

# Two Small Pieces of Glass: The Amazing Telescope

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## Planetarium Show – Teacher’s Guide

### PROGRAM OUTLINE

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**Description:** *Two Small Pieces of Glass: The Amazing Telescope* traces the history of the telescope from Galileo’s modifications to a child’s spyglass -- using two small pieces of glass -- to the launch of NASA’s Hubble Space Telescope and the future of astronomy. It explores the wonder and discovery made by astronomers throughout the last 400 years.

**Activities:** Choosing the location for a telescope, the speed of light, creating a model of the Moon.

### LEARNING OBJECTIVES

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- Understand that telescopes are composed of lens or mirrors that focus light.
- Astronomical observations with telescopes have only been done since the 1600s.
- Larger telescopes collect more light and therefore produce brighter images than smaller telescopes.
- The astronomer Edwin Hubble used telescopes to show that galaxies are moving away from one another and that the Universe is expanding in size.

**Process Skills Focus:** Inquiry, observation and communication.

**Topics:** Light, telescopes, optics, history of astronomy.

### OREGON STANDARDS

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### Scientific Inquiry Standards:

- K.3S.1 Explore questions about living and non-living things and events in the natural world.
- K.3S.2 Make observations about the natural world.
- 1.3S.2 Record observations with pictures, numbers, or written statements.
- 1.3S.3 Describe why recording accurate observations is important in science.
- 2.3S.2 Make predictions about living and non-living things and events in the environment based on observed patterns.

### Engineering Design Standards:

- 1.4D.3 Show how tools are used to complete tasks every day.
- 2.4D.3 Describe an engineering design that is used to solve a problem or address a need.

### Earth and Space Science Content Standards:

- K.2E.1 Identify changes in things seen in the sky.
- H.2E.3 Describe how the universe, galaxies, stars, and planets evolve over time.

### Physical Science Content Standards:

- K.2P.1 Examine the different ways things move.

## NEXT GENERATION SCIENCE STANDARDS

### Practices

2. Developing and using models
3. Planning and carrying out investigations
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence

### Crosscutting Concepts

2. Cause and effect
3. Scale, proportion, and quantity
6. Structure and function

### DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			

PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a	✓	n/a	n/a	✓	n/a	✓	
<b>Life Science</b>									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
<b>Earth &amp; Space Science</b>									
ESS1	Earth's Place in the Universe	n/a			n/a		✓		
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
<b>Engineering, Technology, and Applications of Science</b>									
ETS1	Engineering Design								

### **DCI Grade Band Endpoints**

PS4.B *Objects can be seen if light is available to illuminate them or if they give off their own light. (By end of grade 2).*

*Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (By end of grade 2).*

*An object can be seen when light reflected from its surface enters the eyes. (By end of grade 5).*

*When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (By end of grade 8).*

*The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (By end of grade 8).*

*A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (By end of grade 8).*

*However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (By end of grade 8).*

ESS1.A *The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (By end of grade 5).*

### **Performance Expectations**

- 1-PS4-2. *Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated.*
- 1-PS4-3. *Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light.*
- 4-PS4-2. *Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.*
- 5-ESS1-1. *Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.*
- MS-PS4-2. *Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.*

## **SOURCES**

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The information and activities presented in the *Two Small Pieces of Glass: The Amazing Telescope* Teacher's Guide have been adapted for use and distribution by OMSI from the following:

The State Museum of Pennsylvania

## GLOSSARY

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- Adaptive optics:** A technology used to improve the performance of ground-based telescopes that are forced to view objects through the Earth's atmosphere (remember that the Earth's atmosphere causes blurring of images). Adaptive optics removes some of this blurring.
- Aperture:** The diameter of a telescope's lens or mirror. Larger apertures collect more light, which is important for seeing bright images.
- Chromatic aberration:** The effect that different wavelengths of light focus at different points, causing a fringe of color to appear around bright objects.
- Eyepiece:** The lens closest to the eye in a telescope.
- Lens:** A carefully ground or molded piece of glass, plastic, or other transparent material that causes light to bend and either come together or spread apart to form an image.
- Light year:** The distance that light can travel in one year – approximately six trillion miles.
- Galilean moon:** One of the four largest moons of Jupiter, discovered by Galileo Galilei in 1610.
- Reflector:** A type of telescope that uses one or more polished, curved mirrors to gather light and reflect it to a focal point.
- Refractor:** A type of telescope that uses a lens to gather the light and bend it to a focal point.
- Sunspot:** A region on a star that has a stronger magnetic field and a cooler temperature than the surrounding part of the star. Sunspots often appear dark in color.
- Supernova:** The explosion of a massive star.

## POST-VISIT QUIZ

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*Check your comprehension of the planetarium show!*

- 1) Telescopes use either mirrors or lenses to gather \_\_\_\_\_.
- 2) The “aperture” of a telescope refers to the size of its \_\_\_\_\_  
or \_\_\_\_\_.
- 3) The mathematician \_\_\_\_\_ was the first person to point a telescope to the sky.
- 4) Humans use our eyes like telescopes, but why can't we see as much detail as a big telescope?
- 5) The Earth's atmosphere causes celestial objects to appear to \_\_\_\_\_.
- 6) What units do astronomers commonly use to describe the distances to stars?
- 7) How is a telescope like a time machine?
- 8) Choose the correct statement:
  - a. Everything in the Universe is inside our Milky Way galaxy.
  - b. Our Milky Way galaxy is but one of billions of galaxies in the Universe.
- 9) The astronomer \_\_\_\_\_ found that the Universe is expanding. (Hint: a space telescope is named after this astronomer!)
- 10) Galileo used his telescope to observe the four largest moons of the planet \_\_\_\_\_.

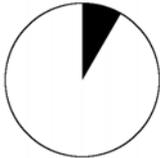
## SUGGESTED CLASSROOM ACTIVITIES

# Telescopes Around the World

*Description:* In this activity, students will learn how astronomers choose the locations for telescopes.

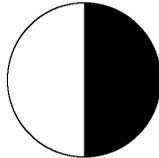
## TIME REQUIRED

### Advance Preparation



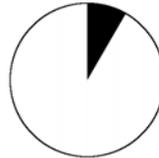
5 minutes

### Activity



30 minutes

### Clean Up



5 minutes

## SUPPLIES

- Projector for showing printed images

## ADVANCE PREPARATION

- Print out one copy of the light pollution map (shown below).

## ACTIVITY

- Discuss with the students that astronomers use large telescopes to study the night sky. These telescopes are larger than the one you might have in your garage. These big telescopes have reflecting mirrors that can be up to 10 meters in diameter! That's nearly 30 feet! (Emphasize that these telescopes are larger than the size of an average classroom).
- Since these big telescopes can't be easily moved, astronomers have to choose a fixed location for each telescope. Brainstorm with the students

some considerations that may be important for choosing where to put telescopes.

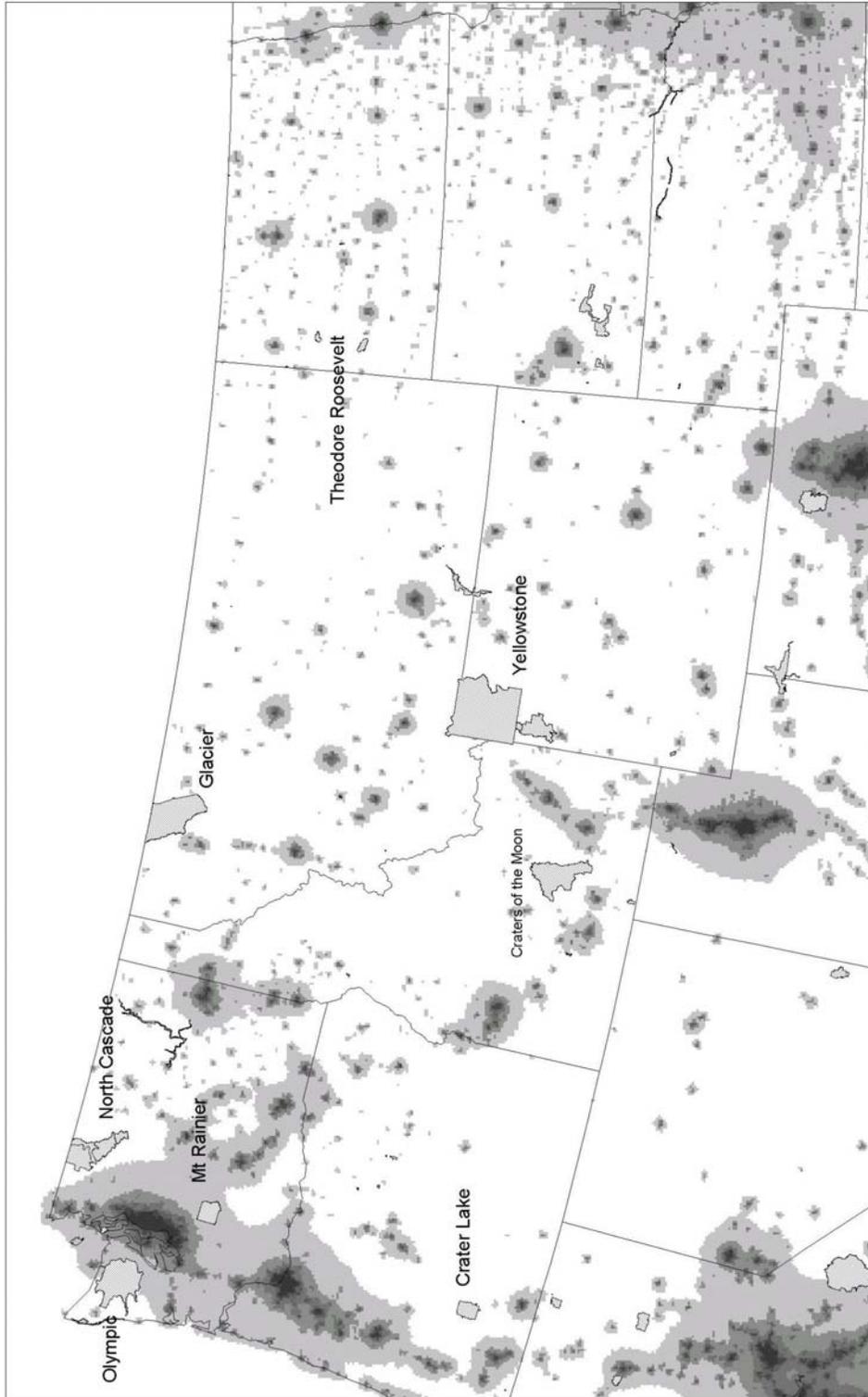
- There are three main qualities that astronomers consider when choosing where to put a telescope:
  - 1) Is the night sky very dark?
  - 2) Is the location at a high elevation?
  - 3) Is the weather mostly clear?

Let's see why each of these considerations is important.

- Having the night sky very dark is important because dark skies let faint objects be seen. Imagine shining a car's headlight next to a candle. Is it easy to see the candle? (No!). If the sky is bright from nearby city lights, it's hard to see the stars. When city lights shine into the night sky, it's called "light pollution".
- Show the students the image of the light map of the Pacific Northwest. Explain that the black areas on the map correspond to places where there is lots of light pollution. Locate Portland – is there lots of light pollution here? (Yes.)
- It's also important that telescopes be located at high elevation. The air moving in the Earth's atmosphere causes images to be blurry. So, if telescopes are high up above more of the Earth's atmosphere, the images will be less blurry. Have the students brainstorm some high-elevation places in the world.
- Lastly, telescopes should be located in places that have good weather! If it's cloudy at night, astronomers won't be able to use the telescope.
- Now, the students will decide which one of two sites is better for the location of a telescope. Copy the following information on the white board:

<b>Site</b>	<b>Sky Darkness</b>	<b>Elevation</b>	<b>Weather</b>
Santa Monica, CA	Not very dark	105 ft	Clear
Mauna Kea, HI	Very dark	13,796 ft	Clear

Which site would be better for the location of a telescope? (Mauna Kea, HI).



<http://laps.noaa.gov/albers/lp/gwpaper/Image7.jpg>

# Light Pollution Map

# Telescopes and Time Machines

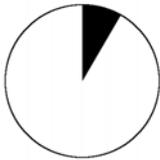
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*Description:* Students will explore the concept that light travels at a finite speed and that telescopes accordingly act like time machines.

## TIME REQUIRED

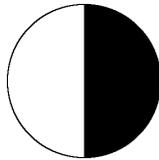
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### Advance Preparation



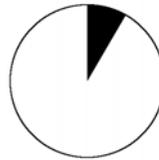
5 minutes

### Activity



30 minutes

### Clean Up



5 minutes

## SUPPLIES

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- Calculators
- Light Travel Time worksheet for each student (copied below).

## ADVANCE PREPARATION

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- Make a copy of the Light Travel Time worksheet for each student.

## ACTIVITY

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- Discuss with the students that all the light that they see moves at the same really fast speed:

Speed of light = 186,000 miles / second

How long does it take light to travel between the Earth and the Moon? The distance between the Earth and the Moon is approximately 250,000 miles. (The students should calculate a light travel time of 1.3 seconds.)

- Objects that are farther away from the Earth will have longer light travel times. How long does it take light to travel from the Sun to the Earth? The

distance between the two bodies is approximately 93 million miles. (8.3 minutes).

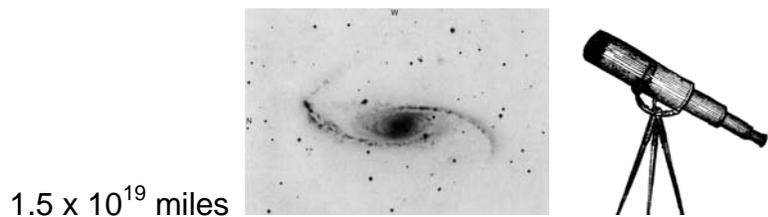
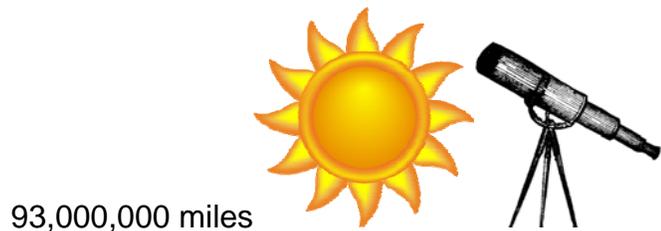
- You can even calculate how long it takes for light to travel between the students and you, the teacher! Ask the students to calculate this time. Is it a long time or a short time? Do you think that our brains notice this time delay? (No.)
- Hand out a Light Travel Time worksheet to each student.

# Light Travel Time

Telescopes are time machines! Let's see how.

For each of the distances given below, calculate the light travel time. Remember, light travels at 186,000 miles per second.

Light travel time:



So, since light takes \_\_\_\_\_ years to reach us from the distant galaxy, that means that we're seeing the galaxy as it was \_\_\_\_\_ years ago. The telescope is a time machine!

# Make a Moon Model

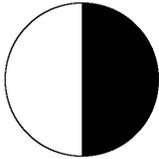
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*Description:* Students create a model of the Moon and decorate it with accurate craters and surface features.

## TIME REQUIRED

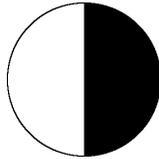
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### Advance Preparation



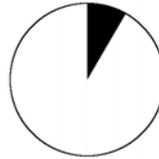
30 minutes

### Activity



30 minutes

### Clean Up



5 minutes

## SUPPLIES

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- One 4" diameter Styrofoam ball for each student
- Sewing pin for each student (don't hand out to the students)
- Colored pens

## ADVANCE PREPARATION

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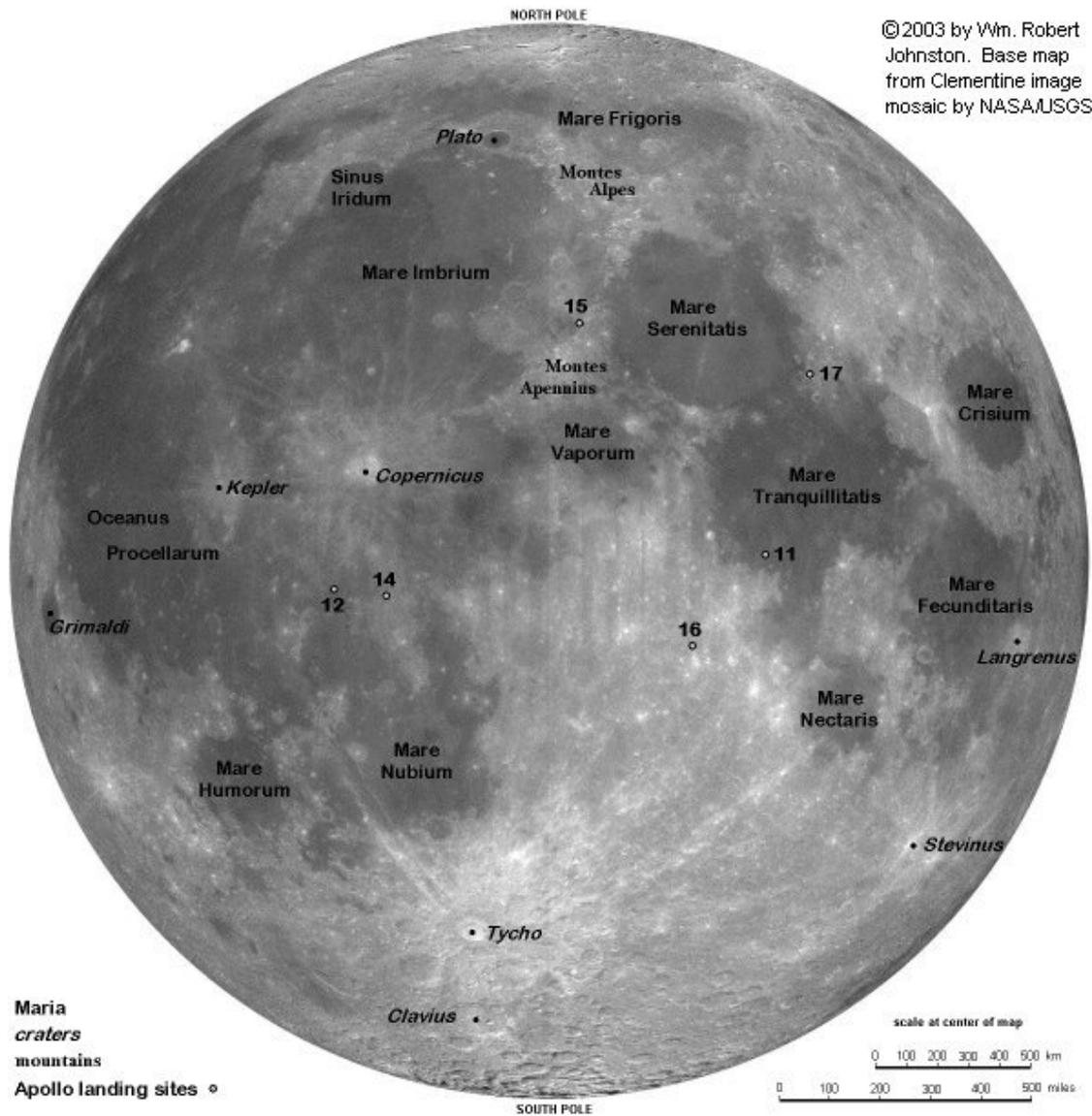
- For added authenticity, spray paint the Styrofoam balls gray before giving them to the students (optional).

## ACTIVITY

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- Discuss with the students that the Moon is our nearest celestial neighbor and that it's the brightest object in the night sky. The Moon is a great target for observing with a pair of binoculars or a small telescope, since it's relatively nearby.
- Show the image of the Moon that is copied at the end of this lesson plan. Explain that the Moon has many features that can be seen with the naked eye, including the dark mare ("mar-ay"). These features are lava beds from old volcanoes on the Moon; they're called mare since that word means "seas" in Latin.

- Several bright craters are also visible: Tycho in the south, Copernicus near the lunar equator, and Plato in the north. All these craters are named for real people.
- Point out that the numbers on the Moon map correspond to the Apollo missions that visited the Moon in the 1960s and 1970s. The first Apollo mission that landed on the Moon, Apollo 11, touched down in the Mare Tranquillitatis (“Sea of Tranquility”) on July 20<sup>th</sup>, 1969.
- Have the students decorate their models of the Moon, using pens to draw the mare and some craters.
- Explain that one side of the Moon faces the Earth all the time, so we don’t know as much about the other side of the Moon (the far side). The students can decorate the far side of the Moon with a few craters; there aren’t many mare there.
- After the students have finished decorating their moons, stick a sewing pin into the Styrofoam ball to mark the position to the landing spot of Apollo 11.



<http://www.johnstonsarchive.net/astro/moonmap-s.jpg>

## RESOURCES

### NASA Education

<http://www.nasa.gov/offices/education/about/index.html>

### Observe the Moon

<http://www.space.com/17702-how-observe-moon-skywatching-infographic.html>