A Lesson From CAP's Astronomy Activity Booklet- 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.

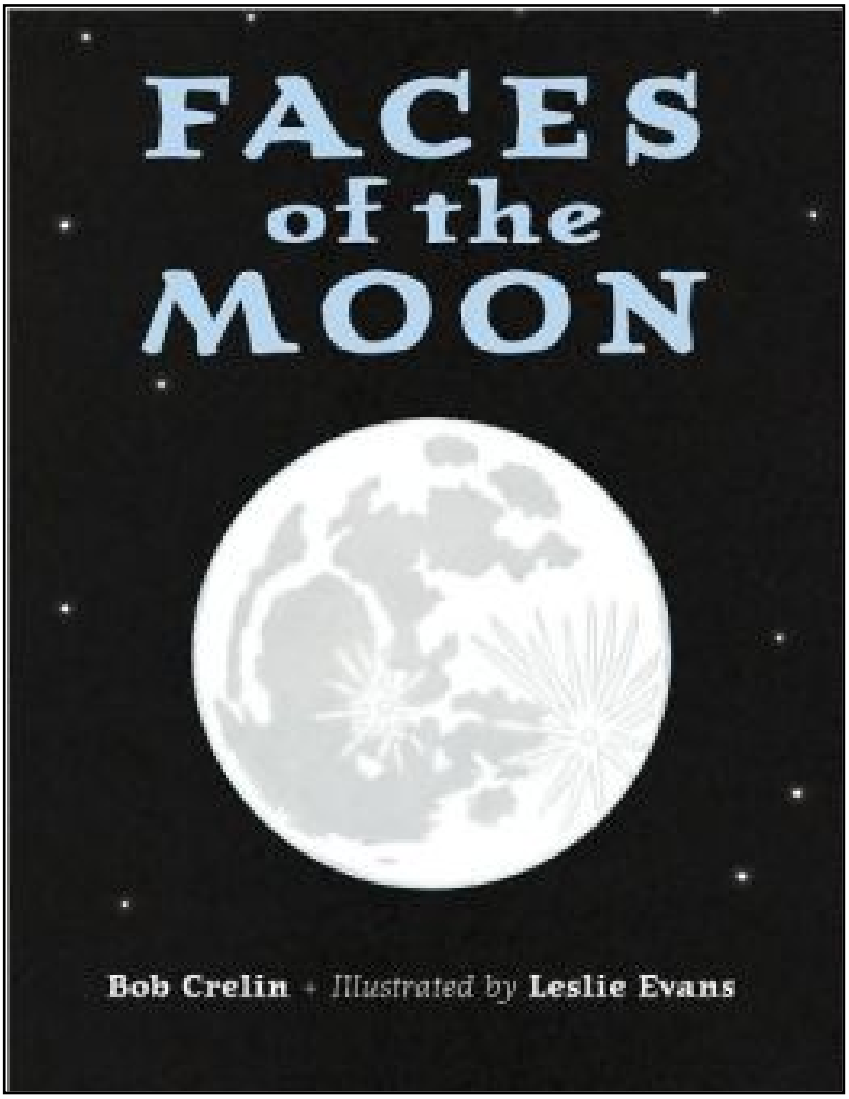
We divide the Moon's orbital cycle into several segments, or phases. When the Sun and the Moon are on the same side of Earth, the sun illuminates the side of the Moon that faces away from Earth. We don't see any reflected sunlight on its front face, so it looks like there is no Moon. We call this the 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.

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

THE UNIVERSE YOURS TO DISCOVER
INTERNATIONAL YEAR OF ASTRONOMY 2009

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FACES of the MOON

Bob Crelin • Illustrated by Leslie Evans

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Teacher's Guide

Northern Hemisphere edition
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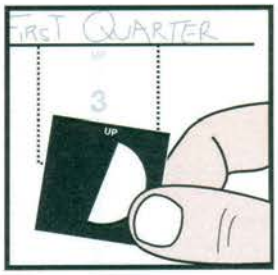
Listen

Do



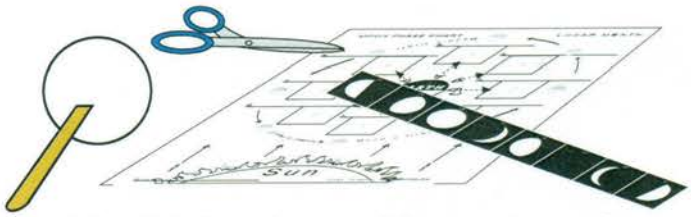
Chart

Review

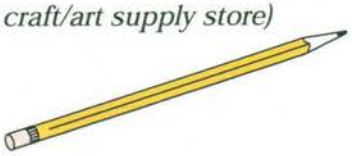
UNDERSTANDING THE PHASES OF THE MOON
A fun, four-stage classroom unit for understanding the Moon's phases (2–3 class periods)

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

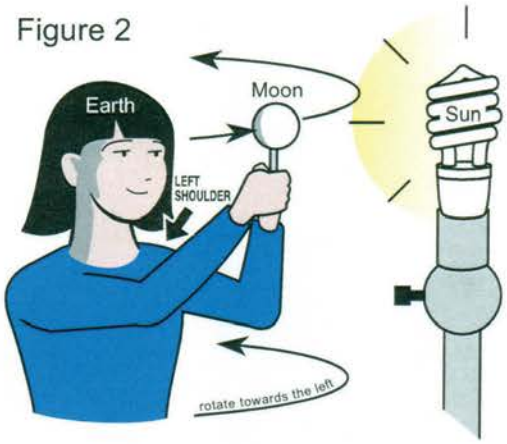
The Hands-on Activity*

*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."

Figure 2

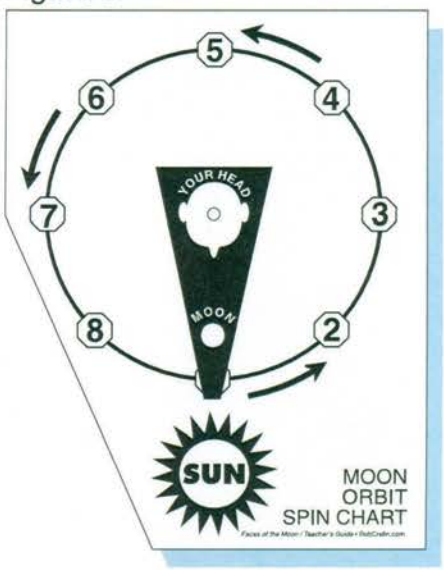


Have the students place their hand on their left shoulder. This represents their "eastern" side. Explain that, during the demonstration, they will turn towards the east, or left, side to simulate the Moon's counterclockwise orbital motion around Earth (see Figure 2).

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.

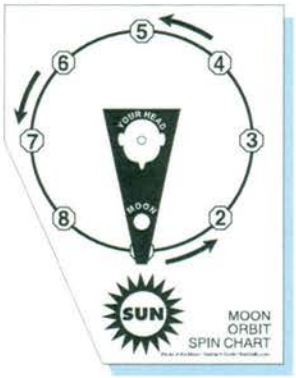
8 Stop #8 - Waning Crescent

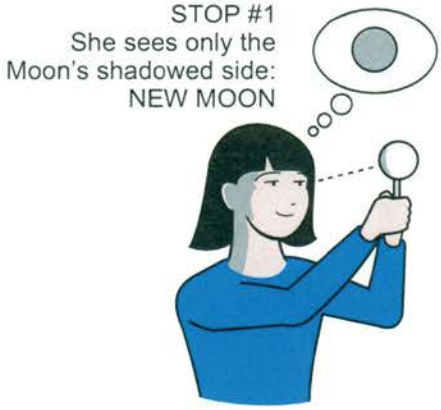
Move the chart dial to stop #8. The students move and notice the Moon's appearance.

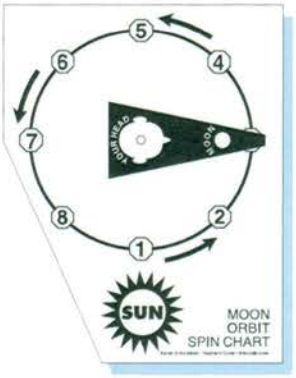
Then move the chart dial–and ask the students to rotate–back to **STOP #1**, where they began their orbit. Ask the students to tell you all together the name of this phase (New Moon). Remind them that they have just modeled one complete Moon orbit around our Earth. This represents the 29.5-day "lunar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

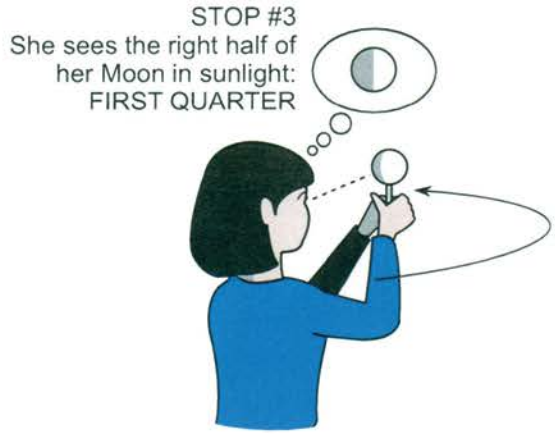
To support this visual demonstration of the changing phases, have the students now do an additional complete rotation (in the same direction), turning slowly without stopping this time. Ask them to watch the changing pattern of light and shadow on their Moon ball as they go. Remind them to keep their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

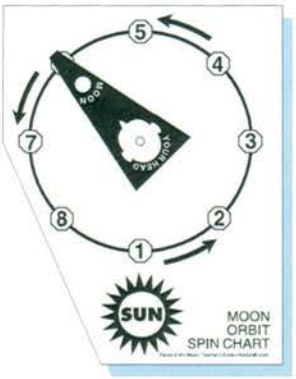
Figure 4

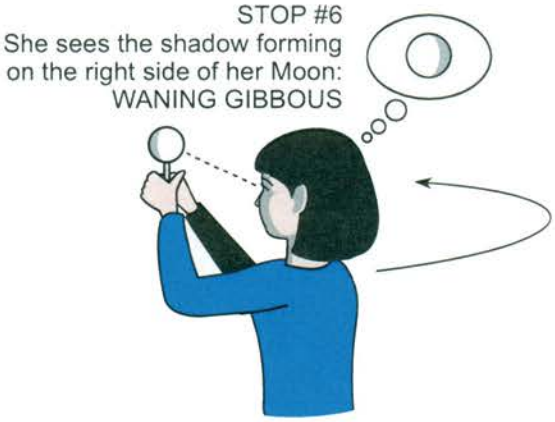










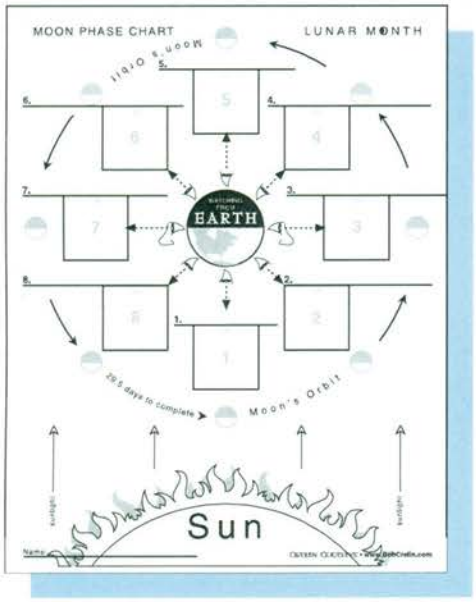


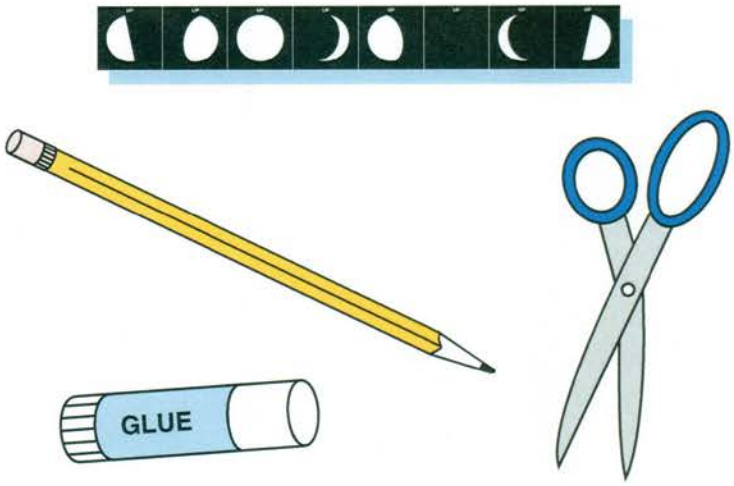
Chart

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.*

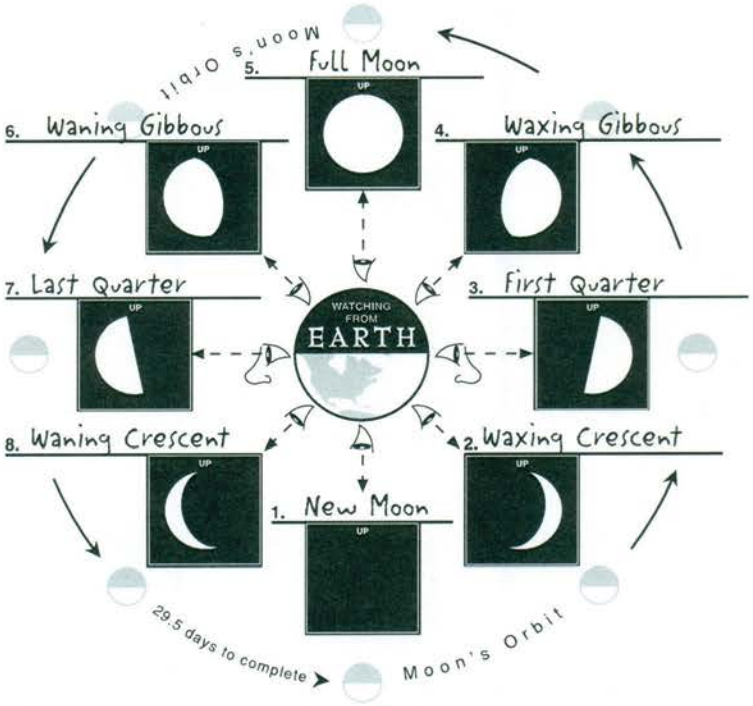
Stage 3, continued

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



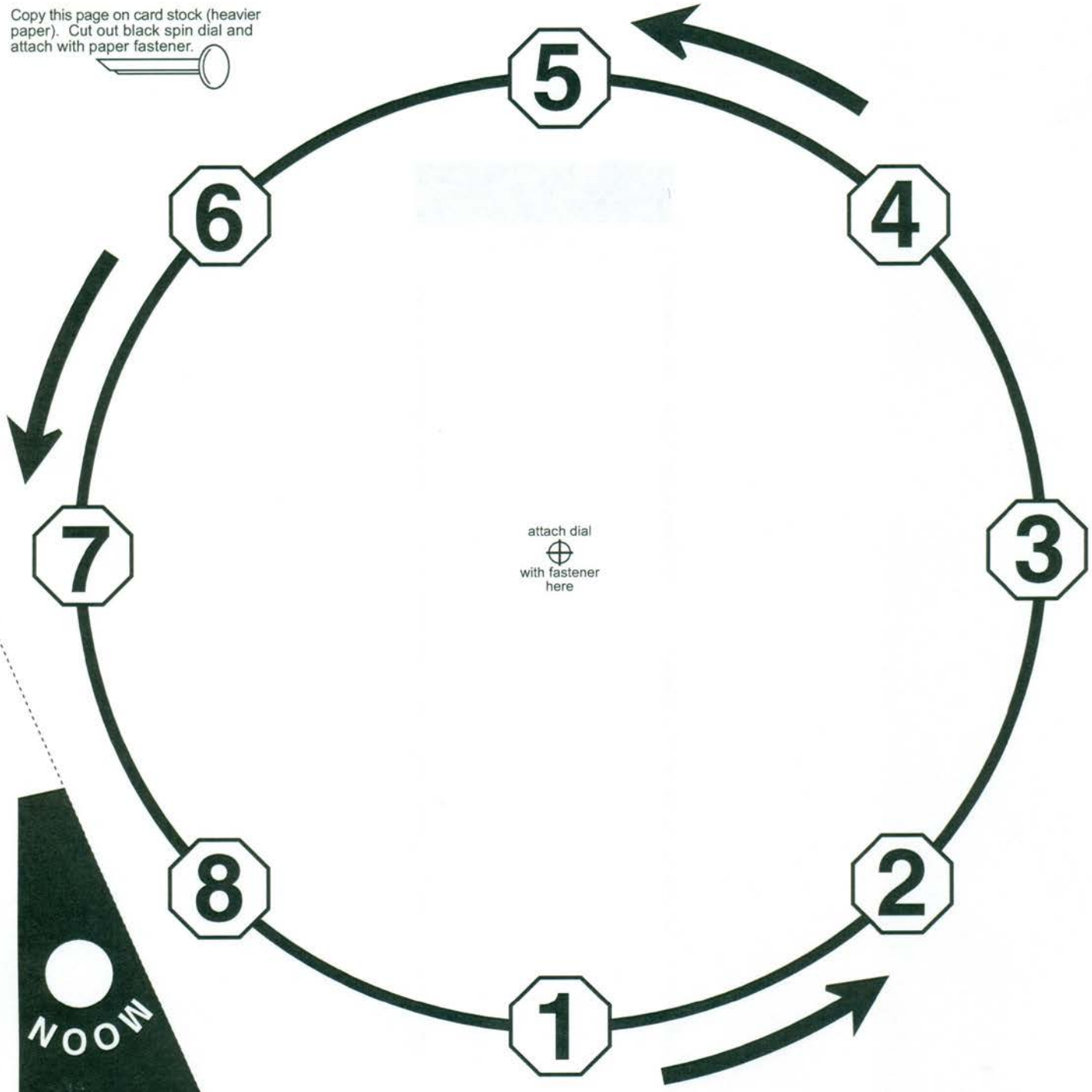
Review

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

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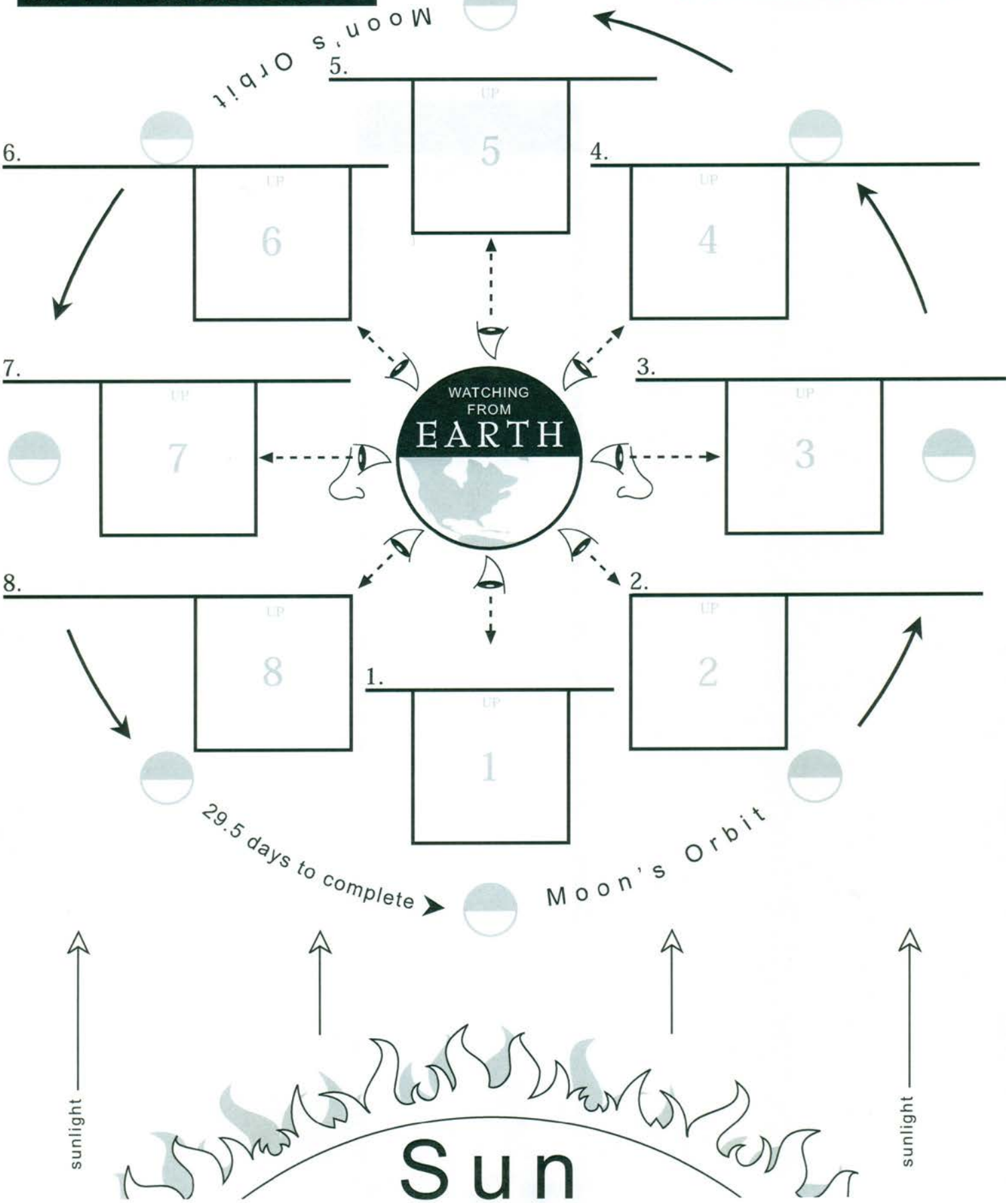
MOON PHASE CHART

LUNAR MONTH



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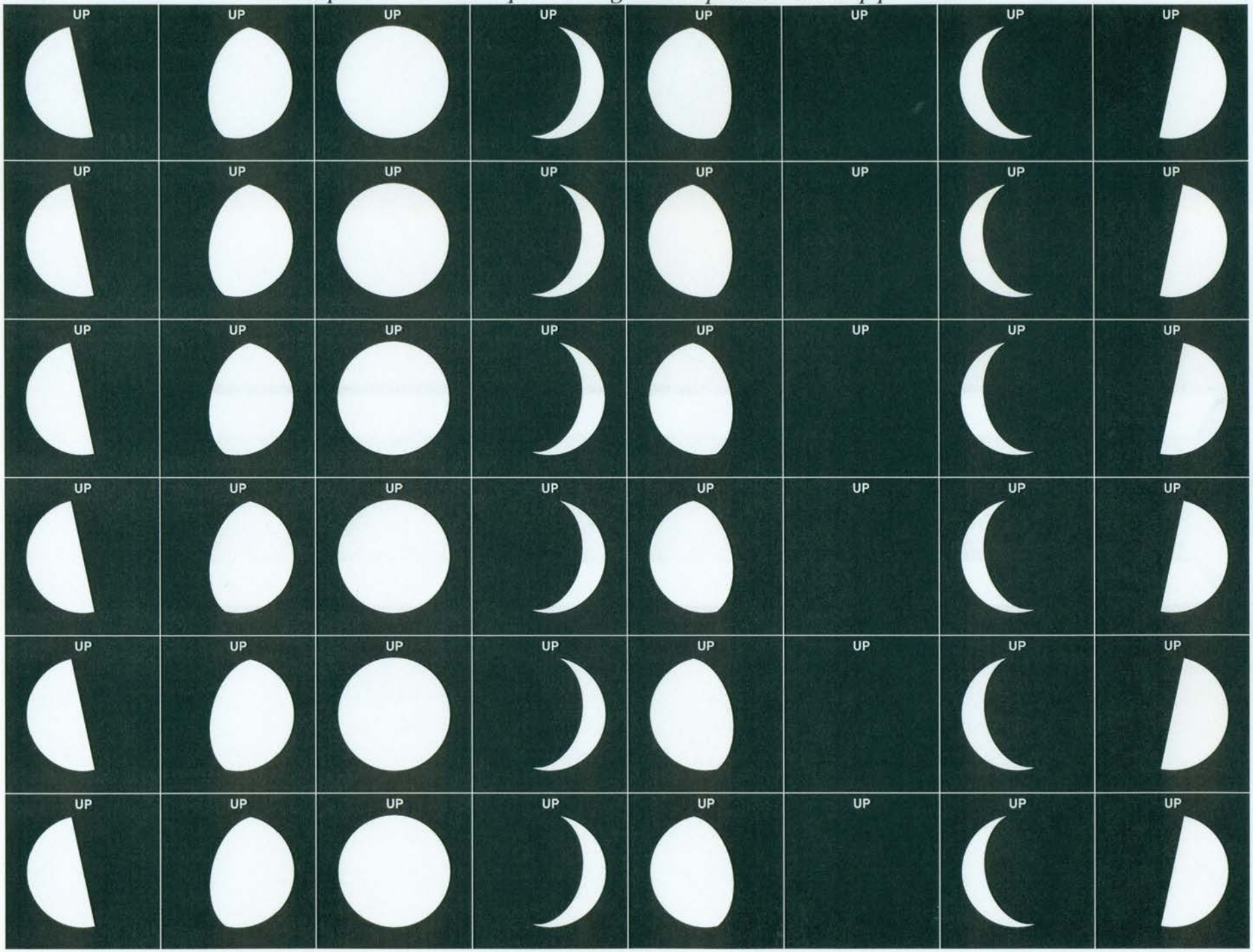
Phase Squares – *cut out strips of the eight Moon phases - one strip per student*