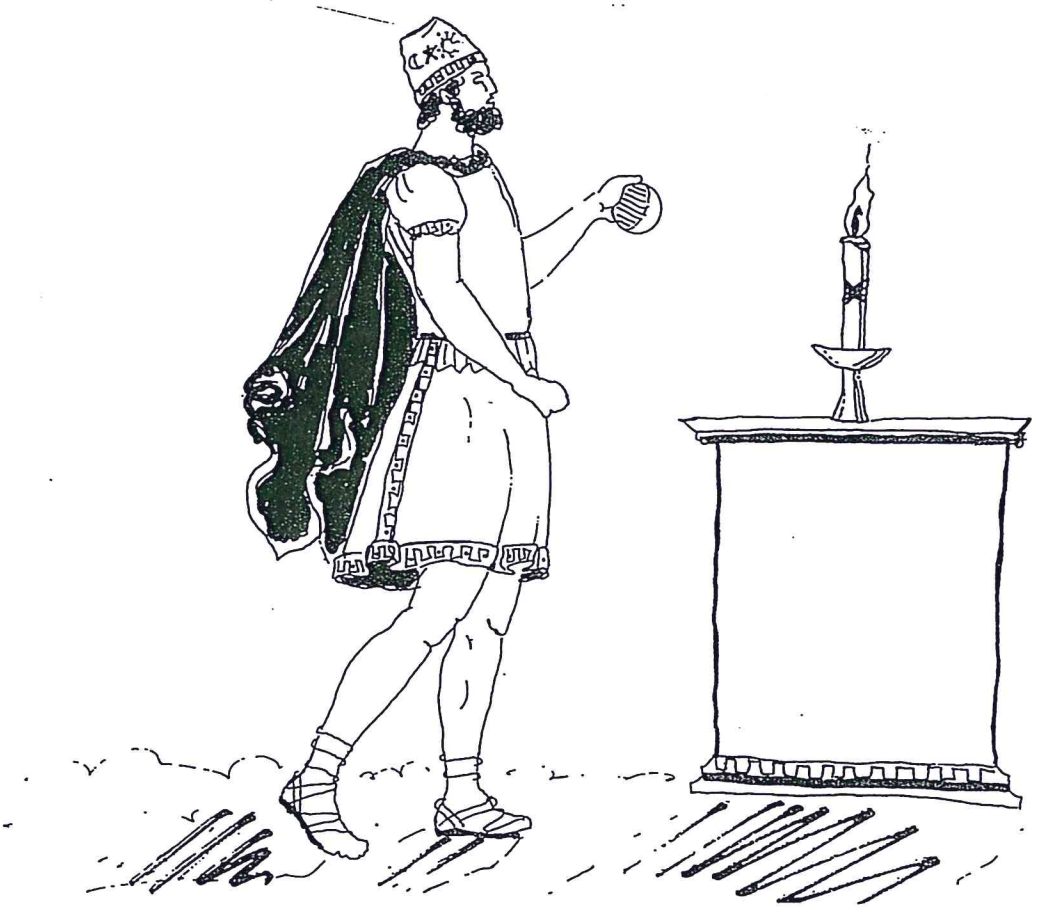
Activity 4: Modeling Moon Phases and Eclipses

Introduction

No one knows how the ancient Greeks figured out that moonlight is really reflected sunlight. However, we can imagine that the discovery might have occurred when a curious philosopher noticed that an orange illuminated by a single candle looked like the crescent moon. When he looked at the orange from different angles, it looked like a half, three-quarters, and even a full moon! Using models to explain observations of the Sun, Moon, stars, and other celestial objects has become a cornerstone of modern astronomy.

In this activity your students use a model to explain the Moon's monthly cycle of phases. The students' head will represent the Earth. They hold "moon balls" in their outstretched hands and slowly move them in circles around their heads. With a single lamp, the "sun," lighting up each student's "moon," the students are able to observe moon phases and eclipses. They will then be able to relate this simple model to their earlier observations of the real Moon and Sun in Activity 3, "Observing the Moon."



Time Frame

Part I: Model Earth, Moon, and Sun	20 minutes
Part II: Observing Moon Phases	10 minutes
Part III: Observing Eclipses	10 minutes

What You Need

For the class:

- ❑ 1 lamp with no shade
- ❑ 1 25-foot extension cord
- ❑ 1 40-watt clear lightbulb
- ❑ 1 75-watt clear lightbulb

For each student:

- ❑ 1 two-inch polystyrene ball.

Note: Styrofoam balls will work if painted with white latex or other water-based paint. Just about any other balls will also work, as long as they are opaque. Polystyrene balls may be purchased inexpensively from a number of sources and are of course supplied in the *Earth, Moon, and Stars* kit from Carolina Biological (see inside front cover of this guide for contact information).

Getting Ready

1. Find a room that you can darken completely by drawing curtains or taping black paper over the windows.

2. Use the extension cord to plug in the lamp. Make sure the cord is long enough for the lamp to be placed in the center of the room. Tape the cord down to the floor for safety.

3. Have a box of balls on hand to give your students. If you use styrofoam balls, the students can stick the balls on the ends of pencils for easy holding.

4. Before class, determine which light bulb is best by placing one of them into the socket and darkening the room. Stand about the same distance from the lamp as the students will stand. Hold a "moon ball" in your hand and move it to one side until you see a crescent. Observe the

contrast between dark and light sides of the ball, then change the bulb and again observe the contrast. Brighter light bulbs usually provide more contrast if you have a large room, or if there is some light coming into the room from outside. Dimmer bulbs will provide greater contrast in smaller rooms with white walls.

Teachers have suggested trying this activity with only half the class at a time. This makes it easier to manage the activity.

Part I: Model Earth, Moon, and Sun

1. Review the results of Activity 3, "Observing the Moon" with your students:

- What are the different shapes or phases of the Moon? [Full, gibbous, half or quarter, crescent, and new.]
- What is the Moon's phase when it is close to the Sun? [A thin crescent, or new moon.]
- Is the lighted side of the Moon away from or toward the Sun ? [Toward the Sun.]
- Optional: How long does it take for the Moon to go from full, to crescent, to new, and back to full again? [One month.] *Note:* If your students did the optional Step #7 on page 23 at the end of Activity 3, they will have recorded a month's cycle.
- Why does the Moon have different phases? [Encourage several answers.]

There are myths, legends, and stories from all over the world with imaginative and ingenious explanations for the Moon's phases and other astronomical phenomena. A few such books are listed in the "Literature Connections" section on page 56.

2. Remind your students of the term ***model*** by noting that their explanations for phases of the Moon are all models.

The GEMS teacher's guide entitled Investigating Artifacts *includes a more extensive listing of diverse Native American and world myths and stories that explain natural phenomena. In Sessions 3 and 4 of* Investigating Artifacts, *students create myths to explain events in nature, just as they do in Session 1 of Earth, Moon, and Stars.*

3. You may wish to tell your students about the ancient Egyptian's model of moon phases. In the city of Thebes, the Moon was called *Khonsu,* meaning "to travel through a marsh." Imagine a person traveling through a marsh. Clumps of weeds and water plants would block parts of the person from view. This was their model for describing why they sometimes saw only part of the Moon.

4. Explain that about 2,000 years ago, the ancient Greeks invented a model for moon phases that is widely believed today. To demonstrate this model, turn on the lamp, and place it in the center of the room. Darken the room so that the only light comes from the lamp in the center.

5. Arrange your students in a circle around the lamp.

6. Hand out moon balls. If the balls are styrofoam, ask your students to push the balls onto their pencil points so they will have "handles" for holding the moon balls.

7. Explain to your students that each of their heads represents the Earth. The ball represents the Moon. The light in the center represents the Sun.

Part II: Observing Moon Phases

1. Ask your students to hold their moon balls out in front of them, directly in front of the "sun."

2. Instruct the students to move the ball a little to the left until they can see a thin crescent lit up.

3. Look around the room to make sure everyone is holding the ball a little to the left of the sun. The most common error students make is looking at the light and ignoring the "moon." Circulate and help individuals as needed.

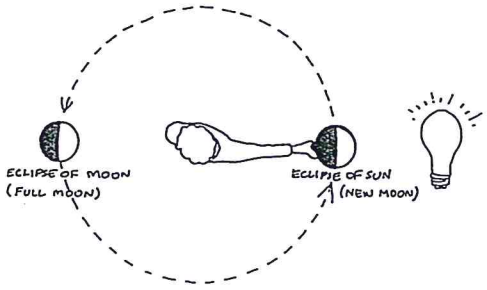
4. When everyone can see the crescent, ask: "Is the bright side of your moon facing toward the sun, or away from it? [Toward the sun, just like the real moon.]

5. Tell the students to continue moving their moons around their heads in the same direction, until exactly half of the moon is lit. Ask: "To make the moon appear fuller, does it have to move toward the sun or away from it? [Away from the sun, just like the real moon.]

6. Tell the students to continue moving the moon in a circle until the part they see is fully lit. Explain that to do this, they will have to hold the moon ball just above the shadow of their heads. Ask: "When the moon is full, is it between you and the sun, or on the opposite side of you from the sun?" [It is on the opposite side of you from the sun.]

7. Instruct the students to continue moving the moon in the same direction until it is just half-full again. Ask: "As the moon moves toward the sun, does it appear to get fuller or thinner?" [Thinner.]

8. Finally, tell the students to move their moons so they are very thin crescents. Explain that most of the time the Moon does not pass directly in front of the Sun, but just above or below the Sun. When the Moon is very close to the Sun we cannot see it in the day or night since the Sun is so bright. When the Moon cannot be seen at all, this phase is called the *new moon*. (It is called "new" because it is at the beginning of its cycle. Some ancient peoples thought a brand new moon was being born at this time!)



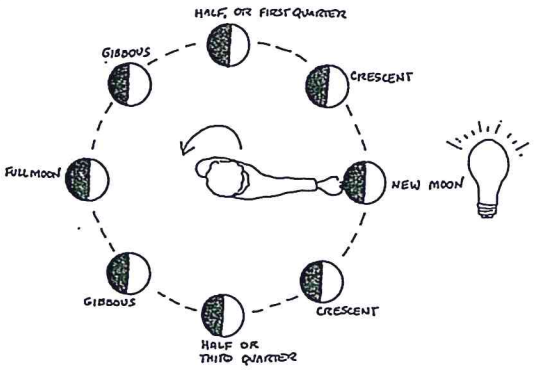
9. Have your students move their moons in circles several times until they fully understand why the Moon goes through phases. The movement of the moon from crescent to full models the two-week period when the Moon is visible in the evening. A full circle represents about a month (more precisely, 29.53 days).

Part III: Observing Eclipses

1. When the students fully understand phases, ask them to move their moons directly in front of the sun to create an eclipse of the sun.

2. While your students observe an eclipse of the sun, tell them: "Hold your moon ball exactly where it is, and glance around the room. Do you see the shadows over everyone's eyes? Remember that your head is the Earth. The people who live where your eyes are see an eclipse of the sun, also called a solar eclipse. But how about the people who live on your chin? Or your ear? [Only the people who live on your eyes can see an eclipse of the sun—the people on your ear or chin can still see the sun!]

3. Instruct your students to move their moon balls around in a circle, as before, until they reach the full phase. This time, tell them to move their moons into the shadow of their heads.

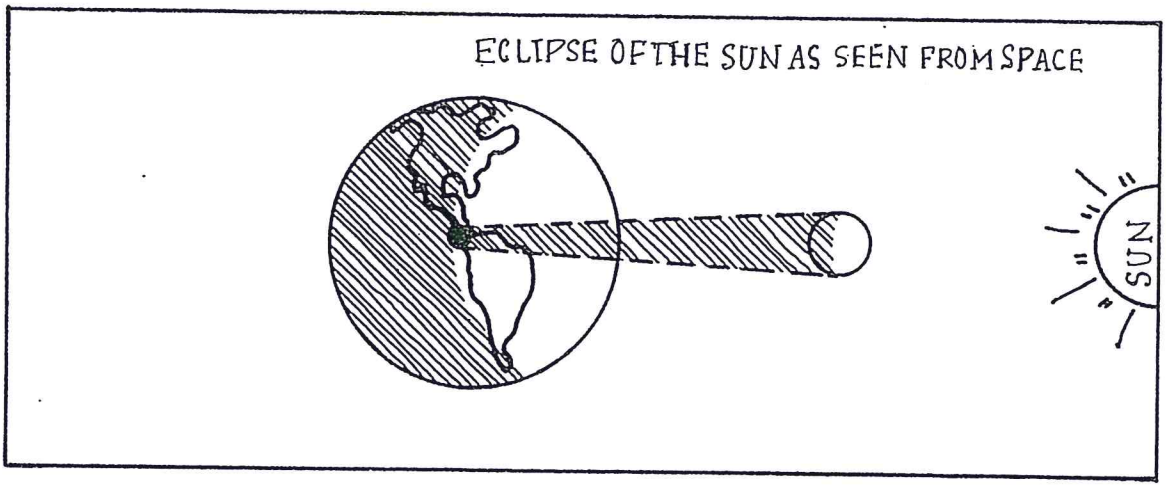


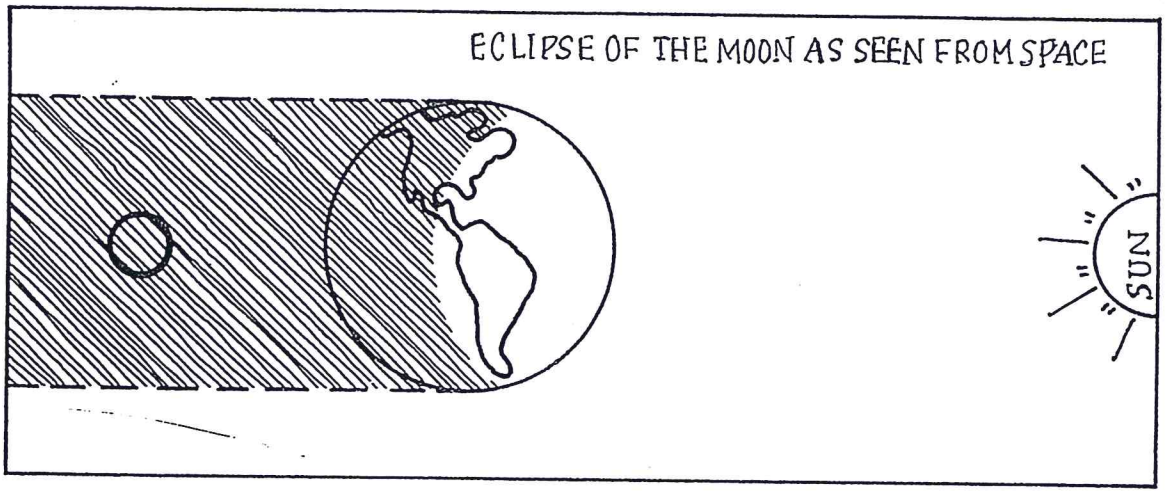
4. While the moons are in the shadow of your students' heads, explain: "This is an eclipse of the moon. Can you see the shape of your hair when the moon moves into eclipse? When there is an eclipse of the real Moon, you can see that the shape of the Earth is round, because it always has a curved shadow."

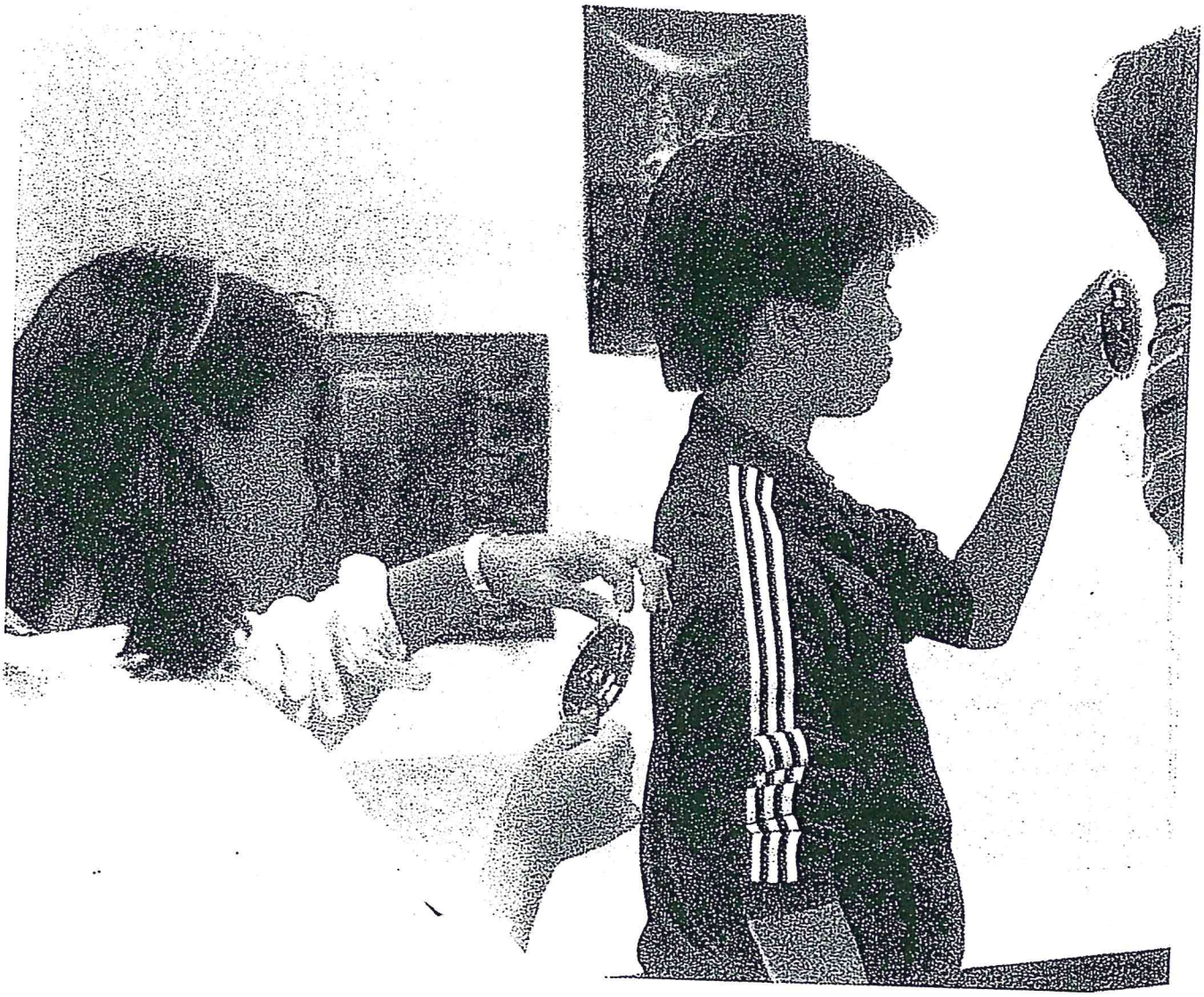
5. While the students continue to observe the eclipse of the moon, point out that everyone who lives on the side of the Earth facing the Moon can see the Moon in eclipse. But during an eclipse of the Sun, only the people inside the shadow see the Sun being eclipsed.

6. Instruct your students to continue moving their moons around their heads until they again see an eclipse of the sun. Ask: "What phase is the moon in just before or just after an eclipse of the sun?" [Thin crescent or new phase.] Tell them to continue moving their moons in a circle until they see another eclipse of the moon. Ask: "What phase is the moon in just before or just after an eclipse of the moon?" [Full.]

7. Remind the students that it takes one whole month (29.53 days) for the Moon to go around the Earth. During the month there is one time when there *might* be an eclipse of the Moon (at full phase) and one time when there *might* be an eclipse of the Sun (at new moon). An eclipse of the Moon will occur when the Moon passes into the shadow of the Earth where it glows a coppery-red for a few hours. Anyone who lives on the night side of the Earth during an eclipse of the Moon can see it. An eclipse of the Sun occurs when the Moon passes directly between our location on the Earth and the Sun, and lasts only a few minutes! Only the people directly under the shadow can see it. That is why eclipses of the Moon are seen more frequently than eclipses of the Sun.


ECLIPSE OF THE SUN AS SEEN FROM SPACE
SUN


ECLIPSE OF THE MOON AS SEEN FROM SPACE
SUN



What You Need

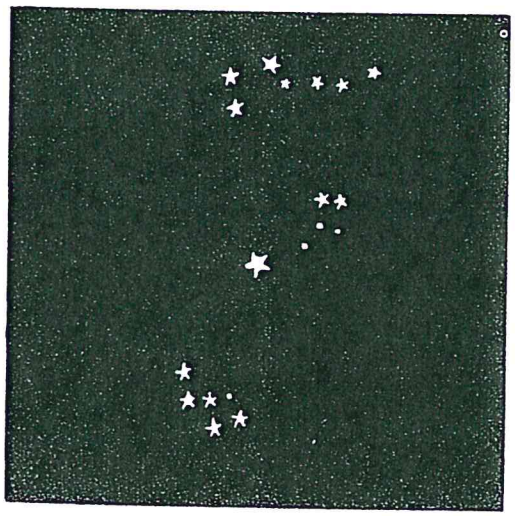
For the class:

- ❑ 1 large sheet of black construction paper (16"x 20" or larger)
- ❑ 1 box of large gold stars or round yellow labels
- ❑ 1 box of small gold stars or round yellow labels
- ❑ 1 roll of masking tape
- ❑ 1 meter stick

For each student:

- ❑ 1 copy of the "Instruction Sheet" for making a Star Clock (master included, page 39).
- ❑ 1 paper fastener
- ❑ 1 pair of scissors (If you do not have enough scissors, students can share.)

Getting Ready



1. Make one copy of the "Instruction Sheet" for each student, plus one for yourself.

2. Make one Star Clock, according to the directions on the "Instruction Sheet," to use as a demonstration.

3. Make a Star Clock poster. On a large sheet of black paper, attach stars in the pattern of the Big Dipper, the Little Dipper, and Cassiopeia. As a guide in positioning the stars, use the constellation map on the small circle of the "Instruction Sheet." The Star Clock Poster does not have to be extremely accurate, but the constellations do have to be recognizable. Do **not** draw the dotted lines on the poster.

4. Tape the Star Clock Poster on the wall at the front of your classroom. Use the demonstration Star Clock that you made to position the poster so it shows the stars at 8PM. Do this by turning the inner circle until "8PM" appears in the notch. Hold the Star Clock vertically with the current month at the **top**. Arrange the poster so the stars appear as they do on your Star Clock. Use masking tape to put the poster up so that you can remove the poster, turn it, and re-tape it during class.

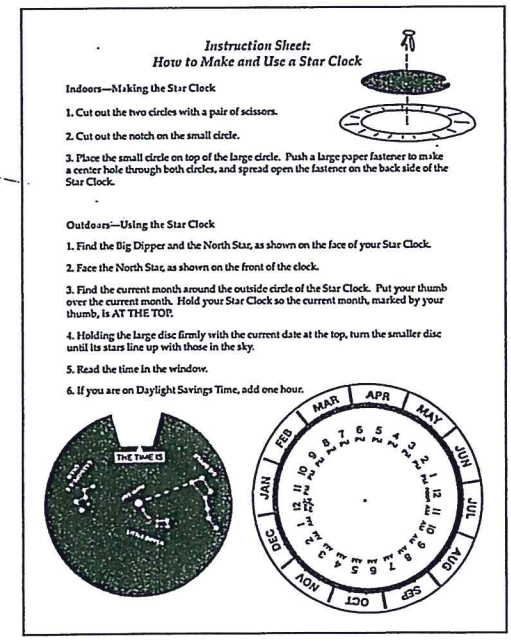
Part 1: Making Star Clocks

1. Introduce this activity by asking your students how people could tell time before clocks were invented. [People used the Sun, dripping water, pouring sand, slow-burning candles, etc.] Explain that a long time ago, people discovered that the stars slowly change position, so they could also use the stars to tell time. After this activity, your students will know how to tell time using the stars.

2. Show the students how to cut out the two circles and the notch in the smaller circle.

3. Then show them how to place the smaller circle on top of the larger one, and insert the fastener through both layers) from the front of the Star Clock. Spread open the fastener on the back.

4. Give an "Instruction Sheet," scissors, and a metal paper fastener to each student. Help individuals as needed.



Instruction Sheet:
How to Make and Use a Star Clock

Indoors—Making the Star Clock

1. Cut out the two circles with a pair of scissors.
2. Cut out the notch on the small circle.
3. Place the small circle on top of the large circle. Push a large paper fastener to make a center hole through both circles, and spread open the fastener on the back side of the Star Clock.

Outdoors—Using the Star Clock

1. Find the Big Dipper and the North Star, as shown on the face of your Star Clock.
2. Face the North Star, as shown on the front of the clock.
3. Find the current month around the outside circle of the Star Clock. Put your thumb over the current month. Hold your Star Clock so the current month, marked by your thumb, is AT THE TOP.
4. Holding the large disc firmly with the current date at the top, turn the smaller disc until its stars line up with those in the sky.
5. Read the time in the window.
6. If you are on Daylight Savings Time, add one hour.

Part II: Using Star Clocks in Class

1. When your students have completed their Star Clocks, focus their attention on the poster at the front of the room.

2. Explain that *constellations* are groups of stars that people have imagined to represent various objects or gods. For example, people imagine the Big Dipper (point to the poster) to be a bowl with a handle that can be used to ladle soup or drinking water. Cassiopeia is supposed to be a queen (some students see it as the queen's crown).

3. Ask your students if they have ever seen these constellations outside at night. Tell them that in order to use the Star Clock, they must be able to find these constellations in the night sky.

4. Ask your students to find the current month around the outside circle of their Star Clocks. Once they find the month, they should put their thumbs on the current month, and hold their Star Clocks so the current month is at the top.

5. Now, ask your students to turn only the smaller circle so that the constellations on the circle look just like the ones on the Star Clock Poster. To help your students adjust their Star Clocks accurately, point out the dotted line drawn from the two Pointer Stars in the Big Dipper to the North Star. Show this imaginary line on the poster by holding a meter stick over the poster. Suggest that the students use this imaginary line in the sky like a hand on a clock.

6. If the current month is at the top, and the inner circle shows the constellations as they appear in the sky, the time can be read in the window where it says "THE TIME IS."

7. Make sure all of your students are reading the same time, within one hour. Help individuals whose times differ from the average by more than one hour.

8. Explain that during the night the stars appear to turn in circles around the North Star. Illustrate by untaping the poster from the wall, rotating it one-quarter turn counter-clockwise, and retaping it to the wall. Ask the students to read the time. [Six hours later than the first reading, or about 1 AM.]

9. Tell the students that they can use their Star Clocks as alarm clocks, by turning the circle so "6AM" appears in the notch. Tell the students to again hold the clock so the current month is at the top and to say "brrring" when the stars appear as they are on the clock. Rotate the poster counter-clockwise, and stop when you hear most of the students' alarms "ring."

10. Once all the students understand how the Star Clock works, challenge them to use the stars in the real sky to tell the time. Suggest that they compare the Star Clock time with the time on a wristwatch. **Important!** If you are on Daylight Savings Time, tell your students to **add** one hour to the time given on the Star Clock.)

11. Urge your students to use their clocks when the stars first come out, and then again just before bedtime, to find out if the Big Dipper really does change its place in the sky during the night. Suggest that they stand near a streetlight, or use a flashlight, to see the Star Clock at night.

Part III: A Spinning Earth

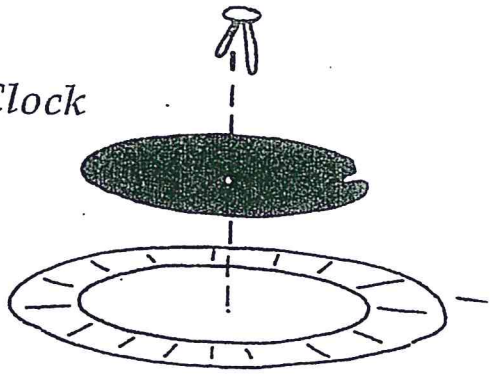
1. The day after a clear evening, when the students have had a chance to use their Star Clocks, ask them to report on their experiences. "Was it difficult? How close was Star Clock time to wristwatch time? Does the Big Dipper really go around the North Star during the night?"

2. Explain that a long time ago, people thought that the sky was a giant ball surrounding the Earth, and that the stars were little points of light attached to the sky. Today we know that the stars are huge balls of fire, just like the Sun, but they appear to be small because they are very far away.

3. To show why the stars seem to go in circles, tell the students to stand up. Then, invite them to imagine that they are each the Earth, and that the ceiling in the room is covered with stars. Now, ask them to slowly turn in place while they look upwards at the ceiling.

4. Ask the students if they can find where the North Star would be in this model. The point directly over their heads will seem to be stationary, while everything else on the ceiling will appear to turn around this point. This demonstrates that the North Star is directly over the North Pole of the Earth. The stars appear to go around the North Star because the Earth turns.

Instruction Sheet: How to Make and Use a Star Clock



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5. Read the time in the window.

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