CHALLENGER CENTER'S JOURNEY through the UNIVERSE

Are There Other Neighborhoods Like Our Own?

Searching for Abodes of Life in the Universe

Observing the Moon

This lesson is taken from an education module developed for Challenger Center's *Journey through the Universe* program. *Journey through the Universe* takes entire communities to the space frontier.

Start the *Journey* at www.challenger.org/journey.

Support for this work was provided by NASA through grant number ED-90170.01-97A from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Incorporated, under NASA contract NAS5-26555.

January 2001

Grade Level
K-12

Family & Home Activity: Observing the Moon

Overview

The most familiar night-time celestial object is the Moon, our nearest cosmic neighbor. Even today, when the night sky is aglow with the bright lights from our cities, a casual observer easily sees the Moon and its phases.

This activity is meant to prompt discussion and observations of the Moon at home. Teacher-led discussions are meant to facilitate the home portion of the activity, and provide a conceptual understanding of the phenomena and modeling explored at home.

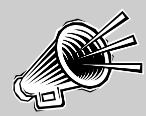
Teacher-Led Discussions *Before* Students do the Home Portion of this Activity

1. Lead a class discussion to explore what students know about the Moon. Explore whether their knowledge comes from reading or observing. Likely most of their knowledge is not through observation. They likely will be surprised how much they can learn by observing the Moon after they begin their observing activities at home.

Teacher-Led Discussions *After* Students do the Home Portion of this Activity

1. Build a Scale Model of Earth and Moon: If the Earth is the size of a dime, then the Moon would be the size of a pea located at a distance from the Earth equal to 30 times the Earth's diameter. On this scale, that means the pea would be 51 cm away. That would not fit on a single sheet of paper. Everything would have to be about half that size to fit on one sheet of paper.

ESSENTIAL QUESTION
What information can we learn from observing the Moon?



OBJECTIVES
Students will:

- Systematically observe the phases and character of the Moon.
- Compare and contrast the Earth and the Moon

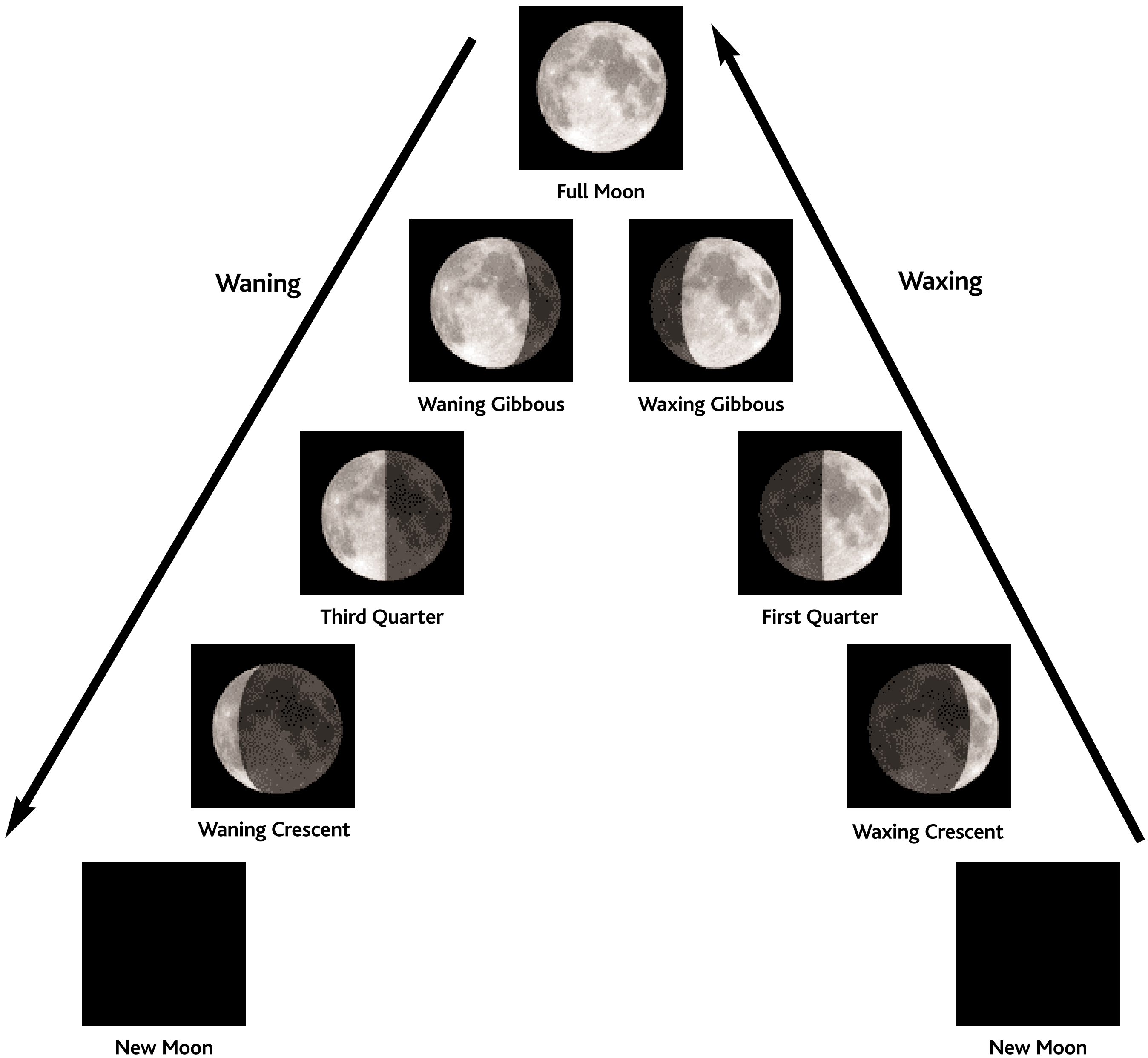
2. Explore with the class the different questions in Section 3 of the Home portion of the Activity, as a means of providing an understanding of the phenomena they have observed at home, or the modeling they have done at home.

   What do the colors of the Moon tell us?
   The Earth is very colorful. It has blue from the atmosphere and oceans, green vegetation, and white clouds. The Moon has none of these colors, and this is an indication that the Moon does not have any bodies of water or atmosphere.

   How rough is the Moon's surface?
   Near the terminator on the Moon, we can see shadows of craters and mountains. That shows that the Moon is rough, just as the Earth is. From the lengths of the shadows it is possible to calculate the heights of the mountains and the depths of the craters.

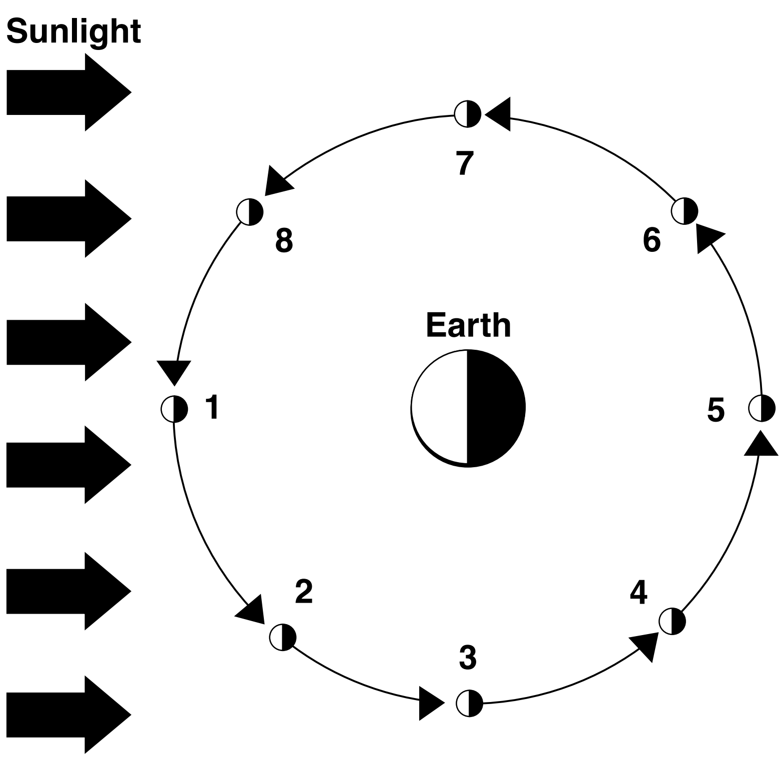
   How does the Moon's appearance change over the month?
   Month after month, the Moon goes through a cycle of changes that cause it to appear to grow from a narrow crescent to the brilliant disk of a full Moon, and then to shrink until it becomes a thin shining sickle again. The apparently changing shape of the Moon is due to the Moon's motion about the Earth. As the Moon changes its position with respect to the Sun, Earth-bound observers see different amounts of the Moon's surface illuminated. The cycle of the Moon's phases is illustrated on the next page.

The Phases of the Moon

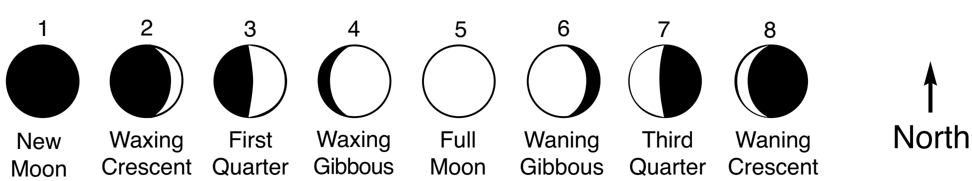


As the illuminated surface of the Moon appears to increase from new to full, the Moon is said to be waxing, and as the illuminated surface appears to decrease from full to new, the Moon is said to be waning. Thus, we may speak of a waxing crescent and a waning crescent. The complete cycle of phases from one new Moon to the next takes approximately 29.5 days. The Moon completes 12.4 cycles in one calendar year.

As the Moon revolves around the Earth, different sides of it are illuminated by the Sun. Below is a schematic diagram of the Earth-Moon-Sun system.



The Moon as Seen from Earth



A good quality activity that models phases of the Moon with illuminated spheres would be an excellent classroom add-on here. *The Quest in the Question* teacher's guide, developed by Challenger Center in support of a 1999 Electronic Field Trip, has an excellent lunar phase modeling activity. The entire teacher's guide can be downloaded at www.challenger.org.

Based on the journal observations, the same features should appear on the Moon throughout the two weeks. (Obviously, features are only visible within the illuminated portion of the Moon.) This seems to imply that the Moon keeps the same side toward the Earth all the time. Why this is the case is demonstrated in the next section, *A Day on the Moon*.

The far side of the Moon is the side we never get to see from Earth. The "dark side" of the Moon is the side that currently is not illuminated by the Sun. At Full Moon the dark side is the far side. At New Moon, the dark side is the near side of the Moon. If you are looking at the New Moon from earth you are looking at the dark side. But since it's dark you can't see New Moon!

A Day on the Moon

You can conduct the walking activity in the classroom. In the first case, if the student playing the Moon does not rotate as she walks around the Earth, then the Earth student will get to see all sides of the Moon student. (Remember to tell the Earth student that he's free to rotate to see the Moon, since the Earth rotates once per day and the Moon takes 29.5 days to go all around the Earth.)

In the second case, the Moon student rotates counter-clockwise once every time she walks around the Earth student once. (She needs to walk counter-clockwise around the Earth as well.) In this case the Earth student will always see the same side of the Moon student. This is called a 1:1 gravitational lock and is exactly what occurs in the Earth-Moon system. This is common in the solar system.

If you were standing on the Moon, the "day" would be 29.5 Earth days long. In other words, each "day" on the Moon, you would be in Sunlight (daytime) for about two weeks, and then you would have two weeks of darkness (nighttime). Those long days provide a lot of time for the Moon to heat up. And the long nights allow the Moon to cool off to extremely cold temperatures. Also, the Moon doesn't have an atmosphere to help hold in the heat at night. The lack of atmosphere, combined with the long days, results in the

Moon changing temperature by 275°C (500°F) between day and night!

Here's an added twist. Since the Moon keeps the same side toward the Earth all the time, that means if you were standing on the Moon, the Earth would always appear in the same part of the sky. You would never see the Earth rise or set!

Conclusion

We discovered that the Moon has no atmosphere and no bodies of water. In addition, there are extreme temperature changes from day to night. These conditions are not very hospitable to life. That's why, when astronauts went to the Moon, they had to bring along air to breathe, water to drink, food to eat, and a temperature-controlled space suit. It seems quite unlikely that any life could survive on the Moon.

Home Portion of Activity: Observing the Moon

Home Procedures

The most familiar night-time celestial object is the Moon, our nearest cosmic neighbor. Even today, when the night sky is aglow with the bright lights from our cities, a casual observer easily sees the Moon. It turns out that we can learn many things about the Moon by carefully observing it. We can even get a good idea about whether it would be a likely place for life to exist. In this activity, there are a number of tasks that you can perform and questions that you can answer yourself or discuss with other members of your family. Following these tasks and questions below, there is a discussion of these items and possible answers that you might have come up with.

1. **Brainstorm with your family what you they already know about the Moon**
   In class you should have brainstormed what you know about the Moon and how you've come to know it. Now it's time for you to lead the same discussion with your family. See what they know about the Moon, and how they think they've come to know it. Don't give them any answers! Has any of their knowledge come from observations of the Moon? How did they do?

2. **Draw a scale model of the Earth and Moon**
   The diameter of the Earth is 12,756 km. The diameter of the Moon is 3,476 km. The distance from the Earth to the Moon is approximately 384,000 km. Using those dimensions, construct a scale model of the Earth and the Moon. If the Earth is represented by a circle the size of a dime, can your scale model of the Earth and Moon (with the distance between them properly scaled) fit on a single sheet of paper?

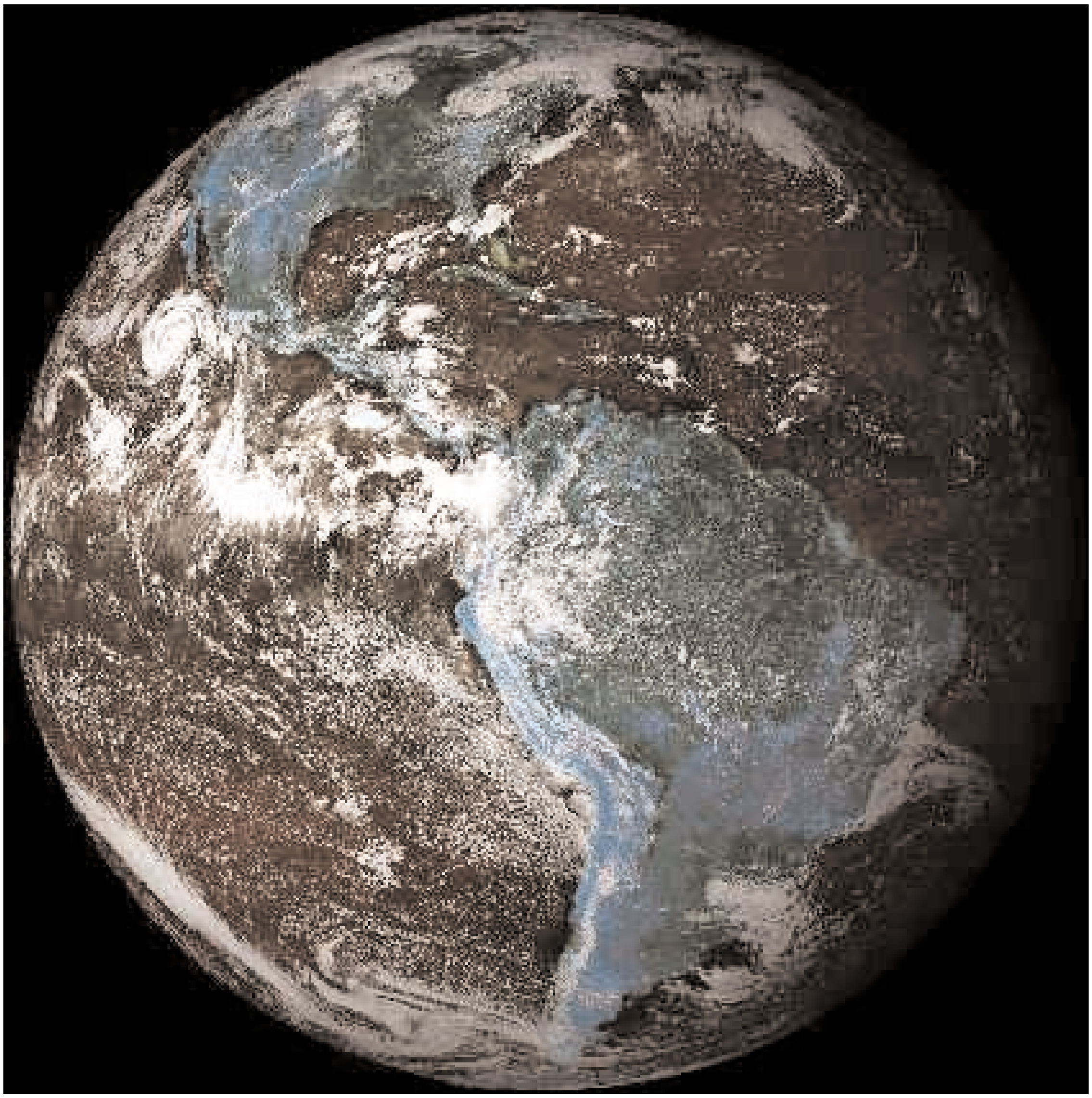
3. **What can you learn about the Moon by observing it?**
   What characteristics of the Moon can you learn about simply by looking at it directly, or by looking at photographs of it? Can you learn about the Moon's surface? Can you learn anything about an atmosphere on the Moon? Can you understand why it appears to change shape? Did you notice how it is visible in different parts of the sky at different times? On the following pages some observations and activities are described that can help you learn about the Moon.

3a. What do the colors of the Moon tell us?

In case you can't easily observe the Moon yourself, here is a picture of it:

Credit: Lick Observatory

And, here is a picture of the Earth:



Credit: NASA/GSFC/NOAA/USGS

You may be looking at a black and white version of this document. Yet the actual color of the Moon is not much different from what you see in a black and white photo of the Moon. You can search the World Wide Web for color photographs of the Moon and Earth.

Compare the colors of the Moon to the colors of Earth. What are the causes of the colors you see on the Earth? What might you conclude about the Moon?

3b. How rough is the Moon's surface?

Below is a photograph of the Moon near "first quarter phase," when the Moon looks about half full. You can see this easily through a good pair of binoculars. Through a small telescope the view is superb.

Credit: John Settle, Greenbelt Astronomy Club

Look at the *terminator* _ the borderline between the daytime side and the nighttime side. Does the appearance of the terminator tell you anything about how rough or smooth the surface of the Moon is? Do you see any shadows on the Moon? What can the shadows tell you?

3c. How does the Moon's appearance change over the month?

This exercise should be done over about a two-week period. If you will be observing the Moon shortly after Sunset, start your observations when the Moon is in its waxing crescent phase. At this time, the Moon will be visible low in the western sky shortly after Sunset. If you will be making your observations later in the night, you may have to wait another week – perhaps until first quarter phase – until you will be able to see the Moon. (You can check the Moonrise and Moonset times on the weather page of a daily newspaper, along with phase information, to make sure that the Moon will be visible at the time you plan to observe it.) Keep a journal by drawing the appearance of the Moon every day for 2 weeks. *Be sure to include in your drawings any craters or features that you can see*.

After two weeks, go through your journal and note how the Moon's appearance changed. What would you expect to see if you observed the Moon for the following two weeks?

What did you notice about the craters or other features on the Moon during the two weeks you observed it? Did you get to see different sides of the Moon, or were you always seeing the same side of the Moon?

Here's a good question: what is the difference between the dark side of the Moon and the far side of the Moon? Which is the one you are never able to see from Earth?

3d. A Day on the Moon

In a big enough room, let a family member be the Earth, and you be the Moon orbiting the Earth. Walk around them so you are moving counterclockwise if you imagine looking down on this from above. Ask your family member to let you know what side of you they see as you walk around them (orbit the Earth). Try this two different ways:

First orbit them without rotating, which means that you must always be facing the same wall in your room as you walk around them.

Second, try rotating counter-clockwise once for each time you orbit them once. Start by facing them, and note which wall you happen to be facing as well. By the time you are 1/4 around them you should have rotated to face the next wall. By the time you are 1/2 way around them the first wall should be at your back. Keep going until you are back where you started. If you do this right, you'll have rotated once as you orbited once. Did your family member get to see all sides of you this time? No? What did they see?

Now repeat the second experiment above, but put a model Sun on the wall you are facing when you start your walk. Why the Sun's right over your face! It must be noon! How long will it be before it's noon for you again? You should find the Sun over your face again when you've completed one orbit of your friend. But the Moon takes a month to go around the Earth once. If noon to noon is defined as a day, how long is a day on the Moon? Imagine what that might be like. Do you think there should be much change in temperature between day and night on the Moon? What if the Moon has no atmosphere?

Challenger Center Programs

The internationally acclaimed **Challenger Learning Center** Network currently consists of state-of-the-art, innovative educational simulators located at 49 sites across 29 states, Canada, and the United Kingdom. Staffed by master teachers, the core of each Center is a two-room simulator consisting of a space station, complete with communications, medical, life, and computer science equipment, and a mission control room patterned after NASA's Johnson Space Center. See *www.challenger.org* for information.

A joint initiative of Challenger Center for Space Science Education, the Smithsonian Institution, and NASA, ***Voyage — A Journey through our Solar System*** is a space science exhibition project that includes permanent placement of a scale model solar system on the National Mall in Washington, DC, and at locations all over the world. See *www.voyageonline.org* for information.

Space DaySM launches new *Design Challenges* created by Challenger Center each school year. The inquiry-based challenges are designed to inspire students in grades 4-8 to create innovative solutions that could aid future exploration of our solar system. See *www.spaceday.org* for information.

Challenger Center's ***Journey through the Universe*** program provides under-served communities with diverse national resources, including K-12 curriculum materials, teacher workshops, classroom visits by scientists from all over the country, and Family Science Nights. See *www.challenger.org/journey* for information.

The **MESSENGER** spacecraft (MErcury Surface, Space ENvironment, GEochemistry and Ranging) is to be launched in 2004 and go into Mercurian orbit in 2009. Challenger Center is one of the partner organizations charged with MESSENGER education and public outreach activities. See *www.messenger.jhuapl.edu* for information.

Through the Challenger Center **Speakers Bureau, Voyages Across the Universe**, staff members speak to student audiences of 30-1,000, conduct workshops for 100-300 educators, give keynote and featured presentations at conferences, as well as conduct Family Science Nights at the National Air and Space Museum, and other facilities across the nation, for audiences of 300-1,000 parents, students, and teachers. See *www.challenger.org/speakers* for information.