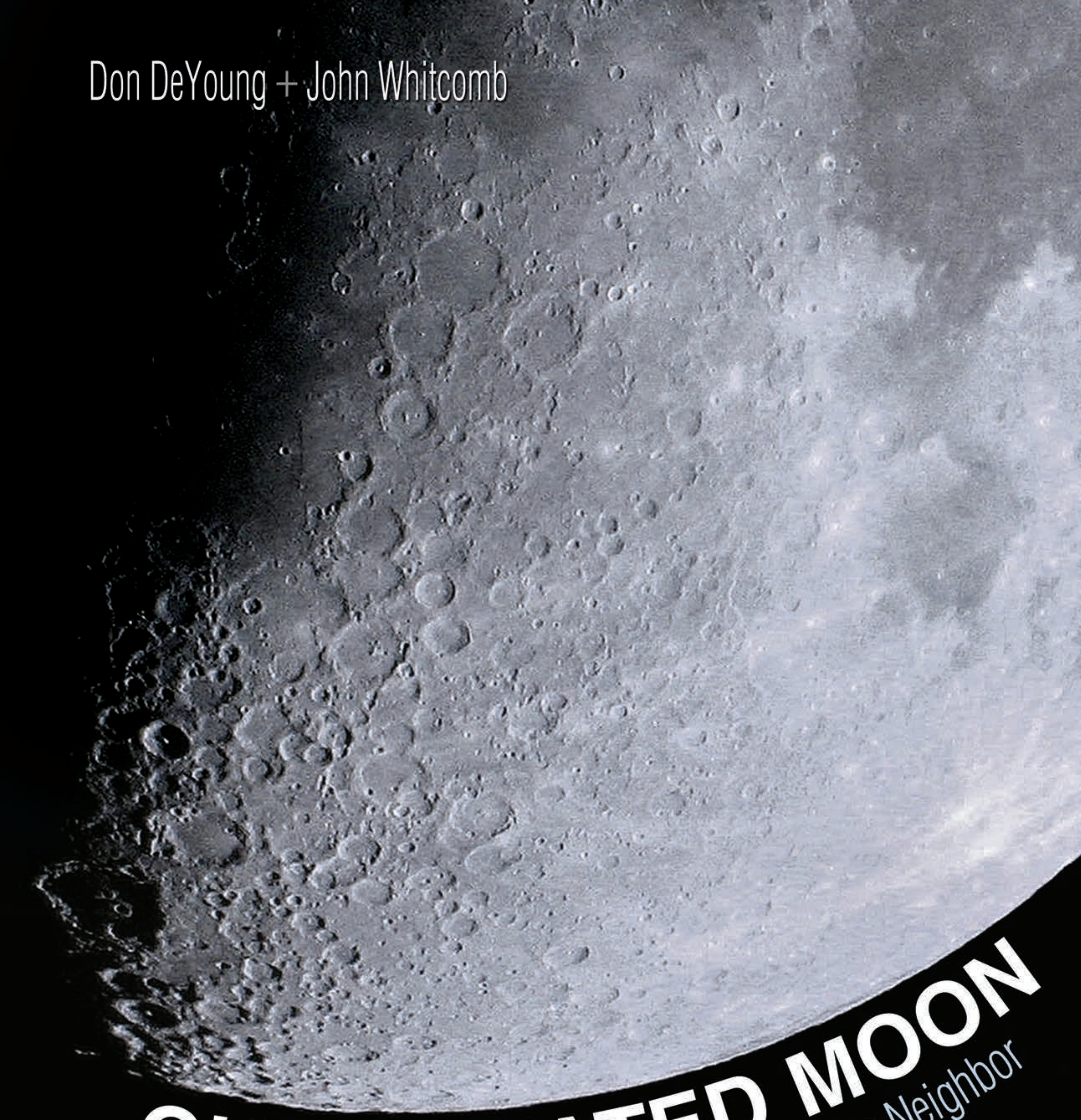
Don DeYoung + John Whitcomb



OUR CREATED MOON

Earth's Fascinating Neighbor

Our Created Moon

Earth's Fascinating Neighbor

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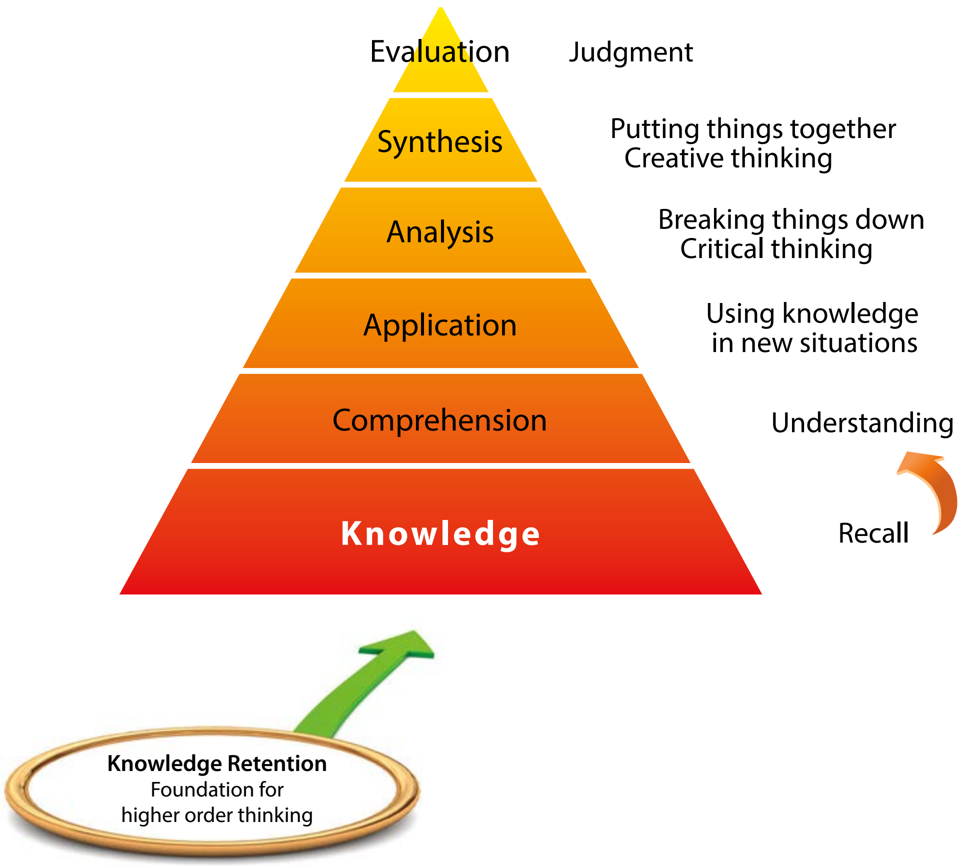
EDUCATIONAL OBJECTIVES

Our Created Moon has been developed as an educational resource and can be utilized to assist in classroom study, independent learning, or homeschool settings. Utilizing the intellectual or cognitive section of Benjamin Bloom's Taxonomy, cognitive skills are developed from basic (e.g., one learning the alphabet) through advanced levels (e.g., one writing an opinionated research paper).

The following list displays the words used on each chapter objective and the level of skill desirable:



1. **Knowledge objectives**: focuses on a student remembering or recognizing basic facts, ideas, and concepts, using words such as define, describe, and identify.
2. **Comprehension objectives**: focuses on a student demonstrating an understanding of these facts, ideas, and concepts, using words such as cite, discuss, estimate, explain, and summarize.
3. **Application objectives**: focuses on a student taking basic knowledge or facts and applying it in new situations or different ways, using words such as articulate, assess, and relate.
4. **Analysis objectives**: focuses on a student examining information and finding a cause or motive behind any associated relationships, using words such as analyze, compare, contrast, differentiate, illustrate, and outline.
5. **Synthesis objectives**: focuses on a student combining different pieces of information, compiling them in ways that provide unique or alternative results, using words such as evaluate and respond.
6. **Evaluation objectives**: focuses on a student assessing differing ideas, making judgments concerning the value of these ideas and concepts, using words such as appraise and debate.

HOW TO USE THIS BOOK

Watch for the following highlights throughout the book to help provide the best educational experience:

Words to Recognize
At the beginning of each chapter, look over these words that hold special significance to the upcoming questions and answers. At the end of the chapter you can check the chapter word review to ensure that these terms were properly understood.

Learning Objectives
Examine these learning objectives at the beginning of each chapter. They were developed to help the teacher or independent learner build upon basic learning principles as a foundation for the more developed learning skills and are based on the question/answer format of each chapter.

Moon Activities
Make your own interesting findings and observations from suggested activities at the end of each chapter. Watch for this symbol denoting something that can be done to further enhance the learning experience and take the theory from the pages into your own lab or backyard.

Shooting for the Moon
To shoot for the moon is a phrase that suggests setting high goals for yourself. Watch for this symbol to find unique and fascinating facts and insights on the moon that are found throughout the text.

Flip Pages
The book has been designed so you can flip through the pages and watch the phases of the moon where the page numbers are found.

PREFACE

The first edition of this book was written in 1978. Since then, a wealth of new information has appeared concerning the moon and space. There have been lunar probes such as LCROSS, completion of the Hubble Space Telescope and the Keck Telescope in Hawaii, and even a new theory of lunar origin by a collision process.

In this book we concentrate on the topics that directly relate the moon to creation studies. This goal is both straightforward and rewarding because the moon is an excellent witness to creation in many ways. We use a question-answer format throughout the book, as well as added educational material for this new updated and expanded version. Special thanks to NASA engineer Tom Henderson for helpful suggestions.

For many years it has been the deep desire of the authors of this book to glorify the Creator of the world. Our greatest discovery, however, has been the grace and mercy of this awesome God, in providing eternal salvation through faith in His Son. The same Person who created the moon and the entire universe became a human being and died on a cross to pay the full penalty for sin that we could never pay. Such sacrificial love transforms all things for those who believe in Him. “If you confess with your mouth the Lord Jesus and believe in your heart that God has raised Him from the dead, you will be saved” (Rom. 10:9). “Praise Him, sun and moon. . . . Praise the Lord . . . kings of the earth and all peoples. . . . For His name alone is exalted; His glory is above the earth and heaven” (Ps. 148:3–13).

—Dr. Don DeYoung and Dr. John C. Whitcomb

"That's one small step for man; one giant leap for mankind."
Neil Armstrong (Apollo 11 commander)

1 OUR NEAREST NEIGHBOR

Learning Objectives

1. Define what makes something a moon.
2. Describe the distance of the moon from earth, what keeps it in the sky, and its size.
3. Summarize why we see only one side of the moon, what caused the lunar craters, and the moon's surface features.
4. Explain what moon rocks are like, the notion of water on the moon, and the question of possible life on the moon.
5. Describe the cause of moon phases and how they affect the earth.
6. Analyze when eclipses occur and what causes ocean tides.
7. Discuss the Apollo program and what it was.
8. Compare our moon with other moons in the solar system.

Words to Recognize

breccias, cold traps, libration, lowlands, lunar eclipse, lunar highlands, moon, neap tides, regolith, sidereal period, solar eclipse, spring tides, synodic period

1. What is a moon?

A moon is any natural satellite that orbits a planet. It is held captive by the planet's gravity force and moves in a continuous elliptical orbit. Our moon circles the earth about once each month. There are about 100 known planetary moons in the solar system, and additional small moons continue to be found circling the outer planets.

Our moon is described as "the lesser light that rules the night" in Genesis 1:16. The actual word *moon* comes from Old English. In the Old Testament the most common Hebrew word translated "moon" is *hōdesh*, signifying the beginning of a new month or new moon. Another Old Testament word for moon is *ya-reah*, also related to the word *month*. Three times the Hebrew word used is l^{e}*bana*, meaning "white one." In the New Testament, the Greek word for the moon is *selene*, meaning "brilliant" or "attractive." Our beautiful, dependable moon lives up to its name.

Table 1–1. The relative nearness of the moon can be appreciated by comparing its distance from Earth with several other space objects:

	Moon	238,712 miles (384,090 km)
	Sun	93,000,000 miles (149,637,000 km)
	Pluto	3,700,000,000 miles (5.95 billion km)
	Alpha Centauri	24,000,000,000,000 miles (38.6 trillion km) The nearest nighttime star, 4.3 light years away
	Big Dipper stars	558,000,000,000,000 miles (898 trillion km) An average of 100 light years away
	Remote Galaxies	55,000,000,000,000,000,000,000 miles (88.5×10^{21} km) 10 billion light years away

Other World Travel

Our moon is the only other "world" that astronauts have visited. From the desolate lunar surface the earth appears as a pleasant blue oasis in space.

2. How far away is the moon?

Our moon is the nearest neighbor to Earth in space. Its distance varies annually between 225,600 and 251,815 miles, with an average of 238,712 miles (384,090 km). There are many alternate ways to express this Earth-moon separation:

- 238,712 miles (center to center)
- 384,090 km
- a light travel time of 1.3 seconds
- a three-day trip for Apollo astronauts
- at 60 mph the trip would take 52 months
- equal to ten trips around the world
- 400 times closer than the sun

3. What keeps the moon in the sky?

How can a massive round rock weighing 81,000,000,000,000,000,000 tons (7.35 x 10^{22} kg) float overhead in our sky? Actually, it doesn't; the moon falls toward the earth continually. However, it does not get any closer to us. This paradox occurs because of the moon's orbital motion. Figure 1-1 shows how the moon's tangent speed and falling motion add together to result in a smooth, curving orbit around the earth. The explanation is similar for all orbiting objects, including moons, artificial satellites, and planets. If the moon's tangent speed ceased, it then would fall directly toward the earth and collide with us. On the other hand, if gravity ceased, the moon would leave its Earth orbit on a straight line path like a stone from a whirling slingshot.

The moon moves about 3,350 feet (1,020 m) each second tangentially while falling just one-sixteenth inch (1.6 mm) toward the earth. This combination results in a smooth, elliptical orbit. The attractive force toward the earth, called the centripetal ("center-seeking") force, is provided by gravity. Gravity is an attractive force occurring between all objects, whether on earth or in space. For example, your weight is simply the gravity attraction between you and the earth. On the scale of large space objects the gravity force becomes immense. The attraction between the earth and moon is about 4.5 x 10^{19} pounds, or over 20 million billion tons (2 x 10^{19} kg). This gravity force continually acts on the moon to maintain its orbit like a whirling ball held by a string, and, in turn, pulling back on the earth, the moon's gravity force results in our ocean tides.

What really is gravity? This mysterious force continues to puzzle scientists even as it gives stability to the entire universe. How is gravity able to act across vast stretches of empty space, and why does it exist in the first place? Science has never been very successful in explaining fully such natural phenomena as gravitation. Einstein proposed in 1915 that the gravity force results from a "distortion of the fabric of space." Others have searched for unseen graviton particles that move between space objects. Whatever the case, clearly this universal force rule cannot somehow arise by gradual change such as biological mutation or natural selection. Gravity was established from the very beginning of time. Gravity, along with every other intricate physical law and constant, is surely a testimony to God's planned, orderly creation.

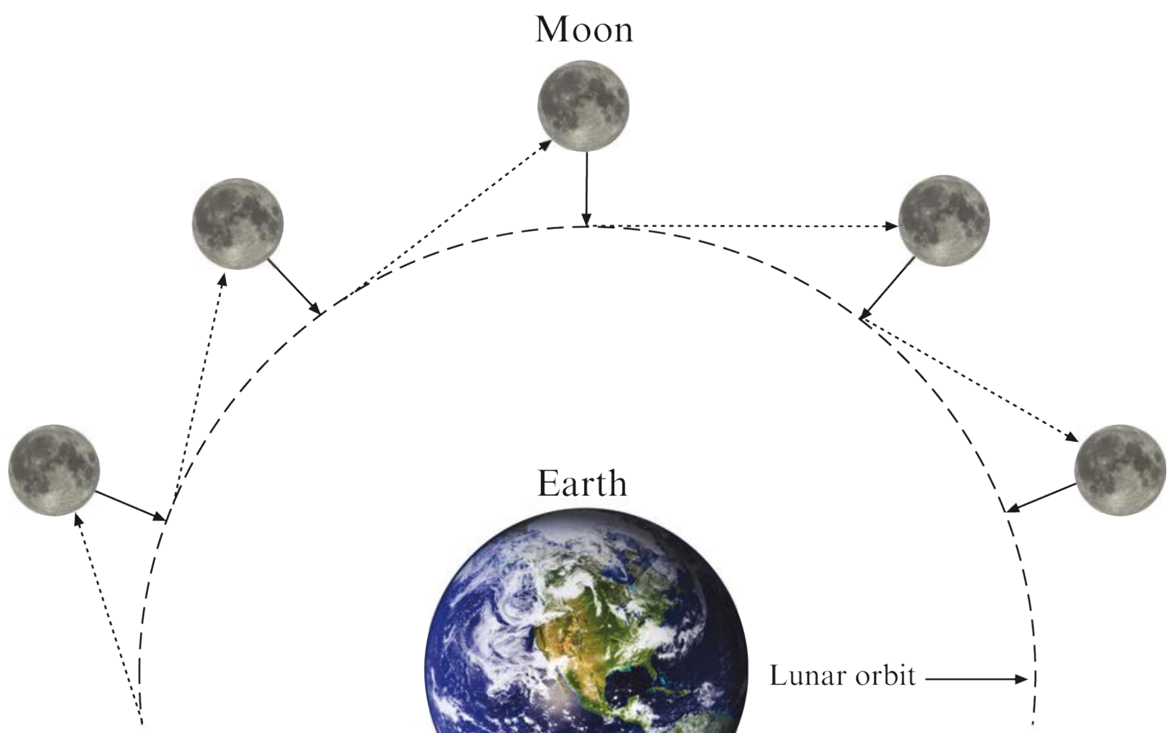


Figure 1-1. The moon circles the earth due to the combination of straight-line (dashed arrows) and falling (solid arrows) motions. This "saw-tooth" pattern leads to a stable orbit. The figure is not drawn to scale.

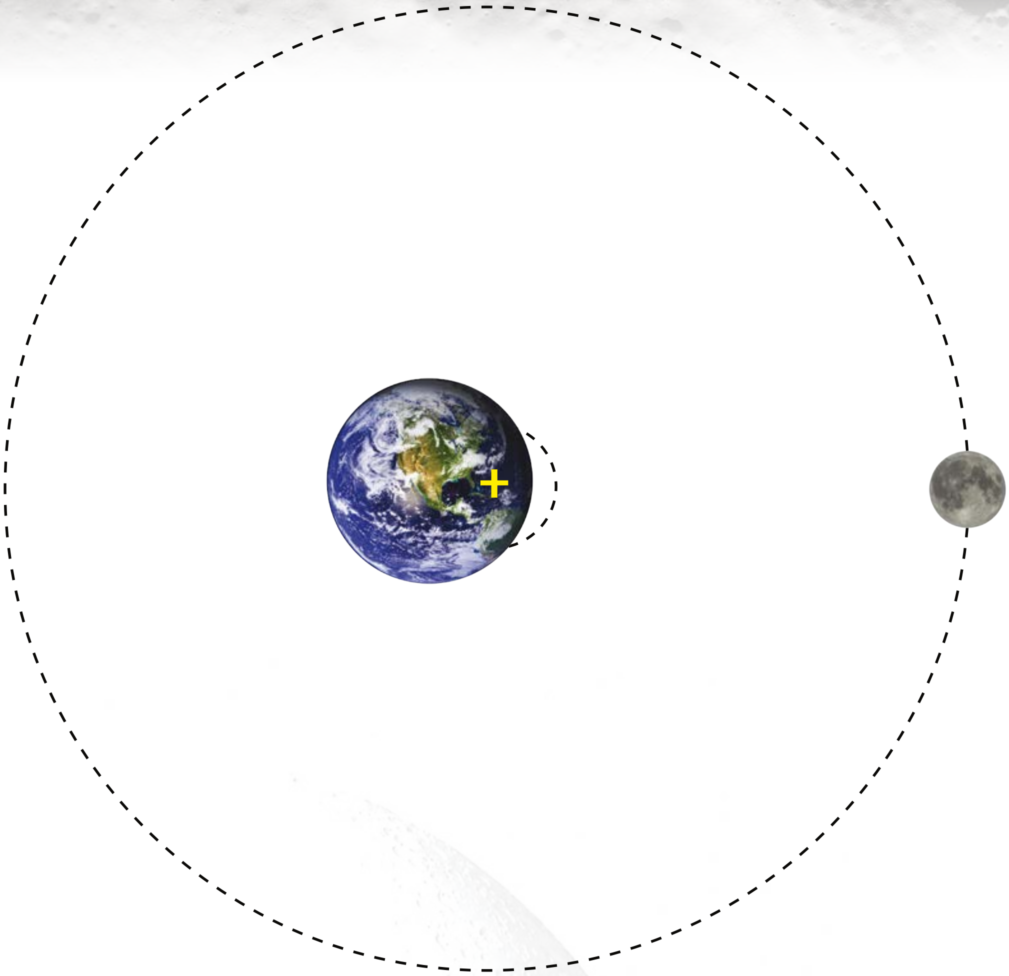


Figure 1-2. The motions of the earth and moon about their mutual center of mass (+). The earth's center moves around the small dotted circle as the moon moves around the much larger dotted path. The figure is not drawn to scale.

4. How large is the moon?

Our moon is approximately one quarter the size of the earth. The respective diameters are 2,160 miles (3,475 km) and 7,928 miles (12,756 km). In terms of actual mass, the earth is 81 times more massive than the moon. It is for this reason that we say the moon orbits the earth. Actually, both objects move about their mutual balance point or center-of-mass. This balance point, or *fulcrum*, is positioned within the heavy earth, which moves on a much smaller circle than the moon (Figure 1-2). The actual motion is much more complicated than this because of gravity interactions with the sun and other planets. The center-of-mass position changes continually depending on the positions of all these objects. A moment-by-moment analysis is called *a many body problem* in physics, and remains a difficult challenge even for the most powerful computers available.

Our moon is very large when considering the size of the earth. There are four other solar system moons larger than ours, but they are typically much smaller than their planets (Figure 1-3). Only Pluto's moon, Charon, is closer in size to its planet than the earth-moon system. All the other moons are less than 5 percent of the diameter of their planets. This makes the lunar masses less than 0.025 percent that of their planets. For this reason, our moon is sometimes called a "secondary" or "double planet" companion to the earth. Suppose the moon remained at its current distance but its mass was reduced 100 times to make it an "average size" solar system satellite. As a result, the moon's diameter would be decreased by about 78.5 percent. Since the light reflected from the moon depends on its surface area, which is proportional to the square of its diameter, the full moon brightness then would be reduced to just 5 percent of its present value, a 20-fold diminishment of its light. The moon's unusually large size, therefore, is necessary for it to provide significant evening light.

The Book of Genesis states, "Then God made two great lights: the greater light to rule the day, and the lesser light to rule the night" (Gen. 1:16). The Hebrew term translated *light* in this passage is flexible enough to include light reflectors such as the moon and the planets. Some critics have called Genesis 1:16 untrue because the sun is not the largest star in all of space, and the moon also produces no light of its own. However, the fact that the moon, which is a reflector, and the sun, which is far from being the largest star, are named "two great lights" is perfectly consistent with the language of appearance that the Bible uses throughout. A God who could not communicate with men in terms that they could understand would be limited indeed. From our human perspective, the only light that truly dominates the night sky is the nearby moon.

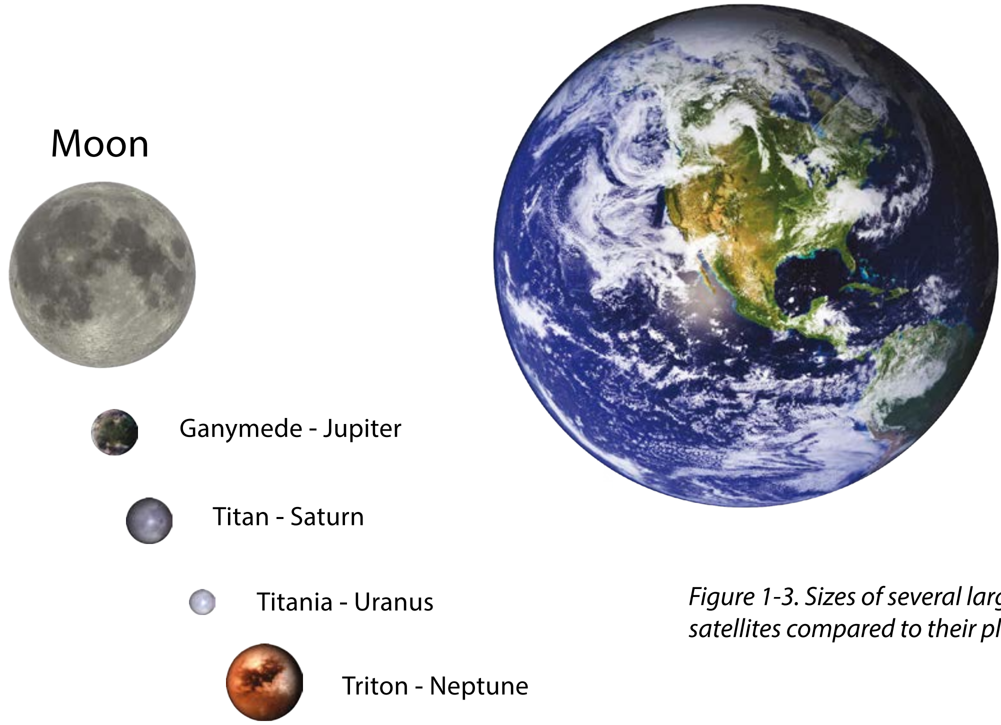


Figure 1-3. Sizes of several larger satellites compared to their planets.

5. Why do we see only one side of the moon?

The moon rotates once on its axis during the very same time that it orbits the earth, 29½ days (actually 29 d., 12 hr., 44 min., 2.98 sec.). As a result we always see the same side of the moon. This is not unusual for solar system moons; many others are likewise "locked in" as they orbit their respective planets. Our own moon has slightly more mass distributed on its near side so gravity attracts and holds this side toward the earth. The effect is similar to whirling a ball on a string with the side with the attached string always facing inward. The moon also "rocks" slightly back and forth during its orbit, which allows us to see slightly more than half the moon, about 59 percent. This is called *libration*.

Mark Twain in his novel *Pudd'nhead Wilson* (1894) made an interesting reference to the moon. He wrote, "Everyone is a moon and has a dark side which he never shows to anybody." This quote may well describe Twain's own struggle with his sinful nature. However, Mark Twain was incorrect in his description of the opposite side of the moon. It is dark only half the time and is fully lit during the new moon phase. The back of the moon is the *hidden* side but not always the *dark* side.

The opposite side of the moon may become an important future location for astronomers. Radio wave signals from space are a valuable source of information. They are detected with large radio telescope antennas. However, radio *noise* from satellites and Earth electronics can cause serious interference. A radio observatory constructed on the far side of the moon would be shielded from this interference. The lack of a lunar atmosphere could also be a bonus for clear observing of space.

Further comment is needed on the moon's rotation time. The stated value of 29½ days is measured with respect to the earth, called the *synodic* period (Figure 1-4). This is the time from one full moon to the next. The moon's rotation time is somewhat shorter with respect to the stars, 27½ days. This is called the *sidereal* period. Both lunar rotation times are commonly found in the literature.

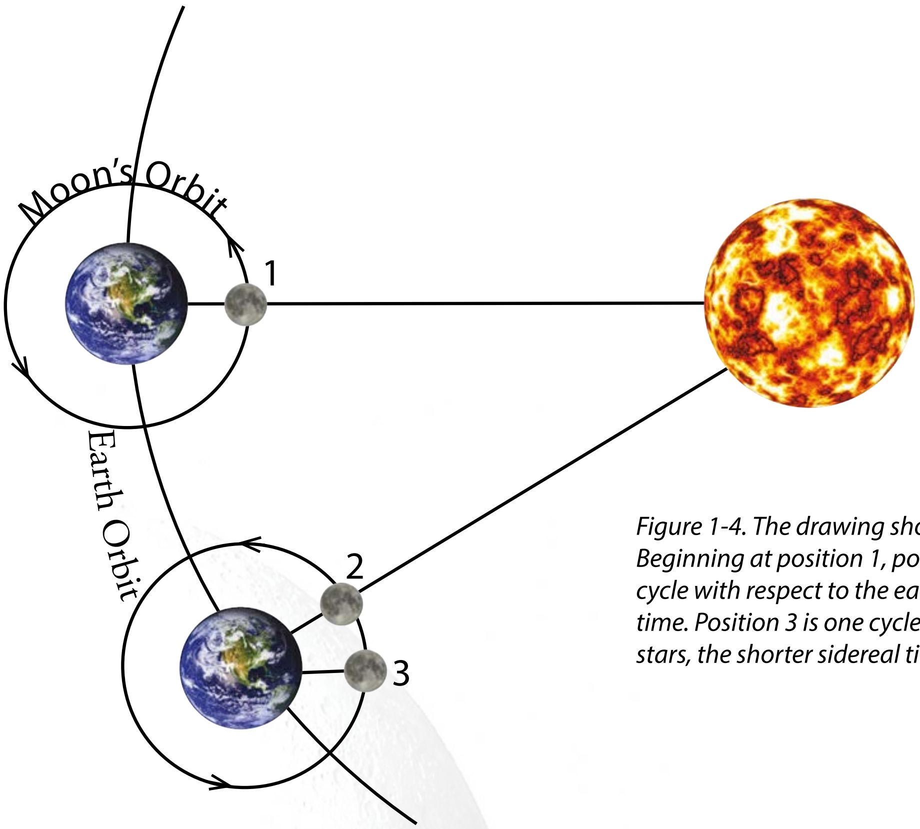


Figure 1-4. The drawing shows one lunar orbit. Beginning at position 1, position 2 is one full cycle with respect to the earth, the synodic time. Position 3 is one cycle with respect to the stars, the shorter sidereal time.

6. What caused the lunar craters?

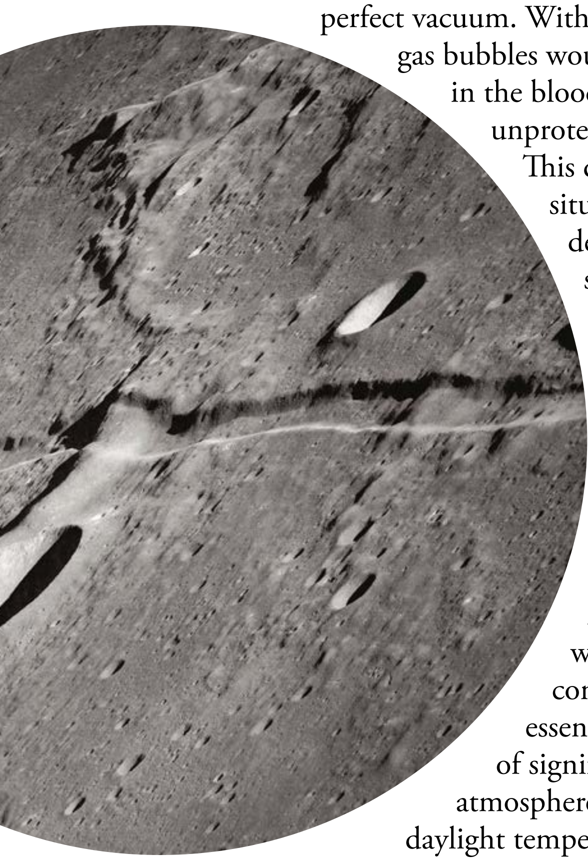
Until recent decades this question often led to lively debate. Suggestions included volcanic activity, giant gas bubbles rising to the moon's surface from the interior, and collapsed sinkhole formations from dissolved underlying bedrock. The idea of impact collisions first became popular in the 1950s. Around this time, it was realized that a large meteorite collision had formed the well-known Barringer Crater ("Meteor Crater") in northern Arizona.

The moon displays countless numbers of craters. Some are hundreds of miles in size while most are much smaller. The Sea of Storms (*Oceanus Procellarum*), thought by some to be a crater remnant, exceeds the entire Mediterranean Sea in area. There are estimated to be 200,000 craters across the moon with diameters larger than a kilometer. Smaller craters within larger craters cover the moon like a battlefield. Since the moon has no atmosphere, all approaching space rocks strike the moon's surface. On Earth, in contrast, smaller objects may "skip off" our atmosphere and miss us completely, or else may burn up from friction on their rapid descent. Many other meteorites that hit the earth leave no trace because they land in the seas, which cover over two-thirds of the earth's surface.

About 200 craters have been identified across the earth. These blemishes gradually are eroded away by wind, water, and tectonic processes. In contrast, on the moon, craters become permanent records of past collisions.

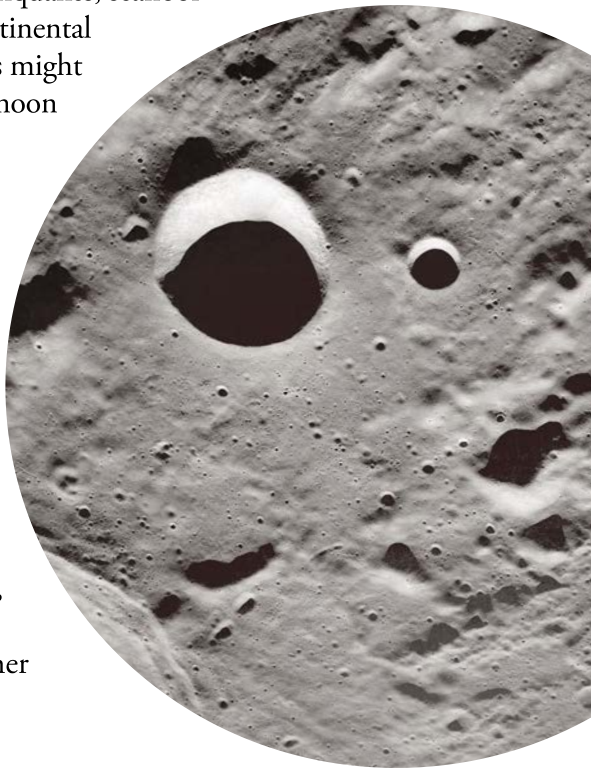
7. What are the moon's surface features?

Suppose you could visit the moon to explore its surface. A space suit would be essential for your survival since there is no air to breathe in the near-perfect vacuum. With no air pressure, gas bubbles would form quickly in the bloodstream of an unprotected person. This dangerous situation is called decompression sickness or "the bends." If you land on the sunlit side of the moon, with its temperature up to 266°F (130°C), a reflecting suit with built-in air conditioning is essential. The lack of significant water or atmosphere results in a daylight temperature greater than the boiling point of water. Meanwhile, on the darkened portion of the moon, the temperature plunges lower than -292°F (-180°C).



You will notice shadows on the moon, and greatly reduced gravity. In fact, your weight will be only one-sixth of its value on Earth. For example, if you weigh 150 pounds on Earth, your moon weight will be just 25 pounds. The feeling is somewhat like the buoyancy of water. One can imagine the daily weather report for the moon: *no rain is in sight; also no breeze, clouds, sounds, or blue sky. Skies will be black instead. Humidity will remain at zero percent. The high temperature today will be a scorching 266°F. When night finally comes after two weeks of sunlight, the temperature will plunge to -292°F.* Lunar astronaut Buzz Aldrin called the moon a place of "magnificent desolation." How different the moon is from the specially prepared earth.

During the imaginary moon visit you will notice large flat areas or *lowlands* that cover one-half of the moon's visible side. Early astronomers named them *maria* (mar-eé-a, singular: mare), the Latin word for seas. They are indeed seas, but made of hard basalt rock instead of water. From the earth, these hardened lava flows have the appearance of large, circular, dark-colored patches. *The lunar highlands* are rugged mountain ranges that appear from Earth as light-colored patches. Some of these lunar peaks rise five miles above the surrounding plains, rivaling Earth's Mount Everest in height. Especially high elevations near the northern lunar pole, the so-called mountains of eternal light, withdraw from constant sunshine only at times of a lunar eclipse. Astronomers do not understand how the lunar mountains formed. The moon does not show mountain-forming activity analogous to earthquakes, seafloor spreading, or continental drift. Creationists might suggest that the moon was created with great variety in its topography, similar to the earth. Appendix 1 suggests some particular lunar features of special interest for close observation.



Besides the lunar mountains, basaltic seas, and craters, many other

distinctive surface features of the moon can be seen with a telescope. Bright *rays* appear to radiate outward hundreds of miles from some of the larger craters. They are debris tracks deposited from the *ejecta* of major impact collisions. The rays appear as elongated, gentle hills rounded by further impact erosion. Sinuous lunar *rilles* that meander across the moon's surface are probably collapsed lava drainage channels, since the lack of water rules out river channels. The many visible cracks and valleys on the surface are apparently adjustments in the moon's surface to stress from heating and tidal pull. The far side of the moon was first photographed in 1959 by the Russian spacecraft *Luna 3*. Fanciful speculation about hidden features and even a lunar civilization was ended by pictures of emptiness. There are many large craters and seas of solid basalt.

Rocks and large boulders are strewn about the lunar surface. But there are no rivers, lakes, grass, or trees to complete the landscape. Upon returning from a voyage to the moon, one conclusion is inescapable: there is no place like home!

8. What are moon rocks like?

The Apollo astronauts returned to Earth with about 843 pounds (382 kg) of moon rocks, core samples, pebbles, sand, and dust for study. Some meteorites collected on the earth appear to have been blasted from the moon by past impacts. The lunar rocks collected by astronauts resemble Earth varieties in some respects and differ significantly in other ways. The three varieties of collected samples are *crystalline rock, soil,* and *breccia*. The geological term *regolith* is given to the general lunar surface collection of dust, pebbles, and boulders.

The lunar *crystalline rocks* contain the same chemical minerals found in Earth rocks. Lunar basalt is common, similar to our abundant terrestrial volcanic rock. It forms by cooling from molten lava, and is especially common in the lunar maria areas. The small crystals within the basalt suggest a rapid cooling of the moon's surface in the past. Some of this material also may be original, created lunar crust. All the moon rocks contain higher proportions of heat-resistant elements such as calcium, aluminum, and titanium than Earth rocks. Conversely, the easily vaporized elements sodium, potassium, and lead are relatively depleted on the moon.

Moon rock presented to Smithsonian Institute by the Apollo 11 crew, 1969.

Along with basalt, another important lunar rock is *anorthosite*. It is light gray in color, which makes the lunar highlands lighter in appearance than the basalt-covered maria. The color contrast between anorthosite and basalt is also responsible for the appearance of the illusion of a human face ("man-in-the-moon"), which some people see on the moon's near side.

The lunar *soil* consists of the powdered remains of many collisions between meteorites and the igneous surface. Unlike the typical soil of Earth, it contains no organic matter and very little moisture. Small, bright beads of colored glass give variety to the soil, indicating the melting of material during past impacts and subsequent rapid cooling.

Breccias are rocks composed of small rock fragments, glass, and soil that have been compacted into cohesive rocks. The lunar particles are sharply angular rather than rounded, as is the case for most terrestrial conglomerate rocks. Lunar breccias may result from *shock melting* during the impact of meteorites.

The moon lacks some of the most common rocks found on Earth, including granite, and also sedimentary varieties such as limestone, shale, and sandstone. The lack of sedimentary deposits rules out any hint of a large lunar water supply.