meaning of its word parts. Use the word parts and sentence below to make an educated guess about the meaning of the word *penumbra*.

Word part	Meaning
<i>umbra</i>	shade or shadow
<i>pen-</i> , from the Latin <i>paene</i>	almost

**Example sentence**  
An observer in the penumbra experiences only a partial eclipse.

**penumbra:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## Vocabulary Terms

- satellite
- gravity
- lunar phases
- eclipse
- umbra
- penumbra

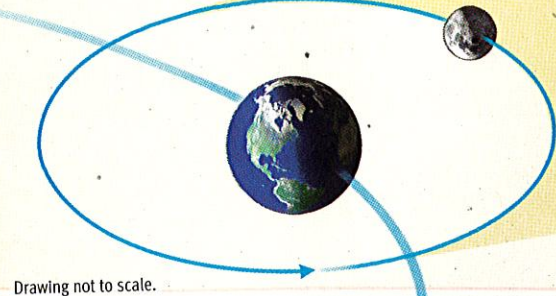
**4 Apply** As you learn the definition of each vocabulary term in this lesson, create your own definition or sketch to help you remember the meaning of the term.



# 'Round and 'Round They Go!

## How are Earth, the moon, and the sun related in space?

Earth not only spins on its axis, but like the seven other planets in our solar system, Earth also orbits the sun. A body that orbits a larger body is called a **satellite** (SAT'l•yt). Six of the planets in our solar system have smaller bodies that orbit around each of them. These natural satellites are also called moons. Our moon is Earth's natural satellite.



Earth revolves around the sun as the moon revolves around Earth.

Drawing not to scale.

## Earth and the Moon Orbit the Sun

All bodies that have mass exert a force that pulls other objects with mass toward themselves. This force is called **gravity**. The mass of Earth is much larger than the mass of the moon, and therefore Earth's gravity exerts a stronger pull on the moon than the moon does on Earth. It is Earth's gravitational pull that keeps the moon in orbit around Earth, forming the Earth-moon system.

The Earth-moon system is itself in orbit around the sun. Even though the sun is relatively far away, the mass of the sun exerts a large gravitational pull on the Earth-moon system. This gravitational pull keeps the Earth-moon system in orbit around the sun.

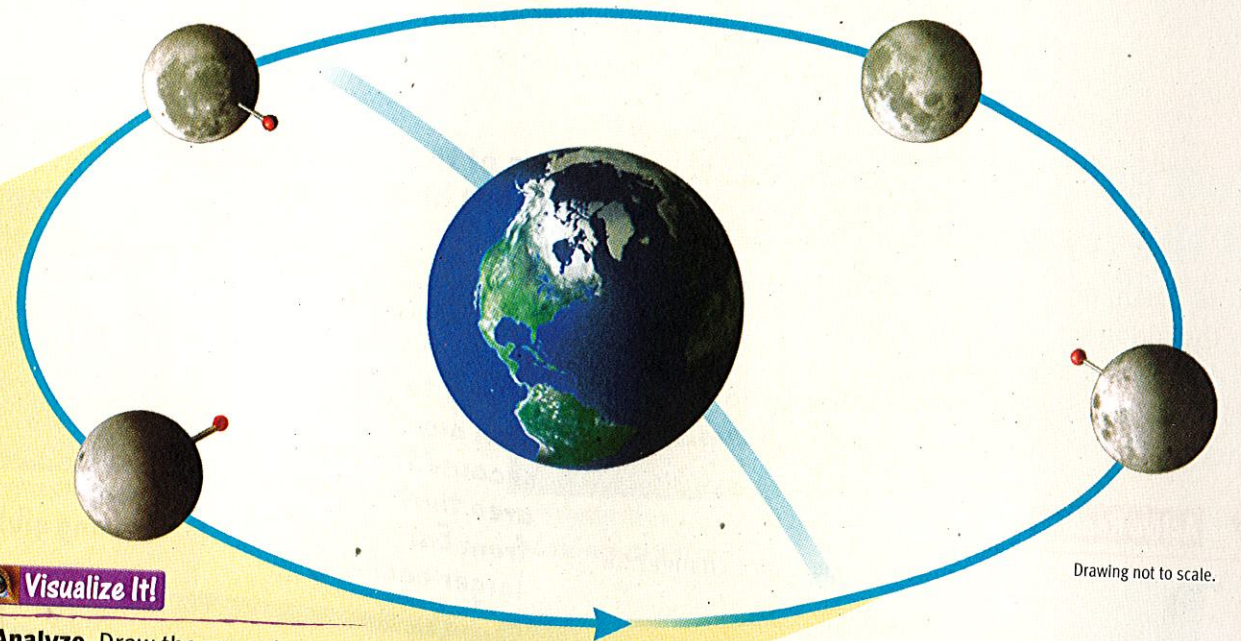
### Active Reading

**5 Identify** As you read, underline the reason that the moon stays in orbit around Earth.

## The Moon Orbits Earth

The pull of Earth's gravity keeps the moon, Earth's natural satellite, in orbit around Earth. Even though the moon is Earth's closest neighbor in space, it is far away compared to the sizes of Earth and the moon themselves.

The distance between Earth and the moon is roughly 383,000 km (238,000 mi)—about a hundred times the distance between New York and Los Angeles. If a jet airliner could travel in space, it would take about 20 days to cover a distance that huge. Astronauts, whose spaceships travel much faster than jets, need about 3 days to reach the moon.



Drawing not to scale.

### Visualize It!

**6 Analyze** Draw the correct position of the pin when the moon is in the position shown in the top right corner of this figure.

The moon completes one rotation for every revolution it makes around Earth.

## What does the moon look like from Earth?

The moon is only visible from Earth when it reflects the sunlight that reaches the moon. Although the moon is most easily seen at night, you have probably also seen it during daytime on some days. In the daytime, the moon may only be as bright as a thin cloud and can be easily missed. On some days you can see the moon during both the daytime and at night, whereas on other days, you may not see the moon at all.

When you can look at the moon, you may notice darker and lighter areas. Perhaps you have imagined them as features of a face or some other pattern. People around the world have told stories about the animals, people, and objects they have imagined while looking at the light and dark areas of the moon. The dark and light spots do not change over the course of a month because only one side of the moon faces Earth, often called the near side of the moon. This is because the moon rotates once on its own axis each time it orbits Earth. The moon takes 27.3 days or about a month to orbit Earth once.

### Inquiry

**7 Analyze** How would the moon appear to an observer on Earth if the moon did not rotate?

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# It's Just a Phase!

## How does the appearance of the moon change?

From Earth, the moon's appearance changes. As the moon revolves around Earth, the portion of the moon that reflects sunlight back to Earth changes, causing the moon's appearance to change. These changes are called **lunar phases**.

### Active Reading

**8 Describe** Why does the moon's appearance change?

## Lunar Phases Cycle Monthly

The cycle begins with a new moon. At this time, Earth, the moon, and the sun are lined up, such that the near side of the moon is unlit. And so there appears to be no moon in the sky.

As the moon moves along its orbit, you begin to see the sunlight on the near side as a thin crescent shape. The crescent becomes thicker as the moon waxes, or grows. When half of the near side of the moon is in the sunlight, the moon has completed one-quarter of its cycle. This phase is called the *first quarter*.

More of the moon is visible during the second week, or the *gibbous* (GIB•uhs) phase. This is when the near side is more than half lit but not fully lit. When the moon is halfway through its cycle, the whole near side of the moon is in sunlight, and we see a full moon.

During the third week, the amount of the moon's near side in the sunlight decreases and it seems to shrink, or wane. When the near side is again only half in sunlight, the moon is three-quarters of the way through its cycle. The phase is called the *third quarter*.

In the fourth week, the area of the near side of the moon in sunlight continues to shrink. The moon is seen as waning crescent shapes. Finally, the near side of the moon is unlit—*new moon*.

## Views of the moon from Earth's northern hemisphere

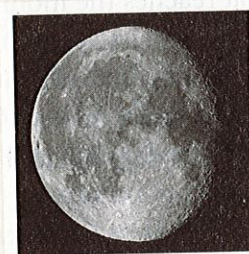
The waxing moon appears to grow each day. This is because the sunlit area that we can see from Earth is getting larger each day.



Waxing gibbous



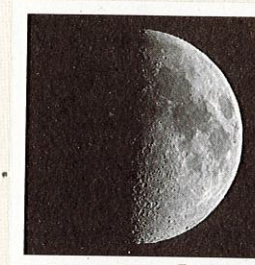
Full moon



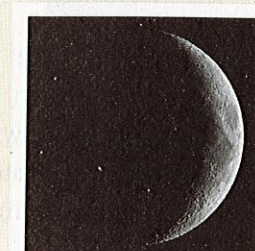
Waning gibbous

## Think Outside the Book

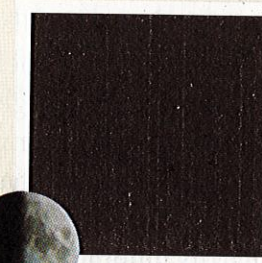
**9 Apply** Look at the night sky and keep a moon journal for a series of nights. What phase is the moon in now?



First quarter

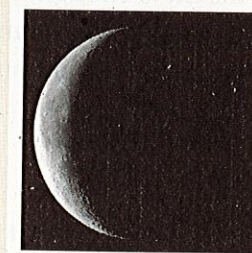


Waxing crescent

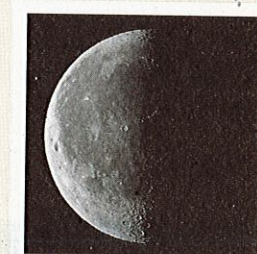


New moon

Drawing not to scale.



Waning crescent



Third quarter

## Visualize It!

**10 Analyze** What shape does the moon appear to be when it's closer to the sun than Earth is?

The waning moon appears to shrink each day. When the moon is waning, the sunlit area is getting smaller. Notice above that even as the phases of the moon change, the total amount of sunlight that the moon gets remains the same. Half the moon is always in sunlight, just as half of Earth is always in sunlight. The moon phases have a period of 29.5 days.



# Exploring Eclipses

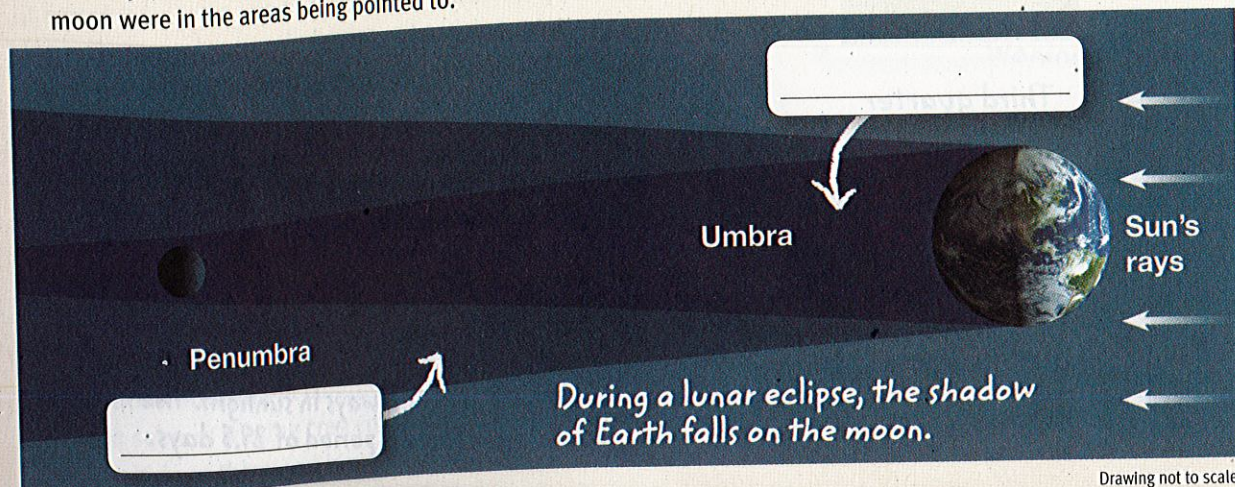
## How do lunar eclipses occur?

An **eclipse** (ih•KLIPS) is an event during which one object in space casts a shadow onto another. On Earth, a lunar eclipse occurs when the moon moves through Earth's shadow. There are two parts of Earth's shadow, as you can see in the diagram below. The **umbra** (UHM•bruh) is the darkest part of a shadow. Around it is a spreading cone of lighter shadow called the **penumbra** (pih•NUHM•bruh). Just before a lunar eclipse, sunlight streaming past Earth produces a full moon. Then the moon moves into Earth's penumbra and becomes slightly less bright. As the moon moves into the umbra, Earth's dark shadow seems to creep across and cover the moon. The entire moon can be in darkness because the moon is small enough to fit entirely within Earth's umbra. After an hour or more, the moon moves slowly back into the sunlight that is streaming past Earth. A total lunar eclipse occurs when the moon passes completely into Earth's umbra. If the moon misses part or all of the umbra, part of the moon stays light and the eclipse is called a partial lunar eclipse.

You may be wondering why you don't see solar and lunar eclipses every month. The reason is that the moon's orbit around Earth is tilted—by about  $5^\circ$ —relative to the orbit of Earth around the sun. This tilt is enough to place the moon out of Earth's shadow for most full moons and Earth out of the moon's shadow for most new moons.

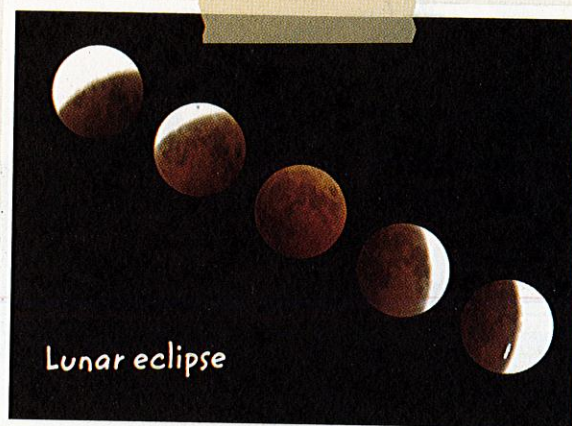
### Visualize It!

**11 Identify** Fill in the boxes with the type of eclipse that would occur if the moon were in the areas being pointed to.



Drawing not to scale.

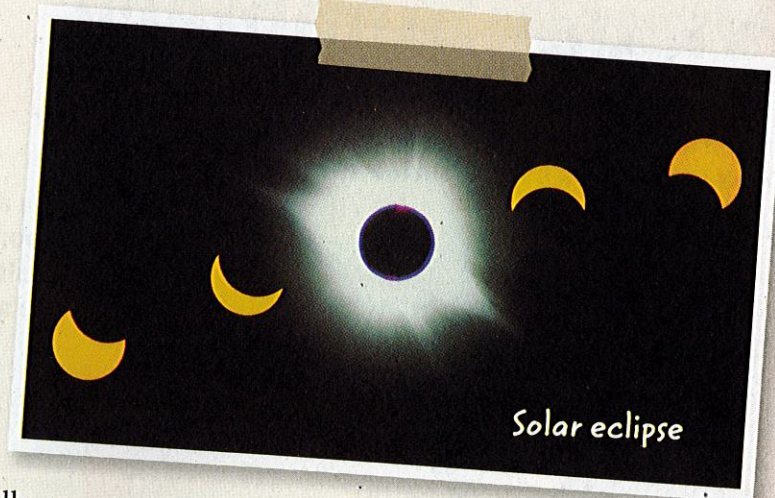
*This composite photo shows the partial and total phases of a lunar eclipse over several hours.*



## How do solar eclipses occur?

When the moon is directly between the sun and Earth, the shadow of the moon falls on a part of Earth and causes a solar eclipse. During a total solar eclipse, the sun's light is completely blocked by the moon, as seen in this photo. The umbra falls on the area of Earth that lies directly in line with the moon and the sun. Outside the umbra, but within the penumbra, people see a partial solar eclipse. The penumbra falls on the area that immediately surrounds the umbra.

The umbra of the moon is too small to make a large shadow on Earth's surface. The part of the umbra that hits Earth during an eclipse, is never more than a few hundred kilometers across, as shown below. So, a total eclipse of the sun covers only a small part of Earth and is seen only by people in particular parts of Earth along a narrow path. A total solar eclipse usually lasts between one to two minutes at any one location. A total eclipse will not be visible in the United States until 2017, even though there is a total eclipse somewhere on Earth about every one to two years.



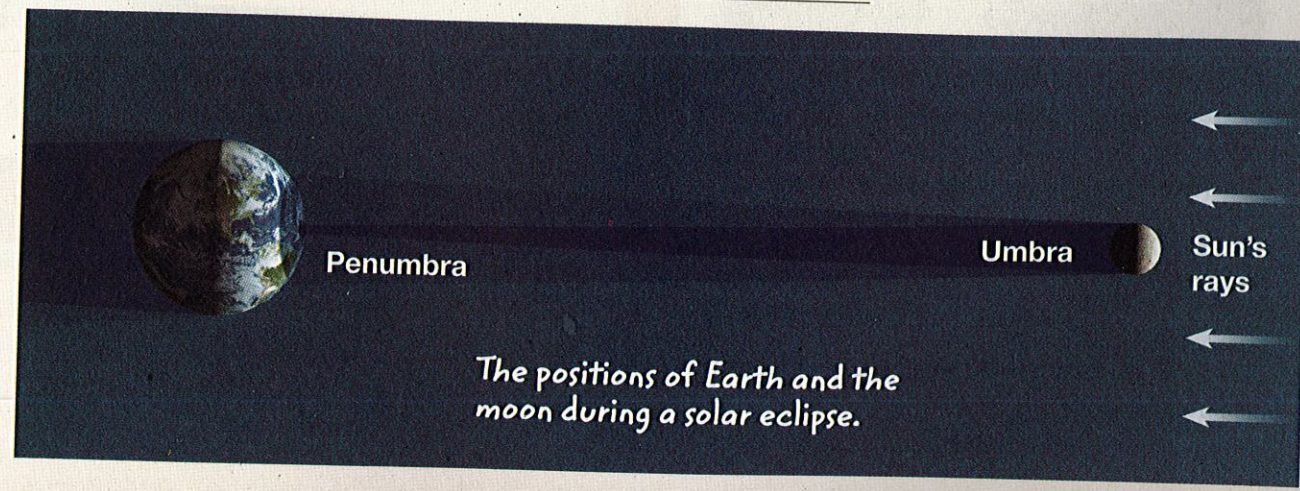
*During a solar eclipse, the moon passes between the sun and Earth so that the sun is partially or totally obscured.*

### Active Reading

**12 Explain** Why is it relatively rare to observe a solar eclipse?

### Visualize It!

**13 Describe** Explain what happens during a solar eclipse.



Drawing not to scale.

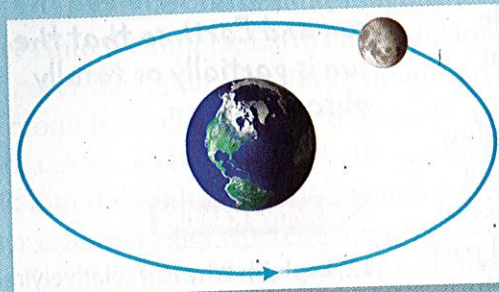


# Visual Summary

To complete this summary, circle the correct word. Then use the key below to check your answers. You can use this page to review the main concepts of the lesson.

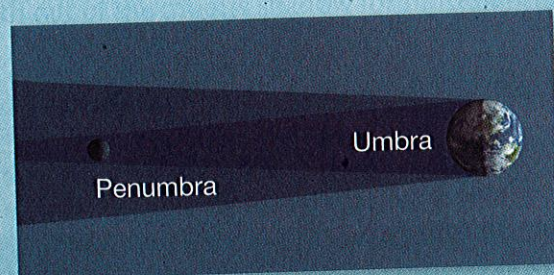
## Moon Phases and Eclipses

The Earth-moon system orbits the sun.



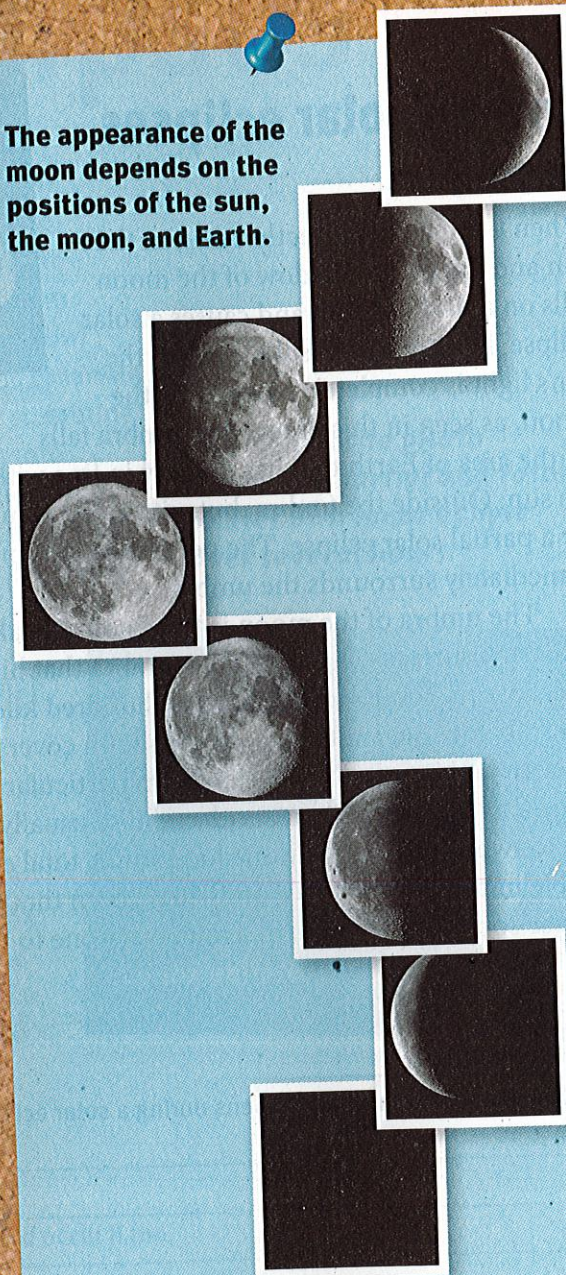
14 The moon takes about one day/month/year to orbit Earth.

Shadows in space cause eclipses.



15 When the moon is in Earth's umbra, a total solar/lunar eclipse is occurring.

The appearance of the moon depends on the positions of the sun, the moon, and Earth.



16 The fraction of the moon that receives sunlight always/never changes.

# Lesson Review

## Vocabulary

In your own words, define the following terms.

1 gravity

2 satellite

3 umbra

## Key Concepts

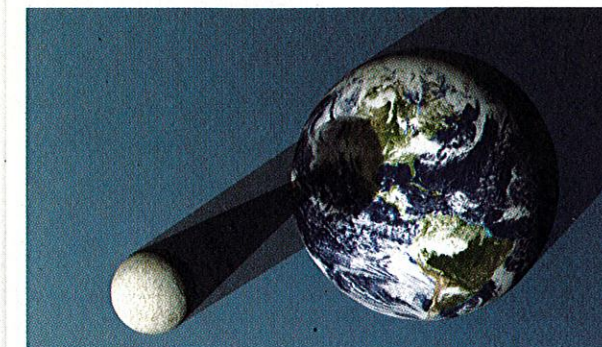
4 **Describe** What are two phases of a waxing moon, and how do they appear?

5 **Identify** Explain why the moon can be seen from Earth.

6 **Describe** What is the relationship between Earth, the sun, and the moon in space?

## Critical Thinking

Use the image below to answer the following question.



7 **Identify** What type of eclipse is shown in the diagram?

8 **Describe** Where is the moon in its orbit at the time of a solar eclipse?

9 **Infer** What phase is the moon in when there is a total solar eclipse?

10 **Predict** Which shape of the moon will you never see during the daytime, after sunrise and before sunset? *Hint:* Consider the directions of the sun and moon from Earth.

11 **Synthesize** If you were an astronaut in the middle of the near side of the moon during a full moon, how would the ground around you look? How would Earth, high in your sky look? Describe what is in sunlight and what is in darkness.

17 **Describe** What causes the lunar phases that we see from Earth?