



Teaching Moon Phases

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Activity originally developed by Dennis Schatz,
Pacific Science Center



<p>Age Range: Grades 4-14</p>	
<p>Duration: 30-45 minutes</p>	

Overview:

This is an activity to teach and learn Moon phases and eclipses through hands-on modeling. It has three sections:

1. Understanding what causes Moon phases activity
2. Understanding what causes eclipses activity
3. Assessment/Firm-up – ordering Moon phase imagery activity

This activity is inspired by one originally taught by Dennis Schatz to the Astronomical Society of the Pacific’s Project Astro participants. The full activity is described in “Astro Adventures,” a publication of the Pacific Science Center. It is also available through the Astronomical Society of the Pacific shop, as part of their *Universe at Your Fingertips* DVD. It is highly recommended that users purchase one of these write-ups for doing a more extensive unit on moon phases and eclipses:

<http://www.astrosociety.org/education/the-universe-at-your-fingertips-2-0/>

and

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB4QFjAAahUKEwiTrZ3qlrvHAhVQKYgKHSDkBBM&url=https%3A%2F%2Fwww.pacificsciencecenter.org%2Fwp-content%2Fuploads%2Fastro_adventures_order.pdf&ei=AqDXVZOkA9DSoASgyJOYAAQ&usq=AFQjCN Gqb_1F-qvHqt0jXCNdBpuR3uDoGA&sig2=EukJnLFOIgyZB-DRn27UYA

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Activity Goals:

Participants will learn that:

- The Moon is always half-lit by the Sun.
- Moon phases are caused by observing the half-lit Moon at different times during its orbit of the Earth.
- All people on Earth see the same moon phase at the same time, though those in the southern hemisphere see the moon upside down compared with the northern.
- Solar eclipses are caused by the Moon coming exactly between the Earth and the Sun, blocking all but a small shadow of the Sun's light to the Earth. Only a small number of people can observe a solar eclipse because of the small size of the shadow.
- Lunar eclipses are caused by the Earth coming directly between the Sun and the Moon, casting a shadow on the Moon. Everyone on the night-side of the Earth can observe a lunar eclipse.
- Solar and lunar eclipses do not occur every month because the Moon's orbit is tilted to the Earth's plane of orbit around the Sun. So the Moon, Earth, and Sun rarely line up exactly.

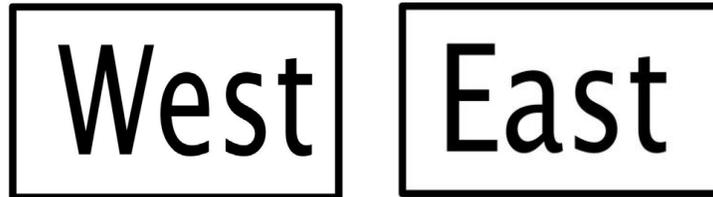
Materials:

- **Light source:** A tall floor lamp with the shade taken off. Or, a light bulb on a stand or clip that can be placed about 1.5-2 meters high. Clear incandescent light bulbs work best. Battery-powered lanterns sometimes work.
- **Small ball:** A white (or light-colored) ~5cm (2") ball for each participant. These could be made of Smoothfoam™, Styrofoam™, Model Magic™, clay, paper mache, or they could be golf balls, tennis balls, wooden globes, round fruits, whatever. You may need to drill a hole in each ball for the holder to be inserted.
- **Stick:** 1 satay stick, pencil with a sharp point, wooden stick, etc. to serve as a holder. You'll need 1 for each ball. (Avoid very sharp sticks when working with children.)





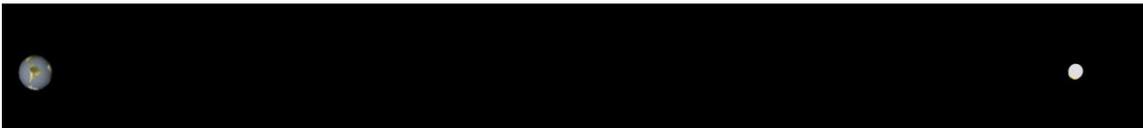
- **Signs (optional):** A set of small **West** and **East** paper signs for each participant; use tape or pins to attach these to their shoulders (i.e. clothes over shoulders). Stick-on name tags work well.



- **Dark place:** A room that can be darkened, large enough for participants to form a circle around the light bulb, about 1.5 meters (5 feet) away from it. You may need to form 2 circles (and add another light bulb), depending upon the number of participants you have. If you absolutely cannot find a dark room, you can still do the activity by using small flashlights to light the model Moons. See *Drive By Science – Teaching Moon Phases*:
<http://solar-center.stanford.edu/activities/MoonPhases/Drive-By-Science-Moon-Phases.pdf>

Preparation:

Mention that the scale is way off in this activity. Give an example of the real Earth-to-Moon scale, e.g. show a picture of the Earth and Moon to scale, or have a model of an Earth and Moon to scale then mention how far away and how large the Sun would be on that scale.

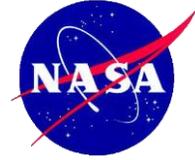


At this scale, the Sun would be about 4.5 meters in diameter and 1.4 km away.

Lesson Plan:

1. Get Oriented

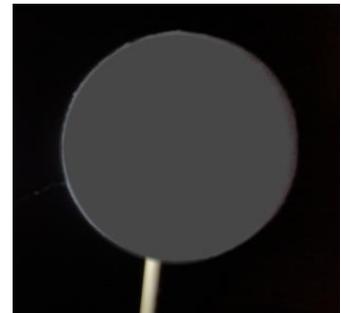
- Have participants pin or tape their **East** card on their left shoulder, and **West** card on their right shoulder. When they turn, they should turn towards their left shoulders.
- Darken the room and gather participants around the light bulb, but do not pass out the Moon balls yet. Tell participants that:
 - The light bulb = Sun
 - Their head = Earth
 - Their nose = current location
 - Their left ear/shoulder = east



- Their right ear/shoulder = west
 - The ball on a stick will eventually represent the Moon (but don't pass out the balls yet)
- c. Ask participants to stand where it is "noon", then midnight, sunrise, sunset. Remember, they should turn towards their left shoulders. When all participants get this right, have them
- Turn around fully = 1 day
 - Walk around the Sun (counterclockwise) = 1 year
 - Repeat the daily cycle to make sure they "get it"
- d. Pass out the ball Moons. Tell participants that the ball models represent the Earth's Moon. Ask them how long it takes for the Moon to orbit the Earth [about 1 month ("moonth")].

2. Moon Phases Activity

- a. Have participants hold up their Moons.
- b. Ask participants where the light on the Moon comes from [the Sun]
- c. Have them stand facing the Sun/lamp at "noon" with the Moon between them/Earth and the Sun. What do they see? [New Moon or No Moon or a dark moon] *For now, ignore the fact that they are also viewing a solar eclipse.*
- d. Have them stand at midnight, with the Moon opposite the Sun. Make sure people hold their Moon high enough for it to catch the light. What do they see? [Full Moon]
- e. Go back to noon (New/No Moon) and move their Moon a bit to the left. What do they see? [small, waxing crescent] On what side of the Moon is the crescent? [right]





- f. Have participants continue moving their Moon leftward to first quarter, waxing gibbous, full, waning gibbous, last quarter, and back to new.
- g. Give participants time to experiment with their Moons.



First Quarter



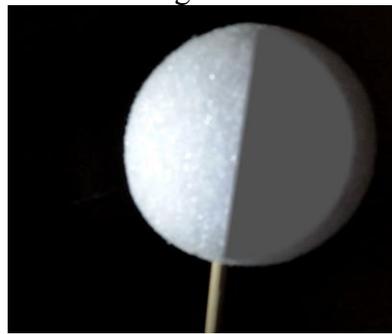
Waxing Gibbous



Full Moon



Waning Gibbous



Last Quarter



Waning Crescent

- h. Remind them that, all this time, their head/Earth is spinning through about ~ 29 day-night cycles during the time it takes for one month/*moonth* to go by.
- i. Point out that there are 2 points during the cycle when the Moon is in a crescent phase (waxing and waning), a gibbous phase (waxing and waning), and a quarter phase (first and last quarter). Ask participants to verbalize what differentiates these [the sides of the Moon which are light or dark; the light part is always “pointing” towards the Sun]

3. Timing

- a. Explain to participants that, to determine rising and settings times, they will need to use their periphery vision to determine when the light bub appears over their left/east shoulder and when it “sets” beyond their right/west shoulder.
- b. Have participants figure out roughly what time of day the New Moon rises. [sunrise]
- c. What time of day does the Full Moon rise? [sunset]



- d. What time of day do first quarter and last quarter rise? [1st quarter=noon, last quarter=midnight)
- e. What percentage of time is the Moon up during the day? [roughly half the time]

Moon Phases Timing

<i>Day of cycle</i>	<i>Phase</i>	<i>Rise (approximate)</i>	<i>High in Sky (approx.)</i>	<i>Set (approx.)</i>
0	New Moon	sunrise	noon	sunset
3.7	Waxing crescent	~ 9 AM	~3 PM	~9 PM
7.4	First Quarter	noon	sunset	midnight
11	Waxing gibbous	~3 PM	~9 PM	~3 AM
14.7	Full Moon	sunset	midnight	sunrise
18.4	Waning gibbous	~9 PM	~3 AM	~9 AM
22	Last Quarter	midnight	sunrise	Noon
25.7	Waning crescent	~3 AM	~9 AM	~3 PM
29.5	<i>New Moon</i>	<i>sunrise</i>	<i>noon</i>	<i>sunset</i>

4. General

- a. Ask them if all people on Earth see the same phase of the Moon on any given day? [yes]
- b. Do the people in the southern hemisphere see the same phase of the Moon as in the northern hemisphere [yes, except that it is upside down]

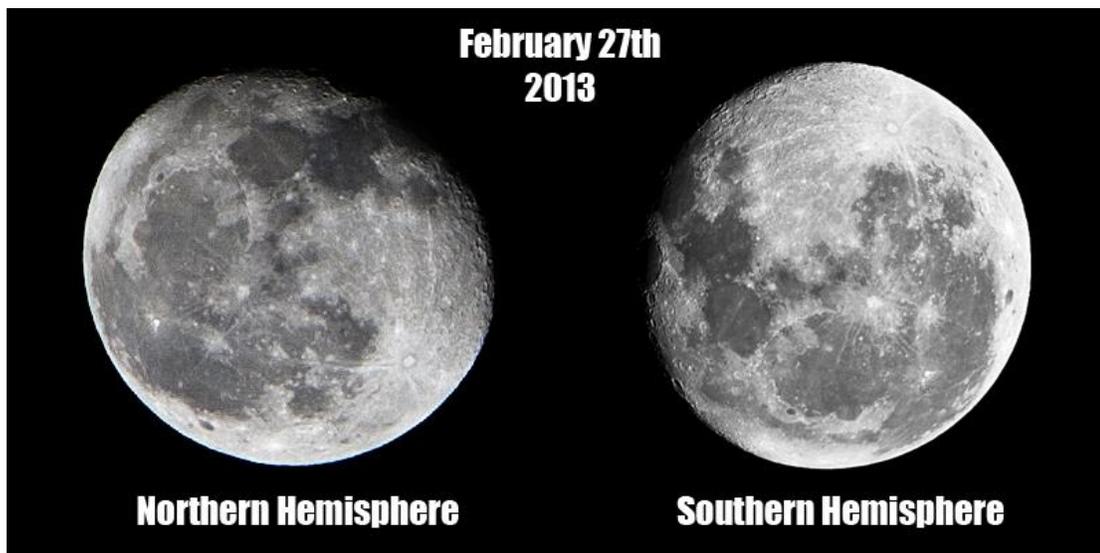


Image credit:

https://www.reddit.com/r/astrophotography/comments/19dx8z/last_nights_moon_from_the_southern_hemisphere/



5. Eclipses

- a. Have participants model a solar eclipse by placing the Moon, at noon, between the Earth & Sun. In what phase is the Moon? [new] [this is also how they observed the New Moon]
- b. Model a lunar eclipse by placing the Earth between the Moon and Sun at midnight. This time, they should lower their Moon ball to fall into the Earth's shadow. In what phase is the Moon? [full]
- c. How many people on Earth can see a total solar eclipse? Go back to the solar eclipse arrangement and refer to the small shadow that falls on people's faces when they are modeling a solar eclipse. [Only a few people on Earth fall into that shadow, so only a few can see the total solar eclipse.]
- d. Go back to the total lunar eclipse. How many people can see a total lunar eclipse? [everyone on the night side, because the shadow covers the entire Moon]
- e. Why don't we have solar eclipses and lunar eclipses every month? [the Moon's orbit is tilted so it rarely falls exactly in line with the Sun]
- f. If you wish, show participants an image of a total solar eclipse (one is attached). During a solar eclipse, what color is the corona? [white]. Hence what color is the Sun? [white – see <http://solar-center.stanford.edu/activities/SunColor/>]



Credit: NASA/Cirtain

- g. If you wish, show participants an image of a total lunar eclipse (one is attached). During a lunar eclipse, the Moon is often reddish. Ask your participants if they know why. [light is scattered through the Earth's atmosphere and only the long red & orange waves get through to illuminate the Moon – see <http://solar-center.stanford.edu/activities/SunColor/What-Color-is-the-Sun.pdf>]

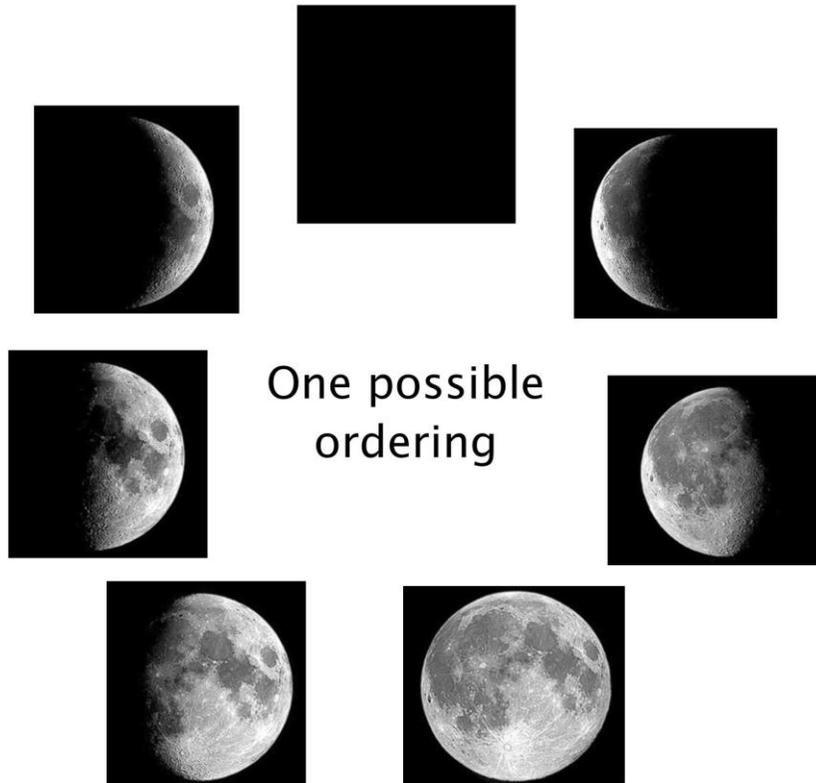
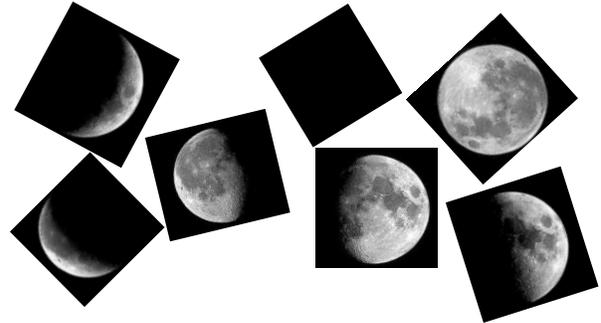


Credit: Heribert Propepper / Associated Press File



6. Firming up the Information (could also be used for assessment) by Ordering Moon Phase Imagery

- Divide participants into pairs.
- Copy a sheet of the Ordering Moon Phases imagery (attached) for each pair. Either cut out the images beforehand, or have participants cut them out. If you wish to reuse the cards, you could laminate the sheet before cutting.
- Ask participants to arrange the imagery in the order of the Moon phase cycle. They may start with any phase they want. It might help if they arrange the imagery in a circle.
- Have participants discuss order with their pairs and come to a consensus.
- Have pairs report to the group. Are there different interpretations?





Going Farther:

- In what season does the Moon get highest in the sky (northern hemisphere)?
- Where does the Moon rise at the equator? At the poles?
- Does the Moon rise & set at the same places along the horizon each day? If so, how long does it take for the Moon to go from its most northern rising point to its most southern rising point?



Teaching moon phases to undergraduate students in Kenya (using a flashlight because we could not darken the room)

Resources

Universe at Your Fingertips DVD:

This activity is inspired by one that was taught to a collection of Project Astro participants. It was developed by Dennis Schatz and originally described in “Astro Adventures”, a publication of the Pacific Science Center. It is also available through the Astronomical Society of the Pacific, as part of their *Universe at Your Fingertips* DVD. It is highly recommended that teachers purchase one of these write-ups for doing the complete activities:

<http://www.astrosociety.org/education/the-universe-at-your-fingertips-2-0/>

or

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB4QFjAAahUKEwiTrZ3qlrvHAhVQKYgKHSDkBBM&url=https%3A%2F%2Fwww.pacificsciencecenter.org%2Fwp-content%2Fuploads%2Fastro_adventures_order.pdf&ei=AqDXVZOkA9DSOASgyJOYAQ&usq=AFQjCNGqb_1F-qvHqt0jXCNdBpuR3uDoGA&sig2=EukJnLFQIgyZB-DRn27UYA



Activities and Information about the Moon:

<http://nasawavelength.org/> - search on "moon"

<http://moon.nasa.gov>

<http://www.nasa.gov/moon>

<http://www.nasa.gov/topics/moonmars>

<http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html>

NASA Lunar Missions:

<http://nssdc.gsfc.nasa.gov/planetary/lunar/lunartimeline.html> (All)

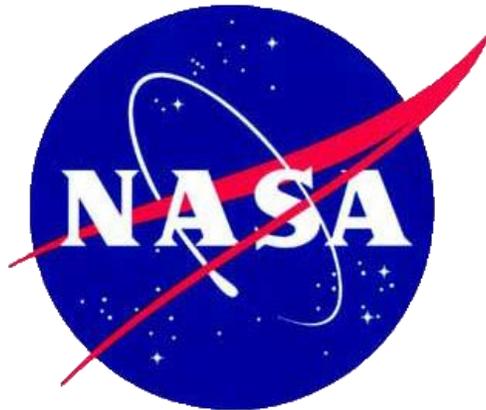
<http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2013-047A> (LADEE)

<http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-046A> (GRAIL)

<http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2007-004B> (THEMIS-B / ARTEMIS-P1)

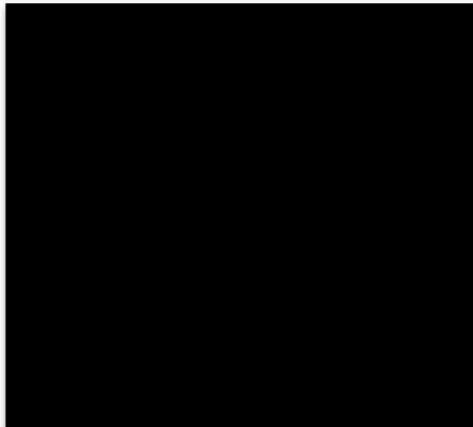
<http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2009-031A> (LRO)

<http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2009-031B> (LCROSS)





Ordering Moon Phases





East

West

East

West

East

West

East

West



Sun and New Moon

Rays from the Sun are almost parallel

From the Earth, the Moon appears dark.



The Sun is very far away, much farther than in this diagram. So the Sun appears small.

The Moon's orbit keeps it above or below the Earth's orbit. Only during an eclipse are the Sun, Moon, and Earth exactly lined up.

Sun and Full Moon

Rays from the Sun are almost parallel

From the Earth, the Moon appears full.



The Sun is very far away, much farther than in this diagram. So the Sun appears small.

The Moon's orbit keeps it above or below the Earth. Only during an eclipse are the Sun, Moon, and Earth exactly lined up.



Total Solar Eclipse



"NH53 - Outer corona (by)" by NH53 - Outer corona Uploaded by ComputerHotline. Licensed under CC BY 2.0 via Wikimedia Commons - [https://commons.wikimedia.org/wiki/File:NH53_-_Outer_corona_\(by\).jpg#/media/File:NH53_-_Outer_corona_\(by\).jpg](https://commons.wikimedia.org/wiki/File:NH53_-_Outer_corona_(by).jpg#/media/File:NH53_-_Outer_corona_(by).jpg)



Total Lunar Eclipse



Photo: Wiki commons