Unit Title: The Moon (Phases, Eclipses, & Tides)

Grade Level: Fifth

GLCEs:

Science Content

- E.ST.05.22 Explain the phases of the moon.
- E.ST.05.24 Explain lunar and solar eclipses.
- E.ST.05.25 Explain the tides of the oceans as they relate to the gravitational pull and orbit of the moon

Inquiry Process

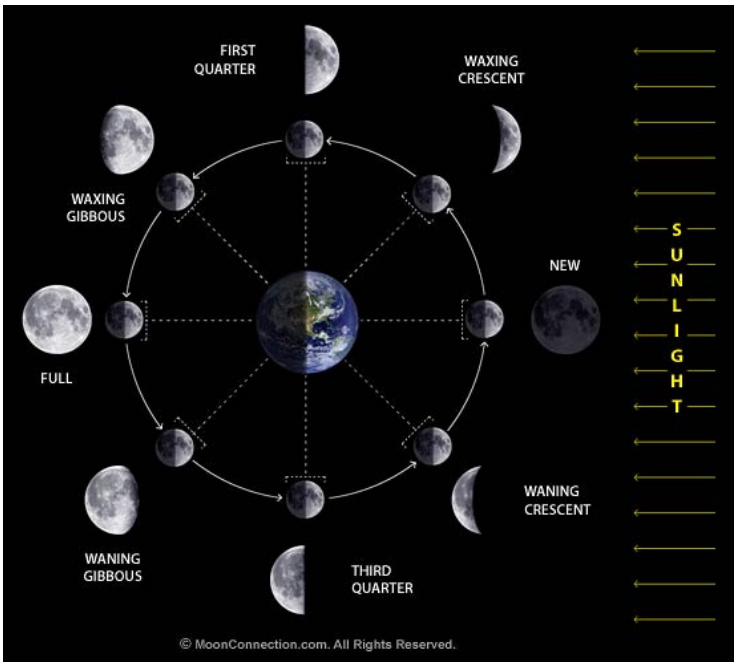
- S.IP.05.11 Generate scientific questions based on observations, investigations, and research
- S.IP.05.15 Construct charts and graphs from data and observations
- S.IP.05.16 Identify patterns in data
- S.RS.05.15 Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities

Science Background:

- While many theories exist about the formation of the moon, the one most accepted is that it was formed around the same time as the Earth, approximately 4.6 billion years ago. It is believed that a rogue body collided with Earth and a large amount of material was broken off into space. Some of the material was captured into the Earth's orbit and gradually formed the current shape of the moon. The collision may have caused the depression that is now the Pacific Ocean and subsequent collisions resulted in other smaller depressions on Earth and many of the remaining craters on the moon. These collisions tapered off around 3 billion years ago (Shaffer, 1994, p. 72).

Phases of the moon:

- Similar to the Earth's motion around the Sun, the moon orbits around the Earth. The moon maintains an average distance 382,400 kilometers and travels in an oval orbit at a speed of 3680 kilometers per hour. The lunar month (period from one new moon to the next) is 29.5 days, during this time the moon will pass through each phase in the illustration below (BCAMSC, 2009, p.45):



(Moon Connections, 2011)

- The moon does not create its own light, but instead reflects light from the sun. Half of the moon is always lit, but that half is not always facing the Earth. The difference in appearance (or phases) correlates with how much of the lit side is facing the Earth.

- New Moon – a phase that is rarely visible from the Earth. This phase occurs when the moon is in between the sun and Earth, so the only side that is lit is facing the sun. The moon cannot be seen due to reflection of light from the sun, but is sometimes seen from the light that is reflected off the Earth from the sun (called Earthshine). A common misconception is that since the moon is between the Earth and sun that a solar eclipse would happen monthly, but this does not occur because of the 5 degree tilt in the orbit of the moon off of the plane between sun and Earth.

- First Quarter – a phase when the moon has completed one quarter of its trip around Earth. The right half of the moon is visible and this happens 6-8 days after the new moon.

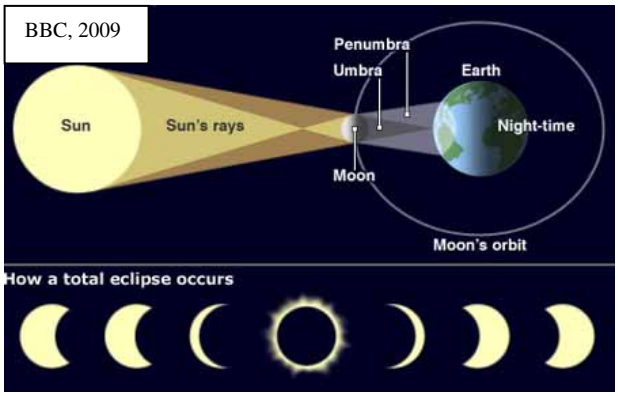
- Full Moon – a phase where the Earth is between the sun and moon. The full circle of the moon is visible to an observer on the Earth. The light is often bright enough to cast shadows on the Earth.

- Last Quarter – a phase when the moon has completed three quarters of its trip around Earth. The left half of the moon is visible and this happen 6-8 days after the full moon.

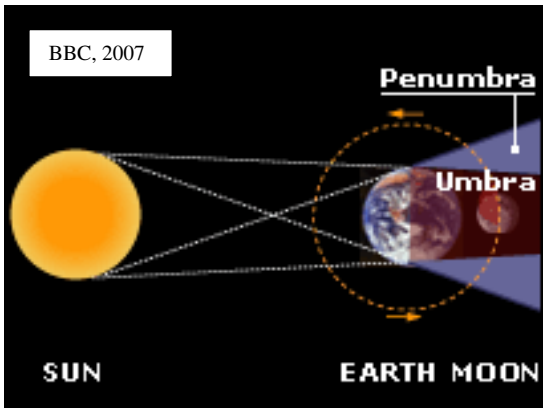
- When only a sliver of the moon is visible, it is called a crescent. This occurs between the new moon and each of the quarter moons. When the moon is between the quarter moons and full, it is called a gibbous.

- As the visible portion of the moon grows larger each day, the phases are called and labeled waxing. This begins on the right side with a very small crescent and becomes a full moon half way through the lunar month. As the visible portion of the moon gets smaller each day, the phases are called and labeled waning. The darker parts begin to appear on the right side the day after a full moon and continue until the small crescent in on the left side the day before the next new moon (BCAMSC, 2009, pp.45-47).

Solar and Lunar Eclipse



- A solar eclipse can only happen during a new moon. This occurs when the moon passes between the sun and the Earth. The moon follows a close path to the sun throughout the day, rising and setting at similar times. The solar eclipse is when the moon passes within the plane of the sun and the Earth and casts a shadow on the Earth, temporarily blocking some of the sun's light. When the moon passes through the penumbra, there is a partial eclipse on the Earth. When the moon passes through the umbra, there is a total eclipse in a small region of the Earth. Due to the 5 degree tilt of the orbit for the moon off of the plane between the sun and the Earth, solar eclipses geometrically line up only 2 times per year. (BCAMSC, 2009, p.55)

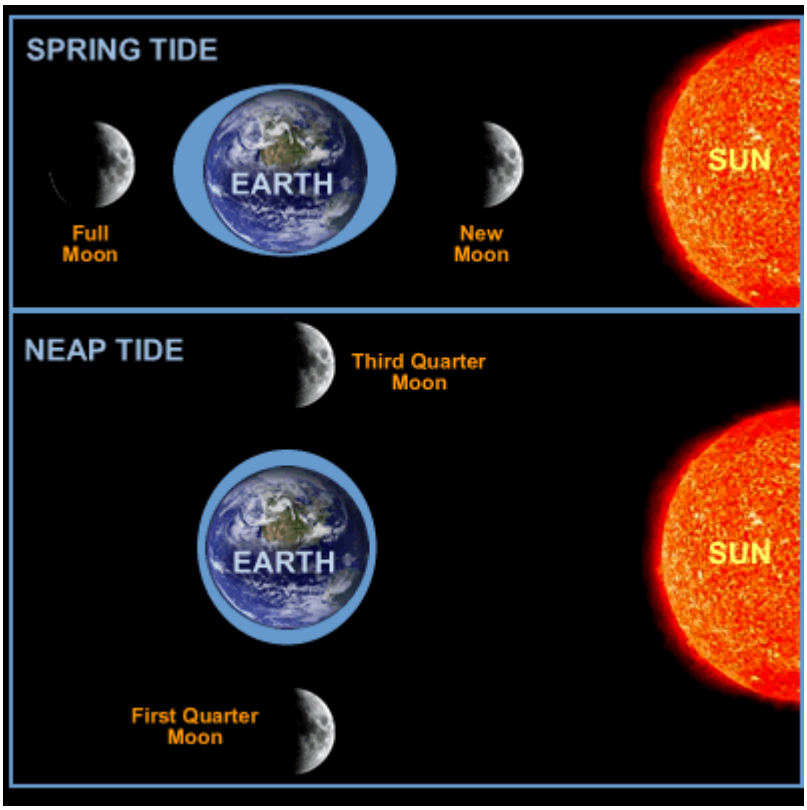


- A lunar eclipse can only happen at a full moon and is when the moon passes within the Earth's shadow. The full moon rises at sunset and is visible the entire night. The full moon sets as the sun is rising; this is because they are opposite each other during this phase. This eclipse also needs the geometry of the plane between the sun and the Earth to line up with the orbit of the moon, but occurs 2-4 times per year. As the moon passes through the penumbra, the eclipse is partial; it then is total eclipse while in the umbra shadow. Unlike the limited viewing area of the solar eclipse, the lunar eclipse is viewable from all areas of the Earth that are experiencing night (BCAMSC, 2009, p.56)

Tides

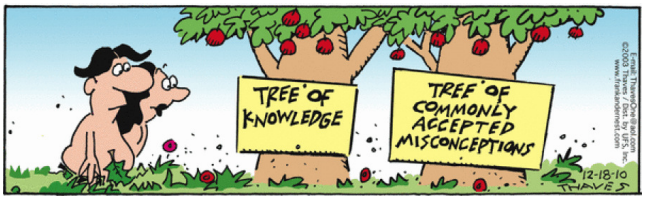
- The oceans of the world are changing all of the time. Winds and current cause waves along the surface of the water and the gravitational pull as the sun, Earth, and moon interact cause the tides that change the level of the water daily. The moon and sun pull at the oceans and cause them to "bulge" out. This is predictable because of the consistent movement of the Earth around the sun and the moon around the Earth. Although the mass of the sun is much greater than the moon, the close proximity of the moon has a greater impact on the tides.

- As the Earth rotates on its axis over the 24 hour day, each position lines up with the moon to produce two high tides and two low tides. There are two types of tides based on the position (or phase) of the moon. Spring tide (not related to the season) occurs during new and full moons and produces the largest high tides. Neap tide occurs during the quarter moons and is not as significant as the spring tide.



Misconceptions:

- The moon generates its own light
- The moon phases are shadows on the moon
- Clouds cause the moon phases



- The moon is larger than the sun and Earth
- The moon is only visible at night
- When we see a full moon locally, people on the other side of the world see a different phase (Stepans, 2003)

Lessons

1. Intro – Students will explore moon landmarks and lunar landing history. They will be assigned to make nightly observations of the appearance of the moon.

2. Phases (Part 1) – Students will learn about moon phases by participating in a model, reading a trade book, operating an online simulator.

3. Phases (Part 2) – Students will continue to learn about moon phases by singing a review song and creating another model.

4. Eclipses – Students will learn about eclipses by participating in a model and operating an online simulator.

5. Tides (Part 1) – Students will learn about tides by participating in a model and reviewing prior knowledge about gravitational forces.

6. Tides (Part 2) – Students will continue to learn about tides by looking for patterns in current tidal charts and data.

7. Closure/Field Trip – Students will visit a local planetarium to view an interactive show about moon phases and eclipses.

Resources:

- (2008). *Total solar eclipse* [Online video]. Exploratorium. Retrieved June 9, 2011, from http://www.youtube.com/watch?v=XMyqPxFh5Zw
- Beuter, C. (n.d.). Paper plate education. In *Depaul univeristy*. Retrieved June 9, 2011, from http://analyzer.depaul.edu/paperplate/Oreo%20Moon%20Phases.htm
- BBC. (2009). *Total solar eclipse* [online image]. Retrieved from: http://news.bbc.co.uk/2/hi/science/nature/8161578.stm
- BBC. (2007). *Total lunar eclipse* [online image]. Retrieved from: http://news.bbc.co.uk/2/hi/6411991.stm
- BCAMSC Outreach Staff. (2009). *Objects in the sky*. Battle Creek, MI: Battle Creek Area Mathematics and Science Center.
- Branley, F. (1987). *The moon seems to change*. New York, NY: Harper Collins
- Branley, F. (1986). *What the moon is like*. New York, NY: Harper Collins
- Crowley, J. (n.d.). The moon's relation to ocean tides. In *Massachusetts marine educators*. Retrieved June 9, 2011, from http://www.massmarineeducators.org/curriculum/pdf/Ocean_Tides_MA_STDS.pdf
- Hart-Davis, A. (Actor). (2008). *How do tides work?* [online video]. Explain-it. Retrieved June 9, 2011, from http://www.youtube.com/watch?v=CTQ6ciHENgI
- Gardiner, L. (2011). *Tides of the ocean* [online image]. Retrieved from http://www.windows2universe.org/earth/Water/ocean_tides.html
- Moon Connection. (2011). *Understanding the phases of the moon* [online image]. Retrieved from http://www.moonconnection.com/moon_phases.phtml.
- Moon song. (2011). In *Sing. dance. learn.*. Retrieved June 9, 2011, from http://singdancelearn.com/science-songs/moon-song/
- Shaffer, R. (1994). *Your guide to the sky*. Los Angeles, CA: Lowell House
- Stepans, J. (2003). *Targeting students' science misconceptions* (3rd ed.). Riverview, FL: Idea Factory.

Simulators:

- Eclipse – available online at http://www.forgefx.com/casestudies/prenticehall/ph/eclipse/eclipses.htm
- Google Earth – download free from earth.google.com
- Moon Phases – available online at http://astro.unl.edu/naap/lps/lps.html
- Stellarium – download free from www.stellarium.org

Lesson #1

Title: Introduction

Lesson Overview:

- Students will be introduced to the moon by visiting it on a virtual field trip through the Google Earth application. After visiting landmarks and doing brief research, they will be instructed to observe the moon at home. During the observations, they will create questions to investigate in upcoming lessons.

GLCEs:

- S.IP.05.11 Generate scientific questions based on observations, investigations, and research

Objectives:

- The student will create questions to investigate based on nightly observations of the moon.

Assessments:

- Use take home journal entries to check for student questions based on observations

Subject Integration:

- Language Arts – Students will be writing sentences based on moon research
- History – Students will be researching Apollo moon landings

Scientific Background:

- While many theories exist about the formation of the moon, the one most accepted is that it was formed around the same time as the Earth, approximately 4.6 billion years ago. It is believed that a rogue body collided with Earth and a large amount of material was broken off into space. Some of the material was captured into the Earth's orbit and gradually formed the current shape of the moon. The collision may have caused the depression that is now the Pacific Ocean and subsequent collisions resulted in other smaller depressions on Earth and many of the remaining craters on the moon. These collisions tapered off around 3 billion years ago (Shaffer, 1994).

Materials:

- Computer with projector
- Google Earth application

- Student computers/laptops
- "What we think" chart

Preparation:

- Warm up projector and load Google moon application within Google Earth
- Reserve computer lab time or lap tops
- Plan the activity just before a weekend when the moon will be visible (check weather too!) before student bed times

Safety Considerations:

- Students should be reminded of appropriate computer conduct when doing research.

Engage:

- Begin by telling the students that they are going to go on a field trip to outer space. Allow them to make any appropriate sound effects as the class "blasts off" for the moon.

- Project the images from Google moon onto a screen and ask students what they are viewing (the moon).

- Zoom in to landmark features and locations marked from lunar landings. Allow students to guide the moon exploration. Record the locations and features that have been visited on the board.

- After students have become familiar with the application, allow them time to explore on their own computers with a partner. Ask them to select one natural landmark and one lunar landing location to research.

- After students have researched their selected locations, ask for volunteers to share what they have learned about the moon.

Explore:

- Ask students if they have any questions about the moon. Ask if they can answer these questions by "visiting" the moon as they just had on Google moon. Present the "What we think" chart and begin to fill out the first column with the current understandings of students.

What we **T**hink	**H**ow can we find out?	What do we **C**onclude?

- Tell the students that they are going to watching the moon over the weekend to see if there is anything of interest that can be learned from observing from Earth.

- Instruct them to draw a picture of the moon each night, and write one sentence about the appearance of the moon.

- While observing the moon, they are to continue to think of more questions to add to the chart when they return to school and to think of way that they can investigate the questions.

- Students that may have trouble thinking of questions can be provided with the book *What is the Moon Like* by Franklyn Branley.

Lesson #2

Title: Phases (Part 1)

Lesson Overview:

- The class will begin by sharing some of the observations from the weekend, focusing on any appearance changes in the moon. The students will then sort out cards depicting 8 different moon phases. They will then partner read a book explaining how the moon seems to change its appearance and then they will have the opportunity to change their card set if needed. Finally, students will explore phases further on an online simulator that provides three different points of view.

GLCEs:

- E.ST.05.22 Explain the phases of the moon.
- S.IP.05.11 Generate scientific questions based on observations, investigations, and research
- S.RS.05.15 Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities

Objectives:

- The student will explain how the motion of the Earth, moon, and sun is related to the phases of the moon.

Assessments:

- Use the student journal entry of moon phases found manipulating the simulator to check for understanding of phase change in relation to the position of the Earth, moon, and sun.

Subject Integration:

- LA – Students will use a trade book for additional explanation of moon phases

Scientific Background:

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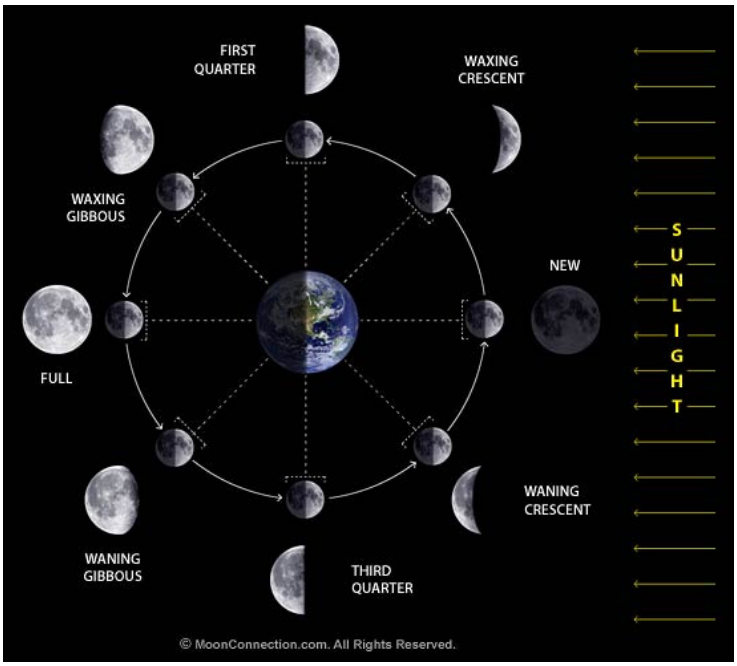

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<u>Phases of the moon:</u>

- New Moon – a phase that is rarely visible from the Earth. This phase occurs when the moon is in between the sun and Earth, so the only side that is lit is facing the sun. The moon cannot be seen due to reflection of light from the sun, but is sometimes seen from the light that is reflected off the Earth from the sun (called Earthshine). A common misconception is that since the moon is between the Earth and sun that a solar eclipse would happen monthly, but this does not occur because of the 5 degree tilt in the orbit of the moon off of the plane between sun and Earth.

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- Full Moon – a phase where the Earth is between the sun and moon. The full circle of the moon is visible to an observer on the Earth. The light is often bright enough to cast shadows on the Earth.

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- When only a sliver of the moon is visible, it is called a crescent. This occurs between the new moon and each of the quarter moons. When the moon is between the quarter moons and full, it is called a gibbous.

- As the visible portion of the moon grows larger each day, the phases are called and labeled waxing. This begins on the right side with a very small crescent and becomes a full moon half way through the lunar month. As the visible portion of the moon gets smaller each day, the phases are called and labeled waning. The darker parts begin to appear on the right side the day after a full moon and continue until the small crescent in on the left side the day before the next new moon (BCAMSC, 2009).

Materials:

- Moon Phase cards – 1'x1' cards depicting 8 distinct moon phases
- Lamp
- Styrofoam balls (1 per student)
- *The Moon Seems to Change* book (1 per partner group)
- Computer lab/laptops
- Projector

Preparation:

- Cover windows and cracks in doorways that could provide light
- Reserve computer lab or laptops
- Load simulator and warm up projector for demonstration

Safety Considerations:

- When exploring phases with Styrofoam balls, there is minimal light. Remind students to keep movement to a minimum and hands to themselves.

Engage:

- Begin by asking students to share observations of the moon from over the weekend. Ask them to think about why the moon is lit differently from night to night. Check for understanding that the moon's light is reflection from the sun. Record student brainstorm ideas on the board and do not correct misconceptions at this time.

- Distribute Moon Phase card sets to small groups (3 or 4) and ask students to place cards in order based on their observations and experience. Ask students to explain to their group reasons for different appearances.

- Move throughout the groups and check for understanding and progress by asking questions that include:

    - What would the order be if you started with…?

- Which phases are similar? Different?
- Did everyone agree on the sequence?
- Are there other possibilities?
- How can you find out if you are correct?

- Invite groups to share the order they placed the cards and reasoning. Ask all students to record their group's order in their student journal.

Explore:

- Tell students that they will be exploring the phases of the moon with a model. Place a lamp (without a shade) in the middle of the room at a height above all students' heads. Attempt to cover light from windows and doors as much as possible.

- Pass out one Styrofoam ball to each student and tell them to use a pencil or pen to hold it. Tell them that the tennis ball will be the moon, their head will be the Earth, and the lamp will be the sun. Tell students that they will be holding they ball about a foot in front of their face for the exploration.

- Ask students to spread out around the room so that they have a clear view of the lamp.

- Turn the lamp on and the room light off, ask students to begin by facing the lamp. Ask them to describe how the ball looks. They will not be able to see the lighted half of the moon; this is a model of a new moon.

- Ask the students to turn to the left 90 degrees or one quarter, the right shoulder will be toward the lamp. Remind them to keep the ball in front of their face. Ask the students to describe how the ball looks. They will see half of the ball lit; this is a model of the first quarter moon.

- Ask the students to turn so that their back is facing the lamp. Ask the students to describe how the ball looks. They will see the entire ball lit; this is a model of a full moon.

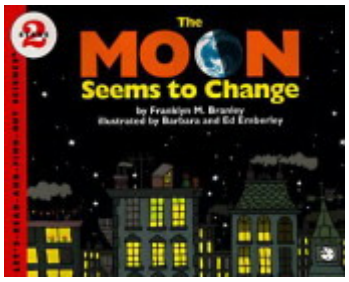
- Ask the students to turn to the left 90 degrees or another quarter turn, the left shoulder will be toward the lamp. Ask the students to describe how the ball looks. They will see half of the ball lit; this is a model of the third quarter moon.

- Ask students to turn once more so that they are facing the lamp and are showing the model of a new moon again.

- Ask students to repeat the demonstration again, this time turning slowly and observing how the moon looks between the previous stops.

- After students have observed at least one more rotation, ask them to describe what is causing the moon to appear differently.

Explain:



- Read the book "The Moon Seems to Change" by Franklyn M. Branley. Students can partner read record 5 facts from the book to share with the class about moon phases.

- After students have completed reading the book, allow time for students to share facts and explanations for moon phases based on information from reading.

- Ask groups to return to their sorting cards from earlier in the lesson, allow time for them rearrange their cards if needed. Ask students if they changed their order and why.

Elaborate:

- Use the computer simulation to show moon phases from different points of view. The simulator is found at http://astro.unl.edu/naap/lps/lps.html.

- Show students different controls offered on the simulator, then allow them time to explore.

- Instruct students to record in their journals 8 different locations/phases of the moon. Ask them to record the day/time and draw the appearance of the moon.

- Ask students to continue making nightly observations (as much as possible) to share as they continue to do more lessons about the moon.

Lesson #3

Title: Phases (Part 2)

Lesson Overview:

- Students till review the phases of the moon through song. They will then create a model using Oreo cookies and complete a final individual evaluation using a "show and tell" method with the teacher.

GLCEs:

- E.ST.05.22 Explain the phases of the moon.
- S.RS.05.15 Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities

Objectives:

- The student will be able to show the moon phases using a model

Assessments:

- Use the paper plate model to check for understanding of the correct name and position of each moon phase.

- Use the "show and tell" to check individual understanding of various moon phases, including the position of the sun, the moon, and the Earth.

Subject Integration:

- Music – Students will review the phases of the moon through song

Scientific Background:

- See information provided in Lesson #2 – Phases (Part 1)

Materials:

- Paper plates (1 per group)
- Oreos (8 per group)
- Plastic knife (1 per group)
- Glue
- Audio player/guitar
- Flashlight
- Styrofoam ball

Preparation:

- Plates with 8 Oreos, glue, and knife can be preset for easy distribution
- Determine how the music will be presented and gather appropriate materials
- Check with fellow teachers for use of space in hallway or elsewhere for evaluation
- Plan independent reading or another self guided project during evaluation time

Safety Considerations:

- Always check for allergies when provided food (or a food-like substance like Oreos)

Explain:

- Begin by reviewing the phases learned in the previous lesson by singing the song "Moon song." This can be played through the audio file on the website, played on a guitar, or taught and sung a capella (since half of it is rap).

Moon Song

The Earth's Moon orbits all around us
It reflects the light from the sun
These are the phases of the Moon
When the Moon is in between
The Earth and the Sun
It's a New Moon phase
And it looks like it's gone
When the Earth is in between
The Sun and the Moon
It's a Full Moon phase
And it looks like a balloon
The Moon goes through eight different phases
The Moon looks different, but it never really changes
It depends on the position of the Earth, Moon and Sun
Come on everybody make the lunar cycle fun
New Moon, Waxing Crescent, First Quarter, Waxing Gibbous
Full Moon, Waning Gibbous, Last Quarter, Waning Crescent
(singdancelearn.com, 2011)

Elaborate:

- Tell the students that they are going to create another model of moon phases with something that they can eat.

- Divide students into small groups (2 or 3) and distribute a paper plate, plastic knife, glue, and 8 Oreos per group.

- Tell the students to twist apart the Oreos, keeping the side that has filling and setting aside (or eating) the other half.

- Tell the students to draw a picture of the Earth in the center of the plate.

- Ask the students what the filling might represent in the model (reflected light from the sun). Instruct them to create the phases for full moon, new moon, first quarter, and third quarter by cutting away filling where sunlight is not reflected.

- Allow time for them to glue the completed cookies into the appropriate place.

- Ask students which phases are missing and invite them to explain how these different appearances occur.

- Allow time for students to complete 8 phases of the moon and affix the cookies to their plates.

- Ask students to label the phases of the moon on their plate.

Evaluate:

- Check for understanding by setting up a show and tell station in the hallway using a flashlight to substitute for the lamp in the model. Show 2-4 different phases to students and ask them to name them. Name a particular phase and ask student to arrange positions of the sun, the moon, and the Earth.

Lesson #4

Title: Lunar and Solar Eclipses

Lesson Overview:

- Students will view a video of a 2006 solar eclipse in Turkey; they will then create questions about eclipses based on the viewing experience or previous understandings. The students will then create a model of both lunar and solar eclipses using a similar method (lamp as sun and ball as moon) from the moon phase lesson. The students will use an online simulator to understand the terms of the eclipses and see where shadows are cast and their effect. Finally, students will be evaluated by creating a Venn diagram in their journals based on the characteristics of both eclipses.

GLCEs:

- E.ST.05.24 Explain lunar and solar eclipses.
- S.IP.05.11 Generate scientific questions based on observations, investigations, and research
- S.RS.05.15 Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities

Objectives:

- The student will be able to describe the characteristics of lunar and solar eclipses

Assessments:

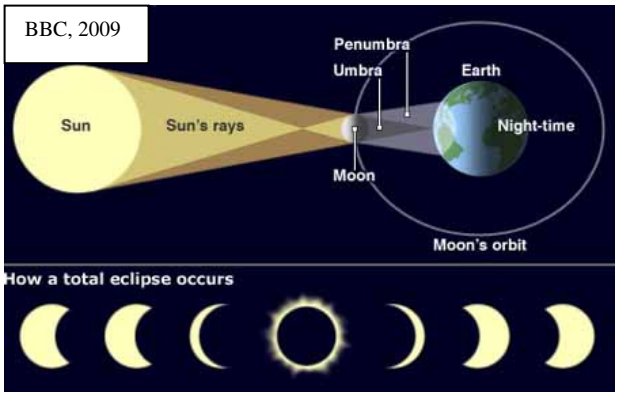
- Use the Venn diagram to check for understanding of characteristics of lunar and solar eclipses.

Subject Integration:

- Geography – investigate on the world map the location of the 2006 eclipse (Turkey) and others that may be researched during the investigation.

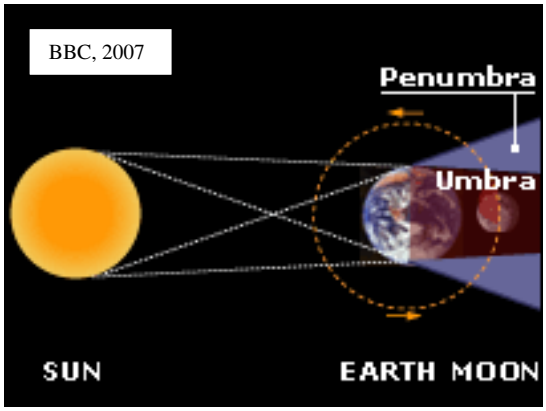
Scientific Background:

- A solar eclipse can only happen during a new moon. This occurs when the moon passes between the sun and the Earth. The moon follows a close path to the sun throughout the day, rising and setting at similar times. The solar



eclipse is when the moon passes within the plane of the sun and the Earth and casts a shadow on the Earth, temporarily blocking some of the sun's light. When the moon passes through the penumbra, there is a partial eclipse on the Earth. When the moon passes through the umbra, there is a total eclipse in a small region of the Earth. Due to the 5 degree tilt of the orbit for the moon off of the plane between the sun and the Earth, solar eclipses geometrically line up only 2 times per year. (BCAMSC, 2009, p.55)

- A lunar eclipse can only happen at a full moon and is when the moon passes within the Earth's shadow. The full moon rises at sunset and is visible the entire night. The full moon sets as the sun is rising; this is because they are opposite each other during this phase. This eclipse also needs the geometry of the plane between the sun and the Earth to line up with the orbit of the moon, but occurs 2-4 times per year. As the moon passes through the penumbra, the eclipse is partial; it then is total eclipse while in the umbra shadow. Unlike the limited viewing area of the solar eclipse, the lunar eclipse is viewable from all areas of the Earth that are experiencing night (BCAMSC, 2009, p.56)



Materials:

- Lamp
- Styrofoam ball (1 per group)
- 10 meter string (1 per group)
- Computer with projector
- Computer lab/laptops

Preparation:

- Load video from YouTube and warm up projector
- Gather materials for model
- Reserve computer lab/laptops for simulator activity
- Check windows and doorways

Safety Considerations:

- When exploring phases with Styrofoam balls, there is minimal light. Remind students to keep movement to a minimum and hands to themselves.

Engage:

- Begin by showing students a short video of a 2006 solar eclipse in Turkey. The video is available at http://www.youtube.com/watch?v=XMyqPxFh5Zw.

- Ask students what they think about eclipses and what they think about the video. Allow students time to share any experiences from viewing eclipses or information they have seen on programs.

- Record questions that students may have about eclipses on the board. Some questions may include:

    - How often do solar and lunar eclipses occur? When will the next one be?
    - What is the difference between lunar and solar eclipses?
    - Do these eclipses happen every time there is a new moon or full moon?

Explore:

- Tell the students that they are going to make a three dimensional model that compares an eclipse to the phases of the moon. Divide the class into small groups (3 or 4) and pass out 4 Styrofoam balls and string (10 meters long).

- Explain that they are going to review the moon phases from the previous lesson and focus on the new and full moon phases. Place the lamp in the center of the room at height above the heads of all students.

- Turn the lamp on and the lights off, ask the students to hold the ball in front of them facing the lamp. Ask the students to describe and name the phase of the moon (new moon).

- Review all moon phases by asking students to turn counter clockwise 90 degrees at a time. Ask them to describe and name the phase at each stop. Remind students that the cycle takes 29 ½ days to be completed (almost a month).

- Set up the three dimensional models for eclipse by explaining jobs to students

    - 1 student to be the Earth and hold the ball as the moon – "Earth"
    - 2 students to "map" the plane of the orbits using the string – "mappers"
    - 1 student to observe the eclipse and position the moon one width of the ball above the string – "observer"

- Give students the following directions:

    - The "Earth" stands in the new moon position with the moon in front, slightly above eye level, facing the sun.
    - One "mapper" holds the string at the center of the sun (lamp)
    - The second "mapper" traces the path of light from the sun (lamp) to the Earth (head or eye).

- The observer measures one width of the ball above or below the string and moves the moon (ball) above or below the string. The observer records the observation of the moon phase.
- The "Earth" moves the moon so that it is aligned on the string with the sun (lamp), moon (ball), and Earth (head or eye); all are in one line on the string
- The observer describes and records the observation of the new position of the moon. This is a demonstration of when a solar eclipse occurs.
- The second "mapper" traces the path of the light from the sun (lamp) to the Earth (head or eye). See illustration below:

- Tell the students that this model represents what occurs when the orbit of the moon is aligned with the sun and Earth. This occurs at approximately 5 degrees above or below the plane of the Earth and sun. Ask the students what object is casting the shadow in the solar eclipse (moon). Ask students to describe where the shadow of the moon will appear (Earth or head). Ask students to describe the view from Earth (The moon passes between the Earth and the sun, blocking the view of the sun with the body of the moon).

- Allow students the opportunity to change roles in the model. Each student should take a turn as the "Earth" and "Observer"

- Tell the class that they are going to create the three-dimensional model of a lunar eclipse. Have students return to the original roles and give groups the following directions:

  - The "Earth" stands in the full moon position with the moon (ball) in the front, slightly above eye level and their back to the sun (lamp).
  - One "mapper" holds the string at the center of the sun (lamp).
  - The second "mapper" traces the path of light from the sun (lamp) to the Earth (back of the head, eye level). See illustration below.
  - The observer measures one width of the ball above or below the string and moves the moon (ball) above or below the string. The observer records the observation of the moon phase (full moon).
  - The "Earth" moves the moon so that it is aligned on the string with the sun (lamp), moon (ball), and Earth (head or eye); all are in one line on the string.
  - The observer describes and records the observation of the new position of the moon. This is a demonstration of when a lunar eclipse occurs.

    - Ask the students to describe what object is casting the shadow in the lunar eclipse (Earth). Ask students to describe where the shadow is observed (on the moon). Ask students to describe the view from the Earth in a lunar eclipse (Earth's shadow on the moon dims the moon's glow).

Explain:

- Ask the students why they think that there is not a solar eclipse every time there is a new moon. Look for responses that include the 5 degree angle of the path of the moon. Tell students that eclipses only occur 2-3 times during the year.

- As a class, visit the website http://www.forgefx.com/casestudies/prenticehall/ph/eclipse/eclipses.htm

- Demonstrate the simulator while projecting the images, and then allow students time to control it in small groups. Use the simulator with the "labels off" since the terms penumbra and umbra are not being discussed yet.

- Write the terms *solar eclipse* and *lunar eclipse* on the board. Ask the students to explain the meaning of each term. Have students create a definition for each term, including what phase of the moon for each eclipse, what object casts the shadow, and where the shadow is cast. Ask students to record these definitions in their journal.

- Use the simulator to capture a picture of solar and lunar eclipses that can be copied in the student journals.

- Return to the questions that were posed at the beginning of this lesson. Check for understanding on each.

Evaluate:

- Instruct students to complete a Venn diagram in their journals to compare and contrast the characteristics of lunar and solar eclipses.

Lesson #5

Title: Tides

Lesson Overview:

Students will first review their understanding of gravity and apply it to the relative masses of the Earth, moon, and the sun. They will then work in groups to investigate cards that depict different tides. They will watch a video and participate in a classroom discussion about their models to understand the effect of the moon's gravity on ocean tides. They will show this understanding by drawing and writing in their journals.

GLCEs:

- E.ST.05.25 Explain the tides of the oceans as they relate to the gravitational pull and orbit of the moon
- S.IP.05.11 Generate scientific questions based on observations, investigations, and research
- S.RS.05.15 Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities

Objectives:

- The student will be able to explain the effect the moon has on the tides of the ocean

Assessments:

- Use the journal entry to check for understanding of the effect the moon has on the ocean tides.

Subject Integration:

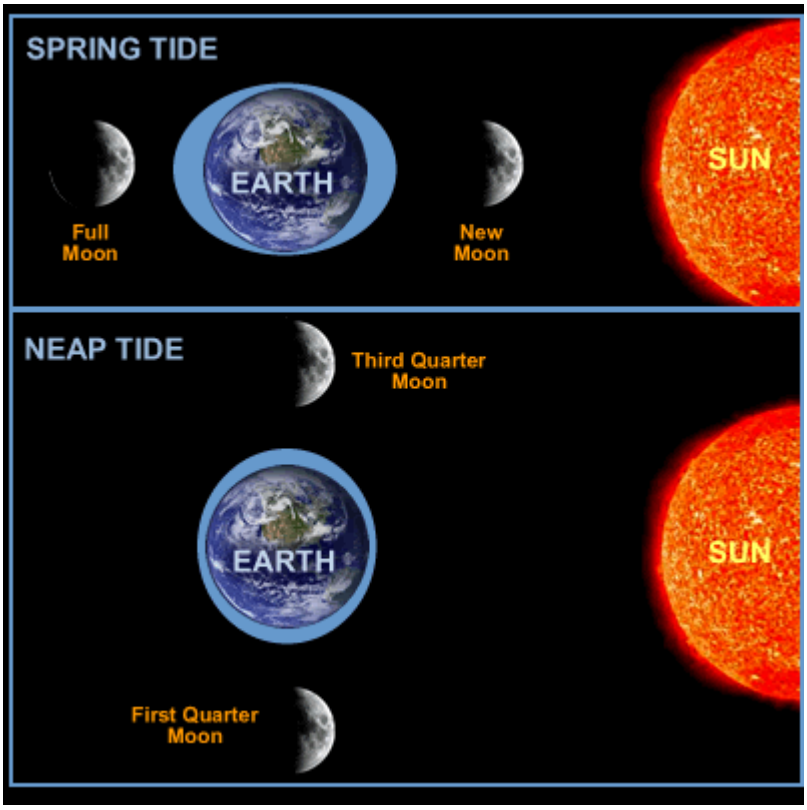
- Geography – Students can identify places on the map that will be affected by tides

Scientific Background:

- The oceans of the world are changing all of the time. Winds and current cause waves along the surface of the water and the gravitational pull as the sun, Earth, and moon interact cause the tides that change the level of the water daily. The moon and sun pull at the oceans and cause them to "bulge" out. This is predictable because of the consistent movement of the Earth around the sun and the moon around the Earth. Although the mass of the sun is much greater than the moon, the close proximity of the moon has a greater impact on the tides.

- As the Earth rotates on its axis over the 24 hour day, each position lines up with the moon to produce two high tides and two low tides. There are two types of tides based

on the position (or phase) of the moon. Spring tide (not related to the season) occurs during new and full moons and produces the largest high tides. Neap tide occurs during the quarter moons and is not as significant as the spring tide.



Materials:

- Card set showing various views of tide (high and low from shore, spring and neap tide from space)
- Tennis ball (1 per group)
- Ping-pong ball (1 per group)
- Marble (1 per group)
- "What we think" chart
- Computer and projector

Preparation:

- Gather materials for the model
- Load video and warm up projector

Engage:

- Begin by dropping an object on the floor and ask students what caused it to fall to the ground. Ask them to explain the force and review what they know about gravity. Explain that the mass of the Earth is greater than the mass of the object, so the object was pulled to the Earth.

- Ask students to rank the sun, moon, and Earth in order of size or mass (sun, Earth, moon). Ask which has the greatest gravitational pull (sun). Explain that it is the sun's gravitational pull that keeps the Earth in orbit around the sun and Earth's gravitational pull that keeps the moon in orbit around the Earth.

- Ask the students to brainstorm ideas about ocean tides in general, and how it might relate to the moon and gravity. Ask students to share experiences of visits to seashores with tidal pools (compare to visits to Lake Michigan). Record thoughts on the "What we think" chart and listen to student ideas of how they might find out.

Explore:

- Distribute the card set for tides, tennis ball, ping-pong ball, and marble to each group. Ask students to make the models shown on the cards and allow time for the group to discuss the role of gravity in the model.

- Facilitate group work by checking for understanding with questions that include:

    - Where would you place each ball during a new moon?
    - Which balls are closest together and which are farthest apart?
    - Explain the direction of the pull of the different ball on each other?
    - Which ball has the greatest pull?
    - Which ball has the smallest pull?

Explain:

- Ask volunteers from the groups to explain what they have discussed while making their models. Record a class survey on the board on which object has the greater influence on tides, the larger gravity of the sun or the closeness of the moon.

- Show the video about tides at http://www.youtube.com/watch?v=CTQ6ciHENgI

- Display the graphic from the scientific background or draw a representation of it on the board

- Explain that the sun, moon, and Earth change positions in their orbits, the ocean water levels fluctuate. Tell the class that the large amount of water in the oceans is susceptible to the pull of the moon and sun's gravity then the rock or solid surface of the Earth. As the moon travels around the Earth and as they, together, travel around the sun, the combined gravitational forces cause the world's oceans to rise and fall.

- Demonstrate the effect of gravity onto the water by placing a water balloon on a table. Pick up the balloon by the spout and demonstrate how Earth's gravity pulls it downward. Explain that the moon has a similar effect on the oceans; this is what we call a tide.

- Explain that even though the gravitational pull of the sun is greater than that of the moon because of their comparative size, the closeness of the moon has then most effect on the tides.

Evaluate:

- Ask students to draw spring and neap tide in their journals, labeling locations for high and low tides. Write one or two sentences explaining the effect the moon has on these tides

Lesson #6

Title: Tides (Part 2)

Lesson Overview:

- Students will use current tide charts to plot patterns between high and low tide. They will individually complete different weeks, to put together a long set chart from one data set. They will then complete a worksheet and discuss the patterns seen in the charts.

GLCEs:

- E.ST.05.25 Explain the tides of the oceans as they relate to the gravitational pull and orbit of the moon
- S.IP.05.15 Construct charts and graphs from data and observations
- S.IP.05.16 Identify patterns in data

Objectives:

- The student will learn that extremely high and low tides are related to very specific times of the month

Assessments:

- Use the student answers in the journal to check for understanding of the patterns between high and low tides each month.

Subject Integration:

- Math – the students will interpret data and plot a graph
- Geography – the students will indentify their location of study on a map

Scientific Background:

- See information in Lesson #5: Tides (Part 1)

Materials:

- Tide plotting chart
- One week of tide data
- Red, blue, and yellow markers or colored pencils
- One set of tidal readings available at tidesandcurrents.noaa.gov

Preparation:

- Tide charts should be duplicated and then cut so that each student has the information for a single week to plot.
- Collect and print tidal data

Elaborate:

- Begin by explaining how to read the chart and how to interpret where time and height are on the plotting sheet.

- Give to each student a week of data.

- Instruct students fill in the month, year and dates at the top of the sheet. Students are asked to plot tide points on the sheet.

- Rotate throughout the class to check a few points on each student's paper and offer assistance. All initial plotting should be done in pencil to allow for corrections to be made.

- After the tides are plotted, tell students connect the points for high and the points for low tide and then ink in the line.

- Instruct the students to fold the right side of the chart to the black edge line. Match student charts week to week on the front board. Invite volunteers to connect their final points on each side with the other charts and finish their data and coloring.

- Tell students to follow the instructions for coloring found at the bottom of the plotting chart.

- As a class determine the tidal range for each day, by subtracting the lowest of the low tides for each day from the highest of the high tides for the day. This figure is now then in the blank box on the chart between the 5 and 6-foot tide levels.

- Show students that a very definite cyclical pattern develops over several weeks or months.

- Instruct the class to trace a dime on the yellow paper to cut out the phases of the moon and attach them over the correct day on their chart. Lunar phases are pasted in the time block at the top of the day the phase occurs on.

    - Use the following for phases:
    - New moon - full circle shaded gray
    - First quarter - half circle with opening to the right
    - Full moon - full yellow circle
    - Last quarter - half circle with opening to the right

Evaluate:

- When the chart is completed ask students to answer the questions with a partner on their activity sheet. Put complete answers in the student journal.

    - 1. What has caused the patterns that have appeared on the tidal sheets? Is there a pattern?
    - 2. Can you see any relationships between the pages and the moon's phases? At what point in the month is the tidal range the greatest? What lunar phase is closest to this time of the month? Where do you think the moon is at this time?
    - At what point in the month is the tidal range the smallest? What lunar phase is near this point? Where do you think the moon is relative to the earth at this time?

- After they have finished the questions, a class discussion can be held discuss their answers and the reasons for the cyclical pattern for the tides.

Lesson #7

Title: Conclusion (Celebration/Field Trip)

- The class will visit a local planetarium to view an interactive show about moon phases, lunar eclipses, and solar eclipses.

- The program will allow them to see the moon in action, in a more real setting than the simulators they have manipulated.

- In preparation for the trip, students will be asked to create one question that they will ask the expert that is hosting the program.

- They will be asked to record their question and answer received in their journal as one final assessment.