Section 27.2

Objectives

- **Describe** the history of lunar exploration.
- **Recognize** lunar properties and structures.
- **Identify** features of the Moon.
- **Explain** the theory of how the Moon formed.

Review Vocabulary

lava: magma that flows onto the surface from the interior of an astronomical body

New Vocabulary

albedo
highland
mare
impact crater
ejecta
ray
rille
regolith

The Moon

MAIN Idea **The Moon, Earth's nearest neighbor in space, is unique among the moons in our solar system.**

Real-World Reading Link How many songs, poems, and stories do you know that mention the Moon? The Moon is a familiar object in the night sky and much has been written about it.

Exploring the Moon

Astronomers have learned much about the Moon from observations with telescopes. However, most knowledge of the Moon comes from explorations by space probes, such as *Lunar Prospector* and *Clementine,* and from landings by astronauts. The first step toward reaching the Moon was in 1957, when the Soviet Union launched the first artificial satellite, *Sputnik I.* Four years later, Soviet cosmonaut Yuri A. Gagarin became the first human in space.

That same year, the United States launched the first American, Alan B. Shepard, Jr., into space during Project Mercury. This was followed by Project Gemini that launched two-person crews. Finally, on July 20, 1969, the Apollo program landed Neil Armstrong and Edwin "Buzz" Aldrin on the Moon during the Apollo 11 mission. Astronauts of the Apollo program explored several areas of the Moon, often using special vehicles, such as the *Lunar Roving Vehicle* shown in **Figure 27.8** After a gap of many years, scientists hope to return to the Moon before 2029. In the planning stages are a new spacecraft and lander that can carry more astronauts. Also, astronauts hope to remain longer on the Moon and eventually establish a permanent base there.

Reading Check **Identify** the source of most information about the Moon.

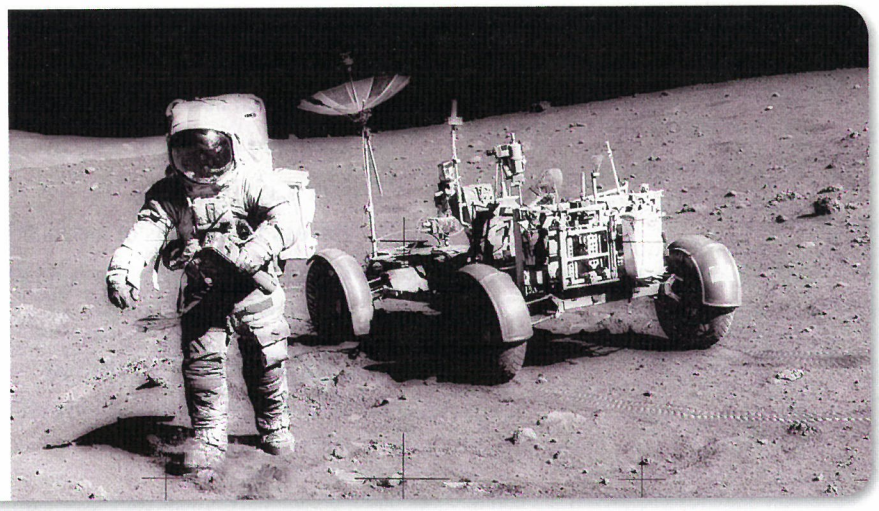


Figure 27.8 Apollo 15 astronauts used the *Lunar Roving Vehicle (LRV)* to explore the Moon's surface.
Explain *how the* LRV *might have resulted in improved mission performance.*

The Lunar Surface

Although the Moon is the brightest object in our night sky, the lunar surface is dark. The **albedo** of the Moon, the percentage of incoming sunlight that its surface reflects, is very small—only about 7 percent. In contrast, Earth has an average albedo of nearly 31 percent. Sunlight that is absorbed by the surface of the Moon produces extreme differences in temperature. Because the Moon has no atmosphere to absorb heat, sunlight can heat the Moon's surface to 400 K (127°C), while the temperature of its unlit surface can drop to a chilly 100 K (−173°C).

The "man in the Moon" pattern seen from Earth is produced by the Moon's surface features. Lunar **highlands** are heavily cratered regions of the Moon that are light in color and mountainous. Other regions called **maria** (MAH ree uh) (singular, mare [MAH ray]) are dark, smooth plains, which average 3 km lower in elevation. Maria have few craters.

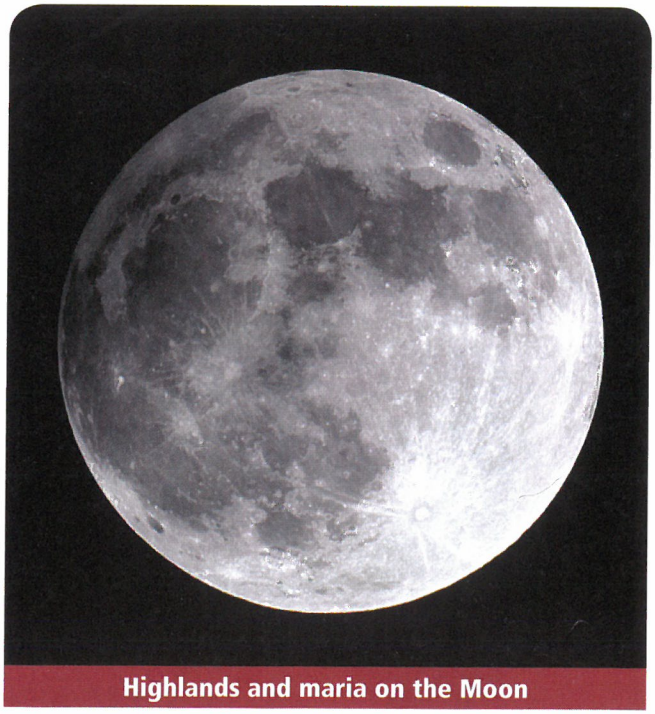
Reading Check **Explain** what lunar features produce the "man in the Moon."

Lunar craters

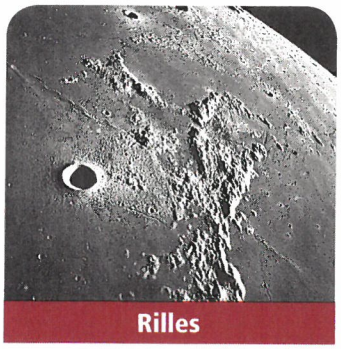
The craters on the Moon, called **impact craters,** formed when objects from space crashed into the lunar surface. The material blasted out during these impacts fell back to the Moon's surface as **ejecta.** Some craters have long trails of ejecta, called **rays,** that radiate outward from the impact site, as shown in **Figure 27.9.** Rays are visible as light-colored streaks. Although the maria are mostly smooth, they do have a few scattered craters and rilles. **Rilles** are meandering, valleylike structures that might be collapsed lava tubes. In addition, there are mountain ranges near some of the maria.

Aristarchus crater

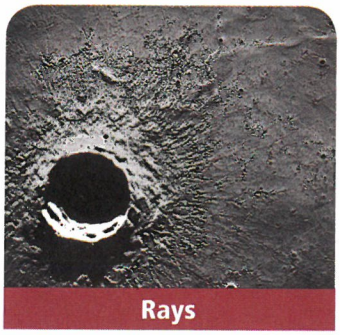
Ejecta



Highlands and maria on the Moon



Rilles



Rays

Figure 27.9 You can see some of the details for the maria and highlands in the view of the full moon. Craters, ejecta, rilles, and rays are visible in close-up views of the Moon's surface.

Concepts In Motion
Interactive Table To explore more about the Moon and Earth, visit glencoe.com.

Table 27.2 The Moon and Earth

	The Moon	Earth
Mass (kg)	7.349×10^{22}	5.974×10^{24}
Radius (km)	1737.4	6378.1
Volume (km^3)	2.197×10^{10}	1.083×10^{12}
Density (kg/m^3)	3340	5515

Lunar properties Earth's moon is unique among all the moons in the solar system. First, it is one of the largest moons compared to the radius and mass of the planet it orbits, as shown in **Table 27.2.** Also, it is a solid, rocky body, in contrast with the icy compositions of other moons of the solar system. Finally, the Moon's orbit is farther from Earth relative to the distance of most moons from the planets they orbit. **Figure 27.10** shows a photo of Earth and the Moon taken from space.

Composition The Moon is made up of minerals similar to those of Earth—mostly silicates. Recall from Chapter 4 that silicates are compounds containing silicon and oxygen that make up 96 percent of the minerals in Earth's crust. The highlands, which cover most of the lunar surface, are predominately lunar breccias (BRE chee uhs), which are rocks formed by the fusion of smaller pieces of rock during impacts. Unlike sedimentary breccias on Earth, most of the lunar breccias are composed of plagioclase feldspar, a silicate containing high quantities of calcium and aluminum but low quantities of iron. The maria are predominately basalt, but unlike basalt on Earth, they contain no water.

Reading Check **Describe** the compositions of the lunar highlands and maria.

History of the Moon

The entire lunar surface is old—radiometric dating of rocks from the highlands indicates an age between 3.8 and 4.6 billion years—about the same age as Earth. Based on the ages of the highlands and the frequency of the impact craters that cover them, scientists theorize that the Moon was heavily bombarded during its first 800 million years. This caused the breaking and heating of surface rocks and resulted in a layer of loose, ground-up rock called **regolith** on the surface. The regolith averages several meters in thickness, but it varies greatly depending on location.

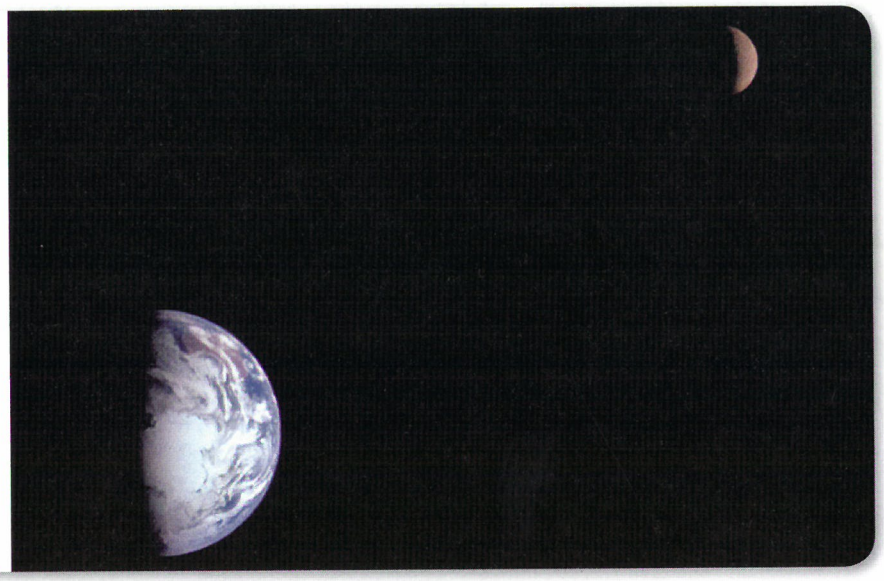


Figure 27.10 This photograph of the view of the Moon and Earth was taken by *Mariner 10* on its way to Venus.

Layered structure Scientists infer from seismic data that the Moon, like Earth, has a layered structure, which consists of the crust, upper mantle, lower mantle, and core, as illustrated in **Figure 27.11.** The crust varies in thickness and is thickest on the far side. The far side of the Moon is the side that is always facing away from Earth. The Moon's upper mantle is solid, its lower mantle is thought to be partially molten, and its core is solid iron.

Formation of maria After the period of intense bombardment that formed the highlands, lava welled up from the Moon's interior and filled in the large impact basins. This lava fill created the dark, smooth plains of the maria. Scientists estimate the maria formed between 3.1 and 3.8 bya, making them younger than the highlands. Flowing lava in the maria scarred the surface with rilles. Rilles are much like lava tubes found on Earth, through which lava flows in underground streams. The maria have remained relatively free of craters because fewer impacts have occurred on the Moon since they formed.

Often lava did not fill the basins completely and left the rims of the basins above the lava. This left behind the mountain ranges that now surround many maria. As shown in **Figure 27.12,** there are virtually no maria on the far side of the Moon, which is covered almost completely with highlands. Scientists hypothesize that this is because the crust is thicker on the far side, which made it difficult for lava to reach the lunar surface. You will determine the relative ages of the Moon's surface features in this chapter's GeoLab.

Tectonics Seismometers measure strength and frequency of moonquakes. Seismic data show that on average, the Moon experiences an annual moonquake that would be strong enough to cause dishes to fall out of a cupboard if it happened on Earth. Despite these moonquakes, scientists think that the Moon is not tectonically active. The Moon has no active volcanoes and no significant magnetic field. Scientists know from the locations and shapes of mountains on the Moon that they were not formed tectonically, as mountain ranges on Earth are formed. Lunar mountains are actually higher elevations that surround ancient impact basins filled with lava.

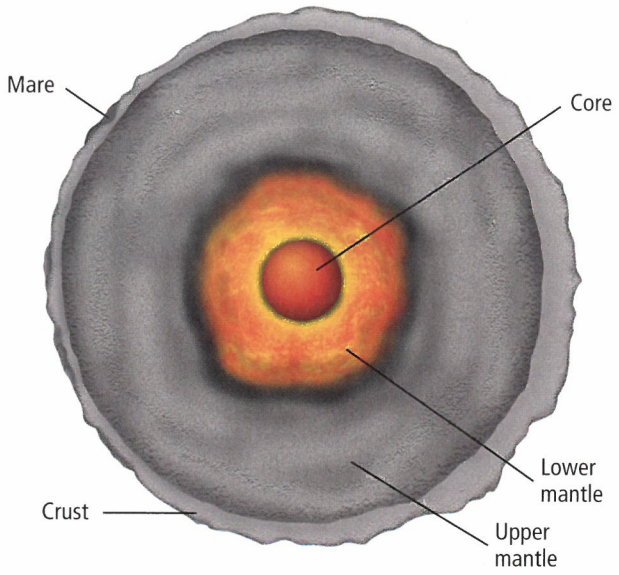
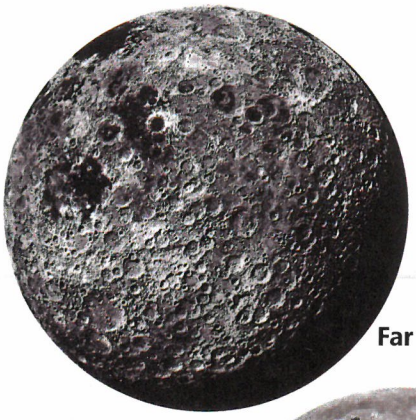


Figure 27.11 Scientists deduce the structure of the Moon's interior from seismic data obtained from seismometers left on the Moon's surface.



Far side of the Moon

Near side of the Moon

Figure 27.12 The heavily cratered far side of the Moon has many fewer maria than the more familiar near side of the Moon.

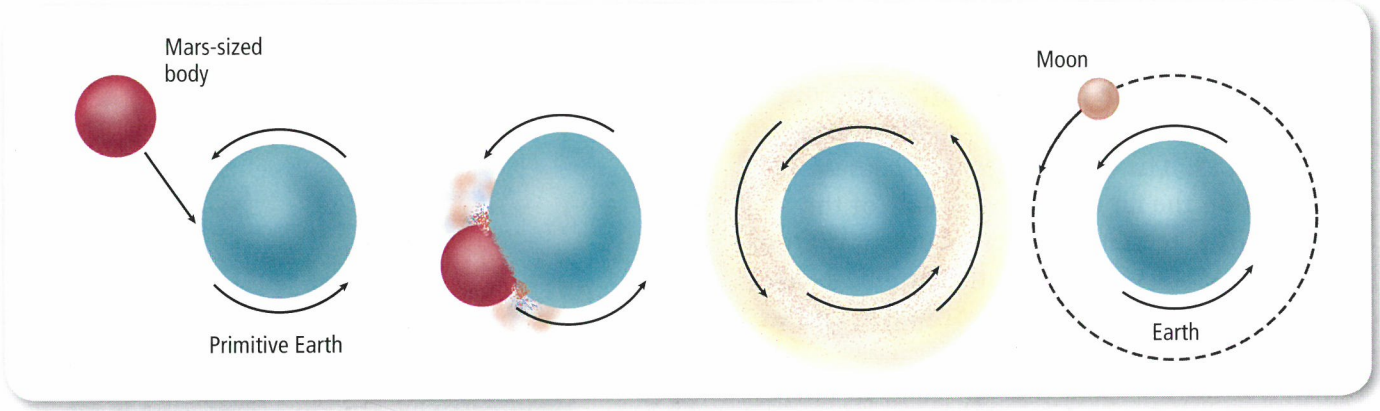


Figure 27.13 The impact theory of the Moon's formation states that material ejected from Earth and from the striking object eventually merged to form the Moon.

Concepts in Motion

Interactive Figure To see an animation of the Moon impact theory, visit glencoe.com.

Formation

Several theories have been proposed to explain the Moon's unique properties. The theory that is accepted by most astronomers today was developed using computer simulations. This theory is known as the impact theory.

According to the impact theory, the Moon formed as the result of a collision between Earth and a Mars-sized object about 4.5 bya when the solar system was forming. This computer model suggests that the object struck Earth with a glancing blow. The impact caused materials from the incoming body and Earth's outer layers to be ejected into space, where over time they merged to form the Moon, as illustrated by **Figure 27.13.** According to the model, the Moon is made up of a small amount of iron at the core, and mostly silicate material that came from Earth's mantle and crust. This explains why the Moon's crust is so similar to Earth's crust in chemical composition. This theory has been accepted as similarities have been found between bulk samples of rock taken from Earth and from the Moon.

Section 27.2 Assessment

Section Summary

- Astronomers have gathered information about the Moon using telescopes, space probes, and astronaut exploration.
- Like Earth's crust, the Moon's crust is composed mostly of silicates.
- Surface features on the Moon include highlands, maria, ejecta, rays, and rilles. It is heavily cratered.
- The Moon probably formed about 4.5 bya in a collision between Earth and a Mars-sized object.

Understand Main Ideas

1. MAIN Idea **Compare and contrast** the Moon and the moons of other planets.
2. **Classify** the following according to age: maria, highlands, and rilles.
3. **Explain** how scientists determined that the Moon has no tectonics.
4. **Distinguish** the steps involved in the impact theory of lunar formation.

Think Critically

5. **Infer** how the surface of the Moon would look if the crust on the far side were the same thickness as the crust on the near side.
6. **Summarize** the major ideas in this section using an outline format. Include the following terms: *highlands, crust, lava, maria, craters, tectonics,* and *impact theory.*

WRITING in Earth Science

7. Write the introductory paragraph to an article entitled *History of the Moon.*

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