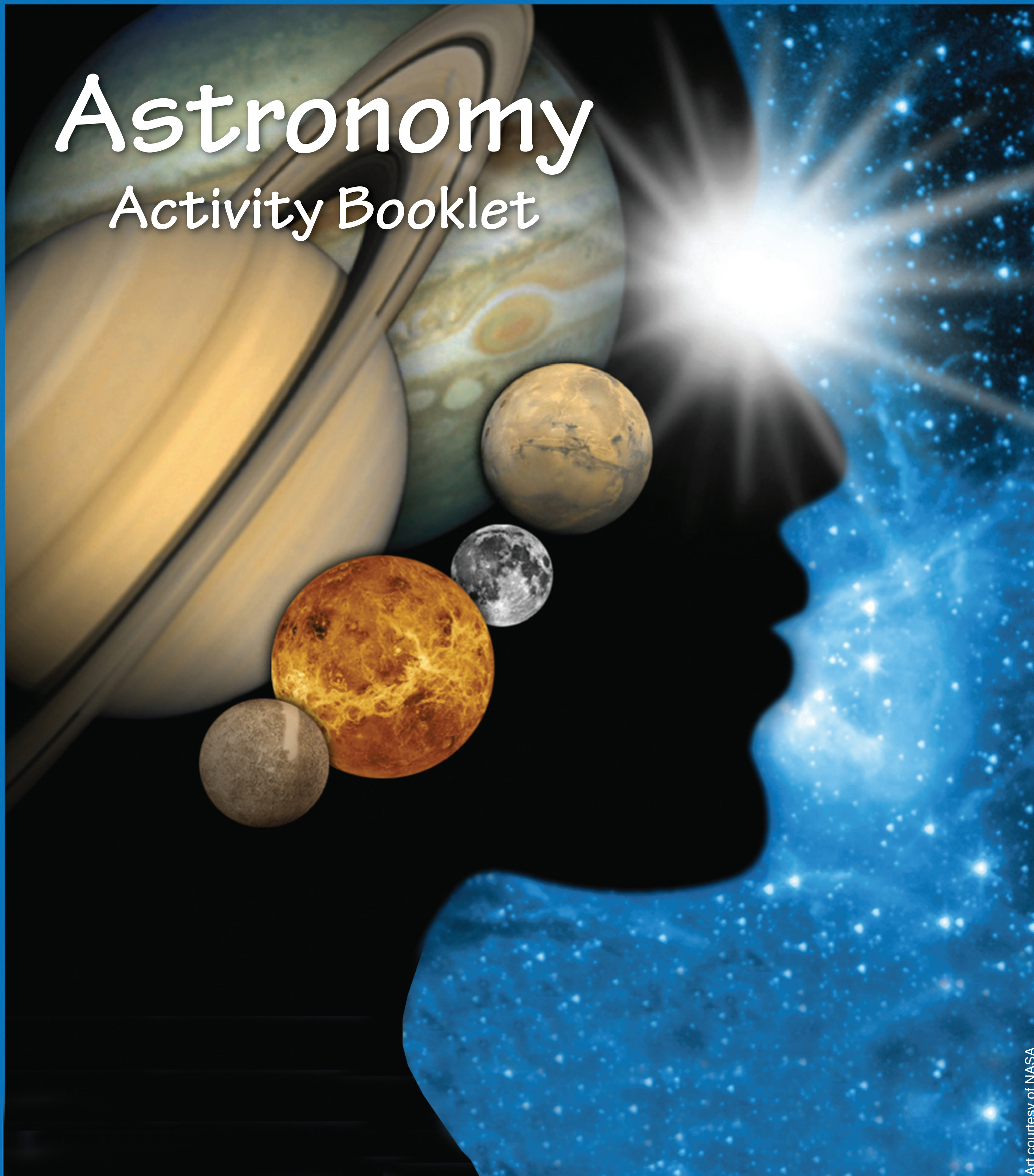
Astronomy

Activity Booklet



Art courtesy of NASA

Civil Air Patrol

For STEM Kits and AEX Participation

as a compendium to AEX Astronomy Module

ASTRONOMY

ACTIVITY BOOKLET

for STEM Kits and
***A**erospace **E**ducation E**X**cellence*
Participation

as a compendium to AEX Astronomy Module

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Introduction

This booklet of astronomy activities was designed to accompany the Astronomy STEM Kit and to provide an additional resource for students/cadets who wish to study more about astronomy in the CAP units and America's classrooms. The activities in this booklet can be used for those participating in the Civil Air Patrol Aerospace Education Excellence (AEX) Award Program, as a compendium to the AEX Astronomy Module. Activities can be done in any order, as fits with educational program supplemental.

Next Generation Science Standards (NGSS)

The Science Standards used in this activity booklet came from the Next Generation Science Standards. These standards are based on the *Framework for K-12 Science Education* developed by the National Research Council. The *Framework* outlines the three dimensions that are needed to provide students a high quality science education. The integration of these three dimensions provides students with a context for the content of science, how science knowledge is acquired and understood, and how the sciences are connected through concepts that have universal meaning across the disciplines. The *Framework's* three dimensions are: Practices, Crosscutting Concepts, and Disciplinary Core Ideas including Earth and Space Science (ESS and Physical Science (PS).

To find out more about the NGSS, go to http://www.nextgenscience.org/.

Disclaimer: Websites and other information were accurate and current as of the printing of this booklet.

Table of Contents

Astronomy Careers

Engineering Careers and Astronomy

Engineering is an important part of astronomy. Behind every piece of machinery or computer program astronomers use to make fantastic discoveries, there is an engineer or computer programmer that helped make it happen. NASA and other research institutes are always looking for talented engineers and computer programmers to help keep their machinery and programs running smoothly.

Teachers

Teaching about astronomy is one of the best jobs available. There are opportunities for teaching astronomy in high schools as well as undergraduate and graduate courses in universities and colleges. To become an astronomy teacher, you should first develop your own love for astronomy. The teaching opportunities can occur in a classroom, in a planetarium or science museum, or online. A good foundation in science and math are essential as is a college degree.

Industry and Business

Hundreds of astronomers are employed by private industry (many with PhDs). These contractors typically design and manufacture everything from telescopes to space probes, write software, and do many tasks in support of NASA labs and space missions, ground-based observatories, and data processing / management offices. Writing software is an especially fast-growing field for astronomers in private industry.

Public Relations and Journalism

Astronomers with a talent for explaining complex ideas to the general public play a big role in keeping the taxpayers informed and interested in government funded research. Every NASA mission has public relations, education, and outreach staff with astronomy expertise. Organizations like the National Academy of Sciences and the American Association for the Advancement of Science hire people with astronomy backgrounds. Companies that manufacture telescopes and space probes need knowledgeable public relations people. Also, science journalism is a growing field.

Astrophysicist

Astrophysicists study objects in the universe, including galaxies and stars, to understand what they are made of, their surface features, their histories, and how they were formed. Astrophysicists spend most of their time in laboratories and offices looking at a lot of information gathered by instruments such as telescopes, sensors, and probes. They decide what the information means and write papers and reports about what they find to advance mankind's quest for astrophysical phenomenon.

Education/Training Needed

For most careers involving astronomy, the education requirements range from at least two years of specialized training in science or science-related technology to a PhD in an astronomy-related or engineering field. An interest in solving physics and math problems, formal writing skills, and the ability to work in a team, as well as independent environment, is also important.

For more information on astronomy careers, to include geologists and mathematicians, visit **http://www.sciencebuddies.org/science-fair-projects/science-engineering-careers/Astro_astronomer_c001.shtml#whatdotheydo** or the American Astronomical Society website at **http://aas.org/learn/careers-astronomy**. The American Astronomical Society can provide mentors, demonstrations, and assorted assistance in building varied interest in astronomy careers. Find chapters near you for assistance!

AMERICAN ASTRONOMICAL SOCIETY

ADVOCATES FOR SCIENCE SINCE 1899

Activity One: Building a Telescope – PVC Pipe and Paper Towel Roll

(Credit for this lesson: Bouchet Outreach and Achievement in Science and Technology (BOAST) in Illinois - http://www.life.illinois.edu/boast1/index.htm)

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 Science Education Practices, Crosscutting Concepts, and Core Ideas

Objectives: Students will learn the parts of a telescope and how they work together to view an image by constructing a telescope.

Practices:
2. Developing and using models
4. Analyzing and interpreting data

Crosscutting Concepts:
3. Scale, proportion, and quantity
6. Structure and function

Core Ideas:
PS4.A: Wave properties
PS4.B: Electromagnetic radiation
PS4.C: Information technologies and instrumentation

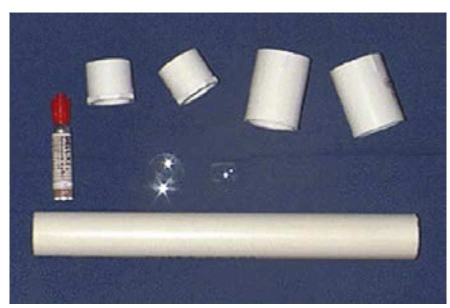
Background Information:

There are two main types of telescopes: refractor and reflector. A refractor telescope uses two lenses to magnify distant objects. A reflector telescope uses a series of mirrors. The purpose of a telescope is to make objects that are far away seem closer, so they can be seen well. Telescopes have two main parts: the first lens and the second lens. The first lens is called the objective lens and the second lens is called the eyepiece.

Materials:

- Copy of the Telescopes chapter of this book and copy of the parts of the Celestron FirstScope telescope.

<u>**PVC Pipe Telescope**</u>



- One 38 mm (3.75 cm) thick double convex lens (Nasco item #SB10480M) (Nasco is an educational supply company – website is at http://www.enasco.com/science/)
- One 38 mm (3.75 cm) thin double convex lens (Nasco item #SB10476M)
- 2 pipe adapters (1" by 1 ¼ ")
- 2 pipe couples (1 ¼ ")
- 35 cm length of 1 ¼ " diameter PVC pipe (schedule 40)
- Ruler with metric scale

<u>Paper Towel Telescope</u>

- One 38 mm (3.75 cm) thick double convex lens (NASCO item #SB10480M)
- One 38 mm (3.75 cm) thin double convex lens (NASCO item #SB10476M)
- Clear polyvinyl tape
- One 5” by 9” sheet of black construction paper (15 x 22 cm)
- Paper towel roll
- Stickers (or bright colored crayon or marker)

Procedure:

1. Students should receive a set of materials and discuss the background information included in this lesson.
2. Students should be given a copy of the parts for the Celestron FirstScope to compare to the parts of each telescope that they will make in this activity.

<u>PVC Pipe Telescope</u>

Students should:

1. Press a pipe adapter into the pipe couple. Make sure that the adapter goes all the way into the couple. You may need to push the couple against a table or the floor.
2. Repeat this procedure for the other pipe adapter and couple.
3. Place one lens through the opening of the couple (it doesn’t matter which lens you put in which end because you can always turn the telescope around and use the opposite end). Note: Be sure to label the lenses so you know which end is the thick lens and which end is the thin lens. The lens should rest inside the couple, against the rim of the adapter.
4. Place the couple on the floor with the adapter side down. Be sure the lens is resting flat against the adapter inside the couple.
5. Push one end of the PVC pipe into the couple. Keep pushing until it will not go any further.
6. Gently shake the pipe. If you hear or feel a rattling, you need to push the pipe further into the couple to secure the lens.
7. Place the second lens in the other couple as described above.
8. Push the other end of the PVC pipe into the second couple and check for rattling.
9. You are now ready to use your telescope!
10. The thick lens of the telescope is the eyepiece, the lens you look through. Look through the thick lens to magnify objects.

Remember: Never look at the sun with a telescope! It can damage your eye!

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<u>Paper Towel Roll Telescope</u>

Students should:

1. Place the thin lens inside one end of the paper towel roll. The lens should be even with the end of the paper towel roll. Note: All paper towel rolls do not have the same diameter. If the diameter of the roll is larger than the diameter of the lens, you may need to roll a piece of construction paper and insert it into the paper towel roll.
2. Tear off a few inches of polyvinyl tape. Cut small tabs into the tape so that it curves with the lens and paper towel roll.
3. Place the tape on the paper towel roll and on the lens. Try to cover the surface of the lens as little as possible for optimum visibility.
4. Roll the 5” by 9” piece of construction paper into a tube that is just slightly smaller than the paper towel roll.
5. Insert the construction paper tube into the paper towel roll. Be sure that the construction paper tube can be moved in and out of the paper towel roll.
6. Tape the construction paper tube so that it stays rolled.
7. Place the thick lens into one end of the construction paper tube you just made.
8. Tape the lens to the construction paper tube the same way you secured the other lens.
9. Place the open end of the construction paper roll into the open end of the paper towel roll. Note: There should be a lens showing at each end of the telescope.
10. A tab must be added to the construction paper tube so it does not completely slide into the paper towel roll. To make this tab, tape two pieces of polyvinyl tape to each other. Fasten this tab to the construction paper tube.
11. Look through the thick lens of the scope. To adjust the focus of the telescope, slide the construction paper tube in and out of the paper towel roll.
12. When you have found the best focus (which should be about 35 cm, with the lenses used in this activity), place a sticker or make a mark on the construction paper roll where the construction paper enters the paper towel roll. This will indicate the best position to view objects.

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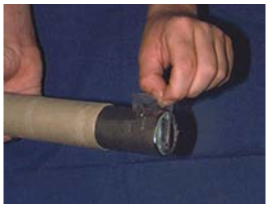

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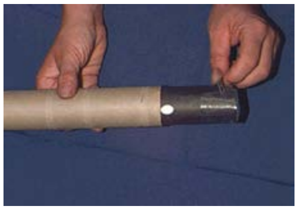


Summary:

This activity allows students to construct and use a homemade telescope. Comparing and contrasting each type of homemade telescope with the Celestron FirstScope furthers understanding of the telescope and its parts.

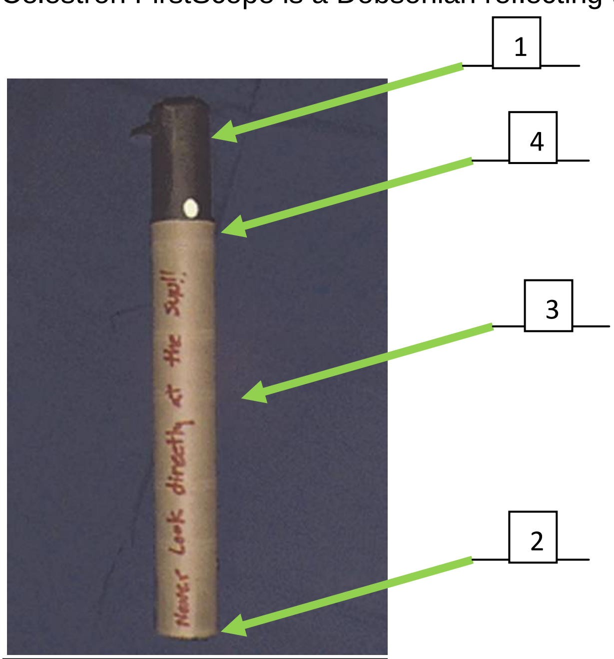
Evaluation:
Students should successfully complete the telescope comparison worksheet. Note: The major difference between the telescopes that students assemble in this activity and the Celestron FirstScope is that the built telescopes use lenses and the Celestron uses mirrors.

Additional Resources and Enrichment:

1. The youtube video at http://www.youtube.com/watch?v=uZeF1KETaU4 tells how to build your own refracting telescope out of everyday materials.
2. The Celestron FirstScope Instruction Manual – Model #21024 has many useful instructions on how to use the telescope as well as astronomical background and information. You can find the manual at: http://www.celestron.com/c3/images/files/downloads/1235589497_firstscopemanua.pdf.
3. Kits can be ordered from vendors such as Science First on How to Make and Use a Project STAR Telescope. Science First's website is www.sciencefirst.com (http://www.sciencefirst.com/Refracting-Telescope-Single.html).

Answers for Student Worksheet

1. Answers will vary.
2. The telescopes that the students built are refracting telescope with lenses. The Celestron FirstScope is a Dobsonian reflecting telescope that uses mirrors.



1. **Eyepiece**
2. **Secondary lens**
3. **Optical tube**
4. **Focus**

Activity One: Worksheet for Building a Telescope
Name:____

1. Look at three objects at three different distances with each telescope that you built. Draw a diagram of each view.

Distances	Distance #1 ________________m(yd)	Distance #2 _______________m(yd)	Distance #3 _______________m(yd)
PVC Telescope			
Paper Towel Roll Telescope			

2. Compare the telescopes you built with the Celestron FirstScope. What type of telescope is each and what are the parts? (Use back of paper to explain.) Use the diagram of the Celestron FirstScope below to label the Paper Towel Roll Telescope you built with similar parts.

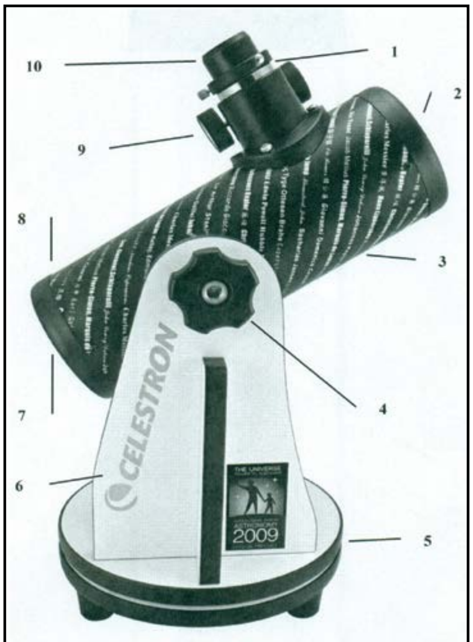
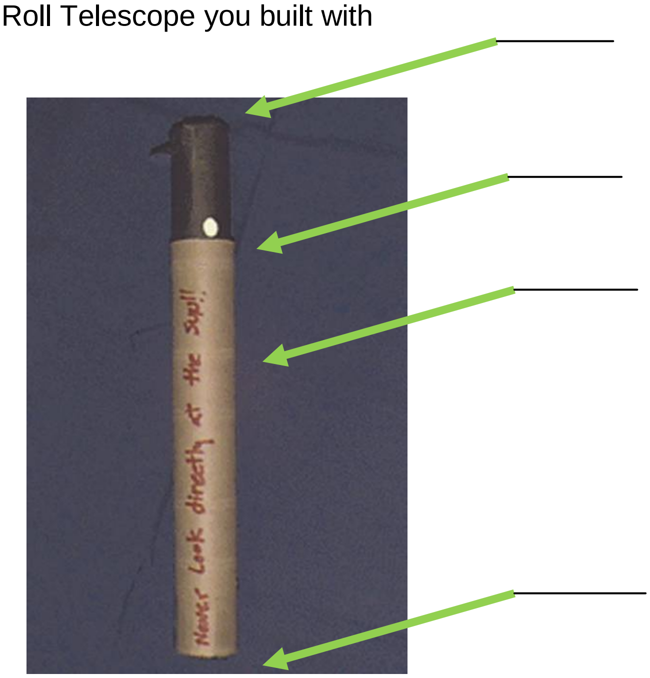


Figure 1-1



1. **Eyepiece**
2. **Secondary lens**
3. **Optical tube**
4. **Focus**

1.	Focuser	6.	Arm
2.	Secondary (Diagonal) Mirror-- inside	7.	Tube End
3.	Optical Tube	8.	Primary Mirror -- inside
4.	Lock Nut	9.	Focus Knob
5.	Base	10.	Eyepiece

Activity Two:Determining the Focal Length and Magnification of Lenses

(Credit for this lesson: Bouchet Outreach and Achievement in Science and Technology (BOAST) in Illinois http://www.life.illinois.edu/boast1/index.htm)

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

Objectives: Students using refracting telescopes with varying lens sizes is an important part of astronomy. Students will learn how to determine the focal length of a convex lens and determine the distance between two lenses that results in the clearest magnification.

Practices:

2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data

Crosscutting Concepts:

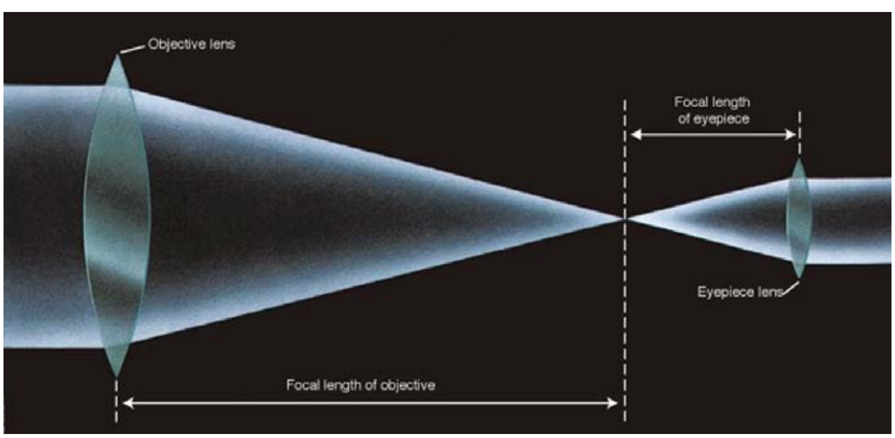
2. Cause and effect: Mechanism and explanation
6. Structure and function

Core Ideas:

PS4.A: Wave properties
PS4.B: Electromagnetic radiation
PS4.C: Information technologies and instrumentation

Background Information:

A convex lens, such as the ones found in refracting telescopes, uses lenses to focus the light and make objects look closer to you that they really are. The convex lens is in a shape that is thicker in the middle and thinner at the edges. Convex lenses work by bending light inwards. This allows all of the light to come together at a focus point (called the focal point). The point of focus is where the image is created. The distance from the lens to the focal point is called the focal length of the lens. The biggest refracting telescope in the world is located at the Yerkes Observatory of the University of Chicago at Williams Bay, Wisconsin. It has an objective (convex) lens that is 1.02 meters (40 inches) across, and it's total power is 195x (magnification).



Materials:

- 38 mm (3.75 cm or 1.48 inches) thick double convex lens (with 30 cm or 11.8 inch focal length)*
- 38 mm (3.75cm or 1.48 inches) thin double convex lens (with 5 cm or 1.97 inch focal length)*
- Ruler (with metric scale)
- Flashlight or florescent ceiling light
- Sheet of white paper with words on it and plain white paper

3.75 cm diameter, 5 cm Focal Length lens

3.75 cm diameter, 30 cm Focal Length lens

*The convex lenses in this activity may be purchased from any scientific school supply company such as Nasco, who sells them for $1.35 - $1.40 each. They can be found at www.enasco.com (Items #s SB10476M and SB10480M). DO NOT TELL STUDENTS THE MEASUREMENTS ON THE THICK AND THIN LENSES. THEY WILL NEED TO DETERMINE THE FOCAL LENGTH ON THEIR OWN.

Procedure:

Part 1: Determining the Focal Length of a Convex Lens – The spot where all the light rays come together after going through the lens is called the focus. The focal length is the distance between this spot of light and the lens.

Method 1: Flashlight

1. Have students work in pairs on this activity. Have one student hold the flashlight about three feet above a blank sheet of white paper.
2. Turn on the flashlight and point the light towards the piece of paper.
3. The other student should then bring the thick (30 cm) lens between the paper and the flashlight. A bright dot of light should appear on the paper.
4. With the other hand, place a ruler on the sheet of paper, with the 0 cm side down.
5. Move the lens up and down until the bright dot of light is the smallest and brightest it can be. The bright dot is the focus. The distance from the lens to the paper is the focal point of the lens.
6. Repeat for the thin 5 cm or 1.97 inch lens.

Method 2: Florescent Ceiling Light

1. Place a piece of blank paper underneath a florescent ceiling light.
2. Position the 30 cm (11.8 inch) lens above the piece of paper. A bright spot of light should appear on the paper.
3. Place the ruler, 0 cm side down, on the sheet of paper.
4. Move the lens up and down until you see the clearest picture of the light fixture. The picture of the light fixture is the focus. The distance from the lens to the paper is the focal point of the lens.
5. Repeat for the 5 cm or 1.97 inch lens.

6. Students should note that the focal length of the thick lens is 30 cm and the focal length of the thin lens is 5 cm.

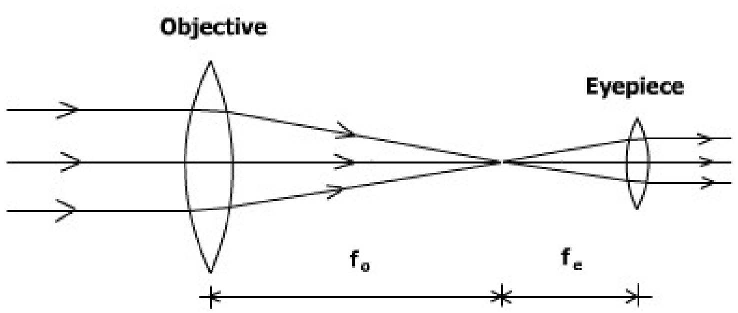
Part 2: Magnification of Two Lenses – The distance between the two lenses that result in the clearest magnification should equal the sum of the two focal points. Using these two lenses, the distance should be 35 cm.

1. Hold the thick (30 cm) lens about 3 inches (7 cm) from your eye.
2. With your other hand, slowly move the thin (5 cm) lens away from the thick lens until you can clearly see an object from across the room.
3. The other person should hold up a meter stick and note the distance between the lenses.
4. To calculate the magnification produced when two lenses are used together, use the following equation:

   magnification = focal length of thin lens / focal length of thick lens

   For the lenses used in this activity, the magnification would be:
   Focal length of thin lens = 5 cm
   Focal length of thick lens = 30 cm
   magnification = 6 times (30 cm / 5 cm)

   Using the two lenses in this activity, objects would be magnified 6 times!



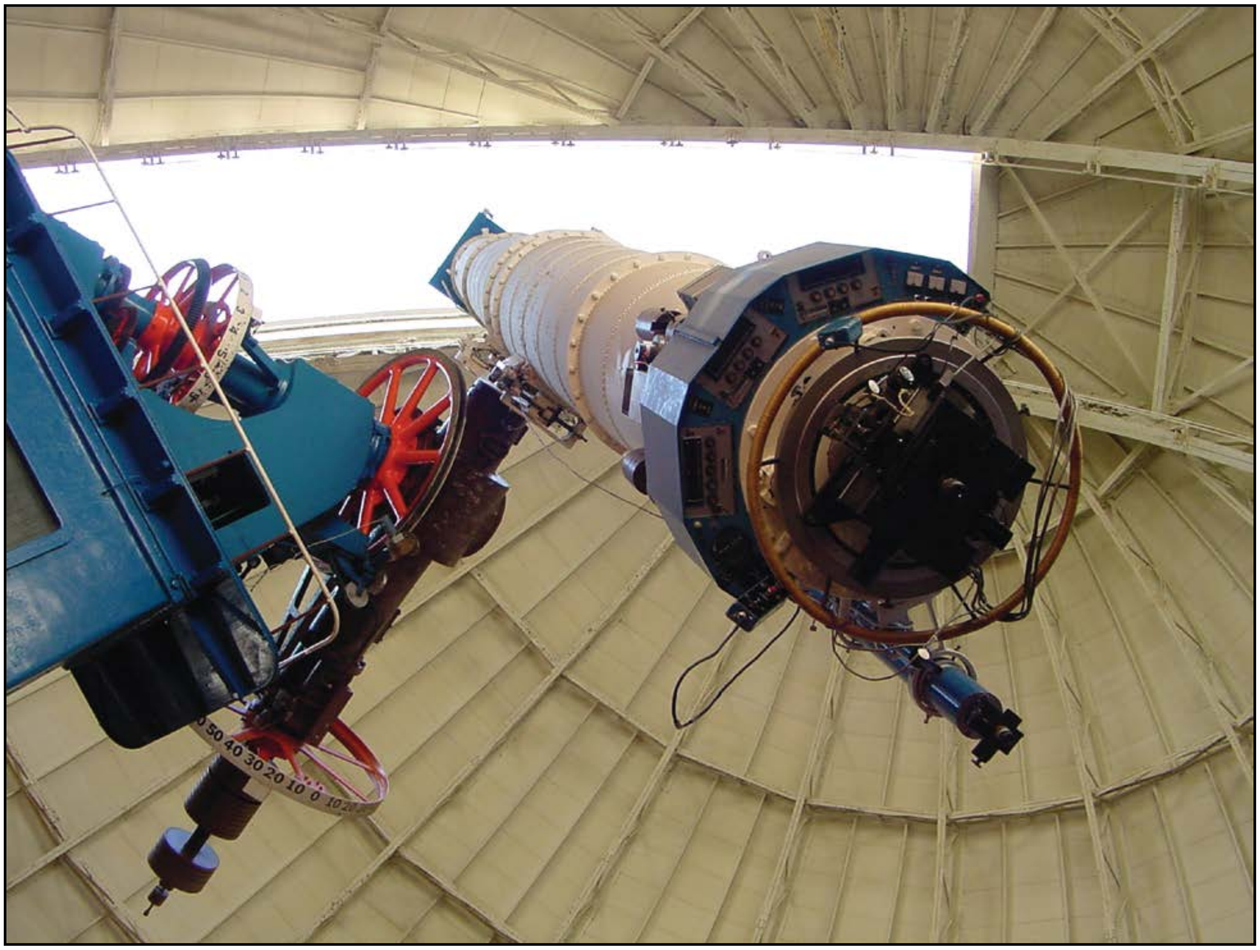
Summary: This lesson shows students how to measure for focal length and magnification and get a better understanding of how convex lenses work.

Evaluation: Have students satisfactorily complete the worksheet questions on focal length and magnification.

Additional Resources:

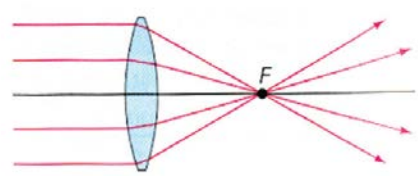
- Website for videos on telescope basics, as well as weekly videos on what to watch for in the sky, can be found at http://www.eyesonthesky.com/.

- Northrop Grumman has a unit on telescopes on their website at: http://www.northropgrumman.com/pdf/Telescope_Guide.pdf



World's Biggest Refracting Telescope –
Yerkes Observatory of the University of Chicago at Williams Bay, Wisconsin

Explanation of Double Convex Lens:



Converging lens

When the rays of light approach the lens, each ray is refracted or bent according to the effective angle of incidence at that point of the lens. Since the surface is curved, different rays of light will refract to different degrees; the outermost rays will refract the most. As light rays exit the lens, they once again encounter a curved surface, and refract again. This further bends the rays of light towards the centerline of the lens. Images appear to be larger and closer as well as upside down. A thicker double convex lens would have a shorter focal length than a thin one.

Activity Two: Worksheet Questions for Determining the Focal Length and Magnification of Lenses

Name: ____

Answer the following questions concerning the focal length of each lens in this activity.

<u>Using the Flashlight</u>

1. Predict what the distance between each lens and the paper will be when the brightest dot of light will be visible.
   - Thin Lens: Predicted distance __________________cm or __________________inches
   - Thick Lens: Predicted distance ________________cm or ________________inches
2. Measure the distance from the lens to the paper when the brightest dot of light is visible on the paper.
   - Thin Lens: Actual distance __________________cm or ________________inches
   - Thick Lens: Actual distance _________________cm or ________________inches
3. The distance from the paper to the lens is called the focal length. Why do you think each lens has a different focal length?

<u>Using the Florescent Ceiling Lights</u>

1. Predict the distance between each lens and the paper when a clear picture of the light fixture will be visible.
   - Thin Lens: Predicted distance _____________(cm or inches)
   - Thick Lens: Predicted distance _______________(cm or inches)
2. Measure the distance from the lens to the paper when the brightest dot of light was visible on the paper.
   - Thin Lens: Actual distance __________________(cm or inches)
   - Thick Lens: Actual distance _________________(cm or inches)

Magnification

Lens Observations

1. Look through the thin lens at a piece of paper with words on it. Draw and describe what the letters look like.
____
____

2. Look through the thick lens at a piece of paper with words on it. Draw and describe what the letters look like.
____
____

3. Hold the thin lens in front of your eye. Look at an object across the room. Describe what you see.
    - Is the object bigger or smaller? ______________
    - Is the object upside down or right-side up? ________________
4. Hold the thick lens in front of your eye. Look at an object across the room. Describe what you see.
    - Is the object bigger or smaller? _______________________
    - Is the object upside down or right-side up? ________________________

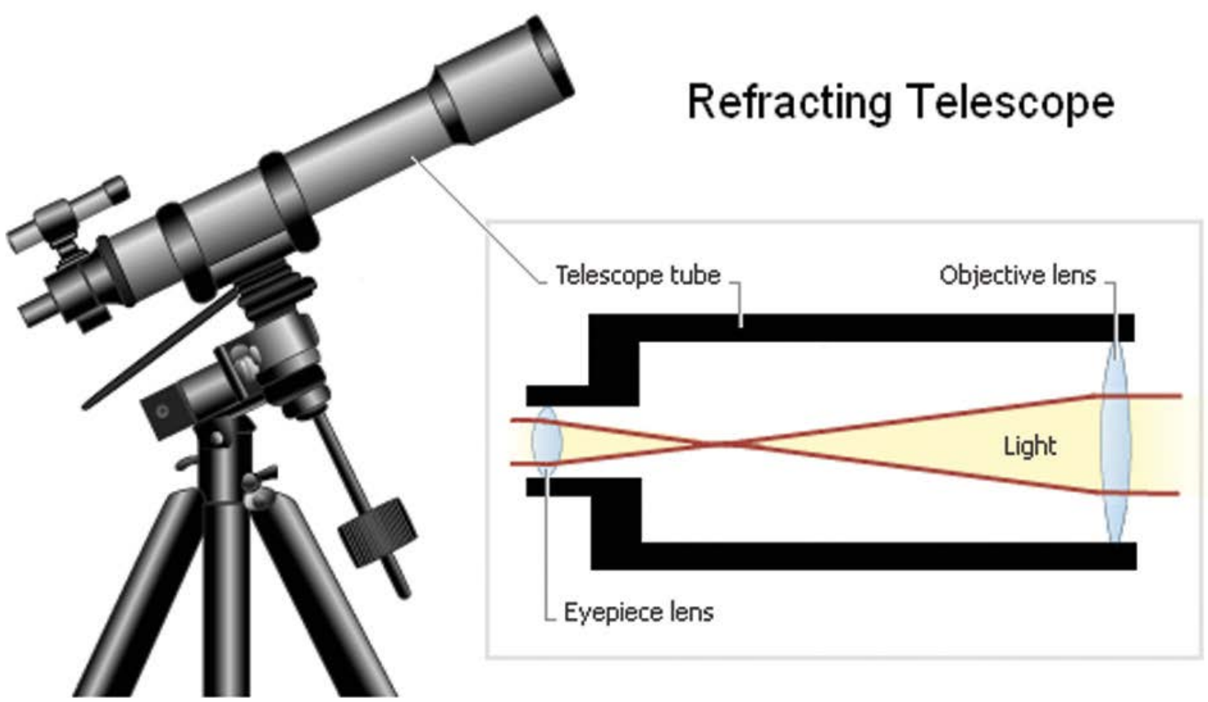
<u>Finding the Clearest Magnification</u>

In this section, you held two lenses in front of your eye to see an object. How far apart were the lenses when you could see the object clearly? __________________

Calculating Magnification

What is the magnification that these two lenses produce? ________________________

Note: Magnification = focal length of thin lens / focal length of thick lens



Activity Three: Measuring Degrees in the Sky Using Your Hand

Next Generation Standards Correlations: Relationship to A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

Objective: Students will use the astronomical system of degrees to measure objects on the horizon.

Practices:
3. Planning and carrying out investigations
8. Obtaining, evaluating, and communicating information

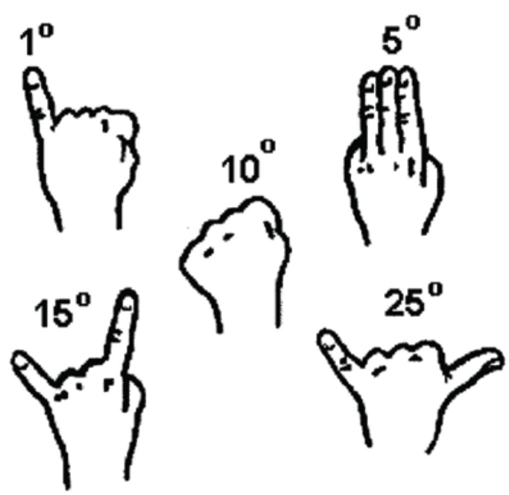
Crosscutting Concepts:
3. Scale, proportion, and quantity

Core Ideas:
ESS1.B: Earth and the solar system

Background Information:

Astronomers measure distances in the sky in units of degrees. The degrees are originally taken from the degrees in a circle (360°). It is easy to use hands and fingers to represent the degree increments. To use your hand as a measuring tool, you need to hold your hand in front of you at arm's length.

Held at arm's length, your pinky finger is about 1 degree wide. Your three middle fingers, held together, are about 5 degrees wide. If you hold out your fist, it will measure a 10 degree width of the sky. If you hold up just your pointer finger and your pinky finger, it will be about 15 degrees of sky between them. If you spread the thumb and pinky of one hand as far apart as they will go, it will be about 25 degrees from outside edge to outside edge.



Materials:

- Student copy of the worksheet “Measuring Objects on the Horizon and in the Night Sky”
- Pencils
- Horizon with features to measure

Procedure:

1. Read the Background Information to learn how the hand measuring works. Practice the hand measurements with students in the classroom.
2. Before going outside, students should be grouped in pairs so they can discuss and assist each other with the measurements.
3. Before having the students do the problems, do the first problem together.
4. Monitor students as they measure. Encourage students to compare answers.
5. While still outside, go over student responses.

Summary:

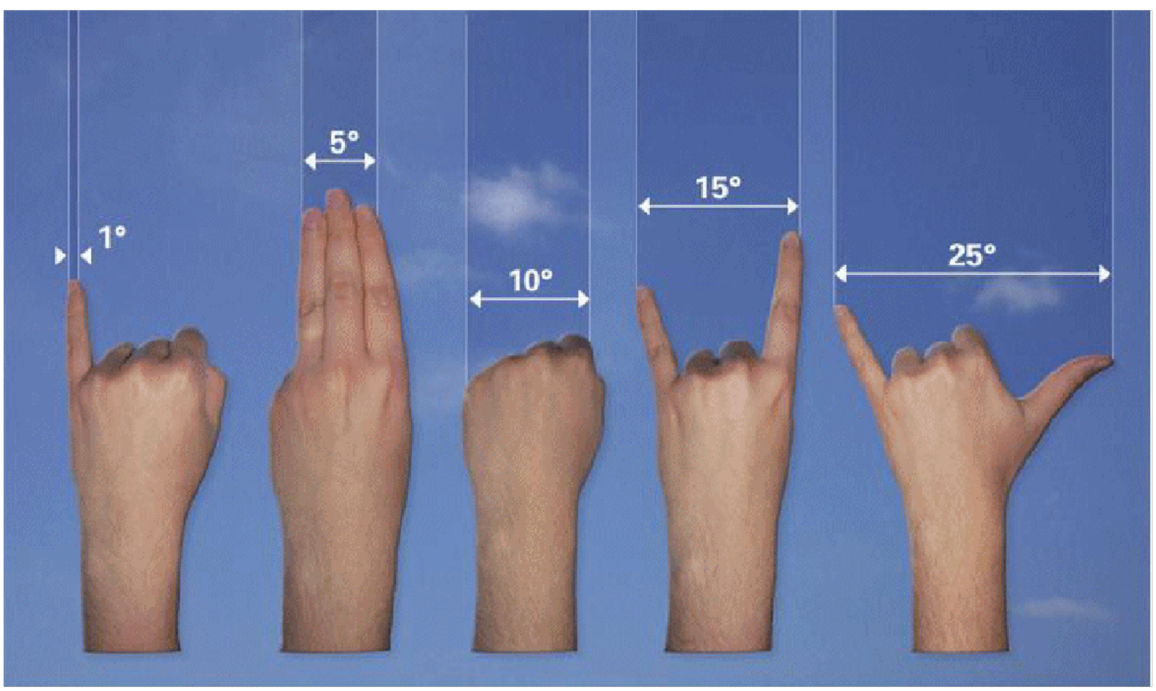
This exercise will prepare students to locate stars in the sky. It will motivate and prepare students to go out at night on their own and measure objects in the night sky.

Evaluation:

Students will satisfactorily complete the worksheet and discuss the answers as a group.

Additional Resources and Enrichment:

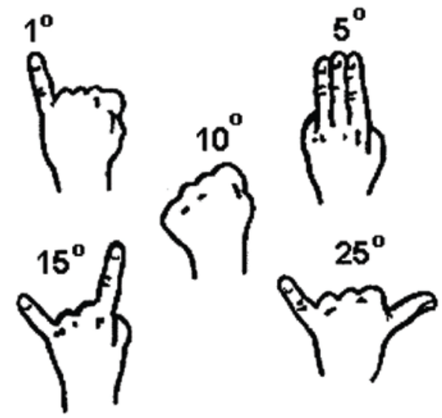
1. This website will provide a unit on Legends of the Night Sky: Orion (constellations) **http://www.spitzinc.com/pdfs/educ_guide_orion.pdf.**
2. Explanation of the Celestial Sphere from University of Michigan can be found at **http://www.astro.ufl.edu/~altheam/handouts/sphere.pdf.**
3. More information on Counting and Measurement from Teach Astronomy is at **http://www.teachastronomy.com/astropedia/article/Counting-and-Measurement.**



Activity Three: Worksheet to Measure Objects on the Horizon and in the Night Sky

Name:____

Go outside. Look at objects that are as far away as you can see. We call that the horizon. Use the hand measurements discussed and practiced in class (shown here) to measure the following objects:



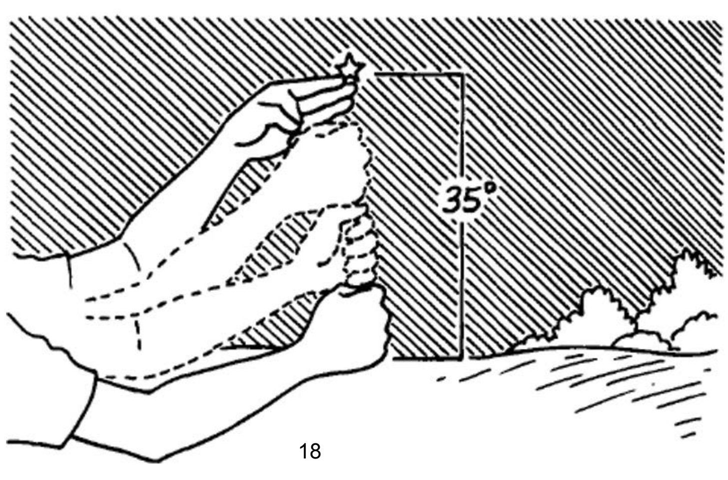
1. What two objects on the horizon seem to be one degree apart?
   ____
2. What two objects on the horizon seem to be 10 degrees apart?
   ____
3. What two objects on the horizon seem to be 25 degrees apart? ______________________________________

Next, go outside at night. Find a bright star in the sky.

4. What time of night is it? _______________
5. How high is the star you selected above the horizon? _________
6. How high is the moon above the horizon? ____________________
7. How far apart are Mercury and Venus, measured in degrees? ____________*

**As an evening object, Venus is often the first bright object visible, before any stars appear in the sky. Mercury also appears in areas of the sky around sunrise and sunset, but never looks as bright as Venus nor is as far from the Sun as Venus. Mercury appears only during twilight and Venus never remains visible through the night. Whenever a very bright yellowish white point of light appears in the sky in the middle of the night, it is probably Jupiter. Unlike Mercury and Venus, Jupiter is not always near the Sun in the sky and can appear high in the sky at midnight. Mars and Saturn can also appear far from the sun in the sky, rising well after sunset. Mars rarely outshines Jupiter and the brightness of Saturn never equals that of Jupiter or Venus. Mars can often be distinguished by the fact that it has a slight but distinct reddish or orange color. Saturn, on the other hand, appears to be yellowish. The other planets are too faint to be seen with the naked eye.*

How to measure from the horizon using the hand measurement.



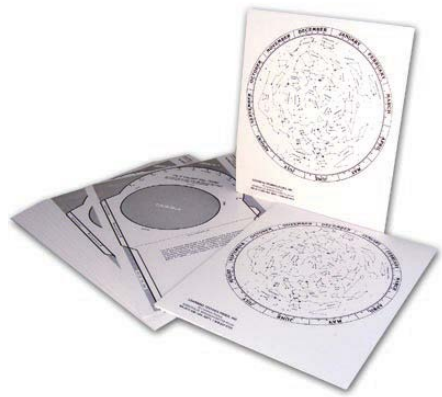
Activity Four: Creating a Star Finder

(Portions of this lesson were reprinted with permission from Astro Adventures, by Dennis Schatz and Paul Allan, copyright 2003 by Pacific Science)

Relationship to A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas:

Objectives: Students will use a star chart to locate objects in the sky.

Practices:
2. Developing and using models
4. Analyzing and interpreting data



Crosscutting Concepts:
4. Systems and system models

Core Ideas:
ESS1.A: The universe and its stars
ESS1.B: Earth and the solar system
PS4.B: Electromagnetic radiation
PS4.C: Information technologies and instrumentation

Background Information:

When standing on Earth (which is rotating), we see everything in the sky wheeling around us once every 24 hours. Each object in the sky appears to move 15° westward every hour as Earth rotates (15°/ hour = 360°/ 24 hours). The motion of the stars marks the passage of time during the night. As Earth turns on its axis, the stars appear to rise in the east and set in the west, just as the Sun and Moon do. This means that you'll see different stars overhead at different times of night. Likewise, as Earth makes its annual trek around the Sun, you'll see different stars from month to month. To identify stars and constellations in the night sky, use a Star Finder to help you locate them. These Star Finders can be built such as the one in this activity or they can be purchased from a science store.

Materials:

- Star Finder patterns for each student (print on cardstock and laminate each individual piece before assembling or have students glue each piece to a cut-apart file folder)
- Scissors
- Stapler
- Masking tape to tape items to wall (painter's tape is gentler on painted surfaces)
- Poster or flip chart paper for each group
- Markers
- Set of Cardinal Direction cards (attached)
- Set of Major Constellation cards (attached)

Procedure:

1. Divide the class into groups of three or four.
2. Have all supplies needed ready for each group to pick up (scissors, stapler, markers, paper, templates, and poster board). This can be done with plastic or wooden boxes the size of a piece of paper (have supplies in one box per group).
3. Have cardinal direction cards for practice in the classroom and allow students to make their own for use viewing the night sky. Remind students that the Sun sets approximately in the West and rises approximately in the East. You can also use a compass to locate the cardinal directions (North, South, East, and West).
4. Have students cut out the Star Finder and assemble it by first stapling the front and back together. Place staples exactly on the staple lines shown on the front of the Star Finder Holder.
5. Distribute copies of the star wheels and have students cut them out.
6. Have students insert the simple star field wheel between the stapled pages so the simple star field appears through the oval opening. Once the star wheel is completely inserted, test the movement of the star wheel to be sure it moves freely. Check to see that the black line under the dates on the star wheel approximately lines up with the edge of the Star Finder cover showing the time of day.
7. (Since this activity may take place in the daytime during school, simulate the viewing of the stars and tell students to use it when they get home after dark in a spot that does not have a lot of artificial light.) To use, tell students to turn the star wheel on the Star Finder until the current date lines up with the time you wish to observe. Have them hold the Star Finder over their head so "North" on the Star Finder is facing north. The stars showing in the oval window are those that can be seen overhead. The edge of the oval represents the horizon and the center of the oval is the point directly overhead when they look up in the night sky. This point is called the zenith. Stars near the center of the oval will be high overhead when they observe. *The term azimuth (mentioned on the Cardinal Directions cards) means the angular distance along the horizon to the location of the object*
8. Discuss the constellations that may appear in the northern sky when they use their Starfinder. Such constellations as Ursa Major (Big Dipper) on the Starfinder should be simple to find.
9. Have students answer questions on the Star Finder Student Worksheet about Ursa Major from observing the location on the Star Finder Wheel. Use this information to point at the direction they should look to see the constellation when they go outside at night. If possible, create the constellation formation of Ursa Major on poster paper and attach it to the wall of the classroom in the location it would be in the night sky.
10. The teacher should write the names of the major constellations on pieces of paper and put them in a container. Have each group draw a constellation name out of the container and create a different constellation. Have them display it in the room in the correct location for viewing in the sky. Do not have them put the name of their constellation on the drawings so that other groups have to guess which one they did.

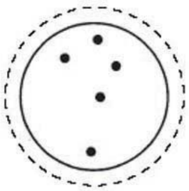
Evaluation: Have students answer the Star Finder Student Worksheet and work in groups to draw and show a constellation. Answers to Star Finder Student Worksheet will vary according to the date used.

Summary: This activity will provide help in identifying the location and names of the major constellations.

Additional Resources and Enrichment:

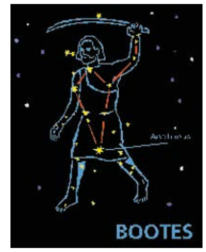
- **Locator for Astronomy Clubs from Night Sky Network is found at https://nightsky.jpl.nasa.gov/club-map.cfm.**
- **Interactive Sky Chart from Sky & Telescope magazine is found at http://www.skyandtelescope.com/observing/skychart.**
- **Youtube video called: "Amateur Astronomy for Beginners: START HERE!! is found at http://www.youtube.com/watch?v=B1UJ2sAyPPo.**

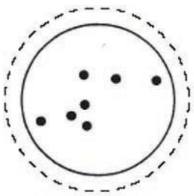
Major Constellations Cards



BOOTES,
the Herdsman

Bootes, the Herdsman

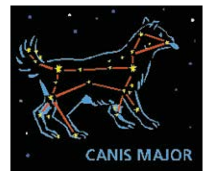


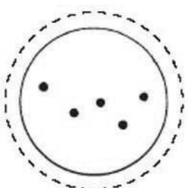


CANIS MAJOR,
the Big Dog

Canis Major,

the Big Dog

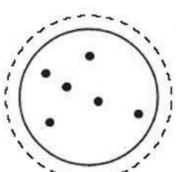




CASSIOPEIA,
the Queen

Cassiopeia,

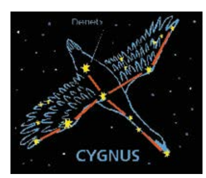
the Queen

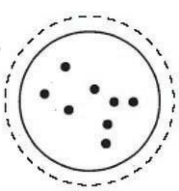


CYGNUS,
the Swan

Cygnus,

the Swan

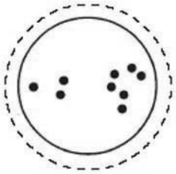




GEMINI,
the Twins

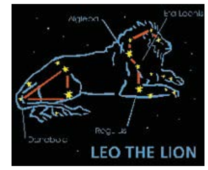
Gemini,

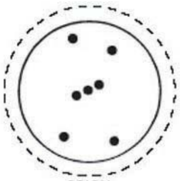
the Twins



LEO,
the Lion

Leo, the Lion

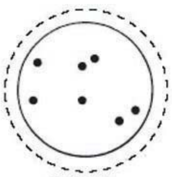




ORION,
the Hunter

Orion,

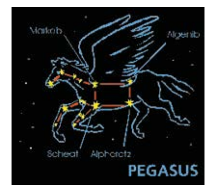
the Hunter

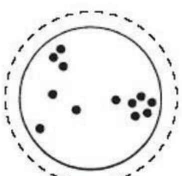


PEGASUS,
the Flying Horse

Pegasus,

the Flying Horse

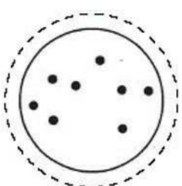




PISCES,
the Fishes

Pisces,

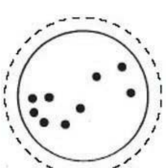
the Fishes



SAGITTARIUS,
the Archer

Sagittarius,

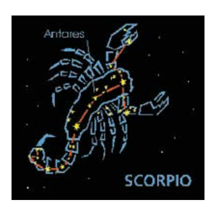
the Archer



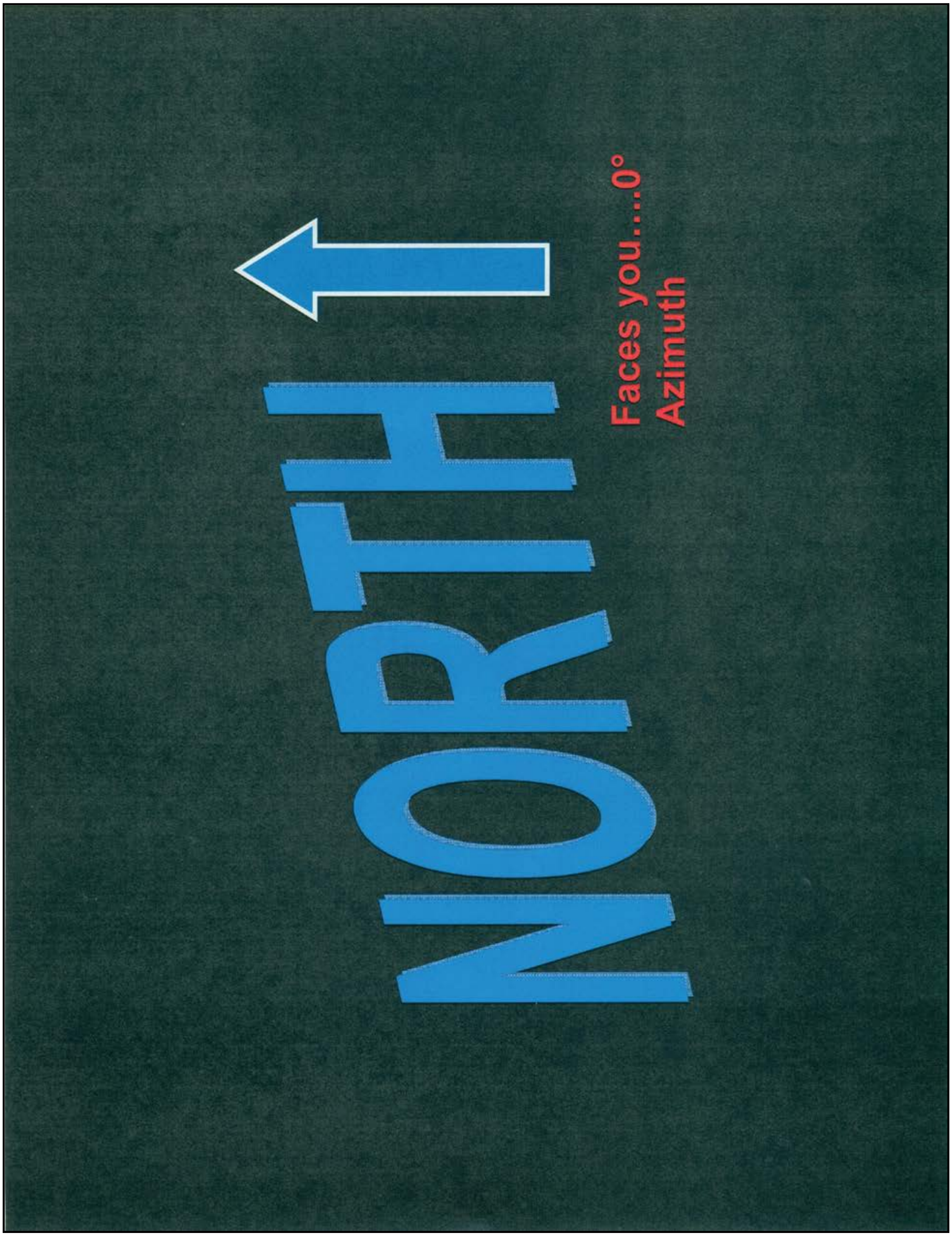
SCORPIUS,
the Scorpion

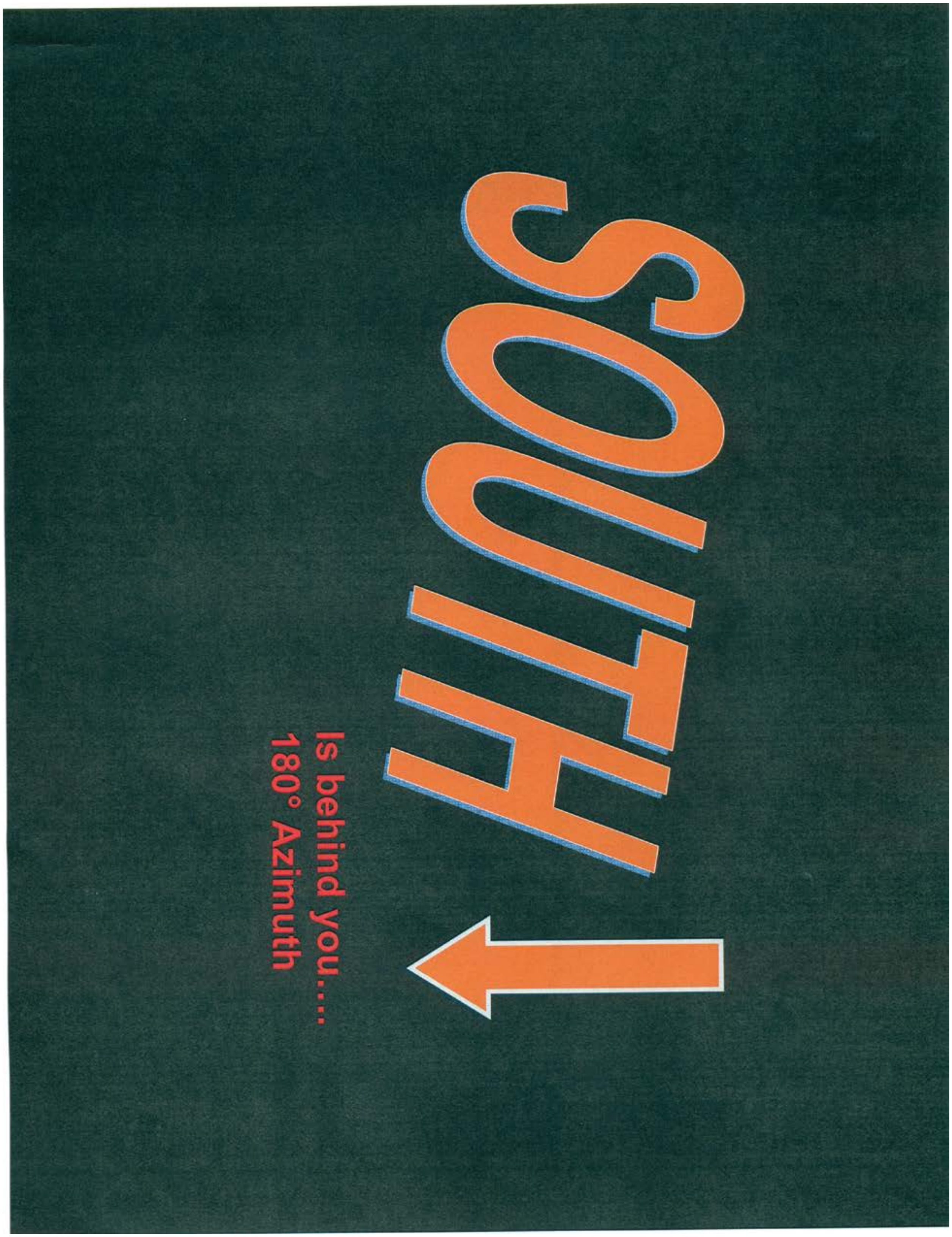
Scorpius,

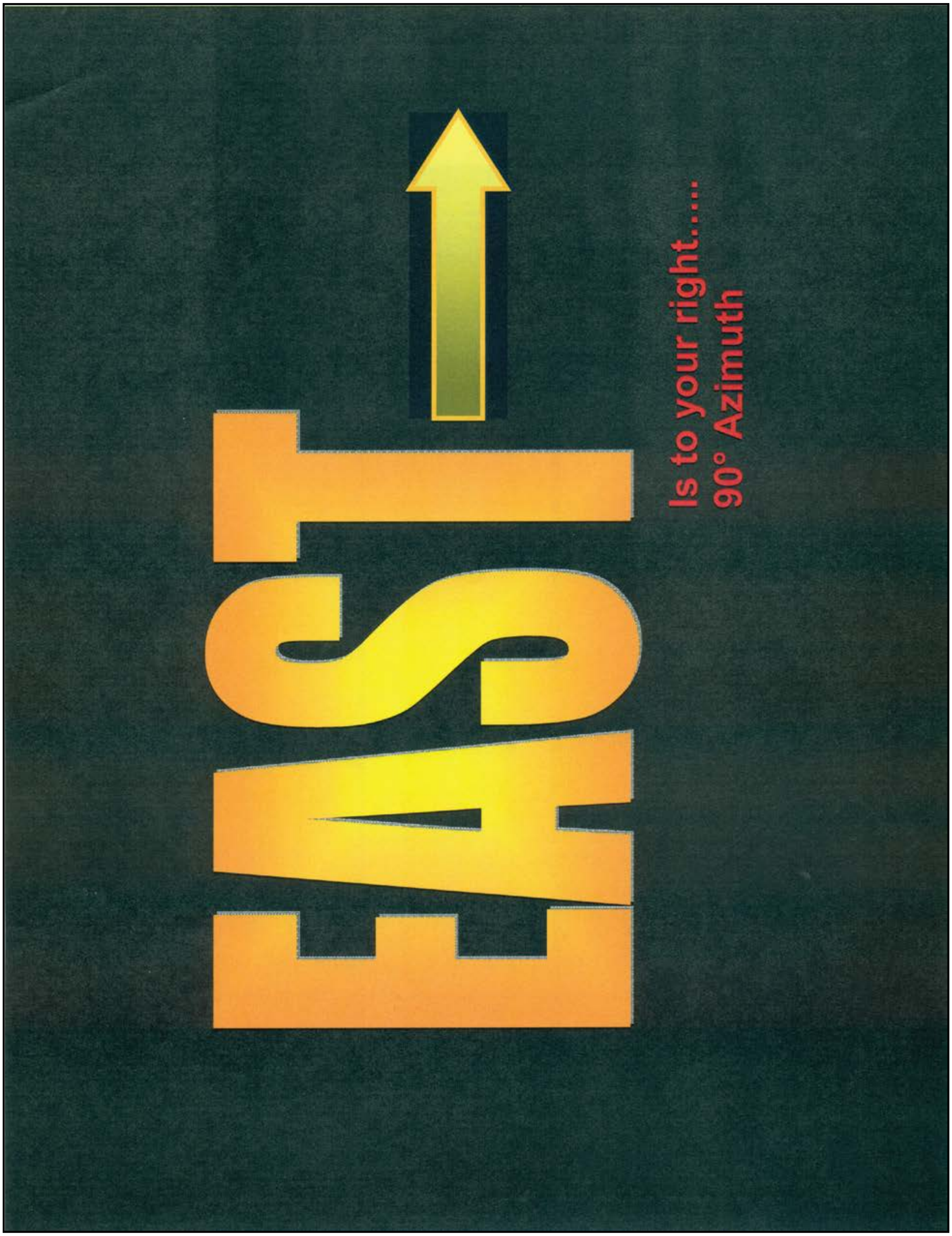
the Scorpion

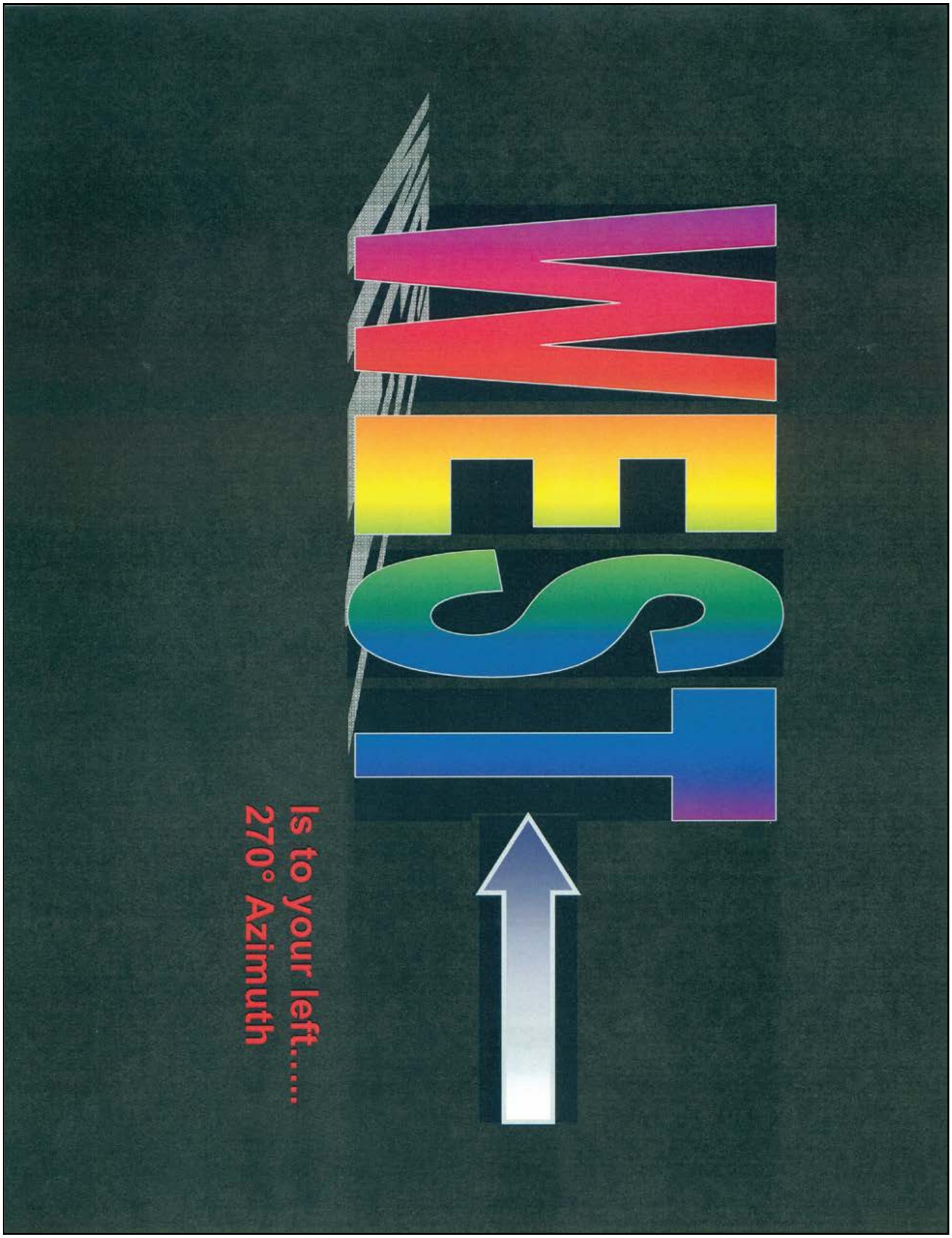


Cardinal Directions Cards




SOUTH
Is behind you....
180° Azimuth

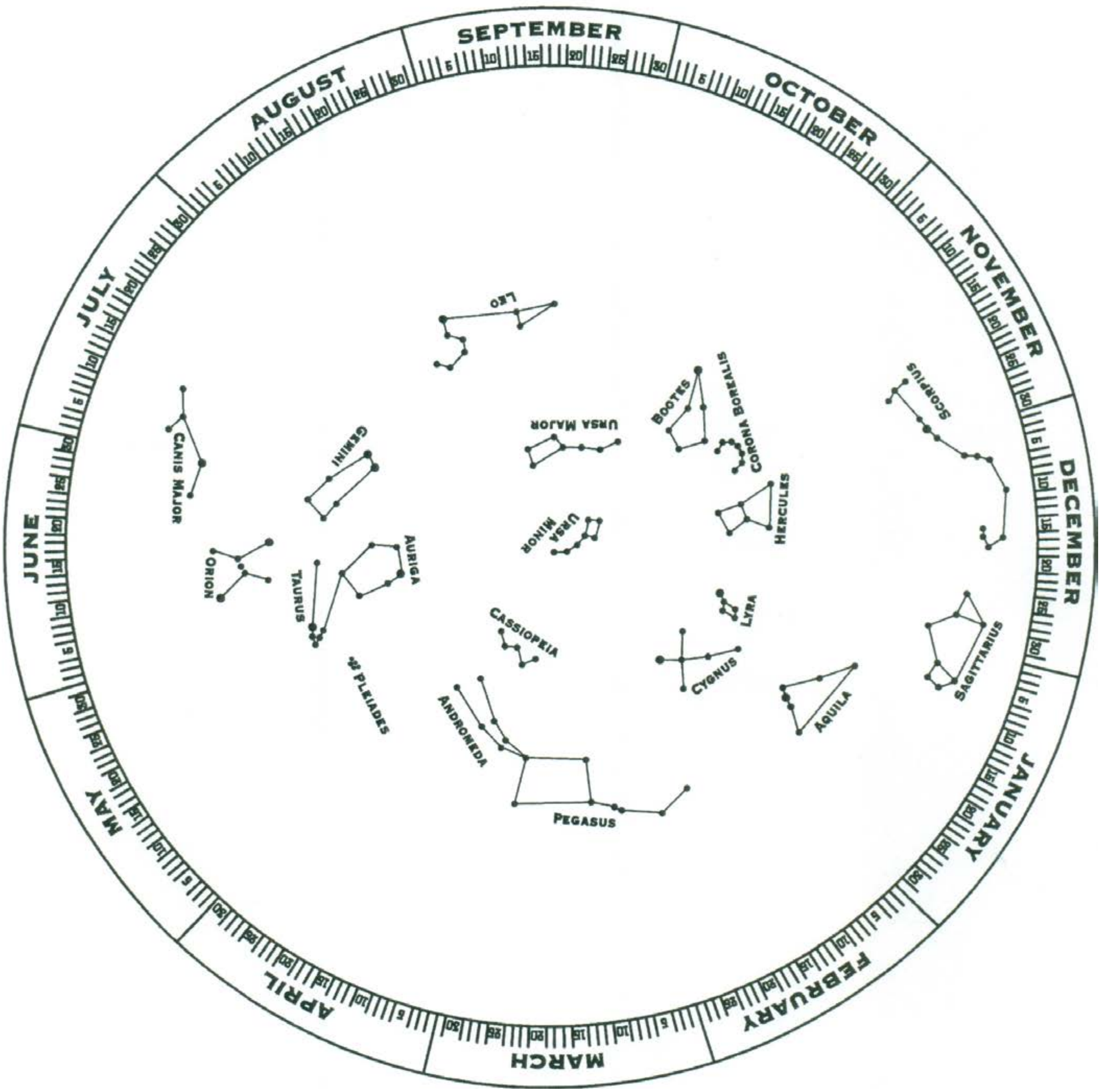

EAST
Is to your right.....
90° Azimuth


WEST
Is to your left.....
270° Azimuth

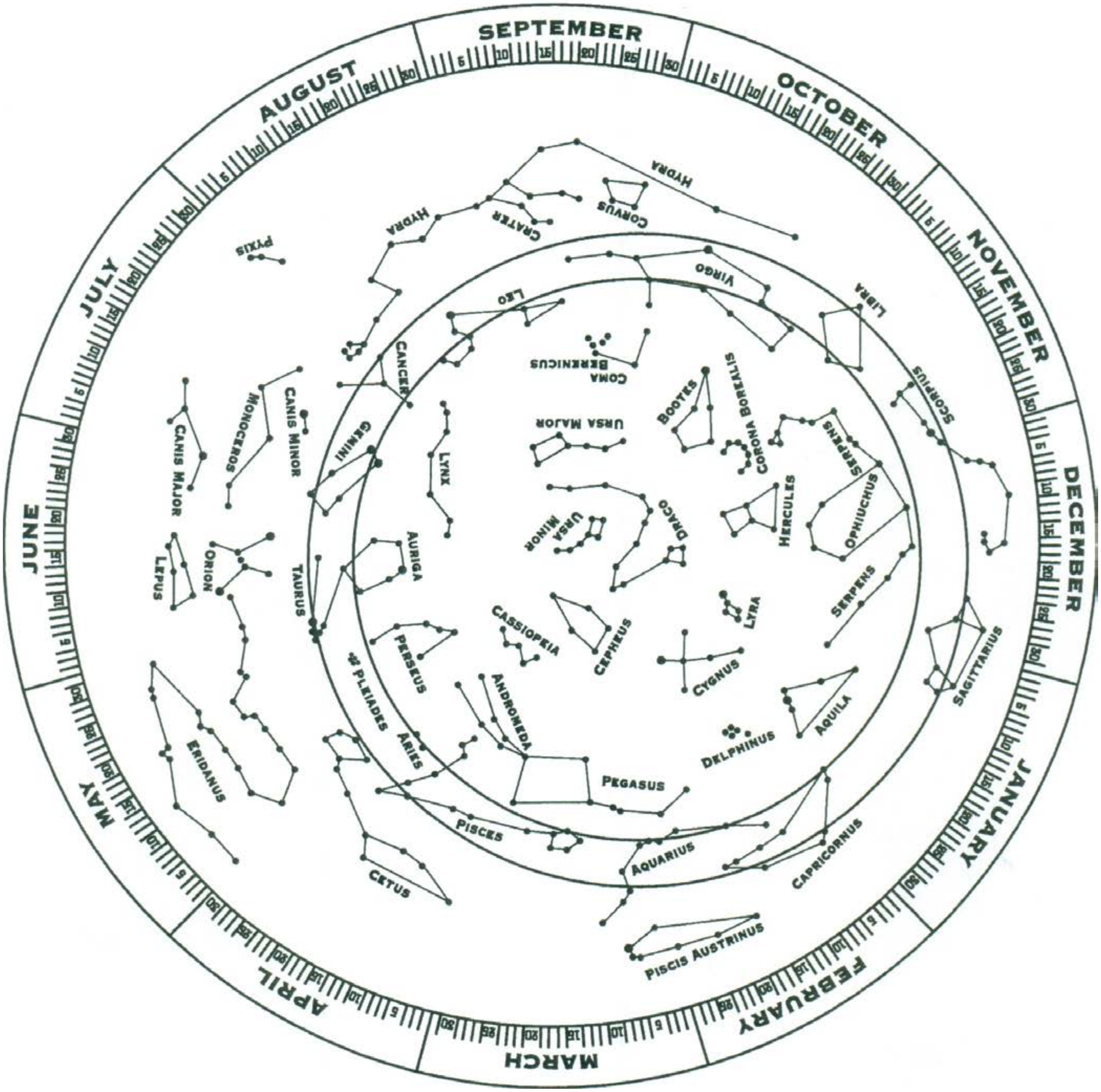
Starfinder Holder

Starfinder Holder Backing

STAR WHEEL
SIMPLE STAR FIELD



STAR WHEEL
COMPLEX STAR FIELD



Activity Four: Star Finder Student Worksheet

Name: ____

Using the completed Star finder, practice using it by answering the following questions:

Sir Isaac Newton invented the Newtonian telescope which is a reflecting telescope.

1. **Set the Star finder to show the sky for 9 p.m. today. Today's date should be next to 9:00 p.m. What constellations are visible?**

   ____

   ____

   ____

2. **Turn the dial until it is set for 11:00 p.m. tonight:**

   a. **What constellations are visible?** ______________________________

   ____

   ____

   b. **Which constellations were visible at 9 p.m., but are no longer visible at 11 p.m.?** ____

   c. **Which horizon is closest to the disappearing constellations?** ____________

   d. **Which constellations are visible at 11 p.m. but not at 9 p.m.?**

   ____

3. **Turn the dial until it is set for 6 a.m., just around sunrise.**

   a. **Which constellations are still visible that were up at 9 a.m.?**

   ____

   b. **Describe the motion the constellations follow from 9 p.m. to 6 a.m.**

   ____

4. **Adjust the Star Finder so it is again set for 9:00 p.m. tonight. Remember that the Star Finder is based on standard time. Subtract one hour from the clock time to**

get standard time if Daylight Saving Time is in effect. Hold the Star Finder over your head so the the “north” designation on the Star Finder is pointing north. The stars showing in the oval opening are those that can be seen overhead at the time and date set on the Star Finder. The edge represents the horizon, so stars near the edge of the oval are low on the horizon. The center of the oval is the point directly overhead when you look up in the night sky. This point is called the zenith. Stars near the center of the oval will be high overhead when you are observing.

5. **Now you are ready to go star finding in the night sky. A small flashlight or penlight will help you read the Star Finder at night. A red balloon or red plastic over the front of the flashlight will allow you to read your sky chart by the red light, but will not reduce your ability to see faint stars in the sky.**

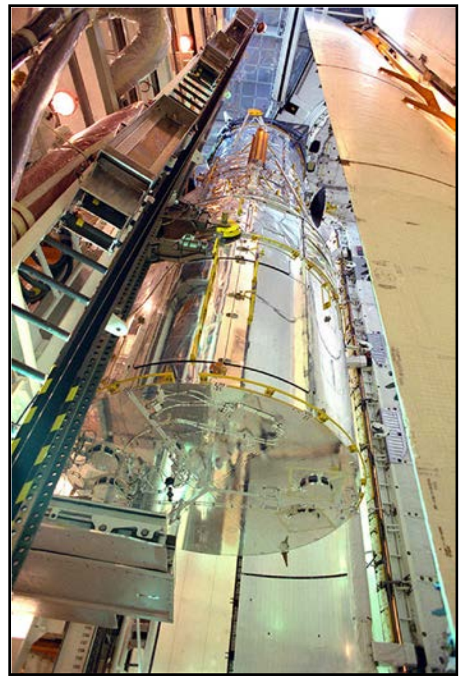
Draw your constellation and tell which time of year it will be visible closest to the zenith.

Activity Five: Make Your Own Hand-Held Hubble and Learn About This Space Telescope

(Credit: NASA HubbleSite at http://hubblesite.org/education_and_museums/)

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

Objectives: Students will learn about the history and purpose of the Hubble Telescope. Students will also learn about the parts of this space telescope by building a model.



Practices:
2. Developing and using models
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts:
4. System and system models
6. Structure and function

Core Ideas:
ESS1.A: The universe and its stars
PS4.C: Information technologies and instrumentation

Background Information:

NASA named the world's first space-based telescope after American astronomer, Edwin Hubble (1889-1953). The Hubble Space Telescope's launch in 1990 sped humanity to see more, see farther, and see deeper into space. Hubble is a telescope that orbits Earth. Its position above the atmosphere, which distorts and blocks the light that reaches our planet, gives it a view of the universe that typically far surpasses that of ground-based telescopes.

Every 97 minutes, Hubble completes a spin around Earth, moving at the speed of about five miles per second (8 km per second) – fast enough to travel across the United States in about 10 minutes. As it travels, Hubble's mirror captures light and directs it into its several science instruments.

Hubble is a type of telescope known as a Cassegrain reflector. Light hits the telescope's main mirror, or primary mirror. It bounces off the primary mirror and encounters a secondary

Workers study Hubble's main, eight-foot (2.4 m) mirror. Hubble, like all telescopes, plays a kind of pinball game with light to force it to go where scientists need it to go. When light enters Hubble, it reflects off the main mirror and strikes a second, smaller mirror. The light bounces back again, this time through a two-foot (0.6 m) hole in the center of the main mirror, beyond which Hubble's science instruments wait to capture it. In this photo, the hole is covered up.

mirror. The secondary mirror focuses the light through a hole in the center of the primary mirror that leads to the telescope's science instruments.

People often mistakenly believe that a telescope's power lies in its ability to magnify objects. Telescopes actually work by collecting more light than the human eye can capture on its own. The larger a telescope's mirror, the more light it can collect, and the better its vision. Hubble's primary mirror is 94.5 inches (2.4 m) in diameter. This mirror is small compared with those of current ground-based telescopes, which can be 400 inches (1,000 cm) and up, but Hubble's location beyond the atmosphere gives it remarkable clarity.

Even though Hubble has had several servicing and repair missions since its launch in 1990, it is expected to extend its life to at least 2013. The last servicing mission took place in May 2009. Hubble will continue to beam images of the heavens back to Earth, transferring about 120 gigabytes of data every week.

Hubble's successor, the James Webb Space Telescope (JWST), is currently in the works and is scheduled to be launched in 2018.

Materials:

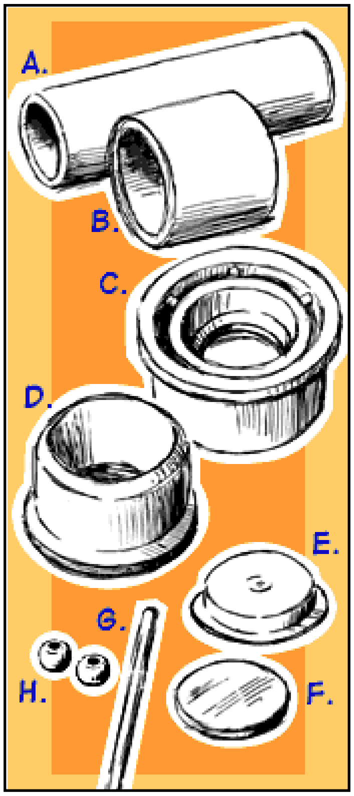
- Background Information from this activity as well as internet access to view the Hubble website is found at **http://hubblesite.org/the_telescope/.**
- Download either the black-and-white wrappers (if you wish students to color them) or the color wrappers at **http://hubblesite.org/the_telescope/hand-held_hubble/pvc.php.** Put these wrappers around your model to make it more realistic and to identify the parts.

Tools Needed: (The teacher may wish to prepare some of the steps ahead of time to be able to use the time more wisely. Read all directions before shopping since sometimes you may have an idea for an improvement to customize your model.)

- Drill with 3/16" drill bit
- Handsaw
- Miter box (optional)
- C-clamp or vise
- Sandpaper or file
- Scissors or craft knife
- Stapler
- Ruler
- Pencil
- Safety glasses (when working with power tools)

Hardware (plumbing) supplies: (Take this list and picture to the hardware or plumbing supply store and ask for assistance.)

- 2" PVC (polyvinyl chloride pipe used in plumbing), at least 6 ¾ " long (A) *– Ask if the hardware or home improvement store has some cut ends or scraps that will work.*
- 3" PVC pipe, at least 2 ¾ " long (B)
- 3"-to-2" PVC bushing to connect the pipes (C)
- 3" snap-in drain cap (D)
- 2" plastic test cap (E)



Craft Supplies:

- One 2” diameter round mirror (F)
- One 3/16 “ diameter wooden dowel, at least 21” in length (G)
- Two ½ “ diameter wooden beads with pre-drilled holes (holes should be big enough for the end of the dowel to fit inside) (H)
- One sheet of poster board, at least 11” x 17”
- Silver paint (spray paint works best)
- Small paint brush (not needed if using spray paint)
- Cellophane tape
- Duct tape
- White glue and/or permanent gluestick
- Dish soap for washing PVC

Safety First!!!

- Make sure you have an adult present before you begin using any of the tools.
- Have an adult inspect all tools before you use them. Do not use tools that appear damaged (frayed cords, cracks, dull cutting blades, etc.).
- Have an adult show you how to use each tool safely and supervise you while you use them.
- Keep your work area well-lighted and clear of clutter.
- Carry tools properly. All sharp-edged tools should be carried with the cutting edge down. Never carry sharp tools in a pocket!
- Do not wear loose or baggy clothing, ties, jewelry, or sandals. If you have long hair, tie it back or wear a cap – especially when drilling.
- Wear eye protection when sawing and drilling. Safety glasses or goggles are inexpensive and available at any hardware or dollar store.
- Do not hold your finger on the switch button while carrying a plugged-in tool – it may start accidentally.
- Grip all tools firmly.
- Keep your mind on your work. Avoid distractions such as loud music or conversation.
- When sawing or drilling, make sure you clamp the material you are working on securely to a table or other solid surface with a C-clamp or vise.
- When sawing, make sure to cut away from your body and to keep your hands away from the cutting area.
- When drilling, pay attention to what is underneath the piece being drilled. Be sure that drilling is done into a secure block of scrap wood or into a clear space.
- Be careful when handling materials that have just been drilled or sawed – the edges may be sharp!
- Be sure to work at a safe distance from others.
- Do not use electric power tools in wet or damp locations.
- Never carry a power tool by its cord.
- Never leave a running power tool unattended.
- When unplugging a power tool, first be sure that it has stopped running. Then unplug it by grasping the plug, not the cord!

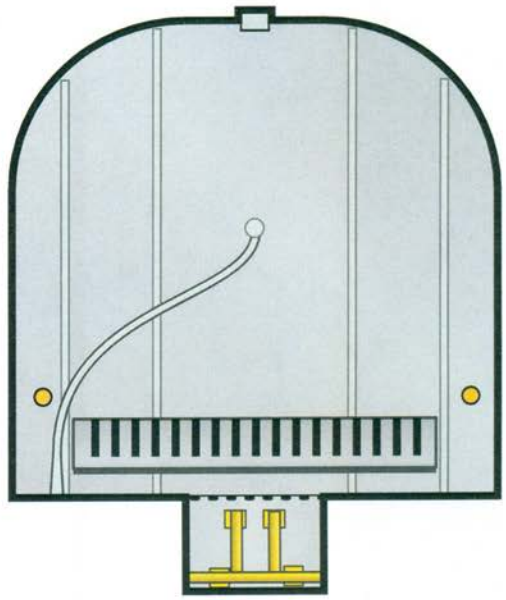
HAND-HELD HUBBLE

Model Wrappers

The wrappers show the Hubble Space Telescope's exterior features and the locations of its science instruments.

These pages contain all of the wrappers needed to complete the Hand-Held Hubble model. The assembly instructions can be found on the Web at: **www.hubblesite.org/go/model.**

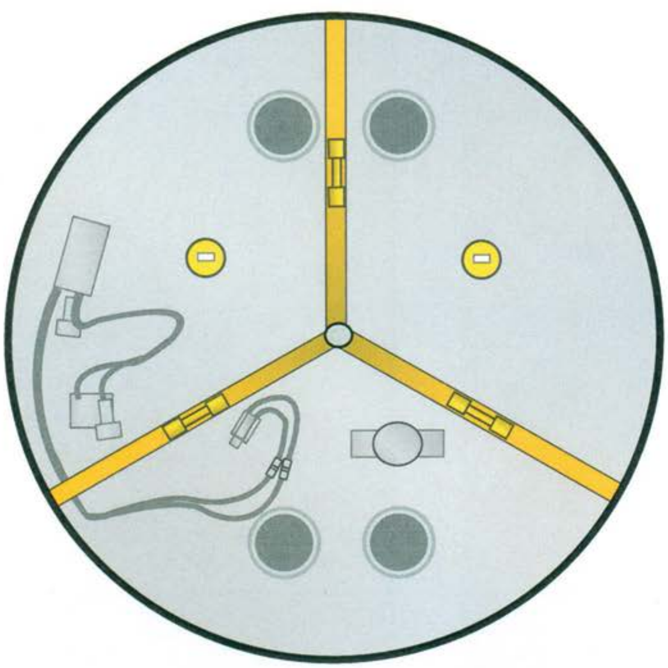
Aperture Door



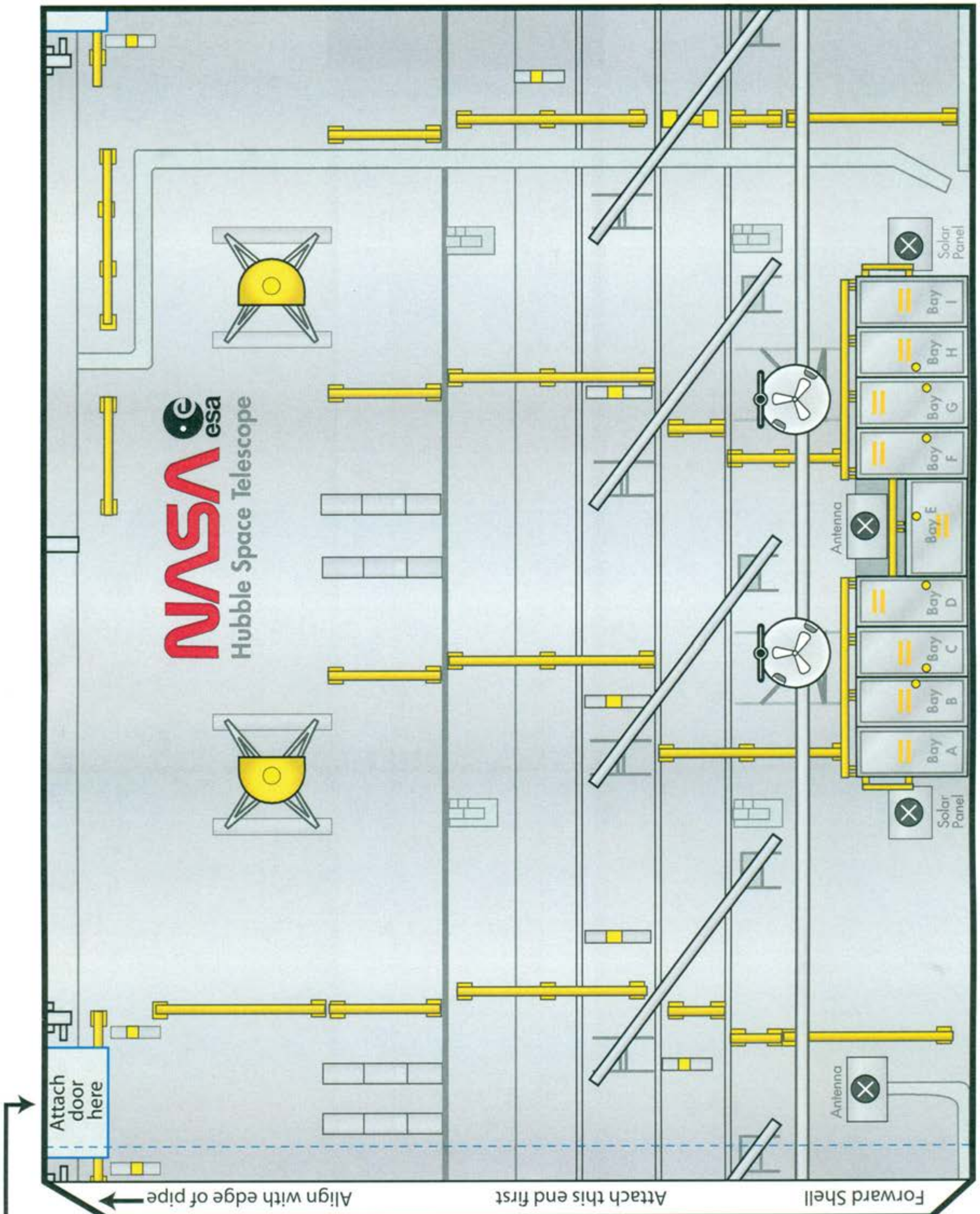
Fold Aperture Door at dotted line. Glue or tape flap to Forward Shell where indicated.

Glue the Aft Bulkhead and Aperture Door pieces to cardboard or posterboard before cutting them out.

Aft Bulkhead



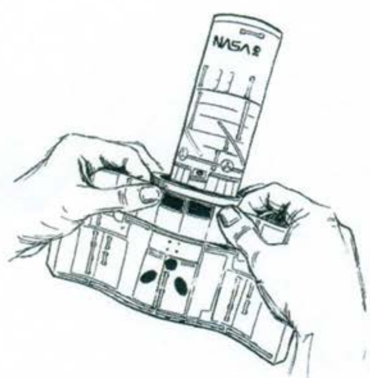
Forward Shell



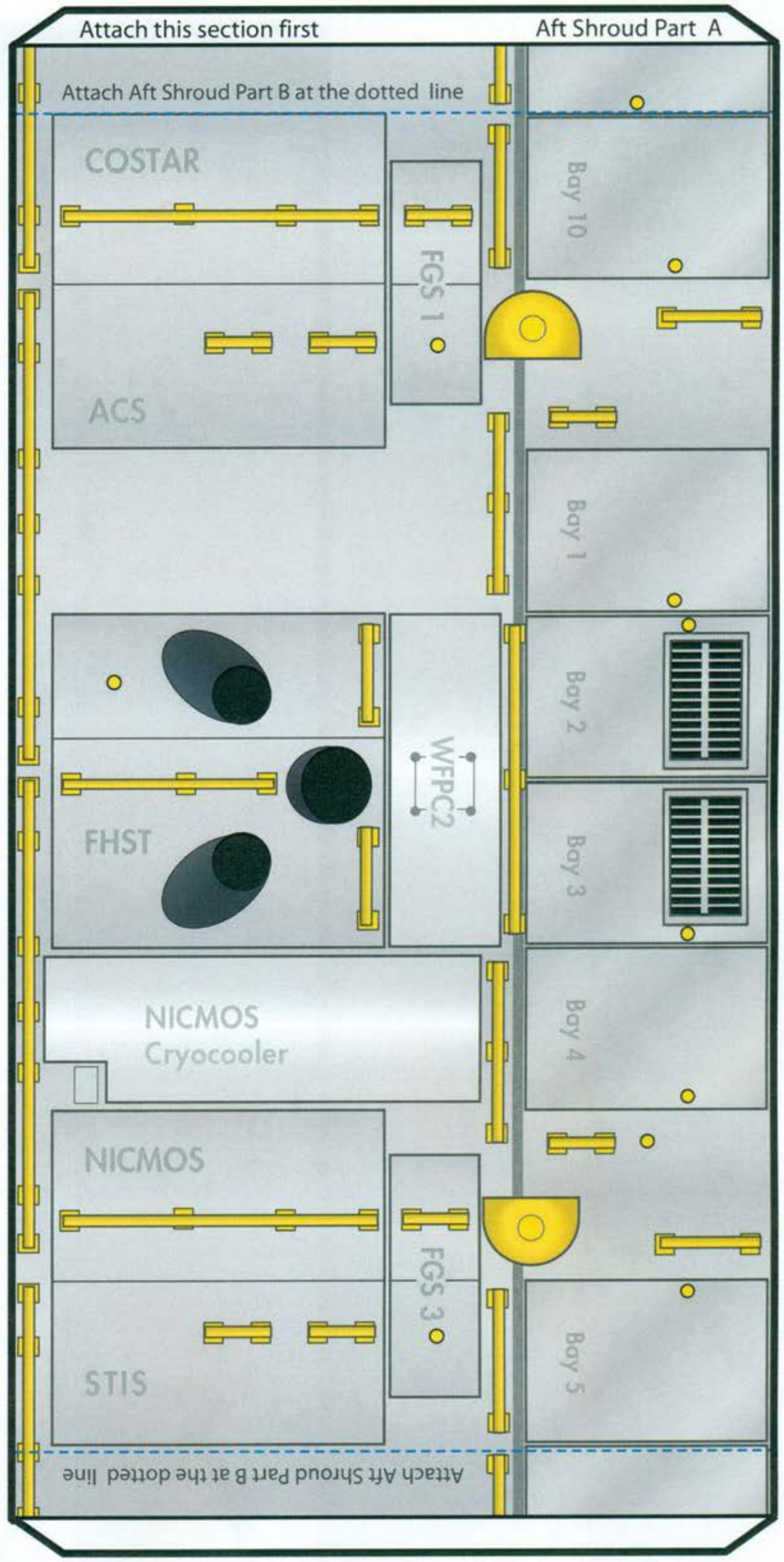
Aperture door attaches here

Drill holes through the ⊗ for the Communications Antennae and the Solar Panels.

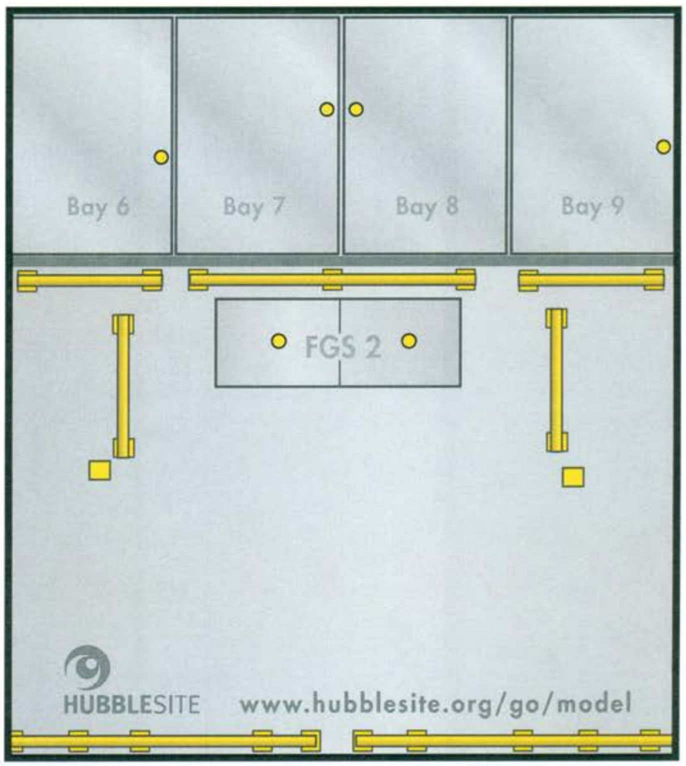
Aft Shroud Part A



When attaching Part A of the Aft Shroud wrapper, make sure that the NASA logo on the Forward Shell and the three circular shapes on the Aft Shroud Part A form a straight line.

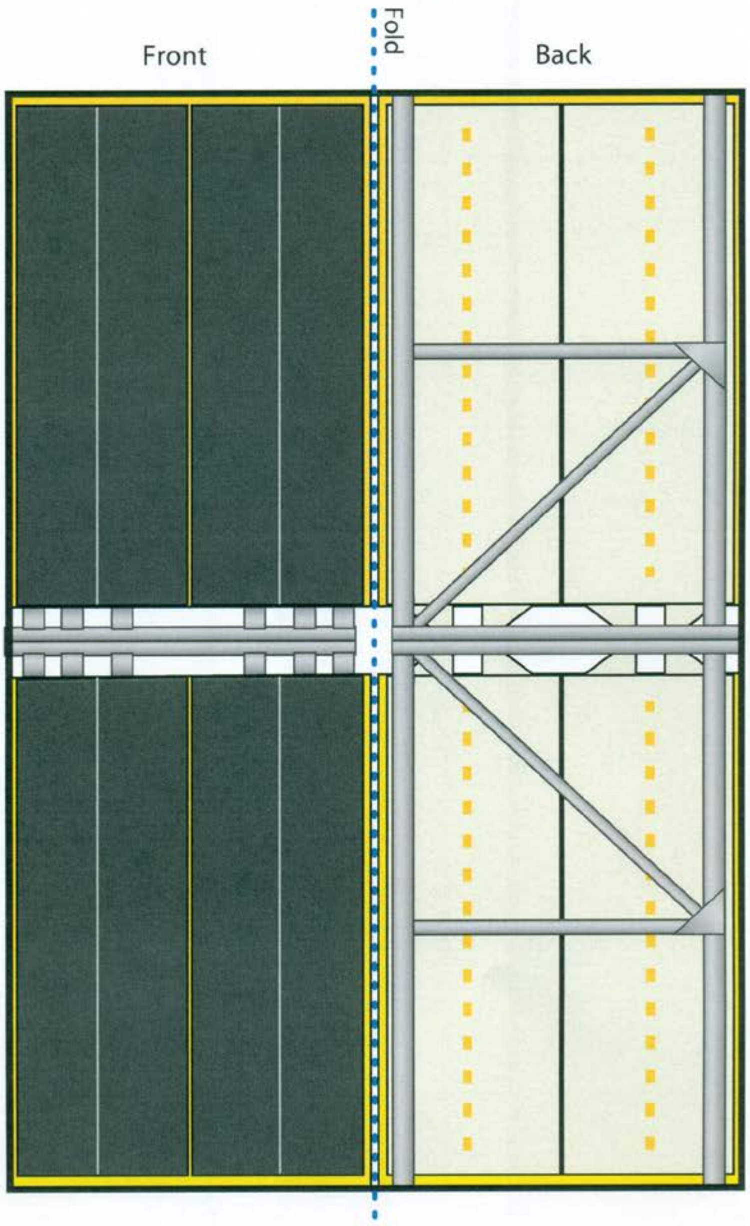


Aft Shroud
Part B

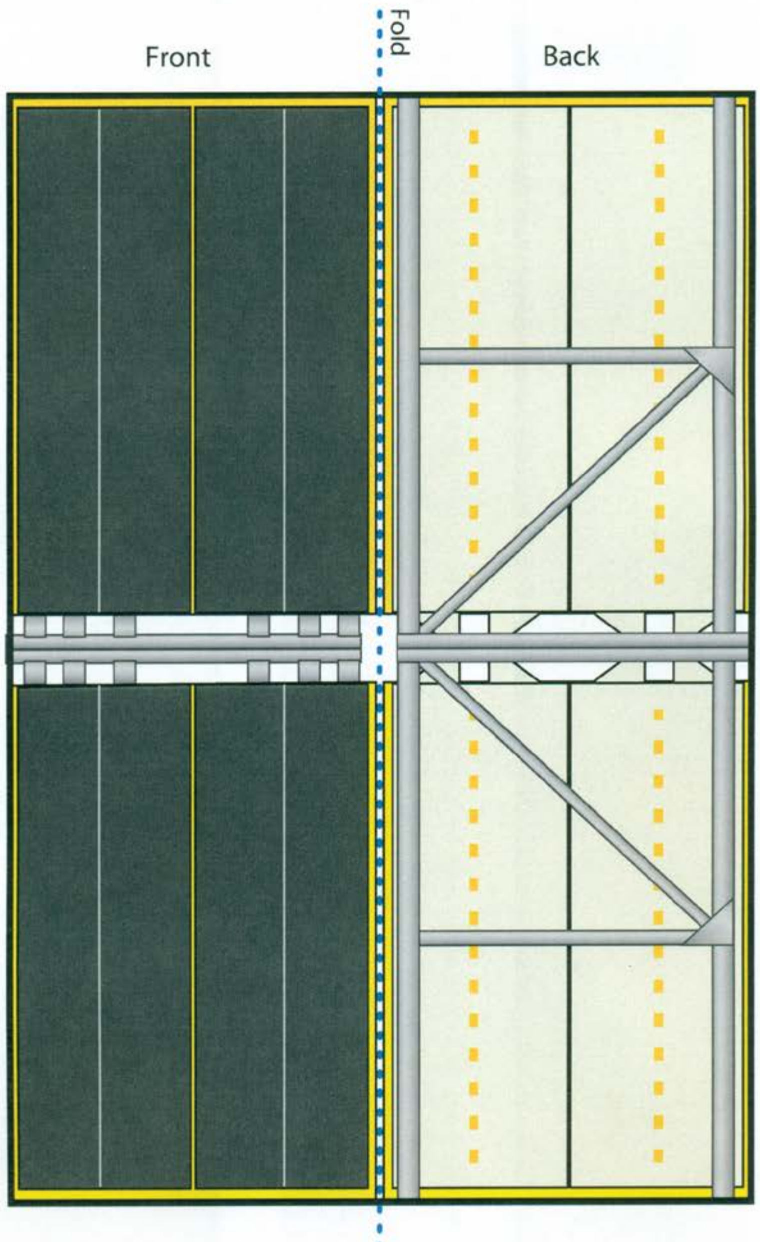


Line up Part B of the Aft Shroud wrapper along the dotted lines on Part A and secure it with cellophane tape. Check that the wrapper's features are lined up correctly in the area where the two pieces overlap.

Solar Panel 1

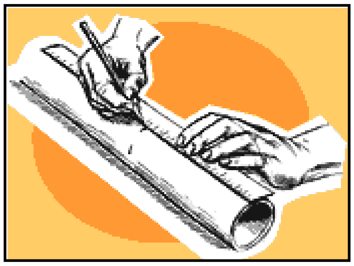


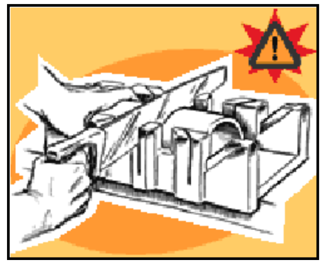
Solar Panel 2



Procedure:

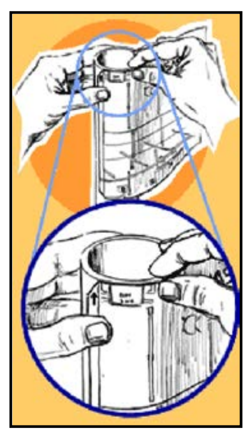
1. Measure and cut the PVC pipes. Clamp the pipe to a sturdy surface. From the 3" pipe, measure and cut a 2¾" length; from the 2" pipe, measure and cut a 6¾" length. (Teacher may decide to have lengths cut ahead of time.)



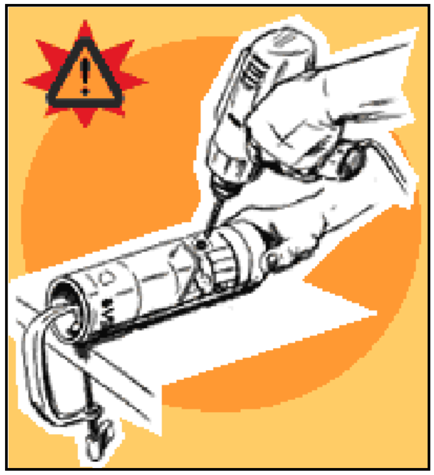


2. Sand any rough edges from the cut pipes. In addition, sand off any printing on the pipes to prevent it from showing through the paper wrapper later.
3. Wash the cut pipes with dish soap to get rid of any dirt, oil, and flakes left behind by the saw. Dry the pipes thoroughly.
4. Cut four 6 ¼ "x 2"pieces out of the poster board. Set aside the rest to use later.
5. Cut the black construction paper into one 5"x 6 ½ "sheet.
6. Cut the wooden dowel into one 12" length and one 9" length.

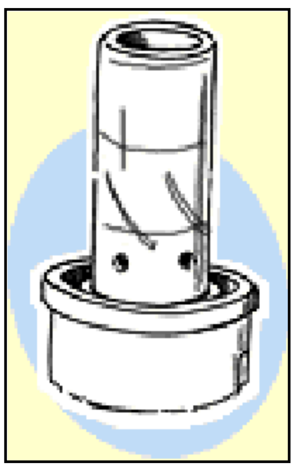
7. Paint the dowels and the beads with the silver paint and allow them to dry. (Remember: when using paint, work in a well ventilated area.)
8. Cut out the Aperture Door and Aft Bulkhead sections from page 32 of the printed wrapper pages (you need not be accurate because you'll be trimming them once they are glued to the poster board). Using white glue or a glue stick, attach each section to a piece of poster board (don't use the 6 ¼ " x 2" pieces you cut out earlier). Allow them to dry, then cut them out carefully and set them aside.
9. Cut out the remaining sections of the wrapper. Be sure to cut along the heavy outlines.
10. Construct the Forward Shell. Tape the Forward Shell section of the wrapper securely to the 2" PVC pipe with cellophane tape. Be sure to first attach the end with the flap marked "Attach this end first." Align the top of the Forward Shell wrapper with the edge of the pipe.



11. Prepare to drill holes in the Forward Shell. Determine the locations of the four holes to be drilled. They are marked with the symbol X in four places around the Forward Shell. Then clamp the Forward Shell securely to your work surface.
12. Drill four holes in the Forward Shell using a drill with a 3/16” drill bit. Drill right through the four X symbols in the wrapped pipe. Be careful not to drill all the way through the other side of the pipe!

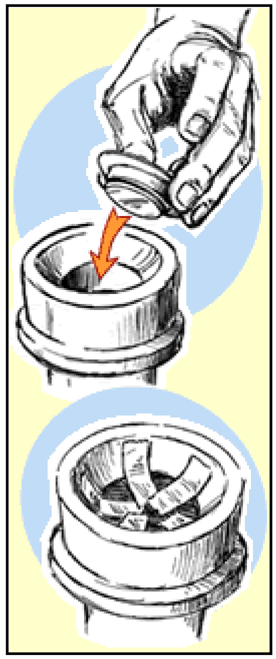


13. Insert the unwrapped end of the Forward Shell into the wide end of the bushing. It should fit securely.

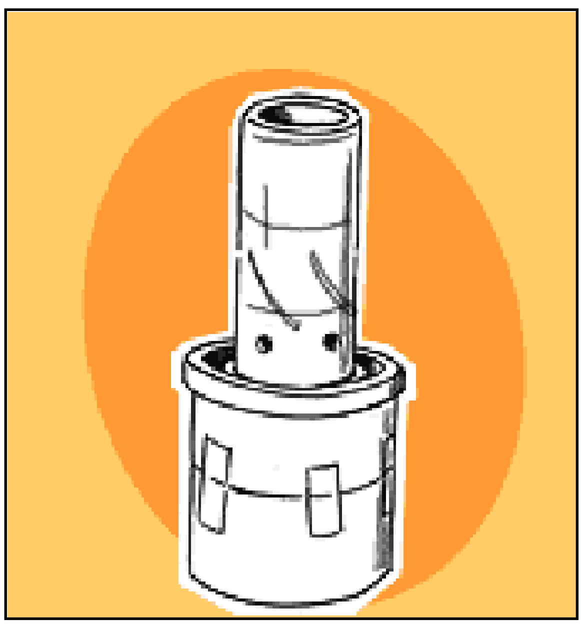


14. Attach the mirror to the test cap with a loop of duct tape. This is now the mirror assembly.

15. Insert the mirror-and-test cap assembly face-down into the open end of the bushing and secure it with cellophane tape. Make sure that the tape does not go outside the bushing.

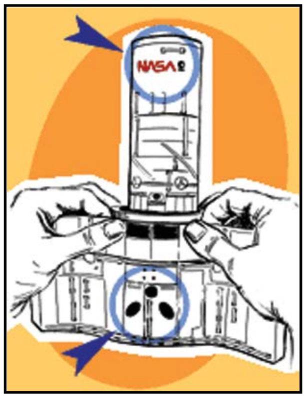


16. Prepare to construct the AFT Shroud by securing the 3” PVC pipe to the wide end of the bushing with several pieces of cellophane tape.

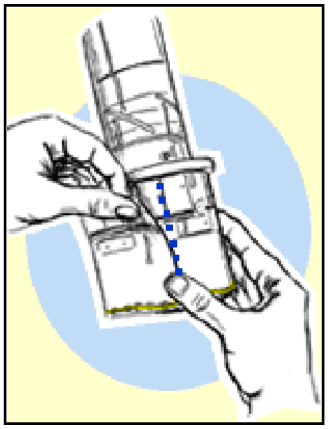


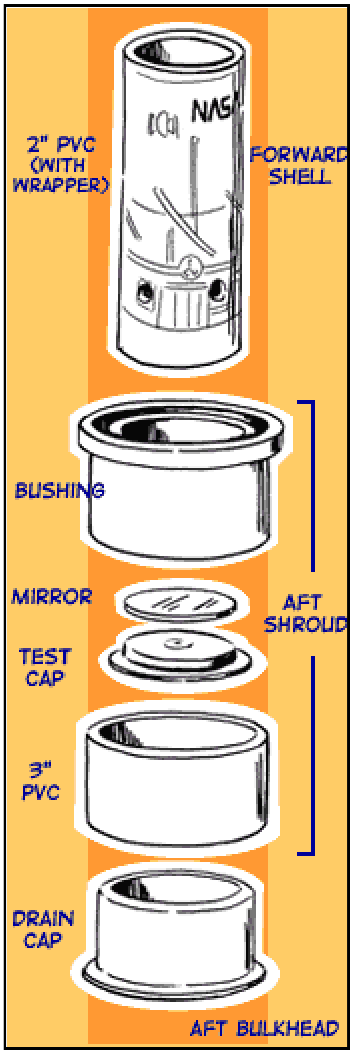
17. Insert the drain cap in the open end of the 3” PVC and tape it together.

18. Attach the Aft Shroud wrapper (which comes in two parts) to the taped-together 3" PVC pipe. First, line up Part A of the wrapper so that the three circular shapes are directly below the NASA logo. Tape the wrapper in place with cellophane tape.

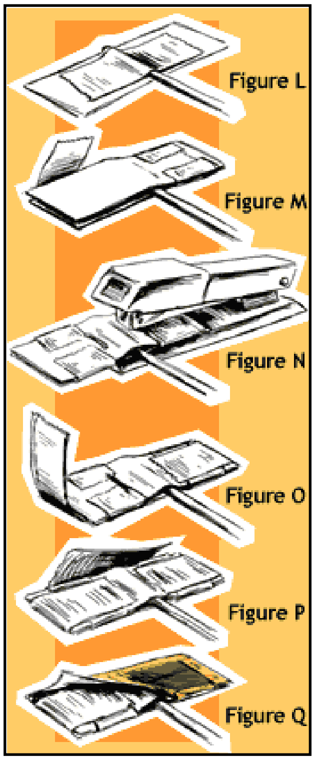


19. Line up Part B of the Aft Shroud wrapper along the dotted lines on Part A and secure it with cellophane tape. Check that the Wrapper's features are lined up correctly.

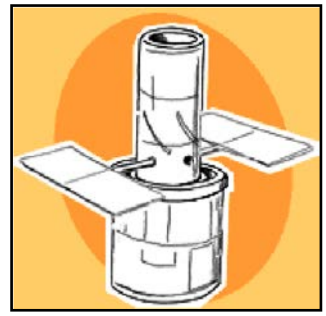




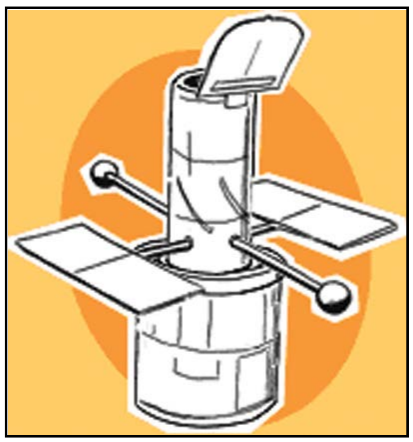
20. Begin assembling the Solar Panels. First, center one of the 6 ½ " x 2" poster board rectangles over the end of the 9" length of dowel. Tape it securely with duct tape.
21. Line up a second poster board on top of the first one, sandwiching the dowel between the two. Tape the pieces together with duct tape.
22. Staple once on either side of the dowel for extra stability. Staple as close to the dowel as possible.
23. Seal both ends of the panel with duct tape.
24. Seal the outside edge of the panel (where the dowel ends) with duct tape.
25. Attach the Solar Panel wrapper by wrapping it around the poster board "sandwich." First fold it along the dotted line – then secure it with cellophane tape.



26. Insert the bare end of the dowel all the way through the set of drilled holes in the Forward Shell that are marked "Solar Panel."
27. Repeat steps 20-25 to construct the second Solar Panel on the bare end of the dowel you just inserted through the Forward Shell. Make sure both the panels have the same side facing up. Then center the completed Solar Panel assembly in the Forward Shell.

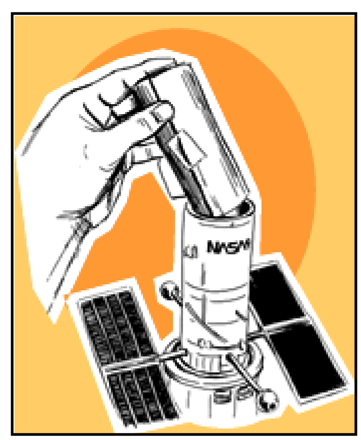


28. Insert the 12" length of dowel into the set of drilled holes marked "Antenna." Glue a bead onto each end of the dowel by applying a drop of white glue inside the bead's pre-drilled hole and then inserting the dowel. If the dowel is too big to fit into the bead's hole, sand it down to size with sandpaper.
29. Fold or lightly score the Aperture Door cutout on the dotted line so it will bend easily. Place a piece of cellophane tape across both sides of the fold to reinforce the "hinge." Then tape or glue the Aperture Door to the Forward Shell where marked with "Aperture door attaches here."

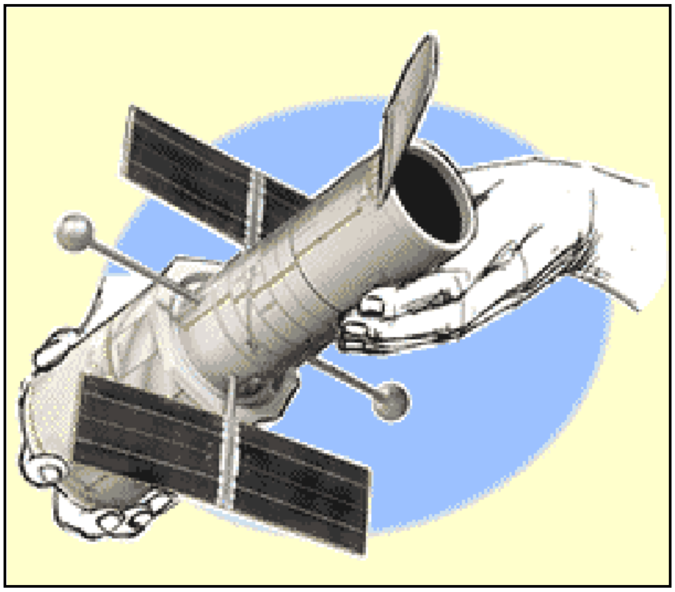


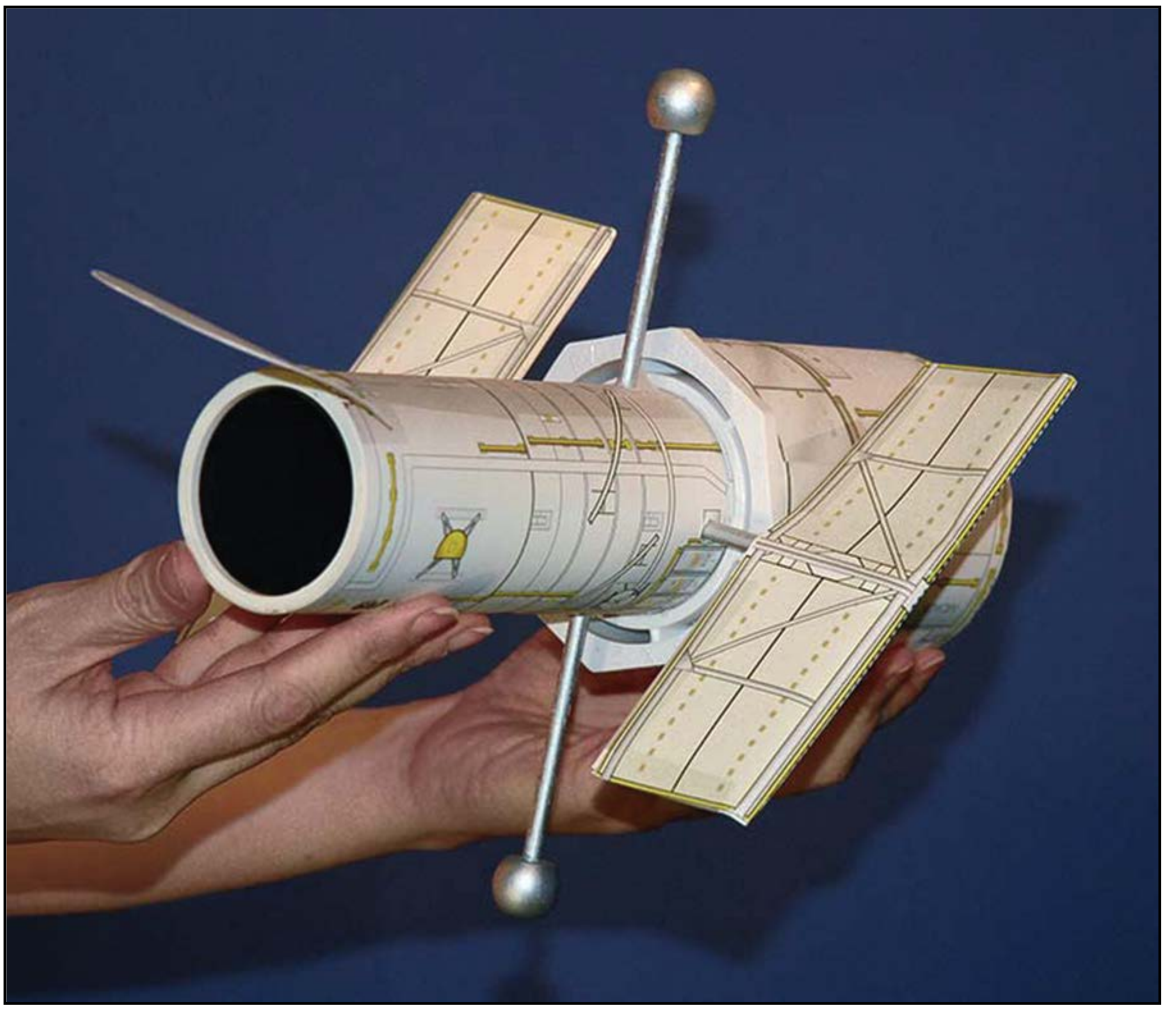
30. Tape the Aft Bulkhead cutout onto the bottom of the model (over the drain cap).

31. Construct the Light Baffle. Loosely roll the black construction paper (starting at the 5-inch side) and insert it into the front of the Forward Shell. The "roll" should be 5 inches tall. You may secure it with cellophane tape if you wish. Drop the rolled-up Light Baffle into the barrel of the Forward Shell. The dowel representing the Communications Antennae will stop it from going in too far. On the real Hubble Space Telescope, the Light Baffle keeps stray (unwanted) light from bouncing around the inside of the telescope.



IT'S ALL DONE!





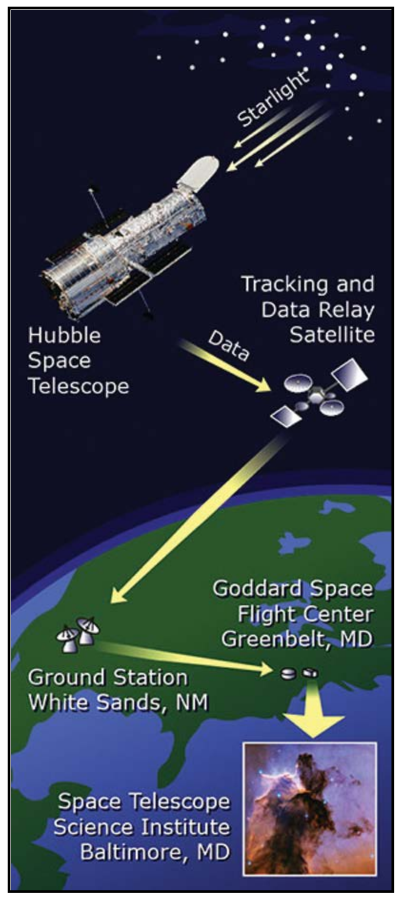
Parts of the Hubble Explained:

ACS – The Advanced Camera for Surveys (ACS) is Hubble's newest camera. It is used to observe weather on other planets in our solar system, conduct new surveys of the universe, and study the nature and distribution of galaxies.

Aft Shroud – The Aft Shroud is simply the rear section of the telescope. It contains all of Hubble's science instruments.

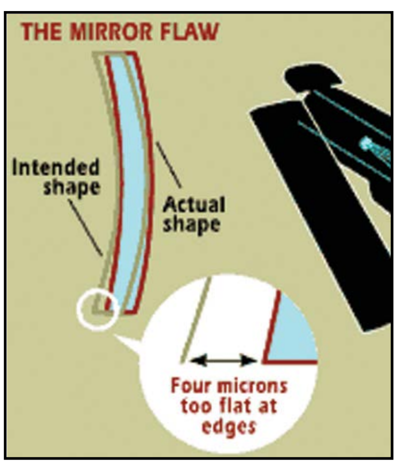
Aperture Door – The Aperture Door "guards" the telescope's internal mechanisms. It is usually open, which allows starlight to enter the telescope and be picked up by the science instruments. Sometimes the door is closed to protect the mirror and instruments from space debris.

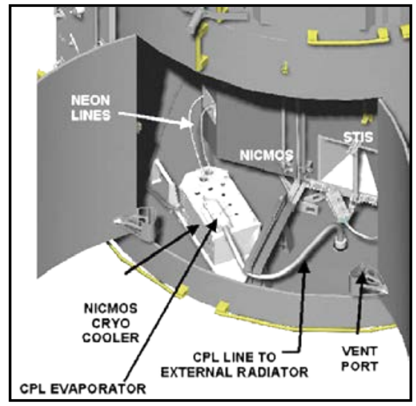
Bays – Hubble's 20 bays are "closets" that contain the telescope's instruments and electronics.



Communications Antennae – Hubble's communications antennae allow astronomers and technicians to communicate with the telescope – telling it what to do and when to do it. The antennae send and receive information between the telescope and the Flight Operations Team at the Space Telescope Science Institute.

COSTAR – The Corrective Optics Space Telescope Axial Replacement (COSTAR) apparatus functions like eyeglasses for Hubble. When the telescope was launched in 1990, the shape of the primary mirror was flawed, which resulted in "fuzzy" images. COSTAR's small, carefully designed mirrors, which sit in front of the telescope's science instruments, correct this problem.





NICMOS Cryocooler – The NICMOS cryocooler is a “refrigerator” that keeps the instrument very cold – below -321°F, or 77 degrees Kelvin. The sensitive infrared detectors in NICMOS must operate at very cold temperatures to avoid exposure to unwanted light in the form of heat.

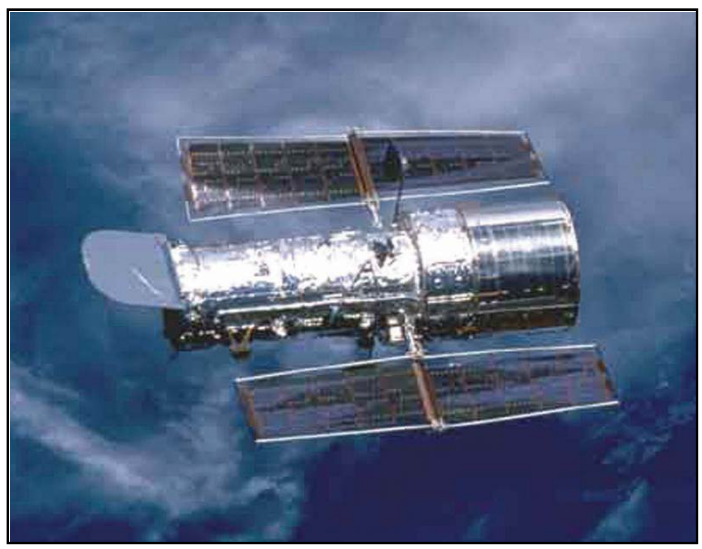
FGS – Hubble’s four Fine Guidance Sensors (FGS) are targeting devices that lock onto “guide stars” and measure their positions relative to the object being viewed. Adjustments based on these precise readings keep Hubble pointed in the right direction.

FHST – Fixed Head Star Trackers (FHST) are small telescopes with wide fields of view that are used in conjunction with the Fine Guidance Sensors. The star trackers locate the bright stars that are used to orient the telescope for scientific observations.

Forward Shell – The Forward Shell makes up the front part of the telescope. It houses Hubble’s light baffle and mirrors.

Mirrors – Hubble has two mirrors: the primary mirror and the secondary mirror. The primary mirror reflects the light gathered by the telescope back to the secondary mirror, which focuses it and bounces it back toward the science instruments.

NICMOS – The Near Infrared Camera and Multi-Object Spectrometer (NICMOS) is Hubble’s heat sensor. Its sensitivity to infrared light makes it useful for observing objects hidden by interstellar gas and dust (such as stellar nurseries and planetary atmospheres) and for peering into deepest space.



Solar Panels – The Solar Panels are Hubble’s power stations. They gather sunlight and convert it to electricity, which runs the telescope’s scientific instruments, computers, and radio transmitters. The Solar Panel’s solar cell “blankets” generate 3000 watts of electricity – enough to power 30 household light bulbs.

STIS - The Solar Telescope Imaging Spectrograph (STIS) is a versatile instrument that can act somewhat like a prism, separating light from the cosmos into its component colors. The colors of an object reveal many clues about its age and composition.

WFPC2 – The Wide Field and Planetary Camera 2 (WFPC2) is the “workhorse” instrument behind nearly all of the most famous Hubble pictures. As Hubble’s main camera, it is used to observe just about everything.

Summary:
This activity will introduce the space telescope (Hubble) to the students and lend an understanding to the technology involved in its construction.

Evaluation:

- Have students identify and give the function of three major parts of the Hubble using the website **http://hubblesite.org/the_telescope/** and the student worksheet.

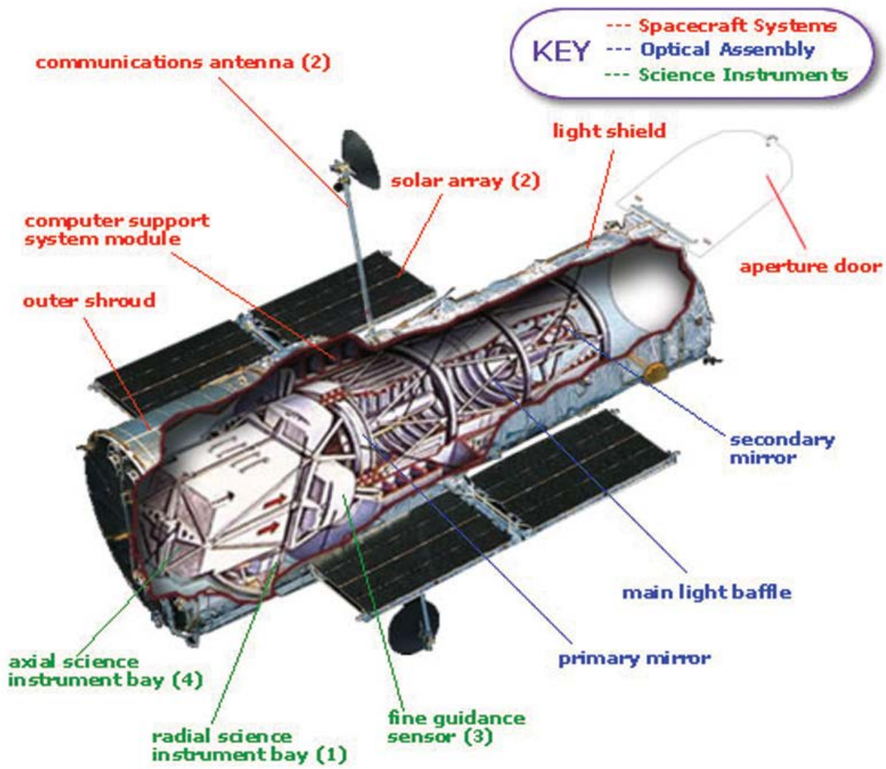
Additional Resources and Enrichment:

1. **http://hubblesite.org/explore_astronomy/tonights_sky/** **-** video episodes tells about constellations, deep sky objects, planets, and events during the current month.
2. **http://www.imax.com/hubble/** - IMAX 3D Hubble from Spring 2010 release shows Hubble parts and explains each.
3. Have students research images taken by the Hubble. Have each student choose one image and share their findings with the class.

Hubble Images

Activity Five: Hubble Student Worksheet

Name: ____



1. Discuss the function and location of three of the major components of the Hubble. (website for info on Hubble can be found at **http://hubblesite.org/the_telescope/**)

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(If you need more room, use the back of this worksheet.)

Activity Six: Satellites and Other Man-Made Objects

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

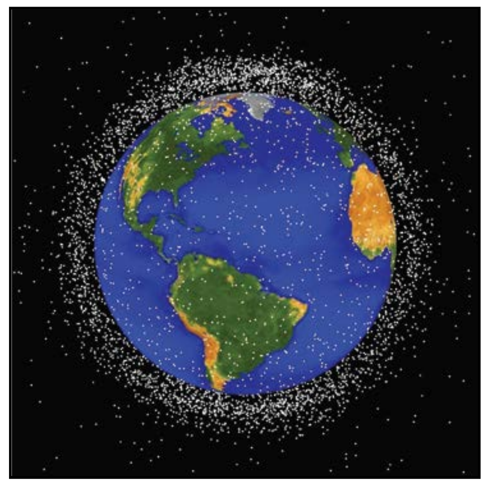
Objectives: Students will use internet search technology to find the location of several satellites for night viewing.

Practices:
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts:
1. Patterns

Core Ideas:
PS4.C: Information technologies and instrumentation

Background Information:



Studying the sky near dusk or dawn, there will be opportunities to observe one or more of the more than 35,000 satellites now in orbit around Earth. Many of the man-made objects that circle our Earth are actually “space junk” ranging in size from as large as 30 feet, down to the size of a softball. The Joint Space Operations Center (JSpOC) headquartered at Vandenberg AFB, in California, keeps a constant watch on all orbiting debris.

The satellites and space debris that are easily seen from Earth are those that are large enough (typically more than 20 feet in length) and low enough (100 to 400 miles above Earth) to be most readily seen as sunlight reflects off them. To spot satellites, all you need is your eyes and a clear, moonless sky. Usually spotting 10 to 20 satellites from a location is average. Most satellites travel from west to east, in the same direction from which they were launched. If you look slowly across the sky you will spot a satellite if you see a pinpoint of light in the night sky that looks like a moving star. You will realize that it is not a meteor, because meteors streak by in a flash and then are gone. And you will know it isn’t a jet plane if you don’t see any blinking lights or hear any sound.

The International Space Station (ISS) is the biggest and brightest of all the man-made objects orbiting the Earth. Presently circling the Earth at an average altitude of 225 miles (360 km) and at a speed of 17,200 miles per hour (27,700 km per hour), it completes 15.7 orbits per day, and it can appear to move as fast as a high-flying jet airliner, sometimes taking about four to five minutes to cross the sky. To see the sighting opportunities for the area you live in, go to NASA Skywatch at http://spaceflight.nasa.gov/realdata/sightings/.

Materials:

- Access to the internet
- Student Worksheet for Satellites and Other Man-Made Objects
- Pencil

Procedure:

1. Use Background Information to introduce the subject of man-made satellites and how we observe them from the ground.
2. Have students use the Internet site http://spaceweather.com/flybys/ to put in their zip code and locate the information found on the Student Worksheet.
3. Have students take the worksheet home and locate 5 satellites in the sky. Give them a week to locate and record their findings.
4. Have students share what they observed with the rest of the class.
5. Have students choose one satellite they observed to do a report on listing the items asked for on the Student Worksheet.

Summary:

This activity will help students know what to look for when observing man-made satellites in the night sky.

Evaluation:

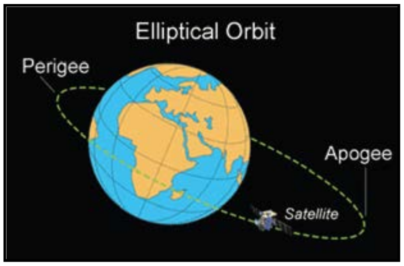
A rubric may be used for the report presented by each student along with the observations made on the Student Worksheet.

Additional Resources and Enrichment:

1. http://www.heavens-above.com/ is a website to assist in satellite spotting.
2. Students may choose to build a model of one of the satellites they observed and reported on to the class. Several satellite models can be built using NASA's Goddard Space Flight Center site: http://science.gsfc.nasa.gov/sed/index.cfm?fuseAction=foreveryone.coolstuff&&navOrgCode=600&navTab=nav_epo.
3. An activity to engineer your own scale model of an Earth Observing satellite can be found at http://aura.gsfc.nasa.gov/outreach/engineerAsatellite.html.

Answers to Student Worksheet for "Satellites and Other Man-Made Objects":

1. a. The Joint Space Operations Center (JSpOC) headquartered at Vandenberg AFB, in California, keeps a constant watch on all orbiting debris.
   b. Most satellites travel from west to east, in the same direction from which they were launched.
   c. The International Space Station (ISS) is the biggest and brightest of all the man-made objects orbiting the Earth.
   d. You will realize that it is not a meteor, because meteors streak by in a flash and then are gone. And you will know it isn't a jet plane if you don't see any blinking lights or hear any sound.
2. Answers will vary.
3. Reports will vary. Use a rubric to evaluate the reports.



Activity Six: Student Worksheet for Satellites and Other Man-Made Objects

Name: ____

1. Answer the following about the Background Information that was discussed in class:
   a. What Center keeps a constant watch on all orbiting debris over the Earth?
   ____
   b. What direction do most satellites travel? ____________________________
   c. What is the biggest and brightest man-made object orbiting the Earth?
   ____
   d. How can you tell you are viewing a satellite and not a meteor or a jet plane?
   ____
   ____.

2. Use the website http://spaceweather.com/flybys/ to locate satellites to view in your zip code. List the name of the five satellites as well as the times, dates, maximum elevation, and magnitude of each satellite that you observed for the week of this assignment. On another sheet of paper give a short description of the satellites and use the internet to locate a picture of each satellite to include with your descriptions.

Name of Satellite	Date	Rise time	Max Elevation	Magnitude
1.				
2.				
3.				
4.				
5.				

3. Write a short report describing one of the satellites you observed. Include what country launched it; the purpose of the satellite; what instruments were onboard to accomplish the mission; and any other information you found interesting. Include a picture of the satellite and a sample picture or data that was received from the satellite. Present your report to the class.

Activity Seven: Faces of the Moon

(Reprinted with permission from Bob Crelin – Author of *Faces of the Moon* - http://bobcrelin.com/fotmdownload.html .)

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

Objectives: Students will model how the relationship of our Earth, Moon, and Sun creates Moon phases; chart the sequence and names of the eight primary Moon phases; identify each Moon phase by its appearance; and identify the Moon's position in orbit during each primary phase.

Practices:
2. Developing and using models
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts:
1. Patterns
4. Systems and System Models

Core Idea:
ESS.B: Earth and the solar system

Background Information (from Newton's Apple Season 15: *Phases of the Moon*):

What you see when you look at the Moon depends on its location in relationship to the Sun and Earth. The Moon never goes away or changes shape – we just see a different fraction of sunlight being reflected from the Moon to Earth.

The Moon is Earth's only natural satellite. Its diameter is about a quarter that of Earth's. The Moon takes about 27.3 days (about a month) to revolve around Earth, traveling at an average distance of about 384,000 kilometers.

We divide the Moon's orbital cycle into several segments, or phases. When the Sun and the Moon are on the same side of Earth, the sun illuminates the side of the Moon that faces away from Earth. We don't see any reflected sunlight on its front face, so it looks like there is no Moon. We call this the new Moon phase. When the crescent Moon begins to appear, if you look carefully you may see some faint illumination of the Moon from earthshine. About two weeks later, when the Moon and Sun are on opposite sides of Earth and all are in a line, the Sun shines past Earth directly onto the full face of the Moon and we see a "full Moon." What happens in between?

As the new Moon phase ends, the Moon waxes, or appears to grow larger, and we see more of the Moon's face. The lighted area increases over time from right to left from our perspective on Earth. When the Sun/Earth/Moon angle is very small, we see only a thin bright curve, called the waxing crescent. Over the next seven days the angle between the Sun, Earth, and the Moon grows to 90 degrees. We see the sunlight spread to cover the right half of the Moon. This is called the first quarter. The visible part of the Moon continues to wax through the gibbous phase over the next seven days until we see the full Moon.

As the cycle continues, we say the Moon is waning, or growing smaller. The amount of lighted area we see decreases, and the darkened area increases from right to left. You can tell if the Moon is waxing or waning by whether the right side of the Moon is dark or light.

Activity Seven: Faces of the Moon

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8. Obtaining, evaluating, and communicating information

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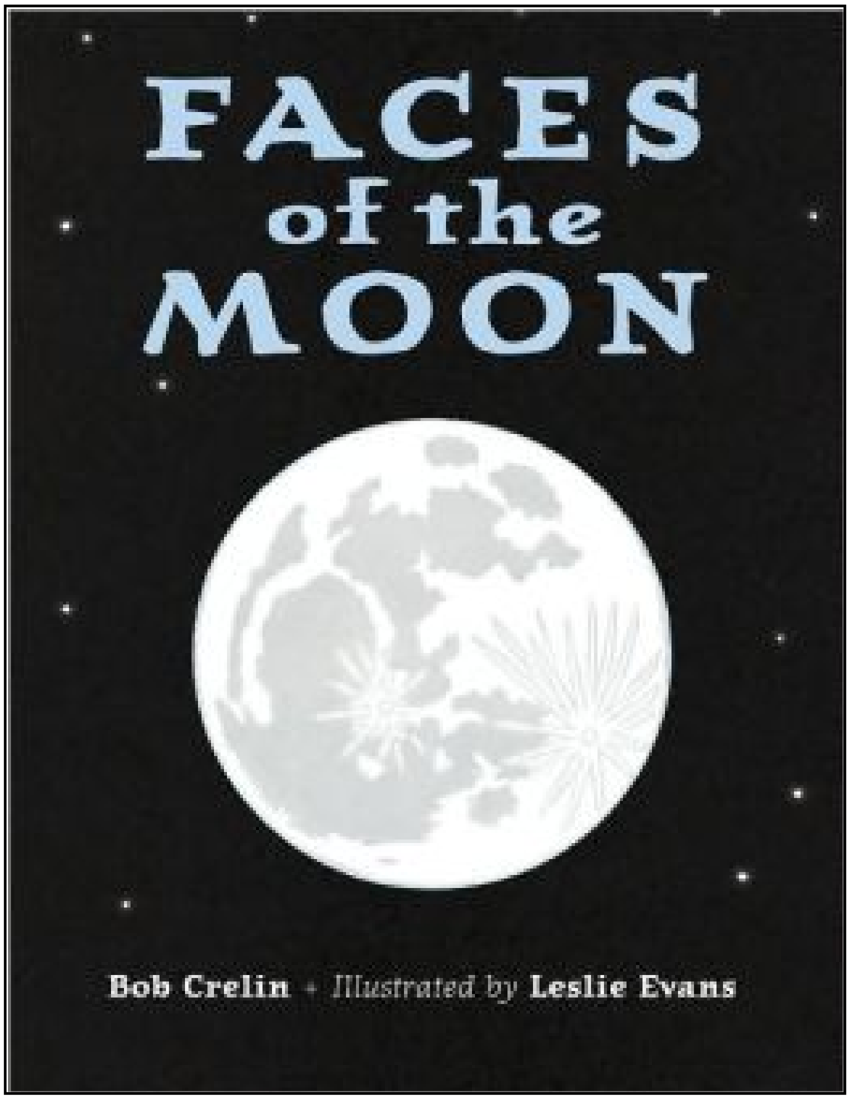
Another 14 days passes as the Moon moves through the waning gibbous phase, then the third quarter, then the waning crescent phase, and seems to finally disappear in the new Moon phase. Now we're back to where we started about a month ago!

NOTE ON FOLLOWING PAGES FROM ACTIVITY SEVEN:
The following pages in Activity Seven are excerpts from Bob Crelin's *Faces of the Moon* Teacher's Guide. View the complete guide with references to his *Faces of the Moon* book at **http://www.bobcrelin.com/FOTM-TG.pdf.**



FACES of the MOON

Teacher's Guide

© Leslie Evans

FACES of the MOON

Bob Crelin • Illustrated by Leslie Evans

Charlesbridge

Teacher's Guide

Northern Hemisphere edition
Bob Crelin

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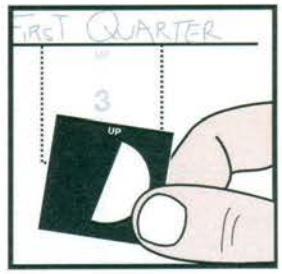
Listen

Do



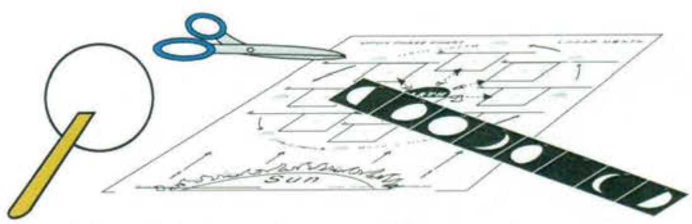
Chart

Review

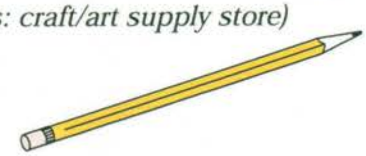
UNDERSTANDING THE PHASES OF THE MOON
A fun, four-stage classroom unit for understanding the Moon's phases (2–3 class periods)

Objectives
Students will be able to do the following:
1) Model how the relationship of our Earth, Moon, and Sun creates moon phases.
2) Chart the sequence and names of the eight primary Moon phases.
3) Identify each Moon phase by its appearance.
4) Identify the Moon's position in orbit during each primary phase.

Materials you will need:
- Room that can be darkened, with enough open floor space to fit students standing in a circle
- Bare light bulb on a stand (example: a floor lamp with shade removed)
- Earth globe
- Extension cord
- *Moon Orbit Spin Chart* (included)
- Paper fastener



Each student will need:
- Pencil or pen
- 2"–4" (5–10 cm) Styrofoam ball mounted on a Popsicle stick *(suppliers: craft/art supply store)*
- *Moon Phase Chart* (included)
- Strip of eight *Phase Squares* (included)
- Scissors
- Glue stick



NOTE: *Before starting this unit, make paper photocopies of the Moon Phase Chart and the Phase Squares. Cut the Phase Squares into strips of the eight lunar phases. Photocopy the Moon Orbit Spin Chart on heavier card stock paper and assemble using a paper fastener.*

For best results, choose a room that can be made completely dark when the lights are turned off (dark window coverings can help) Clear the floor space of obstacles and place a tall lamp with bare bulb (the brighter, the better) in the center of the room. Use an extension cord if necessary. Covering or taping down the lamp/extension cord will help to prevent students from tripping on it. For the hands-on demonstration, make sure that there is plenty of space for the students to stand and form a circle (with elbow room) around the lamp (see Figure 1 on page 3). Desks are not required. Students can sit on the floor during the introduction (Stage 1) and while constructing their charts (Stage 3). Have materials, including photocopies of the Moon Phase Chart and Phase Square strips, ready to hand out to students.

Listen

Stage 1 • Introduction

(run time: approximately 5–10 minutes)
In storytelling fashion, students sit, listen, and look as the basic concepts and terms used throughout the lesson are introduced.

Concept: *The Moon cycle*
Explain that the word "month" comes from "Moon." Long ago, a month represented the time it took to complete one cycle of the changing Moon phases (approximately 29.5 days). Today, we call this a "lunar month," compared to our modern "calendar month."

Concept: *Moon phases as light and shadow*
Explain that we are able to see the Moon from Earth because the Sun's light shines on it. The sunlit part of the Moon makes the phase, or shape, of the Moon that we see (the rest of the Moon is in shadow).

Concept: *Earth's relationship to the Moon and Sun*
Explain that the sunlit part of the Moon changes because we are watching from the surface of Earth as the Moon moves in orbit around our planet. The changing Moon phases have been given names that describe their appearance, and their place in the phase cycle.


Do

Stage 2 • Modeling the Phasing Moon

(run time: approximately 20–30 minutes)

After a brief explanation of the activity, students participate by following the step-by-step directions of the instructor, and by learning about each phase from the book.

Explain to the class that by building a model of the Moon's orbit, we can demonstrate *why* we see the changing phases of the Moon.

To make a model of the Moon phases, we will need three "players" from our solar system. Ask students to identify who these players are. (Answer: Moon, Sun, and Earth)
Show the items that represent each player:
- The Styrofoam ball on the Popsicle stick for the Moon
- The light bulb on the stand for the Sun
- The globe for Earth (for now)

Briefly review (and demonstrate) with students the basic orbital motions of these players:
- Earth orbits around the Sun.
- The Moon orbits around Earth.

It helps to visually demonstrate these motions by walking the globe (Earth) in a counterclockwise "orbit" around the light bulb (Sun), while circling the Styrofoam ball (Moon) counterclockwise around the globe.

Figure 1

The Hands-on Activity*

Elements of this exercise are based on an Astro-Adventures learning activity, Dennis Schatz and Doug Cooper • pacsci.org

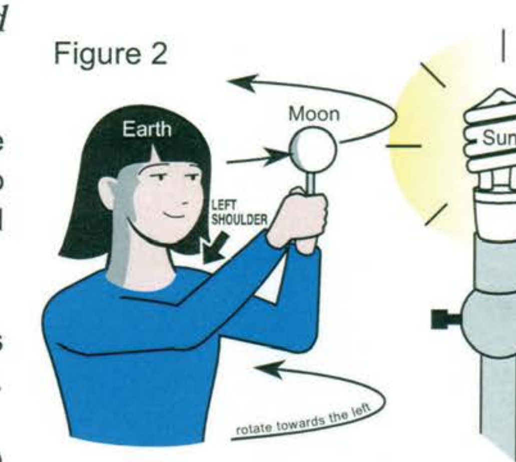
Turn on the light bulb "Sun" in the center of the room. Turn off all other room lights.
For safety, remind students not to touch the hot light bulb.
Have each student get a Styrofoam Moon ball on a stick. Have the students stand and form a circle around the light bulb Sun (see Figure 1). *Tip: Students should leave elbow room between themselves for easier movement during the demonstration.*

Explain that the globe will *not* represent Earth in the activity, because as we learned earlier, we watch the Moon phases change from Earth's surface. Instead, *each student's head will represent Earth* for the demonstration. Because their eyes are set in their head, they can watch the changing appearance of the Moon from their "Earth."

Stage 2 • Modeling the Phasing Moon, *continued*

Have the students place their hand on their left shoulder. This represents their "eastern" side. Explain that, during the demonstration, they will turn towards the east, or left, side to simulate the Moon's counterclockwise orbital motion around Earth (see Figure 2).

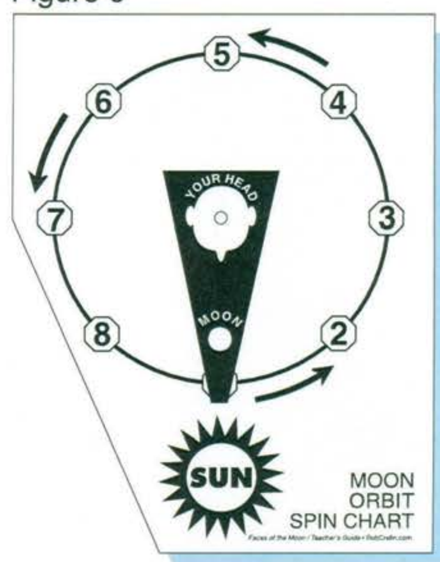
Figure 2



Explain to the students that they will demonstrate the Moon's orbit in step-by-step movements, following your direction.

Introduce the assembled **Moon Orbit Spin Chart** (Figure 3) to the students. Point out the parts of the chart that represent their head, their Styrofoam Moon ball, and the light bulb Sun. Show how the orbit circle has eight numbered stops that represent the eight primary Moon phases. When modeling the "orbit," students will pause together at each stop (see Figure 4 on page 64). At each stop, they will observe the appearance of their Moon ball, and listen to a rhyme that names and describes this Moon phase.

Figure 3



Show the students the Orbit Spin Chart dial set at stop #1 (as shown in Figure 3). Ask them to position themselves and their Moon as shown on the chart. *Each student should hold their Moon out in front of their head and face the light bulb Sun.*

1 Stop #1 - New Moon 

Remind students that it is the Sun's light shining on the Moon that shows us the phase we see. Ask them how much sunlight they see on their Moon in position #1. They should see *no sunlight*, because the shadowed side of the Moon is facing their "Earth" (their head). Ask if anyone knows what phase this is. (Answer: New Moon)

2 Stop #2 - Waxing Crescent 

Explain that, together, the students will now begin to rotate, stopping at each phase around the Moon's orbit. Hold the Orbit Spin Chart up for all to see, and move the dial from stop #1 (New Moon) to stop #2 (Waxing Crescent). Ask the students to turn to the east (left) as shown on the chart. Once students are in the correct position, ask them to look at their Moon ball to notice the sunlight illuminating the right edge of it.

The term "Waxing"
This is a good point in the lesson to associate the term "waxing" with the apparent growth of the Moon. A great comparison is the old practice of "candle dipping," in which each dip of a candle wick in hot wax would make the candle grow thicker. The growing Moon can be seen as "waxing," like the candle.

3 Stop #3 - First Quarter
Next, move the chart dial to stop #3. Ask the students to rotate to this position. They should notice that the sunlight has "grown" to fill the right half of their Moon ball.

4 Stop #4 - Waxing Gibbous
Continue to stop #4 on the Orbit Spin Chart. The students move accordingly and notice the increasing sunlight on the right side of their Moon ball.

5 Stop #5 - Full Moon
Move to stop #5. Make sure that students hold their Moon ball a little above their head in this position so as not to cast a shadow on the ball. If positioned correctly, they should see a Full Moon, without shadow.

6 Stop #6 - Waning Gibbous
Mention that the Moon has now "waxed" full of sunlight. As students continue on to stop #6 in the orbit, they should notice how the sunlight begins to decrease, or "wane" on their Moon ball. A shadow now begins to "grow" on the Moon's right side.

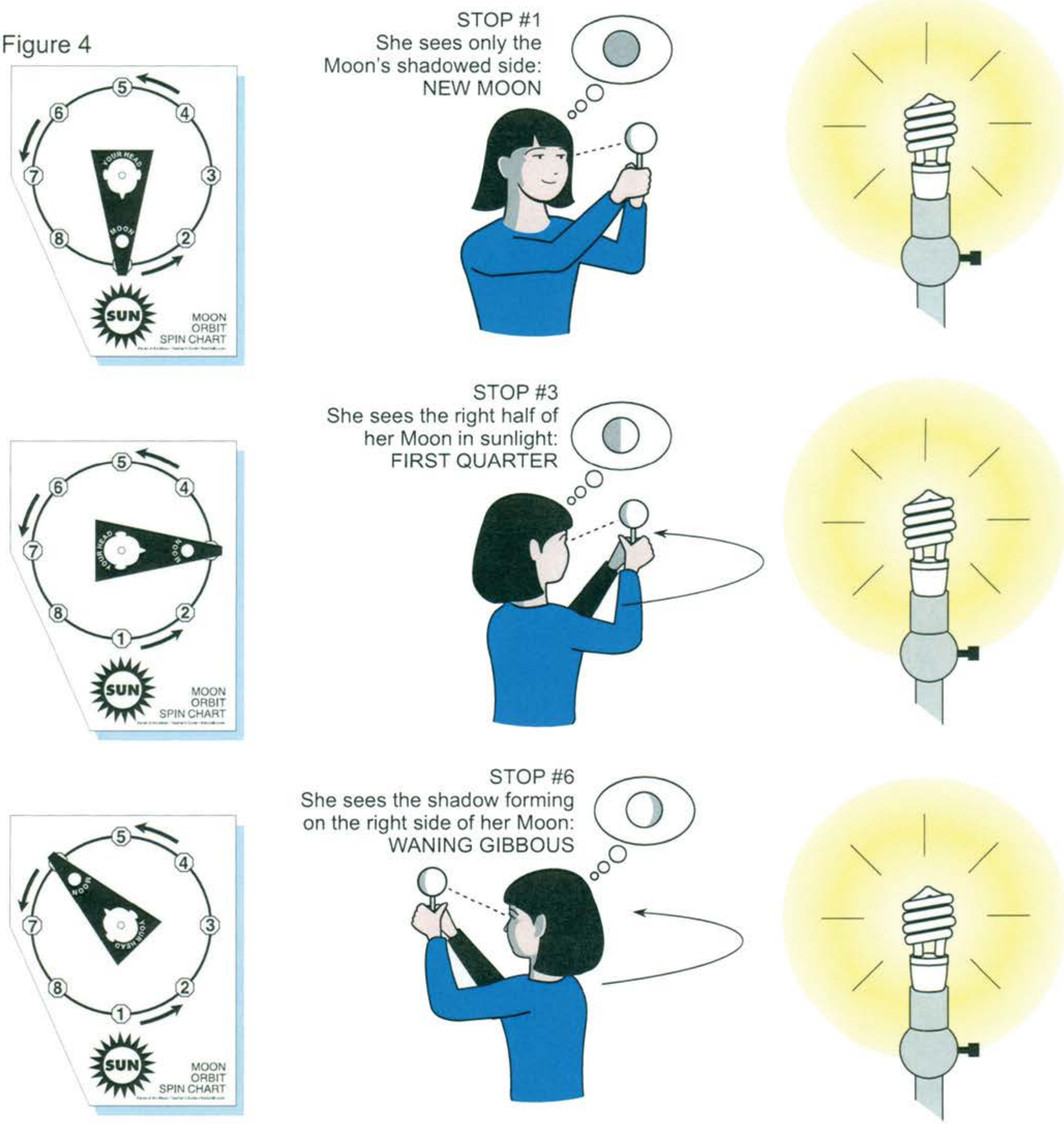
7 Stop #7 - Last Quarter
Continue to stop #7. The students move and notice that the sunlit part has decreased. Their Moon ball is now lit on the left half.

8 Stop #8 - Waning Crescent
Move the chart dial to stop #8. The students move and notice the Moon's appearance.

Then move the chart dial–and ask the students to rotate–back to **STOP #1**, where they began their orbit. Ask the students to tell you all together the name of this phase (New Moon). Remind them that they have just modeled one complete Moon orbit around our Earth. This represents the 29.5-day "lunar month."

To support this visual demonstration of the changing phases, have the students now do an additional complete rotation (in the same direction), turning slowly without stopping this time. Ask them to watch the changing pattern of light and shadow on their Moon ball as they go. Remind them to keep their Moon ball a little above their head to prevent a "head-shadow lunar eclipse" at the Full Moon position.

Figure 4

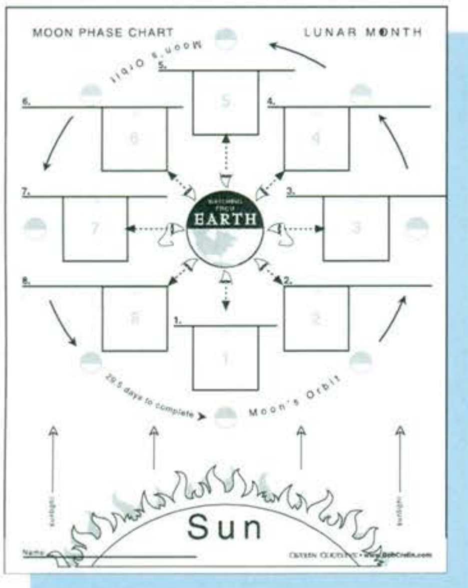


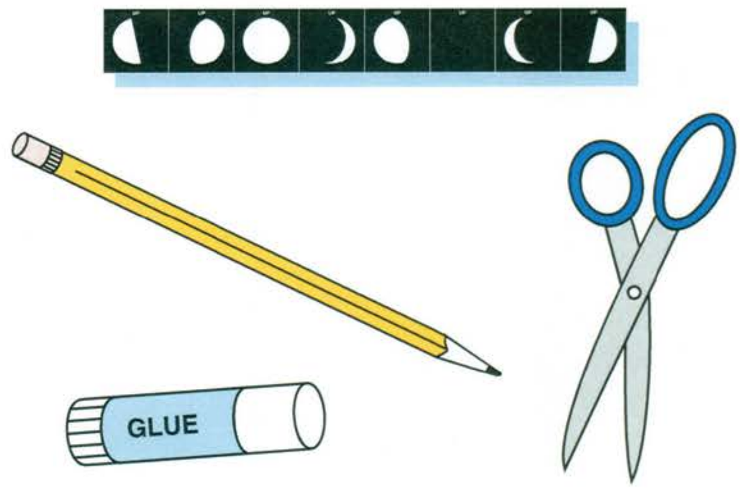
Chart

Stage 3 • Recording Our Observations

(run time: approximately 20–30 minutes)
Students create their own charts to record what they've learned from the hands-on Moon phase activity.

Students can move to their desks, or to a clear spot on the floor, to assemble their Moon charts. Each student will need a pencil or pen, a copy of the Moon Phase Chart, a strip of the eight Phase Squares, a pair of scissors, and a glue stick.





Show the students how the Moon Phase Chart is modeled after the *Orbit Spin Chart* used during the demonstration, with the Sun, Earth and Moon in the same relative positions. Once assembled, the chart will show and name the pattern of Moon phases throughout a lunar month. For best results and participation, ask the students to follow the steps together as a class. A simple mistake, like a reversed Phase Square, can throw off the rest of the phase pattern.

First, ask students to separate the eight Phase Squares by cutting them apart along the white lines. *Before cutting, many students will notice that the phases on the strip are out of sequence.*

Next, ask students to find the box marked #1 on their Moon Phase Chart. Remind students that this is where they began the Moon's orbit in the demonstration. Ask if someone can identify the phase they saw when the Moon ball was in this position, between Earth (their head) and the Sun. (Answer: New Moon)

Ask students to write "New Moon" on the line above box #1. Next ask the class what Phase Square would represent the New Moon phase. (Answer: the blank black square). Instruct students to glue the blank square in box #1. *Tip: For less messy results, direct the students to apply glue to the blank box on the chart, instead of on the back of each Phase Square.*

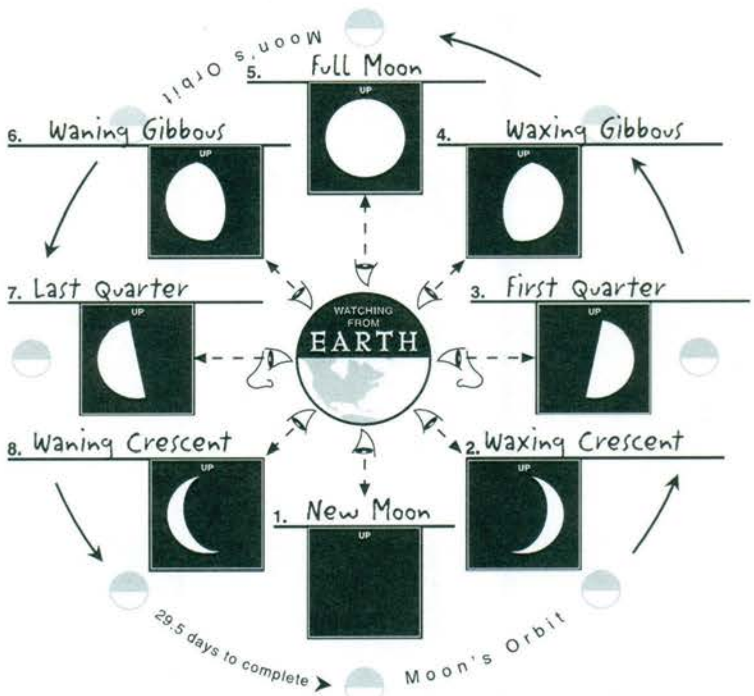
Stage 3, continued

Continue "in orbit" to box #2 on the chart. Ask if someone can identify what phase happens here. (Answer: Waxing Crescent) If there is hesitance, or confusion, give the students clues: "as you turned to your left, the light began to shine on the right side of the Moon ball," etc.

Once students have identified the Waxing Crescent, have them write the phase name above box #2 and glue the correct Phase Square in place. For each phase, show the corresponding phase illustration from *Faces of the Moon* so students can double-check their Phase Square choice.

Continue this procedure until all eight Phase Squares are correctly glued in place and all of the phase names are labeled (see Figure 5).

Figure 5



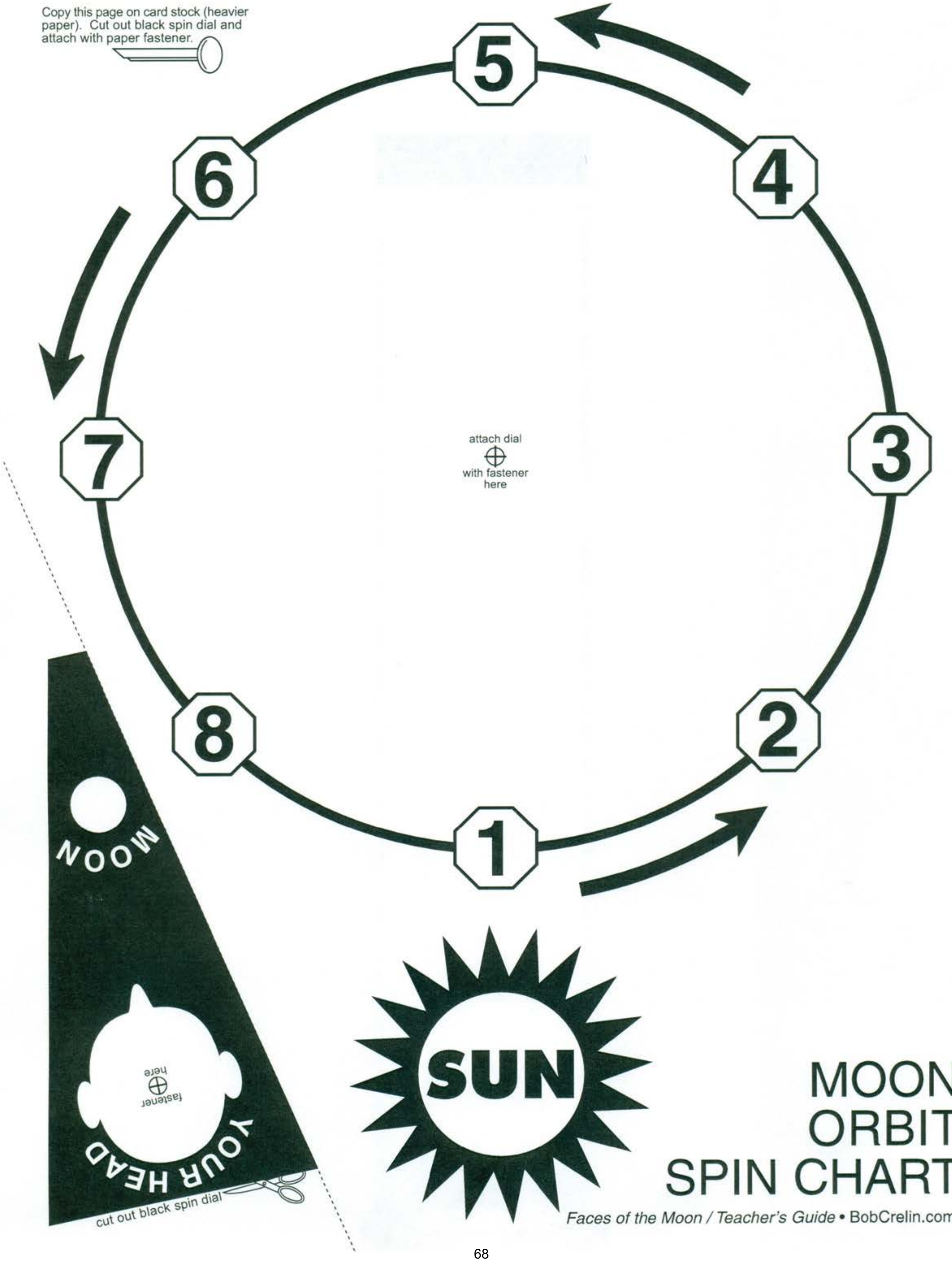
Review

Stage 4 • Reviewing What We've Learned

(run time: approximately 10 minutes)
Students now test their Moon knowledge through a fun review exercise.

Ask students to turn their *Moon Phase Chart* over, so they cannot see it. Draw a random Moon phase on the board or a piece of paper and ask if someone can identify the phase by name. Ask students if they can name the phases that would be seen before and after this phase. Once a phase has been correctly identified, ask if someone in the class can move the dial of the *Orbit Spin Chart* to show where in orbit this phase occurs. Continue quizzing the class with random phases until all of the phases and orbital positions have been correctly identified. Allow students to take home the charts to share.

Copy this page on card stock (heavier paper). Cut out black spin dial and attach with paper fastener.

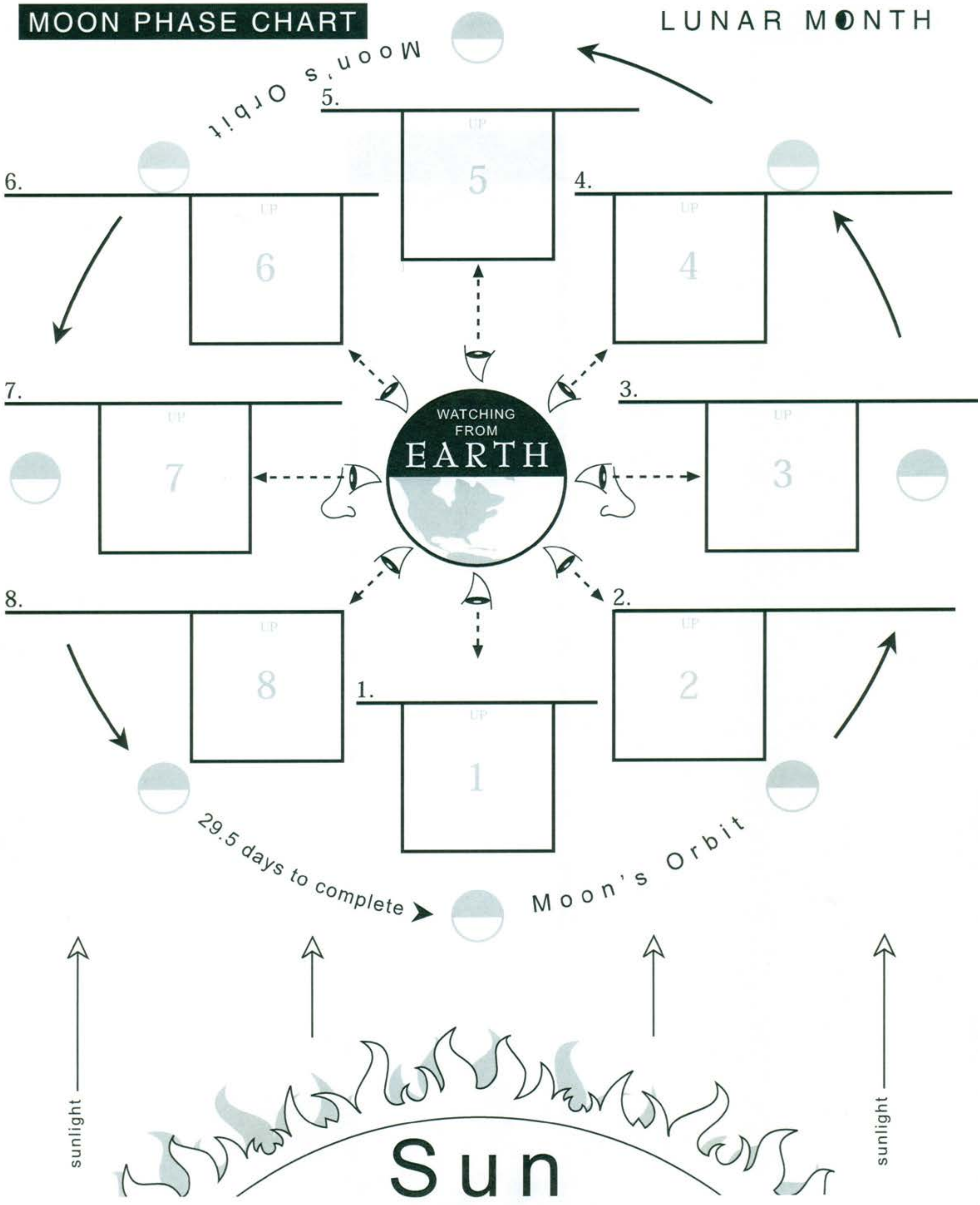


MOON ORBIT SPIN CHART

Faces of the Moon / Teacher's Guide • BobCrelin.com

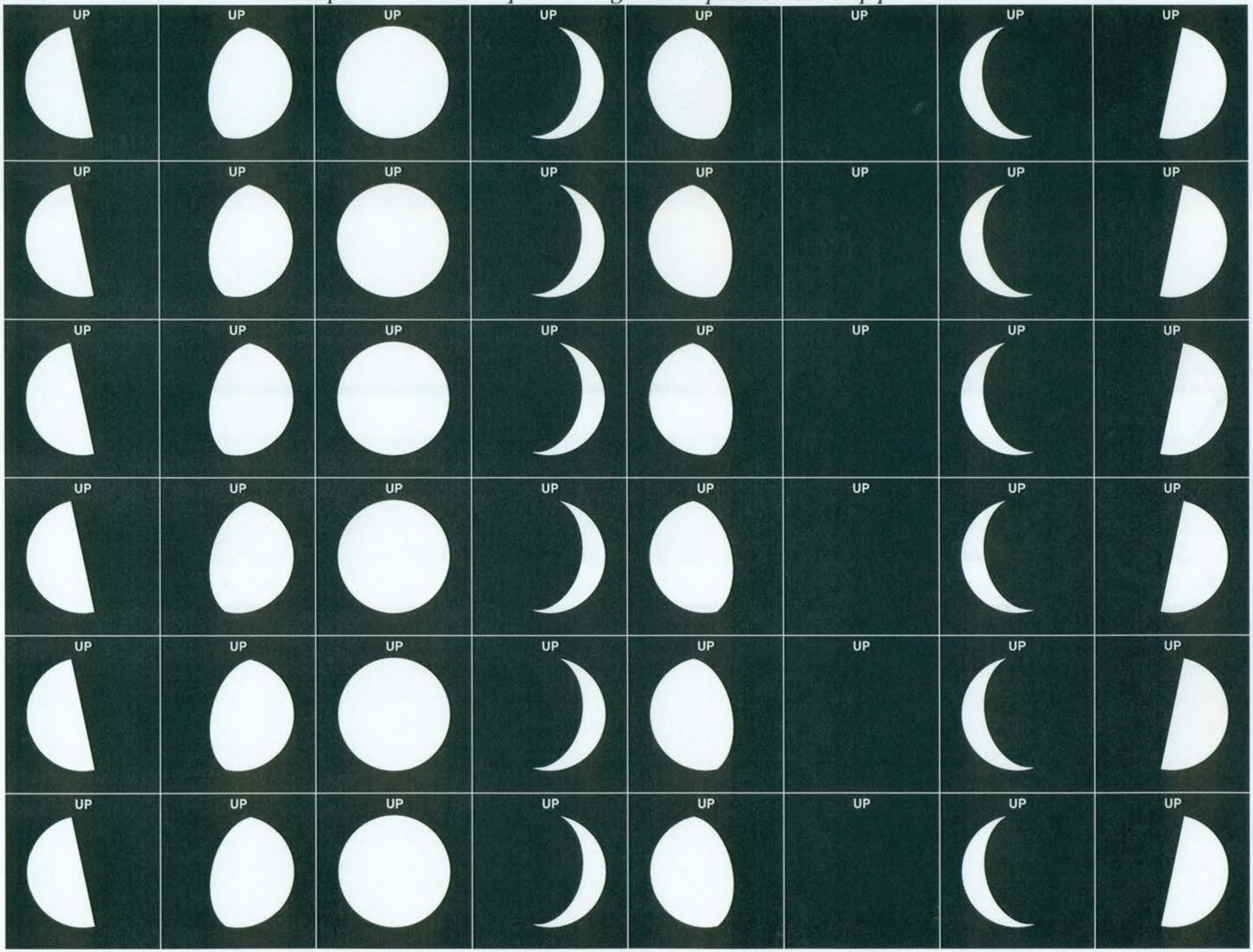
MOON PHASE CHART

LUNAR MONTH



Name: ______________________

Phase Squares – *cut out strips of the eight Moon phases - one strip per student*



Activity Eight: Observing the Moon

(Credit: Night Sky Network -http://nightsky.jpl.nasa.gov - and the Astronomical Society of the Pacific – www.astrosociety.org)

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 *Science Education: Practices, Crosscutting Concepts, and Core Ideas*

Objectives: Students will learn what to look for when looking at the Moon. Students will use their observation skills to compare what they see to what is presented on a Moon map guide.

Practices:
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts:
2. Cause and effect: Mechanism and explanation

Core Ideas:
ESS1.B: Earth and the solar system

Background Information: ***(Information from Geoff Gaherty of Space.com and*** **provided to SPACE.com by Starry Night Education, the leader in space science curriculum solutions. Follow Starry Night on Twitter *@StarryNightEdu.)***

"Take a look at the Moon with your unaided eyes. The most noticeable thing about the Moon is that it is large enough to show some detail without any optical aid. As the Moon moves in its orbit around the Earth, the Sun's light strikes it from different angles, sometimes illuminating only a thin crescent from behind, at other times shining full on, making it a full Moon. These are called the Moon's phases.

You can see a large amount of detail on the Moon with your unaided eye. Most obvious are the shades of gray: the large bright areas mostly on the southern half, and the darker gray areas mostly on the northern half.

The best time to observe the Moon with binoculars or telescopes is at the two "quarters" which are the times when the Moon is a quarter way around its orbit, and the sun is hitting it from right or left. Concentrate along the terminator, the boundary between light and dark. The sun is rising along this line, and so the shadows are at their maximum length. With a good Moon map in hand, try looking at craters up or down the terminator. See how many craters you can identify, and what they have on their floors. What other topographic features can you see? Look for mountains, both isolated peaks and mountain ranges. Many of these are named for their counterparts on Earth.

There are things on the Moon that you never or almost never see on Earth. There are rilles, systems of grooves in the surface, thought to be the remnants of collapsed lava tubes. There are domes, gentle swellings in the relatively flat surfaces of lunar "seas" and flat-floored craters.

Look for the landing sites of the Apollo astronauts. You won't see any of the stuff they left behind, because they are too small to see from this distance, but you can often identify nearby geographic features. The first Apollo landing on July 20, 1969, took place in the open flats of the Mare Tranquillitatis, just north of Theophilus. This location was chosen because it was so flat and the Apollo planners wanted the landing to be as easy as possible. There are three small craters just north of the Apollo 11 landing site named for the three first Apollo astronauts. Armstrong, at 2.9 miles (4.6 km) is the largest. Aldrin is 2.1 miles (3.4 km) in diameter, and Collins is only 1.5 miles (2.4 km) large.

Two years later, on July 30, 1971, Apollo 15 touched down in a mountainous area to the northwest of the Apollo 11 landing site. The Apollo 15 site was located in a small valley just west of Mount Hadley, where a rugged mountain range, called the Lunar Apennines, forms a wedge between the Mare Serenitatis and the Mare Imbrium.

A long, narrow groove meanders across this valley, the Rima Hadley, and the astronauts explored this feature on the ground. If you have a fairly large telescope, at least 8 inches aperture, and lighting conditions are just right, you can get a "bird's eye" view of this surface feature yourself."

Materials:

- Copies of the Skywatcher's Guide to the Moon
- View of the Moon
- Student Worksheet
- Pencil

Procedure:

1. Students should be handed a copy of the Skywatcher's Guide to the Moon.
2. Discuss with students the Background Information and ask them to take the Student Worksheet home and observe and label the Moon. Be sure they are given this assignment when the Moon is a quarter way around its orbit.
3. Tell students to compare the Moon in the sky to the large Moon map on the handout.
4. Tell students the Moon map shows the side of the Moon that is always facing us. Also, remind students that they if they look at the Moon in their telescopes, they may need to turn the map to match the view of the Moon in the eyepiece. Some telescopes will flip your view as if you were looking at the Moon in a mirror. The small photo of the Moon in the Skywatcher's Guide to the Moon shows a mirror image of the Moon.
5. Discuss the observations with students the next day in class. (Answers will vary.)

Summary: This lesson will give students an awareness of the easiest object to observe in the night sky – the Moon.

Evaluation: Students should complete the Student Worksheet and participate in the discussion concerning the assignment. A rubric may be used to evaluate the observations of the students.

Additional Resources and Enrichment:

- Site images and a tour of Apollo landings by Google Earth are found at **http://www.google.com/Moon/.**

- To locate the Terminator (the boundary between light and dark on the Moon), **www.virtual-Moon-atlas.en.softonic.com** lets you download a free Moon atlas program. With it you can find any lunar feature, Apollo landing sites, pictures, and other useful information about the Moon.

Activity Eight: Observing the Moon Student Worksheet

Name: ____

Date: ___________________________ Time: _______________________________

Observations of the Moon

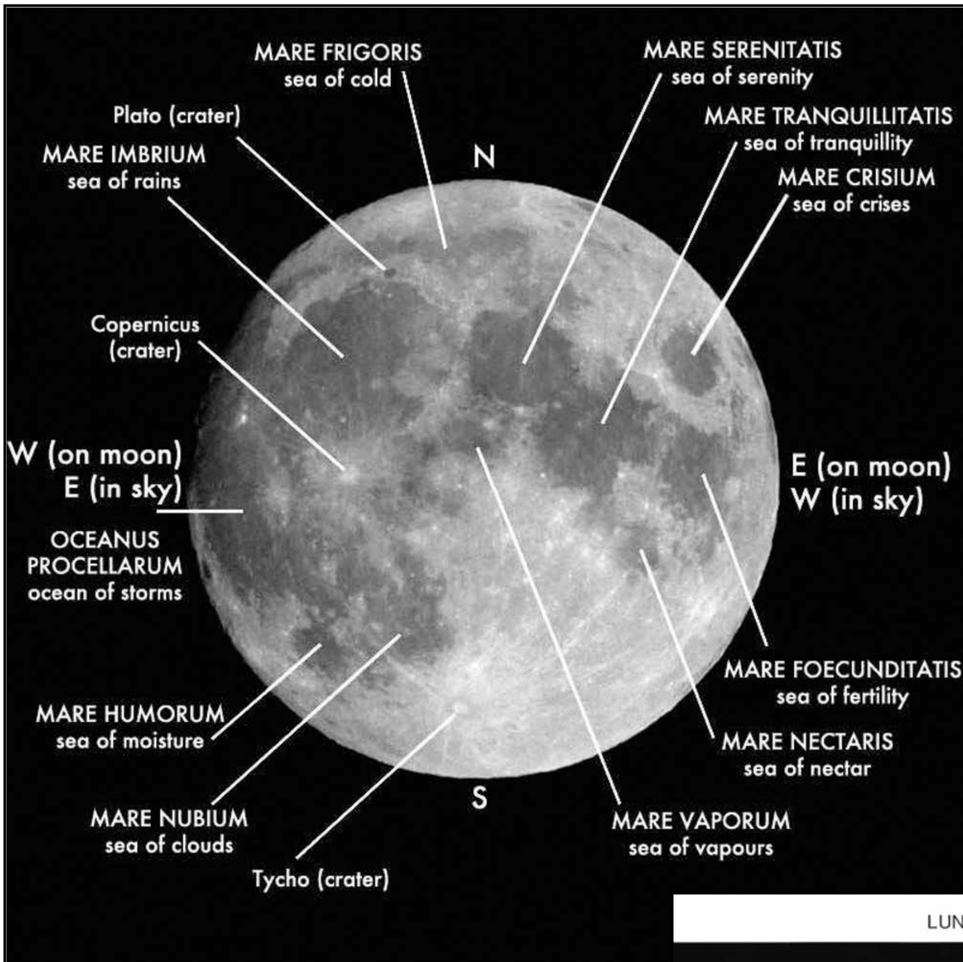
The circles below indicate the Moon. Draw and shade the features you see from different observing methods. Indicate North and South, shade dark and bright areas, label the maria, highlands, and craters, and label those features with their proper names using your lunar map. Also label any of the lunar landing sites from the Apollo missions.

Eye

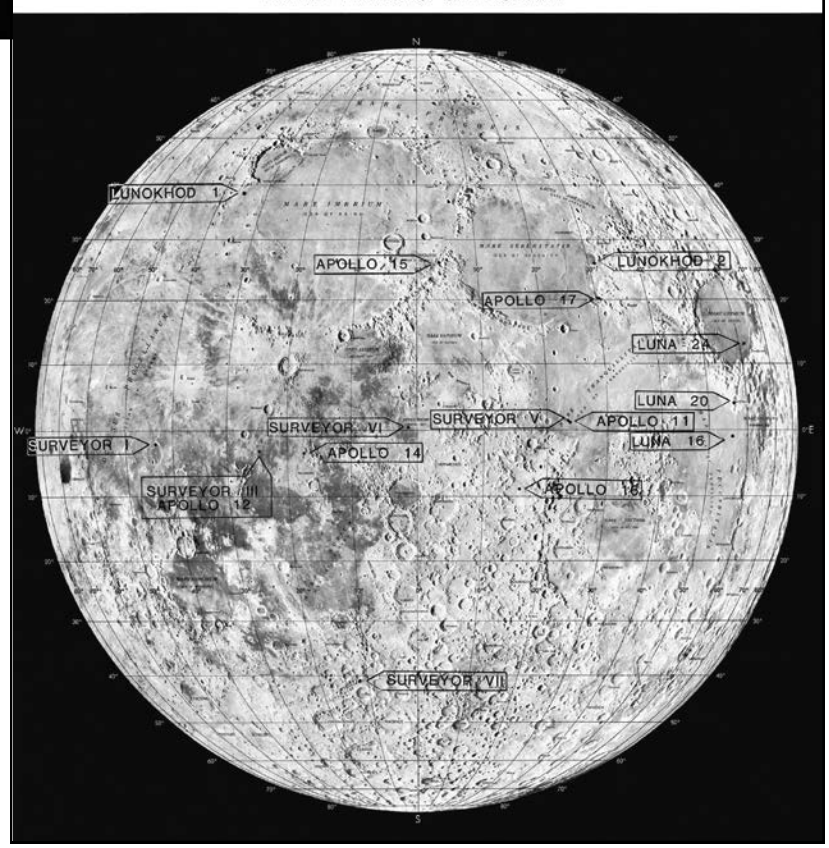
Binoculars/Finder scope

Entire Moon through Telescope
Telescope Size: __________ inches
Eyepiece: _____________ mm

Moon Map of Craters and Lunar Landing Sites



LUNAR LANDING SITE CHART



SKYWATCHER'S GUIDE TO THE MOON

Impact!

The Moon's cratered surface tells a violent story. Bright areas are ancient crust that make up the highlands. Dark areas are newer regions of lava that formed after asteroid impacts.

Copernicus

This crater (left) is easy to spot. It formed about 800 million years ago, and is 57 miles (92 km) wide. Note central peaks and terraced walls, caused by impact.

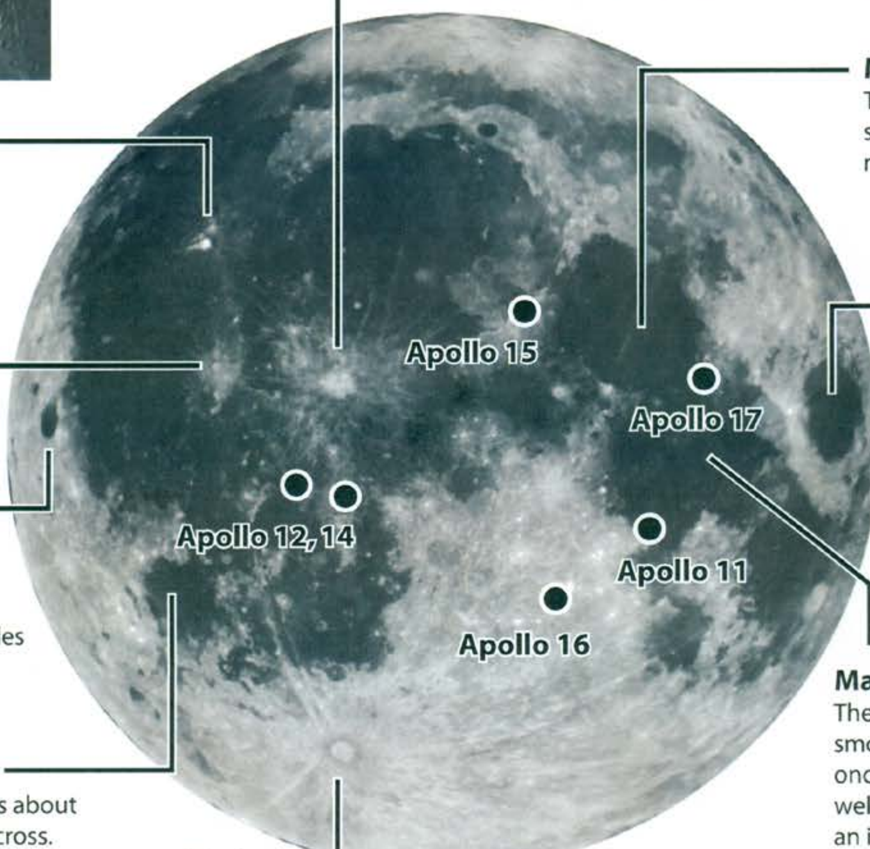
What do you see on the Moon?

Face south and look up in the sky.

Can you find the Moon?

Compare the Moon in the sky to the large Moon map below. The Moon map shows the side of the Moon that is always facing us. How much of the Moon in the sky is lit up right now? You will only see the features on the part of the Moon that is lit up.

Through a telescope, you may need to turn the map to match your view of the Moon in the eyepiece. Some telescopes will flip the image, so the Moon might look like the image to the right through a telescope.



Aristarchus
Young crater. So bright that Sir William Herschel thought it was an active volcano.

Kepler
Small version of Copernicus

Grimaldi
Lava-filled crater is one of the darkest spots you can see on the Moon. It's 145 miles wide (233 km).

Mare Humorum
The Sea of Moisture is about 220 miles (350 km) across. You can spot it with the naked eye. With a telescope, you might notice two craters along its edge.

Tycho
Young crater best seen during a full Moon. Rays of bright material are ejecta blasted out of the crust when a large asteroid struck about 109 million years ago.

Mare Serenitatis
The Sea of Serenity is solid lava, some 380 miles (610 km) across.

Mare Crisium
The Sea of Crisis is about 340 miles wide (550 km) and visible to the naked eye.

Mare Tranquillitatis
The Sea of Tranquility is a smooth plain filled with once-molten lava that welled up from below after an impact billions of years ago. The first humans to walk on the Moon, Apollo 11 astronauts, landed near the edge.

SOURCES: NASA; ADVANCED SKYWATCHING; CAMBRIDGE ATLAS OF ASTRONOMY; DK VISUAL ENCYCLOPEDIA

Photos: James Scala. Layout and text for Moon map used with permission: Robert Roy Britt/SPACE.com.

NASA Night Sky Network (nightsky.jpl.nasa.gov) administered by Astronomical Society of the Pacific (www.astrosociety.org)

Activity Nine: The Planets and Asteroids – Observing Jupiter

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 Science Education Practices, Crosscutting Concepts, and Core Ideas
Objectives: Students will observe the planet Jupiter and record what they observe.

Practices:
4. Analyzing and interpreting data

Crosscutting Concepts:
3. Scale, proportion, and quantity

Core Ideas:
ESS1.B: Earth and the solar system
PS4.C: Information technologies and instrumentation

Background Information:

In general, observing planets is easiest when the planet is high above the horizon (when it is low in the sky a planet's image will be subjected to more atmospheric effects and possibly more light pollution).

Of the planets, Jupiter and Saturn are the easiest to observe. Saturn's rings can be seen by all but the smallest telescopes (except when the rings are edge on). It is also possible to see bands within Jupiter's atmosphere. A challenge is to see Cassini's Division (a gap in the rings which is not visible in small telescopes, but is in medium or large telescopes). Both planets have moons that are easily seen in amateur telescopes.

Observing Mars is a challenge. The only time it is worthwhile to look at Mars through a telescope is near opposition (which occurs approximately every two years). Under good conditions, you can see light and dark areas, polar caps, and possibly even clouds. Some clouds are yellow in color and can develop into dust storms, when a major dust storm hits it can be impossible to observe any surface detail until the storm subsides.

It is easier to observe Mars if you use colored filters. If you wish to observe surface details, a dark yellow, red and/or orange filter is helpful. Violet and blue filters are helpful if you want to observe clouds and other atmospheric phenomena (but not yellow clouds or dust storms). Green filters are helpful for observing the polar caps and other white areas, yellow clouds and dust storms. If you have made either Jupiter or Saturn observations, you may want eyepieces that provide slightly more magnification than the eyepieces you used for Jupiter and Saturn.

Mars has two moons, Deimos and Phobos. However, they are very difficult to see in an amateur telescope. Observations of the Martian moons should only be attempted near Mars opposition.

Venus shows no surface detail under a telescope. However, it is possible to see the phase change over the course of a Venus year.

Mercury is a difficult telescope object. It is never far from the sun, which means the only time it is high above the horizon is during daylight. If you plan ahead, you can observe Mercury near the time of greatest elongation, which is the easiest time to observe the planet. Mercury has craters, however they are not easy to observe from ground based telescopes.

Uranus and Neptune are not difficult to observe, you just need to know where to point your telescope.

Pluto and the various Asteroids are not difficult to observe either. However, they are difficult to distinguish from nearby stars. The only reliable way to be sure an object is Pluto or an asteroid and not a star is to watch it every night for a few nights, if it moves then it is not a star.

Jupiter is thrilling to view with any type of telescope, even a small refractor. Several cloud belts and the four brightest moons, Io, Ganymede, Callisto, and Europa, are visible. With the right view, the Great Red Spot can also be seen. This immense oval-shaped anticyclone has been observed for at least 300 years, and it wanders east and west on the planet unpredictably.

Materials:

- Student Worksheet for *The Planets and Asteroids*
- Pencil
- Telescope
- Cloudless night sky
- Source of light to see worksheet (red filter over flashlight will block harmful light)

Procedure:

1. Introduce the planet, Jupiter, to the students. Use the Background Information and using sites such as http://www.nakedeyeplanets.com/, you can learn much about the planets and how to locate them in the night sky. To help locate the current positions of objects in the night sky, another site is from Sky and Telescope and is called This Week's Sky at a Glance (http://www.skyandtelescope.com/observing/ataglance).
2. Have students use the Student Worksheet and make a full-disk drawing of the planet Jupiter and any visible moons. Because of the planet's rapid rotation, full-disk drawings should be completed in 20 minutes or less to ensure that features are accurately plotted with respect to one another.

Summary:

Students will learn about the planet Jupiter and how to locate planets in the night sky. This activity will help students learn about recording data to review and compare.

Evaluation:

Student Worksheet and observation skills will be evaluated by the teacher. Accuracy and attention to detail is important.

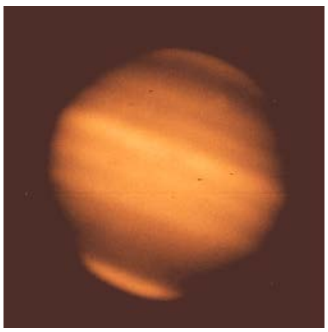
Additional Resources and Enrichment:

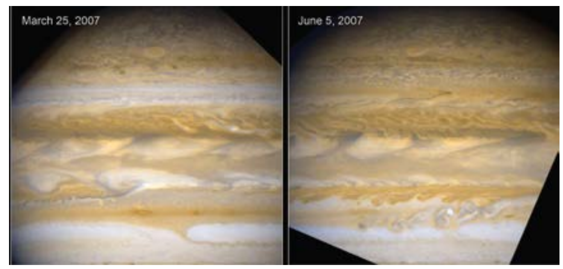
- Have students make a model of Jupiter and indicate the details they observed when they viewed the planet with the telescope.
- Research local star parties in the area and go to one as a field trip. A website that gives some locations can be found at http://stardate.org/nightsky/star_parties. If you cannot find one here, use a search engine for Observatories or Planetariums in your area. Sites such as http://www.touristinformationdirectory.com/Planetarium/Science_Center_Observatory_planetariums_US.htm can be very helpful.
- Ask a local astronomer or astronomy club to speak about the planets in the night sky.

Activity Nine: Student Worksheet for *The Planets and Asteroids – Observing Jupiter*
Name: ____

Date of Observation: ___________
Time of Observation: ____________
Direction of Observation: ______________
Altitude of Observation: _______________

1. Use the pictures below and decide which is the image seen with each of the following:
   a. Binoculars / Small Telescope
   b. Large Earth-based Telescope
   c. Hubble Space-based Telescope





_________ _________ _____________

2. What caused you to label them as you did? ______________________________
   ____

3. Make a full-disk drawing (with as much detail as possible) of the field of view in which you observed Jupiter in the night sky through the telescope.

Activity Ten: Making and Demonstrating a Color Filter Wheel

(Lesson designed by the Yohkoh Public Outreach Project team – funded by NASA)

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

Objectives: Students will demonstrate what happens when different color filters are used to view a picture of a space object.

Practices:
2. Developing and using models
3. Planning and carrying out investigations

Crosscutting Concepts:
2. Cause and effect: Mechanism and explanation

Core Ideas:
PS4.A: Wave properties
PS4.B: Electromagnetic radiation
PS4.C: Information technologies and instrumentation

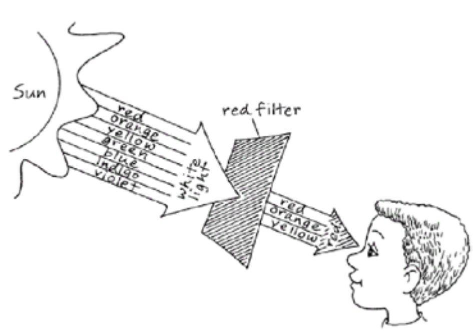
Background Information:

Eyepiece filters are an invaluable aid in viewing planets and the Moon. Filters reduce glare and light scattering, increase contrast through selective filtration, increase definition and resolution, reduce irradiation, and lessen eye fatigue. Filters may include yellow, orange, red, blue, green, violet, neutral density, and polarizing. Each has a specific use due to the colors and contrasts provided by each.

- Choose a light-green or moon filter for enhanced Moon views. This filter can also be used for viewing frost, fog, or ice on Mars or encircling Saturn or Jupiter.
- Choose a yellow filter to brighten desert areas on Mars or darken the blue belt at Jupiter's equator.
- Choose a light-red filter for daytime viewing of Mercury and Venus against a blue sky.
- Choose a light-blue filter in order to bring out detail of clouds on Mars and Jupiter.
- NEVER simply use a colored filter to view the sun. To be safe, make sure you always use a solar filter in front of the objective as well.

Light filters may be glass, gel, plastic, or some other substance that selectively absorbs, reflects, refracts, or diffracts specific wavelengths in the visible light spectrum.

In this activity, when white light hits a red filter (colored cellophane), the filter absorbs the colors of the visible spectrum except for the red, orange, and yellows which are perceived by the eye as a shade of red. The same process happens with the blue and yellow.



Materials (needed for each filter wheel):

- Two sturdy paper plates
- One piece of blue cellophane (approximately 6 inches by 6 inches)
- One piece of red cellophane (approximately 6 inches by 6 inches)
- One piece of yellow cellophane (approximately 6 inches by 6 inches) (cellophane can be found in the craft section of most stores)
- One brass fastener
- An craft knife or sharp scissors
- Clear tape
- A pencil

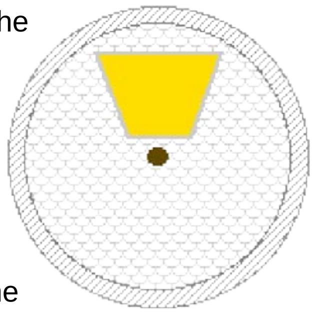
Materials for each person on the team:

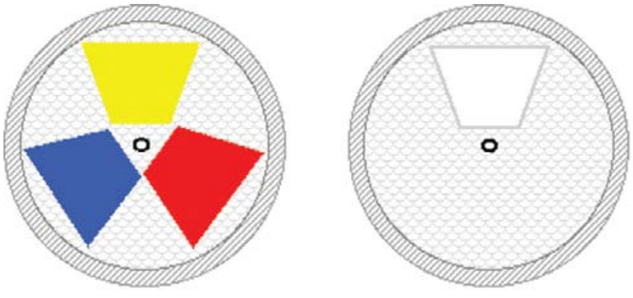
- A set of colored pencils, crayons, or markers
- A color filter wheel (constructed in the first part of the activity)
- A color printout of the Crab Nebula
- Blank paper

Procedure:

<u>Making a Color Filter Wheel</u>

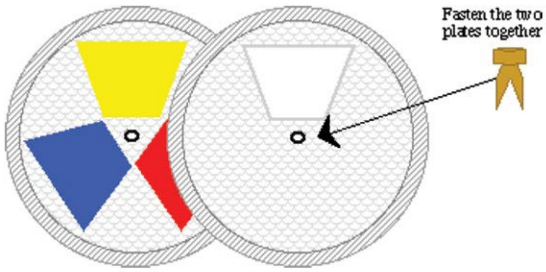
1. Have students discuss what happens when you view an object with a colored filter.
2. Tell students they will construct a color wheel and then use it to demonstrate what can be seen with each filter. Give students the materials they will need to construct the color filter wheel.
3. Have students cut out a small, wedge-shaped, section from one of the paper plates. This section should be a little bit less than one third of the paper plate.
4. Once the students have cut out the first section, have them place this paper plate on top of the second plate and trace around the inside of the cutout portion onto the other plate.
5. Have students rotate the cut plate about 1/3 of the way around and trace out the section again. Have them rotate the top plate another 1/3 and trace out the section one more time onto the uncut plate. The uncut plate should now have three, equal sections traced onto it. Have students make sure there is enough space between each section so the plate will hold together once they cut them out.
6. Have students cut out each of the sections that they just traced onto the plate. They should now have two paper plates, one with a single section and another with three cut out sections.



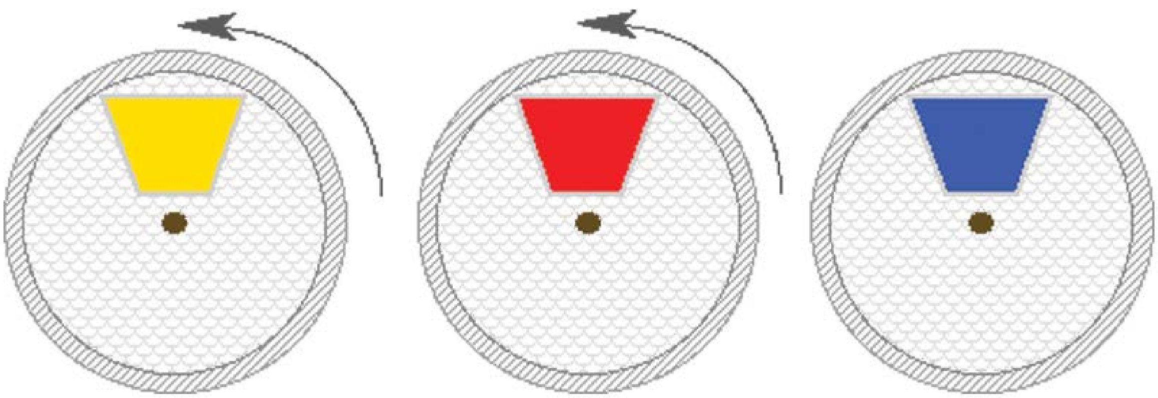


Bottom Plate Top Plate

7. Students should take the plate with three sections and tape a different color of cellophane onto the back of each opening. Have students make sure to trim the cellophane so that it does not extend over more than one opening.
8. Have students punch a small hole through the center of each plate with their pencil.
9. Next, students should fasten the two paper plates together with a brass brad. The plate with the cellophane should be on the bottom.



10. Students are now ready to use the color filter wheel to view the Crab Nebula picture.



Teams of three will work on the next part of this activity:

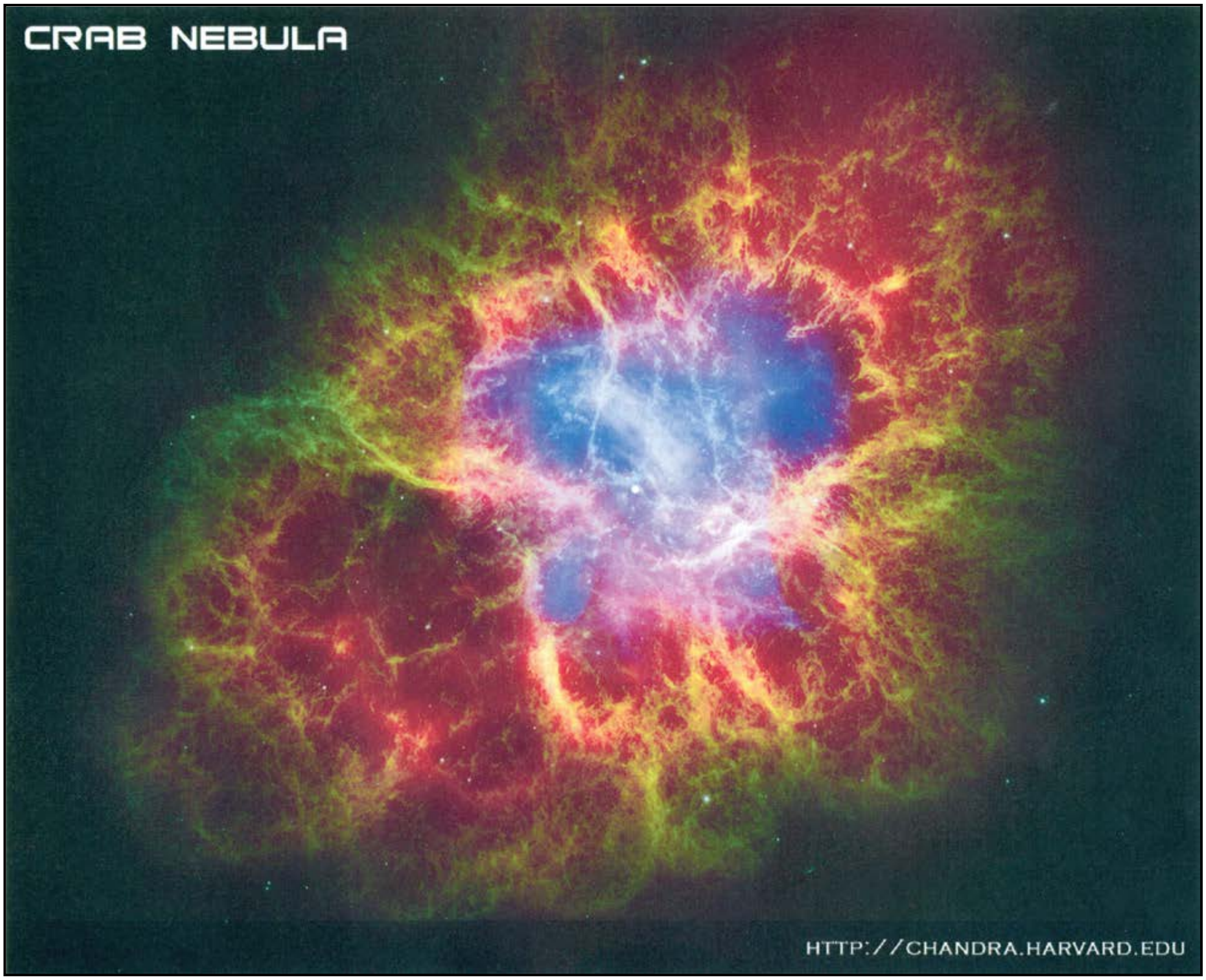
1. Using the materials listed in the team portion of the materials, tell student teams of three that the image they are looking at is of the gas cloud that remains after a star blows up. The materials in this gas cloud will eventually be used to form many new stars. This gas cloud is called the Crab Nebula, the star exploded in the year 1054 AD. The explosion was so bright that several Chinese astronomers reported seeing the bright light in the sky during the daytime! The gas is several different colors because it is at different temperatures. The hottest part is blue in color, the coldest is red.
2. Have each team look at the picture of the Crab Nebula through the color wheel. Within each team, assign one color from the color wheel to each team member. Someone will be blue, someone will be red, and the other person will be yellow.
3. Tell the students to hold their color wheel, with their assigned color showing, over the image of the Crab Nebula. Tell each student to sketch what they see. Tell them not to remove the filter while they are sketching. The sketch should be accurate as to color, size, and detail.
4. After all team members have sketched their color, they should compare sketches with one another. Are they all the same? Are they different? If they are different, discuss the ways in which they differ.

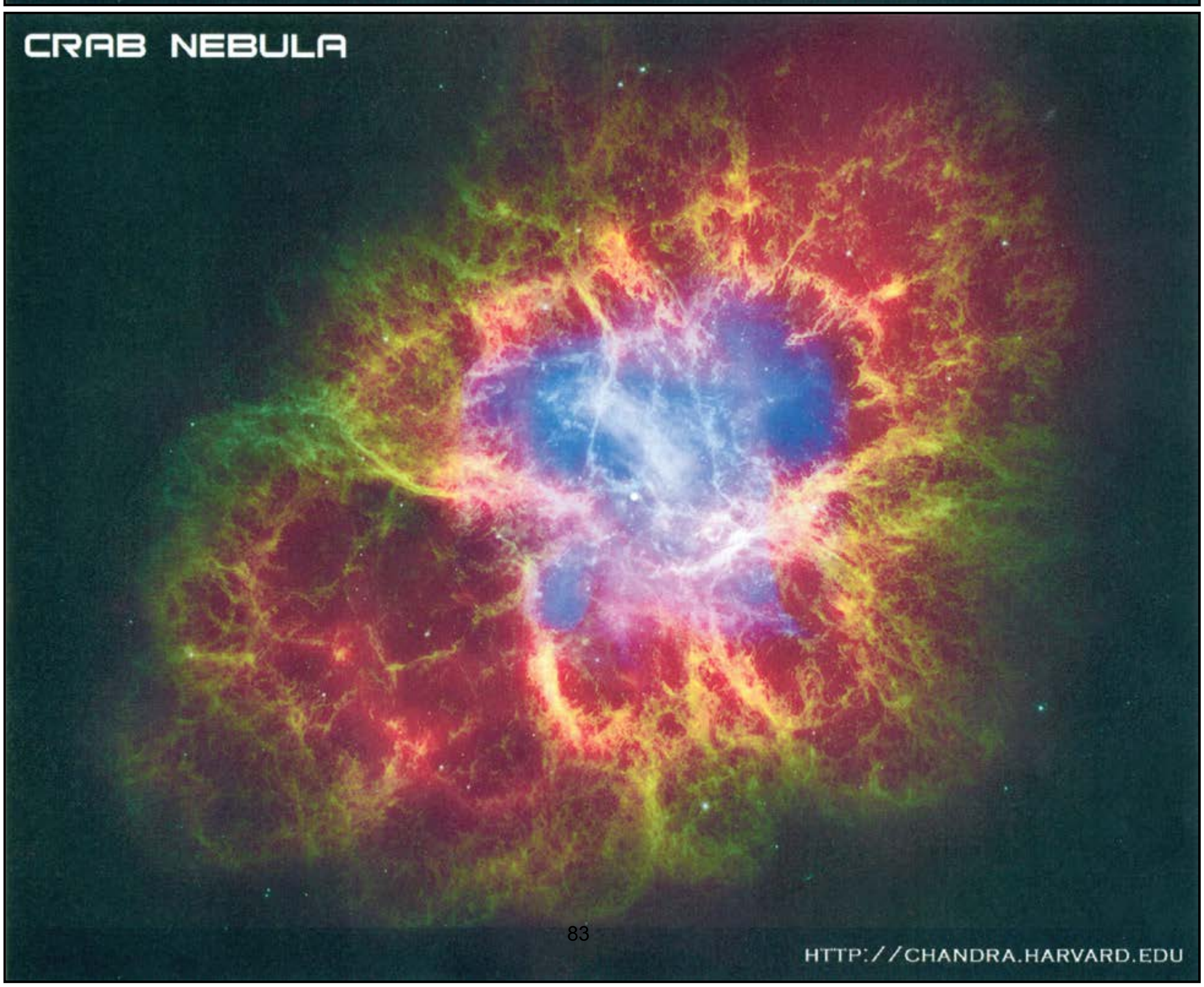
Summary:
When astronomers observe astronomical objects in the sky, they often use different filters to enhance the aspects they are most interested in. At the same time, this mutes other features that might be distracting. In this activity, students learned how this concept works.

Evaluation:
Classroom discussion, sketches, and how the students describe their finished sketches will be the evaluation of the success of this activity.

Additional Resources and Enrichment:

- What does the universe look like in color? – An activity about color from Harvard is found at http://www.cfa.harvard.edu/webscope/activities/pdfs/color.pdf.
- Article: Observing the Planets with Color Filters is found at http://alpo-astronomy.org/mars/articles/FILTERS1.HTM.
- Some Thoughts About Filters from Washed-out Astronomy is found at http://washedoutastronomy.com/content/some-thoughts-about-filters.
- YouTube – What to View with a Telescope is found at http://www.youtube.com/watch?v=S_qsqxGPT-8.


CRAB NEBULA
HTTP://CHANDRA.HARVARD.EDU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Activity Eleven: Locations of Observatories

Next Generation Science Standards Correlations: Relationship to A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

Objective: Students will research an observatory and tell why the location is ideal for observing celestial events.

Practices:
4. Analyzing and interpreting data
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts:
2. Cause and effect: Mechanism and explanation
6. Structure and function

Core Ideas:
PS4.C: Information technologies and instrumentation

Background Information:

Most ground-based optical telescopes are located far from major centers of population to avoid the effects of light pollution. The ideal locations for modern observatories are sites that have dark skies, a large percentage of clear nights per year, dry air, and are at high elevations. At high elevations, the Earth's atmosphere is thinner thereby minimizing the effects of atmospheric turbulence with the result being a better viewing of celestial events.

Materials:
- Internet access with search engine capabilities
- Student Worksheet for Locations of Observatories
- Pencil
- Presentation software such as PowerPoint (optional)

Procedure:
1. Introduce to students what observatories do. Tell them observatories are structures containing large telescopes and other instruments for observing celestial objects and phenomena.
2. Ask students what they think would be a good location for an observatory and why. (Such answers as: a high mountain because the atmosphere of the Earth would not interfere as much, is a good answer.)
3. Tell students they will be researching one of the observatories listed on the Student Worksheet (the teacher may assign several students to work on each observatory).
4. Students will answer the Student Worksheet for Locations of Observatories by researching, reading, and explaining their answers.
5. Students will share information with the class.

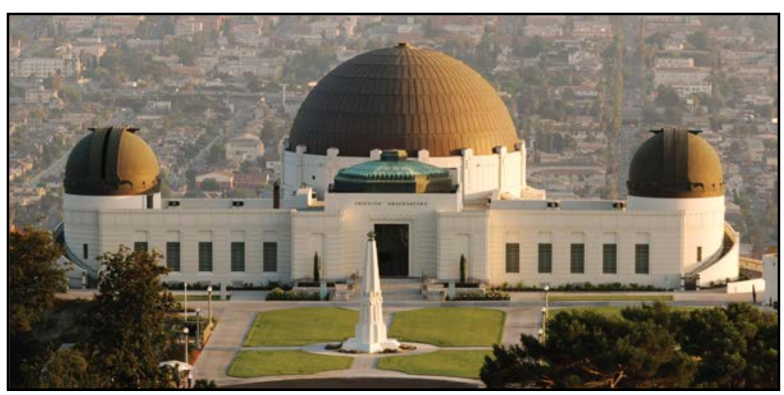
Summary:
This activity will help students understand the importance of location to telescopic observations in observatories.

Evaluation:
Teachers may use a rubric to decide how to evaluate each student's information as well as the answers on the Student Worksheet.

Additional Resources and Enrichment:

1. List of U.S. Observatories is found at http://www.go-astronomy.com/observatories.htm.
2. List of Publicly Accessible Telescope Viewing locations is found at http://telescopes.stardate.org/guide/public.php.
3. Ask students to communicate either by email or phone with an astronomer at an observatory and interview him/her on what the career requires and what they do in their job.
4. If an observatory or planetarium is located nearby, visit and gather information to report to the class.
5. Locations and websites for the observatories used in this activity are:
    - Cerro Tololo Inter-American Observatory in Chile - http://www.ctio.noao.edu/noao/
    - Griffith Observatory in Los Angeles, California - http://www.griffithobs.org/
    - Keck Observatory on the summit of Mauna Kea, Island of Hawaii - http://www.keckobservatory.org/
    - Kitt Peak National Observatory located on the Tohono O'odham Reservation in Arizona - http://www.noao.edu/kpno/
    - McDonald Observatory located 450 miles west of Austin, Texas - http://www.as.utexas.edu/mcdonald/mcdonald.html
    - Mount Wilson Observatory located in southern California - http://www.mtwilson.edu/
    - Pittsburg State University – Greenbush Astrophysical Observatory located at Pittsburg State University near Girard, Kansas - http://www.pittstate.edu/department/physics/psugreenbush-astrophysical-observatory.dot
    - Steward Observatory is located in Tucson, Arizona - http://james.as.arizona.edu/~psmith/61inch/ and https://www.as.arizona.edu/
    - Yerkes Observatory located on Lake Geneva, Wisconsin - http://astro.uchicago.edu/yerkes/

Keck Observatory in Hawaii



Griffith Observatory in California

Answers to Student Worksheet:
Questions 2-4 for each Observatory:

1. For Cerro Tololo Inter-American Observatory
    a. Elevation – 2,200 meters (2,406 yards)
    b. Climate – La Serena has a cool desert climate with temperatures being moderated by a maritime influence
    c. City – About 300 miles north of Santiago
2. For Griffith Observatory
    a. Elevation – 1,134 feet above sea level
    b. Climate – Subtropical-Mediterranean climate that receives just enough annual precipitation to keep it from being classified as semi-arid
    c. City – Los Angeles
3. For Keck Observatory
    a. Elevation – 13,796 feet
    b. Climate – Clear, calm, and dry
    c. City – Mauna Kea on the island of Hawaii
4. For Kitt Peak National Observatory
    a. Elevation – 6,875 feet
    b. Climate – Cool and arid
    c. City – 56 miles southwest of Tucson, Arizona
5. For McDonald Observatory
    a. Elevation – 2,070 meters (6,790 ft)
    b. Climate – Cool and dry; moderate climate
    c. City – 450 miles west of Austin, Texas
6. For Mount Wilson Observatory
    a. Elevation – 1,740 meters (5,710 ft)
    b. Climate – Snow sometimes interrupts astronomical activities but generally the climate is moderate
    c. City – Above Pasadena, California
7. For Greenbush Astrophysical Observatory
    a. Elevation – 301 meters (987 ft)
    b. Climate – Higher than average rainfall with lows in winter around 22 degrees and highs in summer around 91 degrees.
    c. City – Girard, Kansas
8. For Steward Observatory
    a. Elevation – 2,510 meters (8,235 ft)
    b. Climate – Dry desert
    c. City – Tucson, Arizona
9. For Yerkes Observatory
    a. Elevation – 400 meters (1,312 ft)
    b. Climate – Cool to moderately warm and dry
    c. City – 76 miles from Chicago

Question 5: These locations are ideal for observing celestial events because they are remote enough for little interference from light pollution. They also are in very dark areas with a large percentage of clear nights per year, dry air, and high enough elevations that the Earth's atmosphere is thinner, thereby minimizing the effects of atmospheric turbulence.

Activity Eleven: Student Worksheet for Locations of Observatories

Name: ____

Choose (or your teacher will assign) one of the observatories listed below to research and answer the questions that follow.

- Cerro Tololo Inter-American Observatory - http://www.ctio.noao.edu/noao/
- Griffith Observatory - http://www.griffithobs.org/
- Keck Observatory - http://www.keckobservatory.org/
- Kitt Peak National Observatory - http://www.noao.edu/kpno/
- McDonald Observatory - http://www.as.utexas.edu/mcdonald/mcdonald.html
- Mount Wilson Observatory - http://www.mtwilson.edu/
- Pittsburg State University – Greenbush Astrophysical Observatory - http://www.pittstate.edu/department/physics/psugreenbush-astrophysical-observatory.dot
- Steward Observatory - http://james.as.arizona.edu/~psmith/61inch/ and https://www.as.arizona.edu/
- Yerkes Observatory - http://astro.uchicago.edu/yerkes/

1. Which observatory did you choose or were assigned?
   ____
2. What is the elevation of the observatory? ______________________________
3. What is the climate where the observatory is located? ______________________
   ____
   ____
4. What is the name of the nearest city to the observatory?
   ____
5. Why do the answers to questions 2-4 make this location ideal for an observatory?
   ____
   ____
   ____
   ____
6. Extra: Use software such as PowerPoint to create a presentation to present to your class of the importance of this observatory and its location.

Civil Air Patrol
www.capmembers.com/ae

Air Force Association
www.afa.org

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