

## Earth's Moon

Would you want to take a vacation on the moon? Before you answer, think about these facts. There is no air or liquid water on the moon. Temperatures on the moon's surface range from  $100^{\circ}\text{C}$ , the boiling point of water, to  $-170^{\circ}\text{C}$ , well below freezing.

To stay at a comfortable temperature and carry an air supply, the astronauts who landed on the moon had to wear bulky spacesuits. Each spacesuit had a mass of 90 kilograms, about as much as the astronaut himself! Because the moon's gravity is only about one-sixth as strong as Earth's, however, the astronauts were able to leap about like basketball stars despite their heavy spacesuits. What do you think now? Do you still want to go?



Astronaut John W. Young jumps up from the moon's surface as he salutes the flag on April 21, 1972. The machine on the left is the *Apollo 16* lunar lander.

## The Structure and Origin of the Moon

The moon is 3,476 kilometers in diameter, a little less than the distance across the United States. This diameter is only one-fourth Earth's diameter. However, the moon contains only one-eightieth as much mass as Earth. Though Earth has a very dense core, the outer layers are less dense. The moon's average density is about the same as the density of Earth's outer layers.

People have long wondered how the moon formed. Scientists have suggested many possible hypotheses. For example, did Earth at one time spin so fast that the material the moon is made of was thrown off? Was the moon formed elsewhere in the solar system and captured by Earth's gravitational pull as it came near? Was the moon formed near Earth at the same time that Earth formed? Scientists have found reasons to reject all of these ideas.

The theory of the moon's origin that best fits the evidence is called the collision theory. To see the steps in the formation of the moon according to this theory, click on the button at right. About 4.5 billion years ago, when Earth was very young, an object at least as large as Mars collided with Earth. Material from the object and Earth's outer layers was thrown into orbit around Earth. Eventually, this material combined to form the moon.



**The Size of the Moon** The diameter of the moon is a little less than the distance across the United States.

## Looking at the Moon From Earth

For thousands of years, people could see shapes on the surface of the moon, but didn't know what caused them. The ancient Greeks thought that the moon was perfectly smooth. It was not until about 400 years ago that scientists could study the moon more closely.

In 1609, the Italian astronomer Galileo Galilei heard about a device that made distant objects appear closer. Galileo soon made his own [telescope](#) by putting two lenses in a wooden tube. The lenses focused the light coming through the tube, making distant objects seem closer. When Galileo pointed his telescope at the moon, he was able to see much more detail than anyone had ever seen before. **Features on the moon's surface include craters, highlands, and maria.**

Galileo saw that much of the moon's surface is covered with round pits called [craters](#). Some craters are hundreds of kilometers across. For 300 years, scientists thought that the craters on the moon had been made by volcanoes. But about 50 years ago, scientists concluded that the craters on the moon were caused by the impacts of meteoroids, rocks from space.

Galileo inferred that some of the other features he saw were highlands, or mountains. The peaks of the highlands and the rims of the craters cast dark shadows, which Galileo could see.

The moon's surface also has dark, flat areas, which Galileo called [maria](#) (mah ree uh), the Latin word for "seas." Each one is a "mare" (mah ray). Galileo thought that the maria might be oceans. Scientists now know that there are no oceans on the moon. The maria are low, dry areas that were flooded with molten material billions of years ago. Since you always see the same maria from Earth, you can tell that the moon always shows the same face to Earth.

## Missions to the Moon

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to Earth." With these words from a May 1961 speech, President John F. Kennedy launched an enormous program of space exploration and scientific research.

**Exploring the Moon** Between 1964 and 1972, the United States and the Soviet Union sent dozens of rockets to explore the moon. Until spacecraft went to the moon, no one knew what its surface was like. Would spacecraft landing on the moon sink deep into thick dust and be lost? When *Surveyor* spacecraft landed on the moon, they didn't sink in, thus showing that the surface was solid. Lunar orbiters then photographed the moon's surface, so scientists could find a flat, safe spot for a rocket to land.

**The Moon Landings** In July 1969 three astronauts circled the moon in *Apollo 11*. Once in orbit around the moon, Neil Armstrong and Buzz Aldrin got into a tiny Lunar Module called *Eagle*, leaving Michael Collins in orbit in the Command Module. On July 20, 1969, the *Eagle* descended toward a flat area on the moon's surface called the Sea of Tranquility. Armstrong and Aldrin were running out of fuel, so they had to find a safe landing spot fast. Billions of people held their breaths as they waited to learn if the astronauts had landed safely on the moon. Finally, a red light flashed on the control panel. "Contact light! Houston, Tranquillity Base here. The *Eagle* has landed," Armstrong radioed to Earth.

After the landing, Armstrong and Aldrin left the *Eagle* to explore the moon. When Armstrong first set foot on the moon, he said, "That's one small step for man, one giant leap for mankind." Armstrong meant to say "That's one small step for *a* man," meaning himself, but in his excitement he never said the "a."



**Walking on the Moon** On July 20, 1969, *Apollo 11* astronaut Neil Armstrong became the first person to walk on the moon. He took this photograph of Buzz Aldrin, the second person to walk on the moon

**On the Surface of the Moon** Everything the *Apollo 11* astronauts found was new and exciting. Even looking at their footprints taught the astronauts lessons about the moon's soil. The astronauts bounded around the surface, picking up samples of rocks to bring back to Earth for scientists to study.

In later missions, the astronauts were able to stay on the moon for days instead of hours. They even had a lunar buggy to ride around in. The astronauts were also able to land near the highlands, which were more interesting to study than the flat mare where *Apollo 11* landed.

**Moon Rocks and Moonquakes** The astronauts brought back to Earth 382 kilograms of moon rocks, about half the mass of a small car. **Much of what scientists have learned about the moon came from detailed study of the moon rocks gathered by astronauts.** Almost all of the rocks were formed from the cooling of molten material, so the moon's surface must once have been very hot. Some of the rocks showed that they had been broken apart by impacts and then reformed. So scientists concluded that meteoroids had bombarded the moon's surface.

The astronauts brought measuring instruments to the moon to record some of the meteoroid impacts. One type of device, known as a seismometer, is used to detect earthquakes on Earth. The seismometers on the moon detected extremely weak moonquakes, the result of changes deep under the moon's surface.

Until the *Apollo* astronauts landed, scientists knew very little about the moon's interior. Another kind of instrument the astronauts left behind measured the amount of heat flowing out from the moon's interior, in order to study what the inside of the moon is like. This instrument showed that the moon has cooled almost completely since it was formed.

**Photographs of the Moon** The *Apollo* astronauts circled the moon by rocket and photographed all parts of its surface. The pictures show that the far side of the moon is rougher than the near side and has very few maria.



**The Far Side of the Moon** The far side of the moon is much rougher than the side that faces Earth.

The American *Clementine* spacecraft went to the moon in 1994. It took photographs of the moon through different filters chosen to show what types of minerals are on the moon. The name *Clementine* was chosen because it is the name of the prospector's daughter in the old song "My Darlin' Clementine."

In 1998, the American *Lunar Prospector* spacecraft went to the moon. *Lunar Prospector* mapped the entire moon from an altitude of only 100 kilometers. *Lunar Prospector* found evidence that there is ice frozen into the lunar soil near the moon's poles.