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# The Moon: It's Just a Phase It's Going Through...

***Editor's Note:*** The 20th anniversary of the first manned landing on the Moon--when Neil Armstrong and Edwin Aldrin became the first members of our species to walk on another world--will be celebrated this July 20th (1989). To prepare for this epochal event, the next two issues of *The Universe in the Classroom* will be devoted to the Moon. In this issue, we'll take a look at the Moon in our sky--its phases and some ways in which students can enjoy (and learn from) its ever-changing appearance. Our next issue will consider the Moon as a world it its own right--its craters, plains, and mountains--and present a short history of lunar exploration.

Our planet's large natural satellite, the Moon, is the easiest (and cheapest!) astronomical object to observe. The only "scientific instrument" you'll need at first is a pair of eyes. The Moon is the only thing in the sky (other than the Sun) that doesn't look like just a pinpoint of light or an indistinct fuzzy patch as seen with the unaided eye. Even better, the way the Moon looks to us is continually changing; 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's Orbit

The Moon *orbits* around the Earth, taking about a month to go all the way around our planet. Its orbit is very nearly circular; it stays about 380,000 kilometers away from us as it moves counterclockwise (as viewed from a northern hemisphere perspective). It also stays fairly close to the Earth's *equatorial plane* (an imaginary extension of Earth's equator out into space); the point on the Earth directly under the Moon is never more than 29° north or south of the equator.

## Demonstrating the Moon's Motion

Over the millenia, 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 keeps the same face toward us throughout its orbit.

Younger students can enjoy demonstrating this motion by "orbiting" around another student seated in the center of the classroom. Have the "Moon" student begin by facing the "Earth" student (the one seated in the center). Then have the "Moon" student "orbit" — circle around the student in the center. The "orbiting" student will find that if he carefully swivels his body 1/4 turn for each 1/4 "orbit" around the room, then he will always be facing inward as he completes a full circle. (His back will never be visible to the seated "Earth" student in the center.) This is why astronomers speak of the "nearside" and "farside" of the Moon.

## Phases of the Moon

Since the Moon shines by reflecting sunlight, what it looks like to us at any particular time depends on the *angle* at which the Sun's light is hitting the Moon. For example, if sunlight is coming from the right, the right

half of the Moon's globe will be bright and the left will be dark. If sunlight is coming from behind the Moon as we look at our satellite, then its farside will be illuminated, and *we* will see a dark globe or "new moon."

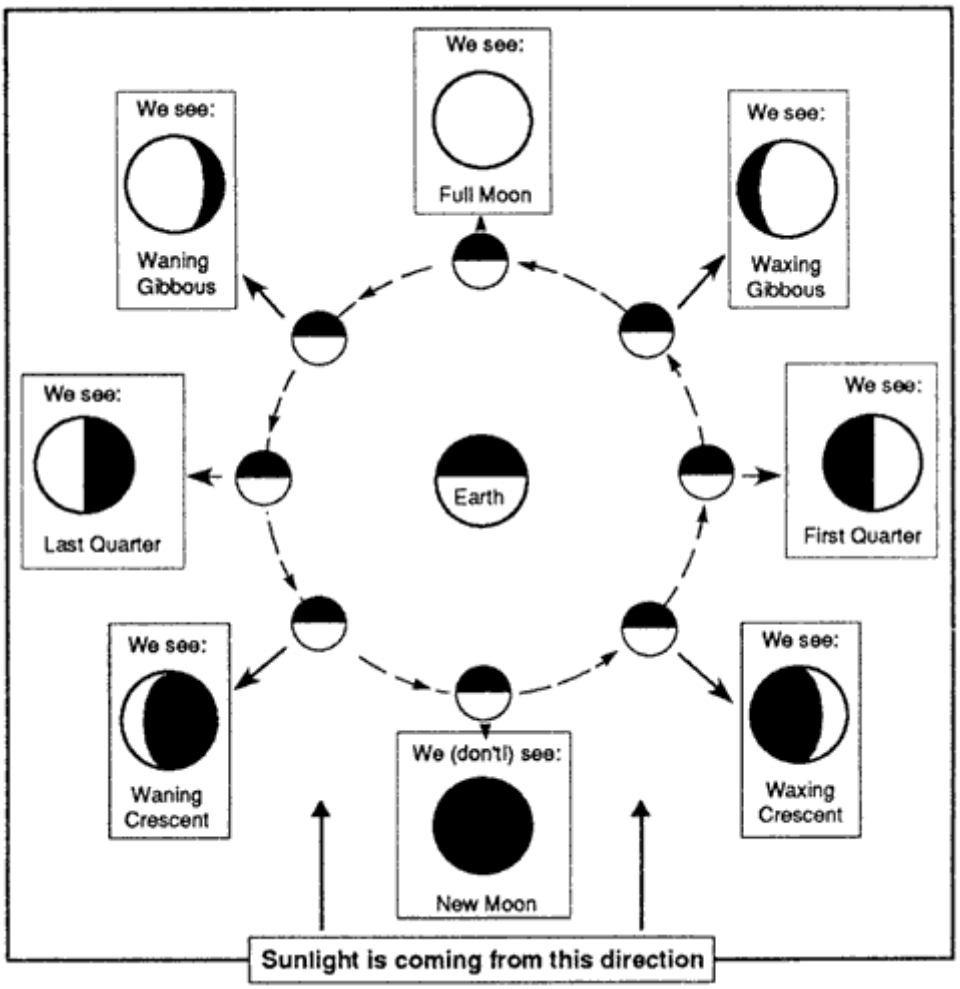


**FIGURE 1:** The pictures are shown from a northern hemisphere perspective. Those of us who live in the northern hemisphere (outside the tropics) have to look generally south to see the Moon when it's highest in the sky, and we wee the right-hand side illuminated at first quarter phase, for example. People who live in temperate or high latitudes south of the equator must look toward the north; to them the first quarter moon has its left side illuminated.

The diagram is not to scale. In reality, the Moon is 1/4 the diameter of the Earth and its orbit's width is about 60 times the Earth's diameter.

Figure 1 shows the Moon during one orbit around the Earth from a vantage point far above Earth's North Pole. It also shows what the Moon would look like when it is highest in the sky at eight times during the month.

Let's look at these phases of the Moon one by one:

### New Moon 

At *new moon,* the Sun and the Moon are quite close to each other in the sky. (In fact, the Moon in its new phase will sometimes block all or part of out view of the Sun. This event is called a *solar eclipse*. The side toward us is in shadow and is dark. Moreover, since the Moon and Sun are so near each other on the sky, they are above the horizon at the same time. Thus the Moon is only in the sky during the day, when the sky is bright--which means a new moon cannot be seen from Earth!

### Waxing Crescent 

As time passes after new moon, the Moon--orbiting counterclockwise around the Earth--moves away from the Sun toward the east from our vantage point, traveling about 12 degrees per day toward the left, as seen from Earth's northern hemisphere. (To help you get a feel for measuring sizes on the sky using degrees, note that the full moon is about half a degree wide. So 12 degrees is about 24 times the Moon's width on the sky.) Two or three days after new moon, a *waxing crescent* can be seen just to the east (left) of the Sun. It is most easily seen just after sunset, following the Sun closely down toward the western horizon. Notice that the

"horns" of a crescent moon always point *away* from the Sun (alternatively, you can think of a crescent moon as a bow about to shoot an arrow toward the Sun). Also, since the Moon in a crescent phase--either waxing or waning--is close to the Sun on the sky, it can't be above the horizon at night unless it's shortly after sunset or before sunrise. (An exception to this is if you are near the Earth's North or South poles. At those places, near the time of the "midnight sun," it is possible to see the crescent moon above the horizon near midnight.)

### First Quarter 

About a week after new moon, the Moon has moved about 90 degrees away from the Sun, a quarter of the way around the sky toward the east (left). At this time, its right-hand half is illuminated by sunlight. This phase is called *first quarter* because it occurs when the Moon has completed the first quarter of its orbit from the previous new moon phase. Since it is 90 degrees (1/4 of a full circle) away from the Sun on the sky toward the East, the Moon will lag behind the Sun by about 6 hours (1/4 of 24 hours): it will rise at about noon, be at its highest in the sky at about sunset, and so on. During first quarter and waxing gibbous phases, the Moon is quite easily seen in the blue eastern sky on a clear afternoon. It's also easy to see in the western sky on clear mornings at waning gibbous and last quarter phases. so the old song's assertion "I got the Sun in the mornin' and the Moon at night" isn't always true--at least for the Moon.

### Waxing Gibbous 

During the following week, the Moon continues to further distance itself from the Sun toward the East by about 12 degrees per day. As it does so, it waxes "fatter" as more and more of the side facing us is illuminated by sunshine. This phase is called *waxing gibbous.*

### Full Moon 

When the Moon has completed exactly half of its trip around the Earth from the previous new moon, it is on the opposite side of the Earth from the Sun; the face toward us is fully illuminated, and *full moon* has arrived.

Strictly speaking, "full moon" occurs only for an instant: the time when the Moon is as nearly opposite the Sun on the sky as it will be during its current orbit. however, the Moon will look only imperceptibly different from full for a night or two around that time.

The Moon's orbit around the Earth is tilted by about 5 degrees relative to our planets orbit around the Sun. (If you think of the two orbits as hoops, the two hoops are tilted relative to each other.) This means that full moon doesn't always bring the Sun, Earth and Moon into *perfect* alignment. If it did, the Moon would move directly into the Earth's shadow, which extend straight back, away from the Sun, at full moon. This *does* happen occasionally though; the phenomenon is call a *lunar eclipse*.

Near the time of full phase, the Moon is opposite the Sun; thus it rises around sunset, is high in the sky around midnight, and sets around sunrise, providing light that's bright enough to read by all night long when the weather is clear. (We're not sure your opthamologist would actually *recommend* reading by the light of the Moon, but astronomers like to point out that it is possible.)

Interestingly enough, though, the Moon is actually one of the *darker* objects in the solar system. it reflects only 7% of the sunlight that strikes it, absorbing the rest. For comparison, the Earth reflects 37%, Venus 65%, and Mars 15%.

### *Blue Moon*

Since the time between one full moon and the next is 29-1/2 days, it is possible for a calendar month to have *two* full moons — one at the beginning and one at the end of the month. When this happens, the second full moon of the month is called a "blue moon" — although its *color* isn't really affected at all. These calendrical coincidences happens every few years.

### Waning Gibbous 

During a week after full moon, as the Moon continues to move eastward in its orbit about 12 degrees per day, the Moon rises later and later and the side we see is illuminated by less and less sunlight — its light wanes. While the Moon is in this *waning gibbous* phase, its east (left) side remains fully sunlit, while darkness creeps in from the right.

It is during this time that the *delay* of moonrise from one night to the next is most easily noticed. As the Moon moves farther toward the east from night to night the Earth has to turn a little farther toward the east each night for us to see it. On the average, the Moon rises about 50 minutes later each night, but this can vary significantly depending on the time of year and your latitude north or south of the equator.

### Last Quarter 

As *last quarter phase* — when the Moon enters the last quarter of its orbit back to new moon — the eastern (left) half of its disk is illuminated. Now, the Moon has moved to 90 degrees west of the Sun, and precedes it by about 6 hours in their daily race across the sky: first quarter moon rises at about midnight, is highest in the sky at sunrise, and sets at about noon. Thus, the last quarter Moon is easy to see in the western sky on clear mornings.

### Waning Crescent 

Finally, during the last week of its monthly orbit the Moon draws closer and closer to the Sun on the sky, approaching it from the west (right). The *waning crescent's* horns extend toward the west, away from the Sun, and add a pretty touch to the pre-sunrise sky, low in the east.

A day or two after this phase, the Moon will be new again, and the cycle begins anew...


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## Activity Corner

1. **How Soon Can You See a Crescent Moon?**

   An interesting activity is to see what the youngest crescent Moon is that you can see. Some very experienced observers are able to see the Moon less than 24 hours after it's new. How well can you do?

   [For an article on an international effort to see a very young crescent, see: "Moonwatch--July 14, 1988" by L. Doggett, et al., in *Sky & Telescope*, July 1988, p.34.]

2. **When is the Moon Visible?**

   It is often surprising to youngsters that the Moon sometimes can bee seen in the *daytime* sky. Just when the Moon rises and sets depends primarily on its phase, and only at full Moon does it behave as some might expect — that is, to rise at around sunset and be up all night long.

   Keeping track of the visibility of the Moon as it cycles through its phases can be a fascinating (and instructive) thing to do. Moon-tracking activities could follow a wealth of different paths — from precise timing of moonrise and moonset to a more general noting of where the Moon is (and what phase it's in) each time you see it.

   To help you devise a program of Moon-viewing, the accompanying table charts the times when the Moon rises, sets and so on during its different phases. we should note that the times in the table are *very general* (correct to within an hour or two). The precise times of moonrise, moonset, and so on depends on a number of factors besides the Moons phase — your location on Earth (latitude and longitude) has a major effect, for example. (Exact local times of moonrise and moonset are often printed in large daily newspapers, usually in the weather section.)

   Notice that knowing when the Moon rises and sets in its various phases allows you to tell time (roughly) whenever it is visible! For example, if you're awakened in the night on a camping trip and you notice a third quarter moon high in the easter sky, then you know that sunrise is coming son. On the other hand, a full moon high in the sky would reassure you that you have plenty of time for more sleep--the full moon is highest around midnight.

3. **Lunar Eclipses**

   Observing a lunar eclipse (which — because it can be seen over a much wider area — is much more easily seen than a solar eclipse) is a sage and enjoyable family activity. upcoming eclipses are listed in astronomy magazines such as *Sky & Telescope* and *Astronomy*, as well as in the *Abrams Planetarium Sky Calendar* that comes with membership in the Astronomical Society of the Pacific. No special precautions need to be taken in viewing such an eclipse, and it's fun to organize family, friends, and neighbors when you know such an eclipse is coming.

## MOON PHASES AND TIME OF DAY

| Phase | Rises | In Eastern | Highest in Sky | In Western | Sets |
|---|---|---|---|---|---|

| | | Sky | | Sky | |
|---|---|---|---|---|---|
| **New** | [~sunrise] | [morning] | [noon] | [afternoon] | [~sunset] |
| **Waxing Crescent** | [just after sunrise] | [morning] | [just after noon] | [afternoon] | just after sunset |
| **First Quarter** | ~noon | afternoon | ~sunset | night (pm) | ~midnight |
| **Waxing Gibbous** | afternoon | ~sunset | night (pm) | ~midnight | night (am) |
| **Full** | ~sunset | night (pm) | ~midnight | night (am) | ~sunrise |
| **Waning Gibbous** | night (pm) | ~midnight | night (am) | ~sunrise | morning |
| **Third Quarter** | ~midnight | night (am) | ~sunrise | morning | noon |
| **Waning Crescent** | just before sunrise | [morning] | [just before noon] | [afternoon] | [just before sunset] |

Times in brackets [] indicate that the Moon can't be seen because it's too close to the Sun on the sky.

### A Moon Kit

A kit of slides and information about the Moon has been released by the Astronomical Society of the Pacific. The 18 slides in the kit show many different aspects of the Moon, including close-ups of dramatic craters, lava tubes, and mountains, as well as a map of the farside of the Moon and photos from the Apollo 11 landing. The slides are accompanied by a 24-page book with detailed captions, background information, projects, activities, and an introductory reading list. Among the topics covered in the book are explanations of the names full moons and a descriptions on what it's like on the lunar surface. The booklet also has tables of the automated and manned lunar probes. (Some of the material in this newsletter is adapted from this kit.)

Click here to order the Moon Kit from the ASP's AstroShop.