Name _____ Class _____ Date _____

CHAPTER 21 A Family of Planets

SECTION 4

Moons

BEFORE YOU READ

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

- How did Earth's moon probably form?
- How does the moon's appearance change with time?
- What moons revolve around other planets?

National Science Education Standards

ES 1a, 3a, 3b, 3c

What Are Moons?

Satellites are natural or artificial bodies that revolve around larger bodies in space, such as planets. 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.

STUDY TIP

Describe In your notebook, create a Concept Map about Earth's moon, including information about its origin, why it shines, phases, and eclipses.

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 other discoveries have come from visiting the moon. Some lunar rocks brought back by Apollo astronauts were 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 moon's crust is made of?

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THE MOON'S SURFACE

The moon 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.

Facts About Luna

Period of rotation	27 Earth days, 9 hours
Period of revolution	27 Earth days, 7 hours
Diameter	3,475 km
Density	3.34 g/cm3
Surface gravity	16% of Earth's

Math Focus

2. Identify What fraction of Earth's gravity is the moon's gravity?

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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 led to a theory about the moon's formation. ☑

Scientists now think that the moon formed when a large object collided with the early Earth. The object was probably about the size of Mars. The collision 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. Eventually, it became the moon.

READING CHECK

3. Identify What discovery caused scientists to revise their theory about the origin of the moon?

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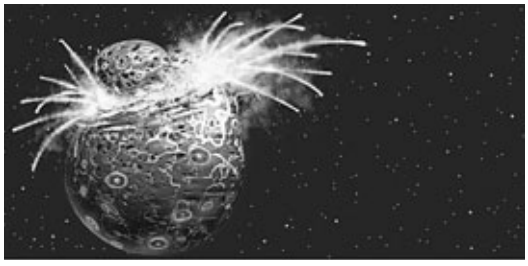
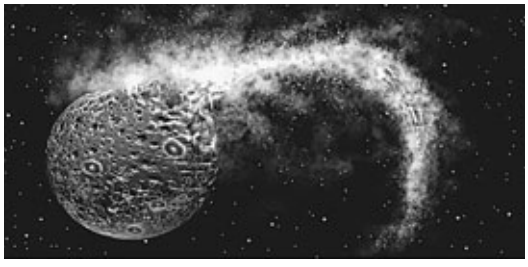
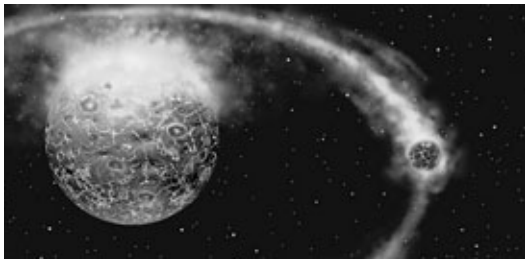
Formation of the Moon



❶ About 4.6 billion years ago, a large body collided with Earth. At this time, Earth was still mostly molten. The collision blasted part of Earth's mantle into space.



❷ Within a few hours of the collision, the debris began to orbit the Earth. The debris was made of mantle material from Earth and some iron core material from the colliding body.



❸ In time, the material began to clump together. Eventually, the moon formed. As it cooled, collisions with smaller objects produced cracks in the moon's crust. Lava flowed onto the moon's surface. This formed the dark patches, or *maria*, that we can see on the moon today.

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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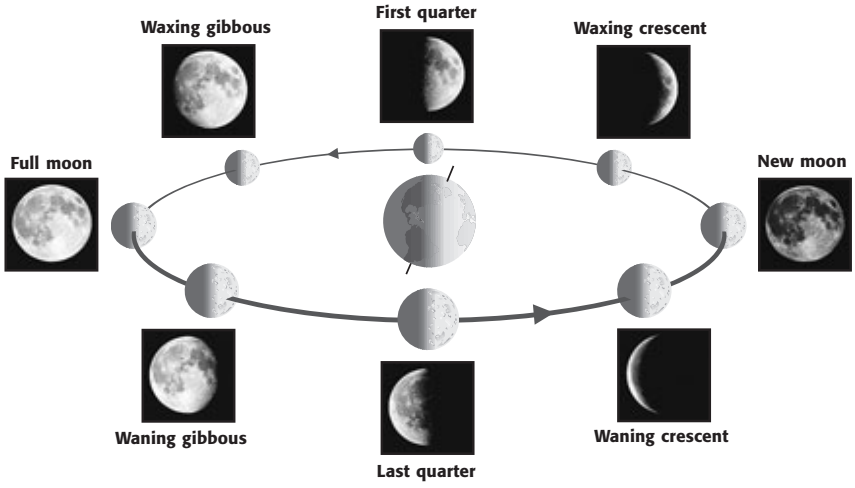
PHASES OF THE MOON

The moon revolves around the Earth once each month. It rotates on its axis in almost the same period. Therefore, we always see the same side of the moon. However, the moon does not always look the same. This is because we cannot always see all of the part that is reflecting light.

As the moon's position changes compared to the sun and Earth, it looks different to people on Earth. During a 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. 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 part of the sunlit side that we can see increases every day. The moon appears to get bigger. When the moon is *waning*, the part of the sunlit side that we can see decreases every day. The moon appears to get smaller.

What Is an Eclipse?

An **eclipse** happens when the shadow of one body in space 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. ☑

Critical Thinking

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

TAKE A LOOK

6. Explain Why does the moon look different on different nights?

READING CHECK

7. Explain What happens during a solar eclipse?

SOLAR ECLIPSES

Because the moon's orbit is elliptical (oval-shaped) instead of circular, the distance between Earth and the moon changes. When the moon is close to Earth, the moon appears to be the same size as the sun. If the moon passes between the sun and Earth during that time, there is a *total solar eclipse*. If the moon is farther from earth, the eclipse is an annular eclipse. During an *annular eclipse*, a thin ring of the sun can be seen around the moon.

TAKE A LOOK

8. Explain Why can't a solar eclipse be seen from every point on Earth?

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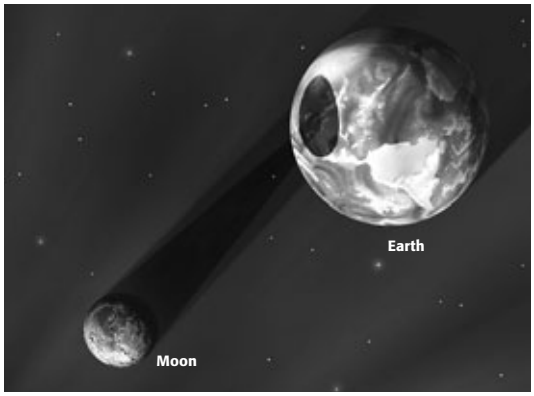

During a solar eclipse, the moon passes between the Earth and the sun.

LUNAR ECLIPSES

A lunar eclipse happens during a full moon when the moon passes through the shadow of Earth. Unlike a solar eclipse, a lunar eclipse can be seen from much of the night side of the planet. The figure below shows the position of Earth and the moon during a lunar eclipse.

TAKE A LOOK

9. Describe What happens during a lunar eclipse?

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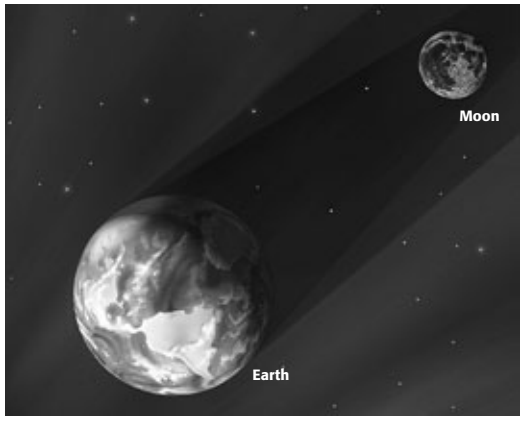


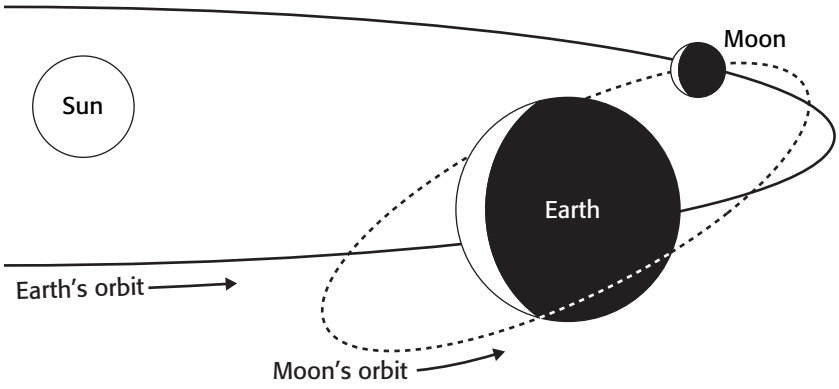
During a lunar eclipse, the Earth passes between the sun and the moon.

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.

THE MOON'S TILTED ORBIT

The moon rotates around Earth each month, so you might expect that there would be an eclipse each month. However, eclipses happen only about once a year.

Eclipses don't happen every month because the moon's orbit is slightly tilted compared to Earth's orbit. This tilt is enough to place the moon out of Earth's shadow during most full moons. It also causes the Earth to be out of the moon's shadow during most new moons. ☑



The moon's orbit is tilted compared to the Earth's. Therefore, eclipses do not happen every month.

READING CHECK

10. Explain Why don't solar eclipses occur each month?

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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.

Are Other Moons Like Earth's Moon?

All of the planets, except Mercury and Venus, have moons. Mars has two moons. All of the gas giants have many moons. Many of these moons 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. They 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. However, some orbit in the opposite direction.

READING CHECK

11. Compare Which types of planets have the most moons—terrestrial planets or gas giants?

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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*, or rocky bodies in space. Phobos is about 22 km across at its largest dimension. Deimos is about 15 km across. Both moons may be asteroids that were captured by Mars's gravity. ☑

READING CHECK

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

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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 compared to Jupiter and each other from night to night.

These moons—Ganymede, Callisto, Io, and Europa—are known as the *Galilean satellites*. They appear small compared to the giant planet. However, Ganymede is larger than Mercury. ☑

READING CHECK

13. Identify What are the names of the Galilean satellites?

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Io, the Galilean satellite closest to Jupiter, is covered with active volcanoes. There are at least 100 active volcanoes on its surface. In fact, Io is the most volcanically active body in the solar system.

Recent pictures of the moon Europa suggest that liquid water may exist below its icy surface. If Europa does contain liquid water, it is one of the few bodies in the solar system to have an ocean. ☑

READING CHECK

14. Identify What may lie below the icy surface of Europa?

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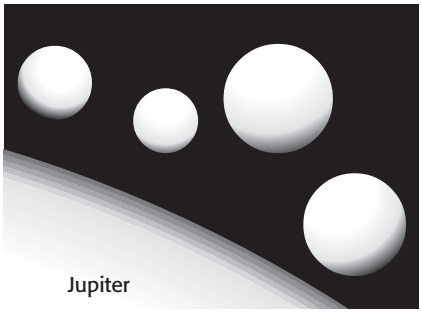

This figure shows the sizes of the four Galilean satellites compared to Jupiter.

THE MOONS OF SATURN

Saturn has more than 50 moons. Saturn's largest moon, Titan, is slightly smaller than Ganymede. Unlike most moons, Titan has an atmosphere. Its atmosphere is composed mostly of nitrogen, with small amounts of other gases, such as methane. Scientists think that Titan's atmosphere is similar to Earth's early 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 made mostly of frozen water and rocks.

Critical Thinking

15. Make Inferences Would humans be able to live unprotected on the surface of Titan? Explain your answer.

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THE MOONS OF URANUS

Uranus has at least 27 moons. Most of them are small. They were discovered by space probes or orbiting observatories, such as the Hubble Space Telescope. Like the moons of Saturn, Uranus's largest moons are made of ice and rock. ☑

READING CHECK

16. Describe What are Uranus's largest moons made of?

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THE MOONS OF NEPTUNE

Neptune has 13 known moons. The largest, Triton, revolves in a *retrograde*, or "backward," orbit. Triton's unusual orbit suggests that it 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. It has active "ice volcanoes" that send gas high into its atmosphere. Neptune's other moons are small and are made of ice and rock.

THE MOONS OF PLUTO

Although Pluto is not considered a planet, it does have at least three moons. The diameter of Charon, the largest moon, 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. These moons are called Hydra and Nix.

Some of the Moons of the Solar System

Planet	Moon	Diameter	Period of revolution
Earth	Luna	3475 km	27.3 Earth days
Mars	Phobos	26 km	0.3 Earth days
Mars	Deimos	15 km	1.3 Earth days
Jupiter	Io	3636 km	1.8 Earth days
Jupiter	Europa	3120 km	3.6 Earth days
Jupiter	Ganymede	5270 km	7.1 Earth days
Jupiter	Callisto	4820 km	16.7 Earth days
Saturn	Titan	5150 km	15.9 Earth days
Uranus	Titania	1580 km	8.7 Earth days
Neptune	Triton	2700 km	5.9 Earth days
Pluto	Charon	1180 km	6.4 Earth days

Critical Thinking

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

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Name _____ Class _____ Date _____

Section 4 Review

NSES ES 1a, 3a, 3b, 3c

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. Compare How is a solar eclipse different from a lunar eclipse?

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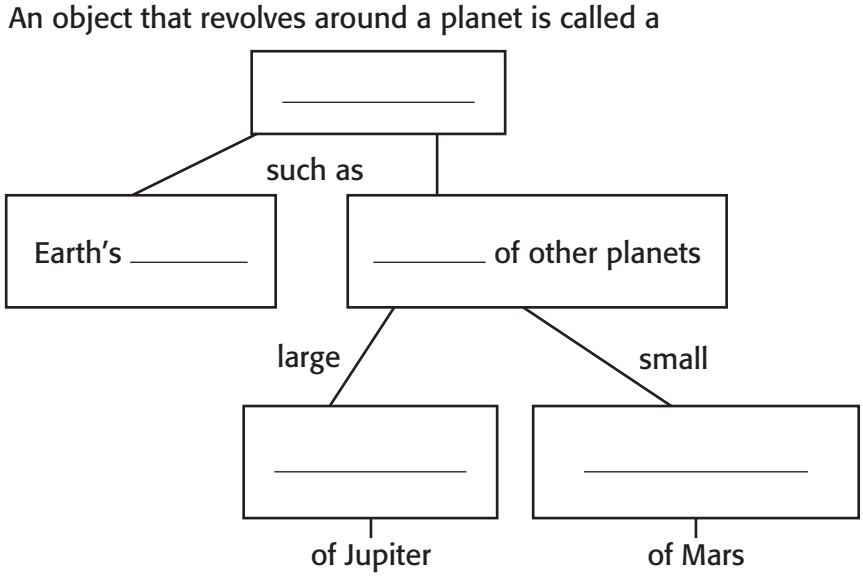
2. Identify Fill in the blanks to complete the chart.



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

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4. Explain Why don't eclipses happen every month?

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