A Content Secondary Science Newsletter from the
Southern Nevada Regional Professional Development Program

Science Dissected

Moon Phases
Model-Evidence Link Diagram (MEL)

The changing of the Moon from New to Full and back again is often a source of misconceptions among students. Many students assume that the phases of the Moon are created from the Earth's shadow slowing going over the Moon and then leaving it just as slowly. As Scientists, we understand that the Earth's shadow has nothing to do with the phases, but instead, eclipses.

One of the biggest hurdles in teaching Moon phases is to get students to think about their perception of the Moon. "Is the Moon really changing or is what I am seeing changing?" Students have to be able to think of how the Moon looks from space and how it appears from Earth to fully grasp the concept of why the Moon's shape changes over time.

Model A: Moon phases are caused by the amount of shadows on the moon.	***Model B: Moon phases are caused by our perception of the amount of shadows on the moon.***

Evidence #1: The relationship between the Earth, Moon, and Sun can be described in a predictable way.

Evidence #2: Lunar Eclipses are caused when the Moon goes through either the Earth's penumbral or umbral shadow.

Evidence #3: The Moon has phases because it orbits the Earth, which causes the portion we see illuminated to change.

Evidence #4: Half of the Moon always is illuminated by the Sun as it makes its way around the Earth every 27.3 days.

The following is a suggestion for using this MEL with students:

1. Hand out the Moon Phases Model Evidence Link Diagram (page 1). Instruct students to read the directions, descriptions of Model A and Model B, and the four evidence texts presented.
2. Hand out the three evidence text pages .
3. Evidence 1 is based off of a PhET computer simulation. Students will need access to computers to finish this activity. When completed, have students construct two lines from Evidence #1; one to Model A, one to Model B.
4. Have students carefully go over the text in Evidence 2-3 and repeat the process for creating lines to Model A and Model B.
5. Evidence 4 is based off of a video clip. Have students watch the video clip and then construct lines to both Model A and B.
6. Hand out page 2 for the students to critically evaluate their links and construct understanding.

Once students have completed page 2, they can then engage in collaborative argumentation as they compare their links and explanations with that of their peers. Students should be given the opportunity to revise the link weighting during the collaborative argumentation exercise. Students should be able to reflect on the model they chose with best evidence supporting it and create questions they may still have about how those on the Earth see the moon.

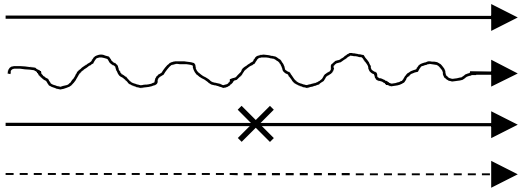
Archived Issues of Science Dissected, *http://www.rpdp.net/link.news.php?type=sciencedis*. ***Instructional Resource resulting from Plausibility, It's All About Connecting the Models Workshop co-sponsored by CPDD and SNRPDP Science March 6, 2012***

Written by: Lori Henrickson

Name:_____ _____ **Period:**_____

Directions: draw two arrows from each evidence box. One to each model. You will draw a total of 8 arrows.

Key:



The evidence **supports** the model

The evidence **STRONGLY supports** the model

The evidence **contradicts** the model (shows its wrong)

The evidence has **nothing to do with** the model

Standard:E.8.B.7.

Evidence #1
The relationship between the Earth, Moon, and Sun can be described in a predictable way.

Model A
Moon phases are caused by the amount of shadows on the moon.

Evidence #3
The Moon has phases because it orbits the Earth, which causes the portion we see illuminated to change.

Evidence #2
Lunar Eclipses are caused when the Moon goes through either the Earth's penumbral or umbral shadow.

Model B
Moon phases are caused by our perception of the amount of shadows on the moon.

Evidence #4
Half of the Moon always is illuminated by the Sun as it makes its way around the Earth every 27.3 days.

Provide a reason for three of the arrows you have drawn. **Write your reasons for the three most interesting or important arrows.**

A. Write the number of the evidence you are writing about.
B. Circle the appropriate descriptor (**strongly supports | supports | contradicts | has nothing to do with**).
C. Write the letter of the model you are writing about.
D. Then write your reason.

1. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

2. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

3. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

4. Circle the plausibility of each model. [Make two circles. One for each model.]

	Greatly implausible (or even impossible)									Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

5. Circle the model which you think is correct. [Only circle one choice below.]

Very certain that Model A is correct	Somewhat certain that Model A is correct	Uncertain if Model A or B is correct	Somewhat certain that Model B is correct	Very certain that Model B is correct

Evidence #1: The relationship between the Earth, Moon, and Sun can be described in a predictable way.

Topic: How does gravity affect orbits?

Topic Description
Using the PhET simulator, students will observe how gravity affects the orbit of the Earth and Moon.

Beginning Ideas
1. What is the relationship between mass and gravity of an object?

2. How is that path of an object affected by the mass of a neighboring object?

3. What is the relationship between the movement of the Earth and the Moon?

Tests
3. Run the simulator using the Sun, Earth, and Moon option. Make sure to turn on the "Path" option. Record your observations in the data table under observations.
4. Click the "Reset All" on the page. Click the Sun, Earth, Moon option and turn on the "path" setting. Change the size of the sun on the slider all the way to the right. Run the simulation. Record your observations in the data table.
5. Click the "Reset All" on the page. Click the Sun, Earth, Moon, option and turn on the "path" setting. Change the Earth's size slider all the way to the right. Run the simulation. Record your observations in the data table.

Observations

Objects used:	Earth's Path	Moon's Path	Sun's Path
Scenario 1 Sun, Earth, and Moon			
Scenario 2 Really big Sun, Earth and Moon			
Scenario 3 Sun, Really big Earth, and Moon			

Claims
6. What claims can you make from your observations?

As evidence by Scenario 1, I claim that objects traveling around a sun go on a predictable path because …..

As evidence by Scenario 2, I claim…

because the bigger mass will have a greater gravitational pull on an object orbiting it.

As evidence by Scenario 3 I claim… because…

Evidence

7. What evidence do you have to support your claims for each scenario? (hint: use what you saw)

Scenario 1-

Scenario 2-

Scenario 3-

Reading

8. Compare your data to another classmate's data. What similarities do you see? What differences do you see? If there are differences, why do you think there are?

Reflection

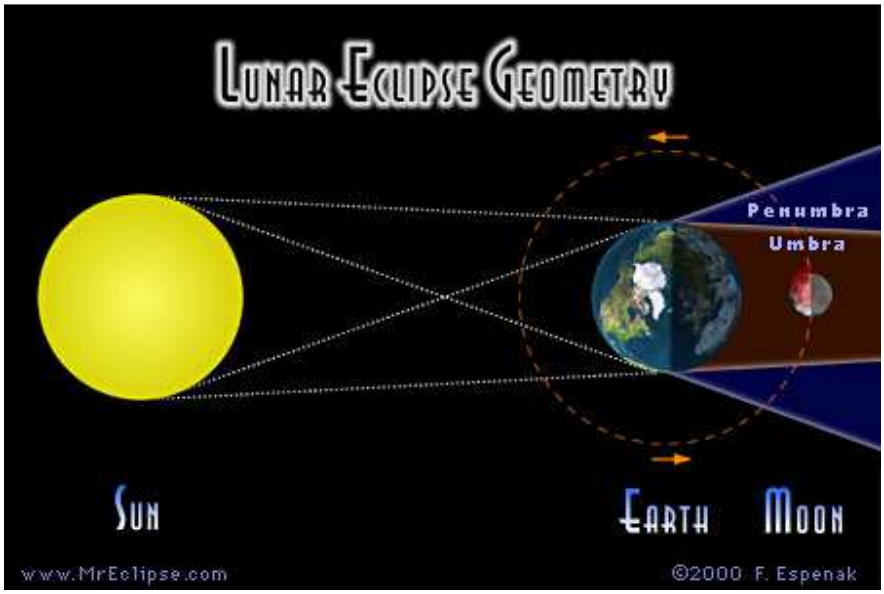
9. How have your ideas about mass's affect on gravity changed over this activity?

10. How does an object's mass affect objects that are orbiting around it? How does the path of an orbiting object change due to fluctuation in mass?

11. What is the relationship between the moon's orbit and the Earth? Describe the movement between both objects. (Is this predictable motion? Does the moon always stay between the Sun and the Earth?)

Evidence #2: Lunar Eclipses are caused when the Moon goes through either the Earth's penumbral or umbral shadow.

LUNAR ECLIPSES



Geometry of the Sun, Earth and Moon During an Eclipse of the Moon
Earth's two shadows are the penumbra and the umbra.
(Sizes and distances not to scale)

Types of Lunar Eclipses

An eclipse of the Moon (or lunar eclipse) can *only* occur at Full Moon, and only if the Moon passes through some portion of Earth's shadow. That shadow is actually composed of two cone-shaped components, one nested inside the other. The outer or penumbral shadow is a zone where the Earth blocks part but not all of the Sun's rays from reaching the Moon. In contrast, the inner or umbral shadow is a region where the Earth blocks *all* direct sunlight from reaching the Moon.

Astronomers recognize three basic types of lunar eclipses:

1. Penumbral Lunar Eclipse

- The Moon passes through Earth's penumbral shadow.
- These events are of only academic interest because they are subtle and hard to observe.

2. Partial Lunar Eclipse

- A portion of the Moon passes through Earth's umbral shadow.
- These events are easy to see, even with the unaided eye.

3. Total Lunar Eclipse

- The entire Moon passes through Earth's umbral shadow.
- These events are quite striking due to the Moon's vibrant red color during the total phase (totality).

Why not every month?

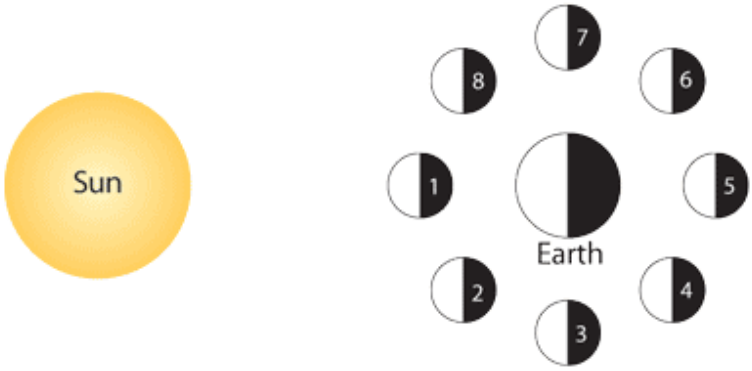
Now you might be wondering "If the Moon orbits Earth every 29.5 days and lunar eclipses only occur at Full Moon, then why don't we have an eclipse once a month during Full Moon?". I'm glad you asked! You see, the Moon's orbit around Earth is actually tipped about 5 degrees to Earth's orbit around the Sun. This means that the Moon spends most of the time either above or below the plane of Earth's orbit. And the plane of Earth's orbit around the Sun is important because Earth's shadows lie exactly in the same plane. During Full Moon, our natural satellite usually passes above or below Earth's shadows and misses them entirely. No eclipse takes place. But two to four times each year, the Moon passes through some portion of the Earth's penumbral or umbral shadows and one of the above three types of eclipses occurs.

When an eclipse of the Moon takes place, everyone on the night side of Earth can see it. About 35% of all eclipses are of the penumbral type which are very difficult to detect, even with a telescope. Another 30% are partial eclipses which are easy to see with the unaided eye. The final 35% or so are total eclipses, and these are quite extraordinary events to behold.

Total Lunar Eclipse of 2004 Oct 27-28
Beginning (right), middle (center) and end (left) of totality Taken from:
http://www.mreclipse.com/Special/LEprimer.html 03/04/12

Evidence #3: The Moon has phases because it orbits the Earth, which causes the portion we see illuminated to change.

Why does the Moon have phases?



The Moon has phases because it orbits Earth, which causes the portion we see illuminated to change. The Moon takes 27.3 days to orbit Earth, but the lunar phase cycle (from new Moon to new Moon) is 29.5 days. The Moon spends the extra 2.2 days "catching up" because Earth travels about 45 million miles around the Sun during the time the Moon completes one orbit around Earth.

At the new Moon phase, the Moon is so close to the Sun in the sky that none of the side facing Earth is illuminated (position 1 in illustration). In other words, the Moon is between Earth and Sun. At first quarter, the half-lit Moon is highest in the sky at sunset, then sets about six hours later (3). At full Moon, the Moon is behind Earth in space with respect to the Sun. As the Sun sets, the Moon rises with the side that faces Earth fully exposed to sunlight (5).

Why do we always see the same side of the Moon from Earth?

The Moon always shows us the same face because Earth's gravity has slowed down the Moon's rotational speed. The Moon takes as much time to rotate once on its axis as it takes to complete one orbit of Earth. (Both are about 27.3 Earth days.) In other words, the Moon rotates enough each day to compensate for the angle it sweeps out in its orbit around Earth.

Gravitational forces between Earth and the Moon drain the pair of their rotational energy. We see the effect of the Moon in the ocean tides. Likewise, Earth's

gravity creates a detectable bulge -- a 60-foot land tide -- on the Moon. Eons from now, the same sides of Earth and Moon may forever face each other, as if dancing hand in hand, though the Sun may balloon into a red giant, destroying Earth and the Moon, before this happens.

From: http://stardate.org/nightsky/moon 03/04/12

Evidence #4: Half of the Moon always is illuminated by the Sun as it makes its way around the Earth every 27.3 days.

Phases of the Moon- Video

http://www.newtonsapple.tv/video.php?id=1671

Watch the linked video.

Overview:
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. So how do you explain why this happens? 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 pass 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!

Taken from http://www.newtonsapple.tv/video.php?id=1671 03/04/12