




# Earth in Space

## chapter preview

### sections

- 1** Earth's Motion and Seasons
- 2** Earth's Moon  
*Lab Viewing the Moon*
- 3** Our Solar System  
*Lab The Slant of the Sun's Rays*
-  **Virtual Lab** How do Earth and the Moon interact to cause the Moon's phases?

## Light Up the Night

For thousands of years humans have looked at the night sky, but only during the past 50 years have we been able to view Earth from space. This photo combines views of Earth taken from the *International Space Station*.

**Science Journal** Describe how our view of Earth has changed in the past 50 years.

# Start-Up Activities



## Model Earth's Shape

Could you prove that Earth is round? What can you see from Earth's surface that proves Earth is round?  

1. Cut a strip of cardboard about 8 cm long and 8 cm tall into a triangle. Fold up about 2 cm on one side and tape it to a basketball so that the peak of the triangle sticks straight up resembling a sailboat.
2. Place the basketball on a table at eye level so that the sailboat sticks out horizontally, parallel to the table, pointing away from you.
3. Roll the ball toward you slowly so that the sail comes into view over the top of the ball.
4. **Think Critically** Write a paragraph that explains how the shape of the basketball affected your view of the sailboat. How does this model show how Earth's shape affects your view over long distances.

## FOLDABLES™ Study Organizer

**Earth and the Moon** Make the following Foldable to help you see how Earth and the Moon are similar and different.

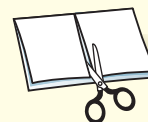
**STEP 1** **Fold** a vertical sheet of paper in half from top to bottom.



**STEP 2** **Fold** in half from side to side with the fold at the top.



**STEP 3** **Unfold** the paper once. **Cut** only the fold of the top flap to make two tabs.



**STEP 4** **Turn** the paper vertically and **draw** on the from tabs as shown.



**Compare and Contrast** Before you read the chapter, list the ways you think Earth and the Moon are alike and different under the appropriate tabs. As you read, correct or add to this information.



Preview this chapter's content and activities at [green.msscience.com](http://green.msscience.com)





# Earth's Motion and Seasons

## as you read

### What You'll Learn

- **Identify** Earth's shape and other physical properties.
- **Compare and contrast** Earth's rotation and revolution.
- **Explain** the causes of Earth's seasons.

### Why It's Important

Movements of Earth regulate life patterns.



### Review Vocabulary

**satellite:** a natural or artificial object that revolves around another object in space

### New Vocabulary

- |              |            |
|--------------|------------|
| ● axis       | ● orbit    |
| ● rotation   | ● solstice |
| ● revolution | ● equinox  |

## Earth's Physical Data

Think about the last time you saw a beautiful sunset. Late in the day, you may have noticed the Sun sinking lower and lower in the western sky. Eventually, as the Sun went below the horizon, the sky became darker. Was the Sun actually traveling out of view, or were you?

In the past, some people thought that the Sun, the Moon, and other objects in space moved around Earth each day. Now it is known that some of the motions of these objects, as observed from Earth, are really caused by Earth's movements.

Also, many people used to think that Earth was flat. They thought that if you sailed far enough out to sea, you eventually would fall off. It is now known that this is not true. What general shape does Earth have?

**Spherical Earth** As shown in **Figure 1**, pictures from space show that Earth is shaped like a ball, or a sphere. A sphere (SFIHR) is a three-dimensional object whose surface at all points is the same distance from its center. What other evidence can you think of that reveals Earth's shape?

**Figure 1** Earth's nearly spherical shape was first observed directly by images taken from a spacecraft. **Describe** observations from Earth's surface that also suggest that it is spherical.





**Evidence for Earth's Shape** Have you ever stood on a dock and watched a sailboat come in? If so, you may have noticed that the first thing you see is the top of the boat's sail. This occurs because Earth's curved shape hides the rest of the boat from view until it is closer to you. As the boat slowly comes closer to you, more and more of its sail is visible. Finally, the entire boat is in view.

More proof of Earth's shape is that Earth casts a curved shadow on the Moon during a lunar eclipse, like the one shown in **Figure 2**. Something flat, like a book, casts a straight shadow, whereas objects with curved surfaces cast curved shadows.



#### Reading Check

*What object casts a shadow on the Moon during a lunar eclipse?*

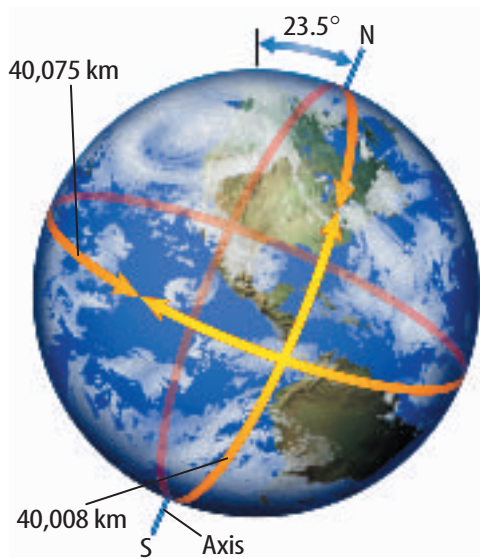
**Influence of Gravity** The spherical shape of Earth and other planets is because of gravity. Gravity is a force that attracts all objects toward each other. The farther away the objects are, the weaker the pull of gravity is. Also, the more massive an object is, the stronger its gravitational pull is. Large objects in space, such as planets and moons often are spherical because of how they formed. At first, particles collide and stick together randomly. However, as the mass increases, gravity plays a role. Particles are attracted to the center of the growing mass, making it spherical.

Even though Earth is round, it may seem flat to you. This is because Earth's surface is so large compared to your size.



**Figure 2** Earth's spherical shape also is indicated by the curved shadow it casts on the Moon during a partial lunar eclipse.





**Figure 3** Earth is almost a sphere, but its circumference measurements vary slightly. The north-south circumference of Earth is smaller than the east-west circumference.

**Table 1 Physical Properties of Earth**

Diameter (pole to pole)	12,714 km
Diameter (equator)	12,756 km
Circumference (poles) (distance around Earth through N and S poles)	40,008 km
Circumference (equator) (distance around Earth at the equator)	40,075 km
Mass	$5.98 \times 10^{24}$ kg
Average density (average mass per unit volume)	5.52 g/cm <sup>3</sup>
Average distance from the Sun	149,600,000 km
Period of rotation relative to stars (1 day)	23h, 56 min
Solar day	24 h
Period of revolution (1 year) (path around the Sun)	365 days, 6 h, 9 min

**Almost a Sphere** Earth's shape is not a perfect sphere. It bulges slightly at the equator and is somewhat flattened around the poles. As shown in **Figure 3**, this causes Earth's circumference at the equator to be a bit larger than Earth's circumference as measured through the north and south poles. The circumference of Earth and some other physical properties are listed in **Table 1**.

## Motions of Earth

Why the Sun appears to rise and set each day and why the Moon and other objects in the sky appear to move from east to west is illustrated in **Figure 4**. Earth's geographic poles are located at the north and south ends of Earth's axis. Earth's **axis** is the imaginary line drawn from the north geographic pole through Earth to the south geographic pole. Earth spins around this imaginary line. The spinning of Earth on its axis, called **rotation**, causes you to experience day and night.



### Reading Check

*What imaginary line runs through Earth's north and south geographic poles?*



**Earth's Orbit** Earth has another type of motion. As it rotates on its axis each day, Earth also moves along a path around the Sun. This motion of Earth around the Sun, shown in **Figure 4**, is called **revolution**. How many times does Earth rotate on its axis during one complete revolution around the Sun? Just as day and night are caused by rotation, what happens on Earth that is caused by its revolution?

**Seasons** A new year has begun. As days and weeks pass, you notice that the Sun remains in the sky later and later each day. You look forward to spring when you will be able to stay outside longer in the evening because the number of daylight hours gradually increases. What is causing this change?

You learned earlier that Earth's rotation causes day and night. Earth also moves around the Sun, completing one revolution each year. Earth is really a satellite of the Sun, moving around it along a curved path called an **orbit**. The shape of Earth's orbit is an ellipse, which is rounded like a circle but somewhat flattened. As Earth moves along in its orbit, the way in which the Sun's light strikes Earth's surface changes.

Earth's elliptical orbit causes it to be closer to the Sun in January and farther from the Sun in July. But, the total amount of energy Earth receives from the Sun changes little during a year. However, the amount of energy that specific places on Earth receive varies quite a lot.

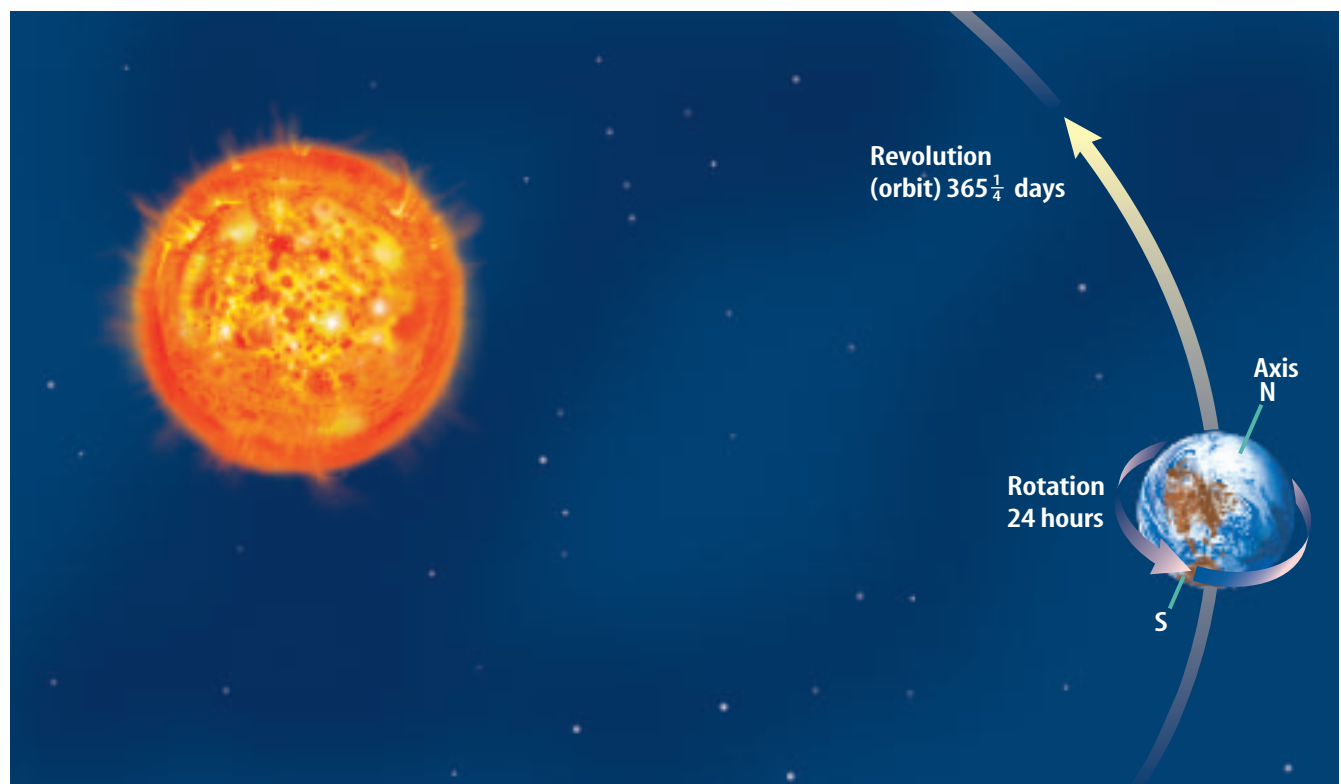


**Topic: Earth's Rotation and Revolution**

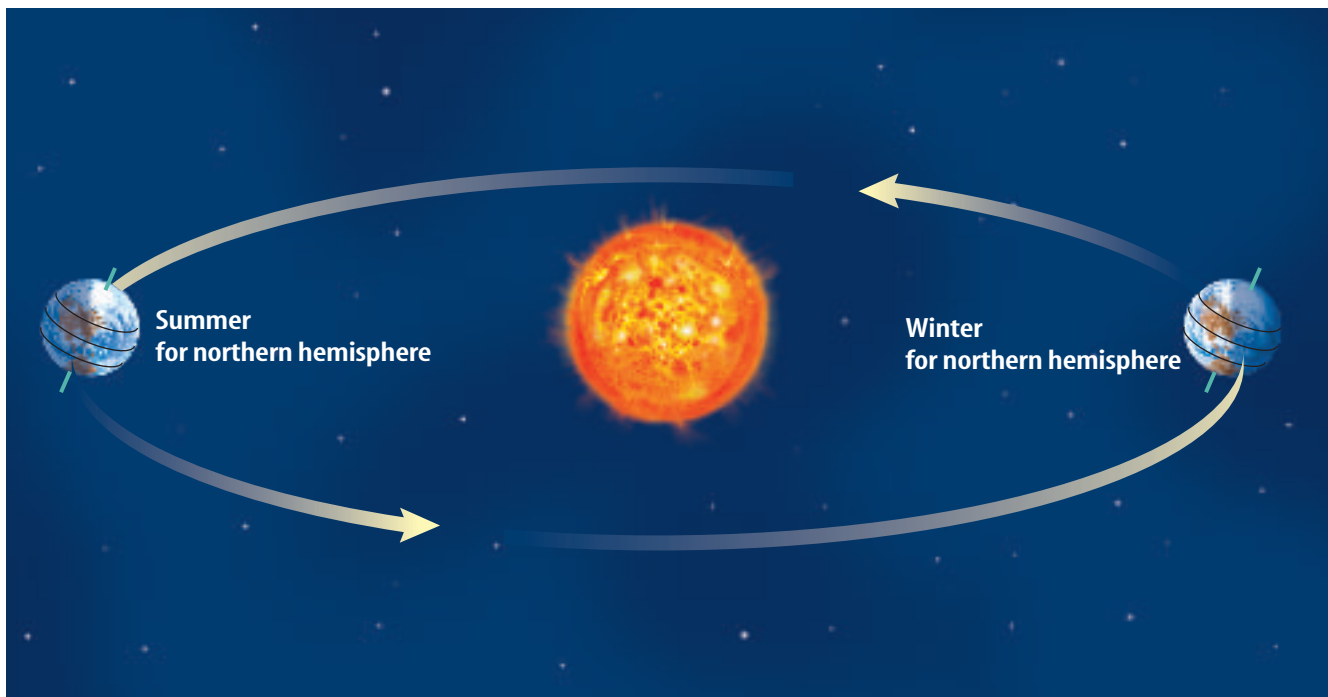
Visit [green.msscience.com](http://green.msscience.com) for Web links to information about Earth's rotation and revolution and the seasons.

**Activity** Build a model, perhaps using a plastic foam sphere and toothpicks, showing how the portion of the surface lit by a small flashlight varies at different angles of tilt.

**Figure 4** Earth's west-to-east rotation causes day and night.







**Figure 5** When the northern hemisphere is tilted toward the Sun, it experiences summer.

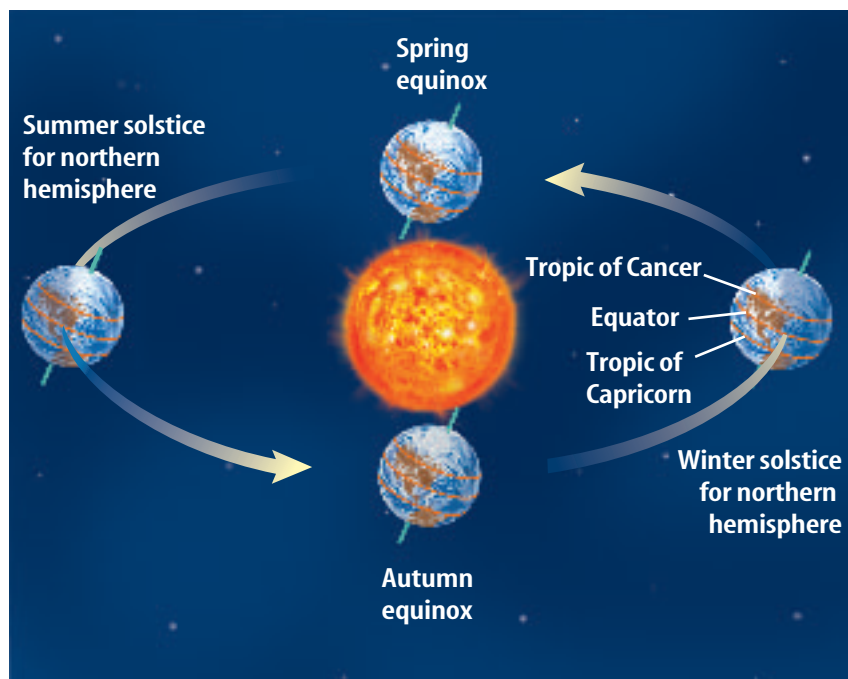
**Explain** *why days are longer during the summer.*

**Earth's Tilt** You can observe one reason why the amount of energy from the Sun varies by moving a globe slowly around a light source. If you keep the globe tilted in one direction, as shown in **Figure 5**, you will see that the top half of the globe is tilted toward the light during part of its orbit and tilted away from the light during another.

Earth's axis forms a 23.5-degree angle with a line perpendicular to the plane of its orbit around the Sun. It always points to the North Star. Because of this, there are more daylight hours for the hemisphere tilted toward the Sun. Think about when it gets dark outside at different times of the year. More hours of sunlight in summer is one reason why summer is warmer than winter. Another reason is that because of Earth's tilt, sunlight strikes the hemisphere tilted toward the Sun at a higher angle, that is, closer to 90 degrees. Sunlight strikes the hemisphere tilted away from the Sun at a lower angle. This lessens solar radiation and brings winter.

**Solstices** Because of the tilt of Earth's axis, the Sun's position relative to Earth's equator changes. Twice during the year, the Sun reaches its greatest distance north or south of the equator and is directly over either the Tropic of Cancer or the Tropic of Capricorn, as shown in **Figure 6**. These times are known as the summer and winter **solstices**. Summer solstice, which is when the Sun is highest in the sky at noon, happens on June 21 or 22 for the northern hemisphere and on December 21 or 22 for the southern hemisphere. The opposite of this for each hemisphere is winter solstice, which is when the Sun is lowest at noon.

**Equinoxes** At an **equinox**, (EE kwuh nahks) when the Sun is directly above Earth's equator, the lengths of day and night are nearly equal all over the world. During equinox, Earth's tilt is neither toward nor away from the Sun. In the northern hemisphere, spring equinox is March 21 or 22 and fall equinox is September 21 or 22. As you saw in **Table 1**, the time it takes for Earth to revolve around the Sun is not a whole number of days. Because of this, the dates for solstices and equinoxes change slightly over time.



**Earth's Place in Space** Earth is shaped much like a sphere. As Earth rotates on its axis, the Sun appears to rise and set in the sky. Earth's tilt and revolution around the Sun cause seasons to occur. In the next section, you will learn about Earth's nearest neighbor in space, the Moon. Later, you will learn about other planets in our solar system and how they compare with Earth.

**Figure 6** When the Sun is directly above the equator, day and night have nearly equal lengths.

## section 1 review

### Summary

#### Earth's Physical Data

- Earth has a spherical shape.
- The evidence for Earth's shape is the way objects appear on the horizon and its curved shadow during a lunar eclipse.

#### Motions of Earth

- Earth rotates on its axis, causing day and night.
- Earth revolves around the Sun in an elliptical orbit.
- Earth's rotational axis is tilted at an angle of 23.5°.
- The tilt of Earth's axis as it moves around the Sun causes the seasons.
- At a solstice, the Sun is directly over the Tropic of Capricorn or the Tropic of Cancer.
- At an equinox the Sun is directly over the equator.

### Self Check

1. **Explain** how planets develop their spherical shapes.
2. **Explain** Although Earth receives the same total amount of energy from the Sun throughout the year, why is it so much warmer in summer than it is in winter?
3. **Describe** whether the shape of Earth's orbit affects or does not affect the seasons.
4. **Explain** why the dates of the solstices and equinoxes vary.
5. **Think Critically** In **Table 1**, why is Earth's distance from the Sun reported as an average distance?

### Applying Skills

6. **Use Models** Use a globe and an unshaded light source to illustrate how the tilt of the Earth on its axis, as it rotates and revolves around the Sun, causes changes in the number of daylight hours.





# Earth's Moon

## as you read

### What You'll Learn

- **Identify** the Moon's surface features and interior.
- **Explain** the Moon's phases.
- **Explain** the causes of solar and lunar eclipses.
- **Identify** the origin of the Moon.

### Why It's Important

Learning about the Moon can help you understand Earth.



### Review Vocabulary

**density:** the amount of matter in a given volume of a substance

### New Vocabulary

- crater
- moon phase
- solar eclipse
- lunar eclipse

## The Moon's Surface and Interior

Take a good look at the surface of the Moon during the next full moon. You can see some of its large surface features, especially if you use binoculars or a small telescope. You will see dark-colored maria (MAR ee uh) and lighter-colored highland areas, as illustrated in **Figure 7**. Galileo first named the dark-colored regions *maria*, the Latin word for seas. They reminded Galileo of the oceans. Maria probably formed when lava flows from the Moon's interior flooded into large, bowl-like regions on the Moon's surface. These depressions may have formed early in the Moon's history. Collected during *Apollo* missions and then analyzed in laboratories on Earth, rocks from the maria are about 3.2 billion to 3.7 billion years old. They are the youngest rocks found on the Moon thus far.

The oldest moon rocks analyzed so far—dating to about 4.6 billion years old—were found in the lunar highlands. The lunar highlands are areas of the lunar surface with an elevation that is several kilometers higher than the maria. Some lunar highlands are located in the south-central region of the Moon.



**Figure 7** On a clear night and especially during a full moon, you can observe some of the Moon's surface features.

**Describe** how you can recognize the maria, lunar highlands, and craters.



**Craters** As you look at the Moon's surface features, you will see craters.

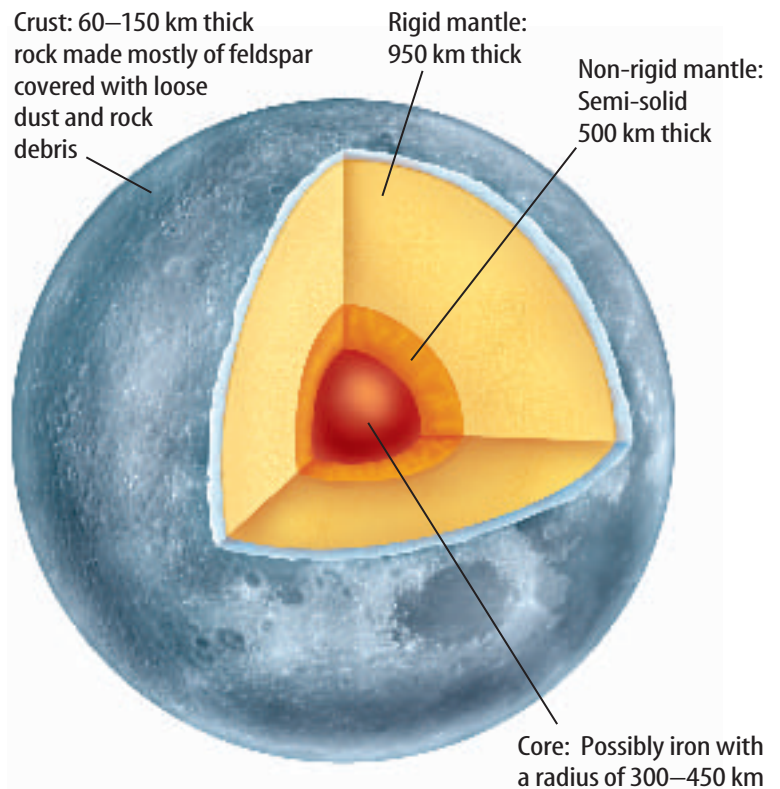
**Craters**, also shown in **Figure 7**, are depressions formed by large meteorites—space objects that strike the surface. As meteorites struck the Moon, cracks could have formed in the Moon's crust, allowing lava flows to fill in the large depressions. Craters are useful for determining how old parts of a moon's or a planet's surface are compared to other parts. The more abundant the craters are in a region, the older the surface is.

**The Moon's Interior** During the *Apollo* space program, astronauts left several seismographs (size muh grafs) on the Moon. A seismograph is an instrument that detects tremors, or seismic vibrations. On Earth, seismographs are used to measure earthquake activity. On the Moon, they are used to study moonquakes. Based on the study of moonquakes, a model of the Moon's interior has been proposed, as illustrated in **Figure 8**. The Moon's crust is about 60 km thick on the side facing Earth and about 150 km thick on the far side. The difference in thickness is probably the reason fewer lava flows occurred on the far side of the Moon. Below the crust, a solid layer called the mantle may extend 900 km to 950 km farther down. A soft layer of mantle may continue another 500 km deeper still. Below this may be an iron-rich, solid core with a radius of about 300–450 km.

Like the Moon, Earth also has a dense, iron core. However, the Moon's core is small compared to its total volume. Compared with Earth, the Moon is most like Earth's outer two layers—the mantle and the crust—in density. This supports a hypothesis that the Moon may have formed primarily from material ejected from Earth's mantle and crust.

## Motions of the Moon

The same side of the Moon is always facing Earth. You can verify this by examining the Moon in the sky night after night. You'll see that bright and dark surface features remain in the same positions. Does this mean that the Moon doesn't turn on an axis as it moves around Earth? Next, explore why the same side of the Moon always faces Earth.



**Figure 8** The small size of the Moon's core suggests the Moon formed from a part of the crust and mantle of Earth.



**Moon Colonies** Research from space probes indicates that conditions on some areas of the Moon might make moon colonies possible someday. Why might a moon colony prove useful?





## Mini LAB

### Modeling the Moon's Rotation

#### Procedure

1. Use **masking tape** to place a large X on a **basketball** that will represent the Moon.
2. Ask two students to sit in **chairs** in the center of the room.
3. Place other students around the outer edge of the room.
4. Slowly walk completely around the two students in the center while holding the basketball so that the side with the X always faces the two students.

#### Analysis

1. Ask the two students in the center whether they think the basketball turned around as you circled them. Then ask several students along the outer edge of the room whether they think the basketball turned around.
2. Based on these observations, infer whether or not the Moon rotates as it moves around Earth. Explain your answer.

**Figure 9** Observers viewing the Moon from Earth always see the same side of the Moon. This is caused by two separate motions of the Moon that take the same amount of time.

**Revolution and Rotation of the Moon** The Moon revolves around Earth at an average distance of about 384,000 km. It takes 27.3 days for the Moon to complete one orbit around Earth. The Moon also takes 27.3 days to rotate once on its axis. Because these two motions of the Moon take the same amount of time, the same side of the Moon is always facing Earth. Examine **Figure 9** to see how this works.

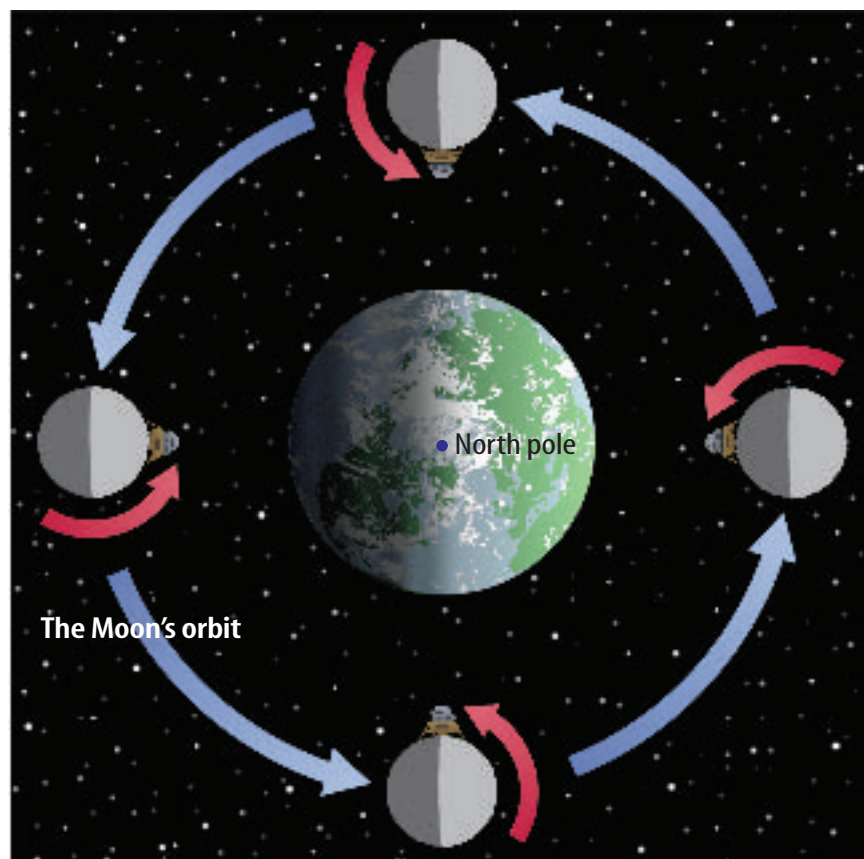


#### Reading Check

*Why does the same side of the Moon always face Earth?*

However, these two lunar motions aren't exactly the same during the Moon's 27.3-day rotation-and-revolution period. Because the Moon's orbit is an ellipse, it moves faster when it's closer to Earth and slower when it's farther away. During one orbit, observers are able to see a little more of the eastern side of the Moon and then a little more of the western side.

**Moon Phases** If you ever watched the Moon for several days in a row, you probably noticed how its shape and position in the sky change. You learned that the Moon rotates on its axis and revolves around Earth. Motions of the Moon cause the regular cycle of change in the way the Moon looks to an observer on Earth.



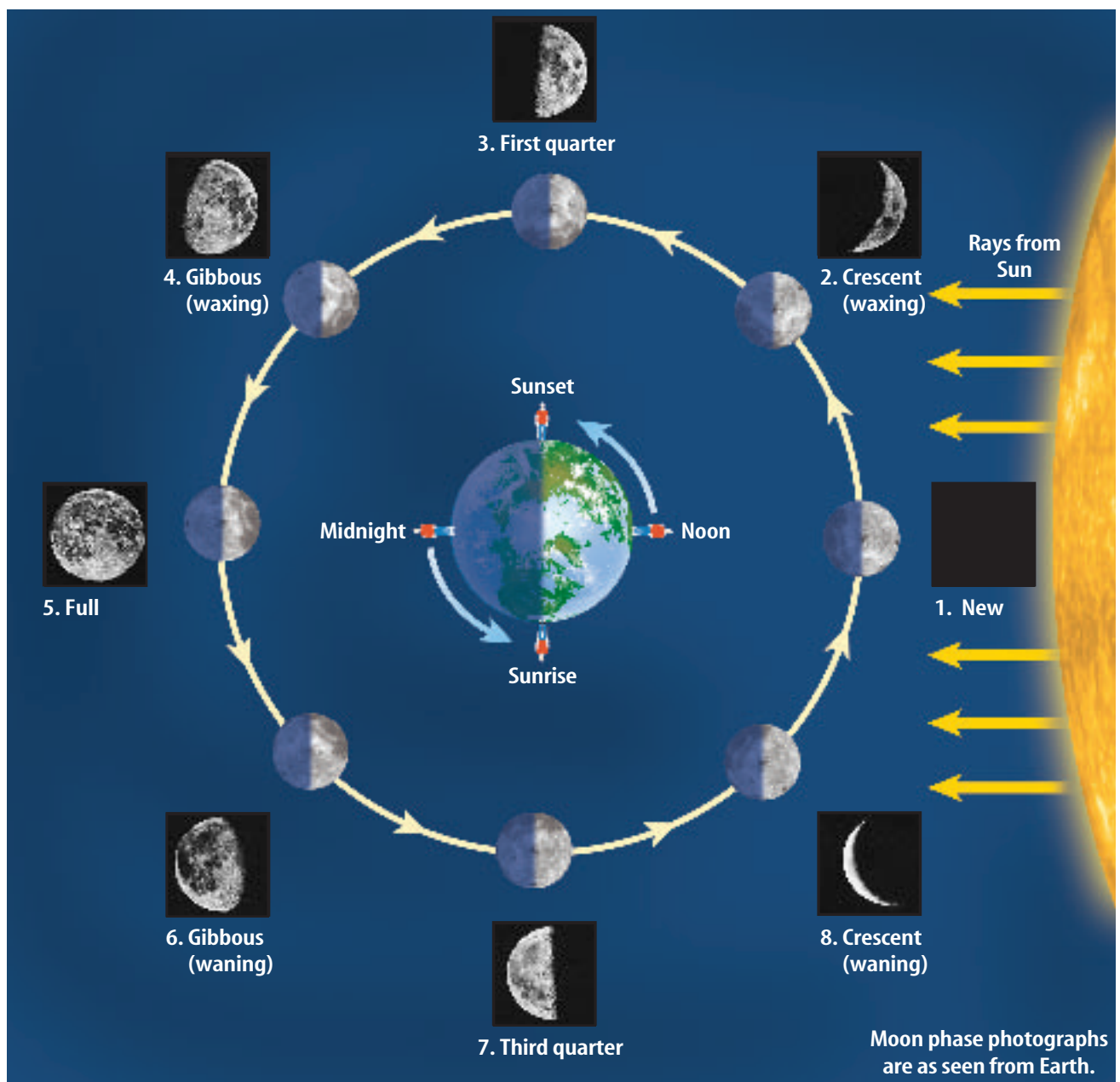


**The Sun Lights the Moon** You see the Moon because it reflects sunlight. As the Moon revolves around Earth, the Sun always lights one half of it. However, you don't always see the entire lighted part of the Moon. What you do see are phases, or different portions of the lighted part. **Moon phases**, illustrated in **Figure 10**, are the changing views of the Moon as seen from Earth.

**New Moon and Waxing Phases** New moon occurs when the Moon is positioned between Earth and the Sun. You can't see any of a new moon, because the lighted half of the Moon is facing the Sun. The new moon rises and sets with the Sun and never appears in the night sky.

**Figure 10** The amount of the Moon's surface that looks bright to observers on Earth changes during a complete cycle of the Moon's phases.

**Explain** what makes the Moon's surface appear so bright.







### Topic: Moon Phases

Visit [green.mssscience.com](http://green.mssscience.com) for Web links to information about moon phases.

**Activity** When weather permits, take photos or make drawings of the Moon every three or four days. Record the date of each photo and make a poster showing the Moon's phases. How do your moon pictures correspond to what you viewed on the Web site?

**Figure 11** It takes about two days longer for a complete Moon phase cycle than for the Moon to orbit Earth.

**Explain** how the revolution of the Earth-Moon system around the Sun causes this difference in time.

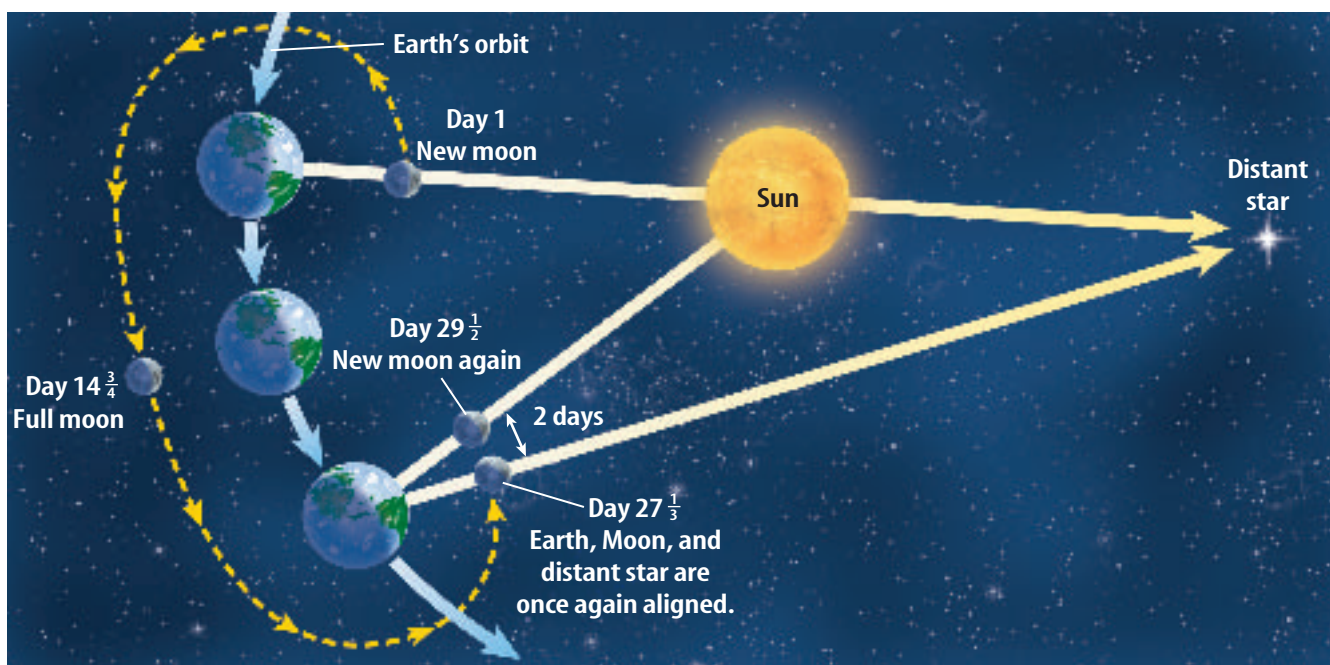
**Waxing Moon** Shortly after new moon, more and more of the side facing Earth is lighted. The phases are said to be waxing, or growing in size. About 24 hours after new moon, a thin sliver on the side facing Earth is lighted. This phase is called waxing crescent. As the Moon continues its trip around Earth, half of that side is lighted. This phase is first quarter and occurs about a week after new moon.

The Moon's phases continue to wax through waxing gibbous (GIH bus) and then full moon—the phase when you can see all of the side facing Earth lighted. At full moon, Earth is between the Sun and the Moon.

**Waning Moon** After passing full moon, the amount of the side facing Earth that is lighted begins to decrease. Now the phases are said to be waning. Waning gibbous occurs just after full moon. Next comes third quarter when you can see only half of the side facing Earth lighted, followed by waning crescent, the final phase before the next new moon.

 **Reading Check** What are the waning phases of the Moon?

The complete cycle of the Moon's phases takes about 29.5 days. However, you will recall that the Moon takes only 27.3 days to revolve once around Earth. **Figure 11** explains the time difference between these two lunar cycles. Earth's revolution around the Sun causes the time lag. It takes the Moon about two days longer to align itself again between Earth and the Sun at new moon.





## Eclipses

You can see other effects of the Moon's revolution than just the changes in its phases. Sometimes during new and full moon, shadows cast by one object will fall on another. While walking along on a sunny day, have you ever noticed how a passing airplane can cast a shadow on you? On a much larger scale, the Moon can do this too, when it lines up directly with the Sun. When this happens, the Moon can cast its shadow all the way to Earth. Earth also can cast its shadow onto the Moon during a full moon. When shadows are cast in these ways, eclipses occur.

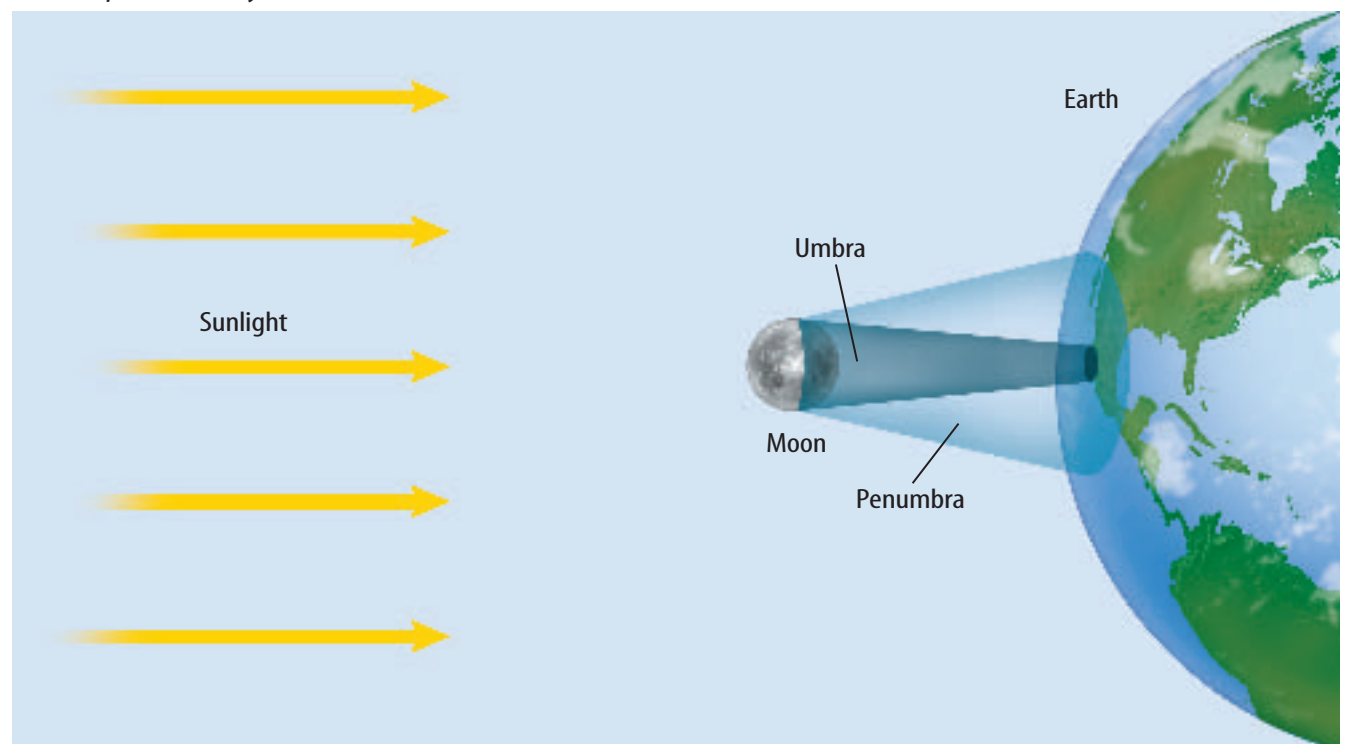
Eclipses occur only when the Sun, the Moon, and Earth are lined up perfectly. Because the Moon's orbit is tilted at an angle from Earth's orbit, the Moon's shadow most often misses Earth, and eclipses happen only a few times each year.

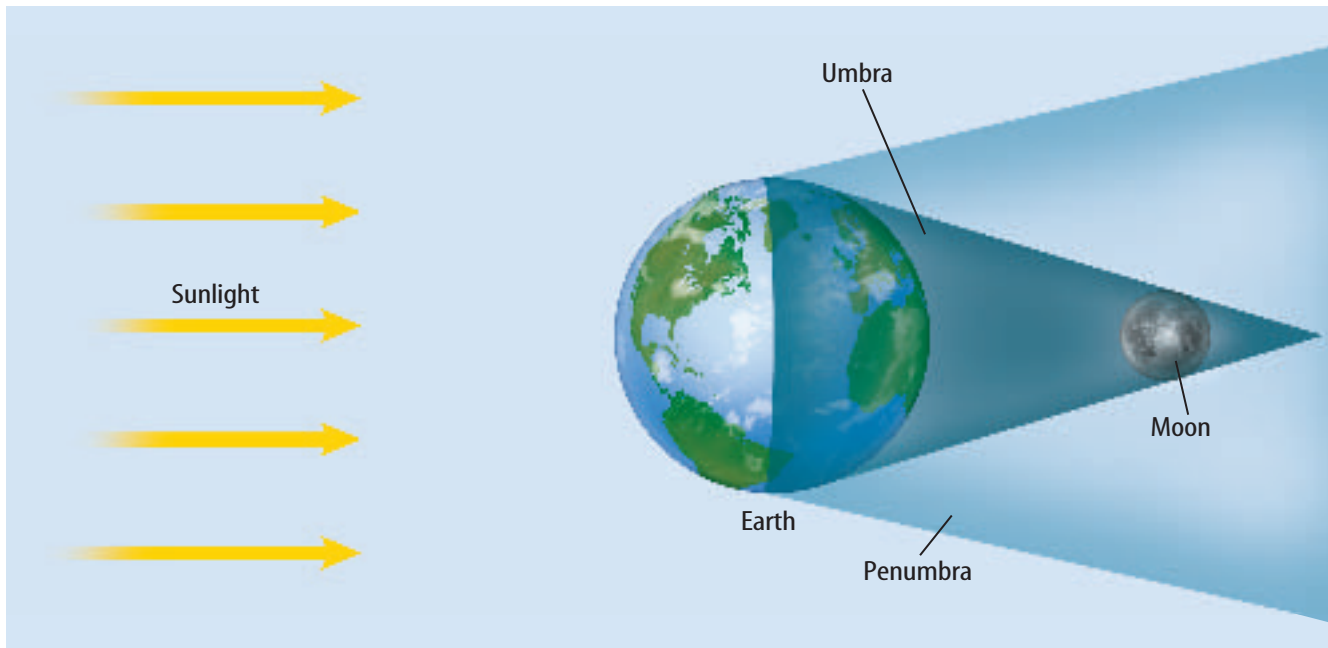
**Solar Eclipses** During new moon, if Earth moves into the Moon's shadow, a **solar eclipse** occurs. As shown in **Figure 12**, the Moon blocks sunlight from reaching a portion of Earth's surface. Only areas on Earth in the Moon's umbra, or the darkest part of its shadow, experience a total solar eclipse. Those areas in the penumbra, or lighter part of the shadow, experience a partial solar eclipse. During a total solar eclipse, the sky becomes dark and stars can be seen easily. Because Earth rotates and the Moon is moving in its orbit, a solar eclipse lasts only a few minutes in any one location.

Viewers on Earth within the Moon's penumbra will see only a portion of the Sun covered. **WARNING:** *Never look directly at a solar eclipse. Only observe solar eclipses indirectly.*



**Figure 12** During a total solar eclipse, viewers on Earth within the Moon's umbra will see the Moon cover the Sun completely. Only the Sun's outer atmosphere is visible as a halo.





**Figure 13** Lunar eclipses occur when the Sun, the Moon, and Earth line up so that Earth's shadow is cast upon a full moon. When the entire Moon is eclipsed, anyone on Earth who can see a full moon can see the lunar eclipse.

**Lunar Eclipses** A **lunar eclipse**, illustrated in **Figure 13**, occurs when the Sun, Earth, and the Moon are lined up so that the full moon moves into Earth's shadow. Direct sunlight is blocked from reaching the Moon. When the Moon is in the darkest part of Earth's shadow, a total lunar eclipse occurs.

During a total lunar eclipse, the full moon darkens. Because some sunlight refracts through Earth's atmosphere, the Moon appears to be deep red. As the Moon moves out of the umbra and into the penumbra, or lighter shadow, you can see the curved shadow of Earth move across the Moon's surface. When the Moon passes partly through Earth's umbra, a partial lunar eclipse occurs.

## Origin of the Moon

Before the *Apollo* space program, several hypotheses were proposed to explain the origin of the Moon. Some of these hypotheses are illustrated in **Figure 14**.

The co-formation hypothesis states that Earth and the Moon formed at the same time and out of the same material. One problem with this hypothesis is that Earth and the Moon have somewhat different densities and compositions.

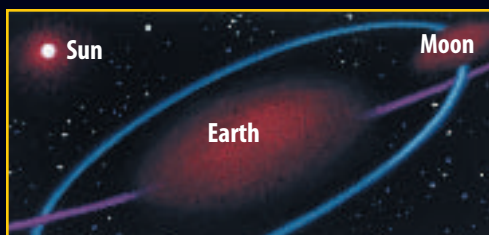
According to the capture hypothesis, Earth and the Moon formed at different locations in the solar system. Then Earth's gravity captured the Moon as it passed close to Earth. The fission hypothesis states that the Moon formed from material thrown off of a rapidly spinning Earth. A problem with the fission hypothesis lies in determining why Earth would have been spinning so fast.





Figure 14

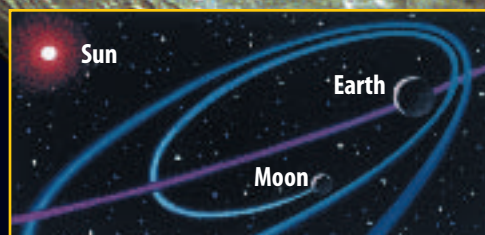
Scientists have proposed several possible explanations, or hypotheses, to account for the formation of Earth's Moon. As shown below, these include the co-formation, fission, capture, and collision hypotheses. The latter—sometimes known as the giant impact hypothesis—is the most widely accepted today.



▲ **CO-FORMATION** Earth and the Moon form at the same time from a vast cloud of cosmic matter that condenses into the bodies of the solar system.



▲ **FISSION** A rapidly spinning molten Earth tears in two. The smaller blob of matter enters into orbit as the Moon.



▲ **CAPTURE** Earth's gravity captures the Moon into Earth orbit as the Moon passes close to Earth.



▲ **COLLISION** A Mars-sized body collides with the primordial Earth. The colossal impact smashes off sufficient debris from Earth to form the Moon.







**Figure 15** Moon rocks collected during the *Apollo* space program provide clues about how the Moon formed.

material that would have been thrown off Earth's mantle and crust when the object collided with Earth.

Earth is the third planet from the Sun. Along with the Moon, Earth could be considered a double planet. In the next section you will learn about other planets in the solar system. Some have properties similar to Earth's—others are different from Earth.

**Collision Hypothesis** A lot of uncertainty still exists about the origin of the Moon. However, the collection and study of moon rocks, shown in **Figure 15**, brought evidence to support one recent hypothesis. This hypothesis, summarized in **Figure 14**, involves a great collision. When Earth was about 100 million years old, a Mars-sized space object may have collided with Earth. Such an object would have broken through Earth's crust and plunged toward the core. This collision would have thrown large amounts of gas and debris into orbit around Earth. Within about 1,000 years the gas and debris then could have condensed to form the Moon. The collision hypothesis is strengthened by the fact that Earth and the Moon have different densities. The Moon's density is similar to

## section 2 review

### Summary

#### The Moon's Surface and Interior

- Surface features include highlands, maria, and craters.
- The Moon has an outer crust, a rigid mantle, a non-rigid mantle, and possibly a small iron core.

#### Motions of the Moon

- The Moon revolves around Earth and rotates on its axis once every 27.3 days.
- The varying portions of the Moon's near side that are lit by the Sun are called phases.

#### Eclipses

- A solar eclipse takes place when the Moon passes between Earth and the Sun.
- A lunar eclipse takes place when Earth passes between the Sun and the Moon.

#### Origin of the Moon

- Evidence obtained from moon rocks supports the collision hypothesis of lunar formation.

### Self Check

1. **Name** the phase of the Moon that occurs when Earth is located between the Moon and the Sun.
2. **Explain** how maria formed on the Moon and how this name for them originated.
3. **Infer** Based on what you know about the Moon's crust, explain why there are fewer maria on the far side of the Moon.
4. **Explain** why the fact that Earth and the Moon have different densities favors the collision theory of lunar formation.
5. **Think Critically** Explain why more people observe a total lunar eclipse than a total solar eclipse.

### Applying Skills

6. **Recognize Cause and Effect** How does the Moon's orbit around Earth cause the observed cyclical phases of the Moon? What role does the Sun play?
7. **Use a Spreadsheet** to compare the four hypotheses of lunar formation in terms of modern factual evidence of the Moon's density.

## Viewing the Moon

The position of the Moon in the sky varies as the phases of the Moon change. Do you know when you might be able to see the Moon during daylight hours? How will viewing the Moon through a telescope be different from viewing it with the unaided eye?

### Real-World Question

What features of the Moon are visible when viewed through a telescope?

#### Goals

- **Determine** when you may be able to observe the Moon during the day.
- Use a telescope to observe the Moon.
- **Draw** a picture of the Moon's features as seen through the telescope.

#### Materials

telescope                      drawing pencils  
drawing paper

#### Safety Precautions

**WARNING:** *Never look directly at the Sun. It can damage your eyes.*

### Procedure

1. Using your own observations, books about astronomy, or other resource materials, determine when the Moon may be visible to you during the day. You will need to find out during which phases the Moon is up during daylight hours, and where in the sky you likely will be able to view it. You will also need to find out when the Moon will be in those phases in the near future.
2. **Observe** the Moon with your unaided eye. Draw the features that you are able to see.

3. Using a telescope, observe the Moon again. Adjust the focus of the telescope so that you can see as many features as possible.
4. **Draw** a new picture of the Moon's features.



### Conclude and Apply

1. **Describe** what you learned about when the Moon is visible in the sky. If a friend wanted to know when to try to see the Moon during the day next month, what would you say?
2. **Describe** the differences between how the Moon looked with the naked eye and through the telescope. Did the Moon appear to be the same size when you looked at it both ways?
3. **Determine** what features you were able to see through the telescope that were not visible with the unaided eye.
4. **Observe** Was there anything else different about the way the Moon looked through the telescope? Explain your answer.
5. **Identify** some of the types of features that you included in your drawings.

### Communicating Your Data

The next time you notice the Moon when you are with your family or friends, talk about when the Moon is visible in the sky and the different features that are visible.





# Our Solar System

## as you read

### What You'll Learn

- **List** the important characteristics of inner planets.
- **Identify** how other inner planets compare and contrast with Earth.
- **List** the important characteristics of outer planets.

### Why It's Important

Learning about other planets helps you understand Earth and the formation of our solar system.



### Review Vocabulary

**atmosphere:** the gaseous layers surrounding a planet or moon

### New Vocabulary

- solar system
- comet
- astronomical unit
- nebula
- asteroid

## Size of the Solar System

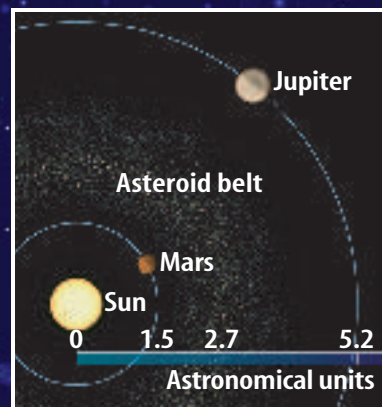
Measurements in space are difficult to make because space is so vast. Even our own solar system is extremely large. Our **solar system**, illustrated in **Figure 16**, is composed of the Sun, planets, asteroids, comets, and other objects in orbit around the Sun. How would you begin to measure something this large? If you are measuring distances on Earth, kilometers work fine, but not for measuring huge distances in space. Earth, for example, is about 150,000,000 km from the Sun. This distance is referred to as 1 **astronomical unit**, or 1 AU. Jupiter, the largest planet in the solar system, is more than 5 AU from the Sun. Astronomical units can be used to measure distances between objects within the solar system. Even larger units are used to measure distances between stars.

Located at the center of the solar system is a star you know as the Sun. The Sun is an enormous ball of gas that produces energy by fusing hydrogen into helium in its core. More than 99 percent of all matter in the solar system is contained in the Sun.

**Figure 16** Our solar system is composed of the Sun, planets and their moons, and smaller bodies that revolve around the Sun, such as asteroids and comets.

The asteroid belt is composed of rocky bodies that are smaller than the planets.

**Evaluate** About how many AU are between the Sun and the middle of the asteroid belt?





**An Average Star** Although the Sun is important to life on Earth, it is much like many other stars in the universe. The Sun is middle-aged and about average in the amount of light it gives off.

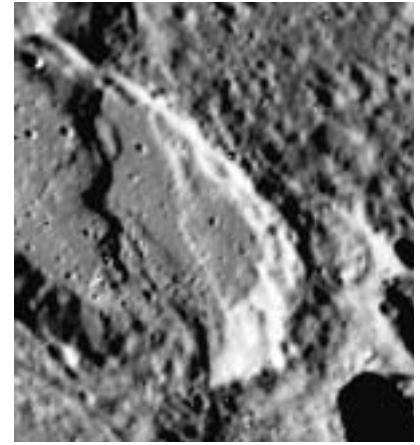
## The Planets

The planets in our solar system can be classified as inner or outer planets. Inner planets have orbits that lie inside the orbit of the asteroid belt. The inner planets are mostly solid, rocky bodies with thin atmospheres compared with the atmospheres of outer planets. Outer planets have orbits that lie outside the orbit of the asteroid belt. Four of these are known as gas giants, and one is a small ice/rock planet that seems to be out of place.

## Inner Planets

The inner planets are Mercury, Venus, Earth, and Mars. Known as the terrestrial planets, after the Latin word *terra* (earth), they are similar in size to Earth and are made up mainly of rock.

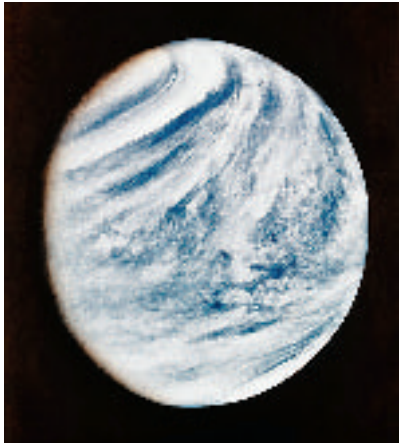
**Mercury** Mercury is the closest planet to the Sun. It is covered by craters formed when meteorites crashed into its surface. The surface of Mercury also has cliffs, as shown in **Figure 17**, some of which are 3 km high. These cliffs may have formed when Mercury's molten, iron-rich core cooled and contracted, causing the outer solid crust to shrink. The planet seems to have shrunk about 2 km in diameter. It has no atmosphere.



**Figure 17** The Discovery Rupes Scarp is a huge cliff that may have formed as Mercury cooled and contracted.







**Figure 18** Clouds in Venus's atmosphere are composed partly of sulfuric acid droplets.

**Describe** What are clouds on Earth composed of?



**Planetology** The space age has opened many new careers. One of these is planetology, the study of other planets. NASA advises those interested in this field to start with basic chemistry, physics, and math. Most planetary scientists first earn advanced degrees in areas such as geology, hydrology, meteorology, and biology and then apply their knowledge to the study of other planets.

**Figure 19** Just as a metal toy left outside on Earth rusts, red rocks on Mars's surface show that iron in the rocks has combined with oxygen to form iron oxide.

**Venus** Venus, the second inner planet from the Sun, shown in **Figure 18**, often has been referred to as Earth's twin, but only because of their similar sizes and masses. Otherwise, the surface conditions and atmospheres of Earth and Venus are extremely different. Thick clouds surround Venus and trap energy from the Sun, causing Venus's surface temperature to reach about 472°C. The process is similar to what occurs in a greenhouse.

**Earth** Earth is the third inner planet from the Sun. It is unique because surface temperatures enable water to exist in three states—solid, liquid, and gas. Ozone, a molecule of three oxygen atoms bound together, exists in the layer of Earth's atmosphere known as the stratosphere. This ozone protects life from the Sun's harmful ultraviolet radiation.

**Mars** Mars is the fourth inner planet from the Sun. It often is called the red planet. Iron oxide, the same material found in rust, exists in Mars's weathered surface rocks, giving the planet a reddish color. The Martian surface is shown in **Figure 19**. The rocks shown here are similar in composition to some volcanic rocks on Earth. The largest volcano in the solar system, Olympus Mons, is found on Mars.

Mars has two polar ice caps that change in size between Martian winter and summer. Recent data from *Mars Odyssey* indicate that both ice caps are made of frozen water covered by a layer of frozen carbon dioxide. Mars has two Moons, Phobos (FOH buhs) and Deimos (DI mos). Also, long channels exist on Mars. The channels on Mars are hypothesized to have been carved by flowing water sometime in the past. Mars's atmosphere, made up mostly of carbon dioxide with some nitrogen and argon, is much thinner than Earth's.



(t) NASA/JPL, (br) Dr. Timothy Parker/JPL





## Outer Planets

The outer planets are Jupiter, Saturn, Uranus, Neptune, and Pluto. Except for Pluto, they all are gaseous giant planets with dense atmospheres. The outer planets are mainly made up of light elements such as hydrogen and helium.

**Jupiter** The giant planet Jupiter, shown in **Figure 20**, is the largest planet in the solar system. It is the fifth planet from the Sun. Jupiter's atmosphere is made mostly of hydrogen and helium and contains many huge storms. The largest and most prominent of these storms is the Great Red Spot, which has raged for more than 300 years. It is about twice the width of Earth and rotates once every six days. With its 61 moons, Jupiter is like a miniature solar system.

### Applying Science

#### What influences a planet's atmosphere?

**T**he inner planets are small and dense and have thin atmospheres. The outer planets are large and gaseous. Do a planet's gravity and distance from the Sun affect what kinds of gases its atmosphere contains? Use your ability to interpret a data table to find out.

#### Identifying the Problem

The table below lists the main gases in the atmospheres of two inner and two outer planets. Each planet's atmosphere also contains many other gases, but these are only present in small amounts. Looking at the table, what conclusions can you draw? How do you think a planet's distance from the Sun and the size of the planet contribute to the kind of atmosphere it has?

#### Solving the Problem

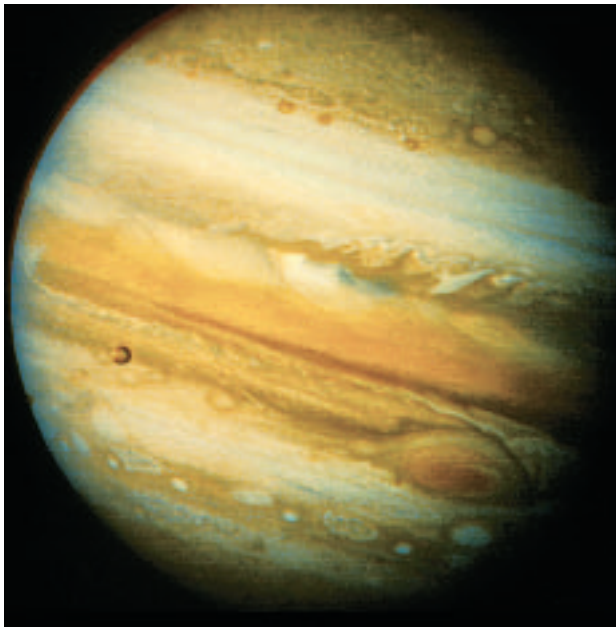
1. What gases do the atmospheres of the inner and outer planets contain?

What is special about Earth's atmosphere that makes it able to support modern life?

2. Can you think of any reasons why the outer planets have the gaseous atmospheres they do? *Hint: Hydrogen and Helium are the two lightest elements.*

#### Atmospheric Composition of the Planets

Earth	78.1% nitrogen; 20.9% oxygen; traces of argon and carbon dioxide
Mars	95.3% carbon dioxide; 2.7% nitrogen; 1.6% argon; 0.13% oxygen; 0.08% carbon monoxide
Jupiter	86.1% molecular hydrogen; 13.8% helium
Uranus	82.5% molecular hydrogen; 15.2% helium; about 2.3% methane



Jupiter's atmosphere is dense because of its gravity and great distance from the Sun.



Saturn's rings include seven main divisions—each of which is composed of particles of ice and rock.

**Figure 20** The first four outer planets—Jupiter, Saturn, Uranus, and Neptune are known also as the gas giants.



**Jupiter's Moons** The four largest moons of Jupiter are Io, Europa, Ganymede, and Callisto. They are called the Galilean satellites after Galileo Galilei, who discovered them in 1610. Volcanoes continually erupt on Io, the most volcanically active body in the solar system. An ocean of liquid water is hypothesized to exist beneath the cracked, frozen ice crust of Europa. Does this mean that life could exist on Europa? The National Aeronautics and Space Administration (NASA) is studying a mission to launch an orbiting spacecraft in 2008 to study this moon.

**Saturn** The next outer planet is Saturn, shown in **Figure 20**. The gases in Saturn's atmosphere are made up in large part of hydrogen and helium. Saturn is the sixth planet from the Sun. It often is called the ringed planet because of its striking ring system. Although all of the gaseous giant planets have ring systems, Saturn's rings are by far the most spectacular. Saturn is known to have seven major ring divisions made up of hundreds of smaller rings. Each ring is made up of pieces of ice and rock.

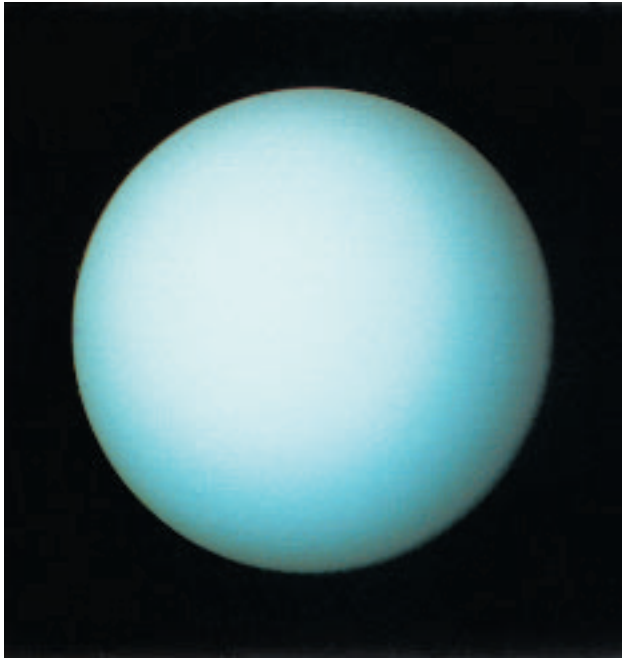
Saturn has at least 31 moons, the largest of which is Titan. The atmosphere surrounding Titan is denser than the atmospheres of either Earth or Mars. The environment on Titan might be similar to the environment on Earth before oxygen became a major atmospheric gas.



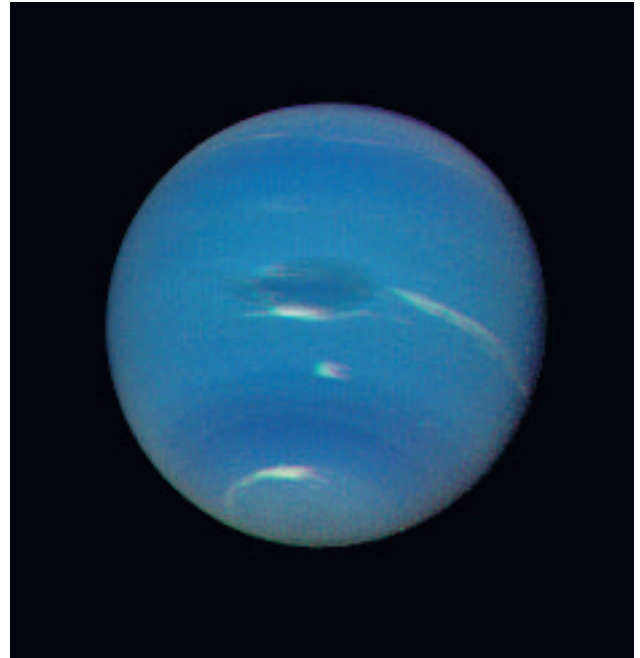
#### Topic: The Planets

Visit [green.mssscience.com](http://green.mssscience.com) for Web links to information about the planets.

**Activity** Decide which planet interests you most and make a list of three questions you would like to ask an astronomer about it.



The bluish-green color of Uranus is thought to be caused by methane in its atmosphere.



Like Uranus, the blue color of Neptune is also thought to be caused by methane. The Great Dark Spot was a storm system similar in size to the diameter of Earth.

**Uranus** Shown in **Figure 20**, the seventh planet from the Sun is Uranus. The atmosphere of Uranus, made up mostly of hydrogen, also contains helium and methane. The methane gives the planet a distinctive, bluish-green color. This is because methane gas reflects blue light and absorbs red light. Uranus is thought to have at least 27 moons. However, additional satellites might exist.

**Neptune** The eighth planet from the Sun is Neptune. It is thought that Neptune's atmosphere of hydrogen, helium, and methane gradually changes into a slushlike layer, comprised partially of water and other melted ices. Toward the interior, this slushy material is thought to change into an icy solid. In turn, this icy layer may surround a central, rocky core that is about the size of Earth.

As with Uranus, the methane in Neptune's atmosphere gives the planet its bluish color, as shown in **Figure 20**. Winds in the gaseous portion of Neptune exceed speeds of 2,400 km per hour—faster than winds on any other planet.

At least eleven natural satellites of Neptune have been discovered so far and many more probably exist. The largest of these, Triton, has great geysers that shoot gaseous nitrogen into space. A lack of craters on Triton's surface suggests that the surface of Triton is fairly young.



### Interpreting Your Creature Feature

#### Procedure

1. Select any one of the planets or moons in our solar system except Earth.
2. Research its surface conditions.
3. Imagine a life-form that might have developed on your chosen planet or moon. Be sure to indicate how your creature would eat, breathe, and reproduce.

#### Analysis

1. How is this creature protected from its environment?
2. How does your creature obtain nourishment for survival?







**Figure 21** Pluto and its moon, Charon, are so close together that they usually can't be detected separately using ground-based telescopes. Because of this, Charon was discovered nearly 50 years after Pluto.

**Pluto** Pluto, shown in **Figure 21**, is so far from the Sun that it has completed less than 20 percent of one revolution around the Sun since its discovery in 1930. Pluto is totally different from the other outer planets. It is a planet that is thought to be made partly of ice and partly of rock. Apparently, a frozen layer of methane, nitrogen, and carbon monoxide sometimes covers Pluto's surface. At times, however, when Pluto is at its closest point to the Sun, these

materials thaw into their gaseous states and rise, forming a temporary atmosphere. The surface of Charon, Pluto's moon, appears to be covered by water ice.

## Other Objects in the Solar System

Other objects that exist in the solar system include asteroids, comets, and meteoroids. **Asteroids** are small, rocky objects that mostly lie in a belt located between the orbits of Mars and Jupiter. The asteroid belt is used by astronomers as a dividing line that separates the inner and outer planets. Jupiter's tremendous gravity probably kept a planet from forming from the matter contained in the asteroid belt.

**Comets** are made mainly of rocky particles and water ice. As their orbits approach the Sun, parts of comets vaporize and form tails. Comet tails, shown in **Figure 22**, always point away from the Sun. Almost all of the solar system's comets are located in the Kuiper Belt and the Oort Cloud. The Kuiper Belt is located beyond Neptune's orbit, and the Oort Cloud is located far beyond Pluto's orbit.

When comets break up, some of the resulting particles remain in orbit. When asteroids collide, small pieces break off. Both of these processes produce small objects in the solar system known as meteoroids. If meteoroids enter Earth's atmosphere, they are called meteors, and when they fall to Earth, they are called meteorites.

**Reading Check** *How are meteoroids related to meteorites?*

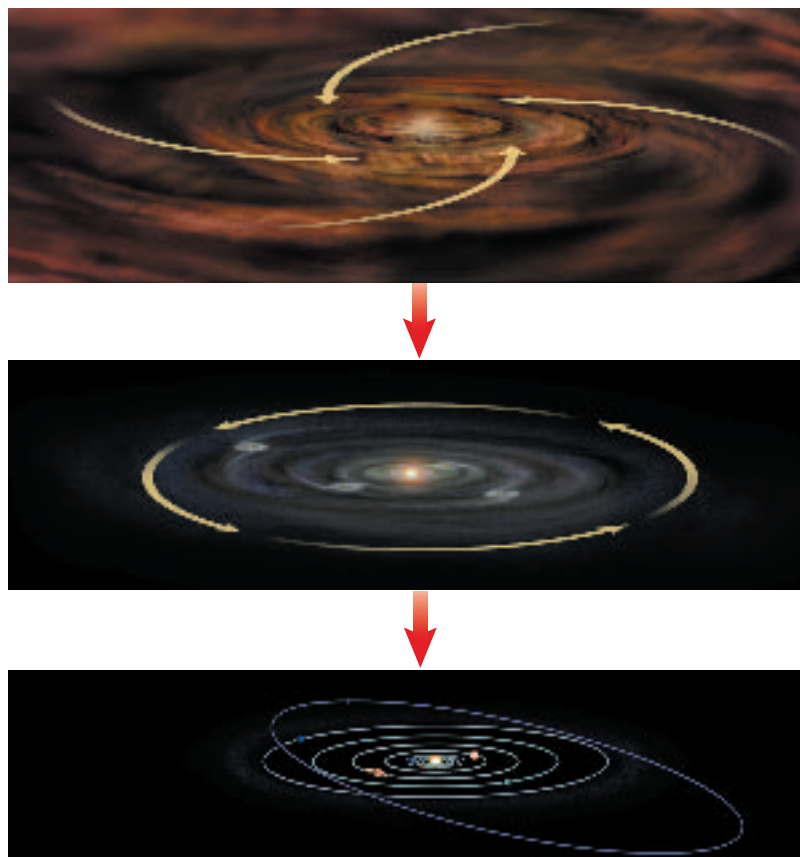


**Figure 22** The brilliant head of a comet, called a coma, glows as its ices vaporize upon approaching the Sun.



## Origin of the Solar System

How did the solar system begin? One hypothesis is that the Sun and all the planets and other objects condensed from a large cloud of gas, ice, and dust about 5 billion years ago, as illustrated in **Figure 23**. This large **nebula** (NEB yuh luh), or cloud of material, was rotating slowly in space. Shock waves, perhaps from a nearby exploding star, might have caused the cloud to start condensing. As it condensed, it started rotating faster and flattened into a disk. Most of the condensing material was pulled by gravity toward the center to form an early Sun. The remaining gas, ice, and dust in the outer areas of the nebula condensed, collided, and stuck together forming planets, moons, and other components of the solar system. Conditions in the inner part of the cloud caused small, solid planets to form, whereas conditions in the outer part were better for the formation of gaseous giant planets. Comets are thought to be made up of material left over from the original condensation of the cloud.



**Figure 23** The solar system is thought to have formed from a cloud of rotating gases and dust particles.

### section 3 review

#### Summary

##### Solar System

- An astronomical unit or AU is used to measure distance in the solar system.
- The solar system includes nine planets and other objects, such as asteroids and comets.

##### Planets

- Mercury, Venus, Earth, and Mars are the inner planets.
- They are similar in size to Earth.
- Jupiter, Saturn, Uranus, Neptune, and Pluto are the outer planets.

##### Origin of the Solar System

- One hypothesis is that the Sun, planets, and other objects formed from a large cloud of gas, ice, and dust about 5 billion years ago.

#### Self Check

1. **Explain** why astronomers do not use kilometers to measure distances in the solar system.
2. **Explain** why Venus is called Earth's twin planet.
3. **Explain** how 3-km-high cliffs could have formed on the surface of Mercury.
4. **Think Critically** How can the composition of the planets in the solar system be explained by the hypothesis described on this page?

#### Applying Math

5. **Calculate Ratios** Research the equatorial diameters of Earth's Moon and the four Galilean moons of Jupiter. Calculate the ratio of each moon's diameter to that of Earth's Moon.

### The Slant of the Sun's Rays

#### Goals

■ **Design** a model for simulating the effect of changing angles of the Sun's rays on Earth's surface temperatures.

#### Materials

shallow baking pans lined with cardboard

\*paper, boxes, or box lids  
thermometers

wood blocks

\*bricks or textbooks

protractor

clock

\*stopwatch

\*Alternate materials

#### Data Source

Copy the data table into your Science Journal and fill it in, providing angles of the Sun's rays for your area. Go to [green.mssscience.com](http://green.mssscience.com) to collect this data.

#### Safety Precautions



Use thermometers as directed by teacher. Do not use "shake down" lab thermometers.

**WARNING:** Never look directly at the Sun at any time during your experiment.

During winter in the northern hemisphere, the north pole is positioned away from the Sun. This causes the angle of the Sun's rays striking Earth to be smaller in winter than in summer, and there are fewer hours of sunlight. The reverse is true during the summer months. The Sun's rays strike Earth at higher angles that are closer to 90°.

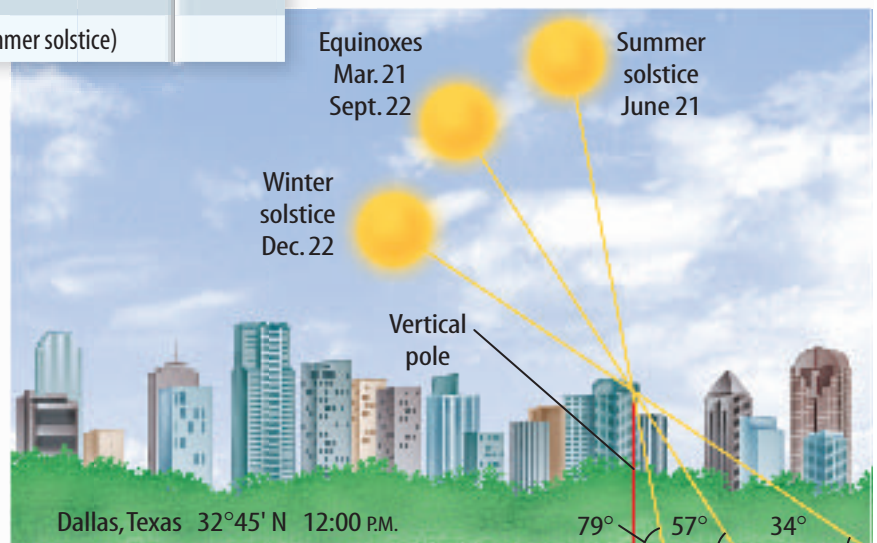


#### Real-World Question

How does the angle of the Sun's rays affect Earth's surface temperature?

#### Angle of the Sun's Rays at Noon at Your Latitude

Date	Angle
December 22 (winter solstice)	
January 22	
February 22	
March 21 (vernal equinox)	
April 21	
May 21	
June 21 (summer solstice)	





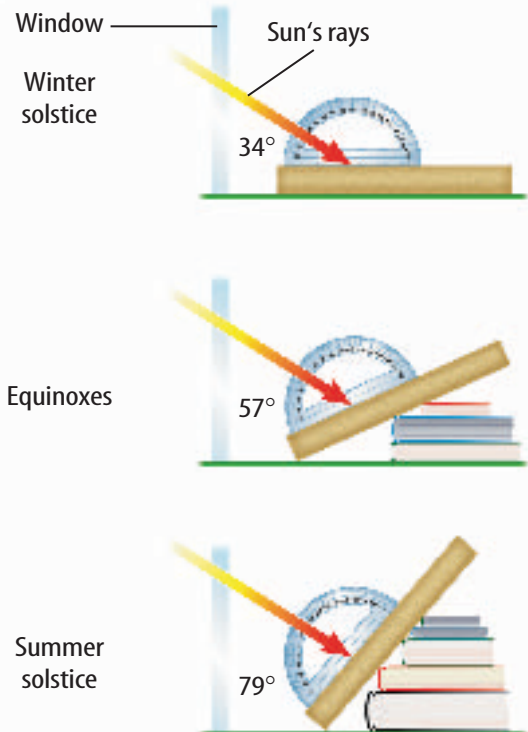
## Using Scientific Methods

### Plan the Model

1. **Design** a model that will duplicate the angle of the Sun's rays during different seasons of the year.
2. Choose the materials you will need to construct your model. Be certain to provide identical conditions for each angle of the Sun's rays that you seek to duplicate.

### Check the Model Plans

1. **Present** your model design to the class in the form of diagrams, poster, slide show, or video. Ask your classmates how your group's model design could be adjusted to make it more accurate.
2. Decide on a location that will provide direct sunlight and will allow your classmates to easily observe your model.



### Make a Model

1. Create a model that demonstrates the effects different angles of the Sun's rays have on the temperature of Earth's surface.
2. **Demonstrate** your model during the morning, when the Sun's rays will hit the flat tray at an angle similar to the Sun's rays during winter solstice. Measure the angle of the Sun's rays by laying the protractor flat on the tray. Then sight the angle of the Sun's rays with respect to the tray.
3. Tilt other trays forward to simulate the Sun's rays striking Earth at higher angles during different times of the year.

### Conclude and Apply

1. **Determine** Which angle had the greatest effect on the surface temperature of your trays? Which angle had the least effect?
2. **Predict** how each of the seasons in your area would change if the tilt of Earth's axis changed suddenly from 23.5 degrees to 40 degrees.

### Communicating Your Data

**Demonstrate** your model for your class. Explain how your model replicated the angle of the Sun's rays for each of the four seasons in your area.

Collision  
CourseWill an  
asteroid  
collide with  
Earth?

**A**steroids have been the basis for several disaster movies. Can asteroids really threaten Earth? “Absolutely!” say many scientists who study space. In fact, asteroids have hit our planet many times.

Earth is scarred with about 120 recognizable craters and others may be covered by erosion, plant growth, and other processes. Visitors to Meteor Crater, Arizona, can see a 1.2-km-wide depression caused by an asteroid that impacted Earth about 49,000 years ago. A much older crater lies in Mexico’s Yucatan Peninsula. This depression is about 195 km wide and was created about 65 million years ago.

Some scientists believe the Yucatan asteroid created a giant dust cloud that blocked the Sun’s rays from reaching Earth for about six months and led to freezing temperatures. This would have put an end to much of Earth’s early plant life, and may have led to the extinction of the dinosaurs and many other species.



**Meteor Crater, near Winslow, Arizona, was formed about 49,000 years ago. It is about 200 m deep.**

## Rocks in Space

Can we protect ourselves from such an impact? Astronomer/geologist Eugene Shoemaker thinks so, and is responsible for alerting the world to the dangers of asteroid impact. In 1973, he and geologist Eleanor Helin began the first Near Earth Objects (NEO) watch at the Mount Palomar Observatory in California. But few others were concerned.

Then, in 1996, all that changed. An asteroid, about 0.5 km wide, came within 450,800 km of Earth. Scientists said this was a close call! Today, groups of scientists are working on creating systems to track NEOs. As of 2003, they recorded 2,565 NEOs. Of those, nearly 700 were at least 1.0 km in diameter.

Don’t worry, though: there is little chance of an asteroid hitting Earth anytime soon. When an asteroid hits Earth’s atmosphere, it is usually vaporized completely. Just in case, some physicists and astronomers are thinking about ways to defend our planet from NEOs.

**Brainstorm** Working in small groups, come up with as many ways as you can to blast an asteroid to pieces or make it change course before hitting Earth. Present your reports to the class.

Science  **online**

For more information, visit  
[green.msscience.com/time](http://green.msscience.com/time)

## Reviewing Main Ideas

### Section 1 Earth's Motion

1. Earth's shape is nearly spherical.
2. Earth's motions include rotation around its axis and revolution around the Sun.
3. Earth's rotation causes day and night. Its tilt and revolution cause the seasons.

### Section 2 Earth's Moon

1. Surface features on the Moon include maria, craters, and lunar highlands.
2. The Moon rotates once and revolves around Earth once in 27.3 days.
3. Phases of Earth's Moon, solar eclipses, and lunar eclipses are caused by the Moon's revolution around Earth.

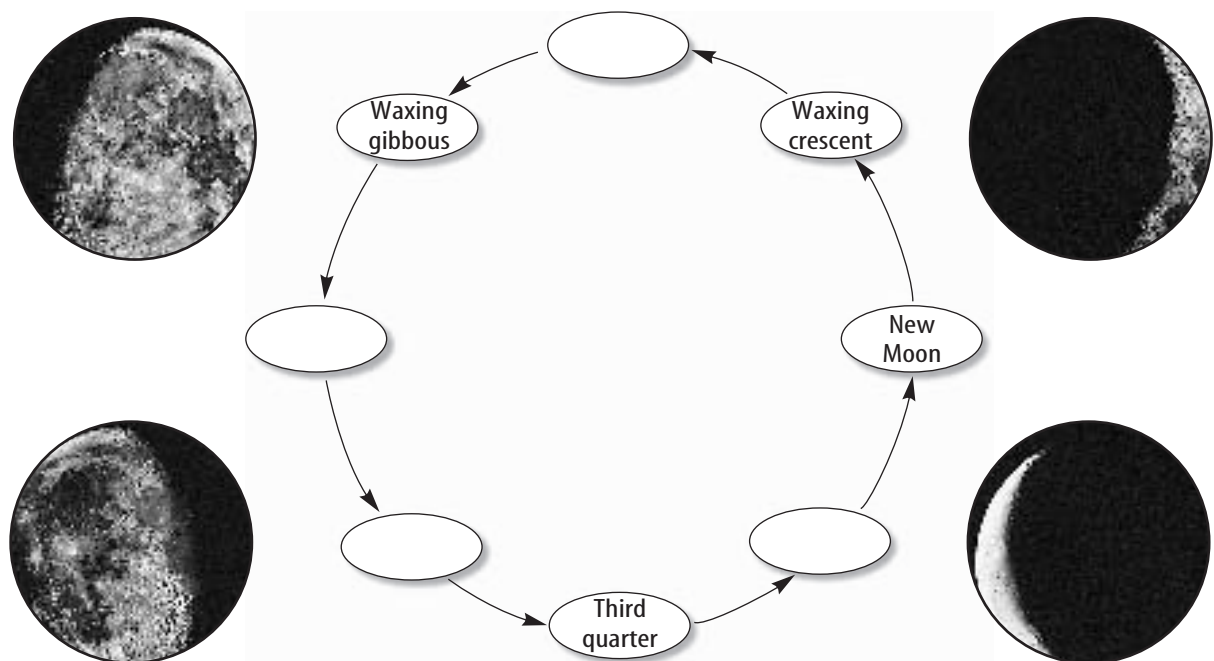
4. One hypothesis concerning the origin of Earth's Moon is that a Mars-sized body collided with Earth, throwing off material that later condensed to form the Moon.

### Section 3 Our Solar System

1. The solar system includes the Sun, planets, moons, asteroids, comets, and meteoroids.
2. Planets can be classified as inner or outer.
3. Inner planets are small and rocky with thin atmospheres (or none). Outer planets are generally large and gaseous with thick atmospheres.
4. One hypothesis on the origin of the solar system states that it condensed from a large cloud of gas, ice, and dust.

## Visualizing Main Ideas

Copy and complete the following concept map to complete the moon phase cycle.





## Using Vocabulary

asteroid p. 200	nebula p. 201
astronomical unit p. 194	orbit p. 181
axis p. 180	revolution p. 181
comet p. 200	rotation p. 180
crater p. 185	solar eclipse p. 189
equinox p. 183	solar system p. 194
lunar eclipse p. 190	solstice p. 182
moon phase p. 187	

Fill in the blanks with the correct word or words.

1. A(n) \_\_\_\_\_ is a chunk of rock that circles the sun between the orbits of Mars and Jupiter.
2. The motion that describes Earth's orbit around the Sun is called \_\_\_\_\_.
3. The times when the Sun reaches its greatest distance north or south of the equator is called a(n) \_\_\_\_\_.
4. When Earth passes between the Sun and the Moon, a(n) \_\_\_\_\_ can result.
5. The changing views of the Moon seen from Earth are called \_\_\_\_\_.

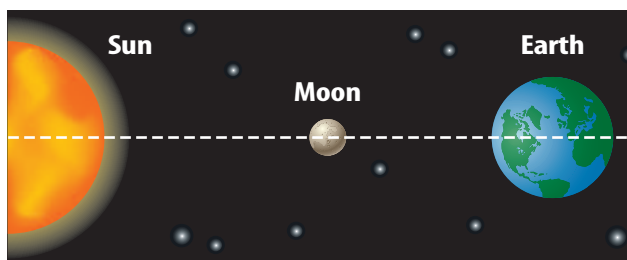
## Checking Concepts

Choose the word or phrase that best answers the question.

6. Which motion refers to Earth's spinning on its axis?  
**A)** rotation  
**B)** waxing  
**C)** revolution  
**D)** waning
7. What occurs twice each year when Earth's tilt is neither toward nor away from the Sun?  
**A)** orbit  
**B)** equinox  
**C)** solstice  
**D)** axis

8. What is the imaginary line around which Earth spins?  
**A)** orbit  
**B)** equinox  
**C)** solstice  
**D)** axis
9. Which moon surface features probably formed when lava flows filled large basins?  
**A)** maria  
**B)** craters  
**C)** highlands  
**D)** volcanoes
10. Meteorites that strike the Moon's surface cause which surface feature?  
**A)** maria  
**B)** craters  
**C)** highlands  
**D)** volcanoes
11. How long is the Moon's period of revolution?  
**A)** 27.3 hours  
**B)** 29.5 hours  
**C)** 27.3 days  
**D)** 29.5 days
12. How long does it take for the Moon to rotate once on its axis?  
**A)** 27.3 hours  
**B)** 29.5 hours  
**C)** 27.3 days  
**D)** 29.5 days

Use the illustration below to answer question 13.



13. What could result from the alignment shown above?  
**A)** lunar eclipse  
**B)** solar eclipse  
**C)** full moon  
**D)** waxing crescent
14. Which planet is most like Earth in size and mass?  
**A)** Mercury  
**B)** Mars  
**C)** Saturn  
**D)** Venus
15. Europa is a satellite of which planet?  
**A)** Uranus  
**B)** Saturn  
**C)** Jupiter  
**D)** Mars

## Thinking Critically

16. **Compare and contrast** the inner and outer planets.
17. **Explain** why more maria are found on the near side of the Moon than on the far side.
18. **Explain** why scientists hypothesize that life might exist on Europa.
19. **Describe** the Sun's positions relative to the equator during winter and summer solstices and equinox.
20. **Classify** A new planet is found circling the Sun, and you are given the job of classifying it. The new planet has a thick, dense atmosphere and no apparent solid surface. It lies beyond the orbit of Pluto. How would you classify this newly discovered planet?
21. **Make and Use Tables** Copy and complete the table of outer planets. Show how many satellites each planet has and what gases are found in each planet's atmosphere.

Planetary Facts		
Planet	Number of Satellites	Major Atmospheric Gases
Jupiter		
Saturn		
Uranus		
Neptune		
Pluto		

22. **Sequence** the phases of the moon starting and ending with the new moon phase, and explain why we can see only these lighted portions of the Moon. Consider the fact that the Sun lights one half of the Moon at all times.

## Performance Activities

23. **Observe** the moons of Jupiter. You can see the four Galilean moons using binoculars of at least  $7\times$  power. Check the newspaper, almanac, or other reference to see whether Jupiter is visible in your area and at what times. Depending on where they are in their orbits and how clear a night it is, you may be able to see all of them.
24. **Display** Design a chart showing the nine planets, using the appropriate colors for each. Include rings and moons and any other characteristics mentioned in this chapter.

## Applying Math

Use the table below to answer question 25.

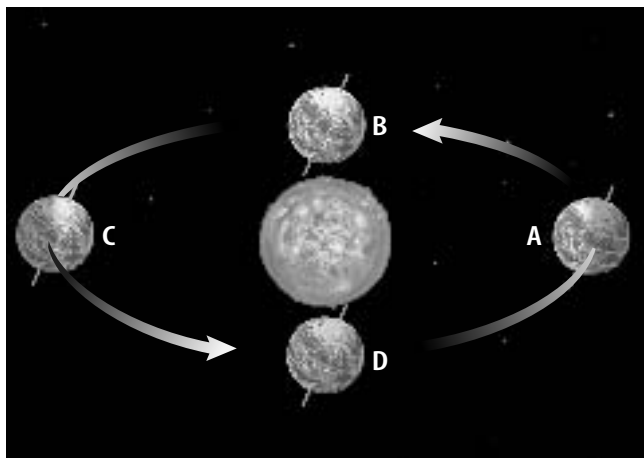
Some Planet Diameters	
Planet	Kilometers (km)
Earth	12,700
Jupiter	143,000
Saturn	120,000
Uranus	50,800
Neptune	50,450

25. **How Giant Are They?** Using the data in the table above calculate the ratios between the diameter of Earth and each of the gas giants.
26. **Jupiter's Orbit** The orbit of Jupiter lies about 4.2 AU from that of Earth. Express this distance in kilometers.
27. **Martian Mass** The mass of Mars is about 0.11 times that of Earth. Assuming that the mass of Earth is  $5.98 \times 10^{24}$  kg, calculate the mass of Mars.

**Part 1 Multiple Choice**

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the illustration below to answer questions 1 and 2.



- At which point in Earth's orbit does summer begin in the southern hemisphere?  
A. A                      C. C  
B. B                      D. D
- Which two positions indicate equinoxes, when day and night lengths are nearly equal all over the world?  
A. A and C              C. B and D  
B. B and C              D. A and D
- Which of these instruments monitors moonquakes to yield information about the Moon's interior?  
A. telescope              C. seismograph  
B. spectroscope        D. centrifuge

**Test-Taking Tip**

**Consider All Choices** Be sure you understand the question before you read the answer choices. Make special note of words like NOT or EXCEPT. Read and consider all the answer choices before you mark your answer sheet.

**Question 2** Be sure that both letters represent equinoxes.

- Which of these is referred to as a terrestrial planet?  
A. Saturn                      C. Neptune  
B. Uranus                      D. Venus

Use the illustration below to answer questions 5 and 6.



- Which letter corresponds to the moon phase waning crescent?  
A. D                      C. B  
B. H                      D. F
- During which moon phase could a solar eclipse occur?  
A. A                      C. C  
B. E                      D. G
- Which of these planets has a large, permanent storm in its atmosphere known as the Great Red Spot?  
A. Saturn                      C. Jupiter  
B. Venus                      D. Neptune
- Between the orbits of which two planets is the asteroid belt found?  
A. Earth and Mars  
B. Mars and Jupiter  
C. Jupiter and Saturn  
D. Mercury and Venus
- Which of the following terms is used to describe the motion of Earth as it orbits the Sun?  
A. revolution              C. rotation  
B. ellipse                      D. solstice
- Which is a satellite of Saturn?  
A. Charon                      C. Phobos  
B. Europa                      D. Titan



## Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

11. Explain how Earth's shape differs somewhat from a perfect sphere.
12. Explain how mass and the distance of an object from other objects affect its gravitational force.
13. Why does the same side of the Moon always face Earth?

Use the illustration below to answer questions 14 and 15.



14. During what type of eclipse might you observe something like the image in this photograph? What causes the dark circle in the center of the image?
15. Identify the three solar system members which line up to cause this type of eclipse. Describe the order in which they align.
16. Define the unit used to describe distances in the solar system. Why is this unit used rather than kilometers?
17. Compare the atmospheres of Venus, Earth, and Mars.
18. Why do Neptune and Uranus appear blue or bluish-green?
19. How can lunar craters help to determine the relative age of a particular area on the Moon's surface?

## Part 3 Open Ended

Record your answers on a sheet of paper.

20. Explain how the tilt of Earth's axis causes warmer summer than winter temperatures in the northern hemisphere.
21. Scientists have proposed several hypotheses to explain the Moon's origin. Choose two hypotheses and describe how they differ.
22. Describe two observations which can be made with the unaided eye from Earth that show Earth is spherical.

Use the illustration below to answer question 23.



23. The photos show Jupiter's moons Io and Europa, respectively. Could life exist on these moons? Why or why not?
24. Compare and contrast the motions of Earth and the Moon in space.
25. Imagine your spacecraft has landed somewhere on the planet Mars. Describe your observations of the surface.
26. Explain the differences among meteoroids, meteors, and meteorites.
27. Describe the composition of comets and explain what happens as they come closer to the Sun.
28. Describe the asteroid belt and explain what may have caused it to form.