Modeling Moon Phases

Activity A3

Grade Level: 4–12

What's This Activity About?

With simple materials, students explore how the Moon's phases arise, why they change, and why a particular phase is visible at a certain time of night or day. Research has shown that students will cling to previous misconceptions about the reasons for lunar phases, even after hearing the correct explanation. This hands-on activity is perhaps the best way for students to confront their personal theories and discover the truth.

This popular activity not only demonstrates the reason for lunar phases, but also starts to develop students' sense of spatial perception as they create a mental image of the Sun, Moon, and Earth in space.

What Will Students Do?

Students use Styrofoam balls to simulate the Moon, which will be lit by a single light source in the classroom. They observe how different portions of their ball are illuminated as they hold it in various positions. They will create a complete series of phases matching the Moon's appearance. They will relate lunar phases to the positions of the Earth and Sun.

Tips and Suggestions

- This activity works best in a very dark room with a very bright light. Leave enough time to prepare if your classroom is not easily darkened, or a bright light is not easy to find. Dark colored plastic garbage bags work well to cover windows. An overhead projector can work as the light source.
- Because the visualization in this activity can be difficult for some students, it is helpful to do this activity with a smaller group while the rest of the class works on their moon phase chart or another project, or to do the activity more than once.
- Students will usually observe that their own shadows will cover the Moon ball when it is opposite the light source, simulating a lunar eclipse during the "full Moon" phase. Ask them to hold the Moon ball above or below the shadow of their head, and ignore that "eclipse" for the time being. Eclipses will be addressed in the next activity.
- To address students' misconceptions, before doing the activity ask the class to list possible explanations for the phenomena of lunar phases. Do not comment on the validity of the theories offered. Ask each student to write down their own explanation, based on what they have heard. After the activity, rewrite their explanation for phases and discuss any changes from earlier ideas. Have students do this activity at home with their families, or demonstrate to younger students and then write about their results.
- You can purchase Styrofoam balls from: Molecular Models Company, 116 Swift St., P.O. Box 250, Edgerton, WI 53334, (608) 884-9877. www.giantmolecule.com

What Will Students Learn?

Concepts

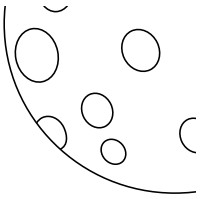
- Phases of the Moon
- Scale Models

Inquiry Skills

- Explaining
- Observing
- Reasoning
- Recognizing Bias

Big Ideas

- Patterns of change
- Cycles



Lesson 4: Modeling Moon Phases

This activity allows students to use models of the Sun, Earth and Moon to discover why Moon phases occur.

Concept

The observed phase of the Moon is determined by the Moon's position relative to Earth and the Sun.

Objectives

Students will:

- be able to state the order of the Moon's phases from one full Moon to the next; and,
- demonstrate how the Moon's position around Earth creates the phases.

Materials

- Light bulb on a stand or clamp (or a lamp with its shade removed)
- Extension cord
- One Styrofoam ball or light-colored sphere for each student (as a model Moon)
- Pencil and paper
- Darkened room
- Copies of the Moon Phases Activity Sheet (one per student)

Procedure

Advanced Preparation

Be sure that there is plenty of space for students to stand and move about as they work through this activity. Check that the lamp or light bulb for the model Sun works properly and that it can be placed high in the front of the room where everyone can see it. The room will need to be completely dark for this activity.

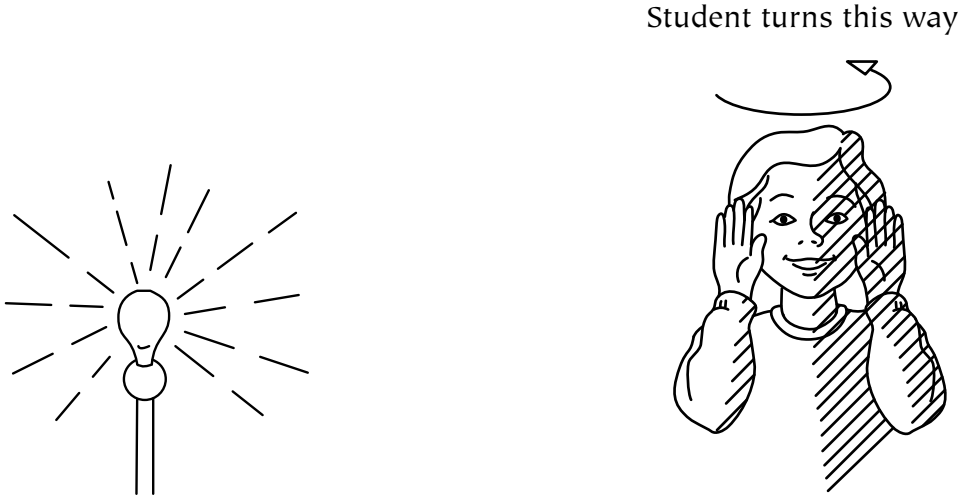
1. Review the results of Lessons 2 and 3, which showed that the Moon goes through a sequence of phases. Work with the students to review the order of the phases from one full Moon to the next. Discuss some of the students' predictions about what causes the phases of the Moon.

2. Since we cannot go into outer space to observe the Moon orbiting Earth and the phase changes, we will be using a model to learn what causes the Moon phases. Place the lamp in front of the room. Remind students of safety near the hot light bulb and electrical cord. Have students stand in a semicircle facing the lamp. Spread them out enough so the light from the lamp reaches each student. Remind students that this activity will be an extension of the Earth-Sun system that was investigated in the previous unit. As with the prior unit, the lamp represents the Sun and their heads represents Earth with their noses being the students' hometown.

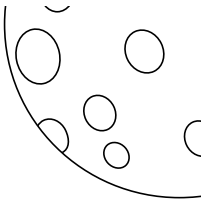
3. Review the model developed in the Sun Watching Unit. Ask students to stand so it is noon in their hometown (noses at noon.) If disagreement occurs as to what position this would be, have students discuss it until it is agreed that noon is when their nose is pointed toward the "Sun." You may want to explain the term "high noon." Next, ask them to stand so it is midnight at their noses. They should turn so that they face away from the Sun.

   Students should recall which way Earth rotates on its axis from the Sun Watching unit. If students do not remember, you will need to review a few things. Determine which way is north, south, east and west for their Earth-heads. If their hometown/nose is in the Northern Hemisphere, north is the top of their heads, south will be their chins, east will be to their left and west to their right. From prior knowledge and their Moon observations, they should know that the Sun rises in the East. Have the students place their open hands on the sides of their heads, acting as horizon blinders. Have them determine which way Earth rotates so that the Sun rises over their left (eastern) hand. After some trial and error, they will be able to determine that Earth rotates from right to left in their model, with their right shoulder moving forward. (See illustration below.)

   Ask students to stand so it is sunrise and sunset. Practice the ideas of sunrise, noon, midnight and sunset until you feel that the students have a good understanding of these relative positions. Spending time to develop this part of the model is very important. You can evaluate the students' understanding by asking for odd times of the day or night. For example, ask them to turn so it is 3 a.m. or 3 p.m. Reinforce the knowledge that as students turn through 24 hours they will make one complete circle. This will be important for them to keep in mind during the next activity. The revolution of the Moon in its orbit of Earth takes about 29 days. This means for us to see all of the Moon's phases will also take about 29 days. During this same time period Earth has spun 29 full turns.



Light bulb represents the Sun. Student's head represents Earth. Hands are "horizon" blinders to help see sunrise and sunset. Local (nose) time for the child in this model is around 6 p.m.

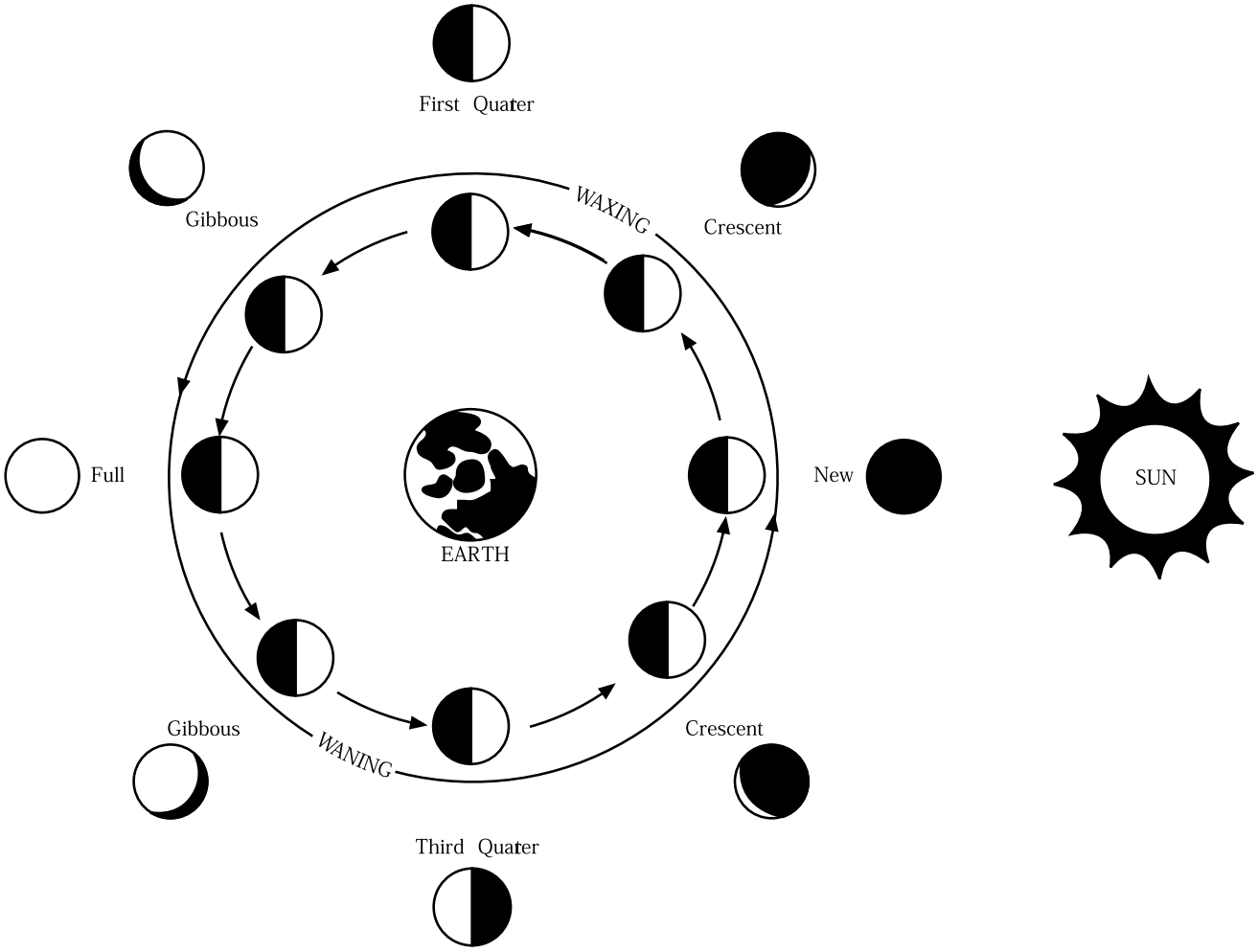


4. Distribute one Styrofoam-ball "Moon" to each student. Stick a pencil into the ball to make it easier to hold and to observe the phases of the Moon model. Have students hold the model Moon at arm's length. Allow time for students to explore how the Sun's light reflects off the model as they place their Moons in different positions around their Earth/head. Help students find a few of the phases of the Moon with which they are already familiar, such as a full Moon, a new Moon and first and third quarters. A new Moon occurs when the Earth, Moon and Sun are aligned with the Moon between Earth and the Sun. A full Moon occurs when the three bodies are aligned but Earth is between the Moon and the Sun. See the diagrams that follow for a visual representation of the proper positions for the different phases.

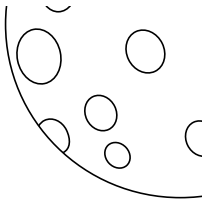
   Students need to develop the notion of the path of the Moon as it orbits Earth. There is a common misconception that Earth's shadow causes the phases. Students who are trying to produce the different phases by hiding parts of the Moon with their head's shadow need to address this. They will come to recognize, possibly with some assistance, that they cannot generate the exact shape of the different phases by using the shadow of Earth. They will need to determine through discussion and modeling that the Moon takes about 29 days to complete one orbit. During these 29 days each phase will be visible for approximately one 24-hour period.

Moon Phases Diagram

The inner sequence shows the Moon's relative position to Earth and the Sun as viewed from outer space, above the solar system. Students are asked to produce this diagram on the "Moon Phase Activity Sheet."



The outer sequence shows the Moon as seen from Earth. For example, you would see the waning crescent (lower right) as a small slice of the Moon illuminated on the left side. A waxing crescent, upper right, would have the right side of the Moon illuminated.



Teacher's Note: Students will have many questions as they explore. Try not to answer their questions directly—encourage them to explore using the model. One question that usually comes up and must be addressed early is how high the model Moon should be held. If it is held at head height there will be an eclipse (instead of a full Moon) during each orbit of the Moon around the student's head. Help the students develop the idea that they did not observe a lunar eclipse during Lesson 2 and generally people make a big deal about eclipses. Therefore they probably do not occur every month. Students should then decide they have to hold the Moon balls up high so the Moon balls are exposed to the Sun's light throughout their orbit around Earth. (The phenomenon of eclipses is an advanced topic. It is recommended that elementary students explore the phenomenon, but they will not be able to construct a complete understanding of how often eclipses occur until middle school or beyond.)

6. After students explore finding the phases, choose one lunar phase and ask the students to determine what position in the Moon's orbit they must place their Moon in order to achieve that particular phase. Full Moon is a good phase with which to start. Encourage students to compare their positions and discuss differences. Ask one student who has the correct position to state why it is correct. As the teacher, you can check for understanding by seeing if all of the students are holding their Moons in the same position. When looking at other peoples' Moon models, students should notice that at all times one-half of the Moon is illuminated by the Sun.

7. Have students model other phases; for example, first quarter, third quarter and new Moon. Use the terminology introduced in Lesson 2 when requesting a particular phase, such as waning gibbous, third quarter, etc.

8. Allow time for students to experiment with the movement of the Moon. They can observe their own model as well as other students' models. This activity is very powerful and can answer many questions that the students generate about the Moon.

   Teacher's Note: Students may find it helpful to change the model slightly to answer certain questions. If one student holds the Moon ball and another student "plays" Earth, they can more easily see Earth spinning on its axis while the Moon is barely moving in its orbit. How much of a circle does the Moon move each 24 hours? About $^{1}/_{29}{}^{th}$ of a circle. So everyone on Earth basically sees the same phase on the same night.

9. Have students work together to complete the Moon Phases Activity Sheet. The goal of completing the sheet is to produce a diagram similar to the one on the preceding page. These drawings should be kept in their Astronomy Notebooks.

10. After completing the diagrams, ask students to write down in their Astronomy Notebook the causes of the changing Moon phases. (The spinning Earth—your head—makes the Moon rise and set each day, but this does not affect the phase of the Moon. Movement of the Moon around Earth and the relative positions of the Sun, Earth and Moon cause the phases.) Encourage them to use diagrams in their explanations.

11. Check student diagrams and explanations for the causes of phases. Ask students if they are sure that their observations and the model support their diagrams and statements. If discrepancies arise, have students go back to the model to further clarify the concepts.

Going Further

Advanced students may want to consider how their observations of the Moon would vary if they lived in the Southern Hemisphere, for example, in Australia. This is a difficult problem for elementary level students, but a nice one that will encourage open-ended study.

Moon Phase Activity Sheet

This diagram represents a view you would see when looking down from above at your head when you are modeling the Moon orbiting Earth. Darken the areas on each Moon that are not illuminated by the Sun. Then label each Moon phase as you would see it when your nose (on Earth) is pointed directly at it.

Moon Phase Terms: New Moon, Full Moon, First Quarter, Third Quarter, Waxing Crescent, Waning Crescent, Waxing Gibbous and Waning Gibbous.