

**California Science Standards****8.2.g, 8.4.d, 8.4.e****BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How did Earth's moon form?
- How does the moon appear as it revolves around Earth?
- What moons revolve around other planets?

What Are Moons?

Organize In your notebook, create a concept map about Earth's moon, including information about its origin, phases, eclipses, and how it shines.

Natural or artificial bodies that revolve around larger bodies such as planets are called **satellites**. Except for Mercury and Venus, all of the planets have natural satellites, called moons. Moons come in a wide variety of sizes, shapes, and compositions.

What Do We Know About Earth's Moon?

Scientists have learned a lot about Earth's moon, which is also called *Luna*. Much of what we know comes from observations from Earth, but recent discoveries have come from visiting the moon. Some lunar rocks brought back by Apollo astronauts were studied and found to be almost 4.6 billion years old. These rocks have not changed much since they were formed. This tells scientists that the solar system itself is at least 4.6 billion years old.

**READING CHECK**

1. Explain How do scientists know what the moon's crust is made of?

TAKE A LOOK

2. Identify What are the circular features on the moon's face, and how did they form?

THE MOON'S SURFACE

The moon's surface is almost as old as Earth. It is covered with craters, many of which can be seen from Earth on a clear night. Because the moon has no atmosphere and no erosion, its surface shows where objects have collided with it. Scientists think that many of these collisions happened about 3.8 billion years ago. They were caused by matter left over from the formation of the solar system.

This image of Earth's moon was taken by the *Galileo* spacecraft while on its way to Jupiter. The large, dark areas are lava plains called *maria*.



SECTION 4 Moons *continued***THE ORIGIN OF THE MOON**

When scientists studied the rock samples brought back from the moon by astronauts, they found some surprises. The composition of the moon is similar to that of Earth's mantle. This evidence has led to a new theory about the moon's formation. ☐

Scientists have created a new theory to explain what they now know. As shown in the figure below, they now think that there was a collision between Earth and another object about the size of Mars. This collision occurred while Earth was still forming. It was so violent that a large mass of material was thrown into orbit around Earth.

Gravity pulled this material into a sphere. The sphere continued to revolve around the planet. We now know it as the moon.

Moon Statistics

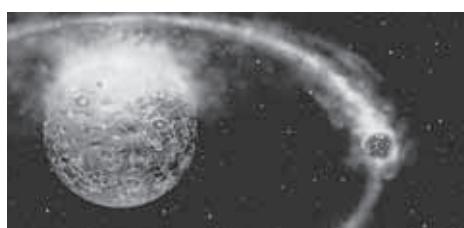
Distance from Earth	384,000 km
Period of rotation	27 days, 7 h
Period of revolution	27 days, 7 h
Diameter	3,475 km
Density	3.34 g/cm ³
Surface gravity	16% of Earth's

Formation of the Moon

1 Impact About 4.45 billion years ago, a body the size of Mars collided with the still molten Earth.



2 Ejection The debris from the collision, much of it from Earth's mantle, began to revolve around Earth.



3 Formation The clumps of material pulled together to form the moon.

**READING CHECK**

- 3. Identify** What discovery caused scientists to revise their theory about the origin of the moon?
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TAKE A LOOK

- 4. Identify** According to this theory, material was thrown from Earth in clumps. What caused the material to come together as a sphere?
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SECTION 4 Moons *continued***CALIFORNIA
STANDARDS CHECK**

8.4.d Students know that stars are the source for all bright objects in outer space and that the Moon and the planets shine by reflected sunlight, not their own light.

- 5. Compare** The moon does not produce its own light. How can the moon be seen from Earth?

**READING CHECK**

- 6. Explain** What causes the moon to have a different appearance during a month?

MOONLIGHT

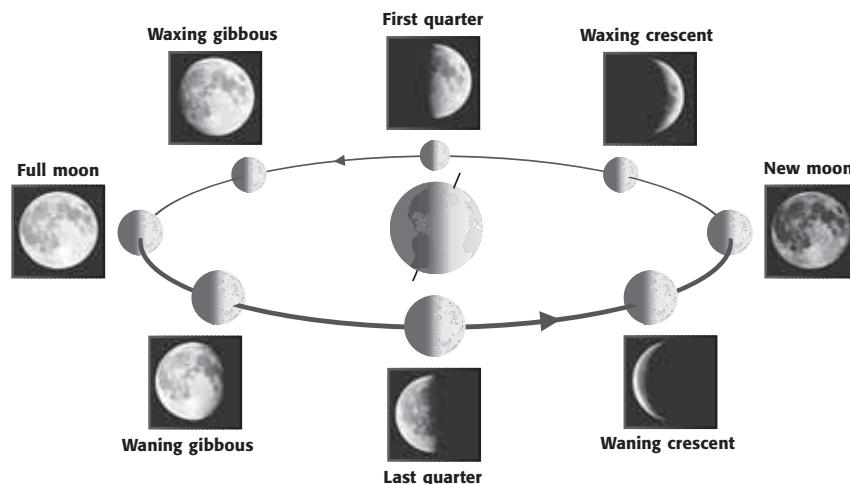
Unlike the sun, the moon does not generate its own energy in the form of light. The moon and all the planets shine because they reflect light from the sun. The total amount of sunlight that reaches the moon is always the same. The amount that is reflected to Earth varies.

PHASES OF THE MOON

Half the moon is always in sunlight. However, because the moon revolves around Earth, we cannot always see all of the part that is reflecting light. The moon revolves around the Earth once each month. It is interesting that it also rotates on its axis in exactly the same period. That's why we always see the same side of the moon.

During the month, the face of the moon that we can see changes from a fully lit circle to a thin crescent and then back to a circle. As the moon changes its position in relation to the sun and Earth, it has a different appearance. The figure below shows how the moon's appearance changes as it moves around Earth.

The different appearances of the moon are called **phases**. When the moon is *waxing*, the amount of sunlight reflected off the moon and toward Earth increases every day. The moon appears to get bigger. When the moon is *waning*, the proportion of the sunlit side that we can see decreases every day. The moon appears to get smaller.



The positions of the moon, sun, and Earth determine which phase the moon is in. The photo inserts show how the moon looks from Earth at each phase.

TAKE A LOOK

- 7. Identify** In the figure, where is the sunlight coming from?

SECTION 4 Moons *continued*

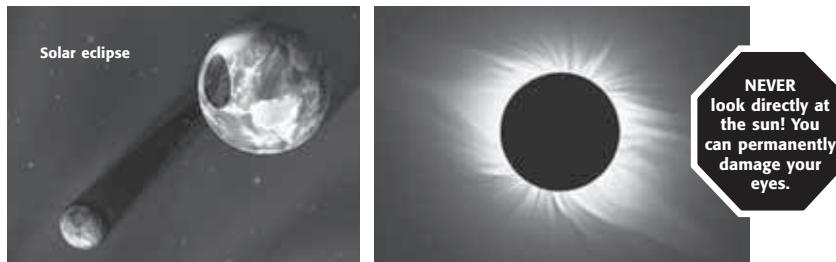
What Is an Eclipse?

An **eclipse** occurs when the shadow of one celestial body falls on another. A *solar eclipse* happens when the moon comes between the sun and Earth. Then the shadow of the moon falls on part of Earth's surface. A *lunar eclipse* happens when Earth comes between the sun and the moon. Then the shadow of Earth falls on the moon.

SOLAR ECLIPSES

Because the moon's orbit is elliptical, or oval, instead of circular, the distance between Earth and the moon changes. When the moon is close to Earth in its orbit, the moon appears to be exactly the same size as the sun.

If the moon passes between the sun and Earth during that part of its orbit, there is a *total solar eclipse*, as shown in the figure below. If the moon is farther from Earth, the eclipse is an *annular eclipse*. A thin ring of the sun can be seen around the moon.



On the left is a diagram of the positions of Earth and the moon during a solar eclipse. On the right is a picture of the sun's outer atmosphere, or *corona*, which is visible only when the entire disk of the sun is blocked by the moon.

THE MOON'S TILTED ORBIT

The moon rotates around Earth each month, so you might expect that there would be a solar eclipse each month. In reality, total solar eclipses occur only about once a year.

Solar eclipses don't occur monthly because the moon's orbit is slightly tilted in relation to Earth's orbit around the sun. Earth must be in the moon's shadow for there to be a solar eclipse. The moon's tilt places Earth out of the moon's shadow for most new moons. So, a solar eclipse is not seen monthly.

**READING CHECK**

- 8. Explain** What is the arrangement of the position of the sun, the moon, and Earth during a solar eclipse?
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-

TAKE A LOOK

- 9. Explain** Why can a solar eclipse not be seen from every point on Earth?
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**READING CHECK**

- 10. Explain** Why don't solar eclipses occur each month?
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SECTION 4 Moons *continued***LUNAR ECLIPSES**

A lunar eclipse occurs during a full moon when the moon passes through the shadow of Earth. Like solar eclipses, lunar eclipses do not occur each month. Unlike a solar eclipse, however, a lunar eclipse can be seen from much of the night side of the planet. The right-hand side of the figure below shows the position of Earth and the moon during a lunar eclipse.

Lunar eclipses are interesting to watch. At the beginning and end of a lunar eclipse, the moon is in the outer part of the shadow. In this part of the shadow, Earth's atmosphere filters out some of the blue light. As a result, the light that is reflected from the moon is red.



As the moon moves into Earth's shadow, the lower part is still in sunlight.

This is the position of Earth and the moon during a lunar eclipse.


Say It

Discuss In a group, discuss why you can't look at the sun during a solar eclipse but you can look at the moon during a lunar eclipse.


READING CHECK

- 11. Compare** Which types of planets tend to have the most moons, terrestrial or gas giant?

Are Other Moons Like Earth's Moon?

All of the planets, except Mercury and Venus, have moons. Pluto has three known moons and Mars has two. All of the gas giants have many moons, some of which were discovered fairly recently, using spacecraft cameras or the Hubble Space Telescope. Some moons may not have been discovered yet. 

The solar system's moons vary widely. Moons range in size from very small bits of rock to objects as large as a terrestrial planet. Their orbits range from nearly circular to very elliptical. Most moons orbit in the same direction as the planets orbit the sun (prograde rotation). However, some orbit in the opposite direction (retrograde rotation).

THE MOONS OF MARS

Mars has two moons, Phobos and Deimos. They are small, oddly shaped satellites. Both moons have dark surfaces and resemble *asteroids*, rocky bodies in space. Phobos is about 22 km across at its largest dimension and Deimos is about 15 km across. Both moons may be asteroids that were captured by the gravity of Mars. 


READING CHECK

- 12. Identify** What are the names of Mars's moons?

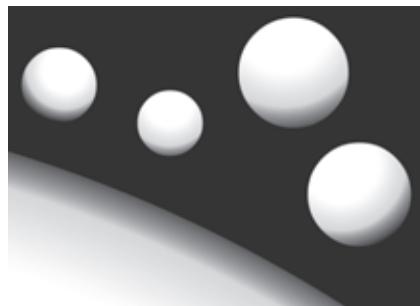
SECTION 4 Moons *continued***THE MOONS OF JUPITER**

Jupiter has more than 60 moons. The four largest were discovered in 1610 by Galileo. When he observed Jupiter through a telescope, Galileo saw what looked like four dim stars that moved with Jupiter. He observed that they changed position relative to Jupiter and each other from night to night.

These moons, Ganymede, Callisto, Io, and Europa, are known as the *Galilean moons*. They appear small compared to the giant planet, as shown in the figure below. Actually, Ganymede, with a diameter of 5300 km, is larger than Mercury. Jupiter's smaller moons range from 1 km to 250 km across.

Io, the Galilean satellite closest to Jupiter, is covered with active volcanoes. There are at least 100 active volcanoes on its surface. Many of Io's craters are covered by material from eruptions.

Evidence suggests that liquid water may lie below the icy surface of Europa. This discovery would make Europa one of the few bodies in the solar system, other than Earth, to have an ocean.



Relative sizes of Jupiter and its four largest satellites, Io, Europa, Ganymede, and Callisto. The distance is not shown to scale.

THE MOONS OF SATURN

Saturn has more than 50 moons. Saturn's largest moon, Titan, is slightly smaller than Jupiter's Ganymede. It is the only satellite in the solar system that has a sizable atmosphere. Titan's atmosphere is composed mostly of nitrogen with small amounts of other gases like methane. Its atmosphere is denser than Earth's atmosphere.

None of Saturn's other moons are as large as the Galilean moons of Jupiter. Most of them are from several kilometers to several hundred kilometers across. They are composed of frozen water and rocks.

READING CHECK

- 13. Identify** What are the names of the Galilean moons?
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READING CHECK

- 14. Identify** What may lie below the icy surface of Europa?
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Critical Thinking

15. Make Inferences

Would humans be able to live unprotected on the surface of Titan? Explain.

SECTION 4 Moons *continued***THE MOONS OF URANUS**

Uranus has at least 27 moons, most of which are small. They were discovered by space probes or orbiting observatories, such as the Hubble Space Telescope. Like the moons of Saturn, the largest moons of Uranus are made of ice and rock. Many of its smaller moons were objects traveling in space that may have been captured by Uranus's gravity.

**READING CHECK**

- 16. Explain** How did Uranus get many of its smaller moons?
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THE MOONS OF NEPTUNE

Neptune has 13 known moons. The largest, Triton, revolves in a retrograde orbit. This suggests that Triton was captured by Neptune's gravity after forming somewhere else in the solar system. Triton has a thin nitrogen atmosphere. Its surface is mostly frozen nitrogen and methane. Triton has active "ice volcanoes" that send nitrogen high into its atmosphere. Neptune's other moons are small objects made of ice and rock.

THE MOONS OF PLUTO

Pluto has three moons. The diameter of Charon is about half that of Pluto. Charon revolves around Pluto in 6.4 days, the same period as Pluto's rotation. That means that Charon is always located at the same place in Pluto's sky. Two additional moons of Pluto, discovered by the Hubble telescope in 2005, are much smaller than Charon.

Some of the Moons of the Solar System**CALIFORNIA STANDARDS CHECK**

- 8.4.e** Know the appearance, general composition, relative position and size, and motion of objects in the solar system, including planets, planetary satellites, comets, and asteroids.

17. Identify Relationships

Some of the moons of the gas giants are larger than Mercury. Why are they not considered to be planets?

Body	Moon	Diameter (km)	Period of revolution (days)
Earth	Luna	3,475	27.3
Mars	Phobos	26	0.3
Mars	Deimos	15	1.3
Jupiter	Io	3,636	1.8
Jupiter	Europa	3,120	3.6
Jupiter	Ganymede	5,270	7.1
Jupiter	Callisto	4,820	16.7
Saturn	Titan	5,150	15.9
Uranus	Titania	1,580	8.7
Neptune	Triton	2,700	5.9
Pluto	Charon	1,180	6.4

Section 4 Review

8.2.g, 8.4.d, 8.4.e



SECTION VOCABULARY

eclipse an event in which the shadow of one celestial body falls on another

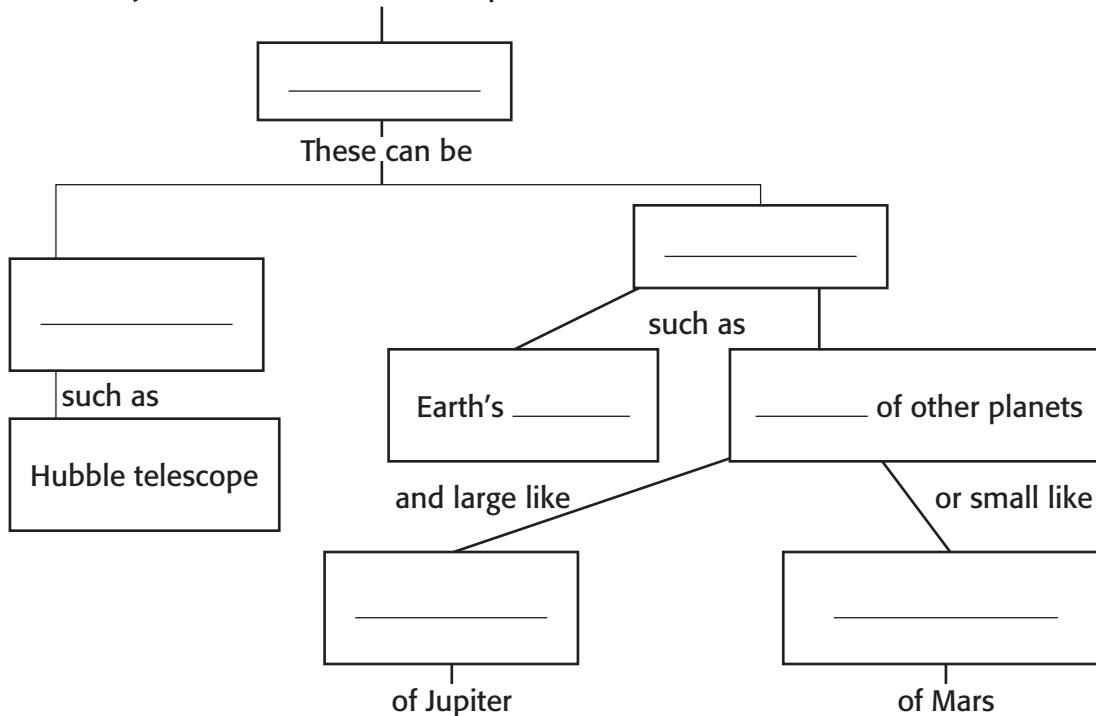
phase the change in the sunlit area of one celestial body as seen from another celestial body

satellite a natural or artificial body that revolves around a planet

1. Identify During which phase of the moon can a lunar eclipse occur?

2. Identify Fill in the blanks to complete the chart.

An object that revolves around a planet is called a



3. Analyze Methods How can astronomers use rocks from the moon to estimate the age of the solar system?

4. Analyze Concepts Does the mass of a planet seem to affect how many moons it has? Explain your answer.
