Emera Astronomy Center
and M. F. Jordan Planetarium

ASTRO.UMAINE.EDU FACEBOOK.COM/JORDANPLANTERARIUM 207-581-1341

Cosmic Classroom Guide

Earth, Moon & Sun

COMPILED & EDITED BY LEISA PREBLE

THE UNIVERSITY OF MAINE

A Member of the University of Maine System

Emera Astronomy Center
and M. F. Jordan Planetarium

Earth, Moon & Sun

Edited by Leisa Preble

Mission Statement:
The mission of the Maynard F. Jordan Planetarium of the University of Maine is to provide the University and the public with educational multi-media programs and observational activities in astronomy and related subjects.

Cosmic Classroom

Looking for fun and interesting space activities? The planetarium staff has prepared a collection of materials we call the Cosmic Classroom for you to use before and/or after your visit. These materials are entirely for use at your own discretion and are not intended to be required curricula or a prerequisite to any planetarium visit. The Cosmic Classroom is one more way that the Jordan Planetarium extends its resources to help the front line teacher and support the teaching of astronomy and space science in Maine schools.

The lessons in this Cosmic Classroom have been edited and selected for the range of ages/grades that might attend a showing of this program at the Jordan Planetarium. Those activities that are not focused at your students may be adapted up or down in level. Our staff has invested the time to key these materials to the State of Maine Learning Results in order to save you time.

The State of Maine Learning Results performance indicators have been identified and listed for the program, the Cosmic Classroom as a package, and each individual activity within the package. The guide also includes related vocabulary and a list of other available resources including links to the virtual universe. We intend to support educators, so if there are additions or changes that you think would improve, PLEASE let us know.

Thank you, and may the stars light your way.

The Maynard F. Jordan Planetarium Staff

The Program – *Earth, Moon and Sun*

This first standards-based elementary show for Omnidome beautifully illustrates basic concepts like moon phases and seasons with the dubious help of Coyote. Based on the trickster of Native American lore, Coyote is constantly corrected in his misunderstandings of how things work. A live tour of the Maine sky and its beautiful constellations completes this micro-unit of astronomy.

We are very glad that you have chosen to visit our planetarium with your group. We hope that this guide either will help you prepare your group or help you review their experience at the University of Maine's sky theater.

State of Maine Learning Results Guiding Principles

The lessons in this guide, in combination with *Earth, Moon and Sun*, will help students to work towards some of the Guiding Principles set forth by the State of Maine Learning Results. By the simple act of visiting the planetarium, students of all ages open an avenue for self-directed lifelong learning. A field trip encourages students to think about learning from all environments including those beyond the schoolyard. A Jordan Planetarium visit also introduces visitors to the campus of the largest post-secondary school in Maine and encourages them to think of this as a place which holds opportunities for their future education, enjoyment and success.

Other sites on the University campus, including three museums, explore a variety of subjects, and the Visitors Center is always willing to arrange tours of the campus. A field trip can contribute to many different disciplines of the school curriculum and demonstrate that science is not separate from art, from mathematics, from history, etc. The world is not segregated into neat little boxes with labels such as social studies and science. A field trip is an opportunity for learning in an interdisciplinary setting, to bring it all together and to start the process of thinking. For a more complete discussion of field trips, please visit the Jordan Planetarium web site at http://www.astro.umaine.edu .

If used in its entirety and accompanied by the Planetarium visit, this guide will help students to:

Become **a clear and effective communicator** through

A. oral expression such as class discussions, and written presentations
B. listening to classmates while doing group work, cooperation, and record keeping.

Become **a self-directed and lifelong learner** by

A. introducing students to career and educational opportunities at the University of Maine and the Maynard F. Jordan Planetarium.
B. encouraging students to go further into the study of the subject at hand, and explore the question of "what if?"
C. giving students a chance to use a variety of resources for gathering information

Become **a creative and practical problem solver** by

A. asking students to observe phenomena and problems, and present solutions
B. urging students to ask extending questions and find answers to those questions
C. developing and applying problem solving techniques
D. encouraging alternative outcomes and solutions to presented problems

Become **a collaborative and quality worker** through

A. an understanding of the teamwork necessary to complete tasks
B. applying that understanding and working effectively in assigned groups
C. demonstrating a concern for the quality and accuracy needed to complete an activity

Become **an integrative and informed thinker** by

A. applying concepts learned in one subject area to solve problems and answer questions in another
B. participating in class discussion

State of Maine Learning Results Performance Indicators

In conjunction with the Maynard F. Jordan Planetarium show *Earth, Moon and Sun,* this guide will help you meet the following State of Maine Learning Results Performance Indicators in your classroom.

Grades 3-5

Science and Technology –

A2. Models – Students use models to represent objects, processes, and events from the physical setting, the living environment, and the technological world.

a. Represent the features of a real object, event, or process using models including geometric figures, number sequences, graphs, diagrams, sketches, maps, or three-dimensional figures and note ways in which those representations do (and do not) match features of the originals.

A3. Constancy and Change – Students identify and represent basic patterns of change in the physical setting, the living environment, and the technological world.

a. Recognize patterns of change including steady, repetitive, irregular, or apparently unpredictable change.

B1. Skills and Traits of Scientific Inquiry – Students plan, conduct, analyze data from, and communicate results of investigations, including fair tests.

a. Pose investigable questions and seek answers from reliable sources of scientific information and from their own investigations.

b. Plan and safely conduct investigations including simple experiments that involve a fair test.

c. Use simple equipment, tools, and appropriate metric units of measurement to gather data and extend the senses.

e. Communicate scientific procedures and explanations.

C3. Science, Technology, and Society – Students identify and describe the influences of science and technology on people and the environment.

a. Explain how scientific and technological information can help people make safe and healthy decisions.

D1. Universe and Solar System – Students describe the positions and apparent motions of different objects in and beyond our solar system and how these objects can be viewed from Earth.

a. Show the locations of the sun, Earth, moon, and planets and their orbits.

b. Observe and report on observations that the sun appears to move across the sky in the same way every day, but its path changes slowly over the seasons.

c. Recognize that the sun is a star and is similar to other stars in the universe.

Performance Indicators Snapshot

The Show

Grades 3 – 5

Science & Technology

A3.a
D1.a, b, c
D4.c

The Guide

Grades 3 – 5

Science & Technology

A2.a
A3.a
B1.a, b, c, e
C3.a
D1.a, b

Phases of the Moon

By Jacquelyn Arthur

Objectives and State of Maine Learning Results Performance Indicators:

1. The learner will make observations and use appropriate technology to build an understanding of the earth/moon/sun system. (3-5. Science & Technology. A2.a)
2. The learner will observe that objects in the sky have patterns of movement including the Sun, the Moon and the stars. (3-5. Science & Technology. A3.a)
3. The learner will recognize that the moon does not actually change shape, but goes through phases that form a pattern. (3-5. Science & Technology. D1.b)
4. The learner will learn that the amount of moon one can see each night depends on where the moon is in its orbit around the Earth. (6-8. Science & Technology. D1.b)

General Overview

Young children may have the idea that the moon actually changes shape. This lesson explains that this apparent change is a result of the moon's revolution around the earth.

Materials/resources

- flashlight or lamp without shade
- model of the Earth and the moon
- Patterns of the Moon activity sheet
- pencils
- Moonwatch Questions
- completed Moonwatch Activity Sheet

Pre-activities

- Students observe the moon for two weeks.
- Students draw moon on the Moonwatch Activity Sheet each night for fourteen days.

Activities

1. In a darkened room, the teacher will set up models of the sun, moon, and Earth.
2. Moving the moon model slowly in a circle around the Earth, the teacher will instruct the students to draw the moon as it would be seen from Earth.
3. Refer back to data collected on the Moonwatch Activity Sheet and pinpoint dates when the moon looks as it did in each point in this activity.
4. Discuss and answer Moonwatch Questions.

Assessment

- Completed activity sheets.
- Verbal answers to questions.

Supplemental information

When collecting data on the Moonwatch Activity Sheet, it may be necessary for the students to infer what the moon actually looks like on any certain night, as some nights may be cloudy and the students may be unable to see the moon that night. This lesson may be adapted to include the creation of bar or pie graphs as a part of a math lesson.

Moonwatch Questions

1. At what point can you see all of the side of the moon facing you?

2. At what point is none of the lighted portion of the moon seen?

3. What do we call the phase of the moon as seen at Point 1?____________________

   Point 2? ______________________________________

   Point 3? ______________________________________

   Point 4? _______________________________________

4. Does the moon really change shape? Explain your answer.

5. Why are we only able to see a portion of the moon at certain times of the month?

6. Using your Moonwatch Activity Sheet as a guide, write the dates when the phases below have or will take place.

   New Moon _____________________ First Quarter ____________________

   Full Moon _____________________ Last Quarter ____________________

Moonwatch Activity Sheet

Watch the moon every night for fourteen days. Draw the shape you see each night in the space provided. If it is cloudy and you cannot see the moon, leave the space blank for that night. You'll be able to fill it in later.

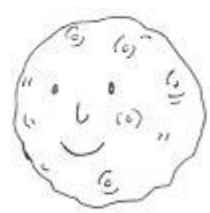
Beginning date of project:______________________________

Project ends on:__________________________________

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6

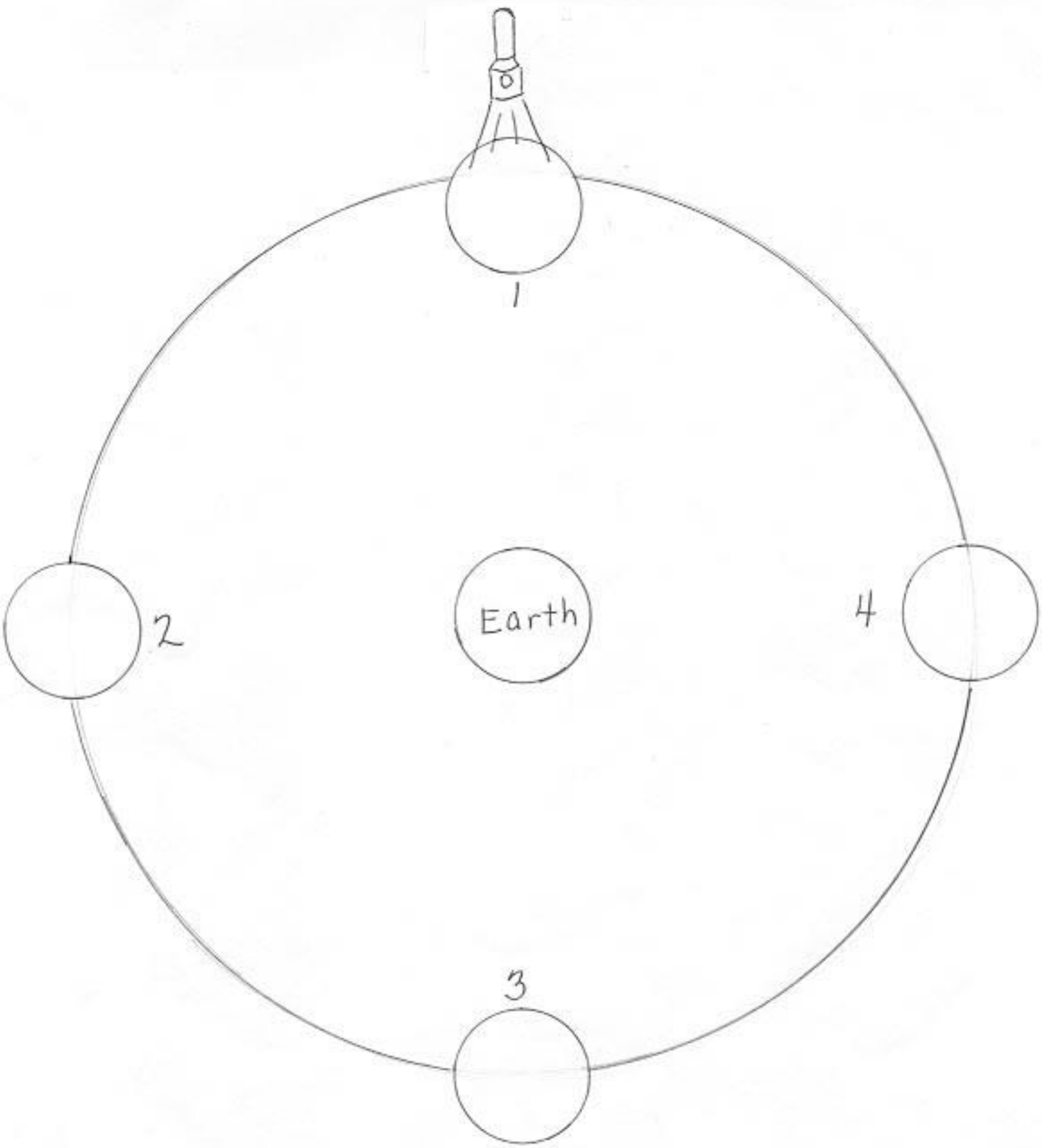
Day 7	Day 8	Day 9	Day 10	Day 11	Day 12

Day 13	Day 14



Patterns of the Moon

Directions: Pretend that you are standing on the Earth as seen below. Draw the moon as you would see it at each numbered point.



Rotation of the Earth

Based on <u>The rotation of the Earth causes apparent movement of the constellations.</u> by Susan Reynolds and Onondaga-Cortland-Madison Board of Cooperative Educational Services math, Science and Technology.

<u>Objectives and State of Maine Learning Results Performance Indicators:</u>

1. Students will be able to infer that the rotation of the Earth causes apparent movement of the constellations in the night sky (3-5. Science and Technology. D1.b.)
2. Students will be able to recognize the patterns of the stars from various directions. (3-5. Science and Technology. A2.a)

<u>The General Idea:</u>

If you look at the night sky on a regular basis you will see that it doesn't always appear the same. Actually it very seldom appears the same. From season to season the constellations twist around the north star. Many students may wonder if the constellations are really spinning around us as they appear to be doing. In this activity students will view constellations from various directions so that they will begin to understand how the stars appear to move through the sky, when in fact it is Earth that is moving through the sky.

<u>Getting Ready:</u>

- Convert the enclosed star chart to an overhead transparency
- Locate a large piece of paper for the students to trace the projected star chart onto

<u>What You Need:</u>

Star chart transparency
overhead projector
large piece of paper
tape

<u>What To Do:</u>

1. Project the star chart onto the piece of paper
2. Have students trace the constellations on to the paper
3. Tape the paper to the ceiling
4. Have students lay on the floor and look up at the constellations
5. Each student should write down which constellation is on top
6. Have all the students move to another place and look at the constellations
7. Again have them record which constellation is on top

What To Discuss:

1. Circumpolar constellations are those that never set.
2. What did you notice as you changed positions and viewed the constellations?
3. Did the pattern of the constellations change? (lead students to notice that the patterns remained stationary but appeared to move as the students changed position).

How Big, How Far: The Earth and Moon

http://earth.rice.edu/shows/EWR/activities.htm

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to represent the relative size of the Earth and moon. (3-5. Science & Technology. A2.a.)
2. Learners will be able to use proportions and averages to describe the difference between the size of the Earth and the moon. (3-5; 6-8. Science & Technology. A4.b.)
3. Learners will be able to use appropriate tools to interpret data. (6-8. Science & Technology. B1.c.)

The General Idea:

The Earth and Moon have been called a "double planet". In this activity you will discover how big (or small) and how close (or far away) the moon really is.

Getting Ready:

- Gather supplies listed.
- Arrange all building materials on a large table and in boxes beside the table.

What You Need:

- Earth globe – as large as you have available
- Ball of string – with individual strings about 5 times the diameter of the globe for each student
- Balloons (round) – can be inflated to at least a fourth of the diameter of the globe that you have chosen.
- Measuring tape or meter stick for each group of students

What To Do:

1. Inflate your balloon until you think it is the size that the Moon would be if the Earth were only as big as the globe in the classroom. Do not tie your balloon, but hold onto it tightly.

2. Watch as your teacher stretches a string around the equator of the Earth globe. The length of this string equals the globe's circumference.

3. The moon's diameter is a fourth of the diameter of the Earth. So the moon's circumference is also a fourth of the Earth's circumference. Watch as your teacher folds the Earth circumference string in fourths. The result is the circumference of the moon balloon. Your teacher will measure the length of the folded string to find the circumference of the moon balloon.

4. Use your string to measure the circumferences of your balloon. Use a measuring tape or meter stick to determine how long your circumference is. Then calculate the difference between your circumference and the correct answer. Record your answers below.

5. Adjust the size of your balloon until it is the correct size compared to the Earth globe.

6. Now place your balloon at the correct scale distance from the Earth globe. Make your best guess about how far away the moon should be. Using a measuring tape, measure how far away your balloon is from the Earth globe. Record it below.

7. The moon balloon should be at a distance that it 9.5 times the circumference of the Earth globe. Multiply the Earth circumference string length by 9.5. Now use a measuring tape to measure how far your balloon is from the Earth globe. Subtract to find the difference between your distance and the correct distance. Record it on the table below.

Your balloon circumference: ______ The correct circumference: _____ Difference: ________

Your balloon distance: ___________ The correct distance: __________ Difference: ________

8. Make a drawing on notebook paper showing the Earth and moon at the correct relative sizes and distances.

Extension

Look at moons of other planets and compare how far or near they are to each other. Are there any other planets that could be considered as “double planets”? Why?

Time – Light and Shadow

By Denise Young

http://www.learnnc.org/lp/pages/3369

This lesson was adapted using ideas from a 6th grade unit called "Measuring Time" by the National Science Resources Center and published by Carolina Biological Supply Company, c. 1994.

Objectives and State of Maine Learning Results Performance Indicators:

1. The learner will understand that the shadow created as the earth rotates on its axis can be used to determine the time of day. (3-5. Science and Technology. D1.b)
2. The learner will recognize and use standard units of metric and customary measurement. (3-5. Science and Technology. B1.c)
3. The learner will understand how to construct a simple sun clock. (3-5. Science and Technology. B1.b)
4. The learner will understand how to record data about shadows and time of day using a sun clock. (3-5. Science and Technology. B1.c)
5. The learner will observe that objects in the sky have patterns of movement including: Sun, Moon, stars. (3-5. Science and Technology. D1.a)
6. The learner, using shadows, will be able to follow and record the apparent movement of the sun in the sky during the day. (3-5. Science and Technology. D1.b)
7. The learner will recognize and use standard units of metric and customary measurement. (3-5. Science & Technology. B1.c)

The General Idea:

Students examine the interplay of the earth and the sun by studying shadows. Students construct a sun clock and record shadows several times during a school day in order to use the earth and the sun to measure time. This activity will require four sunny days.

What You Need:

- sun dial
- compass (for finding North)
- three or more copies of sun clock diagram for each student
- thirty copies of the rubric for student writing
- ten copies of group questions

For each pair of students:

- pencil
- round wheel (from tinker toys)
- stick/pencil (to place in center of wheel)
- flashlight (with wax paper rubber banded to the front to reduce glare)

Technology resources

Computers with internet access to use websites relating to extension activity (how other civilizations have kept track of the passage of time).

Pre-activities

Students should have some prior knowledge and experiences with light and shadows. Shadow searches throughout the school and grounds and shadow tag are some examples of pre-activities. Students should also know how to tell time to the hour prior to this lesson. The teacher should preview supplementary websites to ensure their appropriateness for your students.

Day 1

1. Ask students to consider how they would tell time if they did not have a clock or watch. Students may discuss with a partner or respond in their journals.
2. Students share ideas with the class.
3. Discuss the sun as a "time teller." Questions to consider: In which ways is the sun considered a "time teller?" What kind of time can you tell by the sun?
4. Show students the sun dial and ask what they know about it and how it works. Point out the base and the gnomen (the upright part). Demonstrate how the sun dial works by placing it on a sunny, level place outside and periodically observing how the light casts the shadow of the gnomen. Be sure that the sun dial is pointing north. It is easiest to orient the sun dial at noon.

Day 2

1. Provide directions to students about constructing their own sun clocks. Working in pairs, students will place the stick/pencil in the center of their wheel and place it in the box on the sun clock sheet. One part of their wheel should be touching the place where the box and the center line connect. Encourage students to trace their wheel once they have placed it so that it can be placed in exactly the same place later in the day.
2. Ask students to trace the shadow of the gnomen (stick/pencil in the center of their wheels) and record the time.
3. Ask students to predict where they think the shadow will be exactly one hour later and mark their prediction with an X on the white paper. As a whole class, ask students to explain their predictions.
4. Check students' predictions one hour later. As a class, discuss the results and make predictions about future times during the day. Be sure to check the time using the sun clock at noon. (If all goes well, there should be a short shadow directly over the center line of the sun clock.)
5. Ask students to put their sun clocks in a safe place until tomorrow (or the next day the lesson is continued).

Day 3

1. Repeat the process of recording time using the sun clocks. Ask students to record the same times that the recorded yesterday using a new sun clock sheet.
2. At the end of the day, ask the pairs to compare their sun clock recordings. Are the tracings similar or different? Why? Ask students to write a paragraph explaining their reasoning on the back of their sun clock papers (each partner can write on the back of a different one). Students should attach them and turn them in for teacher review.

What To Discuss:

Day 4

1. In small groups of 3–5 students, students should discuss and complete the questions sheet.
2. Once the sheets are completed, hold a class discussion to check the answers.
3. Students should get in pairs (these pairings can be different than the previous partner work). Give each pair a flashlight (to serve as the sun) and give students several minutes to experiment with the flashlight and their sun clocks. Encourage students to use their sun clocks to recreate the times they recorded when they used the sun as their light source.

Assessment:

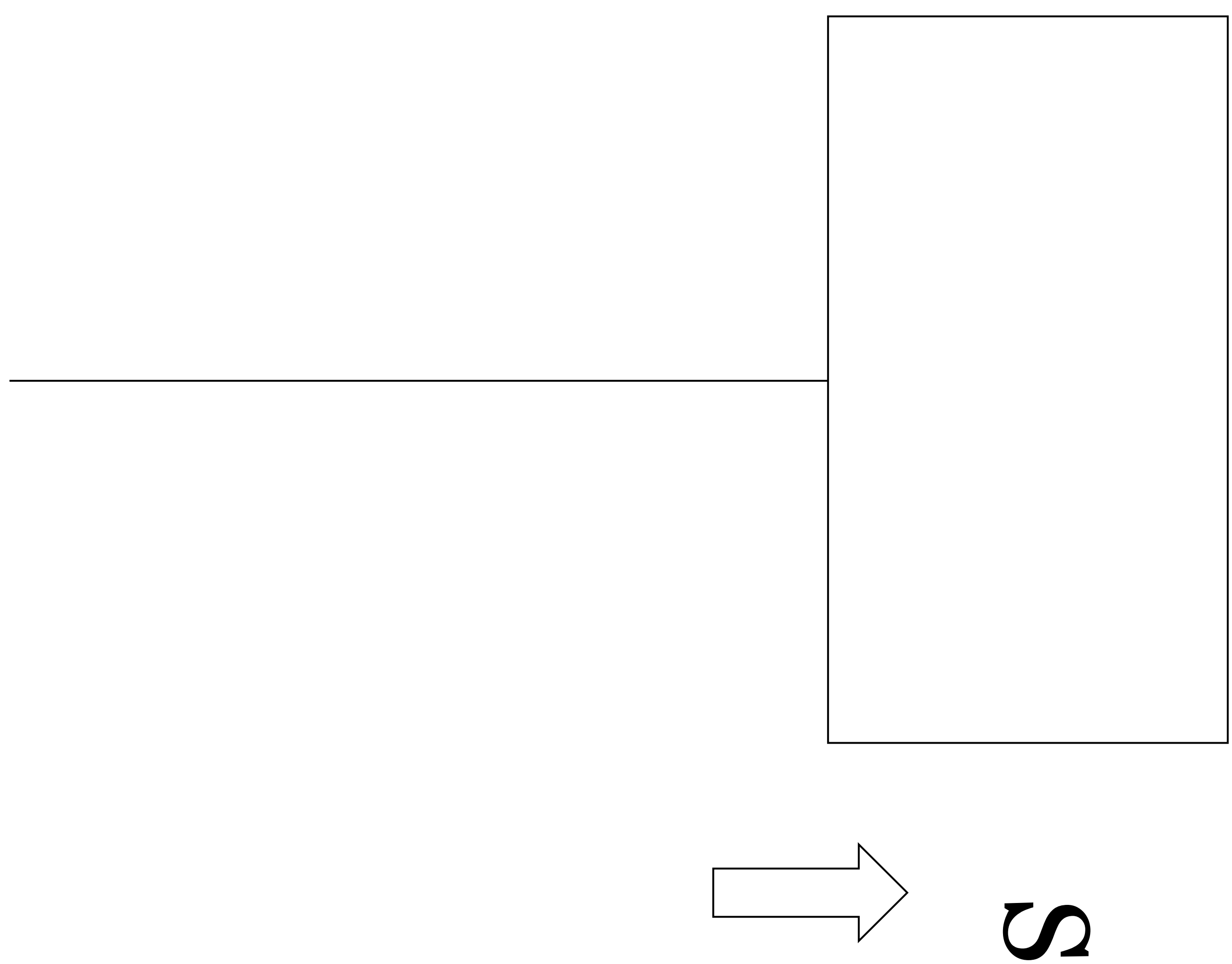
- assessment of student writing from Day 3 (similarity of sun clock recording forms)
- Rubric
- Performance Assessment

Extensions of this lesson: Study how other civilizations have kept track of the passage of time (Mayan and Egyptian Pyramids, Stonehenge, Sun Dials, Wyoming Medicine Wheel, etc.).

http://www.sundials.co.uk/
A variety of links and resources relating to sundials

http://www.ancientegypt.co.uk/
A webpage of the British Museum's Egypt exhibits

http://www.christiaan.com/stonehenge/
Stonehenge information, pictures and legends


S

Name ________________________________

Date ________________________________

Rubric for Student Writing

Content:

_______ Sun clock recording forms are similar (10 points)

_______ Students states why recording forms are similar (10 points)

Writing skills:

______ Student uses correct paragraph format (includes topic sentence and supporting sentences) (5 points)

_______ Student uses correct capitalization and punctuation (5 points)

_______ **Total points out of 30 possible points**

Names of group members ____

Date ______________________________________

Work with your group to answer the following questions about measuring time with a sun clock. Be prepared to discuss your answers with the rest of the class.

1. In what direction did the shadow move?

2. How did the shadow change throughout the day?

3. At what time of day was the shadow the longest?

4. At what time of day was the shadow the shortest?

5. Why do you think the shadows are longer or shorter at certain times of the day?

6. What do you think would happen to your shadow if you stood outside at the same place for the day?

7. Why do you think we do not use sun clocks more regularly?

The Cycle of Light

The Lunar and Planetary Institute
http://www.lpi.usra.edu/education/skytellers/day_night/activities/cycle_of_light.shtml

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to ask questions about the apparent daily movement of the Sun across the sky. (Science and Technology. 3-5. B1.a; D1.a)
2. Learners will be able to answer questions by making observations and investigations, using simple tools to gather data. (Science and Technology. 3-5. B1.b, c)
3. Learners will be able to communicate those investigations and explanations. (Science and Technology. 3-5. B1.e)

The General Idea: Children will observe how Earth's rotation causes light and dark cycles.

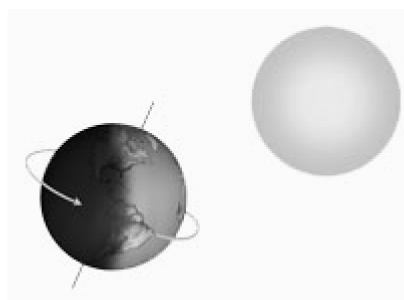
What You Need:

- Globe (optional; for reference)

For each group of 2-4:

- 1 large Styrofoam ball (6-9 inches)
- 2 toothpicks
- 1 flashlight

What To Do:



1. Invite the children to examine the materials provided. Explain that they will explore what causes day and night cycles on Earth.
   - What materials will represent Earth and its axes? (Styrofoam ball and toothpicks)
   - What does the Styrofoam ball represent? (Earth)
   - What is missing in order for them to be able to demonstrate the day and night cycle? (Sun)
   - What can be used to represent the Sun? (flashlight)
2. Have the children place the toothpicks in the ball to represent Earth's north and south poles. For older children, ask them to draw an approximate outline of their continent on the ball, and place a dot roughly where they live. Younger children may just place a dot — or draw an ant — on the ball as a point of reference.
3. Invite the children to experiment with the materials. Can they make day and night occur in their location on the Styrofoam Earth? Suggest that one child holds the Sun and one holds the Earth. Other group members assist with modeling the day and night cycle. Have them experiment with holding the flashlight at different distances and with dimming the lights to discover which produces the best effect.

4. If the children are creating day and night cycles by moving Earth around the Sun, ask how long it takes for Earth to go around the Sun. Our revolution around the Sun takes a full year, so this type of motion does not explain the typical 24-hour day and night cycle. To create a day and night cycle, Earth actually does not have to go around the Sun at all!
5. Use the globe and a flashlight to demonstrate the concept of sunrise and sunset for the location where the children live.
   - Why does the Sun rise earlier in Virginia than in California? Set later in Oregon than in Alabama?
   - In what direction does our Sun "rise" in the morning? (east)
   - Set in the evening? (west)
   - What does this tell us about the direction our Earth rotates? (counterclockwise if viewed from the north pole toothpick)

What To Discuss:

Have the children share their models and show that Earth rotates on its axis once each 24 hours to create daylight and darkness in their location. Be sure to have the children take turns holding the Earth and holding the Sun.

- Can the children demonstrate this rotation with their model?
- What do they observe about day and night from Earth's perspective? (Earth's surface experiences day and night) From the Sun? (Only the sunny side of Earth can be seen)
- Approximately how long is our day cycle? Night cycle?
- Does the Earth do anything to cause day and night? (Earth spins, or rotates, on its axis)
- How often does this happen; how long does one rotation take? (24 hours)

Reasons for the Season

This lesson is part of the Sixth Grade Science Teacher Resource Book (TRB3) http://www.uen.org/Lessonplan/preview.cgi?LPid=2499

Author: Utah LessonPlans

Additional Resources: Alan Gould, Carolyn Willard and Stephen Pompea. The Real Reasons for Seasons Sun-Earth Connections. GEMS Lawrence Hall of Science, University of Berkeley, CA, 2002.

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to describe the relationship between the tilt of Earth's axis and its yearly orbit around the sun. (3-5. Science & Technology. D1.b)
2. Learners will be able to communicate effectively using scientific language and reasoning. (3-5. Science and Technology. B1.a)
3. Learners will demonstrate awareness of social and historical aspects of science. (3-5. Science and Technology. C3.a)
4. Learners will be able to examine the ways people form generalizations. (3-5. Science and Technology. B1.e)

The General Idea:

In this activity students will learn how Earth's axis of rotation affects the angle of sunlight and the length of day. Students will first learn the relationship between the height of a light source and the length of the shadow cast by an object in the path of the light source. They will record shadow lengths to infer changes in the sun's angle over at least a 3-month period. They will also record the high temperatures on the days where shadow lengths are recorded. Finally, students will compare day length with the high temperatures.

Getting Ready:

Have you ever run laps on a track? When you complete one lap you are back in the same place you started. Earth moves around the sun in a path that nearly repeats itself (like running a track) about every 365.25 days. Earth's path around the sun is called its orbit.

Earth's axis of rotation is an imaginary line that passes through Earth's North and South poles. Earth rotates around this axis, which causes day and night. Earth's axis of rotation is not straight up and down with respect to its orbit, but is tilted by about 23.5 degrees with respect to this up and down direction.

If you have ever watched the North Star, you may have noticed that it seems to stay in the same place in the sky all of the time. It is almost directly above Earth's North pole. This shows that Earth's axis of rotation points in the same direction while Earth both rotates on its axis and moves in its orbit around the sun. About June 21 every year, Earth is at a place in its orbit where the northern side of its axis is tilted toward the sun. Six months later, about December 21, Earth is on the other side of the sun where its northern axis is tilted away from the sun.

When the northern side of Earth is pointed away from the sun in December, the sun appears low in the sky and the angle of the sun's rays is small. In June when the northern side of Earth is pointed toward the sun, the sun appears high in the sky, and the angle of the sun's rays is large. In the spring and fall the angle of the sun's rays is half way between the angle in winter and the angle in summer.

The days with the least amount of daylight are not the coldest days, nor are the days with the most amount of daylight the warmest days. This is because some materials can be heated and cooled quickly (especially metals). Other materials can absorb heat without changing their temperature very much, so it takes a long time to heat and cool them. Water is a good example of this. About 3/4 of Earth's surface is covered by water which causes the heating and cooling of Earth to take place slowly. Although the maximum amount of heat received by the sun in the Northern hemisphere occurs on June 21, the highest average temperatures occur about one month later. Similarly, the lowest average temperatures occur after the date when the Northern Hemisphere receives the least amount from the sun.

What You Need:

- “ Season Survey ”, 2-3 copies per student (pdf file – see attached)
- meter sticks or measuring tapes
- lamp or flashlight
- dark room
- outdoor thermometer (a minimum/maximum thermometer would be ideal)
- graphing paper
- sunrise/sunset and temperature dates for the State of Maine (http://www.erh.noaa.gov/er/gyx/index.php)

What to Do:

1. Give each student 2 or more copies of the “Season Survey.” Have each student complete a copy of the survey. Have them ask a family member or friend (not a member of the class) to complete the other(s). When all the surveys have been completed, together as a class, tally the number of responses for each answer choice for each survey question. Discuss with the class to determine which answers are correct. If a particular answer had the highest number of responses, does that mean that it is the correct answer? Explain that historically the majority of people have believed incorrect ideas. Ask if they can think of any examples? (Earth is flat; Earth is center of the universe) Explain that the best way to find out the correct answers is to research the problem. This will be done by making observations and by learning what other scientists have discovered.
2. In a darkened room have a student hold a meter stick upright where everyone will be able to see the shadow. Move the lamp or flashlight up and down to show that when the light source is high, the shadow cast by the meter stick is short. When the light source is low, the shadow is long. Have another student sit near the meter stick and have them point to the light source with their extended arm. The angle of the student 's arm is large when the light source is high and smaller when the light source is low.
   [Sun Shadow Observations - WARNING! - Never look directly at the sun!]
3. Begin shadow measurements on a sunny day. Select a straight up and down object on the school grounds such as a flagpole, tetherball pole, or basketball standard. Choose a time of day when students will be able to consistently make measurements (perhaps a recess break). It is very important that the shadow be measured at the same time of day each time it is measured. With the whole class watching, demonstrate how to measure the shadow cast by the object. It is also important that it is measured consistently each time. Before going outside to measure, decide on a format for keeping track of the records in student science journals. Have students record the date, time and length of the shadow in their science journals.
4. Arrange for an outdoor thermometer to be placed outside your classroom (not in direct sunlight). Have students record the high temperature for the days they observe the sun's shadow. You will need to work out a system for finding the high reading. Thermometers are available with a remote sensor so they could be read inside. Or, if you use a minimum/maximum thermometer it will automatically register the high (and low) temperature each day. An alternative to tracking and recording the actual temperatures is to find and record the official weather temperatures in the newspaper or on the Internet.
5. Continue to make observations with the whole class for about a week. Little change will be noticed, but it will set the pattern for further observations.
6. Organize the class in teams of two or three to continue making observations. Arrange a schedule for the class observations and a method for sharing information with other class members. Continue to make records for a period of at least 3 months. Ideally it would be best to keep records through the school year so students could see the seasonal changes.
7. Periodically discuss with your class what is happening to the length of the shadow. Have them note what is happening to the amount of daylight. This is a good time to discuss sunrise and sunset times. Discuss why this is happening. Be sure students know that Earth's axis of rotation is the reason for the sun's changing position in the sky.
8. Have students calculate the length of daylight for two days each month. Or you may have students gather information from newspaper or Internet sources or from class observations.

9. After sufficient data is collected, organize students in small groups to make the following series of graphs: a graph showing the shadow changes, a graph showing temperature highs, and a graph showing length of daylight. Compare the similarities and differences of the three graphs. Students may notice that the coldest days are not the days with the shortest shadow or the least amount of daylight. Help them understand that one reason for this discrepancy is because the materials Earth is made of take time to cool and warm.

Extensions:

- Students locate and use Internet sources to keep track of sunrises and sunsets and daily temperatures.
- Have students make two or three graphs on the same graph paper to show comparisons.
- Use this demonstration to show students how water heats and cools relatively slowly. Fill a pan with water and place it on a hot plate, turned on high. Help students notice that the pan heats up quickly, but the water does not. Monitor the temperature of the water throughout the experiment. Turn the hot plate down slightly to medium-high. Observe whether the water becomes immediately cooler. It does not. Actually the water temperature may go up. The water temperature does not respond quickly to temperature changes. Relate this to how the earth's surface (3/4 water) does not heat up or cool down immediately.

Assessment Plan:

1. Refer to the original survey students took at the beginning of the unit. Have them take the survey again. Discuss the correct answers.
2. Have students choose one misconception about the way people erroneously think about the seasons and write why the misconception is false and what the correct answer is.

Vocabulary List

Word	Word Description
Atmosphere	The gases that surround a planet, moon or star
Climate	The average weather in different regions of earth
Energy	The capacity for doing work
Erosion	The result of being worn away because of water, wind or glacial ice.
Gravity	A physical force that pulls objects together
Hemisphere	Half of a sphere. The Earth is divided into northern, southern, eastern and western hemispheres.
Horizon	An imaginary circle that delimits the sky and the Earth, or an extension of the plane of th observer.
Lunar Eclipse	What occurs when the Earth's shadow falls on the moon.
Maria (ma – reye – ah)	Dark plains on the moon caused by lava flow during the moon's formation.
Nuclear Fusion	An atomic reaction in which many nuclei combine together to make a larger one. The res this process is the release of a large amount of energy. The sun is powered by nuclear fus like all stars, converting hydrogen into helium.
Orbit	A path that an object takes as it revolves around another object.
Photosynthesis	A process used by plants, involving the Sun, which turns carbon dioxide to oxygen.
Rotation	To turn around an axis
Seasons	Spring, summer, fall, and winter. The seasons are caused by the tilt of the Earth's axis.
Solar Eclipse	What happens when the moon blocks our view of the Sun.
Sundial	An outdoor structure which uses a fixed object called a "GNoman" to project a shadow us the sun's light to tell time.
Sunspots	Dark patches on the Sun's surface that are thousands of degrees cooler than the rest of th luminous surface.
Telescope	A tool that makes distant objects such as the stars look closer, letting humans see things i space.

Some good books to use with *Earth, Moon and Sun*

Science project ideas about the moon.

Gardner, Robert. 1997, Enslow Publishers.

Introduces the phases and other characteristics of the moon.

Our Solar System

Simon, Seymour. 1992, William Morrow Publishing.

A tour of the nine planets, dozens of moons, and thousands of asteroids, meteoroids, and comets that travel around our sun.

Don't Know Much About Space

Davis, Kenneth. 2001, Harper Collins Publishing.

In this book, there are brief explanations about all kinds of interesting topics about space. The book is arranged in questions and answer format so it is perfect for studying up on all of those tough questions students ask

Rock N Learn Solar

Melissa and Brad Caudle Rock N Learn, June 1997

This book provides songs and rhymes that will help your students remember the order of the planets and facts about each one.

American Indian Myths and Legends

Richard Erdoes and Alfonso Ortiz, 1985, Pantheon Books.

Over 100 Native American stories are presented for children ages 8 and older, including the Wasco tale "Coyote Places the Stars," another version of "Why Coyote Howls."

There Once Was a Sky Full of Stars

Bob Crelin and Amie Ziner, 2003, Sky Publishers.

Young children ages 8–11 discover the problem of light pollution and its effects on stargazing through a unique story about the beauty of the night sky.

Some good web sites to use with *Earth, Moon and Sun*

www.moreheadplanetarium.org/index.cfm?fuseaction=page&filename=Earth_Moon_and_Sun.html

Morehead Planetarium and Science Center's page for an Educator Resource Kit for *Earth, Moon and Sun* (includes additional lesson plans, books, and additional resource links).

www.moreheadplanetarium.org/index.cfm?fuseaction=page&filename=ems_teachers.html

Resources for teachers – websites, books, and so much more!

http://www.lpi.usra.edu/education/skytellers/intro.shtml

Explore the mysteries of our Universe with Sky Tellers! Ten Native American myths and legends investigate the reason for day and night, why we have seasons, the origins of the stars, and other wondrous phenomena of our night sky.

hea-www.harvard.edu/ECT/the_book/toc.html

A series of activities provided for teachers to use with students to help them better understand the causes and the effects of the changing of the seasons. This set of activities starts simply by trying to quantify the observation that "it's colder in the winter" and ends by measuring the tilt of the Earth itself. These activities are fun for students and help them to really understand the tilting of the Earth on its axis.

aa.usno.navy.mil/data/docs/MoonPhase.php

From the U.S. Naval Observatory, this is an excellent Web site for teachers to learn more about the different phases of the Moon and why they exist. It provides detailed pictures of each separate phase of the Moon to aid in better knowledge of the subject area.

nssdc.gsfc.nasa.gov/planetary/lunar/apollo_25th.html

The Lunar Exploration page by the national Space Science Data Center

www.atozteacherstuff.com/themes/space.shtml

Moon, Stars, Planets, Solar System. This site includes activities, suggested children's' books, and links for students and teachers. Activities for many grade levels are listed.

Lessons From The World Wide Web

Also, a wide variety of lesson plans and activities can be found on the World Wide Web. These sites are dedicated to lesson planning in a variety of subjects.

cse.ssl.berkeley.edu

The Center for Science Education at U. C. Berkeley Space Science Laboratory home page with a link to the Science Education Gateway, Lesson Plans

btc.montana.edu/ceres

Maintained by the Burns Telecommunications Center, this page links to educational activities and classroom resources.

spaceplace.jpl.nasa.gov/spacepl.htm

This California Institute of Technology and NASA Jet Propulsion Laboratory site for kids offers information and activities .

http://school.discovery.com/

This Discovery Channel education site allows teachers to search for lesson plans by grade and subjects.

http://www.eduref.org/cgi-bin/lessons.cgi/Science

Science lesson plans from the Educator's Reference Desk.

www.thegateway.org

Sponsored by The U.S. Department of Education's National Library of Education and ERIC Clearinghouse on Information & Technology, this site offers lesson plans for all subjects and all grades.

Astronomy Web Sites Worth a Visit

Astro.umaine.edu

The Maynard F. Jordan Planetarium and Observatory home page.

space.jpl.nasa.gov

NASA's Jet Propulsion Laboratory web site

ssd.jpl.nasa.gov

A site about our solar system maintained by the Solar System Dynamics Group of the Jet Propulsion Laboratory.

www.clearsail.net/students.htm

School/Student links from the ClearSail student fun and research site

www.dustbunny.com/afk

A web site about astronomy, designed for kids, with tons of information

hawastsoc.org

The Hawaiian Astronomical Society's home page

www.calacademy.org/teachers/resources/lessons/

Alexander F. Morrison Planetarium Teachers' Resources page

www.nss.org/

The National Space Society webpage

stardate.org

Learn what's going on TODAY in astronomy on the "Star Date" web page, maintained by the University of Texas' McDonald Observatory

The Maynard F. Jordan Planetarium does not guarantee that the information given on the above web sites to be accurate, accessible, or appropriate for students.