Title of Lesson:

Moon Motion

Essential Question:

How does the appearance of Earth's moon change in the sky?

Conceptual Statement:

Earth and its moon move in predictable patterns that can be noted by regular observation.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on the motion of objects in the sky. It is appropriate after students have a general understanding of the kinds of objects in the sky and that observation can reveal patterns. This lesson introduces the study of observable patterns of Earth's moon.

Student Outcomes:

- Students demonstrate their understanding of how the moon changes during a month.
- Students observe and record the phases of the moon during a 6-week period.
- Students use "Contextual Redefinition" to find word meanings using context within the literature selection.

Lesson Overview:

In this lesson, students use the learning strategy "Contextual Redefinition" with *The Magic School Bus Lost in the Solar System* to check their understanding of unknown or difficult words. This literature selection provides an overview of facts and concepts found in an instructional unit about Earth and its moon. Students record, describe and sequence the phases of the moon.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The Magic School Bus Lost in the Solar System is used in the ENGAGE stage. The selected reading introduces how the moon shines and how it orbits Earth.

Learning Strategy:

Students use "Contextual Redefinition" as a method of checking their understanding of new vocabulary and related concepts. This strategy encourages students to look for meaning by using context clues. (See Appendix pages 188-189.)

Literature Selection:

Title: *The Magic School Bus Lost in the Solar System*
Author: Cole, Joanna
Publisher, Year: Scholastic, 1990 ISBN: 0590414283
Annotation: In a fantastical field trip through the solar system, facts are presented in a clever manner as the school bus travels past the Sun and around the planets.
Genre: Narrative Fiction.

California Science Content Standards:*

Science: Grade 3, Earth Science

4. Objects in the sky move in regular and predictable patterns. As a basis for understanding this concept:
   b. Students know the way in which the Moon's appearance changes during the four-week lunar cycle.
   d. Students know that Earth is one of several planets that orbit the Sun and that the Moon orbits Earth.

Science: Grade 3, Physical Science

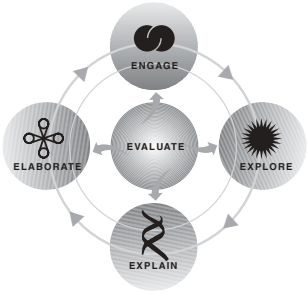
1.Energy and matter have multiple forms and can be changed from one form to another. As a basis for understanding this concept:
   a. Students know energy comes from the Sun to Earth in the form of light.
2. Light has a source and travels in a direction. As a basis for understanding this concept:
   b. Students know light is reflected from mirrors and other surfaces.

5. Investigation and Experimentation

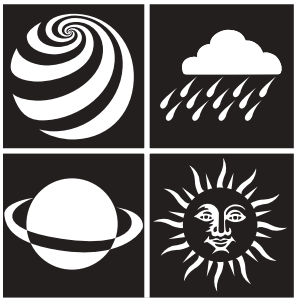
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Repeat observations to improve accuracy and know that the results of similar scientific investigations seldom turn out exactly the same because of differences in the things being investigated, methods being used, or uncertainty in the observation.
b. Differentiate evidence from opinion and know that scientists do not rely on claims or conclusions unless they are backed by observations that can be confirmed.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	Students engage in a discussion on why the students' pictures of the moon look different and find contextual clues from the reading to understand the meanings of new vocabulary. Observing, Communicating, Comparing	30 minutes
EXPLORE	Students predict, then observe and record how the moon looks each day for 4 weeks. Observing, Communicating, Comparing	4 weeks
EXPLAIN	Students explain how the moon changes during the month by sequencing moon phase pictures of their observations. They provide evidence of the moon's phase-change pattern. Communicating, Comparing, Relating	45 minutes
ELABORATE	Students predict the appearance of the moon for the next 2 weeks. Then, they make observations and discuss their findings in relationship to their prediction. Students participate in a physical model that demonstrates the relative position and motion of the sun, Earth and moon. Observing, Communicating, Comparing, Relating, Inferring	2 weeks
EVALUATE	Students further demonstrate their understanding by making a flip-book of the phases of the moon to share with their parents. Teacher evaluates student understanding to inform instruction in the EXPLAIN and ELABORATE stages. Communicating, Ordering, Relating	45 minutes



Moon Motion

Teacher Background:

On Earth, we can observe important clues that provide evidence that phases of the moon are caused by the moon's position relative to the sun. Like the sun and stars, the moon rises east and sets west, as a result of Earth's rotation from west to east. Every day, the moon rises about 50 minutes later, on the average, than the day before. This daily retardation brings the moon out of step with the sun and then into step again over a period of a month or, more exactly of 29.5 days. The moon's appearance is evenly spread over night and day over the course of a complete lunar cycle. The moon's phases can be understood as it is followed throughout one complete period as described below.

NEW MOON: When the moon is between Earth and the sun and appears in the same region of the sky where the sun is. Therefore it rises, roughly, when the sun rises and sets when the sun does. A New Moon is strictly a day fixture and the only reason we don't see it is that the sunlight falls on the far side of the moon.

WAXING (NEW) CRESENT: A few days after New Moon, because of the daily retardation, the moon rises a few hours later than the sun and appears as a narrow crescent, lighted from the right, just before noon. It is in the sky during the day, and follows the apparent movement of the sun across the sky. In this phase, the New Crescent and the sun appear in close proximity.

FIRST QUARTER: About seven days after New Moon, the moon appears half by day and half by night. It rises about 6 hours later than the sun and appears to follow the sun about half the sky away from the sun. It is typically called "half-moon" even though the technical expression is First Quarter. As the moon continues to wax it becomes Gibbous (from Latin *gibbus*, hump).

GIBBOUS (NEW GIBBOUS): Rising later in the afternoon, the moon appears Gibbous into the small hours of the morning.

FULL MOON: Two weeks after the New Moon, we observe Full Moon rising at about sunset. It is opposite the sun in the sky, and sets at about sunrise.

LAST QUARTER: The moon begins to wane and is again gibbous, with its left side lit by the sun until it reaches its Last Quarter (commonly know as a "half-moon"). The Last Quarter, observed more than three weeks after New Moon, rises in the middle of the night and sets around noon.

WANING (OLD) CRESCENT: Rising about 50 minutes later each night, the moon becomes a narrow crescent, shaped like a "C" (when waxing, the crescent was shaped like the curved part of a "D"). It can be observed in the afternoon sky, followed by the sun.

The moon always turns the same side to Earth. We observe the moon as reflected sunlight which varies with the relative positions of the moon and the sun (see description above for each phase). The moon's orbit is not in the same plane as Earth's orbit; it is slightly inclined against the orbit of Earth. If the orbit were on the same plane, we would observe a solar eclipse at every New Moon and a lunar eclipse at every Full Moon. Eclipses and phases of the moon are different phenomena.

Related California Content Standards

Math: Grade 3

Number Sense
1.0 Students understand the place value of whole numbers.

Number Sense
3.1 Compare fractions represented by drawings or concrete materials to show equivalency and to add and subtract fractions in context.

Language Arts: Grade 3

Reading
1.6 Use sentence and word context to find the meaning and other features of unknown words.
2.3 Demonstrate comprehension by identifying answers in the text.
2.6 Extract appropriate and significant information from the text, including problems and solutions.

English Language Development: Grade 3

Reading Comprehension
Read and listen to simple stories and demonstrate understanding by using simple sentences to respond to explicit detailed questions.
Read and use detailed sentences to orally identify main ideas and use them to make predictions and provide supporting details for predictions made.

Grouping: Whole class, groups of 4, groups of 2, individuals

Materials:

Per Class:

Overhead transparency of Teacher Page 1.0
Class Moon Phase Calendar (Enlarged Student Page 1.0)
Index cards, 4x6
Glue sticks
Stapler
Lamp with bare light bulb

Per Group of 4:

Enlarged row only of Moon Phase Calendar (Student Page 1.0)

Per group of 2

Dictionary

Per Individual:

The Magic School Bus Lost in the Solar System
2 Moon Phase Calendars (Student Page 1.0)
Lunar Flipbook (Student Page 2.0)
8, 4x6 Index cards cut in half (large enough for flip book-see Student Page 2.0)
Styrofoam/polystyrene ball, 3"
Pencil
Glue stick

Advanced Preparation:

1. Duplicate materials as indicated.
2. Assemble Teacher Page 1.0 Transparency as indicated at the bottom of the page.
3. Identify the words you want the students to focus on using "Contextual Redefinition."
4. Enlarge and cut strips of top row only from Moon Phase Calendar (Student Page 1.0), one per group of four.

Teacher Resources:

Daily newspaper: weather section, including moon phases.
Great Explorations in Math and Science (GEMS) "Earth, Moon, and Stars," Lawrence Hall of Science, University of California, Berkeley, 1986.
Gerald Foster, *"Look to the Moon," Science and Children* (November/December) Vol. pages 30-33, 1996.
Science Framework for California Public Schools, California Department of Education 1990 and 2002.

Teacher Tips:

- Gather alternate sources of images of the moon. Some suggestions are:
  - Take a picture of the moon each night. Be sure to stand in the same place each night and have a "reference point" in the picture (tree, housetop, etc.).
  - Copy moon phases from a newspaper weather section
  - Use printed images from a web source, magazines or other literature books (See Teacher and Student Resources)
- Check a newspaper or calendar to find the date of the next Full Moon. If possible, schedule this unit to begin three or four days after the Full Moon. During this part of the cycle, the moon will be visible most of the day. If you can schedule the observation activities for the whole class during the morning, when the moon is visible sooner, you will be able to start sooner after the Full Moon and therefore observe for a greater number of days.
- If observations are scheduled for evenings, not all students may observe the moon every night. Use students observations, plus your own.
- Remind students to hold their moon model elevated slightly above their heads during the whole class experience observing the light reflecting from Styrofoam balls as a model of the phases of the moon.

VOCABULARY

Provide still and video images to support understanding of new vocabulary

crater – A bowl-shaped depression on the surface of the moon or a planet caused by the impact of a meteorite

cycle – A period of time between repetitions of an event or phenomenon that occurs regularly

gibbous – Seen with more than half but not all of the surface illuminated

gravity – The force that the Earth or another celestial body exerts on any small mass close to its surface

lunar – Relating to a moon or its movement around a planet, especially the moon in relation to Earth

meteorite – a stony or metallic object from space that remains after burning in the atmosphere and strikes a planet

observation – use of the senses or an extension of the senses (e.g., telescope) to acquire information from the environment

orbit – The path that a planet, moon or man-made satellite follows around a larger celestial body such as the Sun

pattern – A regular or repetitive form, order, or arrangement

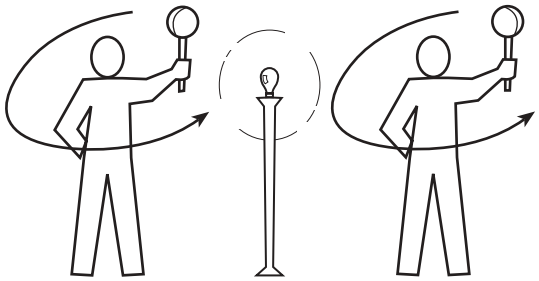
phase – any of the forms, recurring in cycles, in the moon or a planet appearance

reflect – To redirect something (light) that strikes a surface, usually back toward to point of origin

wane – To show a progressively smaller lighted surface, as the moon does when passing from full to new

wax – To show a progressively larger lighted surface, as the moon does in passing from new to full

- Be sure to place the lamp so that its exposed bulb is positioned approximately at students' shoulder height.



In this model the light source represents the sun, the child's head represents Earth, and the syrofoam ball represents the moon.

See ELABORATE steps 20-27.

- A "Word Wall" is a vocabulary reference source kept visible during an entire instructional unit, usually in a bulletin board format.
- Plan a trip to a planetarium for a show on the solar system.

Common Misconceptions:

Students might think that there is a "dark side" of the moon. There is no "dark side." The side we never see is facing way from Earth due to the synchronous rotations of Earth and the moon. A better term is "far side." A New Moon is when the far side is lit.

Related Student Resources:

Asimov, Isaac. *Nuestra luna (The Earth's Moon)*. SM, 1989.

Branley, Franklyn M. *What the Moon is Like*. HarperCollins Children's Books, 2000.

– *The Moon Seems to Change*. HarperCollins Children's Books, 1999.

Rey, H.A. *Find The Constellations*. Houghton Mifflin, 1976.

Silver, Donald M. *The Night Sky (One Small Square)*. McGraw hill, 1998.

Willis, Shirley and FranklinWatts. *Dime porqué cambia de forma la luna (Tell Me Why the Moon Changes Shape)*. 1999.

Lesson Credits:

The lunar calendar graphics in this lesson are from the *What's In the Sky?* curriculum from the Fresno Unified School District, Third Grade Writing Team, 1991.

The overhead solar system diagram is from Tom Campbell of the T.C. Bird Planetarium in Boise, Idaho.

Hands-on ELABORATE activity adapted from GEMS guide, *Earth, Moon, and Stars.*

ENGAGE
EXPLORE
EXPLAIN
ELABORATE
EVALUATE

The Science Learning Cycle:

Moon Motion

ENGAGE:

1. Ask students, individually, to draw a picture of the moon. Select students with different drawings (e.g., Full Moon, Quarter Moons, Crescents) and have them share their drawings with the class. Ask the class "Why do the pictures look different?" Engage students in a discussion by asking questions regarding the differences in the pictures. Focus on the different shapes and the use of descriptive words.

2. Use "Contextual Redefinition" while reading pages 11-13 in *The Magic School Bus Lost in the Solar System* aloud to the class. Use the strategy as follows:

   a. Write these vocabulary words on the board; moon, crater, gravity, meteorite, orbit, reflect, New Moon, Crescent, Gibbous, Quarter Moon, and Full Moon.

3. Have students work in groups of four. Ask students to provide a meaning for each word using a sentence or short paragraph (e.g., The Earth's orbit around the sun is an oval.)

4. Ask groups to share out their contextual definitions.

5. Ask pairs of students to read pages 7-13. Have students focus on the vocabulary words, looking for contextual clues in the illustrations and text to clarify and verify the meaning of the words. Ask students to draw a picture of the words.

6. Ask students to verify and compare their definitions by using a dictionary. Call on several partners to share the meanings they have learned for various words.

EXPLORE:

7. Divide students into groups of four. Provide images of the moon and moon's phases (see Teacher Tips) and ask students to describe and discuss what they see. Encourage students to use accurate math and science vocabulary as they describe the images. As new words are used by the students, add the words to the Word Wall.

8. Distribute an enlarged copy of the top row of blank circles (one week's worth of circles) from Student Page 1.0 to each group. Display a picture of what the moon looked like the night before and ask groups to predict what they think the moon will look like for the next six days. Have groups color their predictions in the circles.

9. Ask groups to share their predictions and explain the information on which they based their ideas. Post the strips. Discuss similarities and differences among the groups' predictions.

10. Distribute a **Moon Phase Calendar** (Student Page 1.0) to each student and assign as homework ongoing observations and recording. Ask students to go outside each day/evening, observe the moon and draw a picture of how it looks for that day's observation. (See Teacher Tips.)

11. After a week of observing the moon, have the students review their observations and compare it with their original prediction. How is their observation like or different than their prediction? Ask students to write at least one sentence describing their observations of the moon so far.

12. Get a consensus from the students as to how the moon looked each day. Ask several students to come to the **Class Moon Phase Calendar Chart** and record the consensus shape for each day. Ask students to draw in the shapes on the **Class Moon Phase Calendar Chart.**

EXPLAIN:

13. Continue to provide time each day during the next four weeks to have students share their daily observations. At the end of each week, get a consensus as to how the moon looked each day for that week and ask students to record shapes on the **Class Moon Phase Calendar Chart**.

14. Ask students to review their four-week observations. What patterns do they notice? How does the shape of the moon appear to change?

15. Ask students to compare their own four-week observations with the **Class Moon Phase Calendar Chart**. What similarities and differences do they notice? How does the shape of the moon appear to change as it approaches the New Moon or the Full Moon?

16. Help students label the phases of the moon on their Moon Calendar. Provide the following words: New Moon, Crescent, Gibbous, Quarter Moon, Full Moon. Remind students that they can use their definitions from the "Contextual Redefinition" and their class discussions to help them identify the phases.

ELABORATE:

17. Based on their four-week observation, ask students to predict what they think the pattern of the moon's appearance will be for the next two weeks. Distribute Student Page 1.0 to each student. Ask students to continue their observations and recordings. At the end of two weeks, have students compare their predictions with their actual observations. How did their observations for the 4-weeks help them understand the 2-week observation?
18. Ask students to think about how the moon's orbit helps explain the pattern that they observed. Ask students to think about how a model might help explain what they have observed. Help students understand that their explanations for phases of the moon are models.
19. Demonstrate a common model for moon phases by placing an exposed light bulb in a lamp in the center of the room at about student shoulder height. Darken the room so that the only light comes from the lamp in the center (the lamp represents the sun in the model).
20. Distribute a Styrofoam/polystryene ball and pencil to each student. Ask students to mount their ball on the pencil point. Explain that the ball represents a model of the moon. Arrange students with their moon model in a circle around the lamp. Explain to students that each of their heads represents Earth in this model.
21. Instruct students to hold their moon models at arm's length, slightly elevated from the shoulder, facing the sun (lamp). Ask students if they observe any reflected light from the lamp on the side of the moon model facing them.
22. Instruct students to move the moon model a little to the left until they can see a thin crescent lit up. Circulate to make sure everyone is holding the moon model a little to the left of the sun.
23. When everyone can see the crescent, ask; "Is the bright curved side of your moon model facing toward the sun, or away from it?" (Toward the sun, just like the actual New Crescent Moon.) Ask students to describe the shape of the reflected light (curved shape of the letter "D").
24. Tell students to continue moving their moon models around their heads in the same direction, until exactly half of the moon is lit. Ask; "To make the moon appear fuller (Gibbous), does it have to move toward the sun or away from it?" (Away from the sun, just as in the actual phases of the moon leading to Quarter Moon.)
25. Tell students to continue moving the moon in a circle until the part they see is fully lit. Remind students to keep their moon model elevated above their shoulders. 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.) Students continue moving their moon model in the same direction until it is just half-full (Last Quarter). Ask; "As the moon moves toward the sun, does it appear to get fuller or thinner?" (Thinner.)
26. Finally, tell the students to move their moon models so they are very thin crescents (Old Crescent). Explain that most of the time the moon does not pass directly in front of the sun, but just above or below the sun, relative to Earth (their head in this model). When the moon is between Earth and 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 New Moon.
27. Have students move their moon models in circles slowly, while standing in the same place, several times until they can fully describe the phases of the moon. The movement of the moon from New Crescent to Full Moon models the two-week period when the moon is visible in the evening. The full circle represents about one month or 29.5 days.

EVALUATE:

28. Distribute Student Page 2.0 and ask students to cut into squares. Ask students to begin with the New Moon and sequence the squares as the moon's appearance changes until a New Moon reappears. Have students mount the pictures on index cards to create a flip-book to share with their family.
29. Ask students to demonstrate the model of the phases of the moon with family members.

Teacher Reflection:

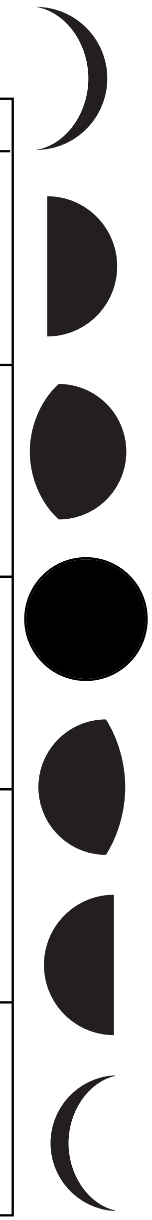
1. How does the student work provide evidence of student understanding that the moon moves in predictable patterns?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

My Moon Phase Calendar

Look for the moon each morning, afternoon, and night.
Draw its shape on your calendar.

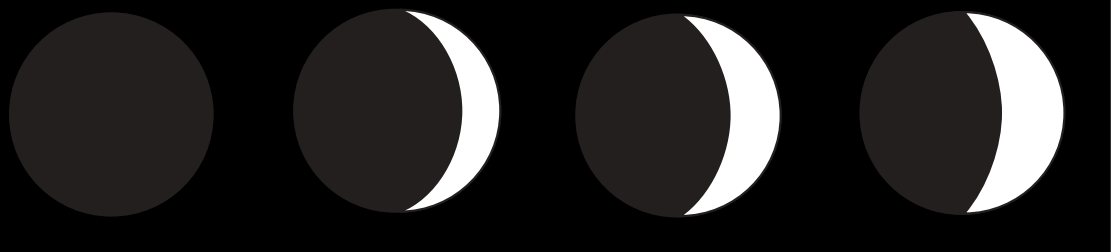
____
Astronomer

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday



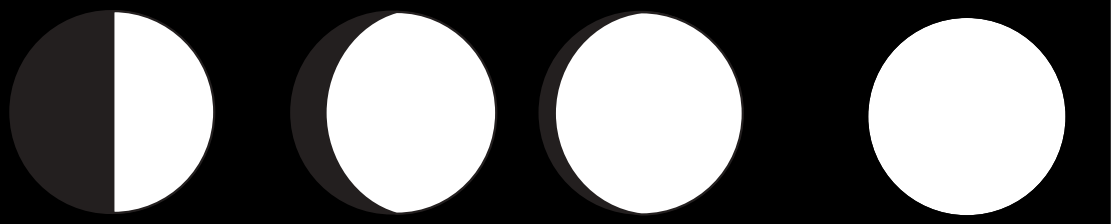
Cut Cut Cut

1	2	3	4
New Moon	New Crescent	New Crescent	New Crescent



Cut

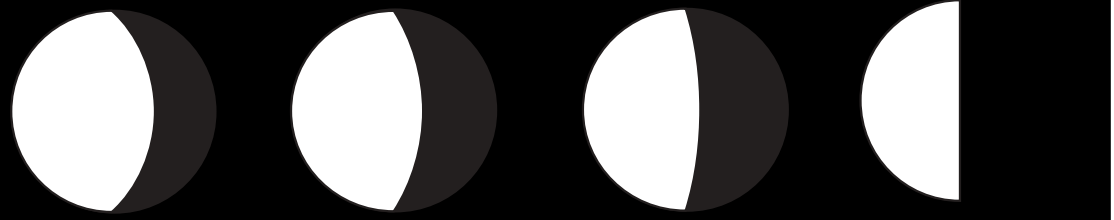
5	6	7	8
Quarter	New Gibbous	New Gibbous	Full Moon



Old is also called Waning

Cut

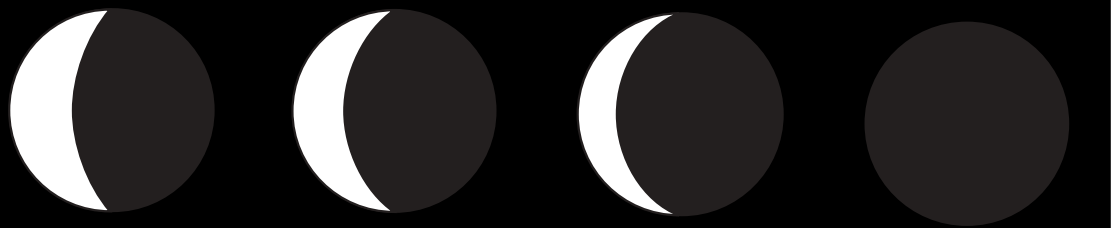
9	10	11	12
Old Gibbous	Old Gibbous	Old Gibbous	Last Quarter



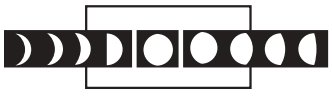
New is also called waxing.

Cut

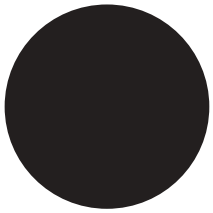
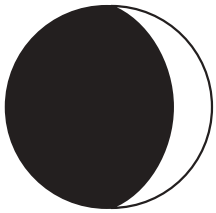
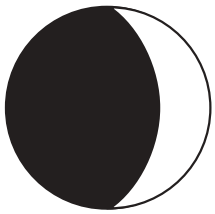
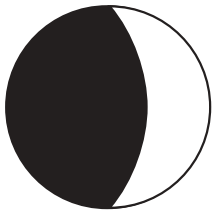
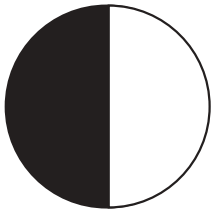
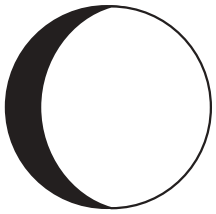
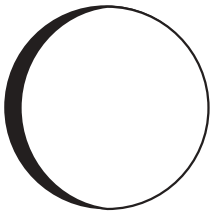
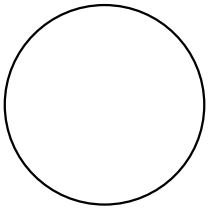
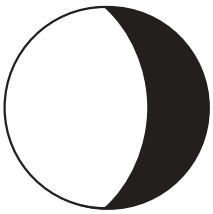
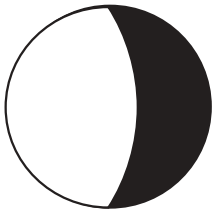
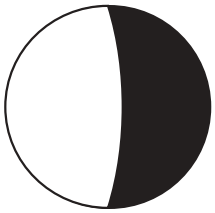
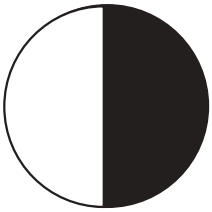
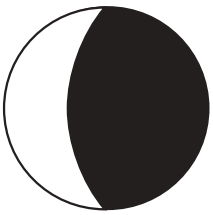
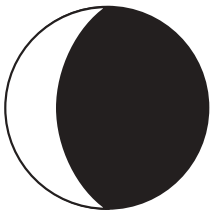
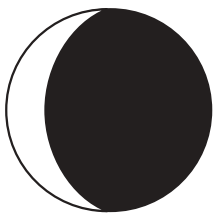
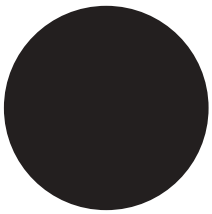
13	14	15	16
Old Crescent	Old Crescent	Old Crescent	New Moon



Make a transparency of this sheet. Cut each strip apart, then tape the 4 strips together to make one long strip. Use an index card to make a holder. Pull the transparency through on the overhead to show moon phases.



Cut Cut Cut

1 New Moon	2 New Crescent	3 New Crescent	4 New Crescent
			
5 Quarter	**6** New Gibbous	**7** New Gibbous	**8** Full Moon
			
9 Old Gibbous	**10** Old Gibbous	**11** Old Gibbous	**12** Last Quarter
			
13 Old Crescent	**14** Old Crescent	**15** Old Crescent	**16** New Moon
			

Cut

Cut

Cut

Leave the phases of the moon uncolored. Color all the other areas black.
Cut out the cards and glue them to the bottom corner of 1/2 pieces of index cards.
Staple together to make a flip book