The Moon
Phases of the Moon

Lesson Plan by Rocky Alvey
and Katie Kendall

The Moon

Rocky Alvey / Beth Nielsen Chapman

Oh the Moon, oh the Moon, oh the big round Moon
I love to watch the beautiful Moon
It's a wonder in the sky from July through June
There's nothing quite as lovely as the Moon, the Moon
There's nothing quite as lovely as the Moon

Circling the Earth every 29 days
Reflecting the Sun's pure light
In a new and a full and a crescent phase
We see a different show every night
We see a different show every night

Well the Moon and Sun pull the surface of the Earth
Causing land and sea to rise
That my friends for whatever it's worth
Is why we experience the tides, the tides
Why we experience the tides

The Moon looks big at rise and set
And smaller when it climbs up high
It's the very same thing if you measure it
The Moon is good at fooling our eyes
The Moon is good at fooling our eyes

Oh the Moon, oh the Moon, oh the big round Moon
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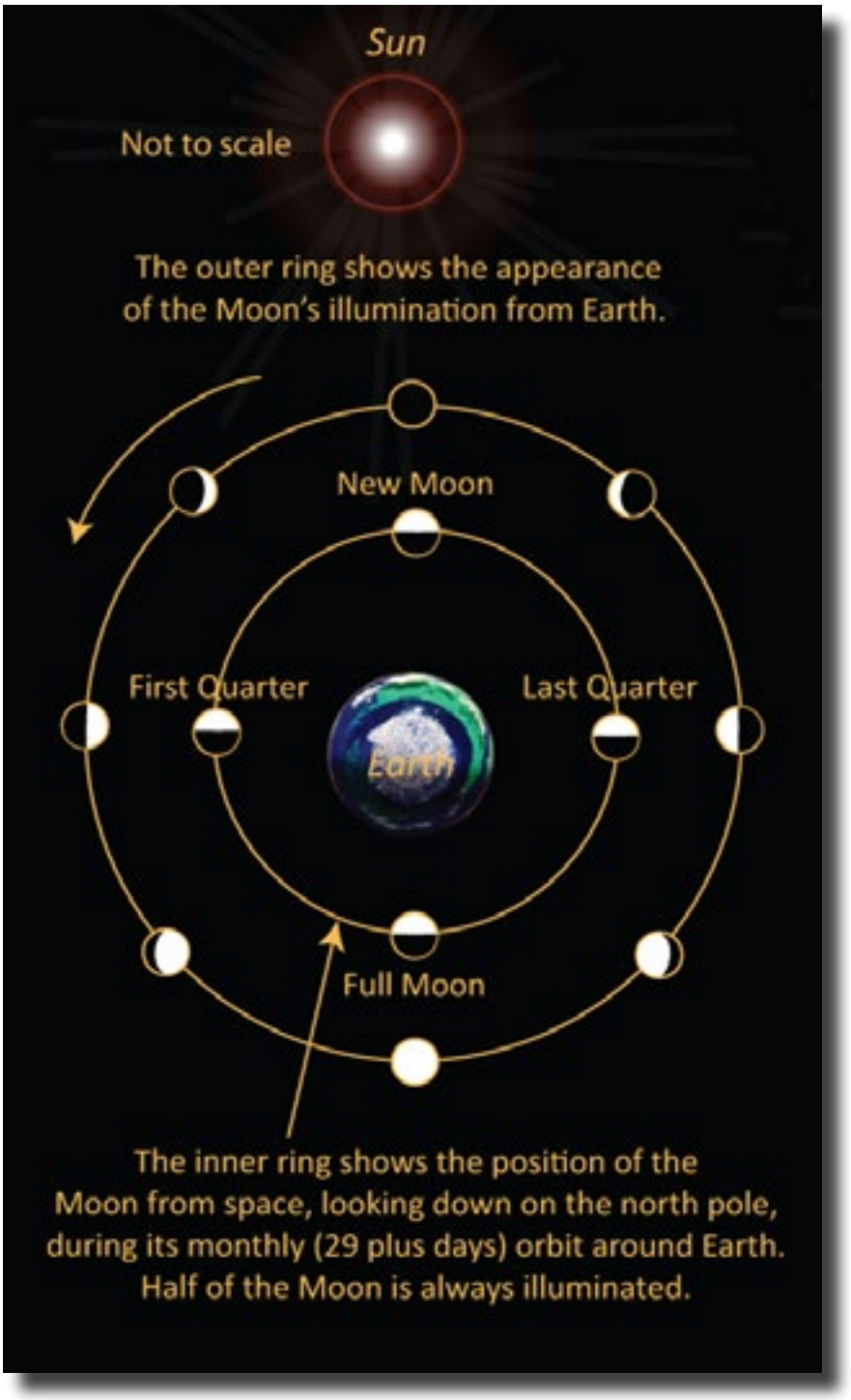

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Lesson Overview
This lesson plan explores how phases of the Moon and eclipses of the Sun and Moon are created by the relationship between the Earth, Moon, and Sun.

Target Grade Levels
5th, 6th, 7th, 8th, 9th

Unit/Topic/Theme/Subject matter
The Moon, Earth-Moon relationship, Sun-Earth-Moon relationship
(5) 45 minute class periods or 2.5 full blocks

Interdisciplinary/Cross-curricular
Mathematics
- Mathematical measurements, relationships, scale models

Engineering
- Instruments: telescopes, measuring devices, scale models

Social Studies
- Archeo-Astronomy:
  - Ancient/historical explanations of Moon phases, eclipses, legends and myths
  - Moon phases influence on cultural celebrations, festivals and holidays
  - Names for the Moon in different phases

History
- Historical theories

Fine Art
- Face painting, drawing/painting, modeling/sculpting

Writing
- Scientific: documentation of actual and modeled Moon phase observations, research reporting on ancient/historical explanations, celebrations and names for the Moon
- Creative: creation of own myth, legend, name for Moon phase

Standards and Benchmarks

K-12 Frameworks

- ESS1: Earth's Place in the Universe
  - ESS1.A: The Universe and Its Stars
  - ESS1.B: Earth and the Solar System
- PS2: Motion and Stability: Forces and Interactions
  - PS2.B: Types of Interactions
  - PS2.C: Stability and Instability in Physical Systems
- Cross-Cutting:
  - Patterns
  - Cause and Effect
  - Scale, Proportion, and Quantity

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Systems and system models
Stability and Change

Science and Engineering Practices
Asking questions and defining problems
Developing and using models
Planning and carrying out investigations
Analyzing and interpreting data
Using mathematics and computational thinking
Constructing explanations and designing solutions
Engaging in argument from evidence
Obtaining, evaluating, and communicating information

National Standards

(Embedded) Inquiry (A)
(Embedded) History and Nature of Science (G)
(Embedded) Science and Technology (E)

Physical Science (B)
Motions and Forces

Earth and Space Science (D)
Structure of the Earth System
Earth's history
Earth in the solar system
Origin and evolution of the earth system
Origin and evolution of the universe

Benchmarks
The Nature of Science
The Nature of Mathematics
The Nature of Technology
The Physical Setting
The Mathematical World
Common Themes
Habits of Mind

STEM 5 E Learning Cycle
Components identified on individual teaching day

December, 1972 - Apollo 17. Earthrise viewed from Apollo 17 (NASA)

Essential question/s

What role has the Moon played in human history?

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Why can we see the Moon? Where does the light from the moon come from?
Why can we see the Moon on some days even in daylight?
What causes the various shapes of light and shadow on the Moon?
Why does the appearance of the Moon change over time?
Can this "change" be predicted?
What is an eclipse? Can it be predicted?

From the lyrics:
"Circling the earth every 29 days…reflecting the Sun's pure light…in a new and a full and a crescent phase…we see a different show every night"

Keywords
Reflection, orbit, moon phases, lunar cycle, new moon, waning crescent, waning gibbous, waxing crescent, waxing gibbous, full, quarter moons, eclipse, partial eclipse

Prior Knowledge Connection/Prerequisite Skill(s)
Planets in a solar system orbit a star, moons orbit planets
Planet Earth orbits the Sun, Earth has a single orbiting satellite called the Moon
Other planets in our solar system have moons that orbit them
Basic SI units of measurements

Real Life Application
Why can we see the moon in the daytime on some days?
Can we predict the nightly appearance of the Moon?
Appreciation and understanding of diverse cultural traditions and heritage

Careers
Astronomer, Archeo-astronomer, Historian, Oceanographer

Science overview
Embedded

Higher Order Thinking Statements/Questions
Interpret the role the Moon has played in human history
Appreciate ancient and modern cultural traditions and heritage
Determine the source of moonlight
Determine what causes the various shapes of light and shadow on the Moon
Create a model to explain lunar phases and eclipses
Predict the movement and appearance of the Moon, nightly, monthly
Compile data and interpret meaning
Create artifacts either written or 3-dimensional (works of art)

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Materials/Supplies
(2) 12 inch long dowels or sticks
(1) 8 inch foam ball
(1) 2 inch foam ball
10 foot length of twine or string
Color markers (for decorating foam balls to look like Earth and Moon)
Flashlight – very bright!
Masking tape
Darkened room - try to cover windows with black paper too
Internet access

Be Safe!
Clear the room of any tripping hazards during lights out activities.

<u>Lesson Activities</u> – Day One
Engage/Foundation Activities

Make copies of the lyrics of "The Moon" and while students are looking at the lyrics, play the song.

Ask students, "Why does the Moon shine? (Accept all answers) Refer them to the lyrics, *"Reflecting the Sun's pure light".*

Demonstrate the reflection of light by pulling the shades and quickly turning the lights on and off in your room five or six times. Ask students, "Do the walls, floors, shelves, books, emit light by their own energy source?" The answer is No. We only see the room objects because they reflect light from the lightbulbs and reflected sunlight in the room.

Again, ask students, "Why does the Moon shine and why is there moonlight on Earth?" Students should concretely answer in terms of the concept of reflection. The Sun's light is reflected from the Moon onto Earth. In very simplified terms, light travels from the Sun to the Moon, bounces off the Moon and onto Earth. The Moon does not have its own energy source for producing light, as our Sun and other stars do.

Then, open a class discussion by stating this song declares that the Moon changes night-to-night. Refer them to the lyrics, *"Circling the Earth every 29 days.....in a new, and a full, and a crescent phase, we see a different show every night."*

At this time it will be helpful to show students images are artists renditions of the Moon in various phases. There are many images on the internet such as http://en.wikipedia.org/wiki/Lunar_phase or use the outer ring of the phase illustration on page one of this lesson plan. Students should have a class discussion about why they think the Moon changes its appearance.

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<u>Lesson Activities</u> – Day Two
Engage/Foundation Activities

Inform students that they are going to mimic the phases of the moon by creating a classroom model. (Note to teacher: you can do this activity with students holding a foam ball on a dowel OR if appropriate, collaborate with the Fine Arts teacher and paint the faces of the students to represent the Sun, the Earth and the Moon. Instructions for face painting are included at the end of this lesson). Hand out the X Circle Model Activity questions included in this lesson plan.

Make a clear space for a central circle of about 3 meters in diameter in the classroom.

Place an X with tape on the floor in the center of the circle. (This is where Earth designee will stand).

Holding one end of the string on the center X, have students trace out a circle whose radius is 1.5 meters, use small tape pieces to mark the outer diameter.

Create a starting point on the perimeter of your circle by marking another X with the tape. This will be the New Moon point of the orbit.

Have students divide the circumference of the circle into 29 equal increments for a 29-day orbit of the Moon around Earth. (Note: the Moon actually has a 27.3 day synodic period; this can be a "further investigation" project).

When the circle perimeter's Xs are complete, it should look like the diagram found on the last page of this document.

Select 3 participants, one each representng the Sun, the Earth and the Moon, respectively. Students who are not initial designees will record observations from outside the perimeter of the circle.

The Sun designee will line up on the outside of the circle perimeter in line with the Earth and New Moon mark. They will hold the flashlight at head-level.

The Moon designee will stand at the starting point of New Moon and face the circle center/Earth.

The Earth designee will take the position at the center of the circle and face the Moon and Sun.

Have the rest of the students record observations from outside the perimeter. Instruct them saying "you represent different celestial bodies in different positions in space and are to record your observations."

For these students, their perspective of shadow and phase will be different than those of the Earth, Moon and Sun.

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Turn off room lights and turn on the Sun's flashlight.

Earth will make a 5-10 second rotation and stop facing the Sun. Simultaneously the Moon will move to Day 1, all the while, facing Earth.

This will be repeated 29 times as the Moon advances around Earth. Have Earth/Moon designees stop at each day and all will observe changes in illumination and shadow on "the Moon and/or Earth".

Have designees stop for a longer period at First Quarter, Full, Last Quarter, and New Moon positions. Compare the phase of illumination on the model to astronomical images of actual lunar phases.

After each complete orbit, switch designees so that many students will experience the Earth/Moon perspective.

Once the class has a desired mastery of the mechanics of the lunar phases, ask the students to manipulate the positions of the Sun, Earth, and Moon to demonstrate both a lunar and a solar eclipse.

<u>Lesson Activities</u> - Day Three
Exploration/Explanation/Direct Instruction

Ask students to use their imagination to travel back in time, long before electricity and lights – go back to the earliest of human history. Have them imagine a life without city lights/electricity – where the sky ignited each night with brilliant stars, meteors, an occasional comet, and of course, the Moon. It is important for you as the teacher to describe the wonders of these ancient celestial scenes. Guide students to consider what life was like in pre-historical times: a time before modern scientific understanding. In the library or computer lab, have the pairs or groups research ancient explanations, folklore, myths, superstitions, cultural festivals/ holidays concerning the Moon. Remind students that early cultures created explanations for what they were seeing with what capabilities and religious beliefs they had at the time. Each group should report their explanation.

Choose one question below for each pair or group (or create your own):

1. How did the ancient _____ explain the changes in the moon's shape/appearance? (Insert Chinese, Babylonians, Assyrians, Africans, Greeks, Hindu, Native Americans, others.)
2. Did the _____ have special names for the Moon and the different shapes/appearances? (Insert Chinese, Babylonians, Africans, Assyrians, Greeks, Hindu, Native Americans, others.)
3. Were there special festivals or holiday celebrations based on the moon or the

shape/appearance of it?

4. Was there a major event in human history impacted by an eclipse?
5. Why were eclipses associated with bad omens and superstition?
6. Is there any evidence of eclipses in sources of literature?

Evaluation

Active group participation/collaboration
Research and reporting of findings - Archeo-astronomy inquiry
Observations from moon phase model
Creation of lunar and solar eclipse model

Differentiated Extension Activities
Application/Revision strategies/activities

Discussions, round robin, cooperative/collaborative groups, guided activity, Socratic circle, small group instruction, differentiated extension activities

Extension Activities/Lesson Extensions "at home"

1. Watch the Moon every night over a specific time period. Record observational data and report to the class your findings. Can specific patterns be determined over time?

2. Research when the next lunar eclipse (visible in your area) will take place.

3. Create a legend or myth story or short play that explains the phases of the Moon.

4. Research cultural names for specific moon phases. Create a piece of art work for this name/phase..

5. Find out how many moons are actually in our solar system.

6. Investigate human space missions to the moon. Create a timeline of these missions.

7. Research a specific lunar mission. Present findings in either report or power point presentation or webpage.

Family/School-wide/Community involvement

Throw "Lunar Parties" celebrating a cultural festival or holiday that was/is Moon related. This would be perfect for a School-wide/Community involvement project for the Science Club and Cultural/Heritage Clubs to sponsor. Throughout the school year, these clubs could host various moon celebrations based on ancient or modern historical fact.

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Teacher: Mental Notes/Reflections
What went well?
What would you do differently the next time you approach this lesson?

Web Resources
NASA
www.NASA.gov – search for links about the moon, phases of the moon and eclipses

The Center for Archeo-Astronomy
http://terpconnect.umd.edu/~tlaloc/archastro/

Astronomy and World Heritage Thematic Initiative
http://whc.unesco.org/en/activities/19

European Society for Astronomy in Culture
http://www.archeoastronomy.org

Archeo-Astronomy Group Project
http://physics.gac.edu/~chuck/astro/archeo.html

Sources for Eclipses in History and Literature:
http://www.britannica.com/EBchecked/topic/178098/eclipse/11214/Eclipses-in-history
http://www.earthview.com/ages/history.htm
http://en.wikipedia.org/wiki/Solar_eclipses_in_fiction
http://www.factmonster.com/spot/eclipse-lit1.html

Cultural names for moons in different phases
http://www.moonconnection.com/full-moon-names.phtml
http://www.enchantedlearning.com/subjects/astronomy/moon/Phases.shtml

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X Circle Model Activity
Observations/Writing from a Perspective

1. Describe the view of the shadow of the Moon for one complete orbit around Earth from Earth's perspective

2. Describe the view of Earth's phases from the Moon's perspective for one complete orbit.

3. Describe the phases of Earth and Moon from the Sun's perspective for one complete orbit.

4. With respect to the Sun, or those in space outside the circle, did the Moon rotate in the course of its orbit?

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Face Painting Activity
Fine Arts/Science Integration

Be Safe!
Always use FDA compliant/approved face paints. Non-toxic does not mean the paint is not harmful to children or those with allergies. Make sure to read the instructions and warnings on your FDA compliant paint kit.

Your school district may require a parental permission slip be signed prior to students participating in this activity. Teachers are cautioned to check with their School Administrator and with individual District Policies.

Use brushes that are dedicated to this exercise and have not been used for other types of paints.

When cleaning up, be careful wiping the paint away from the around the eyes.

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Materials
FDA compliant face paint – black, white, blue, brown, green, red, orange, etc.
Skull caps, bandana or other material to cover student's hair
Assorted brushes and sponges
Rags for daubing, smearing, and cleanup

Have students wear clothing that can be ruined with paint!

Painting the Moon Faces:
Look at the image of the Moon from Earth's perspective. (www.nasa.gov)
To the average person, the Moon primarily seems to be composed of shades of gray, from white or a very light off-white, to dark grey (which represents shadow). In order to get various shades of gray, you really only need to use black and white paints. From those two paints, create a pallet with no more than 4 steps between.

How will you represent the various features of the moon on your subjects face?
Notice in the lunar photos, the prominent features, the bright craters with white ejecta spraying out, darker Maria (plural of Mare, or sea) and then take notice of the shape of these various features and the large patterns they form. The most obvious object is Tycho (a prominent lunar impact crater located in the southern lunar highlands, named after the Danish astronomer Tycho Brahe).

Where will you place this feature on your student's face? Some place Tycho on the chin, but that is not necessary.

There is not a right or wrong way to paint a face, we suggest starting with a white base and then working from lighter to darker areas.

You may want to do various phases on different subjects. Representing a first quarter moon by dividing the face can be fun and dramatic.

Do not overdo it. You may find that the more you paint one area, the less distinct it becomes. See the following image for an example.

Try to create some features that are recognizable. This exercise is great for learning about the features of the moon and how they were formed. As a feature is painted, read about its history

Additional elaboration/extension:
Place Xs (you will need a different color for this, red or blue) at the lunar landing sites. NASA has numerous maps online which show the places of various Apollo missions.

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Painting the Earth faces
From the web, look at a NASA blue marble image of the Earth from space. You can find images here http://visibleearth.nasa.gov/view.php?id=57723

Have students pick an image either east or west in order to try to replicate the image of a hemisphere on their face.

Painting the Sun faces
Look at the many images displayed on the Solar and Heliospheric Observatory (SOHO) website.
http://sohowww.nascom.nasa.gov/data/realtime-images.html

It could be fun to paint the faces in colors other than yellow/orange mimicking the different views of the sun from the various instrumentation that SOHO utilizes.

Clean up
Follow the instructions on your face paint kit for cleanup.
When cleaning up, be careful wiping the paint away from around the eyes!

Beth Nielsen Chapman as Earth from "The Moon" video
http://www.youtube.com/watch?v=ccI-I-Plrdg

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Face Painted Moon Phase activity

Setup

Divide the circumference of your circle (2 -3 meters in diameter) by 29, representing the 29 day orbit of the Moon around Earth. Place a large X in the center of the circle and smaller Xs on the circumference.

An important point to consider-
In this exercise, Moon and Earth will eclipse one another on each orbit. Why doesn't this happen in reality?

Answer: The Moon's orbit is inclined 5 degrees.

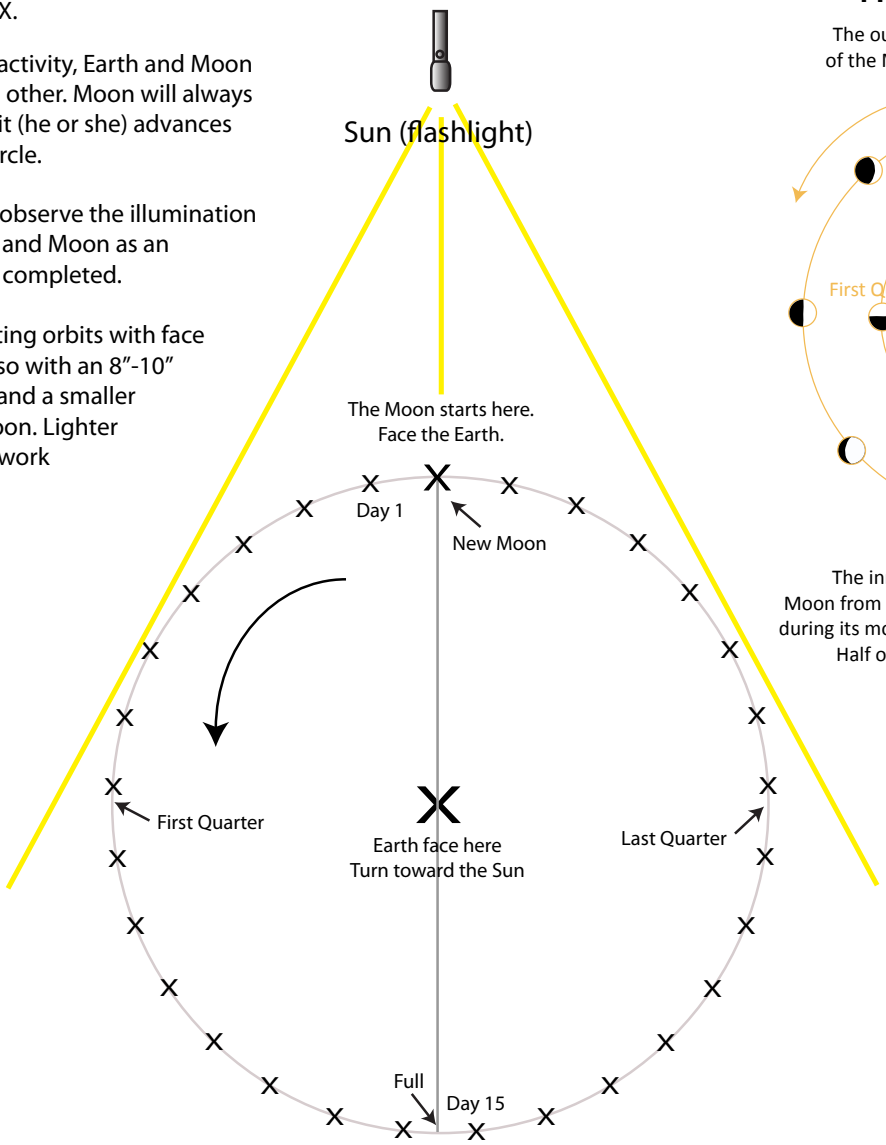
Activity Instructions

Earth will stand on the center X facing the Sun and slowly make 29 rotations. For each rotation, the Moon will advance one X.

To begin the activity, Earth and Moon will face each other. Moon will always face Earth as it (he or she) advances around the circle.

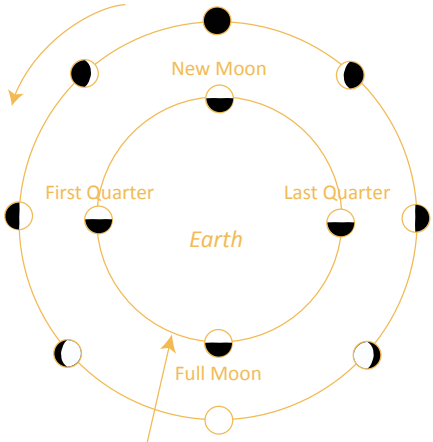
Students will observe the illumination of both Earth and Moon as an entire orbit is completed.

After completing orbits with face paint, try it also with an 8"-10" ball as Earth, and a smaller ball as the Moon. Lighter colored balls work best.



Phase Perspective Key

The outer ring shows the appearance of the Moon's illumination from Earth.



The inner ring shows the position of the Moon from space, looking down on the north pole, during its monthly (29 plus days) orbit around Earth. Half of the Moon is always illuminated.