Name _____ Class _____ Date _____

CHAPTER 16 Our Solar System

SECTION 1

A Solar System Is Born

California Science Standards

8.2.g, 8.4.b, 8.4.c, 8.4.d

BEFORE YOU READ

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

- How did the solar system form?
- How do the sun and other stars produce energy?
- How do astronomers measure large distances?

How Does a Solar Nebula Stay Together?

STUDY TIP

Organize In your notebook, make a concept map by using the terms *gravity*, *pressure*, *nebula*, *solar nebula*, *sun*, and *planets*.

At the center of our solar system is a star that we call the sun. Nine planets and other smaller objects move around the sun. Most planets have one or more moons that move around them.

The ingredients for building solar systems, such as ours, are in areas that seem to be empty space. Just as there are clouds in the sky, there are clouds in space. These clouds are called nebulas. A **nebula** is a mixture of gases and dust. The gases are mostly hydrogen and helium, and the dust is made of other elements, such as carbon and iron. ☑

READING CHECK

1. Identify What is a nebula?

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_____

GRAVITY

The gas and dust of nebulas are made of matter. The force of gravity holds matter together. In a nebula, the force of gravity is weak because the particles are small and far apart. Nebulas are less dense than the air around you. The force of gravity is just enough to keep atoms and molecules in the nebula from moving apart. ☑

READING CHECK

2. Explain Why is the force of gravity in a nebula very weak?

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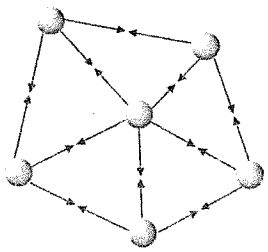
The figure below represents a close-up view of a nebula. Notice that the particles are far apart so there is little gravitational attraction between them. The particles are also moving slowly so the nebula is cold.



Gravity causes the particles in a nebula to be attracted to each other.

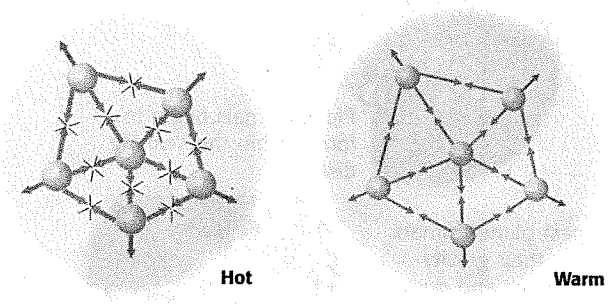
Cold

PRESSURE

Because gravity pulls particles together, you might expect that it would cause the nebula to collapse. However, this doesn't happen, because there is another force that works against gravity. That force is pressure. The particles in the nebula are in constant motion and they crash into one another. These collisions cause pressure. ☑

As particles move faster, pressure and temperature increase. In a nebula, outward pressure balances the pull of gravity and keeps the nebula from collapsing.

The figure below shows how the particles within a nebula behave as the pressure increases and also when pressure and gravity are balanced.



As particles move closer together, collisions cause pressure to increase and particles are pushed apart.

If the inward force of gravity is balanced by outward pressure, the nebula becomes stable.

What Happens When Gravity and Pressure Become Unbalanced?

The balance between gravity and pressure can be upset if two nebulas collide. It can also be upset if a nearby star explodes. These events compress, or push together, small regions of the nebula. As these regions come together, gravity pulls them into a tight mass.

As the mass tightens, particles in the mass move faster, and the temperature increases. The stage is set for a star to form. The **solar nebula**, the cloud of gas and dust that became our solar system, may have formed this way. ☑

How Did the Solar System Form?

On the next page you will see the events that could have occurred during the change from the solar nebula to the solar system. As the solar nebula collapsed, it began to rotate. The center of the rotating cloud became hotter and denser. The gas and dust around the center formed a disk that began to cool and form bigger particles. The pull of gravity caused the particles to come together and form even larger particles.

READING CHECK

3. Identify What is the cause of the pressure that works against gravity in a nebula?

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_____

Critical Thinking

4. Evaluate Models In the figure on the right, the particles appear to be stationary. How do you know that they are actually in motion?

_____

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READING CHECK

5. Identify What is the solar nebula?

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Critical Thinking

6. Identify Which affects a nebular collapse more: gravity or pressure?

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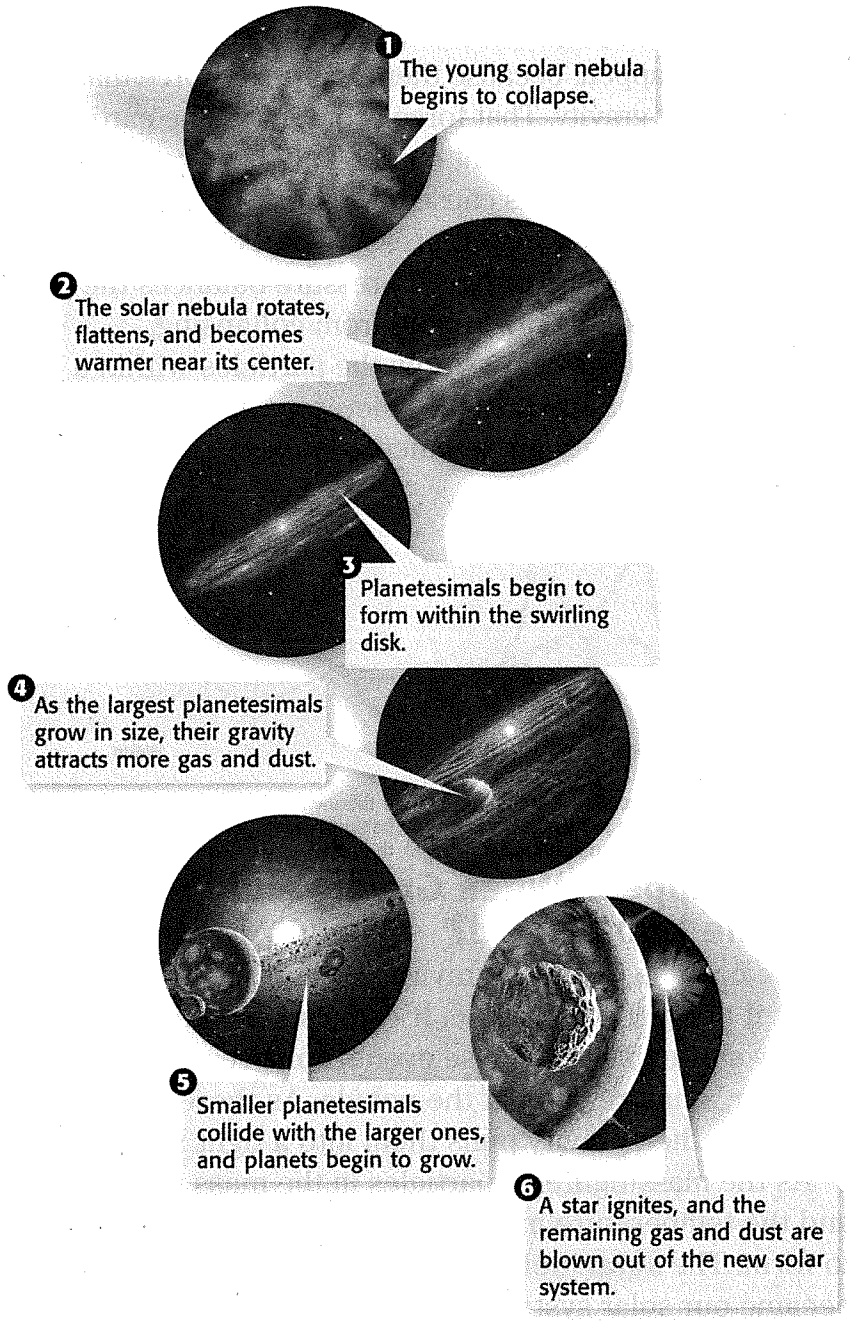
The Formation of the Solar System



TAKE A LOOK

7. Describe In which part of the solar nebula is matter more densely packed, the edges or the center?

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TAKE A LOOK

8. Identify What causes planetesimals to stay together, forming planets, when they collide?

_____

PLANETESIMALS AND PLANETS

As the particles collided and grew, they formed planetesimals, bodies the size of boulders and asteroids. As they grew, the gravity of these planetesimals pulled more and more matter toward them. Eventually, they grew large enough to become planets and moons. The sun, the planets, and the moons are mostly spherical. That is because gravity pulls equally in all directions from the center. ☑

READING CHECK

9. Identify What is the shape of dense bodies the size of planets or larger?

_____

THE BIRTH OF A STAR

As the planets were forming, gravity pulled matter to the center of the nebula. The center became so hot and dense that hydrogen atoms began to fuse, or join together, to form helium atoms. The energy released by fusion pushed outward and balanced the pull of gravity. The gas stopped collapsing and the sun was born. ☑

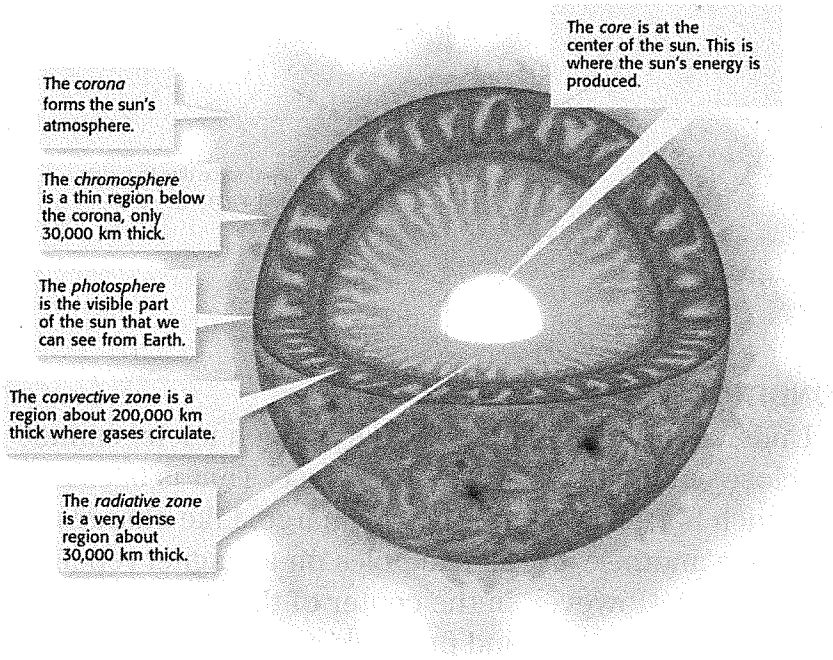
READING CHECK

10. Define What does the word *fuse* mean?

_____

The diameter of the sun is more than 100 times the diameter of Earth. At the sun's surface, its temperature is about 5,500°C. The core of the sun, where energy is generated, is much hotter than that. The figure below shows the structure of the sun and the layers below its surface.

The Structure and Atmosphere of the Sun



TAKE A LOOK

11. List Place the following parts of the sun in order from the center outwards: chromosphere, core, corona, radiative zone.

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_____

_____

_____

How Does the Sun Produce Energy?

The sun has been producing energy and shining on Earth for about 4.6 billion years. How could it stay hot for such a long time?

The answer to that question came early in the 20th century. Albert Einstein figured out that energy and matter can be changed into each other. Einstein's famous formula is $E = mc^2$, in which E is energy, m is mass, and c is the speed of light. Because the speed of light is a very large number, this equation states that a tiny amount of matter can be changed into a lot of energy. This explains the large amount of energy produced by the sun.

Math Focus

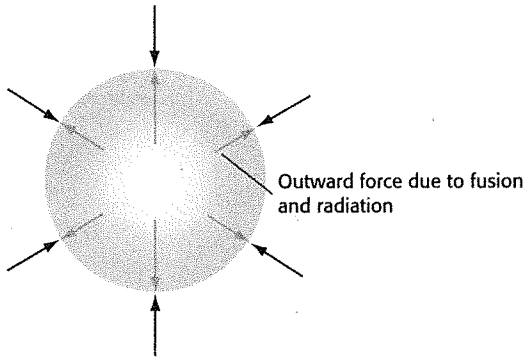
12. Represent Quantities The speed of light, c, in the equation $E = mc^2$, is equal to 300,000,000 m/s or 3.0×10^8 m/s. Using scientific notation, what is the value of c^2? Include units.

_____

_____

NUCLEAR FUSION

Scientists now know that the sun's energy comes from *nuclear fusion*. Nuclear fusion is the process in which two or more low-mass nuclei join together to form a larger nucleus. When nuclei fuse, energy is released. Stars begin to generate energy when hydrogen nuclei fuse to form helium. There is a balance between the extremely high pressure from this energy and gravity due to the star's mass. This balance, shown in the figure below, gives a star its spherical shape.



TAKE A LOOK

13. Identify Label the force indicated by the arrows.

_____

CONDITIONS THAT CAUSE FUSION

Under normal conditions, two hydrogen nuclei cannot get close enough to one another to fuse. That is because they each have a positive electric charge. Like charges repel one another, just as like poles on a magnet repel one another. However, in the center of the sun and other stars, the temperature and pressure are extremely high.

The high pressure and rapid motion of particles are enough to overcome the force of repulsion. Hydrogen nuclei are forced together, and the hydrogen fuses into a different element, helium. ☑

READING CHECK

14. Identify What element is formed when hydrogen nuclei fuse together?

_____

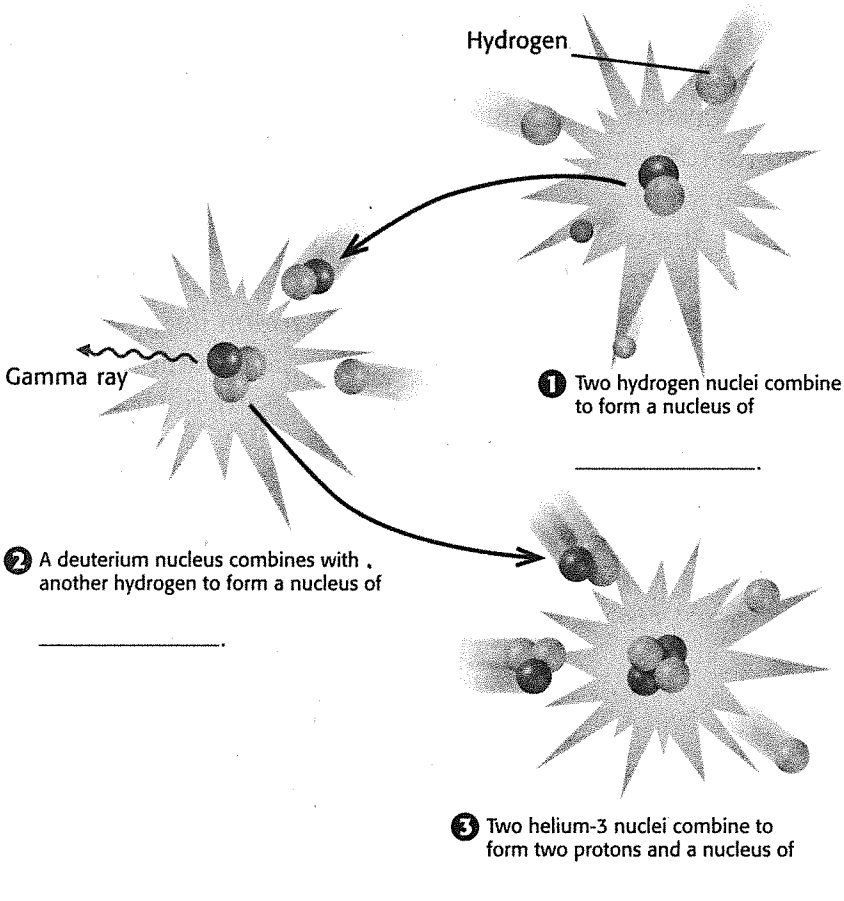
What Happens During Fusion in the Sun?

There are three steps in the fusion of hydrogen in the sun, as shown in the figure below.

Step 1: Two hydrogen nuclei, also called protons, collide and fuse. This process emits particles and energy, and one of the protons becomes a neutron. The proton and neutron combine to form deuterium, a heavy form of hydrogen.

Step 2: Another proton combines with the deuterium nucleus (one proton and one neutron). This forms a nucleus with two protons and one neutron, known as helium-3. This process also releases energy.

Step 3: Two helium-3 nuclei collide and fuse. As this happens, two protons are released. The remaining two protons and two neutrons combine to form a nucleus of helium-4, usually just called a helium nucleus. The mass of the helium nucleus is a tiny amount smaller than the mass of the original protons. This very small amount of mass has been converted into a large amount of energy



Critical Thinking

15. Identify How do you know that deuterium is a form of hydrogen, not a form of helium?

_____

TAKE A LOOK

16. Fill In Label the three nuclei shown in the illustration.

How Are Distances Between Planets Measured?

One way that scientists measure distances in space is by using an astronomical unit. One **astronomical unit** (AU) is the average distance between the sun and Earth. This distance is about 150 million km. This unit is normally used to refer to distances within the solar system. For example, the average distance from the sun to Neptune is about 30.1 AU. So, Neptune is 30.1 × 150 million km = 4,500 million km from the sun.

Another way to measure distances in space is by using the speed of light. Light travels at about 300,000 km/s in space. In one minute, light travels about 18 million km. Light from the sun takes 8.3 minutes to reach Earth.

It takes light over 4 years to reach Earth from the nearest star (other than our sun). That is why distances to stars are measured in *light-years*. Light travels about 9.5×10^{12} km or 9,500,000,000,000 km in one year. A light-year is about 63,000 times farther from Earth as our sun is.

CALIFORNIA STANDARDS CHECK

8.4.c Know how to use astronomical units and light years as measures of distance between the Sun, stars, and Earth.

17. Analyze Ideas If an asteroid is found to be 300 million km from Earth, how many astronomical units is this?

_____

How Is the Solar System Divided?

Astronomers divide the solar system into two main parts, as shown in the figure below. These parts are called the *inner solar system* and the *outer solar system*. The inner solar system contains the four planets that are closest to the sun—Mercury, Venus, Earth, and Mars.

Jupiter is the first planet in the outer solar system. The distance between Mars and Jupiter is much larger than the distance between Earth and Mars. The outer solar system contains four planets—Jupiter, Saturn, Uranus, and Neptune.

TAKE A LOOK

18. Identify What planet is farthest from the sun?

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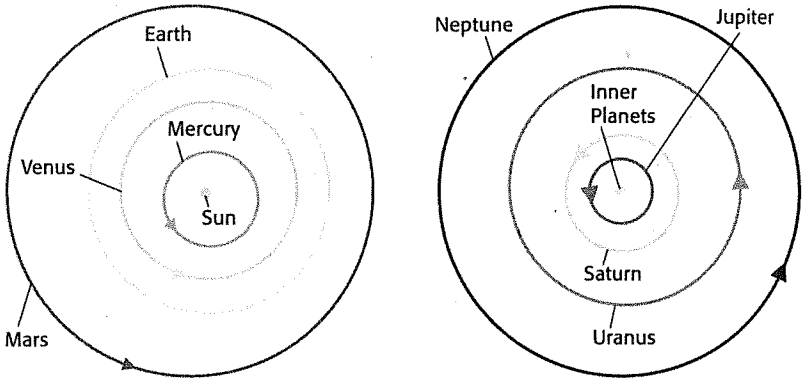

The planets of the inner solar system and their orbits are shown on the left. The planets of the outer solar system and their orbits are shown on the right.

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Section 1 Review

8.2.g, 8.4.b, 8.4.c, 8.4.d

SECTION VOCABULARY

astronomical unit the average distance between the Earth and the sun; approximately 150 million kilometers (symbol, AU)	**nebula** a large cloud of gas and dust in interstellar space; a region in space where stars are born or where stars explode at the end of their lives **solar nebula** the cloud of gas and dust that formed our solar system

1. **Identify** What are the two forces acting on the particles inside a nebula that affect its balance? How do they affect particles?

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_____

2. **Classify** Fill in the blanks to complete the table.

Layer of the sun	Description
Core	
	very dense region surrounding the core, about 300,000 km thick
Convective zone	
	the part of the sun that we can see from Earth
	thin region below the corona, about 30,000 km thick
Corona	

3. **Apply Concepts** Why are all the large bodies in the solar system, the sun and the planets, shaped like spheres?

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_____

4. **Identify** What unit is used to measure distances in our solar system? How large is this unit?

_____

5. **Identify** What unit is used to measure distances to stars? How large is this unit?

_____

Name _____ Class _____ Date _____

CHAPTER 16 Our Solar System

SECTION 2

The Inner Planets

California Science Standards

8.4.c, 8.4.e

BEFORE YOU READ

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

- Which planets are known as the inner planets?
- What properties do the inner planets share?

Why Group the Inner Planets Together?

The inner solar system includes the only planet known to support life, Earth, and three other planets. These four inner planets are called **terrestrial planets** because they all have a makeup similar to that of Earth. The terrestrial planets are much smaller, denser, and more rocky than the outer planets. ☑

STUDY TIP

Organize In your notebook, create a chart showing the similarities and differences among the inner planets.

READING CHECK

1. Explain Why are the inner planets called terrestrial planets?

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_____

Which Planet Is Closest to the Sun?

Mercury is the planet closest to the sun. After Earth, it is the second densest object in the solar system. This is because, like Earth, Mercury has a large iron core in its center. The surface of Mercury is covered with craters.

The atmosphere of Mercury is very thin. Almost all of the gases that once made up its atmosphere have boiled off into space. This happened because it is so close to the sun. ☑

The amount of time that an object takes to rotate once is called the object's *period of rotation*. It is the length of a day on a planet. Mercury rotates on its axis much more slowly than Earth. Its day is about 59 Earth days long.

On Mercury, a year is not much longer than a day. Each planet revolves around the sun at a particular rate. The amount of time needed to go around the sun once is called the planet's *period of revolution*. It's the length of one year on the planet. A year on Mercury is equal to 88 Earth days. So each Mercurian year is only 1.5 Mercurian days long.

READING CHECK

2. Explain Why did the atmosphere of Mercury boil away, while the other planets kept at least some of their original atmospheres?

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Mercury Statistics

Distance from sun	0.38 AU
Period of rotation	58 days, 19 h
Period of revolution	88 days
Diameter	4,879 km
Density	5.43 g/cm^3
Surface gravity	38% of Earth's

Critical Thinking

3. Infer Which of the facts on the table can scientists use to infer that Mercury has a core made of iron?

_____

Is Venus Earth's Twin?

The second planet from the sun is Venus. In some ways, Venus is more like Earth than any of the other planets. Venus is just slightly smaller, less dense, and less massive than Earth. In other ways, the planets are quite different.

If you could observe the sun from the surface of Venus, you would see it rise in the west and set in the east. That is because Venus and Earth rotate on their axes in opposite directions. The rotation of Earth is called **prograde rotation**. This means is spins in a counterclockwise direction if viewed from above its North Pole. When observed the same way, Venus spins clockwise, which is called **retrograde rotation**. ☑

READING CHECK

4. Compare How do prograde rotation and retrograde rotation differ?

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THE ATMOSPHERE OF VENUS

Venus has the densest atmosphere of the terrestrial planets. On it surface, the atmospheric pressure of Venus is 90 times that of Earth's atmosphere. This pressure would instantly crush a human on Venus. The atmosphere is mostly made of carbon dioxide and thick clouds made of sulfuric acid. The thick atmosphere holds heat well, so the surface temperature on Venus averages 464°C, hot enough to melt lead and some other metals.

Venus Statistics

Distance from sun	0.72 AU
Period of rotation	243 days, 16 h
Period of revolution	224 days, 17 h
Diameter	12,104 km
Density	5.24 g/cm^3
Surface gravity	91% of Earth's

TAKE A LOOK

5. Compare How does the length of a day on Venus compare with the length of its year?

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_____

MAPPING THE SURFACE OF VENUS

The atmosphere of Venus reflects sunlight so well that Venus is sometimes the brightest object in the sky. Only the sun and moon are brighter.

Because of its thick atmosphere, the surface of Venus cannot be observed from Earth through telescopes. Between 1990 and 1992, the *Magellan* spacecraft made maps of Venus using radar waves. The waves can travel through the atmosphere and bounce off the surface. Maps made from the radar data showed that Venus has craters, mountains, lava plains, and volcanoes.

Critical Thinking

6. Analyze Methods Why would scientists use *Magellan's* radar instead of telescopes to map the surface of Venus?

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Where Do We Find Life?

Until the 20th century, no one could know what Earth looked like from space. We can now look at a sparkling blue planet. The blue color comes from light reflected from the water of the oceans that cover much of Earth's surface. ☑

READING CHECK

7. Identify What feature of Earth causes it to appear blue from space?

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A CONSTANTLY CHANGING PLANET

As far as we know, Earth is the only planet in the solar system that has the combination of factors needed to support life. These factors include abundant water and just the right amount of energy from the sun.

Earth is always changing. Landmasses are in slow, but constant, motion. These motions, along with weathering by wind and water, constantly reshape the surface of Earth.

Math Focus

8. Calculate Use the information on the table to explain why every fourth year is a leap year. Show your work.

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Earth Statistics

Distance from sun	1.0 AU
Period of rotation	23 h, 56 min
Period of revolution	365 days, 6 h
Diameter	12,756 km
Density	5.52 g/cm^3
Surface gravity	100% of Earth's

STUDYING EARTH FROM SPACE

NASA's Earth Science Enterprise is a program to study Earth from space. Studying Earth from space lets scientists learn about Earth as a whole system. It helps them understand changes in Earth's atmosphere, oceans, ice, landforms, and living things. The study gives clues about how human activities affect everything on Earth.

This image of Earth was taken on December 7, 1972, by members of the crew of *Apollo 17* on their way to the moon.

What Is the Red Planet?

Besides Earth, the most studied planet in the solar system is Mars. Mars has a red color and is known as the Red Planet. Many people believe that there could be life on Mars.

Scientists have learned much about Mars by observing it from Earth. However, most of our knowledge of the planet has come from unmanned spacecraft. So far, these observations have found no evidence of life.

CALIFORNIA STANDARDS CHECK

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

9. Identify What are two reasons that the surface of Mars is colder than that of Earth?

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THE ATMOSPHERE OF MARS

Because it has a thinner atmosphere than Earth and is farther from the sun, Mars is colder than Earth. In the middle of the summer, the spacecraft *Mars Pathfinder* recorded a temperature range from −13°C to −77°C. The Martian atmosphere is carbon dioxide.

The atmospheric pressure on Mars is very low. At the surface, it is about the same as the pressure 30 km above the surface of Earth. Because of low temperature and air pressure, liquid water cannot exist on the surface of Mars.

Mars Statistics

Distance from sun	1.52 AU
Period of rotation	24 h, 37 min
Period of revolution	687 days
Diameter	6,794 km
Density	3.93 g/cm^3
Surface gravity	38% of Earth's

TAKE A LOOK

10. Compare How does the length of a day on Mars compare with the length of day on Earth?

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_____

WATER ON MARS

Even though water cannot exist on the surface of Mars today, it may have in the past. Evidence from spacecraft and surface studies of Mars suggests that some of its features were made by liquid water.

There are many places where surface features are similar to those caused by water erosion on Earth. Other features suggest the presence of sediments that may have been deposited by the water from a large lake. ☑

Scientists cannot prove that these features were caused by liquid water. However, they indicate that at some time in the past, Mars may have had liquid water. If this is true, it would show that Mars was once warmer and had a thicker atmosphere than it does today.

READING CHECK

11. Identify What two Martian features suggest that water once existed on its surface?

_____

THE WATER NOW

Mars has two polar icecaps that are made of a combination of frozen water and frozen carbon dioxide. Most of the water on Mars is trapped in this ice. There is some evidence from the *Mars Global Surveyor* that water could exist just beneath the surface. If so, it may be there in liquid form. If Mars does have liquid water beneath its surface, there is a possibility that life may exist on Mars. ☑

READING CHECK

12. Identify Where does water exist on Mars today?

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VOLCANOES ON MARS

There are the remains of giant volcanoes on the surface of Mars. They show that Mars has had active volcanoes in the past. Unlike Earth, however, the volcanoes are not spread across the whole planet. There are two large volcanic systems on Mars, one of which is about 8,000 km long.

The largest mountain in the solar system, Olympus Mons, is one of the Martian volcanoes. It is a shield volcano that is similar to Muana Kea on the island of Hawaii. However, Olympus Mons is nearly 24 km tall. That is three times as tall as Mount Everest! Its base is 600 km across. It may have grown so tall because the volcano erupted for long periods of time.

MISSIONS TO MARS

Several recent missions to Mars were launched to learn more about the Red Planet. The figure below shows *Mars Express Orbiter*, which reached Mars in December 2003. Since then, it has been investigating Mars from space, including searching for water. In January 2004, the exploration rovers *Spirit* and *Opportunity* landed on Mars. These solar-powered, wheeled robots have found evidence that water once existed on the Martian surface. ☑

READING CHECK

13. Describe What evidence have the rovers *Spirit* and *Opportunity* found?

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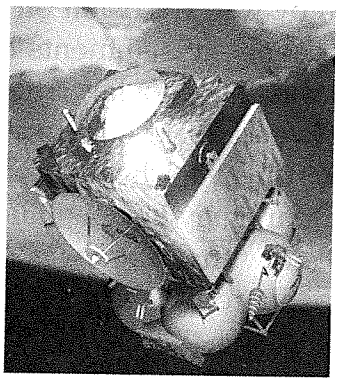
_____



The *Mars Express Orbiter* helps scientists map Mars and study its atmosphere.

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Section 2 Review

8.4.c, 8.4.e

SECTION VOCABULARY

prograde rotation the counterclockwise spin of a planet or moon as seen from above the planet's North Pole; rotation in the same direction as the sun's rotation.

Wordwise The prefix *pro-* means "forward."

retrograde rotation the clockwise spin of a planet or moon as seen from above the planet's North Pole

terrestrial planet one of the highly dense planets nearest to the sun: Mercury, Venus, Earth, and Mars

1. **Compare** How does retrograde rotation compare with the rotation of Earth?

_____

_____

2. **Classify** Fill in the blanks to complete the table.

Planet	Distance from sun	Period of rotation
	0.38 AU	58 days, 19 h
	0.72 AU	243 days, 16 h
	1.00 AU	365 days, 6 h
	1.52 AU	1 year, 322 days

3. **Analyze Ideas** Why do scientists think that Mars was once warmer and had a thicker atmosphere than it does today?

_____

_____

_____

4. **Identify Relationships** How is the surface gravity of the terrestrial planets related to the type of atmosphere that they have? (Hint: Examine the statistics tables.)

_____

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_____

5. **Identify Relationships** The diameter of Venus is almost the same as Earth's, and its surface gravity is less. Why is gravity lower on Venus than on Earth? (Hint: Examine the statistics tables for both planets.)

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Name _____ Class _____ Date _____

CHAPTER 16 Our Solar System

SECTION 3

The Outer Planets

California Science Standards

8.4.c, 8.4.e

BEFORE YOU READ

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

- How are Jupiter, Saturn, Uranus, and Neptune similar?
- How is Pluto now classified?

Why Group the Outer Planets Together?

STUDY TIP

Organize In your notebook, create a chart showing the similarities and differences among the outer planets.

The outer planets are very different from the inner planets. The outer planets are made mostly of gas or rock. These planets are called **gas giants**, because they have massive gas atmospheres.

Which Planet Is the Biggest?

Jupiter, shown in the figure below, is the largest planet in our solar system. Its mass is twice as large as the other eight planets combined. Jupiter is made mostly of hydrogen. As large as it is, Jupiter's rotation takes less than 10 hours.

The atmosphere of Jupiter consists of hydrogen, helium, and small amounts of ammonia, methane, and water. Huge storms blow in the atmosphere with winds of up to 540 km/h. Its largest feature, the Great Red Spot, is thought to be a storm three times the size of Earth. The core of Jupiter is very hot, with temperatures reaching 30,000°C. So, it radiates more energy than it receives from the sun.

TAKE A LOOK

1. Identify Which of the facts on the table can you use to infer that Jupiter has a shorter day than Earth does?

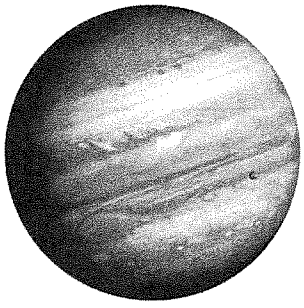
_____

_____

_____

Jupiter Statistics

Distance from sun	5.20 AU
Period of rotation	9 h, 55.5 min
Period of revolution	11 Earth years, 313 days
Diameter	142,984 km
Density	1.33 g/cm^3
Surface gravity	236% of Earth's



This *Voyager 2* image of Jupiter was taken at a distance of 28.4 million km. Io, one of Jupiter's moons, can be seen in the lower right-hand side of the photograph.

What Are Saturn's Rings?

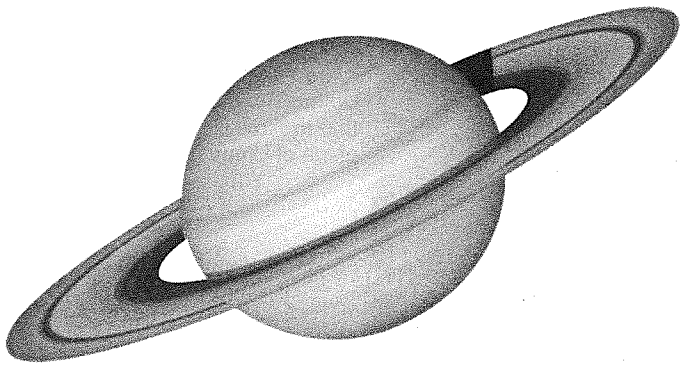
Saturn is the second-largest planet in the solar system. Saturn's volume is 764 times as much as Earth's, but its mass is only 96 times Earth's mass. That is because Saturn it the least dense of all the planets. Like Jupiter, Saturn is made up mostly of hydrogen with some helium and traces of other gases and water.

Saturn Statistics

Distance from sun	9.54 AU
Period of rotation	10 h, 42 min
Period of revolution	29 Earth years, 155 days
Diameter	120,536 km
Density	0.69 g/cm^3
Surface gravity	92% of Earth's

Saturn is best known for the rings that orbit the planet above its equator. They are about 250,000 km across (greater than the distance from Earth to the moon) but less than 1 km thick. The rings are made of trillions of particles of water ice and dust. These particles range from a centimeter to several kilometers across. ☑

Astronomers are still debating the mystery of where Saturn's rings came from. One idea is that the rings are pieces of a large comet that came too close to Saturn. The pull of the planet's gravity could tear a comet apart. Spacecraft have passed close to Saturn and sent information about its rings back to Earth.



This *Voyager 2* image of Saturn was taken from 21 million km away.

Math Focus

2. Compare About how many times does Earth revolve around the sun while Saturn goes around the sun one time?

_____

_____

_____

_____

READING CHECK

3. Identify What materials make up the rings of Saturn?

_____

Critical Thinking

4. Apply Concepts Even though Saturn has more mass than Earth, its surface gravity is less than that of Earth. Why is Saturn's surface gravity less than Earth's?

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What Lies Beyond Saturn?

Saturn is the most distant planet that was known before the telescope was invented. The next planet, Uranus, is the third largest planet in the solar system. It is so far from the sun that it does not reflect much light. It cannot be seen from Earth without using a telescope.

Like Jupiter and Saturn, Uranus is made mostly of hydrogen, helium, and small amounts of other gases. One of these other gases, methane, filters sunlight and gives the planet a greenish color. ☑

READING CHECK

5. Identify What is the main element in the gas giants?

_____

The rotation of Uranus is unusual. As shown in the figure below, the north and south poles of Uranus point almost directly at the sun. The north and south poles of most other planets, like Earth, are directed away from the sun.

For about half the Uranian year, one pole is constantly in sunlight, and for the other half of the year it is in darkness. Some scientists think that Uranus may have started out with the same kind of rotation as the other planets. It may have been tipped over by a collision with a massive object.

Uranus Statistics

Distance from sun	19.22 AU
Period of rotation	17 h, 12 min
Period of revolution	83 Earth years, 273 days
Diameter	51,118 km
Density	1.27 g/cm^3
Surface gravity	89% of Earth's

TAKE A LOOK

6. Compare How does the length of a year on Uranus compare with the length of a year on Earth?

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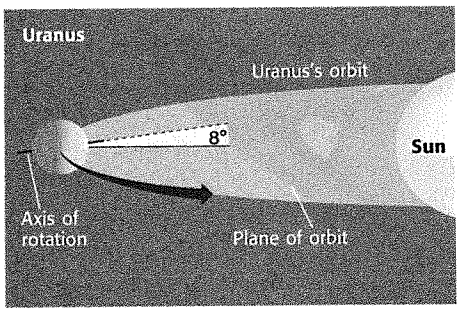
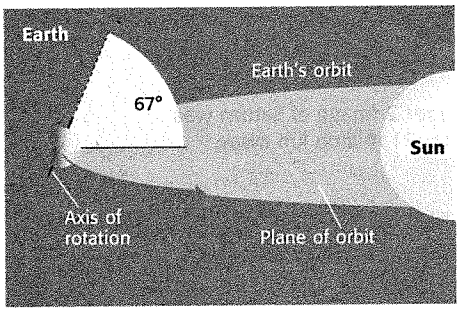


Uranus's axis of rotation is tilted so that the axis is nearly parallel to the plane of Uranus's orbit.



In contrast, the axes of most other planets are closer to perpendicular to their plane of orbit.

TAKE A LOOK

7. Define What two points on a planet's surface are used to define its axis of rotation?

_____

_____

Which Planet Is Next?

Some astronomers predicted that there was a planet beyond Uranus before the planet was observed. Uranus did not move in its orbit exactly as they expected. The force of gravity due to another large object was affecting it. Using predictions of its effect on Uranus, astronomers discovered Neptune in 1846. ☑

Neptune is the fourth largest planet in the solar system. Like the other gas giants, Neptune is made up mostly of hydrogen, helium, and small amounts of other gases. It has a deep blue color, which is caused by methane in its atmosphere. Methane absorbs the red light so more blue light is reflected than red.

Clouds and weather changes are seen in the atmosphere of Neptune. The spacecraft *Voyager* flew past Neptune in 1989 and observed a Great Dark Spot in the southern hemisphere. This spot was a storm as large as Earth. It moved across the planet's surface at about 300 m/s. By 1994, the Great Dark Spot had disappeared. Another dark spot was then located in the northern hemisphere.

Neptune has the fastest winds of any planet in the solar system. Observations from spacecraft show that these winds move through the atmosphere at more than 1,000 km/h. No one knows what causes these winds.

Neptune Statistics

Distance from sun	30.06 AU
Period of rotation	16 h, 6 min
Period of revolution	163 Earth years, 263 days
Diameter	49,528 km
Density	1.64 g/cm^3
Surface gravity	112% of Earth's

READING CHECK

8. Explain What evidence did astronomers have that Neptune existed before they actually observed it?

_____

_____

TAKE A LOOK

9. Compare How does Neptune's average distance from the sun compare with Earth's?

_____

_____

Why Is Pluto Called a Dwarf Planet?

Since its discovery in 1930, Pluto has been called the ninth planet. But in 2006, astronomers created a new definition of *planet*. Pluto does not fit the new definition of a planet. So, Pluto is now classified as a dwarf planet.

TAKE A LOOK

10. Compare How does the length of a planet's year compare with its distance from the sun? Use the period of revolution on this table and on the tables of the other planets.

_____

_____

_____

A SMALL WORLD

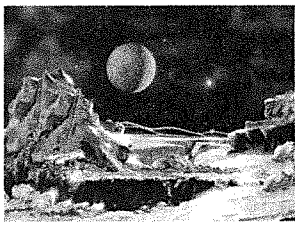
Unlike the outer planets, Pluto is not a gas giant. Pluto is made of rock and ice and has a thin atmosphere composed of methane and nitrogen. Pluto's distance from the sun averages 5.9 billion miles, almost 40 times as far away as Earth.

Pluto Statistics

Distance from sun	39.5 AU
Period of rotation	6 days, 10 h
Period of revolution	248 Earth years, 4 days
Diameter	2,390 km
Density	1.75 g/cm^3
Surface gravity	6% of Earth's

One of Pluto's moons, called Charon, is a little more than half the size of Pluto. Because they are so distant, we know very little about Pluto and Charon.

In 2006, the spacecraft *New Horizons* began a 10-year trip to study Pluto and Charon. The figure below shows an artist's idea of the view from Pluto. The sun looks like a very bright star beyond Charon. The sun is so distant that the temperature on Pluto only reaches about −235°C.



An artist's view of the sun and Charon from Pluto shows how little light and heat Pluto receives from the sun.

BEYOND PLUTO

In recent years, scientists have discovered hundreds of objects in our solar system beyond Pluto. This region of the solar system, which is called the *Kuiper belt*, contains small bodies that are mostly made of water ice. Some of these objects are larger than Pluto.

In October 2003, another object was discovered in the Kuiper belt. Called 2003UB313, it is almost 16 billion km from the sun and is larger than Pluto. ☑

READING CHECK

11. Identify Where is the Kuiper belt located?

_____

_____

Name _____ Class _____ Date _____

Section 3 Review

8.4.c, 8.4.e

SECTION VOCABULARY

gas giant a planet that has a deep, massive atmosphere, such as Jupiter, Saturn, Uranus, or Neptune	

1. **Identify** What is the main element found in the atmosphere of a gas giant planet?

_____

2. **Classify** Fill in the blanks to complete the table.

Solar System Body	Distance from sun (AU)	Period of rotation
	5.20	11 Earth years, 313 days
	9.54	29 Earth years, 155 days
	19.21	83 Earth years, 273 days
	30.06	163 Earth years, 263 days
	39.5	248 Earth years, 4 days

3. **Evaluate Data** As planets get farther from the sun, what happens to the length of their year and their surface temperature?

_____

_____

4. **Make Comparisons** How do the gas giants differ from the inner planets of the solar system? In your answer, discuss composition, size, distance from the sun, length of a year, and how much energy they get.

_____

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_____

5. **Identify Relationships** What properties of Pluto might make scientists think that it is a Kuiper belt object?

_____

Name _____ Class _____ Date _____

CHAPTER 16 Our Solar System

SECTION 4

Moons

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?

STUDY TIP

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

What Are Moons?

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?

_____

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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.

TAKE A LOOK

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

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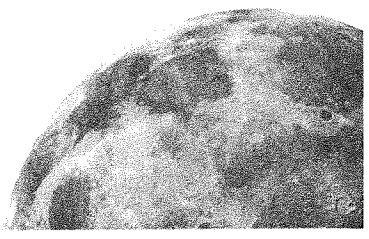


This image of Earth's moon was taken by the *Galileo* spacecraft while on its way to Jupiter. The large, dark areas are lava plains called *maria*.

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.

READING CHECK

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

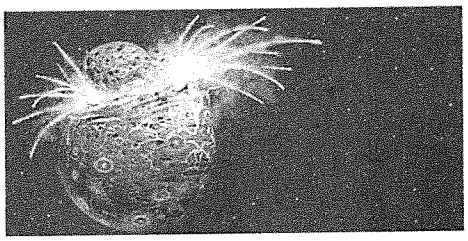
_____

_____

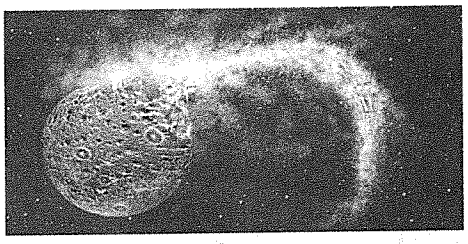
Moon Statistics

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

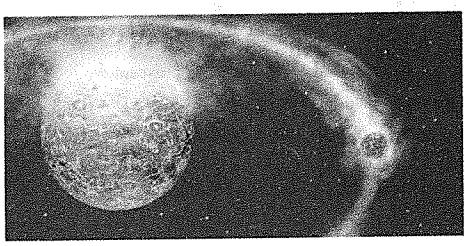
Formation of the Moon



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.

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?

_____

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?

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_____

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. ☑

READING CHECK

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

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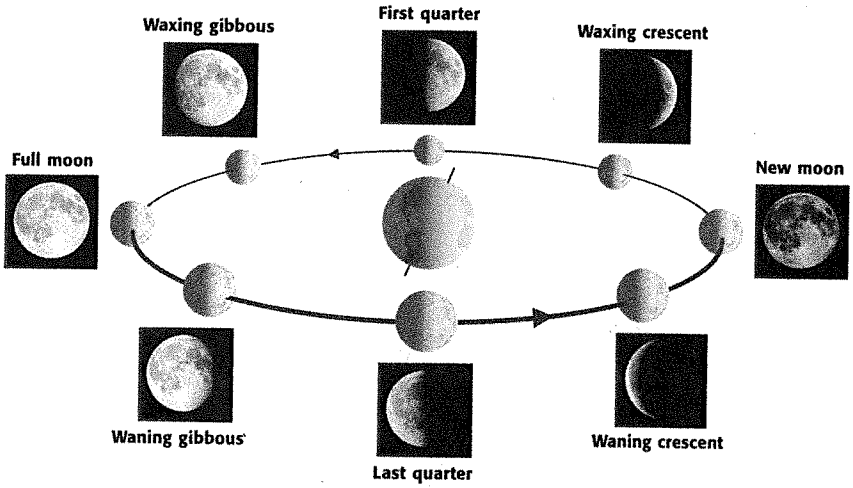
The different appearances of the moon are called **phases**. When the moon is *waxing*, the amount of sunlight reflected off the moon and toward Earth increases every day. The moon appears to get bigger. When the moon is *waning*, the proportion of the sunlit side that we can see decreases every day.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

_____

_____

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. ☑

READING CHECK

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

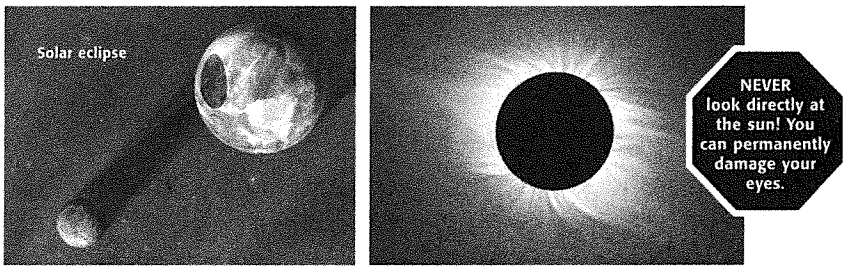
_____

_____

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.

TAKE A LOOK

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

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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

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

_____

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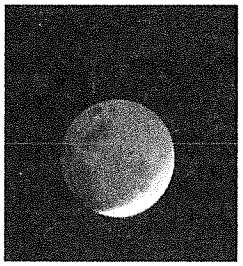
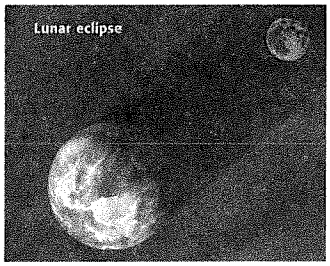
LUNAR ECLIPSES

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.

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. ☑

READING CHECK

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

_____

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?

_____

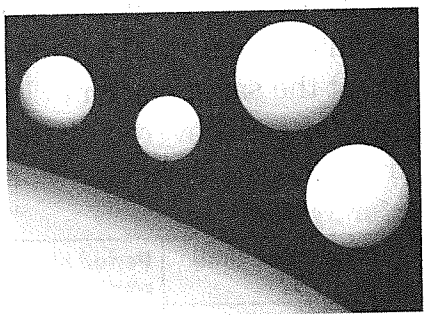
THE MOONS OF JUPITER

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 lay 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.

READING CHECK

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

_____

_____

_____

_____

READING CHECK

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

_____

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.

Critical Thinking

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

_____

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_____

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?

_____

_____

_____

_____

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

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

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?

_____

_____

_____

Name _____ Class _____ Date _____

Section 4 Review

8.2.g, 8.4.d, 8.4.e

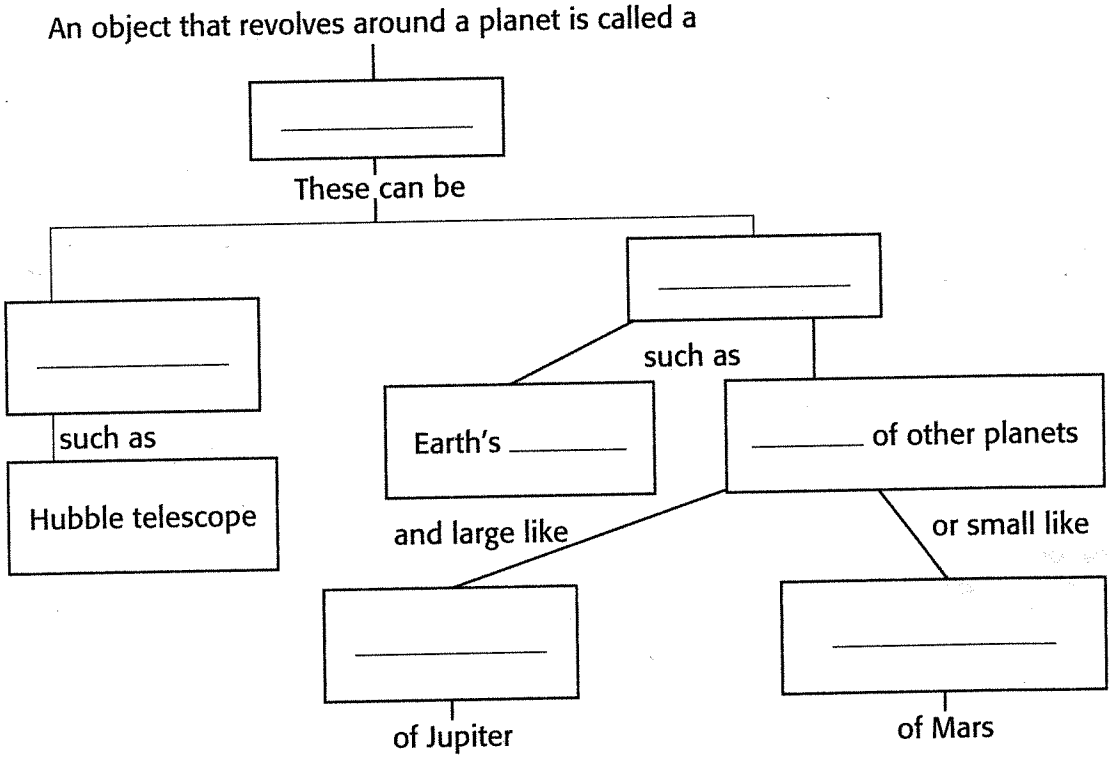
SECTION VOCABULARY

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.



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.

_____

_____

Name _____ Class _____ Date _____

CHAPTER 16 Our Solar System

SECTION 5

Small Bodies in the Solar System

California Science Standards

8.4.e

BEFORE YOU READ

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

- What are comets and what are they made of?
- What are asteroids and where are they found?
- What is a meteoroid?

STUDY TIP

Organize In your notebook, create a Comparison Table that compares comets, asteroids, and meteoroids.

What Is in Our Solar System?

The sun, the planets, and their moons are not the only objects in our solar system. There are also many smaller bodies, including comets, asteroids, and meteoroids. Scientists study these objects to learn about the formation and composition of the solar system.

What Are Comets?

A **comet** is a small, loosely packed body of ice, rock, and dust. The core, or nucleus, of a comet is made of rock, metals, and ice. A comet's nucleus can range from 1 km to 100 km in diameter. A spherical cloud of gas and dust, called a *coma*, surrounds the nucleus. The coma may extend as far as 1 million km from the nucleus. ☑

READING CHECK

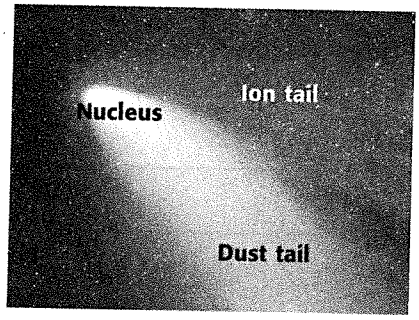
1. Describe What is a comet made of?

_____

_____

COMET TAILS

A comet's tail is its most spectacular feature. Sunlight changes some of the comet's ice to gas, which streams away from the nucleus. Part of the tail is made of *ions*, or charged particles. The ion tail, pushed by the solar wind, always moves away from the sun, no matter which way the comet is moving. A second tail, made of dust, follows the comet in its orbit. Some comet tails are more than 80 million km long, glowing brightly with reflected sunlight.



This image shows the physical features of a comet when the comet comes close to the sun. The nucleus of a comet is hidden by the brightly lit gases and dust.

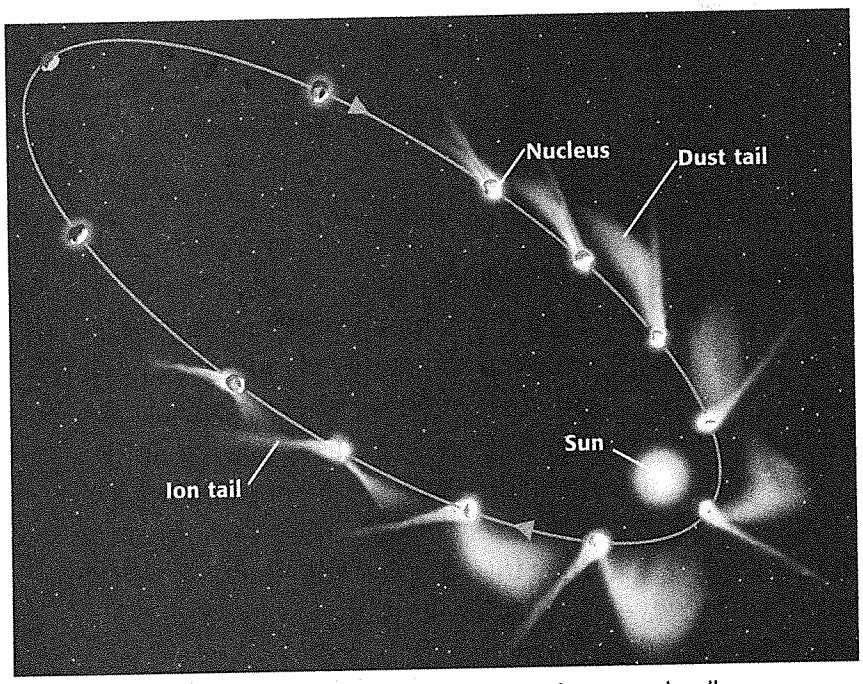
TAKE A LOOK

2. Identify Draw an arrow from the "Nucleus" label to show the direction the comet is moving.

ORIGINS OF COMETS

Scientists think that many comets come from the Oort cloud. The *Oort cloud* is a spherical cloud of dust and ice. It surrounds the solar system far beyond the orbit of Pluto. Comets may be attracted by the gravity of nearby stars. This may cause them to fall into an elliptical orbit around the sun, as shown in the figure below. Other comets are found in the *Kuiper belt*, a flat ring of objects just beyond Neptune's orbit.

Scientists think that comets are made of matter that was left over when the solar system formed. They would like to learn more about comets to better understand the solar system's history. Several spacecraft have been launched to gather comet dust. In 2004, the spacecraft Stardust collected material from a comet named Wild 2.



Comets have very long orbits that take them close to the sun and well beyond Pluto.

LONG- AND SHORT-PERIOD COMETS

Comets in orbit come close to the sun over and over again. Many of their orbital periods have been calculated and some have been observed several times. If a comet takes more than 200 years to complete one orbit, it is called a long-period comet. Other comets, mostly from the Kuiper belt, take less than 200 years. The famous Halley's comet is a short-period comet, returning every 76 years.

READING CHECK

3. Identify Where is the Oort cloud located?

_____

_____

TAKE A LOOK

4. Explain Why does the ion tail extend in different directions during most of the comet's orbit?

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Critical Thinking

5. Describe Events Why can Halley's comet be seen from Earth only for about 1 year of its 76-year orbit?

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What Are Asteroids?

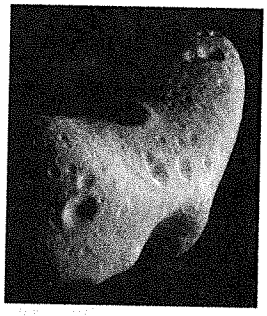
Small, rocky bodies that revolve around the sun are called **asteroids**. They range in size from a few meters to almost 1,000 km in diameter. More than 50,000 asteroids have been discovered. None of them can be seen from Earth without a telescope. In fact, they were not known to exist until 1801.

Most asteroids orbit the sun in the asteroid belt. This is a 300-million-km-wide region located between the orbits of Mars and Jupiter. Astronomers think that asteroids are made of material from the early solar system. The pull of Jupiter's gravity prevented this material from coming together to form a planet. ☑

READING CHECK

6. Identify Where is the asteroid belt located?

_____



NASA's *NEAR* spacecraft landed on the asteroid Eros in 2001. This view of the cratered surface of Eros was taken from an altitude of 200 km.

COMPOSITION OF ASTEROIDS

It is hard to determine what asteroids are made of. This is because they are small and usually far away from Earth. Mostly, they are composed of either rock or metal. Some asteroids may contain carbon and carbon compounds.

In general, asteroids do not have a spherical shape because of their small size. Gravity must be very large to pull matter together into a spherical shape. The table below gives several facts about selected asteroids.

Some Asteroid Facts

Asteroid	Date discovered	Size or diameter (km)	Interesting fact
Ceres	1801	960 × 940	largest known
Pallas	1802	570 × 525 × 482	second largest
Vesta	1807	530	brightest
Ida	1884	58 × 23	has a satellite asteroid
Eros	1898	33 × 13 × 13	first near-Earth asteroid discovered
Ganymede	1924	32	largest near-Earth asteroid

Critical Thinking

7. Make Inferences Why does Eros have an irregular shape instead of a spherical shape?

_____

_____

_____

TAKE A LOOK

8. Compare How do asteroid sizes compare with planet sizes?

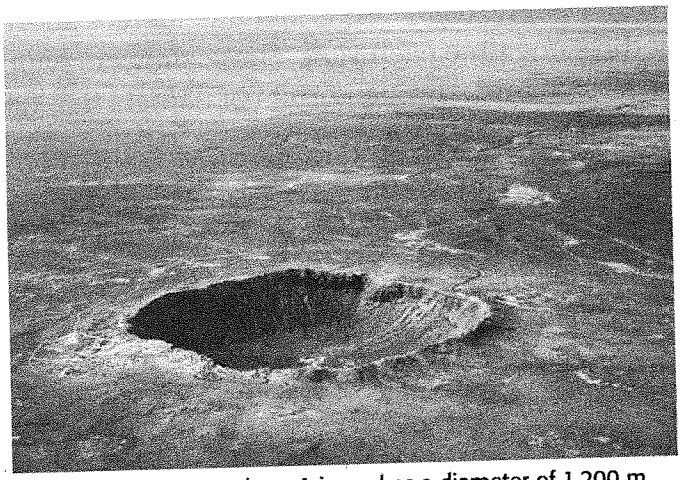
_____

_____

NEAR-EARTH ASTEROIDS

More than 1,000 asteroids have wide, elliptical orbits that bring them close to Earth. They are called near-earth asteroids. Scientists are interested in these asteroids because they can cause great damage if they strike Earth. The Barringer meteorite crater is shown in the figure below. It was made when an asteroid struck Earth about 40,000 years ago. The asteroid was less than 50 m in diameter, but it caused a crater 1,200 m across!

Asteroid detection programs now identify and track asteroids whose orbit may bring them close to the planet. Scientists hope to be able to prevent future collisions by identifying asteroids that could be a problem in the future.



Barringer Crater in northern Arizona has a diameter of 1,200 m.

TAKE A LOOK

9. Identify What struck Earth to form this crater?

_____

What Are Meteoroids?

Pieces of dust and debris from asteroids and comets, called **meteoroids**, are scattered throughout the solar system. Most meteoroids are about the size of a grain of sand. When a meteoroid enters Earth's atmosphere, it can reach a speed between 35,000 and 250,000 km/h.

Friction with the atmosphere heats meteoroids and the air around them to thousands of degrees, causing a bright glow. The glowing trails that form when meteoroids burn up in the atmosphere are called **meteors**. A meteor trail can be a few hundred meters in diameter and tens of kilometers long before it fades.

Every few days, a larger meteoroid enters the atmosphere. Some of these bodies pass through the atmosphere without burning up completely. The meteoroids that reach Earth's surface are called **meteorites**. ☑

READING CHECK

10. Compare What is the difference between a meteoroid and a meteorite?

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_____

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_____

COMPOSITION OF METEORITES

Meteorites are classified as one of three types: stony, metallic, and stony-iron. Stony meteorites are similar to rocks on Earth. Some of them include carbon compounds similar to those found in living organisms. Metallic meteorites have a distinctive metallic appearance and do not look like terrestrial rocks. Stony-iron meteorites are made of rocky material, iron, and nickel. ☑

READING CHECK

11. List What are the three types of meteorites?

_____

_____

_____

METEOR SHOWERS

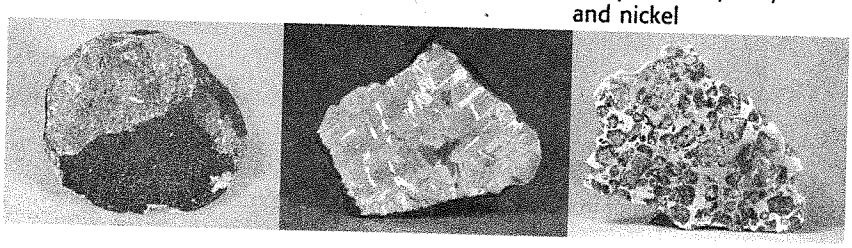
Meteors can be seen on most clear nights. When many small meteoroids enter the atmosphere in a short period, it is called a *meteor shower*. During some meteor showers, several meteors are visible every minute. Meteor showers occur at the same time each year. These showers happen because Earth passes through orbits of comets that have left a dust trail.

Three Major Types of Meteorites

Stony Meteorite: rocky material

Metallic Meteorite: iron and nickel

Stony-iron Meteorite: rocky material, iron, and nickel



TAKE A LOOK

12. Identify What metals are found in a metallic meteorite?

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IMPACTS ON EARTH

Most objects that enter Earth's atmosphere are small and burn up completely before reaching the surface. However, scientists think that impacts powerful enough to cause a natural disaster happen every few thousand years. An impact large enough to cause a global catastrophe may occur once every 50 million to 100 million years.

About 65 million yeas ago, a meteor 10 km wide struck Earth. Massive amounts of debris from this impact entered the atmosphere. The debris may have left the planet in darkness for months and dropped temperatures to near freezing for years. The impact may have caused 15% to 20% of the species on Earth, including the dinosaurs, to become extinct.

Name _____ Class _____ Date _____

Section 5 Review

8.4.e

SECTION VOCABULARY

asteroid a small, rocky object that orbits the sun; most asteroids are located in a band between the orbits of Mars and Jupiter

comet a small body of ice, rock, and cosmic dust that follows an elliptical orbit around the sun and that gives off gas and dust in the form of a tail as it passes close to the sun

meteor a bright streak of light that results when a meteoroid burns up in Earth's atmosphere

meteorite a meteoroid that reaches Earth's surface without burning up completely

meteoroid a relatively small, rocky body that travels through space

1. **Describe** How can a comet become the source of meteoroids and meteors?

_____

_____

2. **Classify** Fill in the blanks to complete the table.

Object	Composition	Main location
	large chunks of rock or metal, much smaller than planets	
		Oort cloud and Kuiper belt
	small chunks of rock or metal	throughout the solar system

3. **Evaluate Theories** Why is information about comets, asteroids, and meteoroids important for understanding the development of the solar system?

_____

_____

4. **Compare and Contrast** How do the orbits of comets differ from the orbits of most asteroids?

_____

_____

5. **Apply Concepts** Why would scientists want to know if an asteroid is on a course to collide with Earth in 20 years?

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