Our Moon's Phases and Eclipses

Our planet's satellite, which we call the Moon, is the easiest astronomical object to observe. The only "scientific instrument" you need is a pair of eyes. The Moon is the only thing in the sky (other than the Sun) that doesn't look like a point of light or an indistinct fuzzy patch to the unaided eye. Even more interesting, the way the Moon looks to us continually changes. Keeping track of its appearance from night to night (or day to day) is a fascinating and easy way to get acquainted with the rhythms of change in the sky.

The Moon is small, only about a quarter the size of the Earth. Looking at its light and dark patches, many people are reminded of the face of a person or the shape of a rabbit. Early astronomers who studied the Moon with the first telescopes were convinced that the dark areas were vast oceans, and so they named them "mare," the Latin word for "sea." We now know there are no bodies of water on the Moon's surface; in fact, it's an airless world, not hospitable to any kind of life. The maria (the plural form of the word "mare") are really large, smooth plains formed out of solidified lava.

The lighter patches are rocky regions covered with craters — circular pits or basins blasted out by high-speed impacts from rocks of varying sizes (from objects the size of small cities down to boulders and pebbles). Most of the craters bear silent witness to a time, billions of years ago, when collisions between such debris and planets were much more common. The Earth, too, experienced a similar bombardment, but erosion by wind, water, and the movement of the Earth's crust has largely erased ancient craters from the Earth's surface. On the Moon there is no wind or rain to wash away the evidence, preserving the cosmic history of our "neighborhood" for humans to study.

Over the millennia, the Moon has become "locked" into a special kind of motion around the Earth. It rotates on its axis at the same pace as it revolves around the Earth. As a result, the Moon always keeps the same "face" pointed toward us throughout its orbit. This is why astronomers speak of the "nearside" (the side we see) and "farside" (the side we never see) of the Moon. Indeed, it wasn't until the 1960s, when we sent spaceships to fly around the Moon, that we got our first glimpse of the far side of the Moon.

We only see the Moon because sunlight reflects back to us from its surface; it has no light source of its own. (This is probably important to emphasize. Many students are quite surprised to learn that moonshine is just reflected sunshine.) During the course of a month, the Moon circles once around the Earth. Indeed, the word "month" comes from "Moon"; younger students really enjoy it if you give them permission to say "moonth" instead of "month" for a while.

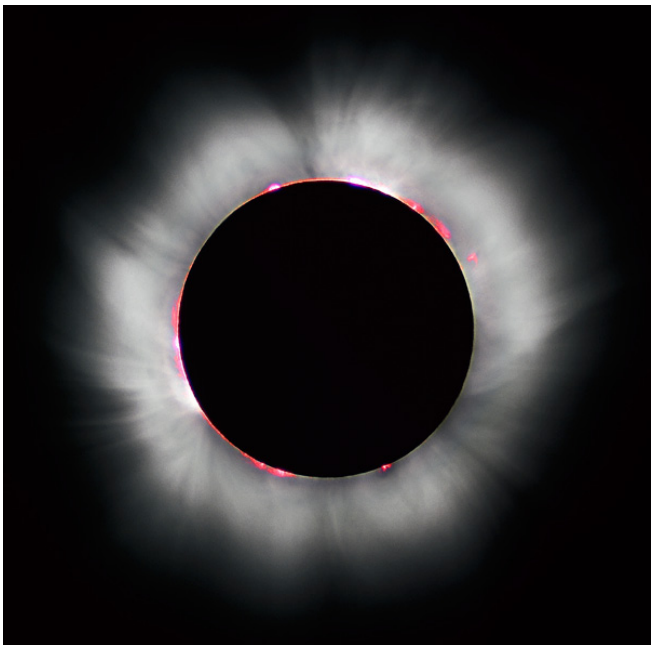
The half of the Moon facing the Sun is always lit; but the lit-up side does NOT always face the earth! As the moon circles the Earth, the fraction of its disk facing us that is lit by the Sun changes, altering how much of the lunar surface appears bright and how much is in darkness. The changes are known as phases, and repeat in a specific cycle each month. There are four primary phases: New Moon, First Quarter, Full Moon and Last Quarter. Each occurs about a week apart, with Last Quarter followed by another New Moon, which begins the cycle anew (it actually takes 29 and ½ days to go from one New Moon to the next). To understand the cycle of Moon phases, there really is no substitute to holding a small white ball in the light from a distant light-bulb and studying the changing shape of the illuminated part of the ball as you move it around you. The activities in this section demonstrate this quite well.

Several points about the Moon's phases should be emphasized. First, during the week it takes to move from one phase to another, the amount of the Moon's surface lit by the Sun changes gradually; it's not an abrupt change from one phase to the next (which is the impression some textbooks give). Second, despite what

some poets claim, the Moon is not limited to the night sky. Near both First and Last Quarter you can see the Moon during the daytime. (See the table below for more on when you can see the Moon.) Finally, it's worth repeating that the phases of the Moon depend only on the amount of reflected sunlight we see. The Earth's shadow plays no role in the Moon's phases.

But our shadow does darken the Moon during a special time — a lunar eclipse. Let's see why. The Earth circles the Sun once per year. The plane of the Earth's orbit is called the ecliptic. The Sun, the Earth and the Earth's shadow all fall within the plane of the ecliptic. However, the plane of the Moon's orbit is tilted a little bit (5°) from the plane of the ecliptic. When the Moon is on the side of the Earth away from the Sun (Full Moon), it passes very close to the Earth's shadow; so there is a chance of an eclipse every month. But because its orbit is tilted, the Moon usually passes just above or below the Earth's shadow. About once every six months the Moon can go right through the shadow of the Earth, creating a lunar eclipse.

Since the entire night side of the Earth faces the Moon when it is in its Full phase, everyone on the night side of the planet can see all or part of a lunar eclipse when it occurs. It takes the Moon a few hours to pass completely through the Earth's shadow. During that time, some parts of the Earth that were in nighttime when the eclipse started will rotate into daylight; people living there will miss the end of the eclipse. Similarly, parts of the Earth that were near sunset when the eclipse started will rotate into nighttime; for those people, the Moon will rise already in eclipse. Most of the Earth's night side, however, remains in darkness throughout the eclipse, enjoying the full spectacle.



Total Solar eclipse 1999 in France. *(Luc Viatour)*

While in the Earth's shadow, the Moon looks reddish-

PHASE	RISES	EASTERN SKY	HIGHEST IN SKY	WESTERN SKY	SETS
New Moon	sunrise	morning	noon	afternoon	sunset
Waxing Crescent	just after sunrise	morning	just after noon	afternoon	just after sunset
First Quarter	noon	afternoon	sunset	evening	midnight
Waxing Gibbous	afternoon	sunset	night (pm)	midnight	night (am)
Full Moon	sunset	night (pm)	midnight	night (am)	sunrise
Waning Gibbous	night (pm)	midnight	night	sunrise	morning
Third Quarter	midnight	night (am)	sunrise	morning	noon
Waning Crescent	just before sunrise	morning	just before noon	afternoon	just before sunset

Crescent moon. You can see the parts of the dark moon faintly illuminated by light reflected from Earth, which we call Earthshine. *(Ilmari Karonen)*

orange. This deep color comes about because the Earth's atmosphere bends the red-orange part of sunlight into the shadow, just as it does at sunrise or sunset (the sky appears reddish when the Sun is below the horizon). How dark the Moon appears depends upon whether the Moon is crossing through the center of the Earth's shadow or nearer to the edge of the shadow, and how much dust or pollution is in the Earth's atmosphere.

In an amazing coincidence, the Sun and the Moon appear to us to be almost the same size in the sky. Although the Moon is actually hundreds of times smaller in size than the Sun, it is, completely by chance, just as many hundreds of times closer to the Earth. Because of this, if the Moon happens to pass directly between the Earth and Sun, it can momentarily block out the Sun, creating a solar eclipse. This happens when the Moon is on the same side of the Earth as the Sun (New Moon). Again, because of the tilt of the Moon's orbit, it usually passes just above or below the Sun's position at this time. But, about every six months the Moon can pass directly between the Earth and the Sun. Because the Moon's shadow is so small, however, only a small portion of the Earth's surface will see the Moon completely block out the Sun, a total solar eclipse. People outside of the small region of totality will see the Moon block only part of the Sun's surface, a partial solar eclipse; it looks like a "bite" has been taken out of the Sun.

The Moon is the only place in the entire solar system, other than Earth, on which humans have walked. The astronauts who landed on the Moon in the late 1960s and early 1970s returned with boxes full of rocks taken from the Moon's surface. Scientists continue to learn a great deal by studying these rocks. But our increasing scientific understanding of the Moon need not take away from our response to its beauty. To be startled by the Full Moon rising in the eastern sky at sunset is to be confronted by one of nature's greatest spectacles. Knowledge need not reduce our sense of awe; it can enhance it.

Portions of this article were reprinted with permission from PASS (Planetarium Activities for Student Success), Vol. 10 Who Discovered America? "Background for Teachers-What Causes a Lunar Eclipse?" p. 52. Produced by the Astronomy Education program at the Lawrence Hall of Science. The PASS series, volumes 1-12, can he ordered from Lawrence Hall of Science, University of California, Berkeley, CA 94720-5200. Published by the Astronomical Society of the Pacific. www.astrosociety.org