TABLE OF CONTENTS

The Solar System

The Moon

Welcome to our collection of children's online astronomy activities. In the following six chapters are hundreds of fun explorations into astronomy as a classroom tool for learning how to theorize, experiment, and analyze data. The activities are fully illustrated and contain detailed, step-by-step instructions as well as suggested discussion topics. This book is lots of fun for teachers and students alike.

This site contains the complete text and graphics of the collection along with related links, a table of contents, an explanation of how to use this book, and email links to the authors. We do hope you enjoy these adventures in astronomy as much as we enjoyed designing them.

Table of Contents | Everyday Classroom Tools

1 2 3 4 5 6

Selected as a Valued Internet Site for the Discovery Channel Online

Made with Macintosh

This site is best viewed with Netscape Communicator. Download Netscape Now!

CHOOSE

The six Chapters of this electronic book are organized into several Topics. These Topics are broken down into many activities which include, in addition to step-by-step instructions, the following:

- an introduction or background material on the Activity
- discussions to encourage predictions, imagination, model development, and analyzation
- cross references to related activities in other topics and
- many diagrams, tables, drawings, and photos to illustrate ideas presented

This book and its activities may be used as a portion of a year's curriculum or as a supplement to one. Educators may find that this book is most effective for grades 2-6. When any of the activities seem more appropriate for older or for younger students, however, we have indicated as such. The activities range from those which take only minutes to those which are observation excercises spanning the entire year, allowing educators the flexibility of time.

Teachers may find they wish to print out the activities to give to their students. We suggest teachers read the background information before doing so in the event that they should choose to present the topics in accordance with a lesson plan or other project.

As a product of the Smithsonian Astrophysical Observatory (SAO), these materials are copyrighted. However, feel free to use them as you wish as long as SAO is cited as the source.

Observing the World Around Us is an inquiry-based investigation of the process of the seasons, and is in a flexible, ready-to-use curriculum format for Kindergarten through sixth grade. It is another facet of the Everyday Classroom Tools project, and is available for free online.

Lastly, to use this book is to have fun! We hope many will learn how to enjoy doing science. We also would like to make sure that anyone participating in these activities has the opportunity to correspond with us with questions, comments, and suggestions.

Table of Contents | Home Page | Everyday Classroom Tools

1 2 3 4 5 6

Dr. Christine Jones is a senior astrophysicist at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. She specializes in the extragalactic X-ray astronomy of clusters of galaxies and in the raising of her three children with astrophysicist husband, Dr. William Forman. Her work includes extensive projects in science education which bring her in and out of the classroom throughout the year. This book is her brainchild.

Ms. Tania Ruiz is an astronomer at the Harvard-Smithsonian Center for Astrophysics. She is presently working on a science outreach project to bring more inquiry-based science education on to the Internet. She is also often seen in classrooms and playgrounds across the East Coast bringing some of the sky down to Earth in the form of lectures, hands-on investigations, and stargazing. She also writes for the Center for Archaeoastronomy as an education consultant

---

Ms. Sara Waters is a third grade teacher at the John A. Bishop Elementary School in Arlington, Massachusetts. She worked with this project from its earliest incarnations in 1991 and then went on to collaborate with us on the Everyday Classroom Tools curriculum, Long Shadows

---

Mr. Jeffrey Breen now works and lives in Virginia. He has a Master's degree in astronomy from the University of Virginia where he specialized in multi-wavelength astrophysics of galaxies. Jeffrey was involved with writing the text of this book during its earliest incarnations in 1991.

Home Page Everyday Classroom Tools

1 2 3 4 5 6

CHAPTER ONE: THE EARTH'S ROTATION

This book begins outside in the sunshine. Measurements made of shadows can trace the path of the sun during the day. If measurements begin early in the fall and continue throughout the school year, students will see changes in their observations that are caused by the change of season, as discussed in the next chapter. After the students understand how shadow measurements are made, classroom records may be kept with groups of students taking turns as the shadow measurers and recorders. They can then share their results with the class.

This chapter looks first at the phenomenon of shadows (how they are made), then uses measurements of shadows to track the motion of the sun across the sky. A companion activity done in the classroom uses an earth-sun model to reproduce the same pattern of shadows the students observed during the day. An outdoor model uses a small clear dome for the sky on which the students record the sun's path. Building and using a sundial is the last activity illustrating the sun's motion. Although probably less obvious to the students, the stars also follow a daily path. Like the sun, they rise in the east and set in the west. Two activities - one in which the students observe the motion of the Big Dipper during the evening and one which takes long exposure photographs of the sky - show the apparent motions of the stars.

The activities in this chapter challenge the students to quantify their observations, and in so doing, learn useful measuring and organizational techniques. The ability to measure and present data is an essential skill in any scientific investigation.

Topic 1: Light and Shadow

A shadow occurs when an opaque object blocks light from the sun or other light source. Observing the behavior of shadows is an easy way to investigate some of the properties of light. Points to understand include:

- Light travels in straight lines
- A shadow of an object will move due to either the motion of the object or of the light source
- Even seemingly transparent objects can form shadows if they absorb or reflect some of the light striking them

Possible questions to consider and discuss: What makes a shadow? Do different kinds of objects make different kinds of shadows? Are shadows different colors? What makes a shadow disappear? What makes shadows at night? Do you have a shadow at noon? Where is the Sun at noon?

Activity 1-1: Making Shadows

This activity gives students a chance to experiment with different ways of making shadows. Shadows often tell as much about the light source as about the objects which cast them. Since light travels in straight lines, if we know where an object is and where its shadow is, we can determine where the light source is. We will use a stationary stick later in this chapter to record the motion of the Sun.

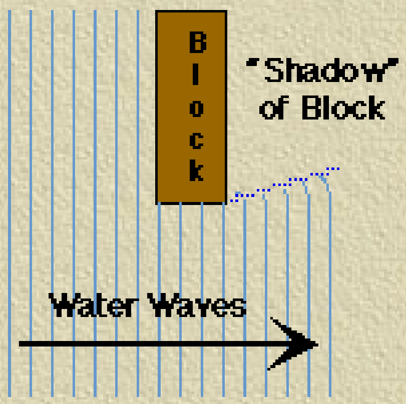
This activity requires a sunny day, though portions could be adapted for use indoors with a slide projector or similarly focused light source. If you include the noon shadow question in your Discussion, you should start outside slightly before noon.

Materials: large pieces of chalk; paper; soap bubble solution; bubble blowers; pencils; markers; paints; various objects such as hoops, lace, balls, etc.

- 1. Have the students make shadows of various objects. Maybe they can start with themselves! Can they tell the relative positions of multiple objects solely from their shadows? Try putting a pebble on the ground and asking the students to try to make a circle around it with the shadow of their fingers. Students may outline their own body's shadow shape with markers on large paper and cut them out.
- 2. What kind of shadow can a hand make? What happens as the hand moves closer or farther from the ground?
- 3. Give students large pieces of chalk. Can they trace another student's shadow on the pavement? How about their own? Can all the students in a circle in turn trace each other's shadows?
- 4. Now add various objects and look at their shadow shapes. What kind of shadows can a hoop, ball, or an umbrella make? Make sure they experiment with different angles for each object. Can they make a circular shadow from an oval-shaped object? Perhaps an oval shadow from a circular shape? Design a recording sheet by making 3 columns on a sheet of paper. Write the object's name, draw the object, and draw the shadows' shapes.
- 5. Try to invent some games to play with shadows. Follow the Leader, Shadow Tag, Simple Simon with shadows are a few suggestions. Students could make an illustrated book of shadow games.

Discussion:

What causes shadows to form? Was it easy or difficult to draw your own shadow? Were there shadows at noon? What happened to the shadow as you moved your hand closer or farther from the ground.



The students may have noticed that the shadows cast by objects farther from the ground are fuzzier than those cast by an object near to the ground. This is due to an effect called *diffraction* and is evidence that light travels as waves.

By placing a block of wood in a pool of water and sending waves towards it, one can see the waves bend around the edge. The farther the waves travel past the object, the more they bend into the "shadow" caused by the object. In the case of light waves, this effect causes fuzziness in the shadows.

Topic 2: Changing Shadows During the Day

While students are aware that day and night occur, they may not yet understand that these changes happen because the Earth rotates once every twenty-four hours. Day occurs when our side of the Earth faces the Sun and night occurs when our part faces away. As the day progresses, the Sun appears to follow a path from its rising in the east to its setting in the west. One way to record the Sun's path is to track the shadow cast by a stationary stick. By repeating the experiment periodically over the course of several months, the effect of the time of year on the Sun's path also should be observed. (These two activities are identical, except for the size of the group.) Important points to understand include:

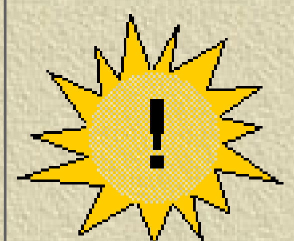
- The Sun appears to move across the sky due to the rotation of the Earth about its axis.

- The Sun's path for a certain day is determined by the location of the observer on the Earth (particularly his latitude - see figure below).

Activity 1-2: Tracking Sun Shadows (Large Group)

For this activity, first find some open outdoor space - preferably in the school yard - that can be used every day. Be sure to choose a spot unobstructed by trees or tall buildings which would shade this area early or late in the day. When working with older students, it may be preferable to have them work in small groups to record their own Sun shadows (see small group activity below). The small group activity also may lend itself more naturally to long-term observations. If long-term observations are to be made, be sure to record the height of the shadowstick and to use the same one each time. The height will be very important for the activity "Measuring the Earth's Tilt" in Topic 5.

Note: Classes which start observations early in September should be able to include the autumnal equinox (around September 21) in their observations. On the equinox, the shadow ends from the shadow stick will all lie on a straight line. Additionally, an early start allows for the refinement of observing techniques before cold winters arrive to northerly climes.



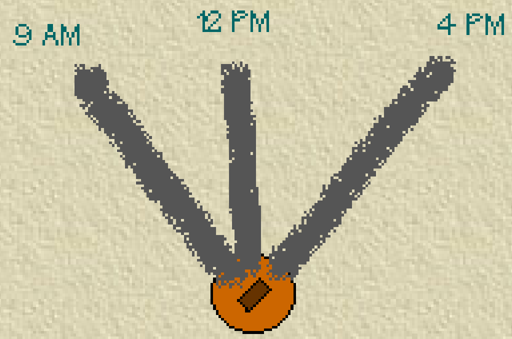
Be sure to remind students that looking at the Sun can cause permanent eye damage- Never look directly at the Sun!

Possible questions to consider and discuss: What are some differences between day and night? Where does the Sun rise? Where does it set? Where is the Sun at noon? At midday?

Note: Due to daylight savings time, the sun may not reach its highest point in the sky until nearly 1:30PM depending on the time of year and your location within your time zone!

Materials: yardstick; large coffee can of soil or stones; large, flat sheet of cardboard or heavy paper (at least 2' x 3'); marker; and compass.

- 1. Begin early on a sunny day and plan to make periodic measurements throughout the day.
- 2. Having selected a suitable spot, use a compass to determine North, East, South, and West. Place the recording sheet of cardboard or heavy paper on level ground such that the edges are aligned with the compass directions. Place the yardstick upright in the large coffee can filled with soil or stones and put this at the center of the southern edge of the recording sheet.
- 3. Mark the direction of magnetic North on the recording sheet. Make sure the students do not move the cardboard, but, just in case, mark the outline of the recording sheet on the pavement with chalk and the outline of the can with a marker, so that their positions may be checked. If permitted, it may be helpful to outline the chart, or its corners, on to the pavement with spray paint so that observations can be repeated from day to day and week to week.
- 4. Mark the line and tip of the shadow cast by the yardstick with a marker and record the time of the observation. Ask students to predict where the shadow will fall after a certain time interval, such as 15 minutes or an hour. Each student or group of students can mark the place they predict with a small stone or popsicle sticks. When the chosen interval has passed, mark the new shadow position with a marker. The class can check their markers against the actual position.



- 5. Throughout the course of the day, periodically (every hour or half hour) record the movement of the shadow of the yardstick by marking the line and tip of the shadow.

Analysis:

After a day of recording, connect the shadow ends recorded near noon time with a line. At Midday, the Sun is at its highest in the sky, and therefore corresponds to the shortest shadow. At this time, the Sun is due South, and so the shadow of the stick points toward the Earth's North Pole. Mark this North-South line. (If not measured, the locations of the noon and midday shadows can be estimated from the positions of shadows marked at nearby times.)

Compare the North-South line marked by the midday shadow with that marked with the compass. Do they agree? Discuss the difference between True and Magnetic North. A compass is simply attracted by the magnetic force. Demonstrate how a nearby magnet can easily fool the compass. Try making it point South by placing a magnet to its south!

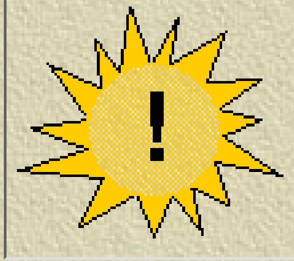
If a computer is available, the length of each shadow could be measured and entered, along with its time, into a spreadsheet or graphing program (like AppleWorks, Excel, or Cricket Graph). The computer could make a graph relating the shadow length to the time of each observation. The data for each day could be saved and compared to later days. Even without a computer, a simple graph could be made by hand.

Discussion:

Discuss observations of shadow lengths. Questions might include: How do shadow lengths change during the day? Why do they change? Is there a pattern to where the shadows fall and their lengths? Why is there a pattern? Is the Sun directly overhead at any time? Why is the shortest shadow around noon? Why does the shortest shadow point North? Why doesn't it point in the same direction as the magnetic compass?

Activity 1-3: Tracking Sun Shadows (Small Group)

This activity duplicates the large group activity above but on a smaller scale; it may be done by groups of 2 to 4 students. The analysis and discussion will be similar to that done for the large group.



Be sure to remind students that looking at the Sun can cause permanent eye damage- Never look directly at the Sun!

Materials (per group): short drinking straws; modeling clay; 9"x12" oaktag; large rock or brick; clear acetate as used with an overhead projector (if not available, use plain paper or tracing paper); compass; crayons and markers.

- 1. Begin early on a sunny day and plan to make periodic measurements throughout the day.
- 2. Have each group mount a straw vertically in clay at the center of the oaktag and outline the clay with a marker.
- 3. Make sure each group has selected an appropriate spot for observing, and be certain the oaktag is anchored with a large rock or brick to prevent it from blowing away (don't let the anchor block the Sun!) Have each group trace the outline of its oaktag on the ground with chalk and mark magnetic north on the oaktag and the ground to insure that the oaktag is identically placed for each measurement. Mark the position and tip of the shadow of the straw at regular intervals throughout the day, noting the time of each observation.
- 4. At the end of the day, remove the straw and clay and mark the location of the bottom of the straw on the oaktag with a marker. Place a plastic sheet over the oaktag and copy the markings with a felt-tip marker. Date the plastic sheet and the oaktag. Save these to compare with later recordings.

Activity 1-4: Day and Night on the Spinning Globe

In the previous activity, students saw how shadows changed during a day. This activity uses a globe and indoor light source to create a classroom model showing day and night on a spinning Earth. (We would like to credit A. Lane and S. Nocelben for first showing us this activity.)

This activity requires a darkened room.

Materials: Earth globe with string attached to North Pole; strong focused light source (such as an overhead projector, a flashlight, or a slide projector); golf tees; small figurines; fun tack or similar material.

- 1. Hang the globe from the ceiling, low enough to be reached easily. Shine the light source directly at the globe from the side. The light source must be large enough to illuminate the entire Earth. If you use an overhead projector, you can cut out the "extra" light by placing a sheet of paper on the glass with a hole cut out of its center. While the Earth is actually tilted in its orbit, this is a complication which will not be dealt with until the next chapter on the seasons.
- 2. Attach a small figurine to the globe at your location with fun tack. Slowly turn the globe so that the figurine "sees" the Sun rise in the east and set in the west. Now attach a second figurine to another part of the globe. Does the Sun rise earlier or later in this new location? Are the figurines always both in light or both in darkness? Or can one be in light while the other is in darkness? What if the two figurines were on opposite sides of the Earth?
- 3. Attach a golf tee to the globe at your latitude. Again, slowly turn the globe eastward and notice the fan-like shadow pattern which the golf tee casts. Is it similar to the pattern cast by the shadow stick in the previous activities? Note that the shortest shadow points towards the North Pole.
- 4. Attach three golf tees to the globe at various latitudes along the same

meridian of longitude. One should be on the equator, one should approximate your latitude, and one should be near the poles. Ask three students to each observe one of the golf tees. As the globe slowly spins, ask the students to call out their golf tee- "top", "middle", or "bottom"- as they cross the day-night boundary. Also, be sure to observe the midday shadows and to note in which direction they point.

Discussion:

How do we know if we're spinning the globe in the right direction? Where does the Sun rise if we were standing on the globe? Where does it really rise? Set? What if we spun the globe in the other direction? Would this also match our observations? It is only by such comparisons with observations that we can verify our models. Are the golf tee shadows longer or shorter at the equator? What about at noon, when the Sun is highest in the sky? Is there any shadow at the equator? What about at your latitude? Where do all the shortest shadows point? Does the pattern made by the golf tee reasonably match that made by the shadow stick of the previous activities? Might a spinning earth, then, not be a reasonable model for the passage of day and night? What if the Earth didn't rotate? What if the North Pole were pointed towards the Sun? Where would it be day and night? Would all locations still have both day and night?

Can you think of any other ways to test this model of a spinning Earth? Maybe shadow stick patterns from schools at other latitudes could be compared to yours. Are they consistent with the differences seen on the spinning globe? Have the students observed any complications which our model does not account for? (More on these, such as the tilt of the Earth in the next chapter.)

Topic 3: The Sun's Daily Path

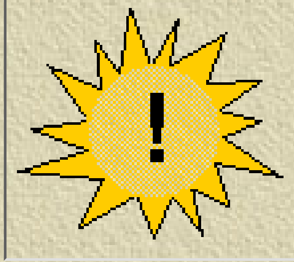
The activities of Topic 2 have shown us that observing the shadows made by the Sun during the course of a day provides information about time: the times of Midday, sunrise, and sunset, for instance. This topic further explores the path of the Sun in the sky, and how we might use this information to determine the current time of day. New ideas to be understood include:

- Analysis of the shadows cast by the Sun yields information about its path in the sky.
- People have been using Sun shadows and sundials to tell time by the sun for thousands of years

Activity 1-5: Tracking the Sun's Path in the Sky

This activity can be done with the entire class and one large plastic dome or by groups of students with their own domes.

It is most appropriate for Grades 4-6 having completed the activities in Topic 2.

	**Be sure to remind students that looking at the Sun can cause permanent eye damage- Never look directly at the Sun!**

This activity allows us to track the apparent motion of the Sun in the sky on a model in which the plastic dome represents the sky. To do this, we mark the position on a clear dome which casts a shadow at the same central spot. As the Sun moves in the sky, so too does the position we must mark. For this activity, an outside spot must be picked which will not be shaded at any time during the day.

How does the Sun appear to move across the sky? How could shadows tell us about the Sun's position?

Materials: clear plastic dome (3" to 8" diameter or clear tops of "Leggs" pantyhose containers will work); grease pens or water-soluble markers; adhesive colored dots; (as an alternative to a plastic dome, a large kitchen strainer and sewing pins with large heads can be used); 9" x 12" oaktag or other stiff paper; compass.

- 1. Begin early on a sunny day. Place a clear plastic dome or a large kitchen strainer on a sheet of oaktag and trace the outline of the dome on the oaktag. Draw a mark on the edge of the dome and on the oaktag, so the alignment of the dome and oaktag can be checked before each observation. Remove the dome and mark the center of the circle just traced. (The center can be found by drawing two intersecting lines across the widest part of the circle, like

- 3.) The dome represents the sky to your horizon, the center mark represents your position on the ground.

- 2. Having carefully selected an unshaded spot for the observations, place the oaktag on level ground or asphalt. Trace the outline of the oaktag on the ground, so that its position can also be verified before each observation. Replace the dome on the oaktag outline aligning the marks on the dome and the oaktag. Using the compass, mark a North-South arrow on a corner of the oaktag.

- 3. Mark the spot on the dome whose shadow falls on the central dot. If using a strainer, large headed pins will work well. For a plastic dome, use an adhesive dot or a grease marker. (It may be easier to use the end of a pen to locate the position before marking it with an adhesive dot.) Number the marks and keep track of the times of the observations in a notebook. Continue to make observations at regular intervals throughout the day. At the end of the day, label the compass directions on the dome, date it, and keep the dome for comparison with later observations.

Analysis:

You should be able to convince yourself that the marks placed on the dome correspond to the position of the Sun in the sky a those times. If an observer (maybe an ant) were to stand at the central dot inside the dome, then each time a dot was marked eclipsing the Sun (casting a shadow on the observer), the dot would have to be in the direction of the Sun. The position of the dot, then, would have to be the same as the Sun's apparent position in the sky.

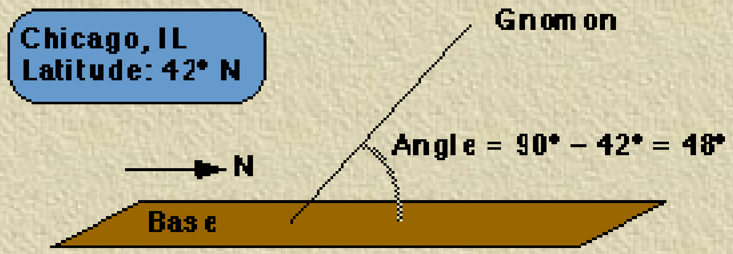
Discussion:

What sort of path does the Sun follow in the sky? Did the Sun travel directly over the top of the dome? Where did the Sun begin in the morning? Where was it in the afternoon? What about at noon? At midday?

Activity 1-6: Building and Using a Sundial

This activity is most appropriate for grades 4-6.

A sundial is a device to measure time by the sun. It is made of two parts: a gnomon (NO-men) and a base. The gnomon casts a shadow on the base, a flat surface with markings indicating each hour. On a properly constructed sundial, the shadow of the Sun moves equal distances each hour. A sundial with a vertical gnomon will work perfectly at the North Pole because there the shadows cast will move equal distances each hour. But as one moves farther from the North Pole, the motion of the shadows varies more.



When you made the shadow stick measurements, you may have noticed that shadows separated by equal time intervals were rarely separated by the same distance. One solution to this problem is to tilt the gnomon so it is aligned as it would be if it were vertical at the North Pole (i.e. parallel with the Earth's axis). Knowing your latitude is all that is necessary to find the correct angle to tilt your gnomon. Since the latitude of the North Pole is 90° (N), just subtract your latitude from 90° to find the angle to tilt the gnomon (refer to the table of latitudes of major U.S. cities). The gnomon should point towards North .

You may want to repeat the shadow stick measurements in Topic 2 at the same time as the sundial measurements to see the difference of a vertical stick and one tilted to match your latitude. Instead of tilting a stick, we will use the "tilted" edge of a triangle for our sundial gnomon.

Materials: scissors, enclosed cut-outs, protractor, oaktag (or other heavy paper), popsicle sticks, graph paper.

- 1. Make a gnomon pattern like the example we've included. Refer to the latitude table to determine the correct angle to mark - 45° is marked as an example. Cut out the gnomon from this pattern.
- 2. Fold pattern along the dashed line so that the flaps A and B are on either side of the gnomon. These flaps will allow the gnomon to stand on its own.
- 3. Tape a sheet of graph paper over the oaktag.
- 4. Tape the gnomon to the middle of the sheet of graph paper on the oaktag. If the gnomon remains floppy, then tape a popsicle stick to it to provide support.
- 5. Start early in the morning. Place the sundial outdoors, with the gnomon pointing North. Record the outline of the gnomon's shadow and record the time next to it. Repeat this process each hour. See if the students notice a pattern in the movement of the shadow.

Discussion:

Count how many squares the shadow moves each hour. Compare how the triangle gnomon measures the hours compared to how the vertical shadow stick measures the hours. In which direction did the shadow appear to move? What if the sundial were in the Southern Hemisphere? Did you ever wonder why clocks run "clockwise"? Before mechanical clocks, people used sundials, which, as we have seen, run clockwise in the Northern hemisphere.

Before the establishment of the standard time zones we know (Eastern, Central, Mountain, and Pacific for the continental U.S.), each city kept its own time based on the observations of the Sun. We have seen how to find midday. Try keeping your own time based on your observations of the Sun by setting noon to midday. How close to the "standard" time are you? Where else on the globe should have the same "local" time as you? Are there any advantages to keeping your own solar time? What about disadvantages? Why might we have standardized on time zones?

Topic 4: The Motions of the Stars

These activities are appropriate for students in grades 4-6 and may require the enlistment of parents for assistance.

Students may be ready to make night time observations. Just as the rotation of the Earth makes the Sun appear to travel through the sky, so too do the stars at night seem to move. And just as the motion of the Sun can be used to track the passage of time, so too can the stars help us tell time.

We know now that the night sky is filled with stars like our sun which are so far away that they look like tiny bright dots. These tiny dots make up a pattern on the sky which does not change on the scale of our short lifetimes; thus, they are a nice wallpaper we can use as a backdrop for other experiments.

One of these experiments is to find the point in the sky under which the Earth does not seem to move, or the point of the sky which seems to neither rise nor set. In other words, the point right above the North Pole. The figure shows why this is true. The wallpaper of stars seems to fly across the sky to observers along the Earth as the Earth rotates its night and day underneath it. However, at the poles, the observer is simply spinning right underneath a specific point, and if he looks straight up at a star, that star does not sweep out an arc like the rest of the stars. You can imagine spinning on a merry-go-round and noticing that if you are sitting in the very middle and looking out, the playground seems to fly around you; however, if you look up, a cloud in the sky seems to stand still.

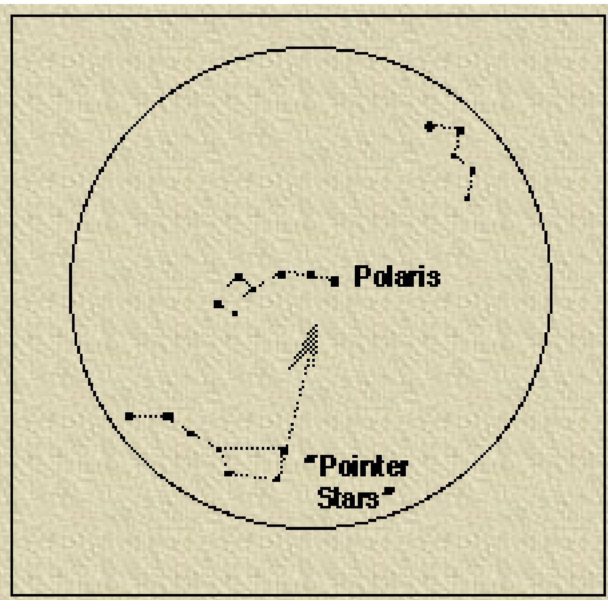
On a spinning Earth, observers looking further away from the center of the spin axis see the wallpaper of the sky rush around them in a day, while observers looking up near the spin axes (the poles) see the wallpaper move less and even see that stationary point which is like the cloud from the merry-go-round example. Only over the North Pole is there a star roughly at that stationary point. It is called Polaris, the Pole star.

Important points to stress include:

- It is the rotation of the Earth which makes the stars appear to move through the sky
- Polaris, The North Star, is nearly directly above the North Pole and the Earth's axis of rotation, so all the stars seem to move around it
- The motion of the stars is just as predictable as that of the Sun, so they too can be used to measure time

Activity 1-7: Simulating the Motion of the Stars

Before the students try observing outdoors, it is important that they know what to look for. Even professional astronomers prepare and study star maps



before a night of observing. This simple activity helps familiarize students with the apparent motions of the stars and the underlying reason for this motion.

Materials: adhesive dots (brightly-colored or glow-in-the-dark, if possible) or a means of projecting a star map onto the ceiling

- 1. Put a simple star map including easily-recognizable stars and constellations such as Polaris, the Big Dipper, and Cassiopeia on the ceiling of the classroom. This can be done either by using adhesive dots for stars or by projecting the star pattern of onto the ceiling. To do this, just cut out the star map or transfer it to construction paper, make holes for the stars with a pin, and shine a flashlight through the pattern.
- 2. With the star map on the ceiling, show the students how to find the Big Dipper and Polaris, the North Star. The two stars at the far edge of the Big Dipper's ladle are often called the "pointer stars"; Polaris can be found by extending the line connecting these pointer stars out of the Dipper.
- 3. Have each student stand below Polaris and turn slowly counterclockwise watching how Polaris stays in one place while the other stars appear to move around it.
- 4. Point out that this is how the stars would appear to move at the North Pole.

Discussion:

Can the students predict how the stars' motions would differ at their location? What about at the Equator?

Activity 1-8: The Big Dipper Clock

The previous activity showed the students how the rotation of the earth causes the stars to appear to move in the sky. Now it is time to try some night time observing. First the students should find the Big Dipper in the sky. The constellation guide from the previous activity can be used as a guide to find the Big Dipper in the classroom with the students. These patterns will help them to find the Big Dipper and the North Star (Polaris). The dotted line directs them from the Big Dipper to Polaris. If we extend the north/south axis about which the Earth turns, it would point to Polaris. As we saw already in the previous activity, as the Earth turns, Polaris does not appear to move, while the other stars appear to move around Polaris. (Native Americans called Polaris "the star that does not walk around".) Since the Big Dipper is easily recognizable, one can follow its motion around Polaris as if it were the hour hand on a twenty-four hour clock.

Materials: Big Dipper Finder; brass fasteners.

- 1. To make the Big Dipper Finder, cut out the two circles from the patterns we've included and place the smaller one on the larger. Fasten the two circles together by inserting a brass fastener through the center of the two circles, marked with little Xs on the patterns.
- 2. Discuss how students should use the finder at home. In the evening students should face North and find the Big Dipper and Polaris. Next, they should hold the large disk so that NORTH is at the bottom. Then they should turn the small circle until its stars match those in the sky. They can then read the month in the window opening. Is that the correct month? Or how about moving the little circle so that the arrow points to the current month. Do the Dippers on the Finder match the orientation in the sky? They should repeat this activity after an hour or so and describe any differences. If possible, repeat this activity a third time after another hour has passed.
- 3. The next morning, discuss with the class their observations.

Discussion:

Could the students find the Big Dipper? Polaris? Did the Dipper appear to move around Polaris? Could it be used as a clock? All of the Big Dipper may not always be visible from your location (it's certainly not visible during the day); when might it still be a useful clock?

Activity 1-9: Photographing Star Trails

Some teachers and older students may wish to photograph the sky. By making a long exposure of the sky, the stars will leave trails as they move during the course of the exposure.

Materials: Camera with manual shutter setting; ASA 400 (or faster) film; tripod.

- 1. Find a dark location (away from houses, streetlights, and roads, if possible) where Polaris is visible.
- 2. Set the camera on the tripod and aim it towards Polaris. Set the focus to its maximum distance (usually marked with a dot). Set the camera's aperture to its widest opening (the smaller the "f-stop", the larger the aperture). The exposure time will vary with the size of the lens opening, the type of film used, and the brightness of the stars you are photographing.
- 3. First take a photograph leaving the shutter open for five minutes. Then make 10-, 15-, 30-minute and even longer exposures. Keep a careful record of the exposure time for each picture. Once the film is developed, you can determine which exposure time works best. The pictures should show the light trails of stars (arcs or partial circles) as the stars appear to move across the sky.

Discussion:

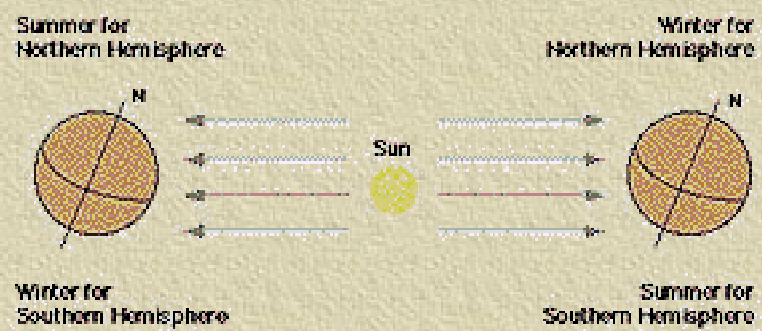
Do the lengths of the arcs change with the exposure time? In what way? Why? Are the arcs closer to Polaris longer or shorter than those farther away. Why? What could we do if we wanted to take a long photograph without the star trails? What would a meteor look like in the picture? What about an artificial satellite?

Related Links

Comments?

Contents | Back to Top 2 3 4 5 6 | Home

While the Earth rotates once a day about its axis between the north and south poles, it revolves about the Sun in its orbit but once a year. The seasons are caused by the simple fact that the Earth's axis of rotation is not perpendicular to the plane of its orbit. Rather, the Earth's axis is tilted some 23°.5 away from the perpendicular, as shown in the figure (which is NOT to scale).



As the Earth orbits the Sun, the orientation of its rotational axis is held fixed, so that if we imagine it extended into space, it is always pointing towards Polaris, the pole star. As the Earth orbits around the Sun, for a portion of the year the Sun is in the same direction as the tilt happens to be. In other words, the Earth is in a part of its orbit where its tilt direction is towards the direction of the Sun. This means that the Northern Hemisphere will have warmer temperatures and hence summer. For the other portion of the year, the Earth has moved around the Sun, putting the Sun not in the direction in which the tilt happens to be. In other words, the tilt direction is off into space behind the Earth (towards the outer planets). With the top of the Earth now tilted away from the Sun, the Southern Hemisphere can enjoy summer. There are, of course, times in between as the Earth is orbiting when it has the Sun neither towards or away from the direction of the tilt. These times are when no hemisphere is experiencing any greater amount of sunlight than another, and so this is Spring or Fall for the hemispheres.

This chapter investigates both the causes and the effects of the changing of the seasons. We start simply by trying to quantify the observation "it's colder in the winter" and end by measuring the tilt of the Earth itself!

Topic 1: Observations of The Seasons

If you ask students what a particular season means to them, they'll probably mention the weather usually associated with it. Summer is hot. Winter is cold. Spring and Fall are in between. (For those of us living close enough to the poles, winter means snow, too!) A common misconception (even among a disturbingly large number of college graduates) is that the Earth is closer to the Sun during the summer, causing summer's warmer temperatures. This model, of course, is inconsistent with the fact that while the Northern Hemisphere has summer, the Southern Hemisphere has winter. Furthermore, while it's summer for the Northern Hemisphere, the Earth is actually slightly farther away from the Sun than during the winter.

As we know, during the Northern summer, the North Pole is tilted towards the Sun. During the winter, it is tilted away. This tilt causes the Sun to appear higher in the sky during the summer than during the winter. The higher Sun causes more hours of daylight and more intense, direct sunlight, or hotter conditions on the surface of the Earth. Questions to ask the class include: How is summer different from winter? What changes as winter gives way to spring? What changes are there as summer becomes fall? What about when winter approaches?

Activity 2-1: The Sun's Changing Path

The shadow stick measurements (Topic 2, "Sun Shadows") and measurements of the Sun's path on a dome (Topic 3, "Tracking the Sun Path in the Sky") from the previous chapter can be continued from week to week and month to month to show seasonal changes. Both will illustrate that the Sun follows a higher arc through the sky in the summer than in the winter. A comparison of shadow lengths all measured at midday will show that the shadow lengths increase as winter approaches becoming longest about December 21 (the shortest day) and then decrease again until June 21 (the longest day).

One way to keep track of the shadow lengths is to draw a graph by hand or on the computer. The plot should have midday shadow length (on the vertical axis) versus the date of the observation (on the horizontal axis). Each week, make a new measurement and update the graph. The measurements on the dome require more time, but provide a much better record of the Sun's path through the sky during more of the day rather than just at midday. Repeating the dome measurements each month (perhaps using the same plastic dome with different colored markers) will very clearly record the changes in the Sun's path through the sky during the year.

Activity 2-2: Recording Daily Temperatures

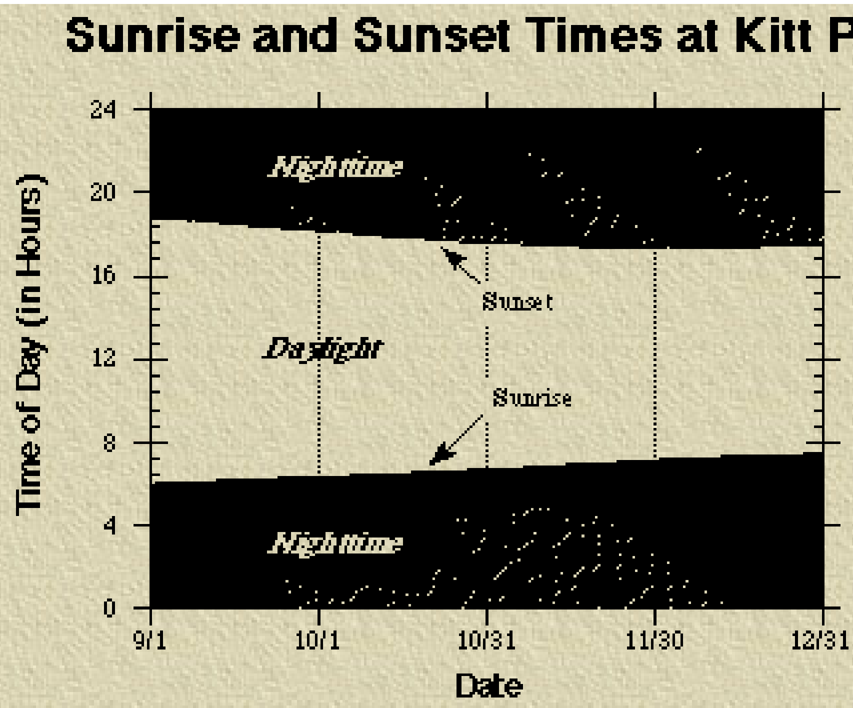
Weather is the result of an almost incalculable number of events. As such, it would be folly to attempt to predict a given city's temperature for a given date, far into the future. It would be equally foolish to point to an exceptionally cold day in June and declare "Winter's coming!" There are just too many variables for such a simplistic view. However, hidden among the randomness are trends which can be measured, and from which conclusions like "winter's coming" can be made.

The class can measure the outside temperature at a particular time each day, perhaps noon or lunch time. From newspapers or broadcast newscasts, the class can collect local high and low temperature readings for each day. These can be plotted on a graph or entered into a data base. For younger students, a classroom chart with cartoon thermometers with daily temperature marks can be made. The exact form of this activity is not important. One should emphasize the importance of recording data in an appropriate way. Sometimes making a simple graph can explain pages and pages of numbers. Simplicity is the key. With clear presentation of data, it is much easier to move forward and, for example, correlate the temperature measurements with the shadow stick and dome measurements.

Activity 2-3: Tracking Sunrise and Sunset Times

The tilt of the Earth in its orbit about the Sun affects not only the intensity of the solar radiation at a given location, but also the number of daylight hours. These two effects combine to create the weather we usually associate with each season.

In the Northern Hemisphere, the Summer Solstice (longest day, shortest night) occurs around June 21. From June 21 to December 21, the days grow shorter and the nights longer. There are two equinoxes, during which the hours of daylight and night are equal: the Vernal Equinox (around March 21) and the Autumnal Equinox (around September 22). One can observe these changes by recording the times of sunrise and sunset and measuring the length of the day. Changes in these times are large enough (about a minute a day) to be seen on a graph. The figure below shows such a graph made from sunrise and sunset times at the National Optical Astronomical Observatory located on Kitt Peak near Tucson, Arizona for September to December. If begun in September and continued through the Winter Solstice (about December 22), the graph should show the gradual decrease in the number of daylight hours (in the Northern hemisphere) with the minimum at the Winter Solstice. It would be interesting to include either of the equinoxes on the graph as well.



Materials: Large paper from roll (3'X6'); markers; yardstick; pencil; circle labels; paints; adhesive dots; daily local newspaper.

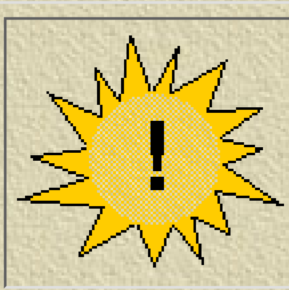
- 1. On a large sheet of paper, make a grid on which to plot the sunrise and sunset times. The time of day should run along the vertical axis, leaving about one inch for every hour. The date of the observation will be recorded along the horizontal axis.
- 2. Look up the times of sunrise and sunset in a daily newspaper. Plot these times on the graph, marking the points with adhesive dots. After plotting for several weeks, connect the dots with a line.
- 3. Optional: These coordinates can be stored and plotted with a computer spreadsheet like AppleWorks.

Discussion

The figure below shows a plot of sunrise and sunset times taken once a week from September through December. Notice that the shortest day occurs around December 21, as expected. In order to reinforce the connection between the number of daylight hours and average daily temperature, try making a wall-sized chart combining sunrise-sunset data with the daily temperature, as collected in the previous activity. While daily fluctuations in the temperature will be apparent, it is the general trends which we seek. How does the length of the day change with season? Does the daily temperature match this trend also?

Activity 2-4: The Analemma

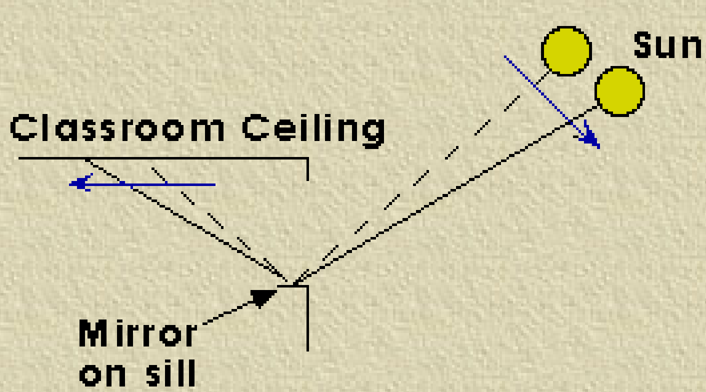
This simple, long-term activity provides an easy way to record the changes of the Sun's apparent motion. We already know that the Earth's tilt causes the Sun's path to be higher in the sky during the summer than in the winter. Because the Earth's orbit around the Sun is not perfectly circular, the Sun's position at a specific time (as given by the clock) changes Eastwardly and Westerwardly as well. By reflecting sunlight onto the classroom ceiling and marking the Sun's position at the same time every week, we can record the change of the Sun's apparent motion, and after a year should notice a figure-eight-like figure known as an analemma.



Be sure to remind students that looking at the Sun can cause permanent eye damage- Never look directly at the Sun!

Materials: Southern window with direct sunlight; small mirror; masking tape; adhesive dots (optional)

- 1. Choose a Southern window with direct sunlight which will remain unblocked throughout the year.
- 2. Place a very small mirror on the window sill and adjust so the sunlight shines on a clear area of the ceiling (without lights, mobiles, etc.). A mirror only an inch across is adequate. It is best to be able to tape the mirror there permanently, but at the very least, mark the mirror's position with masking tape. (If



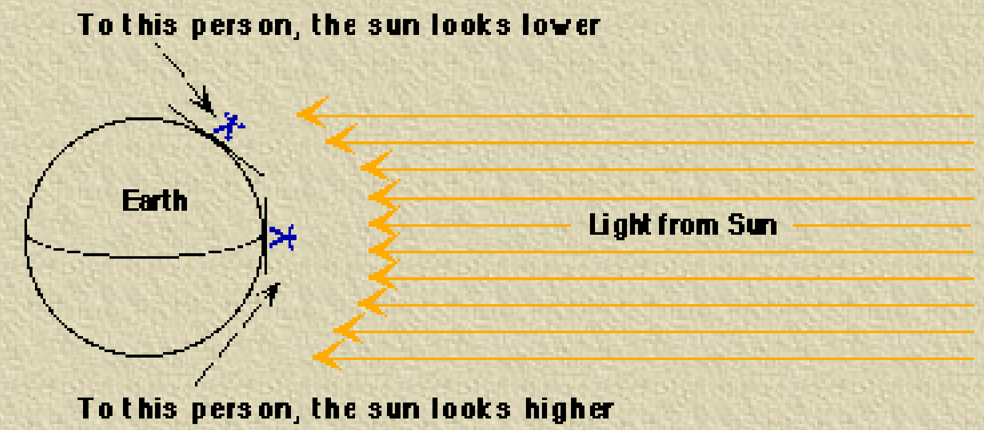
the reflection from a permanently-mounted mirror becomes distracting during the rest of the day, simply cover it with a sheet of paper).

- 3. Once or twice a week, at exactly the same time by the clock, mark the location of the Sun's reflection on the ceiling with an adhesive dot or a piece of masking tape (watch out for Daylight Savings Time changes- adjust the time so that you always make measurements in the same time reference, Standard Time).
- 4. Record the date and time of the observation on the marker.

Discussion

Where would the spot of sunshine be if the Sun were lower in the sky? Higher? more Easterly? more Westerly? How much does the Sun appear to move each week? Is this change constant throughout the year? After we have measured for a year, could we use the previous year's analemma as a rough calendar? Would it work for every day or are there some periods of ambiguity? When are they?
The analemma is longer in one direction than in the other. This longer variation is caused by the seasonal motion of the Sun's path. The other variation (east-west) is the drift of solar time to the average solar time due to the eccentricity of the Earth's orbit around the Sun. (Eccentricity, while precisely defined, can be thought of as an ellipse's lack of circularity- for more information on planetary orbits, see Chapter 4 on The Solar System) If the Earth's orbit were perfectly circular, there would be no east-west drift, and the analemma would be reduced to a line, corresponding to the longer axis of the observed analemma!

Topic 2: Summer and Winter Sunlight



It is important to note that even without the tilt of the Earth, there would still be variations in temperature from one location to another, caused mainly by the curvature of the earth. Locations closer to the equator would still, on the average, be warmer than locations closer to the poles. Light and heat (radiation) from the Sun would still strike polar regions at more of an angle than nearer the Equator . This angle tends to "spread out" the same amount of energy over a larger area, thereby decreasing its intensity and the amount of heat it brings to the Earth. The activities in this topic demonstrate and test this assertion.

Activity 2-5: Energy from the Sun

Solar radiation is emitted in various forms which travel at the speed of light. Light travels through space as waves of different lengths. Our eyes can only see radiation as visible light, but radiation also occurs as radio waves, infrared rays, ultraviolet rays, X-rays and gamma rays. Together these waves make up the electromagnetic spectrum. Most of the radiation is "visible" - no coincidence!

Questions to ask: How can we measure the warmth from the Sun? Is it possible to find a way to measure it outside? What could we use and how could we show differences in temperature? How long would we have to wait until we take a comparative reading? Can we predict the variations? What might influence fluctuations in warmth? What experiences have students had which help in these predications? Will soil be warmer or colder than air temperature? Does this change during the day?

Materials: Thermometers; soil; sunlight; cardboard; stick; glue; pencils; flashlight; paper

- 1. Students (in small groups) predict the time of day and comparison reading times with most pronounced variables in temperature. They choose an appropriate spot to insert a thermometer(s) in the earth. They make and place a sign signifying experiment areas.
- 2. They return at various intervals to read and record the time and temperature.
- 3. Students compare their predictions and the actual readings.
- 4. They read and record the temperature of the air at the same time as the recordings of the earth temperature and compare these.
- 5. These experiments may be repeated in a few months. This data may then be recorded and compared to earlier readings.

Discussion

Students discuss results of these experiments. What caused the highest or hottest temperature? Was this related to the time of day? What were students able to discover from their measurements? How accurate were their predictions? What factors helped them to predict well? What conclusions can they make about the effect of the Sun's rays on the Earth? If done at intervals over a period of time, did earlier experiments help their predictions?

Students may make a graph using this information either on graph paper or on the Bank Street Filer or on the database of AppleWorks. What other elements could students use to measure temperature? How could we devise an experiment to predict and record the temperature of water or sand in the sunlight? Student may predict and then test the model, record date and compare the results.

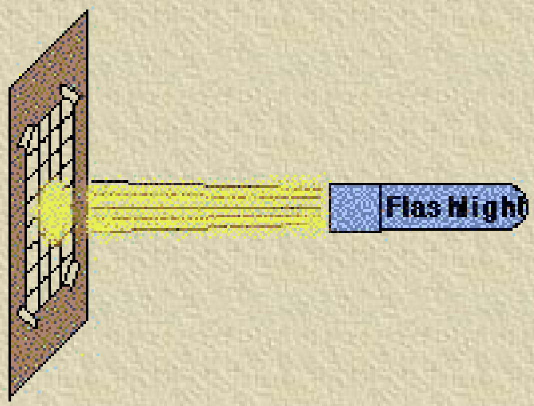
Activity 2-6: How Angle Spreads a Flashlight Beam

This activity requires a darkened room. You may want to do this as a large group activity for younger students. Older students should try it in small groups and compare their results.

Does the illuminated spot on the graph paper always remain the same size? When is it larger? smaller? Is the spot always the same brightness? When is it brighter? fainter?

Materials: Graph paper; cardboard or plywood; masking tape; flashlight; markers.

- 1. Attach a sheet of graph paper to the cardboard or plywood with the masking tape. Hold the board perpendicular to the floor and shine the flashlight directly onto the graph paper from the side, about two feet away. Be sure the flashlight is parallel to the floor, and, therefore, perpendicular to the paper. You might try placing the flashlight on a pile of books.



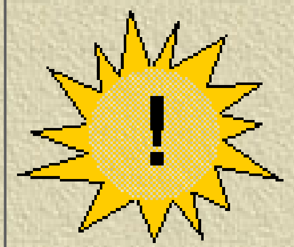
- 2. Trace the outline of the flashlight's beam on the graph paper.
- 3. Keeping the same distance from the paper to the flashlight, try rocking the board towards and then away from the flashlight. Does the area of the beam on the paper increase or decrease? Tilt the board at a large angle like 45° or 60° and trace the new outline of the beam with a different color. Try a couple of other angles, marking the outlines with different colors.
- 4. By counting the squares on the graph paper enclosed or partially enclosed by the circle of light, you can quantify the observation that more area is covered by the beam when the board is tilted at larger angles.

Discussion

No matter how the board is tilted, nothing changes the amount of light which the flashlight produces. When the board is tilted, and the flashlight illuminates a larger area of the graph paper, the same amount of light energy must be spread over a larger area. The lighting is then less intense. Is there any difference between tilting the board and tilting the flashlight? What if we were using a larger, hotter light source, like a halogen lamp, or a star? Wouldn't the heat carried also be less intense when the board is tilted at larger angles? The next activity explores just this question using the closest star, the Sun.

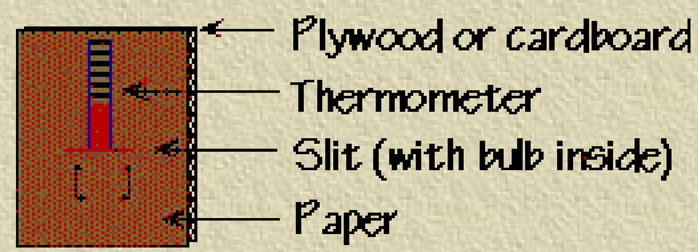
Activity 2-7: How Angle Spreads Sunlight

This activity requires a sunny day and direct sunlight.



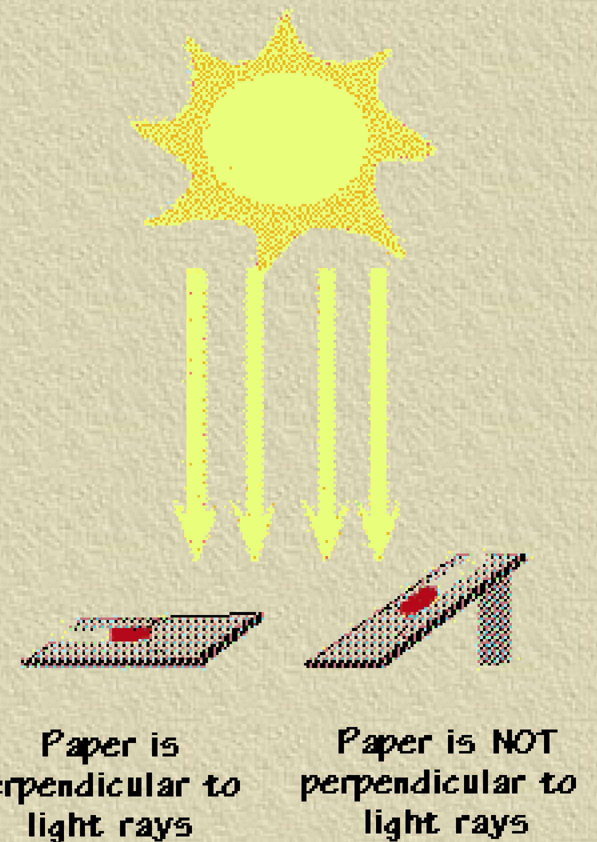
Be sure to remind students that looking at the Sun can cause permanent eye damage- Never look directly at the Sun!

This activity is similar to the previous activity in that it shows how light falling upon a tilted surface is less intense than if it were falling directly. With light comes the energy to heat. This activity examines this "spreading out" of light by measuring how quickly and how much sunlight can warm two sheets of paper, one tilted, one not.



Materials: Two sheets of black construction paper; two pieces of cardboard or plywood; bricks or blocks to prop up board; masking tape; two thermometers.

- 1. Cut an inch-wide slit in the middle of each piece of construction paper. Tape one sheet of black construction paper to each of the cardboard or plywood boards. Place a thermometer into each slit such that the bulb is between the board and the paper, and the scale can be read without removing the thermometer. Tape the thermometers in place. Leave the assembled thermometers in the shade long enough so that they read the same outside temperature.



- 2. Tilt one board so that it faces the Sun and the Sun's rays fall nearly perpendicular to the board. The other should be flat on the ground, or even tilted slightly backwards from the Sun if the Sun is especially high in the sky.
- 3. Periodically (every minute or so) record the temperature on each thermometer until the temperatures level off and stop climbing. Let the thermometers sit for a few minutes. Record their final temperatures.

Discussion

Which paper was heated more quickly? Which got warmer? You might want to try different angles. Beware the effects of clouds and wind, as well as the shadows of over-anxious students! What do the results of this experiment tell you about the changes in temperature from Activity 2-5? What was the angle of the Sun when the temperature dropped? When the temperature was the highest?

Activity 2-8: Sunlight on a Curved Surface

This activity requires a darkened room.

We have already seen how the angle at which light strikes a surface affects its intensity. This activity will demonstrate that light shining on a curved surface may be more intense in one place than in others. If we shine a light on a uniformly colored ball, like a dodge ball or kick ball, the area experiencing more intense illumination will appear brighter than those receiving less intense light.

Materials: Slide or overhead projector or other source of directed light such as a bright flashlight; large, uniformly colored dodge or kick ball; books to lift light source to desired height

- 1. Place the ball on a table. Aim the light source such that it shines directly on the center of the ball, but be sure the beam is wide enough to illuminate the entire ball at once.
- 2. Examine the brightness of the light across the surface of the ball. Rotate the ball. What happens to the bright spot? Does it follow the ball's rotation, or does it always face the light source?
- 3. Experiment with changing the orientation of the ball, the light, or both. Can you provide even illumination of the ball? Why not?

Discussion

Where on the ball was the light the brightest? Where was it the faintest? If you changed the orientation of the ball, what parts would be brightest? Which would be faintest? What if you moved the light source?

Activity 2-9: Sunlight on the Curved Earth

This activity duplicates the previous activity using a globe of the Earth instead of a plain ball. It, too, requires a darkened room.

The previous activity demonstrated that the curvature of an object can cause different areas of the surface to receive light of differing intensities. This activity shows that the Earth is subject to this effect as well. We have seen in our earlier thermometer experiment that less intense light cannot heat a surface as quickly or as completely as intense, direct light. Therefore, we can predict that there should be areas of the Earth where the sunlight is more intense than at others. These areas should be warmer than other areas. This is why locations near the Equator are generally warmer than those closer to the Poles.

Our observations show that the Sun is higher in the sky during the summer than during the winter. Summer approaches for a given hemisphere (North or South) when the Earth moves to a place in its orbit in which that hemisphere's Pole (North or South) is tilted towards the Sun. This causes the Sun to be higher in the sky and its light to be more intense (less spread out). This more intense summer sunlight is better able to heat the land, air, and water. This warming is certainly consistent with our observations of the seasons.

Materials: Slide or overhead projector or other source of directed light such as a bright flashlight; large globe of the Earth; books to lift light source to desired height

- 1. Place the globe on a table with the North Pole upward. Aim the light source such that it shines directly on the center of the globe, but be sure the beam is wide enough to illuminate the entire globe at once.
- 2. Notice that the light appears brighter towards the equator of the Earth. This configuration, with neither Pole tipped towards the Sun corresponds to the equinoxes (strictly speaking, the Earth's axis is still tilted by 23°.5 with respect to its orbit but on an equinox, that tilt is sideways with respect to the Sun, and not towards or away from it).
- 3. Try tilting the North Pole by about 23°.5 towards and away from the light source (the angular distance between noon and one o'clock on a clock's face is 30°, so don't exceed this angle).
- 4. The previous chapter's activity "Day and Night on the Spinning Globe" could be repeated with a tilted Earth, to measure the variation of sunrise and sunset times with season angle.

Discussion

Does the bright area move across the face of the Earth? How should the globe be positioned to show winter? summer? spring? fall?

Topic 3: The Tilt of the Earth

We have built a model of the seasons which agrees with our observations, but there is one important loose end; we accepted the tilt of the Earth as 23.°5. The next activity will allow us to measure this value! The final activity summarizes and demonstrates our model for the class.

Activity 2-10: Measuring the Earth's Tilt

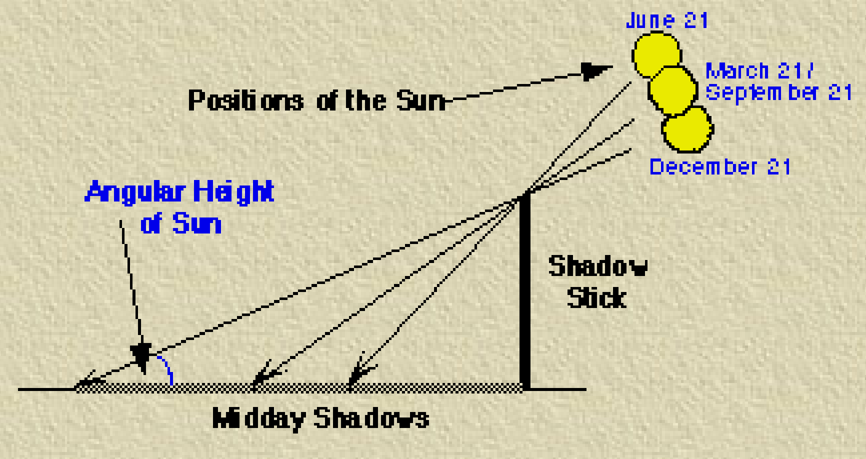
This activity is suitable for grades 3 through 6.

While the effects of the tilted Earth model are consistent with observation, might it not be possible to measure the Earth's tilt directly? Using observations with a simple shadow stick, we can measure the Sun's angular height in the sky over the course of weeks and months. As we've seen, it is the tilt of the Earth's axis which causes the height of the Sun's path to change. In this activity, we will measure this change to infer the amount of the Earth's tilt. shows that as the height of the Sun changes, it casts different length shadows at midday. By recording these midday shadow lengths and the height of the shadow stick, we can "reconstruct" the situations from these days and measure the angular height directly. The difference of the angular heights of the Sun between an equinox (September 21 or March 21) and a solstice (December 21 or June 21) is equal to the tilt of the Earth's axis, 23.°5.

Materials: Shadow stick from Chapter 1; observations of the midday shadow lengths; large sheet of paper; colored markers; protractor.

- 1. Obtain midday shadow lengths for convenient equinoxes or solstices

(September 21, December 21, March 21, June 21) as described in the activity "Sun Shadows" of the previous chapter. Also make sure to keep a record of the height of the shadow stick.



- 2. On a large sheet of paper, draw a line the same length as the shadow stick. To reconstruct the angle of the Sun's height for each equinox and solstice in your data, start at the bottom of the shadow stick and draw a line perpendicular to the shadow stick the same length as the midday shadow for each solstice and equinox in your data. Try using different color markers for each day. Your drawing should resemble the figure above.

- 3. Have the class measure the angular height of the Sun on the paper with a protractor for each equinox and solstice. The difference of the angular height between subsequent equinoxes and solstices should be about 23.°5. The difference in angular height between the two equinoxes or the two solstices should be twice that, or 47°.

Analysis Option

Mathematically, since the shadow stick and its shadows form right triangles, the shadow stick height and the shadow lengths are all that is needed to compute the Sun's angular height; it is simply the arctangent of the ratio between the shadow stick height and the shadow length. While such trigonometric functions are certainly beyond the scope of the elementary school classroom, this fact can be used to verify the students' results.

Discussion

When are the midday shadows the longest? Why? When are they the shortest? Why? What causes the shadow lengths to change? Can you relate your measurements to our model of the seasons?

Activity 2-11: Demonstrating the Tilted Earth

This activity is suitable for students in grades 3-6.

This activity demonstrates the model of the seasons we have been developing- that of an Earth whose axis of rotation is tilted by 23.°5 degrees with respect to the plane of its orbit around the Sun. By aligning the Earth's axis with a stationary point in space (the location of Polaris), it is easy to demonstrate the tilt of the Earth's axis during the course of an orbit about the Sun (i.e. a year).

Materials: Globe of the earth; sign to mark North; and masking tape. A student can act the part of the Sun and another student can hold the globe.

- 1. Place the Sun student in the middle of the room. Place the Earth student about six feet away. Mark one corner of the room "North". If we could extend this corner much higher, the North Star would be at its top.
- 2. Tilt the globe so that the North Pole tilts towards the ceiling at the corner marked North. The student holding the globe must be careful to preserve this alignment.
- 3. Walk the Earth around the Sun making sure to keep the North Pole properly aligned. When the North Pole points away from the Sun, this is winter for the Northern Hemisphere. When it points towards the Sun, it is summer for the Northern Hemisphere.
- 4. Walk the Earth around the Sun again, and watch the changes in the Southern Hemisphere. When it is summer in the Southern Hemisphere, what is it in the Northern?
- 5. After all of the students understand this example, try this experiment with the Earth turned such that its axis is perpendicular to the plane of its orbit about the Sun. If the Earth had this orientation, there would be no seasons.

Discussion

What differences in climates and seasons can you determine from the observations in these experiments? How would seasonal changes appear to you if you were on the equator or at the north or south poles? What is the pattern of sunlight at the equator? At the North Pole? At the South Pole? What were the differences in how the light was hitting the Northern Hemisphere as you carried the globe around the Sun?

Related Sites

Comments?

Contents | 1 Back to Top 3 4 5 6 | Home

While clocks and calendars are indispensable in our everyday lives, they are also taken for granted, and rarely warrant a second thought. But for young students just beginning to explore their world and universe, questions like "Why are there twenty-four hours in a day?" are important, for it indicates that they are trying to discover the underlying order and sense of everyday life. It is important to address such questions, lest a youngster draw the incorrect conclusion that no one really knows why things are the way they are, or, even worse, that there is no underlying reason or order, and that things just are the way they are.

Already the students have many examples of the importance of time keeping devices. They use alarm clocks to wake up in the morning (or have parents who use alarm clocks), they check the clock to wait until lunch or recess. The calendar even helps the student check if it's a vacation day! Ask the class to help you list all the ways in which they use clocks and calendars on the blackboard, and everyone might be surprised by the length of the list! Most of the uses volunteered by the class will be eminently practical; more than for any other reason, clocks and calendars were developed to satisfy very practical needs. Ancient Egyptian farmers needed to know when the Nile would flood. Farmers today still need to know when to plant certain crops. Carpenters and other workers need to know how much more sunlight they have to work under. Mariners have always needed reliable times for high and low tides.

In this chapter, we explore many different ways to measure and record time. The most important points are these:

- Almost any regular, predictable phenomenon can be used to record the passage of time
- Orderly patterns of these phenomena help to construct useful frames of reference
- Calendars grew out of such phenomena
- The development of calendars is still evolving
- Any proposed calendar must be compatible with observations (100-day years are contrary to observations!)
- Many cultures have divined mystical significance from the timing of natural phenomena, often integrated into their calendars

---

Topic 1: Recording The Passage of Time

Discussions of the nature of time tend to be more philosophical than scientific. While the concept of time effects our everyday lives, it eludes a simple definition. Science can, however, measure the passage of time with remarkable precision. Most of the clocks we use today are either mechanical (with springs, gears, pendula, etc.) or electronic (with batteries, computer chips, vibrating quartz crystals, etc.). Before mechanical clocks, sundials (see Activity "Building and Using a Sundial" in Topic 3 of Chapter 1) were commonly used. Sundials can still be seen on older buildings. The motion of the stars at night also mark time (see Activity "The Big Dipper Clock" in Topic 4 of Chapter 1). There are still other ways to measure the passage of time, however. In this topic, we will make several types of clocks which measure the passage of time in different ways. We will also take a look at a very modern time keeping device: The Atomic Clock. Some questions to consider throughout this topic are: Why would we choose one clock over another? What functions do clocks serve? Are all clocks designed for the same purpose? Are some clocks better suited to some tasks than others?

Activity 3-1: The Hour Glass or Sand Clock

An hour glass marks time by the steady falling of sand. It usually consists of two containers, one on top of another, connected by a narrow opening through which sand is allowed to fall. When all the sand has fallen into the lower container, it can be flipped so that the container with all the sand is now on top. Hour glasses can be of any (reasonable) size. As the name implies, they were commonly used to mark hours, but by changing the size of the opening or the amount of sand, any time interval (within reason) can be measured. Three-minute "hour glasses" to time eggs are still common in kitchens. In this activity, we will make an hour glass with a fairly short duration; perhaps we should refrain from the term "hour glass", and call it a "sand clock". In any case, we can set and adjust our clock by comparing it with a wristwatch or the classroom clock.

Materials: Two small, plastic bottles (e.g. 16-32 oz. soda bottles); sand or salt; masking or duct tape, 1"X 1" square of thick aluminum foil; sharp pencil; wristwatch or classroom clock for calibration.

- 1. Fill one bottle with sand or another fine, homogeneous substance such as salt. Cover the top of the bottle with the small piece of aluminum foil, shape it to fit the bottle, and tape it in place.
- 2. Poke a hole through the aluminum foil at the center of the bottle's

neck with a sharp pencil. Verify that it is large enough for sand to flow uniformly. Try to make th edges of the hole smooth, lest sand build up on rough spots and eventually block the hole.

- 3. Place the second bottle on top of the first, neck-to-neck, and temporarily secure by wrapping some tape around the necks.
- 4. Time how long it takes to empty the top bottle. By adding or removing some sand, try adjusting the hour glass to correspond with a useful time interval, such as one, five, or ten minutes.

Discussion

How could we lengthen the amount of time it takes to empty one of the bottles? How could we shorten the time? How does the size of the hole between the bottles affect this time? What advantages does this type of clock have over the sundial? Are there any disadvantages? Would this be a good clock to try to keep the time of day? What about timing specific events, like hard-boiling an egg?

Activity 3-2: The Water Clock

Uniformly dripping or flowing water also can be used to mark time. This activity builds a clock based on dripping water.

Materials: Coffee can; glass or clear plastic container to collect water; small nail; hammer; masking tape; marker; water; wristwatch or classroom clock for calibration.

- 1. Poke a small hole in the center of the bottom of the coffee can with the nail and hammer.
- 2. Over a sink, put some water in the coffee can. Ideally, water should drip from the hole at a uniform rate. Adjust the size of the hole as necessary, perhaps using a larger nail, for example.
- 3. Place the coffee can on top of the clear container. The clear container

must be narrow enough so that the coffee can does not fall through its opening and strong enough to support the coffee can filled with water.

- 4. Place a strip of masking tape along the height of the clear container, on which will be recorded the time required for the water to reach a given level.
- 5. Fill the coffee can with water and see how much of the clear container is filled in one minute. Mark the height of the water at convenient intervals (e.g. minutes) on the masking tape.

Discussion

What advantages does the water clock have over the sand clock? Does it have any disadvantages? Does it serve the same purpose? How does it compare with the sundial?

Activity 3-3: The Candle Clock

This activity involves candles and flame. It is best for older students under strict supervision.

Any process which is observed to occur at a constant rate can be used to mark the passage of time. The burning of a candle is just such an example. As a candle flame burns, it consumes the fuel contained in the paraffin on the candle. As it is used up, the candle appears to shrink in length. The rate of shrinkage should be roughly constant throughout the life of the candle, and, therefore, can be used as a marker of the passage of time.

Because fire is involved, it may be best to perform this activity as a demonstration for the class instead of as a strictly "hands-on" activity.

Materials: Two identical, thin candles; candle holders; sharp pencil; match or lighter; wristwatch or classroom clock.

- 1. Set the two candles next to one another in their candle holders. Light one of the candles and note the time.

- 2. At convenient intervals (e.g. one, five, or ten minutes depending on the size of the candle), mark the new height of the burning candle on the unlit one.
- 3. When complete, the unlit candle will be "calibrated" with timing marks and can therefore be used as a clock. The timing marks could also be transferred to other identical candles.
- 4. This activity could be repeated with a variety of candles, from thin birthday cake candles to very thick candles in order to make clocks of different durations.

Discussion

What advantages does this clock have over either the sand or water clocks? What about its disadvantages? How does it compare to clocks like the sundial? Could the candle clock be used to measure the time of day? Could it measure time intervals? Why might someone choose a sand or water clock over a candle clock?

Activity 3-4: The Atomic Clock

This activity requires a short-wave radio or a telephone toll call.

Keeping precise time is very important not only for astronomers, but for navigators, both civilian and military, as well. As a result, governments often keep precise time and provide signals to navigators, astronomers, and anyone else who wants to "listen in". Today's atomic clocks are indeed very precise; the best will only be off by one second in 300,000 years, and more improvements are on the way!

While atomic clocks are very complicated pieces of machinery which rely on complicated nuclear theory, their overall concept is simple. Cesium is the element which is used in most atomic clocks. Exposing a certain amount of cesium to microwave radiation, electrons in orbit around the nuclei inside cesium atoms will become excited and will change their orbit. Scientists are able to observe how many cycles of electrons jumping between orbits in the cesium atom will happen in a certain time period (say, a second). The clock only needs to detect and count all the cycles until the expected number (in the case of cesium, it is 9,192,631,770 cycles!) is reached. The clock then declares one second to have passed, and starts all over. Instead of grains of sand or drops of water, we are now counting leaping electrons, but the basic idea is the same!

International agreements between many governments have led to the establishment of a standard time, called Coordinated Universal Time, which is coordinated by the Bureau International de l'Heure in Paris. With Coordinated Universal Time (UTC or UT), most time stations are able to remain within one-tenth of a millisecond (0.0001 seconds)!

In North America, radio time signals based on UTC are available from two sources: WWV at Fort Collins, Colorado, and CHU in Ottawa, Ontario. Similar signals are available by telephone from the U.S. Naval Observatory in Washington, D.C., and from Canada's National Research Council in Ottawa. While the service is free via short-wave, there are toll charges for the telephone calls. Either way, it's fun to listen in!

Time Service	Phone Number	Other Number
U.S. Naval Observatory, Washington, D.C.	(202) 653-1800	(900) 410-TIME ($0.50/min.)
National Research Council, Ottawa, Ontario	(613) 745-1576	(613) 745-9426 (French)

Radio Signal Source	Broadcast Frequencies
CHU Ottawa, Ontario	3.330, 7.335, 14.670 MHz.
WWV Fort Collins, Colorado	2.5, 5, 10, 15, 20 MHz.

Materials: Short-wave radio or speakerphone; wristwatch or classroom clock..

- 1. If a short-wave radio is available, tune in to either CHU or WWV at one of the listed frequencies. Otherwise call one of the telephone numbers listed on the next page, preferably from a speakerphone so all can listen in.
- 2. Synchronize a wristwatch or the classroom clock with the signals from the atomic clock. (You may need to account for your time zone.)
- 3. Check the atomic clock again in a week or so, and see if your clock still agrees. If not, by how much do the clocks differ?. Repeat this measurement and make a chart of this time difference for each week. After a while, you should be able to predict the time difference.

Discussion

Why would anyone need the accuracy afforded by atomic clocks? Why does our clock differ from the atomic clock? We can only assume that our clock is less accurate than the atomic clock, and that our clock is responsible for the discrepancy. How could we prove this assumption?

Topic 2: Time Zones

In the activities of Chapter 1, we found that midday, when the Sun is highest and directly South in the sky, rarely corresponds to noon, as told by the clock. It used to be common for each city to keep its own time according to the position of the Sun in the sky. Long train rides, particularly easterly and westerly trips, often required travelers to change their watches several times.

About a century ago, this problem was addressed at an international meeting and twenty-four standard time zones were adopted. All of the clocks in a given time zone are set to the same time, and adjacent time zones differ by one hour. Each time zone is centered about a line of longitude, or meridian. Since it takes twenty-four hours for the Earth to rotate (or for the Sun to pass over all of the Earth), and a circle is 360° around, the width of each time zone is one hour or 15° in longitude.

The establishment of standard time zones is intimately linked with the establishment of the standard grid of latitude and longitude. The prime meridian, corresponding to longitude 0° and passing through Greenwich, England, is the center of time zone zero. Coordinated Universal Time (UTC) is the time at time zone zero and is often given as a standard time for astronomical and navigational purposes. Since the Earth rotates to the east, time zones to the east of time zone zero are ahead; time zones to the west are behind. Accordingly, the time zone to the west of Greenwich, is centered about the 15°W meridian and is one hour behind (-1) Greenwich. Similarly, the time zone centered about 15°E is one hour ahead (+1) Greenwich.

The boundaries between time zones are often altered to correspond to geographical and political borders. The International Date Line corresponds to the meridian at longitude 180°, for the most part passing through the sparsely populated Pacific Ocean. The calendar date jumps discontinuously across this line, moving ahead one day from east to west and moving back from west to east.

Because of this line, a traveler may leave Japan late Monday night and arrive in Hawaii first thing Monday morning! As confusing as this may seem, a simple example should demonstrate the necessity of the Date Line. Pretend it's six o'clock Monday evening in London (1800 UT). Moving 90° to the east, in Tashkent (UT +6), it would be midnight, ending Monday and beginning Tuesday. At the International Date Line (180°), it should be six o'clock Tuesday morning. As we cross the International Date Line, continuing eastward, we should decrement the calendar day back to Monday. If we don't, however, Chicago's time (UT -6) would be Tuesday's Noon and London's would be six o'clock Tuesday evening. But we started this example assuming it was six o'clock Monday evening in London. If we do decrement the calendar day while crossing the International Date Line, however, both Chicago and London are still in Monday, as expected.

There are four time zones in North America: Eastern (-5), Central (-6), Mountain (-7) and Pacific (-8). Alaska and Hawaii are in their own time zone (-8). Between the first Sunday in April and the Last Sunday in October, the United States observes Daylight Savings Time, during which clocks are set ahead one hour of the standard time for their time zone.

Activity 3-5: What Time Is It?

Through the activities of Chapter 1, especially "Day and Night on the Spinning Globe", the students should already understand that different locations on the globe experience day and night at different times. Even still, the whole notion of time zones may seem a bit mysterious at first glance. Concrete examples should help, though, especially if they can be personalized, perhaps by associating different time zones with relatives or friends of the students living in them.

Materials: Globe or world map; Post-It pads; scissors; wristwatch or classroom clock.

- 1. Cut a Post-It pad into inch-wide strips.
- 2. Write the approximate local time on one section (making sure to indicate AM or PM, and the day). Place this at your location on the map or globe.
- 3. Label several other cities and time zones similarly. Try to pick cities with some personal meaning to the students; students may have recently visited other cities on vacations, seen them on TV, or have close relatives living there.
- 4. Also try to pick some very distant cities so some of them will be in night time. If this is done on a globe, a light source could be shone above that time zone for which it is currently noon to approximate the current appearance of the Earth.
- 5. Ask the students "What time is it?" at various locations, both marked and unmarked. Remember that even if a time zone is not marked, every 15° of longitude is about one hour of time.

Discussion

If it's noon in New York, what time is it in Chicago? Why do Miami, New York, and Boston all share the same time, but Chicago is an hour behind? Is there anywhere on the globe where it's "tomorrow"? Is there any time when every time zone is in the same day?

Does noon as given by the "standard time" of your time zone correspond to midday as observed with a sundial or shadow stick? If they don't correspond, where might they? Why doesn't each city just use its own local solar time? What complications would there be?

Activity 3-6: Daylight Savings Time

Through our studies of the seasons in Chapter 1, we have already seen that the number of daylight hours increases as the summer solstice (around June 21) approaches and decreases as the winter solstice (around December 21) nears (see Chapter 1, Topic 5, "Seasons"). How, then, can we "save" daylight?

Daylight savings time doesn't "save" daylight in the traditional sense, since we can't save daylight during the summer and spend it during the winter when we need it; unfortunately, daylight's not like the money we can save for a rainy day! We have already investigated the change of sunrise and sunset times during the year in Chapter 1 (see Chapter 1, Topic 5, Activity "Sunrise and Sunset Changes"). We can use the graph of sunrise and sunset times from that activity or make a new one from an almanac like the Farmer's Almanac. Such a graph shows us that as the number of daylight hours increase, not only does the sun set later, but it also rises earlier. On June 21 in Boston, for example, the Sun rises at 4:07 AM (EST). Few of us are even awake at that hour!

What Daylight Savings Time really does is "save" that early morning light until more of us are awake. By setting the clocks ahead by one hour, the Sun rises at 5:07 instead - still early enough for most of us - and doesn't set until 8:24 in the evening. That extra hour doesn't affect many of us in the morning, but the extra hour of light in the evening when most of us are awake lessens our demand for artificial lighting, thereby saving energy. And it is energy, not daylight, which Daylight Savings Time is really intended to save.

Materials: Chart of sunrise and sunset times from Activity "Sunrise and Sunset Changes" in Chapter 1 or the materials to make one

- 1. If necessary, make a new chart of sunrise and sunset times along the vertical axis and dates during the year along the horizontal. One or two times per month should be sufficient to draw a smooth curve connecting them. Label the daylight and night hours.
- 2. Have the students compare the times of sunrise and sunset during the winter months with those during the summer months. How much earlier does the Sun rise during the summer than during the winter?
- 3. With the assumption that more people need light in the evening than during the early morning, can the students devise a system to "transfer" the early morning light to the evening? The current model of one hour ahead from April to October is only one possibility! Have each student or group study the problem, devise a solution, and propose a solution to the class.

Discussion

Is there any cause for disagreement about the duration or extent of Daylight Savings Time between people living in the same time zone? Does Daylight Savings Time affect people living in the western parts of time zones the same as those living in the eastern parts? What would happen if we always used Daylight Savings Time? Would the effects be felt equally across each time zone?

What makes one solution better than another? Might we not choose to set the clocks ahead by only half an hour for a while and then set them ahead a full hour for June, for example? What advantages or disadvantages might this scheme have?

Topic 3: The Moon: A Natural Calendar

An old New England anecdote describes how farmers received reliable weather reports before radio, TV, and even the Farmer's Almanac. Each morning, the farmer would look at a stone hung outside his window. Just a glance could tell him just as much about the weather as any high-tech modern gadgets: if it's wet, it's raining; if it's white, it's snowing; if it's swaying, it's windy; and if it can't be seen, it's foggy. Similarly, many of the simplest ways of determining time are obvious: if it's dark, it's night; if light, day; if warm, summer; if cold, winter. Unfortunately, such simple indicators are usually not sufficient. It is not enough for people planning winter rations of food to know that it's winterÑ they need to know for how much longer it will be winter. Farmers planning their crops need to know when to plant their fields.

Nature does provide several other ways to keep track of time, however. As we have seen in Chapter 1, the motion of the stars can be used as a calendar of sorts. Even more conspicuous in the evening sky than the stars, however, is the Moon. The Moon shines very brightly with reflected sunlight. As the Moon orbits the Earth, we view it from different angles, and see its different phases. The phases of the Moon provided the foundation for many early calendars. In this Topic, we will explore how we might keep track of time with the Moon.

Activity 3-7: Make a Lunar Calendar

The moon is the most conspicuous object in the night sky. Its differing appearance as it follows its cycle of phases is a natural and obvious way to track time. This activity encourages students to think about our calendar and alternate calendars and also will raise their awareness of the moon.

Materials: Calendar for current year with moon phases; paper; pencil.

- 1. Students should count and write down the number of days between full moons. Is this number the same? What about the number of days between quarter moons? waning crescents? waxing crescents?
- 2. Students should try to devise calendars based on their observations and calculations. They must decide where in the moon's cycle to begin the month. They may name their months.
- 3. Some students may be able to make a whole year of moon months and join them together into a calendar or paste them to charts. They can calculate the number of days in twelve lunar months and devise a strategy to deal with any extra days.

Discussion

How useful are the moon's monthly cycles in constructing a calendar? Are there any difficulties involved with basing a calendar on the lunar cycle? Is seven a good number of days per week? Could we have 5 days in a week or 10? What strategies can be used to insert the extra days into the lunar calendar? How could these days be used? In what ways could this calendar be used? What other data could we use to help improve these calendars? How would we compensate for the 1/4 day extra each solar year? Could there by another system than leap year to even up the calendar?

Topic 4: The Zodiac

As the Earth orbits the Sun during the year, our perspective changes, causing the Sun to appear to move with respect to the much more distant "fixed" stars. During the day, of course, it is impossible to see any stars near the Sun because it appears so much brighter than the other stars. By observing just before sunrise and just after sunset, however, it is possible to determine which stars are presently near the Sun. There are twelve constellations through which the Sun appears to move during the course of one yearÑ the constellations of the Zodiac.

Zodiac comes from Greek words meaning "wheel of life". This name gives an indication of the importance these constellations must have had for ancient people. Indeed, these "sun signs" are the most familiar remnants of the pagan religion of Astrology. About 3,000 years ago, when the Babylonians adopted the twelve familiar constellations of the Zodiac, the Sun appeared to be in the constellation of Aries (The Ram) at the time of the Spring Equinox (around March 21). After Aries, the Sun appears to move through Taurus (The Bull), Gemini (The Twins), Cancer (The Crab), Leo (The Lion), Virgo (The Virgin), Libra (The Scales), Scorpio (The Scorpion), Sagittarius (The Hunter), Capricorn (The Mountain Goat), Aquarius (The Water Bearer), Pisces (The Fish), and back to Aries, thereby completing the yearly cycle (see table).

Astrologers classify people according to which constellation the Sun appeared to be in at the time of their birth. People born near the Spring Equinox, for instance, are "Aries". Horoscopes in newspapers are given according to this assignment of Sun signs. The first activity in this Topic gives the students an opportunity to find out their Sun signs and learn about their zodiacal constellation. We mentioned that when the Babylonians adopted the twelve Zodiacal constellations, the Spring Equinox's Sun was in the constellation of Aries. This is important because in the 3,000 years which have passed, the Earth's axis has moved such that the Sun now appears to be in Pisces on the Spring Equinox, and relatively soon (in about 400 years), the Sun will be in Aquarius on the Spring Equinox. People who are Aries (by the calendar) are actually Pisces (by the stars)! This motion of the Earth's axis is called precession, and we will investigate this phenomenon in the final activity of this Topic.

Activity 3-8: The Sun's Yearly Trip Though the Zodiac

As the Earth travels around the Sun during its yearly path, the Sun appears to move through the sky with respect to the distant, "fixed" stars. In this activity, the students will play the role of the Earth and walk around the Sun to watch this motion.

Materials: 12 index cards; 13 chairs; masking tape; a yellow ball or similar object to represent the sun

- 1. Place one chair in the middle of an open area. Put the Sun on that chair. Place twelve chairs in a large circle around the Sun chair. The fronts of the chairs should point away from the Sun.
- 2. Label each index card with the name of one zodiacal constellation. Tape these cards to the backs of the twelve chairs in order (counterclockwise): Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, Pisces.
- 3. Have the students walk along the outside of the chairs (counterclockwise). Notice that even though it is the Earth (student) which is moving, it is the Sun which appears to move through the entire Zodiac!

Discussion

There are twelve constellations in the Zodiac, just as there are twelve months in the year. While the alignment is not perfect, each month basically has its own Zodiac sign. This fact allows us to use the Zodiac as a crude calendar, accurate to the nearest month. People often refer to their Zodiac sign. This just refers to the constellation which the Sun appeared to be in when they were born, if they were born in Babylonian times! Since then, we know the earth's axis has precessed and has caused an apparent shift of the sun against the background stars. The next activity will allow each student to learn about his own zodiacal constellation.

Activity 3-9: Hi! What's Your Sign?

People's "Zodiac Signs" are just the constellations in which the Sun appeared to be on their birthday 3000 years ago. Perhaps the students will notice that the sun was actually several constellations across the sky from the one claimed. This activity is an attempt to personalize the zodiacal constellations for the student by learning his own zodiac constellation. The students can choose to calculate the actual constellation in which the sun was at the time of their birth. The students then compare their constellations with others in the class, and hopefully learn from one another's work.

Materials: One 3"x 5" index card for each student; markers; chart of zodiac constellations.

- 1. Each student should determine his Sun sign from the chart provided.
- 2. On an index card, each student should write the name of the constellation (e.g., Aries), what it stands for (e.g., The Ram), and draw the stars which comprise the constellation.
- 3. On the other side of the card, each student should determine the constellation the sun was in on their birthday in the year of their birth. They can do this by looking at the monthly star charts provided.
- 4. Have the students compare their constellations and share information about them.

Discussion

Can we make other constellations with the same stars along the Zodiac? Where do the names for the Zodiac constellations come from? Does the sun travel through any other constellations?

Activity 3-10: Precession of the Earth's Axis

The concepts in this activity are probably most appropriate for older students in the late elementary or middle school ages.

Because of the gravitational pull of the Sun, the rotational axis of the Earth moves slowly through a circle with a radius of 23.5° on the sky. This effect is called precession and it can be demonstrated with a spinning toy top. It takes about 26,000 years for the Earth's axis to precess a full circle and return to its starting place. As a result of this precession, in another 14,000 years, the Earth's axis will no longer point toward Polaris, but to Vega, another bright star in our Galaxy. Perhaps Earth's inhabitants then will call Vega "Polaris"!

We need not wait 14,000 years to notice an effect of this precessional motion, however. At a rate of 50 seconds of arc per year, astronomers must correct for it when they consult star catalogs. It also causes the position of the equinox to drift westwards along the zodiac. When the Babylonians adopted the twelve constellations of the Zodiac with which we are familiar, the Spring Equinox did, indeed, occur when the Sun was in Aries. Today, however, the Spring Equinox occurs in Taurus and in about 400 years, it will occur in Aquarius. This is the "Dawning of the Age of Aquarius" popularized by a song of that name.

Materials: A toy top; hard, flat surface.

- 1. Spin a top on a hard, flat surface and observe the small circle the axis makes. As the top loses more energy and slows down, this circle should get larger and larger, until the top actually falls over.
- 2. The Earth is not in any danger of "falling over" since there is no "down" in space. The gravitational pull of the Earth is making the top precess; the gravitational pull of the Sun is making the Earth precess.

Discussion

If we could watch the Earth's axis precess, would each star be shifted by the same amount or would the star nearer the North Celestial Pole be moved more than those near the Celestial Equator? How would the precession of the Earth's axis affect the seasons? In 13,000 years (half the precessional cycle), will there still be a summer and a winter? If so, will the stars and constellations which we associate with each season still be visible in their season, or will they be visible in opposite seasons? If the Babylonians lived in the "Age of Aries" and the "Age of Aquarius" is coming, what "Age" do we live in now?

Topic 5: The History of the Calendar

Even the earliest people noticed that certain celestial phenomena occurred in cycles: the rising and setting of the Sun, the motion of the stars, and the phases of the Moon are but a few examples. Their observations eventually allowed them to predict many celestial phenomena. While the power to predict may have brought a sense of order to their lives, more importantly, it allowed systematic planning for agricultural activity and religious observances.

There is an important distinction to be made between the ability to predict an event and the ability to understand the underlying causes of an event. For thousands of years, people have been able to predict the rising and setting of the Sun and Moon, but until about five centuries ago, it was widely believed that the Sun and Moon moved around the earth. It was not until about 440 years ago that the heliocentric theory of the Solar System of Nicolaus Copernicus (1473-1543) finally removed the Earth from the center of the Universe.

One fact that ancient people were able to infer, however, was the length of the year. The Sun took 365 1/4 days to rise at the same position in the sky. They also recognized the connection between the position of the Sun and the changing seasons. Naturally the Moon, as the most conspicuous night time object, was also studied. Its phases from the dark of the new moon to the bright full moon, with all manners of crescents in between, were carefully observed and recorded. It was discovered that the cycle from new to full Moon and back again took about 29 days. This is very close to a calendar month. The English word "month", in fact, shares the same root as the word "moon". Twelve lunar months almost equal a solar year. The problem is with the "almost"; there are eleven fewer days in twelve lunar months than in a solar year. These days needed to be made up or the seasons would gradually shift on the calendar.

Mesopotamia is widely believed to have been the Earth's first civilization. About 3000 years before the birth of Christ, the Mesopotamians established the city of Sumer in a fertile region between the Tigris and Euphrates Rivers in modern-day Iraq. The Sumerians developed a lunar calendar of 30 day cycles to help them plan their farming. They also devised a form of writing which involved marking clay with triangularly-cut reeds. Their written language allowed them to keep the first written historical, economic, and astronomical records. The Babylonians eventually replaced the Mesopotamian civilization, and in 1750 B.C., replaced the old calendar with one of their own. The Babylonian calendar was a lunar one consisting of 12 months made of 29 and 30 days in a cycle. As mentioned earlier, this lunar measuring was not consistent with the solar year; thus it was 11 1/4 days shorter than the 365 1/4 days which comprise a solar year. To make up for this shortfall, seven times in every span of 19 years, the Babylonians added one month. Interestingly, the Babylonians were one of the first to separate the year into weeks of 7 days. They arrived at this because they worshipped the Sun and Moon and five stars they observed not to twinkle. These "stars" were actually the five closest planets: Mercury, Venus, Mars, Jupiter, and Saturn. The Babylonians noticed that the planets moved across the sky through the constellations. Even today, the days of the week are named for the Sun, Moon, and five bright planets, albeit partially from the Germanic nomenclature: Sunday for the Sun, Monday for the Moon, Tuesday for Mars (Tiv in German), Wednesday for Mercury (Woden in German), Thursday for Jupiter (Thor in German), Friday for Venus (Frigg in German), and Saturday for Saturn.

The Egyptians also developed a lunar calendar to regulate their crop planting. In addition, it was important to predict the annual flooding of the Nile River which irrigated their land. The Egyptians were able to predict the flooding by noticing that before the flooding, Sirius would rise on the eastern horizon just before the Sun. Their calendar year began with the first new moon after this rising. Later, they devised a more accurate solar calendar and added a seven-day week. They needed to add a leap year day too, but their priests refused to let them do this and so the calendar moved away from the original flood time.

The Romans in 753 B.C. developed a calendar based on the solar year. The year began at the vernal (spring) equinox in March (Martius in Latin). Interestingly, the choice of March as the first month of the year is still reflected in our calendar; our names for the months of September, October, November, and December come from the Latin words for seventh, eighth, ninth, and tenth, respectively, reflecting their positions in the Roman year. The year had 305 days made up of 30 and 31 days. Sixty days which were left over had to be interspersed throughout the year. This left 1/4 of a day each year which was not compensated for and so each 120 years, the calendar would be a month late. Later two months were added, Januarius and Februarius and the 12 months were divided into four 31 day and seven 29 day months as well as one 28-day month. This added up to 355 days or 10-1/4 days less than a solar year. Days were added but usually too many so this calendar also proved inaccurate.

By 49 B.C., however, the Roman calendar was a full four months off. Julius Caesar ordered the Roman calendar improved. The politicians wanted Januarius to be the first month of the year to coincide with their terms which began in that month. The new calendar was based on a solar year of 365-1/4 days and began with Januarius, to appease the politicians. A Leap Day was to be added in Februarius every fourth year. When the Julian calendar was implemented, ninety days had to be added to resynchronize the calendar. The Julian names for the months are still with us, with the notable exception of August, named for Caesar's successor. The Julian calendar was not perfect, however, nor was it always strictly followed, so errors continued to propagate.

By the sixteenth century after Christ, these errors became a problem. There were ten extra days before the vernal equinox. But the Catholic Church was supposed to celebrate Easter on the first Sunday after the first full moon after March 21, the vernal equinox. The Pope, Gregory XIII, ordered modifications to correct the calendar. As a result, October 5, 1582 became October 15, 1582 to eliminate the accumulated 10 extra days. But the calendar required fine tuning as well. The Julian calendar's method of adding a Leap Year every fourth year was not accurate enough. As a result, the Gregorian calendar called for a Leap Year every fourth year (when the year number could be divided by four). Also, the last year in a century (1800, 1900, 2000) had to be able to be divisible by 400 in order to be a leap year.

With these changes, it will take about 30,000 years to add only 10 days to the calendar.

The Gregorian Calendar has been the dominant calendar in the West ever since. It is universally used in the business world. It was not adopted by Russia until 1918, a year after the Czar fell. Many churches such as the Moslem, Jewish, and Greek Orthodox, still use their own calendars to determine religious observances, however. The state of Israel uses the Hebrew calendar. While China uses the Gregorian Calendar for daily business, it still uses its ancient lunar-solar calendar to calculate holidays such as the Chinese New Year.

Discussion

What kinds of help do calendars provide? What would it be like if there were no calendars? How might this effect people's lives? How would it effect your life? If you examine the calendar carefully, what do you notice about its construction? Does it ever change? What do you think of the way it is organized? Have you ever heard of a different form of calendar? Could the new year start on another day? Could there be more than seven days in the week?

Activity 3-11: Exploring the Calendar

This activity is most suitable for small groups of students.

Materials: Calendar for each small group of students (can be last year's calendar); glue; markers

- 1. Students meet in small groups to investigate the calendar. They may discuss and list all the uses and assistance a calendar gives us.
- 2. The group finds and records the number of days in each month. Can they devise a system for remembering these numbers?
- 3. Students can find holidays and special days and discuss if holidays and birthdays occur on the same day each year. If not, why not? If they

do, why does this happen?

- 4. Some students may wish to research the names of the months or the days of the week.
- 5. Some of the students could divide their calendars by months, seasons, paste them on four large charts by seasons and illustrate them.
- 6. Students should meet to share their discoveries about the calendar.

Discussion

What did students learn about the calendar? What did they predict about the changes in holidays and birthdays? Could they design a strategy to remember the numbers of days in each month? How do they think the calendar was developed? Does anyone know of another calendar that is used? How can the calendars people use help us to learn more about them?

Activity 3-12: Make Personalized Calendars

The students can now make a calendar for themselves or as a gift, personalized with their own pictures for the months, and their own special days (birthdays, favorite holidays, etc.) included!

Materials: Colored or manila file folders (twelve each); photographs or drawings; date grids for each month to be included in the calendar from a current calendar; scissors; paste; paper punch; yarn; 8-1/2"x 11" plain white paper or 1" graph paper 8-1/2"x 11".

- 1. For each students, photocopy a set of date grids for each month to be included in the calendar from a current calendar.
- 2. Each student takes twelve file folders and cuts off the tabs. Place these together as if making a book, one inside the other.
- 3. Turn these folders sideways so that the fold is upwards. Label and glue a photo or illustration on the top side of each folder for each

month. Paste the corresponding date grid for each month on the bottom side.

- 4. Personalize the date grid by annotating special days like birthdays and holidays.
- 5. When complete, punch two equidistant holes on the folds and thread yarn through these holes. Tie a secure knot to hold the calendar together.
- 6. Students can further personalize their calendars by decorating the covers.

Topic 6: Future Calendars

The Gregorian calendar is fairly accurate but it is still not completely without flaws. While attempts have been made to improve upon it, none have yet been adopted. One such attempt to devise a more convenient calendar is the one by Elizabeth Achelis in 1930 called the World Calendar. One really important improvement in this calendar over the Gregorian one is that it would repeat itself without change yearly. Therefore, every year would start on a Sunday, the first of January. Also, all holidays would be on the same days each year. The year would be divided into four quarters each of which consist of 3 months or 91 days. Each of these quarters would start on Sunday and end on Saturday.

These quarters of 91 days each total 364 days or 1 1/4 days short of the solar year. To make up for this shortfall, a day called Worldsday would be added after December 30 each year and would be celebrated as a universal holiday called W Day. In addition, a day would be added at the end of June every fourth year. This would be called L day for Leap Year Day. Although this calendar would make it easier for people to remember dates and share holidays, it has not been adopted. Many religious groups still use lunar calendars and ancient rules to determine special observances and they are not willing to adapt a universal calendar. Therefore, World Calendar would have to be used in place of the Gregorian Calendar but it would not be accepted universally.

Questions to Ask: Would it be possible to devise a calendar to improve on the present one? What kinds of changes could be made? Using the experiences of organizing data into lunar, solar, and stellar calendars, what could be done to improve upon these phenomena as determining factors? Could we use the computer to help us in this task? Would it be possible to devise a calendar in which all dates would fall on the same day each year?

Activity 3-13: Invent a New Calendar

The Gregorian calendar is probably accurate enough, but might it not be possible to make a calendar which is more convenient? Perhaps each year and each month could start on the same day. Maybe a different number of days per week would allow holidays to fall on the same day each year.

Materials: Computer and database program; data diskette; paper; pencils.

- 1. Students work in small groups to plan a new calendar which solves some of the problems in the present one.
- 2. Some students can enter facts such as the number of days in a lunar month, the days in a solar year, the length of the zodiac months and rearrange the months into the most useful order they can devise. They may then develop a yearly calendar which eliminates some of the current difficulties in our calendar.

Discussion

Discuss innovations developed to improve the existing calendar and discuss examples. What would be the reaction of peoples in the world to this new system? What would be the objections? Who would support these changes?

Related Links

Comments?

Contents | 1 2 Back to Top 4 5 6 | Home

Practicality aside, being able to read and understand a map is an important analytical skill. Mapping has been a part of our lives since the very first explorers set forth to chart the lands beyond their countries. After centuries of such adventures, very little of the Earth's surface is yet uncharted. Orbiting satellites also have been making many detailed maps of the Earth's surface. However, much of the most exciting mapping being done today happens from our explorations away from the Earth! Several robotic space missions have traveled to other planets to map their surfaces. Most recently, the Magellan space probe which orbited Venus made a detailed radar map of its terrain, obscured by Venus' thick atmosphere. The CfA Redshift Survey is a project of over a decade which is mapping the galaxies of the entire Universe!

Whether a map is of a classroom, a city, a planet, or an Universe, the same basic knowledge is required to understand the information it contains: scale, orientation, angles, and measurement. In this chapter, we practice reading maps, first of our nearby surroundings, then of our town, and then of the Earth and stars. We begin this topic by using maps, then learning how to make our own.

Topic 1: Reading Maps

Whether to get across town or across the world, maps are crucial for navigation. They can help us discover the distances between objects and their relative orientation to one another.

The ideas of following direction and relating to a two-dimensional representation of a landscape are to be introduced first with a fun scavenger hunt. The chapter will then move on to political maps, and then see how topographical maps describe terrain.

Activity 4-1: Scavenger Hunt

This activity is best suited to younger students.

Scavenger hunts are always fun, but in this hunt, the rewards include not just the "goodies" found on the course, but also the skill of following a map.

Materials: An interesting, yet safe and supervised, course for the hunt; a simple, handmade map of the course; small prizes like toys, trading cards, booklets of stories, etc.

- 1. Lay out the course for the scavenger hunt on a field or playground. Make a map with the locations of the goodies. Be sure to include enough reference points like buildings, trees, rocks, and playground equipment. (sample map)
- 2. Split the class into small teams and give each student a map of the course. It would be best for the "hunt" to be non-competitive, so plan different maps for each group with different treasuresÊ- even if they cover the same area. The focus should be on the map, not the clock or the other teams.
- 3. Discuss the map with the students to eliminate any areas of confusion, and let the hunt begin!
- 4. After the hunt, make sure all of the treasures were found. If one was missed, analyze the map containing it with the entire class, and go find the missing booty.

Discussion

Were the students able to find all of the goodies? Could they find all of the reference points? Which ones were easier to find? Were they able to find topographical features like hills. Would compass directions help? What about distant landmarks? What makes a good map? What should a map convey? Are all maps meant for the same purpose? How might the map had been different if the students were driving cars or flying planes instead of walking around?

Activity 4-2: Follow a Map of the Town

This activity may be done in small groups.

Instead of looking at a map of a small area, like the playground, we will look at a larger area: our home town or city. See how many landmarks the students can find. Can they find where they live? Can they find their school? You should make a list of places for each student or group to find. The type of places which can be found depends greatly on the type of map available.

Materials: Road map of city or town; list of places, landmarks, or streets to find; rulers.

- 1. Find a good map of the local area. It can be any kind of map: political, road, sight-seeing, etc. The town or city hall or the local Chamber of Commerce may be able to help. You could also find maps to photocopy in the school or public library.
- 2. Make a list of places which each student or group should locate, such as the town or city hall, public library, police station, barber shop, pharmacy, etc.
- 3. Give a copy or portion of the map to each student or group. How many of the places can they find? Can they find where they live?
- 4. This is a good place to introduce the concept of "scale". Show the

students where the scale is on the map and what it means. Provide rulers so they can practice measuring and determining distances. When the students have found some locations, ask them how far it is between any two of them.

Discussion

If one map has a scale of "1 inch = 1 mile" and another has "1 inch = 10 miles", which map covers more area? Which map can show more detail? Is a map with more detail always better? What kind of information might a political map have which a topographic map might not? What kind of information would a nautical chart have? Can anyone think of a problem with making a map of the entire Earth? Hint: is the Earth flat like the map?

Activity 4-3: Topographic Maps

This activity assumes you are in the United States, but similar surveys and maps exist in other countries as well.

In 1960, the federal government conducted a complete topographical survey of the United States. The commission responsible for this survey, the United States Geological Survey Commission, has field-checked and updated the Survey several times in the years since. The Survey maps show features of the land, like lakes, ponds, rivers, and streams, and man-made landmarks like permanent buildings, roads, churches, graveyards. They are very detailed, being of the scale 1:24,000; one centimeter on the map represents 24,000 centimeters (240 m or 0.24 km) on the Earth (in English units, one inch represents about 0.38 miles). Neither the roads nor the buildings are labeled, however; these maps are intended to record surface features, especially variations of altitude. To do this, there are contours drawn on the maps, to indicate 10-foot variations in altitude. As a result, these maps are able to convey a sense of the three-dimensional lay of the land. In this activity, we will compare the Survey maps with the land they represent.

Materials: Topographic map available from the U.S. Geologic Survey (details below).

- 1. Obtain a Survey map for an area around or near the school where the class can visit for an hour or so. The Survey maps may be available in nearby public or college libraries. They are also available for $2 each from the United States Geological Survey Commission, Denver, Colorado 80225.

- 2. Make a photocopy of the map or parts of the map for each student. Discuss the various symbols and the contours. Make a list of obvious geographic features on the map which should be apparent at the site.

- 3. Visit the site with the class. It can be the school grounds themselves, or somewhere near enough for a field trip. See how many of the features on the map are apparent at the site. Did the map help to visualize the site before the visit? Try to find a feature at the site which does not match the map. Why might this be?

Discussion

Who might use a map like this? Is it a good road map? Does it should political boundaries like precincts, counties, and states? What sorts of uses would this map have that, say, a sightseeing map wouldn't? Why bother recording altitude? Can you think of way other than contours to record it? If the contours on a hill are closer together, does that mean the hill is more or less steep than one whose contours are farther apart?

Topic 2: Making Maps

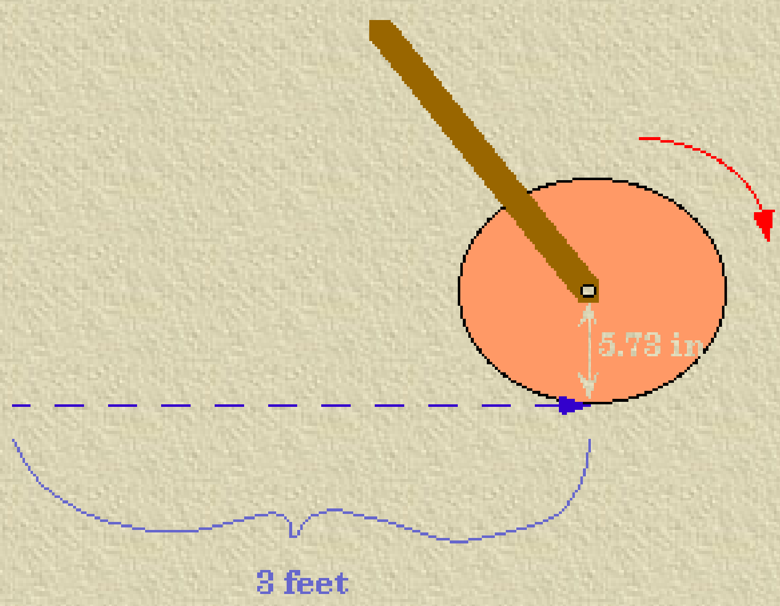
Now that the students have had some experience using and interpreting maps, the next logical step is to try to make some. We'll start small- literally - by mapping a small, familiar area, the classroom. We'll then venture outside and map the school grounds.

Activity 4-4: Making and Using a Trundle Wheel

It is suspected that in the making of the precise dimensions of the Egyptian Pyramids, architects used a device known as the trundle wheel. We have often used rulers or meter sticks to measure distances, but this requires several steps: placing the ruler down, marking the far end of the ruler, lifting the ruler up and putting the close end on the mark, marking the far end, etc., until the distance is measured. Even using a flimsy tape measure requires several people to hold one end firm, to keep the tape from flipping, to measure the end, etc. The trundle wheel, however, relies on the simple fact that a circle with a known circumference can be used as a ruler. The circumference is the distance around any circle. Take a string one foot long and bring the ends together to form a circle -- the circumference of this circle is one foot. Rolling a circle with a known circumference along on its edge and counting how many times the circle can go around will tell you how many feet make up that distance you rolled it.

Materials: Big pieces of cardboard (a movers box is fine), scissors or blade, meter stick with hole at end or strong, narrow piece of cardboard resembling such, brass fasteners, dark marker, ruler and a drawing compass

- 1. Making circles of different circumferences requires knowing the radii of the circles. The relation, Circumference = 2 x radius x p is used. We've figured out circles for circumferences of 1 foot, 3 feet, and 18 feet by calculating their radii. These trundle wheel sizes are convenient



for measuring distances as big as rooms or as small as the distances between desks. For the 1 ft trundle wheel, spread the two legs of the compass such that one end points to the zero line on the ruler and the other lines up with a little less than 2 inches (the radius). Lock the compass if you can, otherwise, be careful not to accidentally readjust them. Firmly stick the pin end of the compass into the cardboard and swing the pencil end around on the cardboard outlining a circle.

- 2. Carefully, with scissors or with a blade, cut out the circle. With a dark marker, make one straight line connecting the center to one edge of the circle. This will help you count how many circumferences the wheel has traveled.

- 3. To the center of the circle in the compass pin hole, fasten one end of the meter stick or the cardboard strip with a brass fastener.

- 4. Repeat those steps for the 3 ft circumference circle, but spread the compass points to a little less than 5.75 inches. The 18 ft circumference circle requires a bit of string cut to 2.87 feet. One end of this string is held firmly onto the cardboard while the other end of the string is pulled taut and held with a pencil. By swinging the string around on the cardboard and marking with the pencil where the end of the string meets the paper, you will have another circle to cut out. Then follow the rest of the steps to make it a trundle wheel.

- 5. Start measuring by lining the marker line pointed down with the ground where you want to begin the measurement. Roll the wheel along, counting how many times the marker line hits the floor. NOTE: Because the shape of the circle is a problem for reaching into corners of the room, simply start room measurements with the wheel edge touching the wall and roll to other end of the room until the wheel touches the other wall. Since from the edge to the center of the wheel is defined as the radius of the wheel, and since you had to line the wheel up with the edge twice, add twice the radius of the circle to any measurement made from corner to corner.

- 6. Practice measuring the size of the blackboard, the length of the room, the distance to first base on the kickball field, the height of students in the class. Compare the measurements with those gotten from laying down meter sticks.

Discussion

Are the trundle wheels easier to use than the meter sticks? Are the measurements different? Can students make their own wheels of different sizes using the circumference relationship to the radius? What are the advantages and disadvantages of the trundle wheel? Can students think of other shapes which might be good measuring tools?

Activity 4-5: Mapping the Classroom

For our first mapping exercise, we'll start small- literally- by mapping the classroom. First we'll examine the room, and discuss the objects in it. Then we'll build a scale model on a large sheet of paper. By tracing the objects we've placed on the paper to represent things in the room, we will have created our first map. The students can then develop a key to represent all of the objects in the room, and then they can make their own versions using their key.

Materials: Trundle wheels or tape measures; small wood scraps (enough of uniform size and approximate scale to represent desks, etc.); large chart paper (cut from 3-4 foot roll); rulers; pencils; markers; 9"x 18" white construction or oaktag paper; stencils of small shapes.

- 1. Students should measure the sizes of the classroom and sizes of a few major pieces of furniture.

- 2. The class should sit around the chart paper cut about 9 x 4 feet. This paper represents the floor of the classroom and on will be placed representations of the objects in the classroom. Mark the length and the width of the classroom.
- 3. Look around the room and discuss the objects in it. Which objects are the same size? Which is the smallest? Are all of the objects the same shape? Students can make up a key which could be useful to themselves or others for this map and include it. For example, all desks could be represented by squares, chairs by circles, and so on.
- 4. Students can start mapping by arranging blocks of wood on the chart paper to represent the various pieces of furniture in the classroom. It may help to start with a few reference points such as the teacher's desk and the classroom door. When students have completed placing the blocks, they should trace the outline of each block onto the chart paper before putting them away.
- 5. Working either alone or in small groups and using the large chart paper as a guide, each student should then make his own map of the classroom on construction paper or oaktag. Rulers should be used to make straight lines and stencils to make circles, squares, and rectangles. How can they draw these objects so that the map will look like their classroom? If they show this to their parents, will they know how to locate their desk when visiting? What other information will this give to others? How could they improve the map? How can they make it look attractive?
- 6. Older students should try to represent objects to scale, perhaps using graph paper.

Discussion

What reference points were the most helpful when starting to map the classroom? Why? How does a key simplify making the map? Would it be more or less work to try to capture the distinct shape of each and every piece of furniture? When might it be necessary to record each shape? How does scale help one make sense of a map? Classes from different rooms could team up, exchange maps, and try to find their partners' desks. Visiting parents could try to use the maps to find their children's desks.

Activity 4-6: Perspective and Reference Points

As students begin to make maps, the importance of scale and perspective become clear.

Materials: Teddy Bear or any suitable objects; large picture; variety of different size balls; paper; markers; blocks; construction paper, 18"x 24".

- 1. Have the students look at the teddy bear on a stool in the center of the room. They can draw it and compare perspectives. Move the students so they view it from a different perspective. How does this affect what they see?
- 2. Students look at a very large picture which has been divided into four numbered quarters. They work in four groups, each student drawing the assigned section of the picture in a variety of paper sizes. When the student finishes, he finds a person from each of the other groups and they put them together. Students may analyze the results and find another way to work together to do a better representation.
- 3. Place various balls on a table. Darken the room and shine a light on the balls. Have students move around the table viewing the balls. They can stoop down low or stand up high on a chair to gain different perspectives. They may then discuss how these objects looked from a variety of reference points.

Discussion

How does measuring with tools help us to make a map? Does it make any difference where you stand when you make a map? Do objects look smaller from one place than from another? How does this effect your map? How can this help students in their map making? If students make another map of their playground (Activity 4 of this topic) will they do it differently? How can they use the measuring reference points in making maps? Would it change the way you made a map if you stand in another place to make it? How can you devise a system to represent the area and the objects in it so that they will be the same relative size or scale on your maps?

Activity 4-7: Mapping the School Grounds

The move outside provides students with different mapping challenges; scale, elevation, and topology take on added importance. Students learn by developing their own techniques for showing these; only when they have experienced this, they will benefit from materials for measurement of elevation such as large rods and levels. Through representations they will increasingly see the relationships between the three-dimensional world and the two-dimensional symbols which represent it on their maps.

When mapping a large area outside, such as the school yard, what tools will help you to make a map? Can you show how far away objects are after you measure them? Does it matter if you move around or should you stand in the same place? How can you use the compass to help you place objects? How can you represent directions accurately? How could you show the hilly parts of the land.

Materials: Large sheets of paper (one for each group of two students), with outline of school grounds and a few key features; pencils; measuring devices; yardsticks; trundle wheels, string; directional compasses.

- 1. Students should work in pairs standing in the center of the school grounds. They should measure and record the distances and directions to different objects on a map.

- 2. The students should discuss and compare their maps with the others. Do the maps look the same? If not, what makes them different? Are some distance determination techniques better for some objects (or some distances) than for others?

- 3. Students should note differences in topography and find a way to represent these differences? What else might help them to do this?
- 4. Students may wish to use materials such as clay, sand, or blocks to represent elevations. This may help them to find a way to represent these area on a two-dimensional map. How many ways can they show this change in terrain? Could colors, shapes, different kinds of lines show height?

Discussion

Students discuss their results. Were their maps similar? What problems did they encounter? How did they represent changes in elevation? What about various surfaces? How did they established directions? What kind of symbols did they use?

Activity 4-8: Mapping the City or Town

The step to mapping a larger area is the next in our investigation of mapping. Representing one's school and playground on a large map allows students to trace their routes to school by moving model cars and buses on the map. The streets represented may lead to major buildings such as libraries, fire and police stations, and town and city halls. Directionality may be established and a compass rose included in the map. Students may work from a map of their town which has been enlarged and then enlarge that again. Students may map a route to a playground or other area of interest and then walk that route together.

How could students help to map an area when the whole area cannot be seen? What materials would be helpful to use in making such a map? What unit of measure would be appropriate to use? If the school is the focus point and placed at the center of the map, how could students represent it? What other buildings would they want to represent on this map? What about other areas of their town? How could they make a very large map even large enough to walk on? How could they determine directions?

Materials: One large sheet (3'x 8') of heavy paper from standard 3' roll for each group; wide tape; yardstick; pencils; markers; photographs of buildings; large piece of heavy plastic to cover map; blocks of wood; map of students' town or city (enlarged to largest size possible on large capacity copy machines); plastic figures and cars; oaktag; glue.

- 1. Students discuss their school location and its proximity to other areas of interest in their town or city. They decide which buildings, areas and landmarks are important to include in a map of their area.
- 2. Students see a map of their town or city. This can be placed on the floor and students may sit around it. They look for their school and discuss the surrounding area such as streets and parks. They locate other buildings of importance and note the relative distance to their school. They discuss making a larger size map.
- 3. Some groups may want to work on streets and others may want to show playgrounds and ponds or lakes. They use markers to color the map. Three dimensional buildings may be made by drawing a building on oaktag. Cutting it out and standing it upon the fold at the bottom and supporting it with a strip of oaktag. These may be glued to the map.
- 4. When the map is finished, all students gather around it sitting in a circle and discuss this map and the experience shared in making it. They may add a compass rose. How is distance represented?
- 5. Discuss and compare the units of measure used in measuring the classroom or playground. Are they able to find a route they take to school? Using figurines to represent the students, could the class find a route to walk to the city hall or library. Would this route be different if going by car? Discuss taking a trip together using this map as a guide and test the route with figurines. Can the class predict how long such a journey would take? Can they devise a system to help them make an accurate prediction?
- 6. Students should walk to a designated area after making this map.

This may be useful in visiting the library or the town hall or an historical site.

Discussion

Was this activity helpful to the students? In what ways? If they had to map an area foreign to them, how might they start? How would they measure large distances? Can the students find their own streets? If so, can they locate where their houses should be? If students were building a new town or city, how would they plan it? What would they include? exclude? What would they do differently?

Topic 3: Coordinate Systems

A coordinate system is just a way of systematically denoting and labeling points in space. Numbered aisles in supermarkets, grids on road maps, and lines of latitude and longitude on the Earth are all coordinate systems which we use every day. Coordinate systems are usually based on two lines, or axes, which are most often perpendicular to one another. In a city, for instance, one building may be "two blocks north and four blocks east", from another, in which case the compass directions of north and east are used as a basis for the grid of the city.

Activity 4-9: Reference Directions on the Earth

This activity requires a sunny day.

On the Earth, we use the directions of the compass for reference: Boston is north and east of New York, San Diego is south of Los Angeles. Canada is north of the United States and Mexico is south. The direction "north" is defined as the direction from any point on the globe towards the North Pole, where the axis of rotation of the Earth sticks out of the surface in the Northern Hemisphere. Similarly, "south" is towards the South Pole. We usually look at maps and globes where North is on the top. Why might this be? Are the two hemisphere's equally populated? Do you think " north is up" seems natural to people in Australia?

If one faces north and extends ones arms straight out to the sides, the left hand points to the west and the right to the east. Looking at a compass rose, one can remember this because the "W" of west and the "E" of east spell a word - "WE" - if they are properly aligned - "EW" is not a word! The Earth is spinning about its axis such that its surface moves eastward. This is why the Sun and Moon and the stars all rise on the eastern horizon, move westwardly through the sky, and set on the western horizon.

In this activity, we use the midday shadow to find true north, much as in the activity "Sun Shadows" of Chapter 1. If there is not sufficient time (or suitable weather) to use the shadow stick, a compass may be used instead, but keep in mind that the compass points towards magnetic north, not towards the North Pole of the Earth.

Materials: Shadow stick from activity "Sun Shadows" of Chapter 1; large piece of paper; markers; rock or brick.

- 1. Using the shadow stick, determine the direction of north, which will correspond to the shortest (midday) shadow and mark this line on the large piece of paper. Secure the paper from the wind with a rock or brick..
- 2. Draw a line perpendicular to the north-south line. This is the east-west line. Mark each cardinal direction on the paper.
- 3. Have four students stand a few paces from the paper, one at each or the cardinal directions. Have the class name the direction at which each is standing.

- 4. Now have four more students stand at the same distance, but have each one stand between two at cardinal points. These students will be standing at northeast, southeast, southwest and northwest. Draw two diagonals on the paper and mark these directions.
- 5. Now have the class stand near the paper with the compass rose. Look around the school yard for reference points like hills, swingsets, jungle gyms, buildings, etc. Also look for distant landmarks; is there a city nearby? tall buildings on the horizon? or maybe some towering overhead! Determine the directions to these points, with the aid of the compass we've drawn on the paper.

Discussion

Is north always the same direction for everyone? What are the advantages of using such a "global" coordinate system? Are there any disadvantages Why not just use directions like "three blocks to the left" or "a mile and a half to the right"? Do these directions make assumptions about the traveler's original position and orientation? Are these directions better for local areas or larger areas? If northeast (NE) is halfway between north and east, where might north by northeast (NNE) be? Where would south by southwest SSW be? If something is northeast of you, what direction are you from it?

Activity 4-10: Mapping on a Grid

This activity will introduce the students to mapping on a grid. While most grids we map by are made of invisible, imaginary lines, the lines of our grid in this activity are clearly visible, the cracks between linoleum floor tiles. Having placed objects on such a grid, the students can then try mapping the area on some graph paper, essentially a scaled down version of the grid. Once the concept of a map on a grid is understood, specific grids like latitude and longitude should make more sense to the students. A great game to play with the students to give them practice with grids is the game of Battleship.

Materials: Linoleum tile floor; masking tape; Post-it pads; markers; objects like blocks, balls, books, boxes to place on the grid; sheet of graph paper for each student.

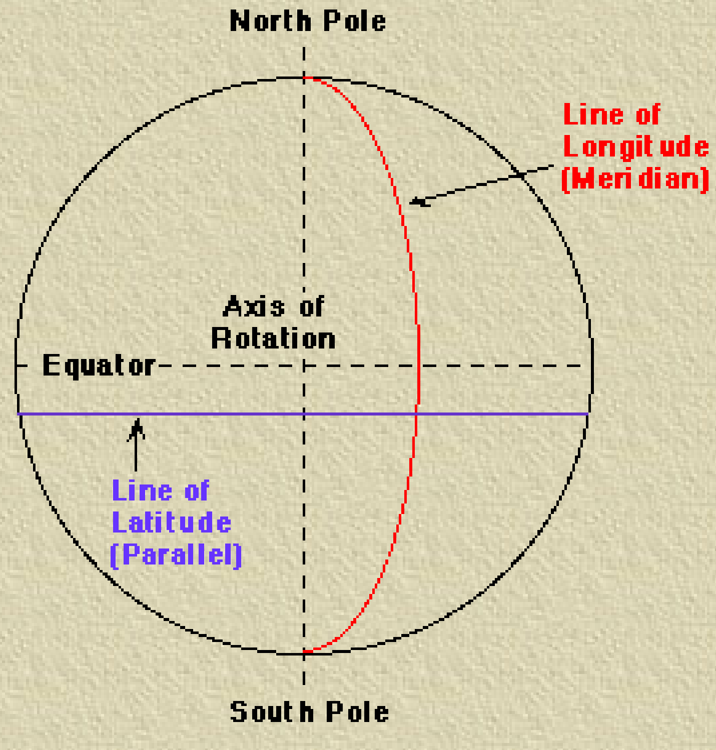
- 1. Tape off a region of a tiled, linoleum floor (6'x 6' or so) to act as the grid area. If such a floor is not available, grid lines can be laid down with masking tape.
- 2. Label the lines of the grid with Post-it pads. To simplify the coordinate system, label one axis with letters ("A", "B", "C"...) and the other with numbers ("1", "2", "3"...).
- 3. Scatter various objects throughout the grid region. Books, blocks, toys, boxes all make good choices.
- 4. Give each student a sheet of graph paper. Have the students map the area on the graph paper, using the graph paper's grid as a scaled-down version of the grid on the floor. Have them compare maps and discuss results.

Discussion

Did the grid help to map the area? How? What kind of maps use grids? Do grids help on interstate highways maps? Why or why not? Are there any grids on the Earth with lines we can see like the ones on the floor?

Activity 4-11: Latitude and Longitude on the Earth

The dawn of the Great Age of Discovery, some five hundred years ago, greatly increased the demand for accurate maps and charts. The explorers needed maps which covered areas much more vast than those we have yet constructed; they required maps of nothing less than the entire world which they were exploring. Indeed, much of the work of these early explorers involved making newer, more accurate maps of little- or never-traveled regions.



Even still, it was not until about a century ago that a standard coordinate system to describe locations on the Earth's surface was adopted. An international convention devised the now-familiar system of latitude and longitude and fixed its reference points. As illustrated in the figure, a line of longitude (a meridian) passes through both the North and South Poles. They are labeled according to their angular distance from the prime meridian which passes through Greenwich, England by international agreement. Meridians are labeled between 0° and 180° East or West of the prime meridian. Lines of latitude (often called "parallels") are parallel to the Equator, and are labeled according to angular distance from the Equator- between 0° and 90° North or South. Any point on the surface of the Earth can be uniquely specified by just these two coordinates, latitude and longitude.

Materials: Globe or map of world and local maps with clearly marked latitude and longitude scales; list of cities (on world map) or landmarks (on local map) to find by latitude and longitude coordinates.

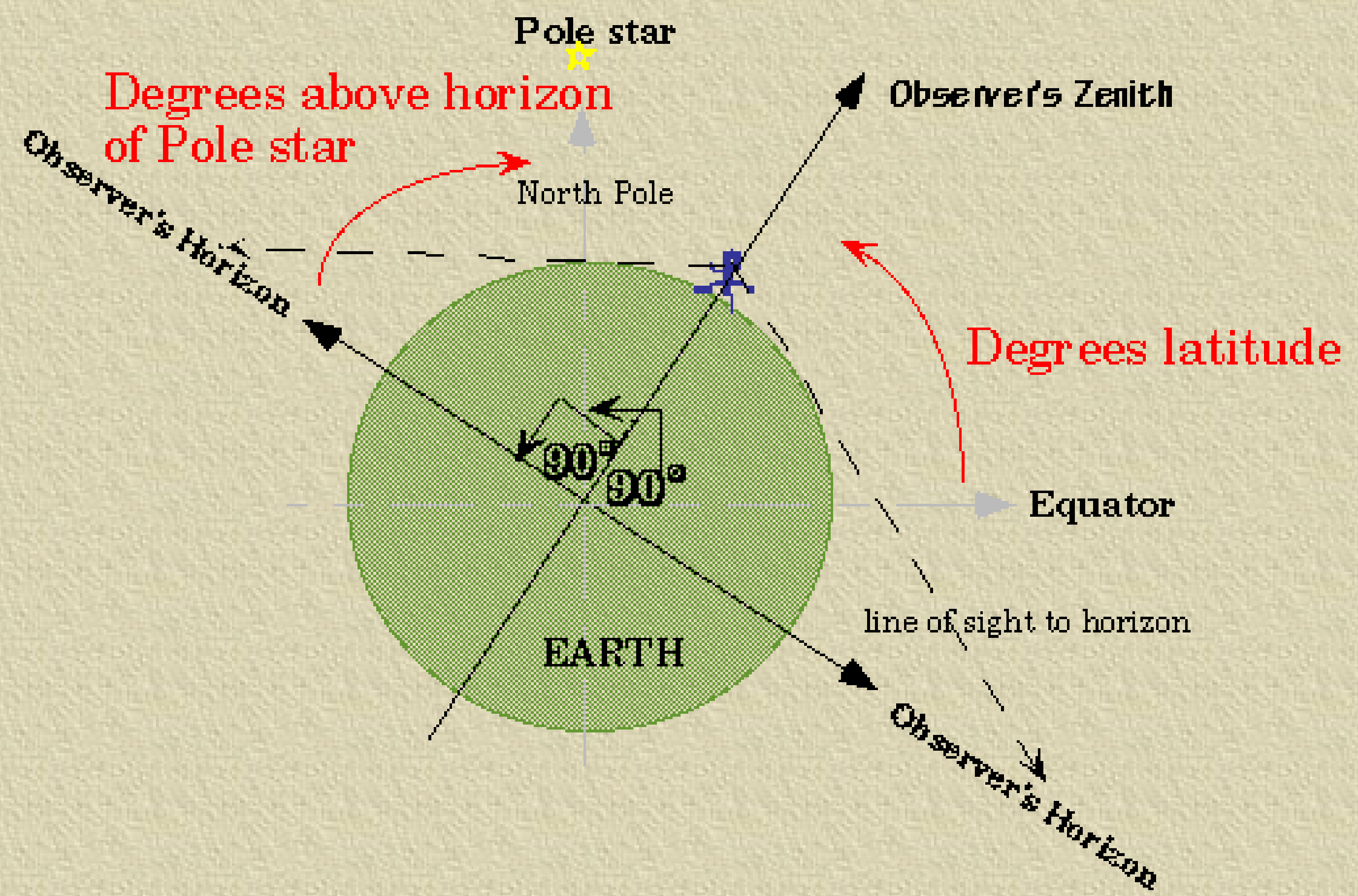
- 1. Make a list of several of places with their longitude and latitude for the students to find.
- 2. List a couple of places for each student or each group of students to find. See if they can identify the right place only knowing its longitude and latitude.
- 3. Have each student make a new list of places. The students can trade their lists and try to find the new places too.

Discussion

The lines of latitude and longitude are not straight, since they are on the surface of a sphere. Nevertheless, if one looks at a small enough region, like a city or a town, that region of the Earth is nearly flat, so the lines of longitude and latitude appear straight and seem to form a square grid. Note that close to the Poles, where the meridians converge, the slant of the meridians is quite noticeable, even on small scales, so even if they appear straight, they won't form a square grid.

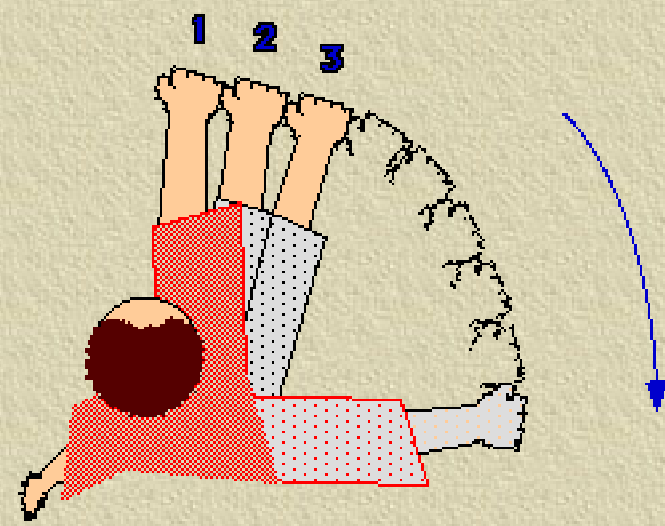
Topic 4: Celestial Mapping

It is possible to determine your latitude and longitude from observations of the night sky wallpaper. Finding your latitude in the northern hemisphere is the easiest, as it only requires one night's observation of the Pole star. This figure shows a diagram of the Earth with the dashed lines denoting the Earth's equator and the axis of spin. We've placed a small figure of a person on the Earth to show someone observing from a city on the Earth.



Notice that tracing the line straight up to the zenith point for this observer makes an angle with the equator which is the degrees latitude for this observer (since latitude is defined as the angle above or below the equator). Also notice that the horizon for this observer is marked as the diameter of the Earth perpendicular to the zenith line, or 90° below the zenith point in all directions, defined as such because you can look straight out as well as straight up. Thus, the equator of the earth, if extended up to the sky, is not on the horizon of this observer, but is above it by a number of degrees which are difficult to determine! So, how do we find out how many degrees from the equator, i.e.; degrees latitude, our city is? The figure below shows you that since you know the equator is 90° from the pole by definition and our latitude is 90° from our horizon by definition, that 90° minus our degrees latitude equals 90° minus the height (in degrees) of the Pole star over the horizon OR our degrees latitude equal the degrees of height of the pole star over the horizon! Using the fists method, students can count how many fists and fingers above the horizon they see the Pole Star and that is how many degrees above the equator they are!

Activity 4-12: Calibrating your fist



All you need to know is that 90° is the angle between holding your arm straight out to the side and straight out in front of you. All you need to do is stand still and put your arm out in front of you at eye level, with your hand in a fist. Close one eye. Carefully begin moving your arm stiffly, watching and counting how many fists you can line up side by side until your arm is 90° away from where you started, or straight out to your side. Use things around the yard as guides to help you count those imaginary fists. The figure helps you see what we are describing. Dividing 90° by the number of fists you counted will give you how many degrees your fist covers! (Hint: In case you are not sure of your answer, an average fist covers 10° on the sky. Your value should be close to this.) Similarly, you can try to calibrate your finger! But we will tell you that the human finger held at arm's length will cover 1° on the sky.

Activity 4-13: Measuring your latitude

Materials: Paper and pencil.

- 1. In the evening after the sun has set, students should face north, using their Big Dipper guide from Chapter 1. Students should locate Polaris.
- 2. Students place their fist straight out in front of them with the bottom of the fist resting on the horizon line. They should then count how many fists they can stack up before the top of their fist reaches Polaris.
- 3. Since the students have already calibrated their fists, they know that the number of fists they counted up to Polaris multiplied by how many

degrees their fist will cover will give them the number of degrees up to Polaris, or their latitude! Write this down for reference.

Discussion

What kinds of values did the students get for their latitude? Checking with the real latitude of your town, how accurate were these measurements? Could the students find this fists method useful for measuring other heights? Distances between stars on the sky? Sizes of constellations? Diameter of the moon (1/2 °, or a pencil held at arm's length!)? Perhaps further night observations will allow students to make star atlases describing the constellations in terms of degree sizes on the sky.

Activity 4-14: Mapping the Sky

The visible stars can be used as markers on the sky which can be placed on a map. Such star maps are useful not only to astronomers trying to find a certain star with a telescope but also to children trying to find the Big Dipper. Making a map of the entire sky is similar to making a map of the entire worldÊ- both are round and too big to observe all at once, for example. It turns out that celestial maps use a coordinate system very similar to latitude and longitude of their terrestrial counterparts, but on a sky map these coordinates are called "right ascension" and "declination".

These activities can be used either to help students become familiar with constellations before locating them or to help reinforce their observations and help them learn. It may be useful to use these activities to introduce the concept of magnitude of stars. Magnitude is the term used to define the brightness of a particular star. The brighter the star, the lower the magnitude number. The brightest stars have magnitudes from negative numbers up to around 3. The brightest star we can see is Sirius in the constellation Canis Major, which is visible in January and February. It has a magnitude of -1.42. This star is labeled on the Star Map included in Activity 1 of this topic. Conversely, the fainter stars have higher magnitudes. A star whose magnitude is 6 is difficult to see without an optical aid. Also, stars differ in color. They range from the hottest which are blue, then green, white, yellow, orange and red, in descending temperature. Stars appear to twinkle although giving off steady light as our sun does because of the atmosphere of the Earth. Therefore , stars just above the horizon appear to twinkle more than stars up above us because we are viewing them through more density of the Earth's atmosphere at the horizon.

Discuss constellations and stars already found. What questions do students have? What would they name these patterns or individual stars if they were just discovering them and making order out of them? They may share their ideas about new shapes and configurations from existing star patterns. Some students may want to make up stories to give more meaning to their ideas or this could be a group activity. One person might begin to tell a story about his new creation/constellation and others add to it around a circle. Did the ancients tell stories this way? Without writing down the story, tell it again the next day or week. Does it change? What value would be gained from writing these stories down? What value might be lost?

Activity 4-15: Introduction to Mythology and Storywriting

This may be an appropriate time to introduce the study of Greek mythology since many of the constellations were named by ancient Greeks. After students have found many constellations the stories will capture their attention and have more meaning for them. Students may do research to find out about the Greek gods and goddesses such as Zeus, Athena, Hera, Apollo, Hermes and others. They may enjoy hearing myths as well as reading them. Perhaps they would enjoy hearing a story for each of the zodiac constellations. These are told in a beautifully illustrated book, The Shining Stars: Greek Legends of the Zodiac.. A companion book to this is The Way of the Stars: Greek Legends of the Constellations or Dauliere's Greek Myths (for older students). These are listed in the bibliography. Myths often were told because there was a problem that needed to be solved and it was solved within the myth. Students may write their own myths, creating their own gods, goddesses, and part god, part human characters. They too will work through their problems as they learn to write and develop their creativity. Myths often explained natural phenomena. This activity may be enlarged to hearing and discussing the elements of myths from different cultures. The comparisons show universality of themes across time and space. Students will find meaning by reading, listening, and writing these stories without extrapolating a moral or reason.

What is a myth? How does it differ from other stories? Why are there so many stories linking gods, goddesses and part god part human figures? What could ancient people have needed to tell, accomplish by telling stories about the constellations in the sky? If you don't know a story about a constellation could you make one up that has meaning?

Materials: Greek Myths and other myths from a variety of cultures

- 1. Students listen to a number of Greek Myths which relate to the constellations. They read some on their own and do research on the characters in these stories.
- 2. Students may write stories of their own choosing using existing gods, goddesses and heroes or creating new ones. They may imagine that they are in the time frame of the ancients and discuss the effect this has on their writing. What kinds of reasons might they have to write a story? (i.e., explaining natural phenomena such as the occurrence of seasons or happens when people die?) Or do they just want to tell about how they feel about their lives and what is important to them?
- 3. Can they find examples of myths from other cultures which are about the cosmos? Are any of these similar to the ones told by the Greeks? Did any other cultures see the same configurations of constellations? Did they give them similar names? Perhaps students will continue to write stories based on other cultural mythology or they may wish to record stories they make up to go with an imaginary constellation configuration.
- 4. Students may record stories on tape, on the computer, or on paper. Sharing these stories out loud might be done in a circle at various times. If students tell their tales (rather than read them), they will be more

expressive.

- 5. Students may wish to tell what this writing experience was like for them. What kinds of stories do people tell now? What about space stories? How has story telling changed? Why has this happened? What kinds of stories will people write in the future?

Activity 4-16: Understanding Star Maps

Materials: Five foot circle of heavy white paper; yarn; pencil; enlarged map of constellations for current month (available in Sky & Telescope, for instance); yardstick; silver, red, yellow, blue shiny paper; blue tempera paint (small amount of black added), watered down; crayons; colored chalk; white glue.

- 1. Students should find several bright stars on the map and noting colors and sizes.
- 2. They help to make a circle on the heavy paper by determining center and using yarn and chalk to circumscribe a five foot circle using radius of two and one half feet. They mark off eight equal sections, like pie pieces, or other pattern.
- 3. They make the same division into eight parts or more on the star chart and number each section on both circles. Try whenever possible to make the pie pieces along lines which do not cut off constellations.
- 4. Students copy stars (in pencil) and patterns from small to large map section by section. They mark over each penciled star in crayon to resist paint. Try to represent star sizes in scale and colors.
- 5. Students paint entire 5 foot circle with tempera paint over crayoned wax marks and paint in a circular direction (Make sure paint is dark enough to simulate the night sky).
- 6. They represent star sizes, colors and positions by cutting stars of various sizes and colors of shiny papers and glue to maps.

- 7. They then cut direction labels; N, S, E, W out of silver paper and glue them as they are on the star chart, i.e., N on northern horizon, S on southern horizon, etc.
- 8. When dry, hang map on ceiling -- if possible, matching directions with the position of the school. If not possible to hang on ceiling, hang on wall as if facing northern horizon (north at bottom of circle).
- 9. Students use map to locate constellations without lines drawn between them and to identify various stars. They help other students to begin star studies.

Discussion

How did this compare to making an earth map? Did this help students to remember the star groupings and other stars? Could they locate the constellations? North Star? What other ways could they help others to learn what they have learned? How have people used stars for maps? In what other way could this new knowledge help them in their lives? Students may choose a constellation formation, draw it and make a new form out of it. What name would they give to it? Students may discuss their observations and share theories about stars, their magnitudes, sizes, and configurations.

Activity 4-17: Understanding Distance in Space

The function of this activity is to give the students an understanding that constellations are not flat pictures in the sky, but rather the product of three-dimensional space. The stars are so far away that they appear flat, as if forming a dome above the Earth. Constellations are patterns of stars. For the most part, they are named after characters or animals in mythology. They usually do not look like what they are named for. For instance, Pegasus doesn't resemble a winged horse at all and Cygnus the swan looks more like a cross. Some, such as Canis Major (the large dog), are easier to imagine. The question of whether the stars that make up a constellation are as close to each other as they appear in the sky is a puzzle for students to solve. They should ask themselves what would they see if one star was both next to and far back from another. They should also be wondering why the sky seems flat. The following activity will demonstrate how constellations really are positioned in space, and should give students a better definition of a constellation.

Materials: Large flat field; paper plates.

- 1. Number seven paper plates.
- 2. Hand out the plates to seven students. These plates will serve as stars.
- 3. Demonstrate the positions for holding the plates as the following:
    - LOW: The student sits with the plate at his/her feet.
    - CHEST: The student stands holding the plate at his/her chest.
    - FACE: The student stands holding the plate over his/her face.
    - HIGH: The student stands holding the plate over his/her head.
- 4. Using the diagrams as a guide, have the even numbered students line up about 30 feet from the rest of the class. Have the student with plate no. 2 stand on the far right (from the point of view of the rest of the class) with the plate at his/her chest. Have the student with plate no. 4 stand with the plate at his/her chest about 5 feet to the right of the student with plate no. 2. Have the student with plate no. 6 stand with the plate over his/her head 10 feet to the right of the student with plate no. 4.
- 5. Have the odd numbered students stand on a line about 20 feet from the rest of the class. Have the student with plate no. 1 sit in front of the student with plate no. 2 with the plate at his/her feet. Have the student with plate no. 3 do the same thing with respect to the student with plate no. 4. Have the student with plate no. 5 stand with the plate over hiss/her face about 5 feet to the right of student no. 3. Have the student with plate no. 7 stand with the plate over his/her face to the right of

student no. 5.

- 6. Have the rest of the class look at the seven plates from a distance of about 20-30 feet with one eye shut. Do they see a flat or three-dimensional pattern?
- 7. Have the odds and evens switch lines so that all the odds are on the back line. Have the rest of the class look at them again. Do they see the same thing?

Discussion

What is a constellation? Are the stars in the sky all the same distance from the Earth? Why do the stars appear to be flat in the sky? What else could be in space besides stars? What do these other objects do in space? Do objects in space move? Are there patterns to the arrangement of the stars? to their movement?

Activity 4-18: Using Star Maps

Note: Finding groups of stars is easier when done with a guide to help. The maps included for this activity are fairly uncomplicated. However, when gazing at the stars, the sky looks much different because of the numerous additional stars visible.

Your students should be able to find the Big Dipper, North Star, and the Little Dipper from the exercises in Chapter 1. Now they will observe more constellations in the night sky.

Materials: Star charts (one for each two month period, included here); flashlight, red cellophane paper to cover lens; rubber bands; binoculars (optional); journals

- 1. Introduce students to the appropriate star map. Discuss using these at home and how to do so effectively. Try them out with students in the classroom using the directions given on the charts. It is important to hold this map so that the direction you are facing is pointing toward you if you are holding it horizontally, or is on the bottom if you are holding it vertically. Have students hold the chart in front of them and raise it above their heads to simulate the actual sky above them. Help them locate Ursa Major (the Big Dipper), Polaris, the Little Dipper, and Cassiopeia. What other constellations (if using November-December chart) do they think they can locate? Have them record observations in journals right after viewing.

- 2. Repeat star map activity with new chart for next two months throughout the year. Are students able to make better predictions to find constellations based on earlier observations? If given one map at a time after using two maps and locating constellations can they predict what the third map will include or not include? Will there be new constellations visible? How about the zodiacal constellations? Can they predict when the next one will appear on the map if given a diagram of the zodiacal procession of constellations?

- 3. Identify particular stars. If observing in September or October look for Vega in Lyra and Deneb in Cygnus. Mizar, which is the star at the bent part of the Big Dipper's handle, has a faint companion star which can be seen by many people without binoculars. If not, binoculars should reveal it.

Discussion

Discuss the observations as a group. Students may have been recording their activities in journals and this should help them to share more easily and accurately. Have the students share their records of the changing positions of the circumpolar stars (or dippers).

How can this pattern be useful to us? What do they notice about the other constellations over a period of time? What do they think is happening? Can they predict what the sky will look like a year from now? Why are some stars brighter than others? Different colors? Throughout this activity students may discuss, compare and predict results of these recordings. How helpful are these predictions to them in their understanding of the patterns of movement they observe in the stars? Are they able to predict the movement of the stars in the next months? Are they able to compare these observations with those form the seasons and the calendar? How can the pattern of the stars and planets help us keep records?

Activity 4-19: Making a Star Plotter

This activity is appropriate for students in grades 4-6.

Sky mapping is an active way to make an original guide to the sky. Since students are actively engaged in this project, it will help them to view and report findings accurately. A star plotter will help them to chart the positions of the stars just as they see them in the sky. This activity provides a means of illustrating changes in the stars' positions. In this activity, students take records of where the stars have been and when they were there. This activity adds to their education of how the universe moves in orderly patterns.

Students may discuss stargazing experiences. How can they record their experiences and select what they want to remember? How could they use this information? How could they plot the stars and planets to help them learn and remember more about patterns? To explain observations to others?

Materials: Plexiglas or Lucite square about 12" by 12" (1/8-1/4" thick), strip of wood (about 6" by 1" by 1/2" thick) for handle; grease pens; tracing paper; glue for Lucite/wood or screws; drill (1/4" bit)

- 1. Students may make a few star plotters to take turns using. To make: drill two 1/4-inch holes about at the middle of one side of the Plexiglas in about 1/2 inch. Attach the handle with wood screws or appropriate glue.

- 2. Discuss using these plotters. Outside, students must remember to find a place to rest the hand holding plotter to steady it on a tree or post. Then they can point the plotter to a section of the sky with many stars visible. They can make a mark for each object visible making them larger or smaller according to the brightness of the objects. Viewers should record on one corner of the Plexiglas, the direction in which viewing, the angle from the horizon (degrees such as 30°, 45°, 60° - see note in box following Activity 1 in this topic), the hour, and the date. When inside, tape tracing paper to plotter and trace marks onto it as well as the information on time, etc. Then clean the plotter. Make another map either in another part of the sky or in the sky or in the same area a few hours later.

- 3. Students may make a number of these maps of the same area of the sky at intervals over a period of months in order to record the movement of the stars.
- 4. They may also make maps of constellations with the plotter. Find one of the constellations already discovered with the sky map. Place the star plotter so that this constellation is in the middle of the Plexiglas square. Mark the stars of the constellation with the grease pen as in other plottings. Then add as many of the surrounding stars as possible. Remember to write in the direction, angle, date, and hour you observe. Then trace the dots on the plotter. Connect the stars in the constellation to make a pattern such as the one on the sky map and write the name. This is a more realistic depiction of the constellation as it appears in the sky than on a star map because it includes surrounding stars.

Activity 4-20: The Astrolabe

These activities are more appropriate for grades 4-6.

When students build and use the star plotter in Activity 2, they learn to estimate angles and distances in the sky using their fists. These measurements are not very accurate. To obtain more accurate figures, an instrument may be made to help determine measurements. This is an astrolabe which was invented by the Greeks and disseminated by Islam. This instrument was used to observe and calculate the position of celestial bodies before the invention of the sextant. This activity includes two models, one simple and the other more complicated to measure angles by the stars. It also includes an exercise in geometry using a clock to understand dividing circles into degrees and naming angles. This system of dividing circles into 360° is an ancient one. A circle of 360 equal parts can be divided into quarter circles (four quadrants) each containing 90 degrees. If using a clock for a model from 12 O'clock to three o'clock is 90 degrees. From 12 O'clock noon to 12 O'clock midnight is 360 degrees.

Polaris or the North Star is a place to start measuring the angle above the horizon. This angle is equal to the latitude at the point where the calculation is figured. Latitude refers to the parallel lines which are numbered from the equator at 0 degrees north to the pole (90 degrees north latitude) and south to the opposite pole (90 degrees south latitude). The latitude of the North Star is 90 degrees at the North Pole and overhead there. At the equator, it would be 0 degrees and visible if possible in a direct horizontal position. If one uses the complex astrolabe it is possible to calculate the position of other celestial bodies by comparing them to the position of Polaris. The complex astrolabe will help students to find constellations and make sky maps with the important stars in their correct positions as viewed from a particular latitude. An inexpensive (around $3.00) astrolabe is available from:

Science Kit, Inc.
777 East Park Drive
Tonawanda, NY 14150.

Is it helpful to have a system to measure the position of the stars and their height from where we stand? Would it help us to be more accurate in these measurements? How would a measurement made by fists compare numerically with one done by an instrument? How could we check for accuracy of results?

Materials: 8-1/2"x11" sheet of paper or 4' tube; protractor; small weight such as key; thread; tape.

- 1. Discuss measuring and the ancient use of an astrolabe to find the angle of the north star and other sky objects. This is called latitude. The system of measuring degrees can be introduced to students by using the clock as an example.
- 2. Use the tube or roll a paper into a 1/4" tube. Tape the protractor to the length of the tube. Tie a thread around the middle of the flat side of the protractor and attach the weight on the free end of the thread. Practice using this model in the classroom. If 0° represents the equator and 90° the position at the North Pole. Can you predict the latitude where you are?
- 3. At night, locate the North Star. Point the tube directly at it. Look through and find the star. Read the degrees on the protractor as you hold the string at that place. Do this a few times to make recording more accurate.
- 4. How can you check this information for accuracy? Did this instrument change the measurement that you determined or estimated? Can you devise another model to measure the position of objects in space? What other measurements can you make with this model? What differences do you think will occur in measurements of these objects from night to night? In one night, measuring at intervals, what changes do you observe and record?

Building a Complex Astrolabe

Materials: Protractor; thread; weight; 1" thick wood 6"x 3"; (2) 1/2" thick wood 12' x 1/2'; 1/4" bolt and wing nut; nail; heavy cardboard for 12" circle;

straw; glue for metal wood; metal fastener.

- 1. Discuss astrolabe; its history and use. Then build one for testing. To build place the two thin strips of wood in a T shape and drill a 1/4 inch hole through the pieces. Fasten them together with the bolt and wing hut leaving it loose enough to move for sighting. Then attach (glue) a protractor to the cross stick centering it on the bolt exactly.
- 2. Attach this to the other piece of wood to form a base. Nail the support stick to the center of one of the long sides. Then cut a 12" circle of heavy cardboard. Divide the circle into quadrants or corners by making two lines at right angles to each other through the center of the circle and mark the end of each of these lines with the directions North, East, South and West. Then divide the spaces between into three equal parts. Each of these represents 30°. Make a hole with a drill through the center of the base and circle. Attach the circle to the base with large metal paper fastener. Draw a line on the center of the base and mark one end North. Tape a drinking straw on top of the narrow strip forming the cross part of the "T". Line the straw up so that it is even with one end of the stick which is the sighting stick. Attach a thread to the bolt and tie the other end to the weight.
- 3. When finished, students can place this outside on a level place with the straw at eye level. After finding Polaris they should sight it through the straw. Since Polaris is always in the North, the circle can be turned so that the mark for North faces Polaris. Have a student locate another bright star. Leaving the wheel intact, he/she turns the sighting stick to face the star. Then he/she sights the star through the straw. It helps to use a flashlight covered with cellophane to read the direction in which the line on the base is pointing. That line tells you the direction and how many degrees the star is from due north. Then find where the thread crosses the protractor. This indicates the angle above the horizon or latitude. Students may record this information.

Discussion

After many experiences testing this model, students may discuss experiences. In what ways did using this instrument prove helpful? Was it easier to locate constellations with this instrument? Did they record changes in position of stars over a period of hours? Days? What did they discover. How could ancient people learn from this instrument? How could this instrument help us if lost? Is this instrument helpful in making sky maps with the Star plotter?

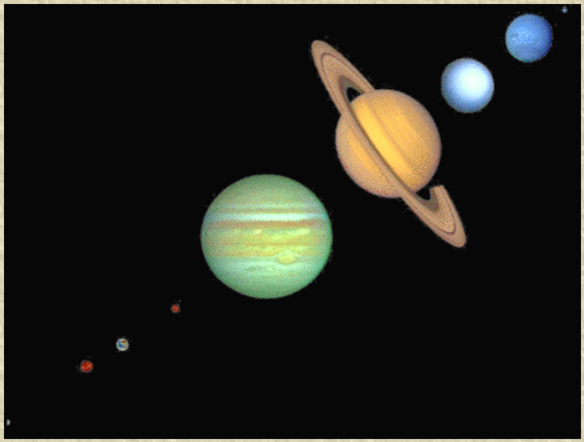
Related Links

Comments?

Contents | 1 2 3 Back to Top 5 6 | Home

The Earth orbits the Sun with eight other planets, millions of asteroids, and perhaps trillions of comets. These objects are held in their orbits by the equilibrium motions of their gravitational attraction towards the Sun and a perpendicular velocity away from the Sun. Strictly speaking, these orbits are ellipses, not circles, though the Earth's orbit is very nearly a circle. While the planets may appear to move through the night sky just as stars do, they are also moving in their own orbits around the Sun. Repeated observations, in fact, show that the planets move with respect to seemingly fixed stars in the distant background. The very word "planet" comes from ancient Greek word meaning "wanderer". In this chapter, we will investigate the nature of the objects in our Solar System, their behavior, and their associated phenomena.

Topic 1: Solar System Overview



The planets of the Solar System fall into two general categories: the terrestrial planets (like the Earth) and the Jovian planets (like Jupiter). The terrestrial planets- Mercury, Venus, Earth and Mars- are relatively small and have rocky crusts and small atmospheres. The Jovian planets- Jupiter, Saturn, Uranus and Neptune-are many times larger and have dense, gaseous atmospheres with no visible surfaces. Because of this, the Jovians are sometimes referred to as gas giants, although it is believed that the cores of these huge planets are liquid if not solid forms of helium and hydrogen. Pluto, the most distant planet, is in a class by itself. It's tiny (only slightly larger than our Moon), its orbit is inclined more than 17 degrees compared to the orbits of the other planets, and its orbit is also very eccentric (its distance from the Sun varies over the course of its orbit). It's so eccentric, in fact, that it even crosses Neptune's orbit, so sometimes Neptune is farther from the Sun than Pluto! For this reason, combined with the facts that Pluto's plane of orbit is several degrees above the planes of all of the other planets and has a moon almost as big as it is, has caused astronomers to reconsider the planetary classification of Pluto and perhaps refer to it as a huge rogue comet instead. The table summarizes the basic physical and orbital data about each of the nine planets of the Solar System.

By comparison, the Moon's diameter is 3,476 km (0.27 of Earth's), while large for a moon, is rather small compared to most of the planets. It only appears so large in the sky because it is so much closer to us than any planet (an average of 384,405 km).

Planet	**Distance (from Sun)**	**Diameter**
Mercury	57,910 km...0.39 A.U.	4,800 km
Venus	108,200 km...0.72 A.U.	12,100 km
Earth	149,600 km...1.00 A.U.	12,750 km
Mars	227,940 km...1.50 A.U.	6,800 km
Jupiter	778,330 km...5.20 A.U.	142,800 km
Saturn	1,429,400 km...9.50 A.U.	120,660 km
Uranus	2,870,990 km...19.20 A.U.	51,800 km
Neptune	4,504,300 km...30.10 A.U.	49,500 km
Pluto	5,913,520 km...39.50 A.U.	3,000 km

.

Activity 5-1: Modeling Planetary Sizes

By relating the sizes of the different planets to familiar objects, this activity helps to reinforce the relative sizes of the planets.

Materials: Marble; walnut; golf ball; raisin; acorn; basketball; soccer ball; softball; grapefruit; kidney bean; Post-It pads.

- 1. Label the objects with Post-It pads as follows: Mercury--marble; Venus--walnut; Earth--golf ball; Moon--raisin; Mars--acorn; Jupiter--basketball; Saturn--soccer ball; Uranus--softball; Neptune--grapefruit; Pluto--bean. As indicates, Uranus is slightly larger than Neptune. If the grapefruit is larger than the softball, switch their labels.
- 2. Have the students arrange the planets in order of increasing size. Does it seem odd to you there are no medium sized planets?
- 3. Now arrange the planets in order of increasing distance from the Sun, with 1 foot = 1 A.U. Do you see any pattern in the distribution of sizes with distance? Where would the asteroid belt go? Comets?

Discussion

Are all the planets the same size? Is the Moon much smaller than all the planets? Is the Moon a planet? Do other planets have moons? How big should the Sun be on this scale? It should actually be over nine feet across-this is higher than an average classroom ceiling!

Activity 5-2: A Classroom Solar System

If it takes around twelve hundred Earths to fill up Jupiter and about twelve hundred Jupiters to fill the Sun, it becomes difficult to represent this in a model! However, if we imagine the Sun is a ball 9 feet across, we can build a scaled down representation of our solar system.

To make this model, the ceiling of the classroom or nearby room must be able to support a few pounds of weight spread over a small distance. You may want to investigate the strength of the ceiling and its physical ability for attaching a hanging mobile. Paneled tile ceilings are great as they have nooks for hooks, wooden ceilings allow minor hook & eyes to be installed, and rooms with lots of overhead pipes are ideal for slinging strings around. Please consider which method of fixture is best to use before attempting this activity.

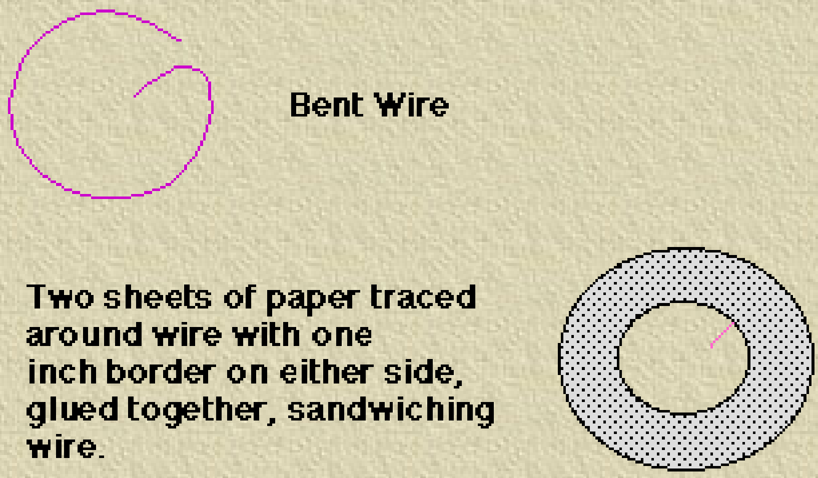
The following objects are appropriate in size to help visualize the relative proportions of sizes of one planet to another:

Planet	Scale Object
Mercury	marble
Venus	walnut
Earth	golf ball
Mars	acorn
Jupiter	basketball
Saturn	soccer ball
Uranus	softball
Neptune	small grapefruit
Pluto	kidney bean

Materials: Items listed above, paper maché, paper, pencils, markers, paint, string, long pipe cleaners or thin wire, spherical rubber balloons, and small paper clips.

- 1. Divide students up into groups which will construct specific planets.
- 2. Cut a set of 10 strings to equal lengths, the length of which they want the planet to hang down from the ceiling. Tie one end of the string tightly to the paper clip. Suggest they build the little terrestrial paper maché planets around this clip. In the case of the bigger planets, the clip will function more like a hook.
- 3. Create the paper maché the planets so that they are the same size as the representative models. Those making Mercury and Pluto need only build their paper maché to cover the paper clip. Those making Venus, Earth, and Mars will need to use very small rubber balloons blown to the right size of the models. Those making the Jovian giant planets will need to have their balloons blown up to their larger respective sizes. The paper maché is applied in two layers or more on the balloon, leaving a small hole at the top for the balloon to come out and for the paper clip/string to be attached. Let the paper maché dry overnight.
- 4. After the paper maché has dried (24-48 hours), pop all balloons, remove and discard the rubber material. This leaves a nice, hollow planet. It is then left up to the students to paint the planets with the appropriate colors and markings as found in astronomy books or on posters.
- 4a. Students making the ringed planets, Jupiter (3 rings), Saturn (too many rings to count!), Uranus (100 rings) and Neptune (9 rings), will need to puzzle out how to attach rings to the paper maché planets, once the paint is dry. Since rings are usually quite distant from the planet, it is quite tricky to portray them. However, our hint is to put the rings on only Saturn and Uranus. Try the following method: some pipe cleaner

or thin wire into a circle made to the diameter of the rings, but bend one end of the circle inwards, like the letter G, enough that it reaches the paper maché ball and can be (but NOT yet!) inserted CAREFULLY into the side via a hole pricked there by a sharp object. For sturdiness, students may want to loop two wires and bend the wire on the other side inwards as well to look like an O with a belt on. Place the ring of wire on to a big piece of paper folded in half and trace around it -- but 1 inch away from it on both sides, so you make a big doughnut. Because the paper is folded, you will get two doughnuts. Cut these doughnuts out after painting them as rings, and "sandwich-glue" them around the wire. When the glue has dried, slip the rings over the planet and insert the bent bits into the pricked holes in the side. Glue these bits if necessary. NOTE: Uranus is a planet which is kicked over on its side, so its rings are vertical, not horizontal!



- 5. When all of the planets are made, the paper clip strings should be hooked into the holes on the tops of the planets. The little planets should already have their strings coming out from inside of them. Tie the free ends of the string to whichever mechanism was constructed/found.

Discussion

Students may see a pattern in the sizes and groupings of the planets. What happens to the size with distance from the Sun? The color? Rings? Which planet does not seem to fit into the pattern? Do students see how Jupiter is the dominant planet? Students should recall what the Sun would look like if placed in their classroom using this scale. It would have to be a sphere nine feet in diameter.

Activity 5-3: Planetary Distances on the Playground

In this activity, each student or small group of students represents a planet in order to illustrate the spacing of the planets. The Planetary Data Table at the beginning of these activities lists the distance of each planet from the Sun (in kilometers and astronomical units). By translating these numbers into paces, the students can pace off the distances to the planets.

Materials: Playground or field, letter-sized sheet of paper for each planet, markers.

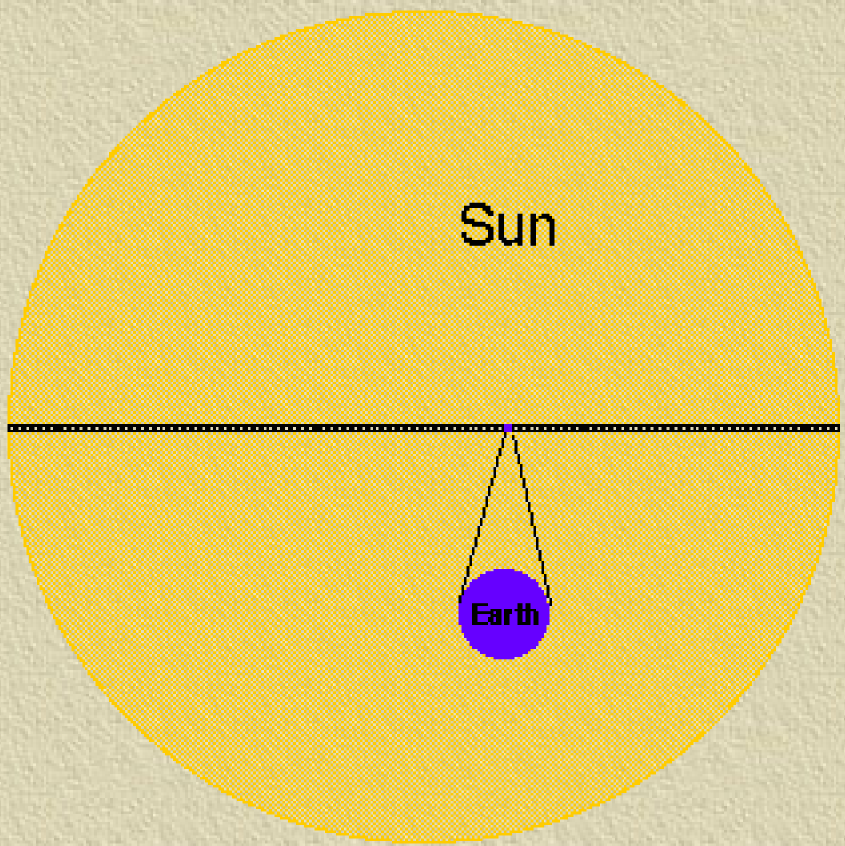
- 1. Calculate the number of paces for each planet's orbit, based on the data on page 4 of the Jupiter booklet, as constrained by the size of the area available. Find a number by which to multiply the Average Distance from Sun (in Astronomical Units) column such that even Pluto's orbit will fit on the field.)
- 2. Split the class into ten groups, and assign each group to represent a planet. Find one volunteer to be the Sun. Have each group make a sign with the name of its planet.
- 3. Take the class to a field or playground. Have "the Sun" stand near the edge of the field or playground; each orbit is measured from the Sun.
- 4. Pace off the orbit of each planet as calculated in step 1. Have each group mark the planet's position by standing there.
- 5. Be sure to stress that this is only an illustration of the relative distances of the planets from the Sun; since each planet orbits the Sun with a different velocity, the planets spend most of their time somewhere along their near-circular orbit around the Sun, rarely along a straight line with the other planets.

Discussion

Are the planets evenly spaced? Is there some pattern you can find which seems to fit what is seen? Could you find some mathematical equation which would fit the pattern? How does a planet's distance from the Sun relate to its temperature? Should planets nearer the Sun be hotter or cooler than those farther away? The next activity will help answer this question.

Activity 5-4: Sun and Earth

While Jupiter is the largest of the planets, by far the largest object in our Solar System is the Sun. More than one hundred Earths (109, to be precise) could fit across the Sun. The figure illustrates this size relation. This activity will illustrate this ratio to the class on the playground. The teacher will mark off one pace to represent the diameter of the Earth, while each student will guess how much bigger the Sun is.



Materials: Playground or field; letter-sized sheet of paper for each student; rock or brick for each student; markers.

- 1. Have each student write his name on a sheet of paper. Each student will use his sheet of paper to mark his guess of the diameter of the Sun. Each student should also find a rock or brick to prevent his sign from blowing away.

- 2. Bring the class out to the playground. Mark off one pace to be the Earth's diameter.

- 3. Starting from the same point, have each student mark his guess of the Sun's diameter.

- 4. Pace off 109 paces and see who came closest!

Discussion

Does it make sense that the Sun should be so much bigger than the Earth? Which has more mass? Which has the stronger gravitational field? You might be tempted to say the Earth, because we can feel it pulling us down, but the Sun's is so great that it pulls the whole Earth!

What would happen if the Earth had as much mass as the Sun? Would the Earth still orbit the Sun? What if it had twice as much mass as the Sun? Could the Earth have other planets orbiting it?

Topic 2: Planetary Orbits

Newton's First Law of Motion states that an object at rest will tend to stay at rest and an object in motion will tend to stay in motion in a straight line, unless acted upon by an external, unbalanced force. If one rolls a ball on a level surface, it will travel in a straight line until the force of friction stops it. There's no air or carpeting to slow the planets in their orbits, but the planets don't travel in straight lines through space. There must be another force acting upon them. That other force is gravity, of course.

When we experience gravity in our everyday lives, the force is usually between two objects of very different masses: one very massive (like the Earth) and another with negligible mass (like a person). Because of this fact, we often simply think of gravity as some property of very massive objects like planets and stars. In reality, though, gravity attracts every object to one another: the Earth pulls on you only as much as you pull on the Earth. Since the Earth is much more massive than you, though, you won't notice the infinitesimal amount the Earth moves towards you, but you can't help but notice how you fall to Earth! There is also gravitational attraction between you and, say, your desk, but neither you nor your desk have enough mass so the force is noticeable. The gravitational force between two bowling balls can be measured in the laboratory with very sensitive instruments, however!

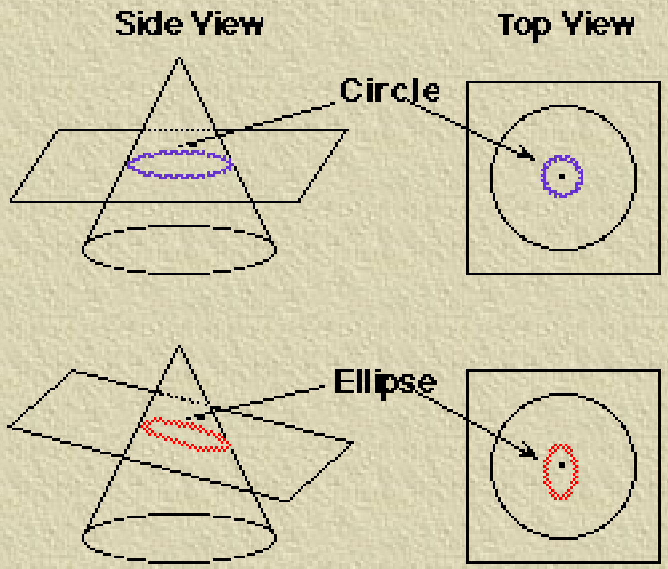
It is gravity which keeps the planets in orbit about the Sun, the Moon and artificial satellites about the Earth, and the Sun about the center of our Milky Way galaxy. In the case of the planets, the force of gravity is analogous to the tension in a string tied to a ball being swung overhead. The swinging is the velocity of the planet perpendicular to the tug of gravity from the sun. The planet (or ball) is kept in orbit by the tug of the Sun (string), and if it were to stop (or if the string were broken), the planet (or the ball) would fly away in a straight line .

By analyzing the observations of Tycho Brahe, a Danish astronomer of the sixteenth century, Johannes Kepler realized that the orbits of the planets about the Sun were not perfectly circular, as had been believed (mainly for aesthetic and religious reasons) for centuries. Rather, the planets orbit the Sun in ellipses, a class of geometric figures of which the circle is a special case. An activity in this Topic is devoted to drawing ellipses.

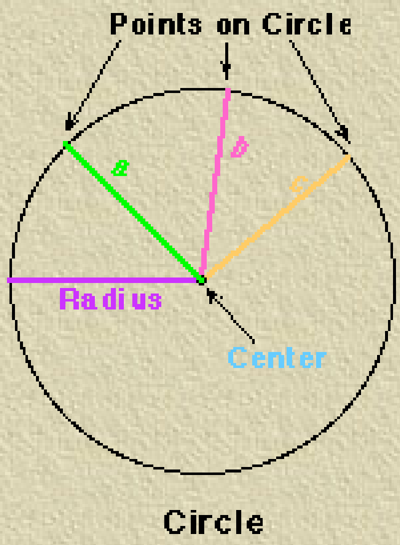
We also explore retrograde motion, a consequence of the fact that those planets closer to the Sun move through their orbits more quickly then those farther away.

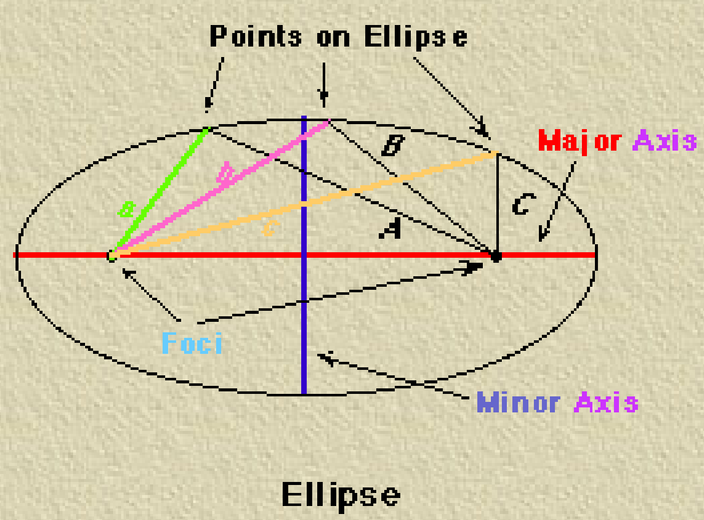
Activity 5-5: Drawing Ellipses

We stated earlier that all orbits are ellipses. But what are ellipses? Ellipses look like ovals, but are very specifically defined mathematically. Technically speaking, ellipses are members of a special class of geometrical shapes known as conic sections. They are so named because all of these shapes (circles, ellipses, parabolas, and hyperbolas) can be made by slicing a cone with a plane. The figure to the right illustrates this process for the circle and the ellipse. You might want to demonstrate this to the class by cutting solid cones (like miniature Styrofoam tree forms) at different angles and examining the resulting cross sections.



A circle is defined such that every point on a circle is the same distance from the center. One can easily construct a circle by tying a pencil to a string, securing the string to the paper with thumbtack, and keeping the string taut while moving around the thumbtack. The string is the radius and the thumbtack marks the center. An ellipse is somewhat more complicated to define and construct. Instead of one point of interest, the center, there are two points, the foci (singular: focus). The sum of the distances from each point on an ellipse to the two foci is a constant.





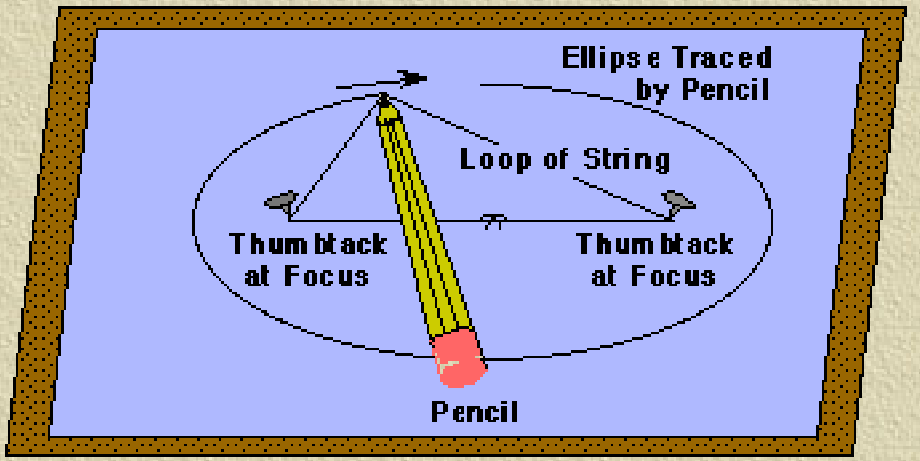
The farther apart an ellipse's foci are, the more eccentric it is said to be. A circle is just a special case of an ellipse; if the two foci are at exactly the same place, the ellipse is a circle. The Earth's orbit is very nearly a circle. If it were very eccentric, the distance from the Earth to the Sun throughout the year would vary a great deal more than it does. This could make the Sun appear much larger when we were closer and much smaller when we were farther away. It would also vary the amount of light and heat the Earth receives from the Sun. While we do experience warmer and cold seasons, it is not because the Sun is closer or farther. In fact, the Earth is slightly closer to the Sun in its orbit during the

Northern Hemisphere's winter than during the summer. For more information about the seasons, see Chapter 1.

Despite the rather unusual and precisely mathematical way we have defined the ellipse, it's really very easy to construct. Terms like "eccentricity" will gain more meaning as the students experiment with different distances between the foci.

Materials: Thick cardboard or plywood; paper; string; sharp pencil, thumb tacks.

- 1. Place the sheet of paper on the cardboard backing and secure with the two thumbtacks as shown below. Do not push the thumbtacks all the way in! We need to be able to loop the string around them.
- 2. Tie the string into a loop and hook it around the thumbtacks. The loop should be large enough to fit around the thumbtacks, but not to large that, when taut, it won't fit on the paper.



- 3. Pull the loop taut with the point of a sharp pencil. Keeping the loop taut, move the pencil around to draw the ellipse.
- 4. Try experimenting with different distances between the foci. What happens when they are farther apart? closer together? How can we make the ellipse rounder (less eccentric)? flatter (more eccentric)? What if the two thumbtacks are right next to one another? What if there's only one thumbtack?

Discussion

With only one thumbtack, the figure is a circle. A circle, then, can be said to be a special case of an ellipse. This is a common way of grouping shapes; a square, for instance, is just a special case of the rectangle, in which two adjacent sides are of equal length. This may be a good place to mention group theory to older students, if such basic logic is in the curriculum ("If all circles are ellipses and all ellipses are smooth figures, does that imply that all smooth figures are circles?").

Activity 5-6: Planetary Distances on the Playground

In this activity, each student or small group of students represents a planet in order to illustrate the spacing of the planets. The Planetary Data Table at the beginning of this chapter lists the distance of each planet from the Sun (in astronomical units). By translating these numbers into paces, the students can pace off the distances to the planets.

Materials: Playground or field; letter-sized sheet of paper for each planet; markers.

- 1. Calculate the number of paces for each planet's orbit, based on the data in as constrained by the size of the area available. (Just find a number by which to multiply the "Average Distance from Sun (Semi-Major Axis in A.U.)" column such that even Pluto's orbit will fit on the field.) For example, on a full-size football field (100 yards), assuming an adult pace is almost a yard, we could double each distance, so Earth's distance from the Sun would be 2 paces and Pluto's would be almost 80.

- 2. Split the class into ten groups, and assign each group to represent one planet. Find one volunteer to be the Sun. Have each group make a sign with the name of its planet.

- 3. Take the class to a field or playground. Have the Sun stand near the edge of the field or playground; each orbit is measured from the Sun.

- 4. Pace off the orbit of each planet as calculated in step 1. Have each group mark the planet's position by standing there.

- 5. Be sure to stress that this is only an illustration of the relative distances of the planets from the Sun; since each planet orbits the Sun with a different velocity, the linear alignment of planets is very rare!

Discussion

Are the planets evenly spaced? How does position relate to temperature? Should planets nearer the Sun be hotter or cooler than those farther away? The next activity will help answer this question.

Activity 5-7: Sunlight Near and Far

As we have seen, the planets are in orbits of greatly varying distance from the Sun. Since the Sun is the sole energy source for the entire Solar System, a planet's distance from the Sun can have profound effects on its composition, atmosphere, and climate. This activity helps to demonstrate that as one moves farther from a light source, the less energy one receives from it.

Materials: Graph paper; cardboard or plywood; masking tape; flashlight; markers.

- 1. Attach a sheet of graph paper to the cardboard or plywood with the masking tape. Hold the board perpendicular to the floor and shine the flashlight directly onto the graph paper from the side, about two feet away. Be sure the flashlight is parallel to the floor, and, therefore, perpendicular to the paper. You might try placing the flashlight on a pile of books.
- 2. Trace the outline of the flashlight's beam on the graph paper.
- 3. Double the distance from the paper to the flashlight. Does the area of the beam on the paper increase or decrease? Try several distances both closer and farther from the paper. What happens to the size of the beam?

Discussion

Is there any relation between the distance the flashlight is from the paper and the number of squares its light covers on the paper? What does this mean about sunlight reaching the outer planets? What does that mean about planets like Mercury or Venus? Remember this activity when we learn about comets, for it will explain why we cannot see them far away but can when they get closer to the Sun.

Activity 5-8: Earth and Sun Revisited

Being the third closest planet to the Sun may make our home seem nice and cozy, but does it have any disadvantages? Besides making us more prone to collisions with comets and meteoroids (see Topic 4), it also means we get more of the brunt of the radiation from the Sun. Solar radiation comes in many forms, most of which are undetectable;e to the human body. One of these is the solar wind, a stream of particles coming from the Sun. Luckily for us, the planets have magnetospheres, or shells of magnetic force fields around them. The particles screaming from the Sun are charged particles which are attracted to the magnetic force field. Like a big bar magnet, the Earth collects most of these particles to its poles where we see their entry in auroras or in bad television reception.

Materials: bar magnet, drinking straw, two sheets of notebook paper, iron filings

- 1. Cover the magnet with a sheet of paper and lay on a desk.
- 2. Fold the other piece of paper down the middle and sprinkle iron filings into the fold.
- 3. Hold the folded paper carefully about 6 inches above the magnet paper and blow gently through the straw across the iron filings. They should be directed towards the bar magnet.

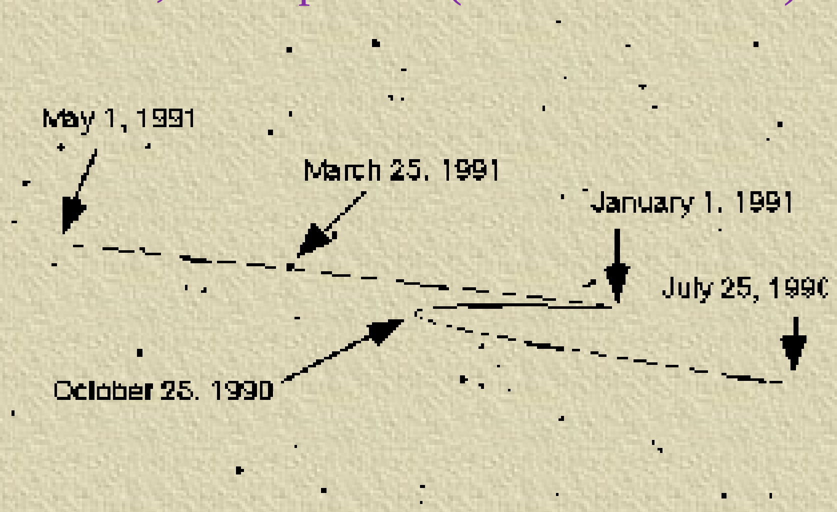
Discussion

The force field around the bar magnet is like any other magnet: looping from the poles of the magnet like a coffee cup with millions of handles. This makes the iron filings surround the magnet in the same way and make the solar wind particles do likewise on the Earth.

What would change the pattern of the filings? What if someone were blowing air low across the table top perpendicular to the one blowing from the straw? Would this explain why Jupiter's magnetosphere extends past the planet Saturn behind it?

Activity 5-9: Retrograde Motion

As we mentioned in the introduction to this chapter, the planets appear to move with respect to the much more distant "fixed" stars. In fact, we even get our word "planet" from a Greek word meaning "wanderer". Beyond simple "wandering" due to the planet's orbit, sometimes the apparent motion of the planets across the sky can seem quite elaborate and surprising. We should expect that if we look at a planet each night, it should move a little with respect to the stars around it due to differences in the orbital speeds of the planets; a planet closer to the Sun completes an orbit in less time that one more distant. Because of these differences, faster planets (closer to the Sun) routinely catch up to and overtake slower planets (farther from the Sun). Viewed from the faster planet, the slower planet would appear to move backwards during the time the fast planet passes the slower planet. We will attempt to demonstrate this effect on a long table or window sill in the classroom.



Materials: Toy car or truck; long table near window or window sill; office chair with wheels.

- 1. Have one student slowly roll the toy car along the sill or the table at a constant rate. The motion of the car should be contrasted with fixed, distant objects, far enough that they appear fixed even as one walks by the window.
- 2. Taking turns, each student should sit in the chair as you push it along the same direction as the toy car, but at a faster, constant rate. Each student should watch the toy car as he passes it.
- 3. Make sure the students try to observe this effect on the way home, or sometime on the highway.

Discussion

If one travels at a constant rate, one does not feel the motion. Does it feel like you're moving in the middle of an elevator ride? on an escalator? in a car at a constant speed on a smooth road? Since we don't feel that the Earth is moving, it looks like anything we pass (like Mars) is actually moving backwards! What would happen if the toy car were moving faster than the student's chair?

Topic 3: Exploring the Planets

Each of the planets in our Solar System has its own unique character, from the acid rains of Venus to the lightning storms on Jupiter. One thing common to almost all of the planets is an atmosphere. Mercury and Pluto are the only two planets which have no atmosphere. The rest have gas layers spanning from tens of miles to hundreds of thousands of miles thick.

To hold on to an atmosphere, a planet must have either enough mass to keep the gas in place preferably with a continuing supply of the gas, or be far enough away from the Sun to keep the gas from boiling away into space.

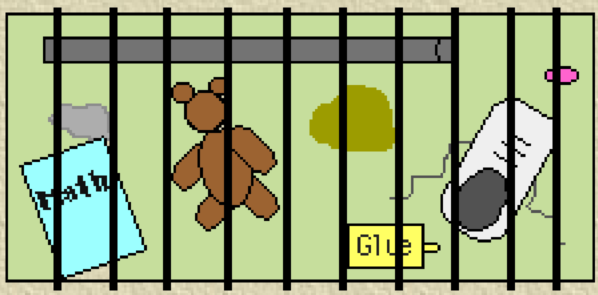
Venus, a planet closer to the hot Sun than the Earth yet smaller in size than the Earth has a greater atmosphere than the Earth. This is due to the fact that its atmosphere is primarily carbon dioxide. This gas built up because Venus was too close to the Sun for any large oceans to form and remain; oceans on the Earth absorb the carbon monoxide and transform it into mineral deposits, primarily found in shellfish. An incredible quality of a carbon monoxide atmosphere is that it can trap heat to the planet's surface. The thick atmosphere has provided Venus with surface temperatures of over 700¡F and surface pressures of over 90 Earths. For years, no one could see below the reflective cloud tops of Venus until radar probes were sent to its surface. Radar is a technique of mapping a hidden surface by sending sound waves to the surface and timing their return bounce upward to the spaceship. This has been a highly successful way of "seeing" the world below the clouds of Venus. we have found from this mapping that Venus has old volcanoes, continental plates, and lots of cracks across its surface.

Activity 5-10: Radar Mapping an Aquarium

Without the use of multi-million dollar equipment and traveling to other planets, it is easy to use the idea of radar mapping in the classroom.

Materials: A large aquarium, black construction paper or black paint, paper maché, random sturdy objects, string, meter stick, pencil, notebook with graph paper pages.

- 1. Students should measure the depth of the tank with a meter stick. They will need this value to determine the height of the objects to be placed inside. A group of students and/or teachers should create a landscape inside the dry aquarium with objects of their choice and paper maché. It should not be too crowded nor too sparse, on average one object per 2 square inches.



- 2. Either paint or construction paper the glass around the tank so that the inside is invisible.
- 3. At 3 inch intervals along the long edge of the top attach lengths of string long enough to stretch across the top of the aquarium to the other side at a corresponding 3 inch mark. Continue this the length of the tank. Also mark the short edge of the tank top with marks every 2 inches. These will later be strung in the same way at step 8.
- 4. Place the tank on a high lab bench or table so that it is eye level, yet the top is above eye level.
- 5. In a graph paper notebook turned lengthwise, have students draw a rectangle to represent the top of the tank. At scaled (i.e.; 3 inches = 2 centimeters, etc) intervals on the paper they should lightly draw lines indicating the strings. Turning the book to the normal position, students should begin to map the tank.
- 6. One student should hold the meter stick (the "zero" end down) carefully over the tank at the back left corner and lower it until it hits something solid beneath. Since the tank is at eye level, she should be able to read off a value on the stick which indicates how far down she had to lower the stick. Since the stick is hitting something, this may mean that it is not yet reaching the bottom of the tank. This means that the "zero" end is not on the bottom, so the height above the bottom is the depth of the tank minus the value read from the stick. The other student should locate on the drawing the position of the stick and put a point on the paper there with the value calculated. This should be repeated along the entire band on the left side until the student reaches the front of the tank.
- 7. When each band has been mapped, and they can be mapped by different groups of students simultaneously or in sequence, each group should have what looks like a line graph occurring in their notebook or their band.
- 8. The strings should then be changed by those not participating in the mapping to the other marks along the short edge and the procedure

should be repeated, this time with the recording student turning the book lengthwise again for easier marking along the band drawing.

- 9. If different groups are mapping different bands, the bands should then be combined on overhead transparencies of tracing paper to create one big set of lengthwise graphs and one big set of shortwise graphs.

Discussion

Is it possible to determine where there are bumps and where there are holes? When looking at both the lengthwise and the shortwise graphs, is it possible to determine where some object spreads into another band? How could a larger three-dimensional map be created from the data? Try to recreate the mystery landscape with clay or paper maché. Take down the tank and look inside to compare results. Is this method of measuring an otherwise hidden planet useful? What are its limitations?

Activity 5-11: Why is the Sky Blue?

The age old question posed to adults by curious children, a question often reflected upon by the adult as well. So here it is asked again, this time with an answer which is fun to discover.Why is the sky blue?

The atmosphere of the Earth is made of several gases, the most common being nitrogen and then oxygen. Chemically speaking, eventhough the human eye cannot see them unaided, these gas molecules are large. The light from the Sun is white light, a combination of a rainbow of colors (see light section). The bluer light is light which travels in smaller packets than does the redder light. When the white light hits the atmosphere, the particles of light hit the large molecules of air. The bigger light packets, the red, oranges, yellows, and some greens are able to bump their way through the molecules and pass to the ground. However, much of the smaller light packets, the blue light and some green, get stuck bouncing around the big molecules like a pinball around the bumpers. Thus, the sky looks blue for the blue light stuck high in the atmosphere and the sunsets look red for the red light being able to pass straight through at the point of light (the Sun).

The effect of reddening can be seen in different places across a town. In the most polluted part of town, the sky looks very red. This is because there are particles of dust, waste, and water in the sky, particles large enough to scatter even the largest of light packets like the red ones. Deep blue skies, in contrast, are clean, dry areas where only the really small packets of light, the blue and violet, are stuck in the highest parts of the atmosphere.

This activity allows the reddeing effect to be explored using simple household objects.

Materials: A bright flashlight, drinking glass, eye dropper, milk, spoon

- 1. Fill a drinking glass 3/4 full with water. Turn off the lights and aim the lit flashlight through the side of the glass. Observe the color of the light passing through the glass and the color of the water.
- 2. Add a drop of milk to the glass and stir the water. Aim the flashlight through the glass again. Observe the color of the light passing through and the color of the water in the glass.

Discussion

A planet with no atmosphere would have a sky which was black and a surface which was bathed in sunlight. Take notice of the Apollo astronaut photos on the Moon to see this effect. The lack of atmosphere allows all of the light to pass right down to the surface, just like the flashlight beam through the water. However, if there is an atmosphere with big molecules in it, or a glass of water with big particles of milk in it, the blue light gets scattered and the redder light does not. The light coming through the glass with milk is redder and the glass of watered milk looks bluer.

What could this mean about the sunsets after a volcanic eruption? What would the sky look like on Mercury?

Activity 5-12: Modeling Jupiter's Atmosphere

Sometimes atmospheres can be more a bane than a boon, as in hurricanes and tornadoes. There are planets whose atmospheres never rest and are constantly churning. Since Venus spins on its axis in the opposite direction it goes around the Sun, its winds are constantly roaring across its surface. On Jupiter there is a hurricane which has raged for at least three hundred years and is occasionally dark red. Is this because of the reddening effect above or something else? Actually, Jupiter's clouds are made of different molecules than on the Earth, molecules like methane and sulfur. These are elements which have different colors with different temperatures. With several layers of these gases over thousands of miles of atmosphere, it is possible to trace depths of Jupiter's atmosphere simply by examining the colors.

Materials: Developing paper, double sided tape, cardboard, scissors

- 1. Cut a shape in the middle of a piece of cardboard.
- 2. In a dark room, tape the cardboard shape on to the glossy side of the photographic developing paper.
- 3. Place the paper in the sunlight for one minute and return to the darkened room.
- 4. Take the cardboard shape off of the paper and observe the result.

Discussion

The developing paper is designed to turn very dark when light hits its surface. The chemicals of the paper react to sunlight and darken, like getting a tan. Without the sunblock, or the cardboard shape, the paper gets a sunburn. Since Jupiter's clouds are made of chemicals which also react to the light and heat of the Sun, they are different colors depending on what's blocking them or how deep they are.

What does this say about the stripes of Jupiter? Or the Great Red Spot? What about storms on other planets?

Activity 5-13 : The Great Red Spot

The churning nature of Jupiter's clouds is suspected to be the result of the planet's hot core which is still trying to cool off. Not unlike Earth's volcanoes, the planet Jupiter needs a method by which it can release heat. It does so by radiating it out through its enormous atmosphere. Strangely, the bands one sees across the planet's atmosphere are due to layers of gases blowing past each other in opposite directions. Thus, the vortex of the Great Red Spot is not too surprising with such terrible weather patterns!

Materials: Glass jar almost filled with water, tea bag, long pencil

- 1. Open the tea bag and spill the leaves into the water jar.
- 2. Put the pencil into the center of the water and rapidly whisk the pencil in a small circle until the tea leaves swirl together in the center. Observe the swirling from the side and from the top.

Discussion

From this activity, is it possible to determine what the section of atmosphere near the Great Red Spot looks like from a side view and from the top? Compare this with the photos of Neptune. What would happen if the water were a flowing river? Would the swirl stay circular or would it spread out? How does this compare to the annual Saturn storms?

Activity 5-14: Rings and Things

The most beautiful aspect of the outer planets is their rings. Each of the gas giants, Jupiter, Saturn, Uranus, and Neptune, all have rings of some kind.

Although these rings are made from the tiniest chunkcs of dust and ice, they still appear very bright to the cameras. How could such tiny particles so far away in space be so visible?

Materials: Flashlight, baby powder in a plastic squeezebox, ice cubes, drinking glasses, hot water

- 1. In a dark room, lie a flashlight in the edge of a desk or table.
- 2. Hold the squeezebox below the beam of light and then quickly squeeze the box to let a fast shot of powder come up through the beam. Observe.
- 3. Fill a glass with hot water and leave another empty.
- 4. Drop an ice cube into the empty glass and observe its color: How clear is it? Bright? White?
- 5. Drop an ince cube into the hot water. It cracks. Observe the color: how clear is it? Bright? White?

Discussion

Before the powder is released, the beam of light is hard to see, like the rays of sunlight through empty space in the Solar System. Since the human eye can only see light if it bounces off of something and into the eye, the beam is hard to see until the powder particles are tossed into it. The particles fly around and bounce the light to the eye. The particles, although tiny, are mirrors for the eye to see reflected light from the Sun and are therefore quite bright.

The particles of the rings are small pieces of ice and dust, but what if they were larger pieces? Would they be as bright? The second part of the activity shows that a large solid ice cube is very clear, or as we learned from the Sky is Blue activity that means lots of light is traveling through it and not getting stuck inside. The broken ice cube looks very white and bright. This is because where there once was a solid cube there is now jagged fractures for light to bounce off of. The rings of planets are made of broken pieces of ice and dust which have lots of jagged surfaces, making them all the more brilliantly bright.

Topic 4: Planetesimals

"Wow! Hey, look over there! I just saw a bright streak in the sky! Are the stars falling?" This is often heard in the countryside on clear nights. Falling stars, or "meteors", are not stars at all. Now that the past exercises have shown how large stars like the Sun really are, it would be impossible to imagine something that big just zooming across the sky! Meteors, so named because they happen in the atmosphere (where meteorology got its name), are actually bits of fast flying space debris which has rammed into the Earth's atmosphere, causing enough friction to burn up and sometimes explode (then, called bolides). The "meteor showers" are times during the year when there are an unusually large number of meteors streaking across the sky. The table below shows you the seasonal showers. How can we create a table like this? We have to understand what causes the showers, and that is comets and asteroids.

Earlier we mentioned how asteroids were also planetesimals orbiting in a belt around the Sun and that each asteroid had its own unique orbit. Sometimes, this seemed organized system of planetesimals can get chaotic, perhaps by the orbit of a large comet which disturbs the order, and asteroids will be knocked out of the belt or collide with each other sending fragments out of the belt. These fragments are then collected onto the surfaces of passing comets or roam about the inner Solar System occasionally coming close enough to Earth to collide with it, burning up in the atmosphere completely or leaving pieces large enough to hit the surface. Many get caught in the ring systems of the large gas giants.

It is estimated by astronomers that our solar system has 1 trillion comets, 1,300 of which have been discovered. Comets are planetesimals which orbit so very far away from the sun that very little sunlight reaches them. They are thus made mostly from ices. As they have orbited around the sun for billions of years, they have collected interplanetary debris, leftovers from the planet-making process, mostly fragments of asteroids, onto their surfaces like snowballs rolled down a sandy sidewalk. Billions of years of accumulation of ice and dirt and more ice has created the comets as we observe them -- "dirty snowballs", as comet expert Fred Whipple described them.

The orbits of the comets are as erratic compared to the orbit of Pluto as Pluto's orbit is the orbits of the planets. Most of their orbits are ellipses, but with one end very close to the sun and the other well out beyond the orbit of Pluto. Periodic comets are known to take from 3 to 1,000 years to complete their orbits around the Sun. Halley's Comet is a periodic comet which orbits the sun about once in a 76 year period; the next time Halley's comet will be visible is in the year 2062, as it was just visible in 1986. Ancient people feared comets, and thought comets were omens of good or evil. The ancients connected them with any major disaster occurring at that time on the Earth and thought the comet had caused it.

Due to their highly elliptical orbits, comets swing out quite far from the sun but also orbit extremely close to the sun. When a comet begins to get closer to the sun, the sun's radiation begins to evaporate the ice off of the surface of the comet, leaving bits of dirt to float off. The comet then is said to have three structure elements: the nucleus, the coma, and the tails. The nucleus is usually from one half to thirty miles in diameter and is the original "snowball". The envelope of gas (many times half of a million miles in diameter) and dust sublimating (changing from solid ice to gas) off of the nucleus by the radiation of the sun is the coma. and the stream of material being blown off by the solar wind or being left behind as the comet moves along its orbit are the tails.

When the Earth in its orbit about the sun passes through the trail of sublimated particles left behind by the comet, it rams into these floating particles, and we call the spectacular friction burn of their impact with the atmosphere meteors. Most meteors never reach the ground, instead burn up in the Earth's atmosphere in nature's fireworks show. But some do hit the Earth's surface and we call these meteorites. Several tons of meteorites hit the earth every day, most in the form of micrometeorites, tiny flecks of space stuff. From analysis of meteoritic particles, we have found that asteroids are mostly made of rocks like the surface of the Earth or are made up primarily of iron, like the core of the Earth, yet as old as the Solar System -- 4.5 billion years old!

Meteor showers occur when the Earth is traveling through a particularly dense trail of leftover comet material. Since man has been observing and recording the changes in the heavens, we are able to pinpoint the dates and the comet responsible for the meteor showers. The table below shows you the major meteor showers and in what constellation to look for the streaks. The "radiant" is the point in the sky from which all of the streaks seem to be coming -- in other words, the direction of the comet trail!

A typical Taurid shower will have many very bright meteors, some that give off so much light that their shadows fall on earth. These are called fireballs. If the fireballs explode in midair, they are known as bolides. Witnessing a bolide is quite rare, but spectacular.

Leonids usually radiate from the curved "sickle" part of Leo. These meteors peak every 33 years, the next one to be in 1999, with numbers of observed streaks reaching 10,000 per hour. The Leonids are not so reliable, but they can be quite amazing when they are highly visible. November of 1833 is famous for the Leonid shower, during which 200,000 meteors were seen in an hour. People thought that all the stars were falling from the sky and that the world was coming to an end.

Quadrantids (first named for an old constellation now found in Bootes) are characteristically faint blue. To see them turn to the northeast and look up almost 90 degrees.

The radiant of the Lyrids is near the star Vega, in the constellation Lyra.

Eta Aquarids are yellow meteors with trails that glow - actually they are the resultant matter left from Halley's Comet.

The dates in this table may not exactly coincide with these showers. It is best to look a couple of days before the dates given and a couple of days after the last. The most reliable meteor showers are the Perseids, Geminids and Quadrantids .

Students may find it helpful to know that the ancient people feared natural phenomenon since they themselves have many fears. They often feel fearful because so much is unknown to them. They may be helped to discuss their own fears and what helps them to alleviate them. Learning about the world such as scientists or students do helps to alleviate fears, clear up misconceptions and increase knowledge.

Activity 5-15: Watching Meteor Showers

Materials: Tables of Meteor Showers, telescopes, binoculars (optional).

- 1. Discuss looking into constellation for meteor showers. A reliable shower to start with are the Geminids in Gemini in December. Because it is so late for students to observe at midnight some of them may wish to get up early to see this spectacle. Have them observe and record their results. How many can they count in an hour. They may also view earlier in the evening and count.
- 2. Students might wish to photograph a meteor shower after they have located one. To do this they can place a camera on a tripod, open the lens to the time exposure stop and leave it open for ten minutes. This should bring quite spectacular results.

Discussion

Are there other objects to find in the sky? How helpful is it to spend longer periods such as an hour viewing the sky?

Activity 5-16: Collecting Micrometeorites

Micrometeorites which are iron flecks can be collected by simply using a magnet. The next exercise allows students to collect their own ancient fragments of the Solar System. This activity can be performed on school ground where rain gutters are present or at home. To raise the odds of a significant find, plan this activity during a time of year when there are meteor showers occurring.

Materials: Alnico Magnet or strong bar magnets; plastic bags large enough to wrap around magnets; Petri dishes, 3x5 index cards, crayons, microscope, distilled water (optional).

- 1. After a rainstorm, students should go outside and locate the rain gutter spouts. On the ground directly under the spout, run the magnet (enclosed in a plastic bag) carefully in a straight line along the ground. Careful not to tear the plastic! Keep running the magnet across the ground in one direction, i.e., from left to right only or top to bottom only.
- 2. Fill Petri dishes with distilled or tap water. Dip the plastic nag end of the magnet into the dish and gently remove the plastic into the dish. Slosh the plastic around until you feel anything that was on it has been rinsed into the Petri dish. Set aside.
- 3. Repeat step one, but move the magnet in the other direction, and collect the particles as in step 2.
- 4. With a crayon (it will not smudge or run with your wet hands), write on an index card the date and time, when you were collecting. You might want to write your address on there as well to compare later with students across the school or world. Keep the index cards with the Petri dishes.
- 5. Leave the Petri dishes out on a windowsill until the water evaporates.

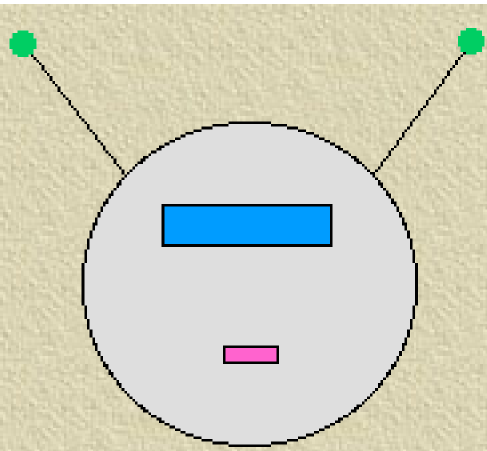
- 6. When the water is gone, put the Petri dish under the microscope. You should hopefully be seeing very tiny particles of meteoritic material. Observe these, count them, draw them, and record the information on the index cards. Repeat for each Petri dish.
- 7. If samples were taken from several different locations, can anyone find any major differences in the sizes or number of micrometeorites found at these different locations?

Discussion:

Does this activity help students understand more about the workings of the inner Solar System? How do the students feel about their ability to do research experiments with the success/failure of this one? How could they use this type of activity in a Science Fair project? Could students be able to make their own meteor shower table from repeating this experiment throughout the year? Why are we able to obtain these micrometeorite particles? Are any students feeling uneasy about the amount of material which is falling on top of their houses/school? Why did ancient people fear comets? What might have helped them to become less fearful? What helps people to become less fearful of natural events and life experiences? How does learning about the cosmos help people to make sense of the world in their lives?

Activity 5-17: Building Extraterrestrials

The possibility of life on other planets, moons and asteroids has captured our imagination almost as long as we have gazed heavenward. These questions still intrigue us, and are undoubtedly all the more fascinating to students who are only recently becoming aware of their place in the Universe. As we shall see, it is unlikely that there is any life as we know it in the Solar System.



Clearly, little green men are not planning a raid from Mars, despite what some popular science fiction may want us to believe. After we explore the atmospheres and surface conditions in our Solar System, this activity challenges the students to invent and build a creature specifically adapted to live in a certain environment on the Earth.

Materials: Paper or Styrofoam cups; tongue depressors; pipe cleaners; construction paper; glue or paste; assorted craft material.

- 1. Each student should pick a planet and research its atmosphere.
- 2. Based on the conditions on that planet, each student should build a creature specifically designed to survive there. A "flare-man", for instance, might survive in the Sun's corona by converting hydrogen to helium for energy. A resident of Venus might thrive on volcanic activity. Most of all, the students should use their imagination!
- 3. Have each student introduce his "E.T." to the class, tell where it lives, how it breathes, what it eats, how it moves, etc.

Discussion

How might life on Earth be different if it were 100 degrees colder? hotter? What if there were no oxygen in the air? Opposite to us, plants take in carbon dioxide and give off oxygen.

What might happen if a Mars creature were put on Venus? What if a Sun creature wound up on Pluto? What would an Earthling need to survive on the Moon? What do humans need to survive in general? What kind of planets are most likely to support human-like life? What might we first look for if we were looking for a planet which could support us?

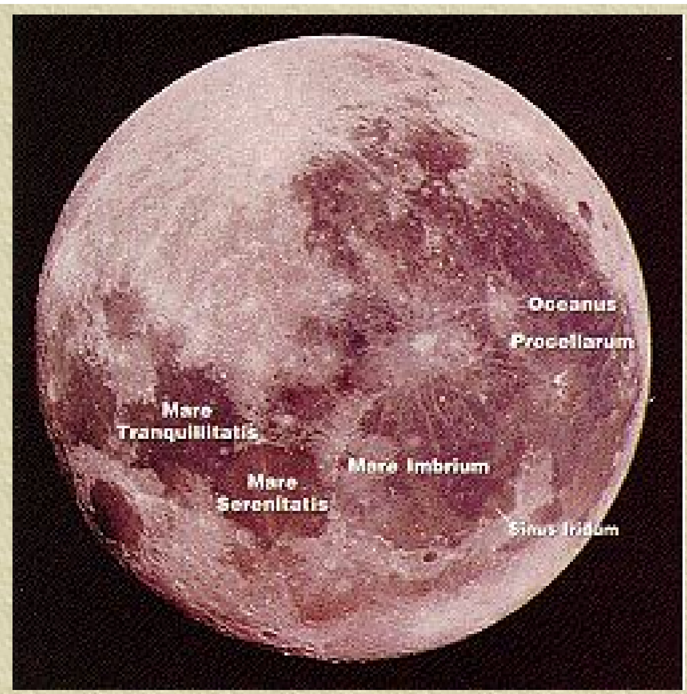
Related Sites

Comments?

Contents | 1 2 3 4 Back to top 6 | Home

Since the dawn of intelligence, man has been trying to make sense of his world. Hunting, gathering, and domestication were spurred by man's desire for understanding, order, and control. Becoming comfortable with the aspects of his world was foremost, knowing the migratory patterns of his prey, the ripening of fruits and grains, and also the ways of the firmament were all crucial steps in early man's development. Before the advent of science, man was attributing the motions of the heavenly bodies to the motions of earthly bodies, seeing the stars in groups resembling bears, lions, or men, naming the friendly face of the Moon after an ancestor or god, or seeing the Milky Way band of stars as the stream of milk given from a heavenly mother to nourish the Earth.

Topic 1: Observing the Moon



The Moon, in particular, has had several names given to it by the many cultures which did and still inhabit the Earth. It was seen by the Greeks as Artemis, the goddess of the hunt, perhaps a reference to the pre-Greek pantheon nocturnal hunting customs. Several cultures have seen the Moon as a god being chased across the sky by a Sun goddess. Some cultures trying to explain the different shapes of the moon (phases) saw them as the story of life and death: the crescent moon is the infant, growing stronger and stronger until maturity at full moon and then growing weaker and weaker and then dying at new moon, only to be born again. The ancient Egyptians called the moon Khonser, which means "traveling through a marsh". Someone traveling through a marsh would be partly obscured by marsh grass for most of his journey, not unlike the appearance of the phases of the moon. Then around 2,000 years ago, the Greeks devised a model to show the moon phases that is still valid now.

What did the Greeks discover which causes the lighted portion of the Moon to appear in several different shapes? The answer is the same reason that the Earth has a day and night. As a sphere, the Moon can have only one half of its shape lit by the Sun at any time. Try to light up more than half of a ball with a flashlight -- it is impossible! Since the Moon goes around the Earth, we have the unique vantage point of being able to at times see the lit and unlit parts at the same time. While trying to light that ball with the flashlight, have a student look at the side of the ball 90° from the lit part, or where the ball appears to only be half lit. The combination of the Moon's period of orbit around the Earth and the direction of the sunlight gives us the monthly change in vantage points, which we call phases, of the Moon.

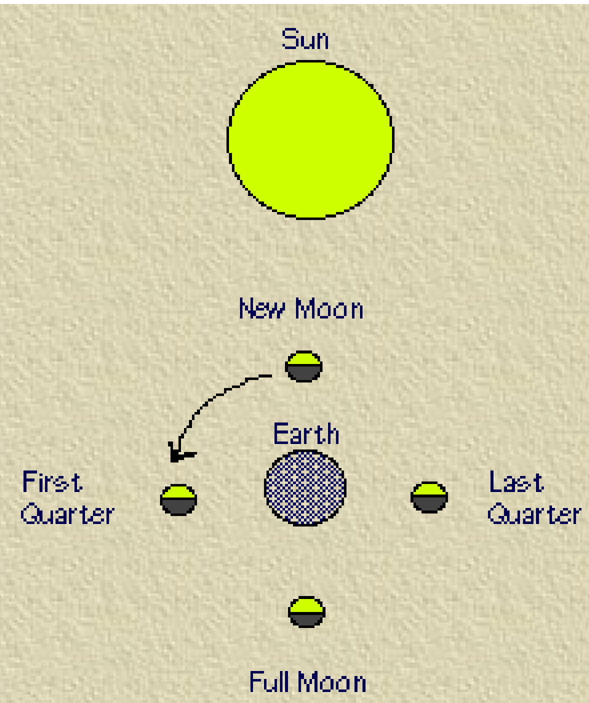
Activity 6-1: The Phases of the Moon

This activity requires a darkened room and is ideal for small groups. The second part of this activity fulfills same goal but for a larger group

Materials: Strong light; extension cord; two inch Styrofoam ball; pencils.

- 1. Darken room and use extension cord to enable light to be placed in middle of room. Each student places moon ball on the end of a pencil and stands in a circle around light.
- 2. Students imagine that their heads are earth. The ball represents the moon and the light, the sun. They hold their moons at arm's length right in front of the sun.
- 3. Students move the ball a little to the left of the sun looking at the moon until they can see a crescent shape in light. Get them to figure out if this crescent is facing the sun or away.
- 4. Students keep moving their moons around their heads (earth). They stop when half the moon is in light. As the moon grows fuller is it moving towards or away from the sun?
- 5. They move the moon in a circle until they can see it fully lighted. To accomplish this, they must hold the moon above their heads. When they observe the ball fully in light ask if it is between them (earth) and the sun or on the opposite side of them and the sun?
- 6. Students continue to move the moons until they are half full again.

As it move toward the sun is it getting fuller or thinner.



- 7. Have them move their moons so that they become crescent slivers. Then explain that when the moon passes the sun it usually is just above or below it and we cannot see it. Why not? this is the phase we call the new moon. It is called new because the ancients thought it was newly born each time.
- 8. Repeat this activity several times making sure that the light source is appropriate so that the phases can be clearly seen.

Discussion

How long does it take from a new moon to a full moon? To the new moon? What is a lunar cycle? Is it possible to have two full moons ever in one month? If so, how could this be possible?

Activity 6-2: The Moon in Orbit around the Earth

This activity requires a darkened room and can involve a large group

Materials: Large ball (about the size of a basketball); slide projector (or some other bright light source).

- 1. Set up the students in a circle so that they are all facing outward, and have them sit. The students are representing different observers around the surface of the Earth.
- 2. Set up the slide projector so that the main beam of light passes over the circle without shadows from the students. The slide projector is the

Sun.

- 3. Have one student carry the ball over his head and walk counterclockwise outside the ring of students, so that the same half of the ball is always being hit by the light. He is demonstrating the Moon in orbit around the Earth. Have this student stop periodically to allow students in the circle to observe what the ball looks like. Perhaps on paper they should draw the ball and the part of it which is lit each time he stops.

Discussion:

Can the students pick out which position was full moon? Quarter moons? Crescents? New moon? Where is the Earth's shadow during the Moon's trip around the Earth? Was the Earth's shadow responsible for the change in shape of the lit Moon? When does the Earth's shadow play a part in the shape of the lit Moon? Which phases of the Moon can be seen in the daytime? In the nighttime?

Activity 6-3: Observing the Moon's Motion

For many cultures, the Moon became an essential tool for survival. Observers of the sky noticed that the Moon's movements were not random and fit a pattern. This pattern would be the foundations of the first calendars (see Chapter 3), and would aide early farmers in predicting planting and harvesting times, or help those living in flood plains of large rivers to be prepared for the rainy season. The moon's regimented pattern can be seen over days and over months in its shape, height in the sky, and location.

Now that the students have seen a simulation of the moon in orbit about the Earth, they should be ready to make actual observations and ask logical questions.

Questions to ask: How does the moon change from day to day? Is it possible to see the moon in the daylight hours? Is there any pattern to the various shapes of the moon? How often does a full moon occur? How could we observe and record the shape and placement of the moon in the sky? When during school hours could we begin this study based on information given in the introduction?

Materials: Sheets of paper 8 1/2" x 11" for each student or small group; heavy cardboard (approximately 9 x 12) for each student or group; pencils; folder such as file folder to store recordings in; Large chart 3' x 6' from standard role; markers; diagram of moon phases; compass.

Morning Observations

Never look directly at the sun.

Begin three days after full moon.

Before beginning this activity, check on the position of the moon and whether it is obstructed. Look for the moon in the western sky.

- 1. Students should practice measuring techniques in classroom. Stand with arms raised above heads. Hold one hand blocking an imaginary sun to protect eyes. Form a fist with other hand and point the wide part to the sun. Move the fist toward the moon counting each fist placed. Practice several times.
- 2. Measure and draw the moon's shape and position in relation to the Sun. Find a place to stand facing South. On the recording sheet, students should place an S in the middle of the top of the paper, E on the left hand upper corner, W on the right hand corner and than draw the horizon leaving a large space for the sky.
- 3. Observe and record daytime moon and sun every other day (does not need to be at the same time) labeling each drawing with the date of the observation and the distance between the moon and sun measured in fists.
- 4. Discuss the changes in shape and distance from sun after observations. After each observation, ask students if the curved part of the moon is facing toward or away from the sun. Ask them to predict where the moon will be after a few days and also to predict how far

from the sun it will be in fists.

- 5. After about five measurements, the observations may be summarized on a large sheet of paper. The moon is no longer visible during the morning ten days after the full moon. Place a large chart on the wall. Draw or have students draw horizon objects and label directions. Start with the first observer. Ask the students to use their observation sheets to describe the shape of the moon on that day. Have them share their fist measurements and use the average of these. Draw the sun and moon as they looked on the day of observation. Write this date and the number of first measurements under moon. Record all other observations in fists and shapes.

Activity 6-4: Evening Observations

- 1. Students should think about and discuss why the moon is no longer visible during the day. They should think about and predict when and where it will be visible again.
- 2. Two or three days after the new moon, students watch at sunset to see when the moon first appears near the setting sun. It will appear as a thin crescent. They record the setting sun and then draw the moon every other clear day at sunset with the date and fist measurement from setting sun to moon and the fist measurement from horizon. They do this on clear days until the full moon which is about two weeks after the new moon and add their recordings to their folders.
- 3. Place another large sheet of paper on wall and draw observations as in daytime observations showing number of fists away from moon to sun, number of fists from horizon to moon, and the date of observation.

Discussion:

Discuss observations and the moon's shapes at different times. What patterns have they observed? Can we predict if this pattern will be recurring? What will help us to decide that? What use could we make of this recorded information? How were these observations of the moon helpful in earlier times? Might the phases of the moon contribute to the understanding and ordering of the ancient world?

Topic 2: Origin of the Moon

Although the Moon is one of the brightest objects in the sky, second only to the Sun, it is not an object like the Sun. The fact that the Sun is a body 93 million miles away that can give you a sunburn from its brightness should give a clue as to its very different nature. And although the Sun and the Moon appear the same size on the sky, the moon is actually 400 times smaller in diameter than the Sun.

The Moon is a body similar to the Earth in many ways. The theories of its origin are many and varied: the moon was a piece spun off from the earth, possibly from the Pacific Ocean basin floor, which subsequently caused the continental drift; the Earth had captured a large, perfectly spherical asteroid or meteorite; rings of orbiting materials around the Earth accreted into a moon. The moon is now most widely believed to have formed during a collision between the Earth and a Mars-sized planet in the early period of the Solar System. The pictures below show you a diagram of what theoretically took place.

Part of the objective of the Apollo manned missions to the moon was to take seismographic readings of the Moon, samples of elements from its surface, and measurements of its mass to try and give planetary geologists back on Earth some more data with which to build the best theory of the Moon's formation. The seismographic readouts showed there was little to no motion inside the Moon, meaning there is no activity inside the moon. Activity inside of the Earth tells us that the inside must not be rigid; it must be partially liquid and therefore very hot. It is no wonder that a boiling hot body weighing over 8 trillion gigatons has not cooled down yet! But the smaller moon cooled off quickly.

The elements from the surface combined with the mass calculations and detailed seismographic information about the compositional layers below the surface showed that the Moon is made up almost entirely of crust materials like those on the Earth, mainly silicates, feldspars, and quartzes. The moon has little to no iron core like the Earth does. This data seems to support the collision model which predicts only crust materials from the early Earth and the Mars-like planet would have been flung off from the collision to form the Moon a quarter of a million miles away.

The Moon's diameter is one quarter the diameter of the Earth, around 2000 miles, but its mass is one hundredth the mass of the Earth. This is because of two things, 1) the Moon is made up of lighter materials on the whole, than the Earth, and 2) because mass is a function of the volume of the object, or the length times width times height of the object (one quarter^3).

The insignificance of this amount of mass means that the Moon cannot hold an atmosphere onto its surface tightly enough before the heat of the Sun burns it away. Similarly, water cannot remain on the surface of the Moon long before the Sun evaporates it. The thick atmosphere of the massive Earth acts as a buffer against much of the heat of the Sun, allowing several forms of water to exist on the surface. Earth's atmosphere acts also as a blanket, keeping the heat of the warmed surface inside. Without this blanket, the surface temperatures on the moon are extreme. In the sunlight, temperatures reach 215°F, while in the dark the temperatures plummet to 270°F below zero. The lack of atmosphere on the Moon also permits all forms of space debris to impact the surface, as the cratering bears witness.

The craters are indeed the sites of tremendous explosions on the surface of an object. Craters on the moon range from about 700 mile wide basins to microscopic impacts on dust grains. The majority of craters were formed by asteroids and meteoroids striking the moon's surface. The Earth had just as many craters billions of years ago but our planet developed an atmosphere, creating rain, wind and weather conditions which have wiped out most of the craters. The moon has no atmosphere and no weather so theoretically, craters, rocks, and soil remain the same over billions of years. However, since the majority of impacts occurring on the moon's surface now are from micrometeorites, the "weathering" which occurs is due to the constant pummeling of these tiny impacts. The largest impacts on the moon were around 3.9 billion years ago. The forces of these explosions were strong enough to crack the fragile young moon's crust, allowing the (then) liquid mantle of the moon to seep into the lowlands the crater basins made and cool there into basalt rock. (The dark basalt is similar to the basalt found on the Earth, as we discovered after astronauts visiting these areas brought bits of them back.) These huge, submerged craters are called mare, the Latin word for seas, due to the fact that to the unaided eye, these dark and flat appearing basins look like large bodies of water. Galileo was the first to turn his telescope to the moon and notice that the mare were not smooth, but were cratered like the rest of the surface.

The lightest parts of the moon are called the highlands, as they are above the low basins of the crater fields and are mostly the remains of the material blasted out and upward after the explosions. Rocks collected from the highlands are the oldest rocks on the moon, as they are the remains of the first parts of the moon's crust that cooled 4.5 billion years ago. The whiteness of the rock is due to the fact that the rock is mostly anorthosite, a type of plagioclase feldspar. When broken, the feldspar crystals are ripped from their nice geometric ordering inside of the rock, causing more crystal surfaces to be exposed. The more surfaces, the more places where light can reflect; thus, these broken rocks look very bright.

What about the other side of the moon? It was the Russians who, in 1959, first took pictures of the unseen back of the moon. These historic pictures revealed that this hidden side differs significantly from the side which faces Earth: 98% of the back surface is highlands and there are only a handful of small mare. Additionally, the back side of the moon hosts the largest impact crater known to us in the Solar System. Boasting a diameter of 700 miles, Mare Orientalis is the remnant of an explosion whose force was strong enough to have sent a shock wave around the surface of the moon as far as the other side where it left cracks in the thin crust. The propagation of the shock wave can be seen most prominently in the concentric rings which surround the crater basin itself. The denotation "mare" for this remnant is misleading, as the melted rock in the center of this basin was not the result of a welling-up of liquid mantle from a deep crack in the crust but was rather contact melting of the surface rock from the tremendous heat of the explosion. An unanswered question remains about the moon abut why the crust on the far side seems to be tough enough to withstand an impact which should have destroyed the little moon, while the near side's crust is so thin as to have let mantle material escape.

So, how is the Moon so bright in the sky if it has no bright atmosphere to reflect light and is so very small? The surface of the Moon may be just rock, but those rocks are mostly silicates, sandy rocks. Try breaking up rocks which have lots of white or clear crystals in them. Notice that when broken, those rocks look brighter. This is because more tiny surfaces of the rocks have been exposed each time one piece was broken into many. Since the Moon is constantly being hit by space debris, its rocks are being continually broken up. The surface of the Moon looks bright for this reason. Secondly, 250,000 miles to the Moon is close compared to 93,000,000 miles to the Sun! The Moon may be 400 times smaller across than the Sun, but it is 400 times closer too! So, it appears as big in the sky and very bright.

The moon cannot appear as bright as the Sun, because the Moon is not making its own light like the Sun is. The Moon is instead reflecting the light which has traveled to it from the Sun. Since the intensity of light will decrease over distance, one can imagine that by the time it travels 93 million miles from the Sun to the Moon and then is reflected another 250,000 miles to the Earth, the light is not going to be as intense as if it had just traveled from the Sun to the Earth. So, the Moon will be very bright as the Earth's closest reflective neighbor in space but not as bright as the Earth's closest emitting neighbor, the Sun, is.

Activity 6-5: Relative Dating, Moon Watch

Now that the students have observed the shape of the moon as we see it with the naked eye, they should be ready to take a closer look at the moon. With the knowledge of the origin of our closest neighbor above, students should be able to distinguish between various features of the moon. This activity will allow the students to see another world.

Questions to think about: Is it possible to identify particular craters when observing the moon with an optical aid? Could we find the landing places of the lunar probes?

Materials: Map and model of the moon; telescope or binoculars.

- 1. Students observe the moon through a telescope or binoculars carefully to observe and become familiar with its topography.
- 2. Students may examine the map of the moon and moon globe and use the key to identify some craters, mare, and the lunar probe landings (numbers with asterisks). How did the features get their names? What names might they choose for these lunar landmarks? Where might the name Apollo have come from? What might they name a lunar space ship?
- 3. The students might view the moon again. How could they watch a sunrise on the moon such as Galileo did with his first telescope? Are they able to find the mare and craters after studying the map and globe? Watch the moon again and observe the pattern on the landscape. Can students predict if the topography will change? Can the layering of craters on craters and the placement of the mare give studetns an idea of the chronological history of the moon's bombardment and volcanic era?
- 4. Optional: Sketch the moon during observation.

Discussion:

Share pictures and observations. What was it like actually observing the Moon? Was it possible to identify major landmarks? If sketched, was it possible to record all the details? Compare sketches with the map. What time is it for someone living on the middle of the moon during full moon? What time is it on Earth? Can there really be mountains on the moon?

Topic 3: Tides

These activities are most appropriate for students who have had many direct experiences viewing the moon's phases and observing tidal actions.

Anything in the universe which has mass has gravity associated with it. Gravity is difficult to comprehend, save that it is a characteristic of mass, an effect of being massive. It is a force which allows one piece of mass to be aware of any other piece of mass anywhere else in the universe. The awareness comes in the form of a gravitational pull, whereby masses will be attracted to each other and either come together, orbit, or warp each other.

Large bodies of mass already in orbit around another mass will be warped by their proximity to it. The moon, for example, is in orbit around the Earth. Because the Earth is so much more massive than it is, the Earth has warped the moon such that it cannot spin on its axis very fast. The moon's near face is stretched towards the Earth, making it closer to the Earth than it should be. This causes the spin of the moon to slow down such that that face can always point towards the Earth.

This "tidal bulging" can also be seen on the Earth. However, since water is easier to warp than rock, and 75% of the Earth's surface is water, we see the tidal bulging affect in the sloshing of water on the Earth. Thus, the face of the Earth pointing towards the moon at any time will be slightly pulled towards it, or the water will pile up there.

The opposite side of the Earth from the moon also has a tidal bulge. Recall how gravity works: it is dependent upon the masses of the objects and their distance from each other. The side of the Earth farthest from the Moon is dragged less than the center of the Earth, allowing it to be essentially spinning a bit faster. The increase in centripetal force (that outward flinging force like a ball spun around one's head faster and faster) causes the material of the far side, mostly water, to bulge farther out. Thus, two tidal bulges. As the solid Earth rotates past the pull of the moon, different places have different tides at different times.

The Earth tides are also affected by the Sun, obviously, because the Earth is in orbit around the Sun. When the Earth, moon and Sun are in line twice a month at new and full moons, the gravitational pull on the Earth is increased, and tides are higher than at any other times. Conversely, any low tides are at their lowest. These are called spring tides.

When the sun and the moon are at 90 degrees or right angles to the earth (the quarter moons), the gravitational pull of the sun and moon are competing. At these times, the high tides do not rise very high and the low tides do not fall very much. These are called neap tides.

Activity 6-6: Tide Watch

The national newspapers will often have a section nestled somewhere in the weather about the tide times, the sunrise/sunset times, and the phase of the moon. It is to this section in a favorite national paper that this activity will go.

Materials: National newspaper, scissors, glue, paper, pencils.

- 1. Students (or the class) should collect a month's worth of the tidal report sections of the newspaper and glue each day's report to the upper left of a single sheet of paper.
- 2. For everyday of that month, observe which phase of the Moon was happening. If you can't do this, often the tidal report will tell you, or you can look it up in an almanac or online.
- 3. On the rest of the paper, students should be able to draw the corresponding phase of the moon with respect to the Earth, referring to the drawing in the previous activities with how to draw different phases. In other words, if the phase of the moon is first quarter, then the drawing would have the moon drawn directly to the left of the Earth with the Sun directly above the Earth. For each day, this kind of diagram should be drawn according to whatever phase the report describes for that date.
- 3. Comparing the heights of the tides and the phase of the moon, can a

correlation be found? When is noon in the diagram? 6 P.M.? Can a graph be made of height versus phase?

Discussion

The height of the tides of the day do depend on the phase of the moon. Why is this? What is the relationship between the heights of the first and second tides of the day? Is it obvious now why there are two tides? If you live in Boston, and the tide is highest at noon during new moon, does this make sense in terms of how the Moon and Earth pull on one another and where Boston is at noon? Drawing and drawing the Earth-Moon-Sun diagrams is very necessary, or else better yet, use a 3-D model with playground balls to understand this relationship.

Related Sites

Comments?

Contents | 1 2 3 4 5 Back to Top | Home

Here are some sites around the World Wide Web which pertain to topics discussed throughout this book. Although each chapter has its own set of links, this page offers the complete collection, with additional sites for those interested in general astronomy, amateur astronomy, professional astronomical institutions, and astronomy news.

1 2 3 4 5 6

General Astronomy Links

Sky & Telescope's vast collection of astronomy sites

A list of astronomy sites

National Aeronautics and Space Administration

National Air and Space Museum

Center for Astrophysics

Space Telescope Science Institute

Boston Museum of Science

Women in Science and Technology

NASA's Women in Science with student chat line

1

- Excellent live cameras across the Web and world
- Current Earth view from different angles
- Balinese Shadow Puppetry
- A page dedicated to sundial links across the Web
- The constellations page

2

- Photos of the four seasons
- Seasons and the Greenhouse Effect
- Most recent values for the global temperatures for different months
- A national organization sponsoring seasonal environmental projects for children

---

3

- Information on historical calendars
- Timekeeping devices
- Make your own sundial!
- A page dedicated to sundial links

4

- Generate a map of anywhere in the United States
- Zoom in on a map of the World
- Mount Wilson Observatory Star Map generator
- Constellations
- Mount Wilson Observatory Constellation Quiz
- Constellation Mythology

5

- The Nine Planets
- The Solar System
- Comprehensive lists of planet facts
- Up to date representation of the solar system
- Ringed planets
- Shoemaker/Levy-9 impact with Jupiter
- NASA`s solar system exploration site
- The Voyager Spacecraft
- The Galileo Spacecraft
- The Magellan Spacecraft
- Spacecraft Images

- New planet around 51 Pegasus
- Comets and meteor showers
- The Search for Extraterrestrial Intelligence

6

- Overview of the moon
- About the moon
- Royal Greenwich Observatory pamphlet about the moon
- Moon phases
- See the present phase of the moon
- Moon photos
- NASA lunar exploration
- The Apollo moon missions
- Clementine
- The moon in science fiction stories

Contents | 1 2 3 4 5 6 | Home

Please send any comments you have to the Everyday Classroom Tools project:

ect@head-cfa.harvard.edu

Press the back arrow to return to where you were or select one of the following:

Contents | 1 2 3 4 5 6 | Home

An inquiry-based science curriculum for kindergarten through sixth grade

Introduction for Teachers and Parents

The Keys to Inquiry

The Threads of Inquiry

About Our Team

Related Resources

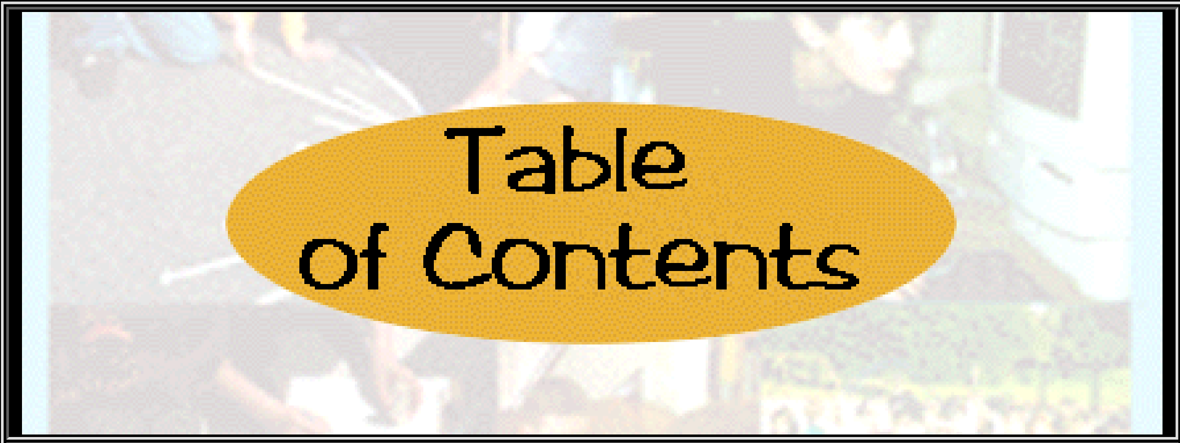
EYES ON THE SKY, FEET ON THE GROUND
HANDS ON ASTRONOMY ACTIVITIES FOR KIDS

EYES ON THE SKY, FEET ON THE GROUND

Additional astronomy activities for grades 2-6

Brought to you by the Smithsonian Astrophysical Observatory
Sponsored by NASA's Learning Technologies Project

CHOOSE This site is best viewed with Netscape Communicator.



Open your eyes, get up off your chair. There's so much to do in the sunlight.
The Monkees

Welcome to the Everyday Classroom Tools web site!

For the past three years, Smithsonian Astrophysical Observatory has worked with elementary schools in Massachusetts to develop an integrated, inquiry-inspiring curriculum framework that brings science and the Internet into the everyday life of the elementary classroom. Our goal has been to infuse the Spirit of Inquiry into every school subject, so that students and teachers can approach learning as a life-long exploration of the world around us.

The result of our efforts is embodied in the "Threads of Inquiry: Observing the World Around Us", a series of ten hands-on, minds-on investigations that focus on the changing seasons and other aspects of our everyday experience. Developed according to the National Science Education Standards, the Threads can guide you and your class towards a practical and enthusiastic understanding of scientific inquiry.

Our investigations have been tested and evaluated and evolved for more than three years by a team of teachers and scientists in Massachusetts elementary schools. Now they are freely available online to you, along with an introduction to inquiry in education and related educational resources (especially connections to folklore).

This work has been supported by the NASA Learning Technologies Project. For more information about LTP, please visit their Web site.

When you see the symbol on the right, , it means there is an accompanying Adobe Acrobat document (in "pdf" format) you can view and print out. The pdf files are designed so that you can bind them into a hardcopy format which includes page numbers. (The files for download are: Title and Contents Section, The Threads of Inquiry, The Keys to Inquiry, and Folklore Resources, Assessment Strategies, and Bibliography and Journal Form. Otherwise, you can access individual pdf files as listed below and within the WWW documents or view the resources as WWW documents without the need to download anything.) To view the pdf documents, you will need to get Adobe Acrobat Reader, a free software program which is easy to install and simple to use. If you already have Acrobat Reader, then it will launch automatically when you click on any of those symbols following a document title.

Introduction for Teachers and Parents

- Observing the World Around Us — Download
- Roles Within the Threads of Inquiry — Download

The Keys to Inquiry

- Section I: Inquiry Learning and Learning from One's Experience
- Section II: Big Messages to Communicate

Download

The Threads of Inquiry

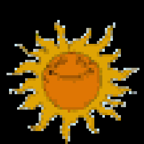
To Seek or Not to Seek?

- Introduction

Resources
Kindergarten - Second Grade
Second Grade - Fourth Grade
Fourth Grade - Sixth Grade
Assessment Strategy Adobe Acrobat file

Download

Hello, Sun!

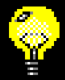


- Introduction

Resources
Kindergarten - Second Grade
Second Grade - Fourth Grade
Fourth Grade - Sixth Grade
Assessment Strategy Adobe Acrobat file

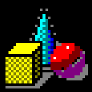
Download

You Light Up My Life

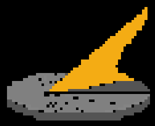


Me and My Shadow

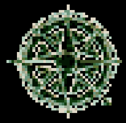
Guess My Shape



This is a Stickup!



Latitudes and Attitudes

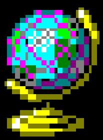


Time Warp

- Introduction
  - Resources
  - Kindergarten - Second Grade
  - Second Grade - Fourth Grade
  - Fourth Grade - Sixth Grade
  - Assessment Strategy

Adobe Acrobat file Download

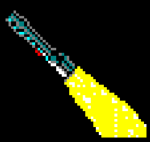
Tilt-A-World



- Introduction
  - Resources
  - Kindergarten - Second Grade
  - Second Grade - Fourth Grade
  - Fourth Grade - Sixth Grade
  - Assessment Strategy

Adobe Acrobat file Download

Through Thick and Thin



- Introduction
  - Resources
  - Kindergarten - Second Grade
  - Second Grade - Fourth Grade
  - Fourth Grade - Sixth Grade
  - Assessment Strategy

Adobe Acrobat file Download

Assessment Strategies

- A collection of ten assessment handouts, one for each Thread

Download

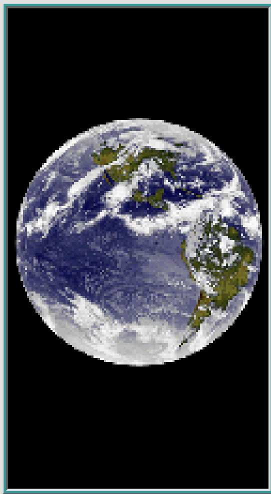
Folklore Materials

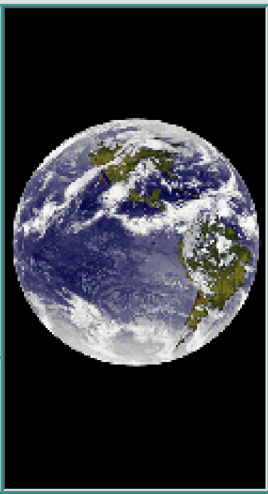
Download

- Scandinavian Daymarks — Download
- Word Lore — Download
- The Story of Gylfi — Download

Made with Macintosh

Everyday Classroom Tools Home Page





Equipped with his five senses, man explores the universe around him, and calls the adventure "science". -- Edwin Powell Hubble

Our everyday experience of the world around us is an invitation to question and explore and wonder:

During the day, we see a bright sphere called the Sun move across the sky. Its path is fairly regular from day to day, but changes gradually during the 365-day seasonal cycle. Why doesn't the Sun always rise in the same place each day? Where does it go at night? How does its light cast shadows on our world?

We experience the alternation of daylight (day) and darkness (night). Clocks show us that the total time needed to complete one day and one night always is 24 hours, but the proportion of each varies for different 24-hour periods. Also, we can see that the Earth never is completely light or dark at one time. How can it be noon in Boston, 5 PM in London, and 9 AM in San Francisco at the same time? Who has the right time?

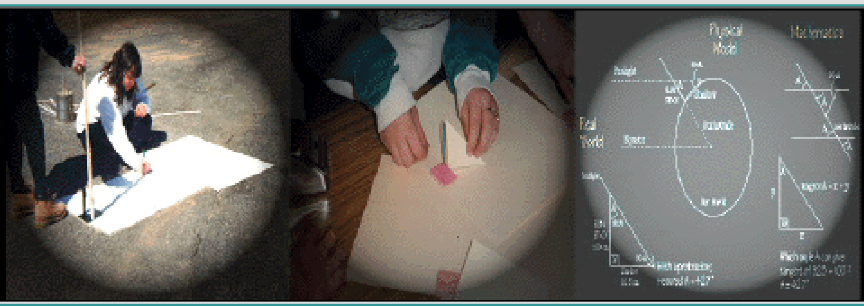
Much of the Earth's population experiences a repeating pattern of temperature and weather changes over a 365-day period. Weather goes from generally cool days (spring) to hot days (summer) to cool again (fall) and then to cold (winter) and back to cool. These seasonal changes affect animal and plant life dramatically. They are of varying duration and varying character at different locations on the Earth. How can we have summer in the USA and winter in Australia at the same time, if they both turn toward the Sun once a day?

Mankind has wondered about these and other aspects of our ordinary experience for millennia. For generations, people just like us have observed and pondered and guessed about the world we live in. They have constructed "models" to explain the phenomena around us and have refined and changed and discarded these explanations based on further observations and reflections. Much of our current understanding is built upon the inspiration of observers and inquirers going back before Plato (427-347 BC); we owe much to the inspired work of Copernicus (1473-1543), Kepler (1571-1630), and Newton (1642-1727).

Today we know that the Earth is a mostly solid sphere that turns on its axis once every 24 hours. The Earth revolves around the Sun, a very large and very hot sphere of gas situated millions of miles away from us. One such revolution takes approximately 365 days. The Earth is tilted on its axis of rotation with respect to the Sun, and this tilt, coupled with the Earth's movement around the Sun, causes the alternation of our seasons. The Moon, in turn, is a smaller solid sphere that revolves around the Earth about every 28 days. It reflects the light of the Sun and shows us its "phases", depending upon the relative position of the Sun, Earth, and Moon.

Although these and other modern scientific explanations can become complicated and even can run counter to our intuition, they really are rooted in the everyday experience of people who wondered about the world around them. This is the essence of science: to be explorers of our own world, to engage ourselves in the Spirit of Inquiry by observing what is around us, asking questions and looking for answers that are consistent with our experience. And although we cannot hope to reconstruct all scientific understanding from first principles, each one of us can be a scientist with regard to our own experience. We can observe the world and wonder about it and see how our observations and deductions mesh with scientific knowledge.

For example, everyone "knows" that the seasons are "caused" by a tilted Earth revolving around the Sun. But what does this really mean? How can we know that the Earth is tilted? How can we know it revolves around the Sun? And what do the Earth's revolution and tilt really have to do with seasons, anyway? Can we find something in our experience that lends credence to these notions, so that we can deeply understand the facts and not just believe them because we are *told* that they are so?



The boy or girl who leaves school without some knowledge of science, some appreciation of what science has done for this world of ours, who does not wish to learn more, who does not desire to be a scientist, has failed dismally to get an education, has failed to enable himself or herself to live a full life, has put aside a great opportunity.
-- Pulvermacher and Vosburgh in **The World About Us** 1930

An Inquiry-Based Classroom

In our Everyday Classroom Tools project, we are seeking to immerse elementary school students in the Spirit of Inquiry, to help them begin to observe and learn from their experience. Our project is rooted in a connected, progressive set of observations and questions which we can use to explore the world around us. We look for answers to these questions that are consistent with our experience and with the accumulated knowledge of humankind. At all times we try to keep ourselves rooted in our own observations. We strive to maintain a connection between what we are exploring now, what we have learned in the past, and what we hope to understand in the future. What the Everyday Classroom Tools project wishes to stress is that before there were encyclopedias, there were authors, and before there were scientific facts, there were curious people trying to explain the world around them.

There are more questions we could ask ourselves about the world around us than we present here, because for every observation, there can be millions more questions we find and want answered. Hopefully, those questions will be ones which appear in our classrooms from eager and inquisitive students. The first question we asked ourselves when we embarked on this project was "Where do we start to build a curriculum based on these principles?"

Our efforts to date have taken the form of the **Threads of Inquiry**, a series of free-flowing dialogues about inquiry-inspiring investigations that maintain a solid connection with our experiences and with one another. The Threads are meant to be a jumping-off point for teachers, suggesting an approach to the Spirit of Inquiry without dictating too much of the content. Of course, they are backed by more formal on-line activities, and they also operate in accordance with contemporary concepts in science education for elementary students (such as the National Science Education Standards).

We understand this classroom method may be new for some teachers, and so we provide an additional text guide to using inquiry in the elementary school classroom. Please read the article entitled **The Keys to Inquiry**, an in-depth look at the practices of constructivism and inquiry in the elementary school classroom. This piece was written by Tina Grotzer, a research associate of Project Zero at the Harvard Graduate School of Education. Her work details the research regarding cognitive development of children, offering techniques for bringing out the best in your students' question asking and answering skills, observation and recording abilities, while its text provides key classroom examples for different grade levels.

The major theme explored in this curriculum is the pattern of change on planet Earth as it relates to the Sun. So many different subjects can be usefully mapped to this set of investigations of the world around us that it gives educators an opportunity to build upon an inquiry framework with their own related and connected ideas from different disciplines.

Here is a look at each of the different investigations and its main aims:

To Seek or Not to Seek?	**Skills**: Observing, collecting, question asking, examination of data, recording of data, changes, patterns, science as a tool. **Topics**: Life cycles.
Hello, Sun!	**New Skills**: Measuring, modeling, predicting, theory building. **Topics**: Sun's path in the sky, Sun's height in the sky, Sun-Earth motions, length of day, degrees.
You Light Up My Life	**New Skills**: Manipulating objects, experimenting with theories. **Topics**: Nature of light and shadows.
Me and My Shadow	**New Skills**: Using our bodies as tools, thinking about information in different ways, believing a theory by testing it. **Topics**: Nature of sunlight as straight rays.
Guess My Shape	**New Skills**: Thinking in more dimensions, bringing our experiences from outside back into the classroom. **Topics**: Nature of three dimensional space, geometry of solids, nature of shadows hitting three dimensional objects.
This is a Stickup!	**New Skills**: Careful data collection, working with real number data, drawing conclusions from our own data, making models of our experiment. **Topics**: Speed of Sun's path across the sky, triangles and angles, degrees on the sky.
Latitudes and Attitudes	**New Skills**: Using three different sound methods for finding an answer, combining number data and recent experience to draw conclusions. **Topics**: Latitude and longitude, Calculating our latitude, angles, triangles, degrees on the sky.
Time Warp	**New Skills**: telling time, building tools to tell time, thinking about time and position on the world. **Topics**: Time and subtraction of times, time zones, Sun's path across the sky with relation to relative time, degrees and angles.
Tilt-A-World	**New Skills**: Combining data with observations, believeing what we are experiencing by testing the data in terms of math and models. **Topics**: Value of the Earth's tilt, orbit of the Earth around the Sun, seasons.
Through Thick and Thin	**New Skills**: Taking everything we have learned about shape, the movement of the Sun, the tilt of the Earth, the passage of time, and the nature of light to believe in the changes we have seen all year. **Topics**: Graphing, calculating area, temperature.

The Keys to Inquiry
Introduction

Everyday Classroom Tools

"We learn best when we learn from our own experiences."

"Children need to be active learners, seeking answers to questions that they care about."

"Science should be hands-on and minds-on so that children make sense of what they experience."

The goal of the Everyday Classroom Tools Project is to provide opportunities for students to learn that inquiry and their own experiences can help them achieve a deeper understanding of their world. It aims to foster a spirit of inquiry in all students. These goals promise to help students grow into life-long learners who are curious and set out to seek and achieve deep understanding of the world that they live in.

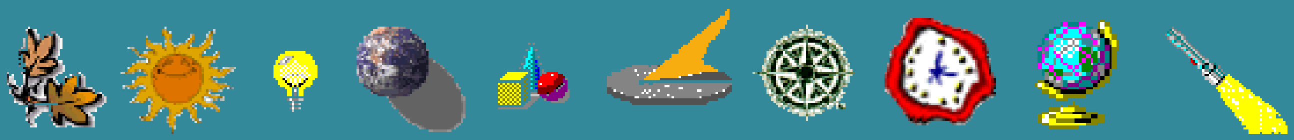
This document has two sections. The first is a series of six brief essays to address the kinds of questions teachers often have about inquiry based learning and learning from one's experience. The intent is to place the central concepts of The Everyday Classroom Tools Project in context--to provide a sense of the variety of ways that the concepts have been thought about as well as how they are interpreted in this project. These essays are written for a teacher audience. The second section is a set of big ideas, questions, and attitudes that are central to the project. This section is written with the expectation that teachers will communicate these messages to their students.

Author: Tina Grotzer
Project Zero
Harvard Graduate School of Education

GO TO: **Section I** **Section II**

ECT Home Page | **Introduction to the Threads of Inquiry** | **Contents of the ECT Pages**

Next



Welcome to the Everyday Classroom Tools curriculum, Observing the World Around Us, which takes its form in The Threads of Inquiry. Before you begin, you will probably like to know how to use the Threads, what they will look like, and what resources are contained in their text. Please read on to find answers to these questions and more...

What does a typical curriculum Thread look like?

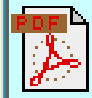
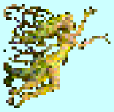
Title Well, first there is a name for each Thread, one which we hope will amuse as well as inform you about the topic it covers. Alongside this is a drawing or photograph showing others experiencing this Thread. Accompanying each Thread is a small icon which represents it. Above, here, you can see all ten of them.

Purpose: The purpose is three-fold. First, it provides an understanding for you of how the Thread fits into the overall scheme of the curriculum. It pinpoints the scientific motivations

You will need: A section on materials needed by each Investigation appears in a grey box on the right side of the introduction page to each Thread. This section lists the different materials you will need to explore this Thread. This box also lets you know the sort of time requirement you will need to investigate this topic thoroughly. Things such as: Does this require a sunny day? Repeated for this Thread, or why it is important for students to understand what is happening around them with regards to the Thread topic. Next, this section informs you of how this Thread fits into your classroom with regards to the National Science Education Standards. Finally, this section of the introduction suggests how this Thread can help you introduce vocabulary words which are useful for your discussions and which may be mentioned in NSES documents as useful for the science curriculum.

observations on an hourly, daily, or monthly scale? What is the materials-gathering time? Computer time? This section describes anything we can think of which will take time in or out of your classroom. This helps you to get a better grasp on the events and fit this curriculum into your own.

Teacher Background: The background information is *not intended for the student*. It is meant to provide you the teacher with data about the topic you are about to explore. Although the Threads are not designed to be vessels of content, it is often necessary for an educator to have a fair grasp of the geometry, physics, astronomy, or other disciplines relevant to the experience before feeling comfortable about facilitating the Thread in their classroom. We hope that this section will help you respond to questions from students in discussion with another question of your own geared to stimulate deeper understanding of the basics of the problem. We also would like this section to aid you in designing your own experiences for the students based on how you and they understand the content. With the information in the Teacher Background section, we hope you will be able to seek related themes and connected activities for your class, and in so doing, truly personalize this Thread. The end of this background section offers suggested reading from books and web sites which may be of use to you and your most highly inquisitive students.

A button here leads you back to the Table of Contents Page. As you progress through the Threads, and additional button will link to the previous Thread you explored.	This section houses  a link to the latest version of the entire Thread in Adobe Acrobat format,  a suggested bibliography list,  folklore and mythology links  and WWW information sites related to this Thread.	A button here sends you to the Thread for your grade level. They are color coded and labeled.

Grade Level - Grade Level Each Thread is divided into sections based on three grade level divisions: K-2, 2-4, and 4-6.

Developmental Issues: Sections on developmental motivation and capacity describe in more detail how certain concepts in this Thread can enhance your students' learning experience by challenging, encouraging, and/or supporting their cognitive skills.

The Threads are divided into the grades kindergarten through second grade, second through fourth grade, and then fourth through sixth grade. This is not a rigid delimitation. Teachers of students on the borders of these groups, (i.e. second and fourth grades), should read both sections of the Trheads which apply to them. Decide, based on your knowledge of your classroom, which version of the Thread you feel is more appropriate for your students, or you may wish to integrate the two versions. **Inquiry Introduction:** The Thread then begins with some introductory discussion questions on this topic to get the inquiry ball rolling. The questions suggested in this portion of the Thread will guide your class along learning of this topic and its set of experiences.

Inquiry Investigation: Then the Thread sets into full swing, where students explore the topic through observation and analysis of their own experiences. The teacher is there as a guide to their discoveries and to move the students through the different arenas of learning. The text of this section is the most lengthy, as it offers questions, suggestions, and hands-on activities to bring students towards a deeper understanding of what they are exploring.

The use of student journals is highly encouranged for the upper grades, and places where we feel a journal entry should be made during the investigation have been noted in the text.

The Everyday Classroom Tools project utilizes the theories of inquiry-based learning through constructivismm which bases students' learning on past experiences and theory building. The National Science Education Standards also stress that the inquiry method be the backbone of science teaching for educational reform. Therefore, the text reads very much like a dialog between teachers and students which emulates an inquiry-based classroom. In the inquiry section, any text you see in this font is directed towards the teacher. The text in this font is in the form of specific direction, example of how students might respond to certain queries, or suggestions for further inquiry or projects. Think of this text as the author-teacher dialog, whereas this text is the teacher-student dialog.

A button here leads you back to the Introduction of this Thread. As you progress through the Threads, an additional button will link to the Table of Contents.	This section houses links to the Inquiry in the Classroom companion document which provides some helpful strategies and suggestions for your inquiry experience. Here in this box is also a button which links to a set of teacher journals with suggestions (for your students' grade level) for related activities (art, writing, and field trips, for example). There is also a button which will link to an online form where you can contribute your own comments to the journal file for this particular Thread.	A button here sends you to the next Thread for your grade level. Buttons are color coded and labeled.

Proceed now to the first of ten Threads, called **To Seek or Not to Seek?**

Contents Page | Everyday Classroom Tools Home Page

Tania Ruiz is an astronomer at the Harvard-Smithsonian Center for Astrophysics. Her work at the CfA includes astronomy curriculum development for elementary schools, Internet-based hands-on astronomy activities for K-8, and science-oriented public outreach programs. She has logged over a thousand hours in Massachusetts elementary school classrooms implementing science curricular materials and giving presentations about recent astronomical events. When not engaged in science education and outreach, Tania works on the high energy astrophysics of clusters of galaxies and irregular galaxies, telescope operation and observation, science fiction writing, and archaeoastronomy.

Eric Mandel is a computer scientist from the Harvard-Smithsonian Center for Astrophysics. He specializes in image manipulation software and research development as well as being a father. This combination of skills is what brought him to conceive of this project, as he saw a need for younger students to discover the power of observation and scientific inquiry. Eric has developed several lessons and activities for elementary schools, combining inquiry with hands-on experiences. It is this spirit which fuels the Threads.

Christine Jones is a senior astrophysicist at the Harvard-Smithsonian Center for Astrophysics. She specializes in research regarding high-energy activity in clusters of galaxies using state-of-the-art X-ray telescopes. Dr. Jones spearheads many educational projects at the Center and has spent countless hours in local public schools.

Tina Grotzer is a Research Associate at Project Zero and a member of the Cognitive Skills Group. She received her Ed.D. in 1993 and Ed.M. in 1985 from Harvard University and her A.B. in Developmental Psychology from Vassar College in 1981. Tina has studied cognitive development both as a teacher and as a researcher. Her research focuses on topics at the intersection of cognition, development, and educational practice, such as the learnability of intelligence and how to help children grow to be effective thinkers. She is particularly interested in children's understanding of complex causalities and the development of systems concepts, and in how these understandings interact with math and science learning. Tina works with teachers in several school systems on an on-going basis, linking theory and practice such that they inform one another.

Carl Anderson is a graduate student at the Cambridge University in

England, studying in the department of Anglo-Saxon, Norse and Celtic. His degrees in both Folklore and Mythology, as well as his present graduate work in Scandinavian and English history, have helped to add a new dimension to this curriculum. Carl speaks and reads several languages, a fact which lead him to conceive of introducing the history of words as a fascinating related topic for the Threads of Inquiry. In his spare time, Carl writes fiction, performs in musical ensembles, and lectures on the finer points of J. R. R. Tolkien's collected works.

We worked extensively with teachers from elementary schools in Massachusetts...

The John A. Bishop School Arlington, MA	The Petersham Center School Petersham, MA
Linda Cohn -- ACE **Sharon Edgar -- Kindergarten** **Betsy Hale -- 5th Grade** **Betty Mottola -- 2nd Grade** **Liz Pedrini -- 1st Grade** **Judith Pooley -- 1st Grade** **Jim Stanger -- 4th Grade** **Caroline Thom -- 3rd Grade** **Jeanne Wall -- 3rd Grade** **Sara Waters -- 3rd Grade**	**Glenede Albertine -- 4th Grade** **Sue Andriski -- 1st Grade** **Robert Buron -- 6th Grade** **Colleen Grady -- 3rd Grade** **Linda Kirousis -- 2nd Grade** **Melanie Palotta -- Kindergarten** **Helen Simms -- 5th Grade**

A special thanks goes to Steve Herzberg for his time and advice and to Sam Palmer for methods and ideas on presenting the background astronomy information.

Contents Page | Everyday Classroom Tools Home Page

This is a large document containing all of the resources we provided individually for each Thread.

To Seek or Not to Seek?	Hello, Sun!	You Light up my Life	Me and My Shadow	Guess My Shape
This is a Stickup!	Latitudes and Attitudes	Time Warp	Tilt-A-World	Through Thick and Thin

To Seek or Not to Seek?

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

About Inquiry: Questioning, Scientific Method, Puzzles

- **You Can: Questions List** - Beakman and Yax's collection of questions and answers. Good fun.
- **Newton's Apple** - This is a great site filled with short and quick experiments which demonstrate some of the excitement and fun of science. This site might encourage more participation by students, as it promotes questions and hands-on answers.
- **Insects Lessons** - Teaching about insects to grades 2 and 3. Since many of your students will be mentioning insects during their observation, this mini-unit might be lots of fun for them.
- **Inquiry Almanack** - Packed full of interesting topics related to inquiry-inspiring uses of literature, science, math, and art in the classroom.
- **Why do leaves change color?** - Questions and complete answers for kids, including information, activities, and graphics.
- **Science Fair Ideas** - A well made list of questions to ask students to pique their curiosity enough to do their own projects.
- **Botany Projects** - Some really fun projects involving the growing of seeds under different conditions.
- **Dr. Bob's Home Page** - A page dedicated to the wonders of science. Dr. Bob says it best: "Science is the observation, investigation, and explanation of the things that happen around us."
- **Thinking Fountain Activity Cards** - Science Museum of Minnesota's inquiry-based fun activities you can do at home or in the classroom with few materials.
- **Links to Earth/Sun Sites** - Here is a site from an online 8th grade lesson plans. This page of the lessons is just for related links around the web. It is a good list on subjects such as the seasons, latitude and longitude, etc.
- **The Natural Perspective** - Fantastic photos of different kinds of animals, plants, fungus and insects which inhabit the world.

The Natural World and Descriptions of Seasons

- **Fall Colors** - A beautiful site with photos and activities about the coming of fall and all of the colors. Includes articles for identifying trees and many other facts. This is a great starting point for observing autumn.
- **The Garden in Autumn: The Neglected Season** - An article about gardening in autumn.
- **Vermont Weathervane: The Time of Falling Leaves** - An article about the coming of autumn in Vermont, USA.
- **Country Chronicle: Autumn (Melancholy Season)** - An article about the onset of autumn

in the American mid-West.

- **Lanark County: Fall** - An article about the onset of autumn in Lanark County, Ontario, Canada.
- **County Cavan Country Diary: 10 Nov 1996** - About the coming of autumn in County Cavan, central Ireland.
- **Walton Hall Nature Trail: What's on September/October** - A description of sights along a nature trail in England's Buckinghamshire.
- **Iwate's Four Seasons: Autumn** - Description, information, and images concerned with autumn in Iwate, Japan.
- **South Korea's Beautiful Autumns** - Brief information intended for tourists about seeing autumn leaf colors in South Korea.
- **Farewell to Spring** - A nice description, in terms of plants and animals, of the coming of summer in the San Francisco Bay area. -

---

Children's  Books

---

- **On the Day You Were Born** by Debra Frasier.Trumpet Club, 1991. A wonderful description of the world and its everyday patterns. At the end, there is a nice section which tells more about the science involved.
- **Possum's Harvest Moon** by Anne Hunter. Houghton Mifflin, 1996.
- **Spider and the Sky God: An Akan legend** by Deborah Newton Chocolate. Troll, 1993. An Akan legend about how spider and his clever wife fulfill a quest.
- **No Moon, No Milk!** by Chris Babcock. Scholastic, 1993. A funny story about a stubborn cow who won't give milk until she's been to the moon. Beware the confusing cover art showing the moon as a sliver on whose edge you can sit.
- **Draw Me a Star** by Eric Carle. Scholastic, 1992. This is about an artist who begins by drawing a star and then encourages us to draw everything we see around us.
- **Owl Moon** by Jane Yolen. Philomel, 1987.
- **Promise to the Sun** by Tolowa Mollel. Little, 1992.
- **Mister who Wanted the Sun** by Jurg Obrest. Atheneum, 1984.

Folklore  Mythology

---

Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?
- **The Story of Gylfi** - Carl has translated portions of the **Prose Edda** which include the story of a king who goes to the gods in search of answers about the nature of the world.

Stories about Using Observation

- **The Wise Little Girl** - A tale about being wise and clever and thinking on one's own to solve problems and riddles.
- **Native American Lore Index** - This site has been named a Discovery Channel Internet resource, and is packed full of all of the Native American stories you can think of. Amazing.
- **Tales of Wonder** - A collection of folk tales from around the world. Easy to print out -- few images.

Lore Surrounding the Earth and the Coming of Autumn

- **North caroline Weather Lore** - Folklore about predicting the autumn weather from watching the world around us.
- **Star Charts and Moon Stations** - An advanced discussion about the Japanese Folklore surrounding the stars and the seasons. Lots of diagrams and pictures!
- **The Japanese Calendar** - An interesting and helpful piece on the Japanese calendar, including the animals and stories related to each Year. There are drawings and diagrams of the calendar and Japanese characters associated with it.
- **St. Valentine's Day** - A myth about Mother Nature and the Birds on St. Valentine's Day.
- **Guide to Wild Foods** - A great site offering photos of and complete characteristics of foods you can pick from the forest or your backyard.
- **Tree Myths and Folklore** - A nice article about all of the cultural aspects of trees, including the myths, beliefs, and qualities of each species of tree.
- **The Lore of Trees** - An intense resource of the qualities and characteristics of trees, as well as their sacred connotations.

Autumn Holidays

(For more on holidays, see the Through Thick and Thin Resources Page)

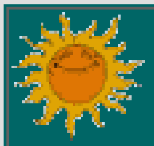
Halloween, or Samhain (pronouced Sow-wun)

- **The Origins of Halloween** - A fairly rational discussion of Halloween's origins in the ancient Celtic New Year festival, Samhain. It over-generalizes somewhat, but is fairly sound. Useful footnotes and bibliography.
- **Dalriada Celtic Heritage Trust: Samhain on Three Levels** - A brief discussion of Samhain, the ancient Celtic New Year festival. It concentrates on an Irish/Scottish angle and indulges slightly in some semi-mystical specualtion.
- **Irish/Celtic Seasonal Celebrations: Samhain** - A long list of customs associated with holidays deriving from Samhain, the ancient Celtic New Year which took place around 1 November. Unfortunately, there are no references to where or when the various customs listed were practiced. Part of a page dealing with several Celtic festivals.
- **Samhain** - Some information on Halloween and its origin in Samhain, the ancient Celtic New Year festival. Generalizes a little.
- **Halloween on the Net (and Day of the Dead): The Story** - Aimed at kids, this site explains the origin of Halloween in the the ancient Celtic New Year festival, Samhain, and mentions the various other holidays which derive from the same source. It does not seem to have been written by someone familiar with Celtic culture, and presents some rather speculative and overgeneralized descriptions. On the whole it is not too bad though.

Harvest and Light Festivals

- **Thanksgiving Resources from the Bellingham Schools** - An excellent page of resources on Thanksgiving, a major harvest festival in the United States (the like-named holiday in Canada takes place slightly later in the year). This site was developed by a school, and so is great for kids. A variety of resources, including maps, historical documents, student and teacher resources.
- **Thanksgiving on the Web** - Another site for kids dealing with Thanksgiving, a major harvest festival in the United States. Some resources, games, and links. Beware of the annoying music which this site automatically plays.
- **Laksmi Divali: The Festival of Lights** - A brief discussion of a Hindu festival honoring Laksmi, a goddess of fortune. The festival takes place in mid- to late October and is associated with light and the harvest.
- **The Fall Holidays on the Web** - A pages with links to sites discussing the various Jewish autumn holidays, including the harvest festival Sukkot.
- **Sukkot: Kids** - Intended for kids, this page discusses the Jewish harvest festival Sukkot.
- **Festivals of Malaysia: Harvest Festival** - Very brief information on Malaysian harvest festivals.

To Seek or not to Seek? | Table of Contents | ECT Home Page



Hello, Sun!

Internet Sites | Children's Books | Folklore & Mythology

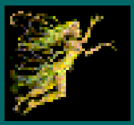
Internet  Sites

Science Behind It

- **Day and Night on the World Right Now** - A short list of the best sites on the web which provide live camera shots of places around the world. You can see who is having day or night right now.
- **K-3 Lessons on shadows** - Some science exercises related to the Sun, shadows, and time.
- **4-6 Lessons on Shadows** - - Some more advanced science exercises related to the Sun, shadows, and time.
- **Virtual Sun** - Cool movies and diagrams about the Sun.
- **Celestial Geometry** - Fairly advanced but interesting web-based geometry lectures on the Earth and the Sun.
- **Time** - A short discussion about angles, the Sun, and time.
- **Sighting Angular Size** - Project for 4-6 grades to gain an understanding of angular measurement and how it is used for things such as surveying and astronomy. The students will also develop an appreciation for the technology used in creating ancient and modern scientific instruments.

Children's  Books

- **Arrow to the Sun** by Gerald McDermott. Harper Collins, 1989. A Pueblo Indian tale about how Sun came to Earth.
- **The Grouchy Ladybug** by Eric Carle. Harper Collins,1986. A funny story about a ladybug who tries to pick fights with everything he sees. The artwork provides good visuals for both the arc of the Sun during the day, and size and scale of animals.
- **How the Sun was Brought Back to Sky** by Mirra Ginsburg. Scribners, 1961.
- **Sun's Up** by Teryl Evvremer. Crown, 1987.
- **Day the Sun Disappeared** by John Hamberger. Norton, 1964.
- **The Sun's Day** by Modrdicai Gerstein. Harper Collins, 1989.
- **Sun Up, Sun Down** by Gail Gibbons. Harcourt, 1983. A nice introduction to the Sun, but beware of an error regarding the length on one's shadow in summertime.
- **The Earth and Sky** A First Discovery Book. Scholastic Inc.
- **The Sun Dancer: World Myths and Legends II - Central America.** Simon and Schuster, Inc.
- **How Grandmother Spider Stole the Sun: Keepers of the Earth, Native American Stories** by Joseph Bruchac. Fulcrum, Inc., Colorado. 1989.
- **Why the Sun and the Moon Live in the Sky** by Elphinstone Dayrell. Scholastic, 1968. A cute African folktale about the friendship between Water and Sun and how this caused Sun and his wife Moon to move to the sky.

Folklore  Mythology

---

Carl's Lessons

- **Ancient Solar Time Keeping** - Carl's lessons on how to tell time using the Sun in the way of the old Norse farmers.
- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?
- **The Story of Gylfi** - Carl has translated portions of the **Prose Edda** which include the story of a king who goes to the gods in search of answers about the nature of the world.

Ancient Skylore

- **Nature Folklore and Customs** - A difficult to read site, however, it is packed with interesting tidbits about how people through history have considered the Sun, Moon, stars, rain, etc.
- **Chinese Moon Festivals and Lore** - A great site with information about customs related to the Moon.
- **Mythology** - A beautiful site about astronomical mythology. Includes sites for kids and teachers, and loads of stories. Probably the best first stop on the web for astronomy mythology.
- **Legends of Forever** - An extremely amazing site about Sun legends around the world. There are a few steps to go through to enter the site, but once in, it is worth it. You can click on any part of the world map and enter different cultures. Be prepared to have a screen full of windows, because this site is dynamic.
- **Solar Folklore** - A fabulous index of folklore, legends, and myths about the Sun. This site is part of a large Solar Home Page from Stanford University.
- **The Story of the MoonCoyote** - A modern myth about the origin of the Moon. This is in a set of stories of **Tanais the Fox** by Clive Grace.
- **Clytie** - A myth on the origin of Sun Flowers.

Hello, Sun! | Table of Contents | ECT Home Page

You Light Up My Life

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

Science Behind It

- **How Far Does Light Go?** - A wonderful site where the debate about the nature of light sits. Students must prepare arguments with evidence to support their theory about whether light travels on forever or if it stops after a while. Good fun!
- **Shadow and Light science activities** - A short list of activities for students about light and shadow designed by an undergraduate Education major in New Foundland.
- **What is Light and How Do We Explain It?** - A National Science Teachers Association lesson on the nature of light.
- **Projecting Shadows** - Fantastic interactive site about how to make shadows from the Light/Block/Shadow technique. Wonderful introduction to shadows! (The site is meant to explain how CAT scans work...)

Sunlight and Us

- **Sunlight and the Skin** - National Institutes of Health Consensus Development Conference Statement about sunlight and its effect on the skin.
- **The Energy Story: Solar Energy** - Aimed towards children, this is a short introduction about solar energy. Contains photos and pictures drawn by students.
- **Solar Thermal Energy** - This is a nice site which tells about solar energy.

Children's Books

- **The Shadow Book** by Bernice DeRegniers. Harcourt, 1960.
- **Shadows, Here, There, and Everywhere** by Ron Goor. Crowell, 1981.
- **Shadows and Reflections** by Tana Hoban. Greenwillow, 1990.
- **What Does the Sun Do?** by Jean Kenney. W. R. Scott, 1967.
- **Raven** by Gerald McDermott. Scholastic, 1993. The classic Native American tale of how light came to be on the world.
- **Sun Song** by Jean Marzollo. HarperCollins, 1995. A lovely description of the coming and passing of a day on a little farm.

Folklore Mythology

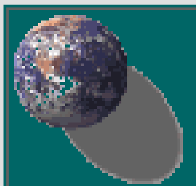
Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "light" come from, or what is the difference between "shade" and "shadow"?
- **The Story of Gylfi** - Carl has translated portions of the **Prose Edda** which include the story of a king who goes to the gods in search of answers about the nature of the world.

Folk Ways and Light

- **Myths and Legends: The Origin of Light** - Alaskan Inuit tale which explains where light came from. A Raven tale.
- **Moon gardening** - Folklore concerning the gardening of plants in moonlight. -

You Light Up My Life | Table of Contents | ECT Home Page



Me and My Shadow

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

Science Behind It

- **K-3 Lessons on shadows** - Some science exercises related to the Sun, shadows, and time.
- **4-6 Lessons on Shadows** - - Some more advanced science exercises related to the Sun, shadows, and time.
- **Seeing Shadows** - Some nice shadow photography and discussion. The photos do not show the position of the Sun. This site might be a good way of assessing students' understanding of shadow and positions.
- **Bill Nye the Science Guy- Episode: Earth's Seasons** - Information about the seasons as well as a project for watching your own shadow through the year.
- **Exploratorium: Colored Shadows** - A fun activity about making colored shadows.

Online Activities

- **Making Hand Shadows** - This is a fun site all about hand shadow making. It asks questions for further learning, and includes a literature connection to The Ugly Duckling.

Children's  Books

---

- **My Shadow** by Robert Lewis Stevenson. David R. Godine, 1989. This famous poem is set to life by vivid and clear illustrations.
- **Shadowville** by Michael Bartalos. ISBN 0-670-86161-8. A site about this book, with related activities.
- **Nothing Sticks Like a Shadow** by Ann Tompect. Houghton Mifflin, 1984.
- **Bear Shadow** by Frank Asch. Prentice Hall, 1985.
- **Me and My Shadow** by Arthur Dorros. Scholastic, 1990.
- **Mr. Wenk and His Shadow** by Dick Gackenback. Harper, 1983.
- **Shadow** by Marcia Brown. Macmillan Publishing, 1982. A very creepy African story about the nature and "lives" of shadows. May not be suitable for younger children.
- **Shadows are About** by Ann Whitford Paul. Scholastic, 1992. Very charming pictures and short descriptions about shadows all around.

Folklore Mythology

Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?
- **The Story of Gylfi** - Carl has translated portions of the **Prose Edda** which include the story of a king who goes to the gods in search of answers about the nature of the world.

Shadow Makers

- **Groundhog Day** - All about Groundhog Day with GREAT photos of Punxsatawney Phil!
- **Wiarton Willy** - The albino groundhog who is Canada's famous weather forecaster. Just like Punxsatawney Phil.
- **Chinese Shadow Puppets** - A lesson on Chinese shadow puppetry, with a history of the art and details on how to recreate it in your classroom. An example of real Balinese shadow puppets is **here**
- **KARAGOZ: Turkish Shadow Puppetry** - Very complete site about the characters and scenarios of this folk art.

Me and My Shadow | Table of Contents | ECT Home Page

Guess My Shape

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

Shapes and Math

- **Zini's Activities** - Some fun lessons on shapes and sizes with pages to print out for teachers to photocopy.
- **Shapes Around the World** - An Internet collaborative for teachers and students regarding the shapes of the world, simple and complex. To preview the project, there are pages to visit. However, to participate, there is FREE registration required. This looks like fun.
- **Bag It! Math Shapes Game** - A fun game for younger students to learn to differentiate between size and shape.
- **Geometry Unit** - Lessons about shapes, angles, and three dimensions. Nice photos of students doing these great activities.
- **Shapes Game** - A quick an easy set-up creates this fun game about naming shapes and also colors of objects.
- **A Fractals Lesson** - Fractals for Elementary School and Middle School math and art lessons.

Shapes and Art

- **Quilting with Children** - A great site about how to inspire designs and shapes from children.
- **Origami Crane** - Photos and instructions for making a Japanese crane in Origami. Very well presented and easy to follow.
- **Origami Jumping Frog** - Diagram for how to make an origami jumping frog.
- **Shapes Lesson** - Nice integrated lesson using Shel Silverstein's Shapes poem and artwork by the students.
- **OpticaI llusions** - Great archive of classic optical illusion drawings.

Children's  Books

---

- **Shel Silverstein's Shape Poem** - A very short poem about a day in the life of shapes.
- **Circles, Triangles and Squares** by Tana Hoban. New York: Macmillan Publishing Company, 1974. Tana Hoban's photos of shapes within our environment can spark interesting discoveries and discussions about shapes within shapes.
- **Taking a Walk** - A story about what we see when we walk around. It is told in both English and Spanish. With related activities.

- **Shapes, Shapes, Shapes** by Tana Hoban. New York: Greenwillow Books, 1986. Rounded and angular shapes are presented through photographs of familiar objects such as a chair, barrettes, and a manhole cover. Encourage your students to find shapes and shapes within shapes as in each picture.
- **The Paper Crane** by Molly Bang. New York: Greenwillow Books, 1985. A mysterious man enters a restaurant and pays for his dinner with a paper crane that magically comes alive and dances.
- **Origami in the Classroom Book I: Activities for Autumn through Christmas** by Chiyo Araki. Rutland, VT: Charles Tuttle, 1965.
- **Origami in the Classroom Book II: Activities for Winter through Summer** by Chiyo Araki. Rutland, VT: Charles Tuttle, 1965.
- **What Goes Around, Comes Around** by Richard McGuire. Viking, 1995. This is a story about a little brother who loses his sister's doll, and the trip the doll takes around the world. Only a round Earth allows her trip to be possible.
- **From Caterpillar to Butterfly** - A book about the life cycle of the butterfly. A good story to learn about shapes of creatures.

Folklore  Mythology

---

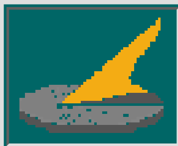
Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?

Shapes in Stories

- **UFO Folklore Center** - See photos of strange cigar shapes in the sky. Are these aliens or insects or what? What do the shapes look like?
- **Grandfather Tang's Story** - A page describing a great book about folklore and shapes.
- **Hofus the Stonecutter** - A story about changing shapes until discovering that our own shape is fine enough. A Japanese tale from the huge site called Realm of Myths, Legends, and Folklore.

Guess My Shape | Table of Contents | ECT Home Page



This is a Stickup!

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

Science Behind It

- **Angles Lesson** - A fun lesson for students about finding right angles.
- **Sun Angles** - Photos of the Sun's height during the year.
- **Shadows '97** - A site of ideas about using the Sun and sunsticks in more mathematical ways. Intended for older students, but useful for advanced elementary school students.

Sundials and Moondials

- **Sundial Activities** - A page of sundial activities including finding north, seasons, clock times.
- **Sundial Links** - A very long list of WWW sites related to sundials and other means of measuring time by the Sun.
- **Make your own SUNDIAL** - With your latitude, you can print out a sundial model to use at your school or home.
- **Moon Dials** - A discussion and drawings of how to make a moondial, or a moon-stick clock for your home.

Online Projects

- **Noon Project** - Here's information about how schools can join in calculations of the size of the Earth.
- **Shadow Project** - This is a sundial project done at Urbana High School. They have some interesting ideas and links here for learning about the sun clocks.

- **Shadows and Latitudes** - A formal online project for collecting shadow length data and collaborating with people around the world.

Children's  Books

---

- **Wake Up, Vladimir** by Felicia Bond. Crowell, 1997.
- **The Day the Sun Danced** by Edith Hurd. Harper, 1965.
- **Who Gets Out of Bed?** by Nancy Carlstrom. Little, 1992.
- **Wake Up, Sun** by David Lee Harrison. Random, 1986.
- **Cock-a-doodle Dudley** by Bill Peet. Houghton Mifflin, 1990.
- **Dawn** by Uri Shulevitz. Farrar, 1974.
- **Sun Up** by Alvin Tressalt. Lothrup, 1991.

Folklore  Mythology

---

Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?

Sun Time and Worship

- **Ancient and Historical Time Keeping** - Great museum exhibit about time keeping in the past. Lots of terrific diagrams and photos. This site could provide many different and interesting ways of telling time for class projects.
- **Japanese Sun Dial** - A nice page about a rope-based sundial used in Japan.
- **Sundials: An Historical Sketch** - A nice introduction to the histories and stories of sundials.
- **Sundial Mottos** - Great fun! A list of sayings inscribed on ancient and modern sundials. Would be fun if you and your class are making your own sundials.
- **The Druids and Stonehenge** - A look at how an ancient stone Sun calendar is worshipped

by modern Druids, people who have resurrected the ancient Celtic religion as their own.

This is a Stickup | Table of Contents | ECT Home Page

Latitudes and Attitudes

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

Science Behind It

- **SchoolNet's Collection of Size of the Earth Data** - Some values calculated by students of the size of the Earth.
- **Noon Project** - Here's information about how schools can join in calculations of the size of the Earth.
- **About Erastothenes** - A cute and short story about how Erastothenes calculated the size of the Earth.
- **Basic Astronomy Demonstrations** - Ways to demonstrate certain aspects of astronomy such as the roundness of the Earth, day and night, the moon and eclipses.
- **Latitude and Longitude** - A very beautiful page describing and diagraming the concepts of latitude and longitude. This would be a good place to show the bird's eye view of the latitude world to older students, especially 2nd-4th graders.
- **Sunrise/Sunset Calculation** - The Naval Observatory's sunsrise and sunset time generator. It is a very quick and easy calculation done by the Observatory computers. You must, however, know your latitude and longitude!
- **Sunrise/Sunset Generator** - A tremendous site designed for movie producers so they can schedule when to shoot scenes in various countries and cities around the world. Lets you choose a city and it tells you the weekly average amount of sunlight time, plus sunrise and

sunset times. Great for geography tie-ins.

Maps and Live Cameras

- **Day and Night on the World Right Now** - A short list of the best sites on the web which provide live camera shots of places around the world. You can see who is having day or night right now.
- **The World Right Now** - Live Internet-linked cameras around the world.
- **Live camera map** - A great map of where the live cameras are in the world. Just click on the map.
- **Map Projections** - A large collection of projections of the world.

NASA

- **Mission to Planet Earth** - A NASA project to explore and archive images of the Earth using different robotic missions.

Children's  Books

---

- **Somewhere in the World Right Now** by Stacey Schuett. Alfred A. Knoph, Inc., 1995. This is a great book which shows you about the differences between day and night around the globe for a certain time of day here.
- **Welcome Back Sun** by Michael Emberly. Little, 1993. Following legend, a Norwegian family hikes up a mountain to welcome the sun's return after the dark winter months.
- **Mirandy and Brother Wind** - To win first prize in the Junior Cakewalk,Mirandy tries to capture the wind for her partner. This site includes fun activities about wind.

Folklore  Mythology

---

Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?

Ancient Navigation

- **Historical Maps Online** - A great collection of maps from all over the world drawn throughout history. Here they be dragons.
- **Polynesian Wayfinding** - The Traditional techniques of sailing used by early Polynesians. This is a Gopher site, which means there are text documents you can look at and print out.
- **Ancient Geography** - A large site full of information about how people long ago viewed the world.
- **Ancient Navigation and Shipbuilding in Greek and Roman Times** - This page is not yet active, but looks to be a good resource for this information. Stay tuned?

Using Fractions

- **Chinese Math** - A set of amusing math puzzles related to fractions, relations, and multiplications of relative values. May be rather tricky, but could also be fun for more advanced students.

Latitudes an Attitudes | Table of Contents | ECT Home Page

Time Warp

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

The Science Behind It

- **US Naval Observatory: Time Zones** - Unofficial, non-authoritative information on world time zones.
- **Day and Night** - A short page listing the best live camera and animation sites about day and night on the Earth.
- **Time** - Six clocks of the 4 major American time zones, Hawaii, and an example of how military time works with a clock for Mountain Standard Time.
- **NJDXA Time Page** - As they say, "More Time Information that U Ever Wanted to Know".
- **Time, GMT, Meridian Line** - A short description of what time zones are. An excellent time zone map.
- **Frequently Asked Questions about Time and the Calendar** - An amazing list of questions about time zones, leap years, atomic clocks....

Children's  Books

---

- **The Great Kettles: A Tale of Time**by Dean Morrisey. Harry Abrams,1997. This is a book about how a boy visits the Great Kettles and learns all about how time is brought to many places.
- **The Reasons for the Seasons** by Gail Gibbons. Holiday House, 1995. Pictures and descriptions of the seasons. Beware of the poorly represented astronomy facts.

Folklore  Mythology

---

Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?

Time Telling

- **Time Keeping and Culture** - Nice site with links to history of time keeping with games and surveys about time in your life. This is a museum site.
- **Mesoamerican Calendars** - How were ancient people calculating time?
- **Medicine Wheels: How they Work** - An explanation of some medicine wheels with diagrams about how they were pointing out the locations of objects in their culture's sky map.
- **Chinese Math** - At the end of this document are some interesting insights into the time keeping of the ancient Tibetans, such as the animal spirits and magic shapes which represented certain aspects of time.

Time Warp | Table of Contents | ECT Home Page

Tilt-A-World

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

Science Behind It

- **Tilt of the Earth** - Beautiful site explaning the tilt of the Earth. It also explains the seasons in terms of the amount of sunlight and height of the Sun.
- **Ice Ages and the Earth's Tilt** - A graph and information from the Illinois State Museum about the Ice Ages. This might be good for older students to think about.
- **Project Athena: Shape of the Earth** - A drawing here by a high school student shows nicely the way light from the Sun hits the curved and tilted Earth. There are ideas here for more projects.

- **Nine Planets: Planet Data** - It might be fun to discover how tilted the other planets are in the Solar System! Check out column 4, Axial Inclination to discover this about the other planets.
- **Project SkyMath** - For upper grades, this project uses the skills of pattern recognition and math to understand the weather.
- **The Weather Unit** - An integration of subjects aimed at learning about weather.
- **Bill Nye the Science Guy-Episode: Climates** - Learn a bit about the Earth's climates and make a model of a weather system.
- **Weather Links for Teachers and Parents** - Nick the Weather Dude's list of useful links about weather.
- **Kids Action: Rainforest Animals** - Question and Answer site of facts about the rainforests and critters. Part of a larger site for kids about the rainforests.

Online Activities

- **Kids as Global Scientists** - Online inquiry-based weather curriculum for middle school students.
- **Weather Here and There** - WEATHER HERE AND THERE is an integrated weather unit which incorporates interaction with the Internet and hands-on collaborative, problem solving activites for students in grades four through six.

Children's  Books

---

- **Goodbye Geese** by Nancy White Carlstrom. Scholastic, 1991. A peaceful dialog between father and child about the coming of winter.
- **Till Year's Good End**by W. Nikola-Lisa. Atheneum,1997. This is a book which introduces the Medieval calendar system. It includes great illustrations.
- **Snow** by Steve Sanfield. Philomel Books, 1995. Follow the steps of a child through the first snow of the year.
- **Thirteen Moons on Turtle's Back**by Joseph Bruchac and Jonathan London. Scholastic (Trumput Special Edition),1992. This is a fantastic book which tells of the 13 moons (or plates) on the shells of turtles which correspond to the 13 moons of the calendar year. This is a beautiful book.

Folklore Mythology

Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?

Ancient Star Mapping and the Earth's Tilt

- **Lakota Star Knowledge** - A page with nice diagrams of the Solar System. Tells about how the Lakota Indians knew much about the Earth and its tilt.
- **Lakota Ethnoastronomy** - A fantastic site detailing everything you wanted to know about what stars, constellations, and eclipses were called and revered.

Weather Lore

- **Weather Lore** - Before weather forecasting and television, how did people determine what the weather would be like for the next week or year?
- **Weather Lore - Fact or Fiction?** - A short page which lists some more ways of predicting weather from watching the world around us. Suggestions for additional school activities included.

Tilt-A-World | Table of Contents | ECT Home Page

Through Thick and Thin

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

The Science Behind It

- **Temperature and Thermometers** - A great site all about how thermometers work, about the temperature scales, and weather.
- **Build your own Thermometer** - Simple instructions and good questions about a water thermometer.
- **Bill Nye the Science Guy- Episode: The Sun** - Here is a site which has a fun experiment you can do about the heat of the Sun.
- **Bill Nye the Science Guy-Episode: Reptiles** - Find out how reptiles deal with the heat of the Sun.
- **Bill Nye the Science Guy-Episode: Energy** - Some experiments and discussions about energy.
- **Reflectivity and Absorption** - Experiment for students about differences in reflectivity and it's effects on temperature.

Heat and the World

- **Heat Wave** - All you wanted to know about the facts and figures of heat waves. Provides indications of how much is too much, and what to do to avoid and/or treat symptoms of heat disorder.
- **Tree Heat Syndrome** - How trees are dying in the heat in Georgia. An interesting example of how heat can be harmful.
- **The Arctic Circle** - Natural resources, history and culture; social equity and environmental justice in the Arctic Circle. There are presentations of textual materials, art, photographic exhibits, and in the future, sound and short video recordings
- **Solar Energy and Environment** - Here's a site to help you make your house warm and snug in the winter and cooler in the summer using the Sun!
- **Ancient Climates** - A site describing recent finds about the climates of the past.
- **Why are there Ice Ages?** - A rather impressive document which describes in detail the processes and examples of making Ice Ages on our world.
- **Climatology: Ice ages** - More student-oriented page on Ice ages, part of the University of Oregon's Electronic Universe Project.

Children's  Books

- **Under the Sun** by Ellen Kandorian. Dodd, 1987.
- **Musicians of the Sun** by Gerald McDermott. Simon and Schuster, 1997. How the Wind God must find the four musicians of the Sun to bring life and color to the Earth.
- **How the Sun Made a Promise and Kept It: A Canadian Indian Myth** by Margery Bernstein. Scribners, 1976.

Folklore  Mythology

Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?

Math and Folk Ways

- **Magic Squares** - Great way of talking about multiplication and the fun of numbers. This should be reserved for the most advanced students.

Seasonal Holidays and Seasonal Lore

- **Celebrating the Seasons: Pagan Holidays** - Selena Fox's site desribing the Pagan holidays. She also includes some activities you can do on these holidays which are very much like those done by families in the past.

Ice and Heat Lore

- **The Origin of Summer and Winter** - An Acoma/Laguna tale about why there are extreme seasons.
- **Origin of Fire** - Native American Tale of the origin of fire.
- **The First Fire** - A Cherokee Tale about a spider carrying fire to her people.
- **The Warm Wind Brothers vs. the Cold Wind Brothers** - A Native American tale explaining the winters and ice ages and other heat related events on the Earth. - -

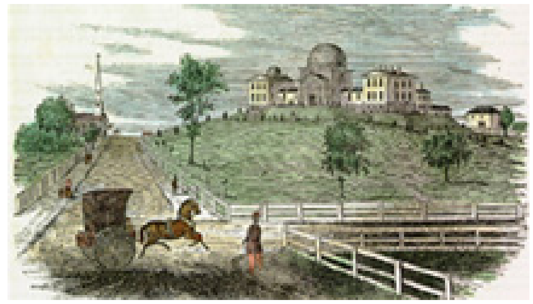
---

Through Thick and Thin | Table of Contents | ECT Home Page

WebMaster Tania Ruiz
Last updated February 25, 1999

Harvard-Smithsonian Center for Astrophysics

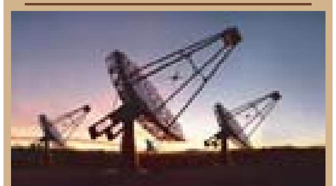
60 Garden Street
Cambridge, MA 02138



CFA HOME | CFA SEARCH | CONTACT CFA

The Harvard-Smithsonian Center for Astrophysics (CfA) is a collaboration between the Harvard College Observatory (HCO) and the Smithsonian Astrophysical Observatory (SAO) . Many CfA staff members are also associated with the Harvard University Department of Astronomy.

What's New at the CfA



VERITAS Moves Ahead
(More)

About the CfA	Overview, maps, scientific divisions, technical services, and administrative departments
Research	Scientific divisions, projects, programs, publications, archives and services, and the John G. Wolbach Library
Events	Weekly calendar, public programs, colloquia, and research seminars
Opportunities	Job postings, post- and predoctoral positions, undergraduate research
Press Releases	Current and past press releases concerning research at the CfA
Facilities	Details on the CfA in Massachusetts, Arizona, Hawaii, and other locales
Directories	Public information about members of the CfA community
Support the CfA	Information on tax deductible contributions
CfA Intranet	Available to members of the CfA community only

Last modified on Friday, 19-Mar-2004 09:08:04 EST

Comments or Questions? Contact www-admin@cfa.harvard.edu

Page Not Found

webteam@www.fi.edu

inQuiry Almanack

Questions Answers

APRIL

---

volume three, issue four

As April arrives, our minds turn to...Science! During the week of April 20 through 27, schools across the United States will celebrate National Science and Technology Week. Plan to celebrate with some hands-on science activities.

A few days later, on April 30, plan to observe National Arbor Day. The National Arbor Foundation offers several suggestions for recognizing the day.

It's probably a busy month, but you'll probably find the Spotlight on Probability to be worth a chance. Developed by teachers, this unit of study investigates the randomness of numbers in both math class and music class.

It's STRINGtime, so Amy's off flying kites. Investigate the beauty and physics of kites with her.

As always, you'll find an excellent way to spend a minute with ME. This month, the connection between math and poetry is a reason for fun.

"inQuiry Almanack" Archives

Back to The Franklin Institute

SCIENCE MADE SIMPLE

Why do Leaves Change Color in the Fall?

The page you requested has moved.

The new URL is
http://www.sciencemadesimple.com/leaves.html

Please update your bookmarks.

If your browser does not automatically forward you in 5 seconds,
please click here.

WHY DO LEAVES CHANGE COLOR IN THE FALL?

by

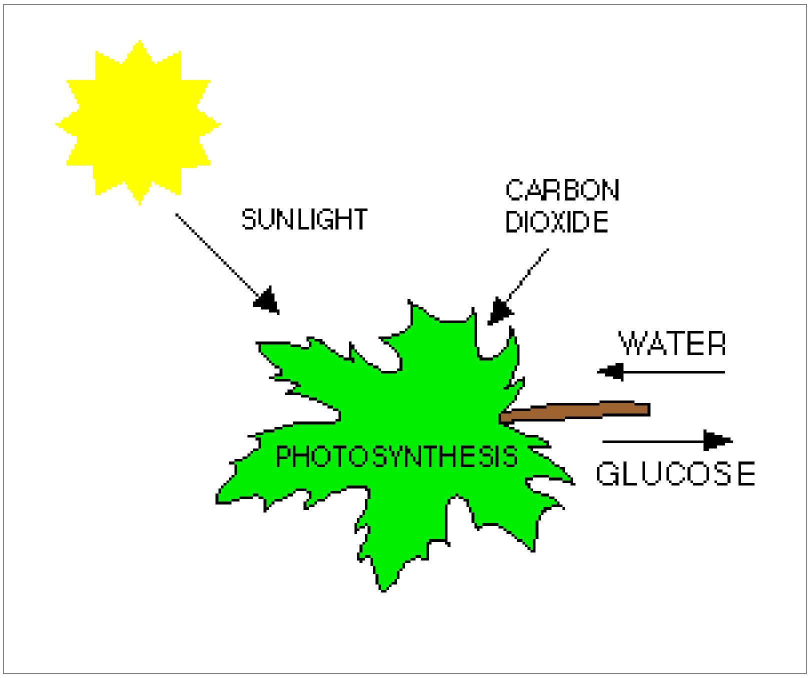
SCIENCE MADE SIMPLE

Science Made Simple / Science Subjects / Science in the News / Measurement Conversions

INDEX: Why do leaves change color in the Fall? --- I Can Read --- Word Puzzle
Learn More About: How plants prepare for winter --- Projects

We all enjoy the beautiful show of colors as leaves change each autumn. Did you ever wonder how and why this happens. To answer that question, we first have to understand what leaves are and what they do.

Leaves are nature's food factories. Plants take water from the ground through their roots. They take a gas called carbon dioxide from the air. Plants use sunlight to turn water and carbon dioxide into glucose. Glucose is a kind of sugar. Plants use glucose as food for energy and as a building block for growing. The way plants turn water and carbon dioxide into sugar is called photosynthesis. That means "putting together with light." A chemical called chlorophyll helps make photosynthesis happen. Chlorophyll is what gives plants their green color.



As summer ends and autumn comes, the days get shorter and shorter. This is how the trees "know" to begin getting ready for winter.

During winter, there is not enough light or water for photosynthesis. The trees will rest, and live off the food they stored during the summer. They begin to shut down their food-making factories. The green chlorophyll disappears from the leaves. As the bright green fades away, we begin to see yellow and orange colors. Small amounts of these colors have been in the leaves all along. We just can't see them in the summer, because they are covered up by the green chlorophyll.

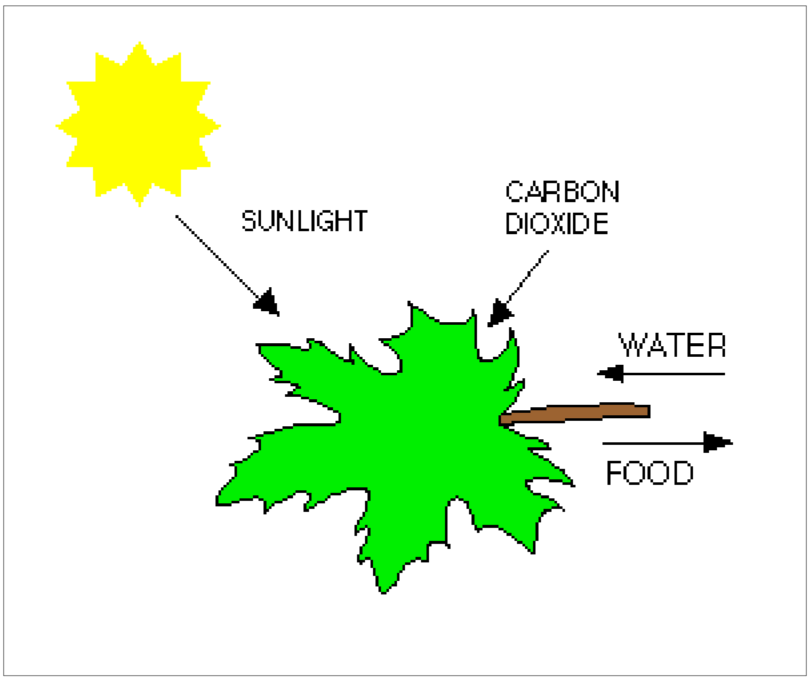
The bright reds and purples we see in leaves are made mostly in the fall. In some trees, like maples, glucose is trapped in the leaves after photosynthesis stops. Sunlight and the cool nights of autumn turn this glucose into a red color. The brown color of trees like oaks is made from wastes left in the leaves.

It is the combination of all these things that make the beautiful colors we enjoy in the fall.

I CAN READ

WHY DO LEAVES CHANGE COLOR IN THE FALL?

Plants make their own food. They take water from the ground through their roots. They take a gas called carbon dioxide from the air. They turn water and carbon dioxide into food using sunlight and something called chlorophyll. Chlorophyll is green. It gives leaves their green color.



Winter days are short and dry. Many plants stop making food in the fall. The chlorophyll goes away. Then we can see orange and yellow colors. These colors were in the leaves all summer, but the green covered them up.

Some leaves turn red. This color is made in the fall, from food trapped in the leaves. Brown colors are also made in the fall. They come from wastes left in the leaves.

WORD SCRAMBLE
How many of these words can you unscramble? (Answers follow the Projects section)
trawe **afle** **rnege** **ernago** **mutanu** **loscuge** **gnlituhs** **holoprycl h**

Answers follow Projects Section.

LEARN MORE ABOUT:

HOW PLANTS PREPARE FOR WINTER

All summer, with the long hours of sunlight and a good supply of liquid water, plants are busy making and storing food, and growing. But what about wintertime? The days are much shorter, and water is hard to get. Plants have found many different ways to get through the harsh days of winter.

Some plants, including many garden flowers, are called "annuals," which means they complete their life cycle in one growing season. They die when winter comes, but their seeds remain, ready to sprout again in the spring. "Perennials" live for more than two years. This category includes trees and shrubs, as well as herbaceous plants with soft, fleshy stems. When winter comes, the woody parts of trees and shrubs can survive the cold. The above ground parts of herbaceous plants (leaves, stalks) will die off, but underground parts (roots, bulbs) will remain alive. In the winter, plants rest and live off stored food until spring.

As plants grow, they shed older leaves and grow new ones. This is important because the leaves become damaged over time by insects, disease and weather. The shedding and replacement continues all the time. In addition, deciduous trees, like maples, oaks and elms, shed all their leaves in the fall in preparation for winter. "Evergreens" keep most of their leaves during the winter. They have special leaves, resistant to cold and moisture loss. Some, like pine and fir trees, have long thin needles. Others, like holly, have broad leaves with tough, waxy surfaces. On very cold, dry days, these leaves sometimes curl up to reduce their exposed surface. Evergreens may continue to photosynthesize during the winter as long as they get enough water, but the reactions occur more slowly at colder temperatures.

During summer days, leaves make more glucose than the plant needs for energy and growth. The excess is turned into starch and stored until needed. As the daylight gets shorter in the autumn, plants begin to shut down their food production.

Many changes occur in the leaves of deciduous trees before they finally fall from the branch. The leaf has actually been preparing for autumn since it started to grow in the spring. At the base of each leaf is a special layer of cells called the "abscission" or separation layer. All summer, small tubes which pass through this layer carry water into the leaf, and food back to the tree. In the fall, the cells of the abscission layer begin to swell and form a cork-like material, reducing and finally cutting off flow between leaf and tree. Glucose and waste products are trapped in the leaf. Without fresh water to renew it, chlorophyll begins to disappear.

Other colors, which have been there all along then become visible. The orange colors come from carotene ('kar-uh-teen) and the yellows from xanthophyll ('zan-thuh-fil). They are common pigments, also found in flowers, and foods like carrots, bananas and egg yolks. We do not know their exact role in leaves, but scientists think they may be involved somehow in photosynthesis.

The bright red and purple colors come from anthocyanin (an-thuh-'si-uh-nuhn) pigments. These are also common in plants; for example, beets, red apples, and purple grapes, and flowers like violets and hyacinths. In the leaves, these pigments are formed in the autumn from trapped glucose. Brown colors come from tannin, a bitter waste product. Different combinations of these pigments give us a wide range of colors each fall.

As the bottom cells in the separation layer form a seal between leaf and tree, the cells in the top of the separation layer begin to disintegrate. They form a tear-line, and eventually the leaf is blown away or simply falls from the tree.

One more important question remains. What causes the most spectacular display? The best place in the world for viewing fall colors is probably the Eastern United States. This is because of the climate there, and the wide variety of deciduous trees. The brightest colors are seen when late summer is dry, and autumn has bright sunny days and cool (low 40's Fahrenheit) nights. Then trees make a lot of anthocyanin pigments. A fall with cloudy days and warm nights brings drab colors. And an early frost quickly ends the colorful display.

FUN FACT
What do autumn leaves and ripening bananas have in common? The green color in unripe bananas comes from chlorophyll, the same pigment that gives green leaves their color. As bananas ripen, the chlorophyll breaks down and disappears, revealing the yellow color which has been there all along. The yellows and oranges of autumn leaves are also revealed as their chlorophyll breaks down. Of course, other changes also occur as banans ripen: the starches change to sugar and the flesh softens as pectin (a carbohydrate) breaks down.

PROJECTS TO DO TOGETHER

NOTE: ADULT SUPERVISION IS REQUIRED. Please read all instructions completely before starting. Observe all safety precautions.

PROJECT 1 - Separate Colors in a Green Leaf using Chromatography

What you need:

leaves, small jars (baby food jars work well)
covers for jars or aluminum foil or plastic wrap
rubbing alcohol, paper coffee filters
shallow pan, hot tap water, tape, pen
plastic knife or spoon, clock or timer.

What you do:

1. Collect 2-3 large leaves from several different trees. Tear or chop the leaves into very small pieces and put them into small jars labeled with the name or location of the tree.
2. Add enough rubbing alcohol to each jar to cover the leaves. Using a plastic knife or spoon, carefully chop and grind the leaves in the alcohol.
   SAFETY NOTE: Isopropyl rubbing alcohol can be harmful if mishandled or misused. Read and carefully follow all warnings on the alcohol bottle.
3. Cover the jars very loosely with lids or plastic wrap or aluminum foil. Place the jars carefully into a shallow tray containing 1 inch of hot tap water.
   SAFETY NOTE: Hot water above 150 F can quickly cause severe burns. Experts recommend setting your water heater thermostat no higher than 125 F.
4. Keep the jars in the water for at least a half-hour, longer if needed, until the alcohol has become colored (the darker the better). Twirl each jar gently about every five minutes. Replace the hot water if it cools off.
5. Cut a long thin strip of coffee filter paper for each of the jars and label it.
6. Remove jars from water and uncover. Place a strip of filter paper into each jar so that one end is in the alcohol. Bend the other end over the top of the jar and secure it with tape.
7. The alcohol will travel up the paper, bringing the colors with it. After 30-90 minutes (or longer), the colors will travel different distances up the paper as the alcohol evaporates. You should be able to see different shades of green, and possibly some yellow, orange or red, depending on the type of leaf.
8. Remove the strips of paper, let them dry and then tape them to a piece of plain paper. Save them for the next project.

PROJECT 2 - Separate Colors in a Fall Leaf using Chromatography

What you need: same as Project 1.

What you do:

1. Repeat step (1)-(8) from Project 1, this time using leaves that have changed color. You may have to wait much longer in steps (4) and (7). There is normally much less of the other colors in the leaves compared to the green chlorophyll.

PROJECT 3 - Observe how light affects color development

What you need:

a tree with leaves that turn red in autumn

aluminum foil or heavy paper and masking tape.

What you do:

1. Before the leaves turn colors in the fall, find a maple tree, flowering dogwood, sweet gum, or other tree or shrub that you know will turn bright red or purple.
2. Find several leaves that receive bright sunlight, and cover part of them with foil or heavy paper and tape.
3. After the leaves have changed color, remove the covering and observe the different colors underneath. These are the colors that were in the leaf all summer. The bright reds and purples are only made in the fall, with exposure to light.

ANSWERS TO WORD SCRAMBLE
water **leaf** **green** **orange** **autumn** **glucose** **sunlight** **chlorophyll**

Go to Main Menu / Science Subjects / Science in the News
Measurement Conversions / Quick Q & A / Send us an E-mail

eduzone.com
you searched for: College

»
»

Top College Sites

Central Christian College of the Bible
Accredited Bible college on a scenic 40-acre campus with majors in preaching, counseling, youth ministry, missions and music offers full-tuition scholarships to every full-time student.
www.cccb.edu

Earn Your College Degree Online
U.S. residents: earn your MBA, BA (BUS, CIS, MIS, Acct, CJ, RN-to-BSN) or AA degree from nationally known, accredited universities with no classroom attendance. Study anytime, anywhere.
info.bisk.com

Westwood College Of Technology
Westwood offers the career education you're looking for. Fast-track degree programs in It, business, aviation technology, design and more. CA, Co, IL and Tx campuses. Online study too.
www.westwood.edu

Ashworth College - Distance Learning
Earn your Associate's degree at home. Ashworth College is a nationally accredited distance learning school offering degree programs in a variety of disciplines. Enroll online today.
www.ashworthcollege.com

Earn Your Degree Entirely Online
Whether you're into IT, nursing, business or more, the Online Degree brings you the online college degree programs you're seeking. A comprehensive guide that makes life easier.
www.theonlinedegree.com

More Sites

Top Searches

American university Higher education Florida college College guide The zone

Online education college California college College term paper College College community

Search :

Go

Welcome to Thinking Fountain

"I grew mold that turned bright orange."

- try growing your own mold
- visit our mold gallery
- make a surprise connection
- explore cool mold sites

What are you looking for?

A to Z
Index of ideas

theme clusters
Gathered by topic

mind maps
Connected together

add your idea

search
Try something new

A Science Learning Network Resource / ©1997 Science Museum of Minnesota

Natural Perspective

The Animal Kingdom (*Animalia*)

(Last modified: 13 May 2000)

The Animal Kingdom is at once the Kingdom most and least familiar to us. Almost all of the animals we commonly think of -- mammals, fish, and birds -- belong to a single subgroup within one of the 33 Phyla comprising the Animal Kingdom. On the other hand, over 100,000 species in some 25 animal phyla -- mostly small worms -- are so unfamiliar that they are virtually unknown to non-scientists. The same goes for several hundred thousand tiny insect-like species populating the *Arthropoda* phylum.

All told, around 800,000 species have been identified in the Animal Kingdom -- most of them in the Arthropod phylum. In fact, some scientists believe that if we were to identify all species in the tropical rain forests the ranks of *Arthropoda* would swell to over 10 million species!

Here are highlights of the larger members of the animal kingdom:

Spinal Cords (*Chordata*)

All animals having a spine, including fish, mammals, birds, reptiles, amphibians, sharks, and eels are grouped into *Chordata*.

Because these animals are so familiar to us, biologists have come up with elaborate classification schemes including subphyla, superclasses, infraorders, and the like.

The vast majority (including all the Classes listed above) fit into the subphylum *Vertebrata* -- those having a backbone. Subphyla *Agnatha*, jawless fish, includes certain eels such as the Lamprey. *Cephalochordata* and *Tunicata* round out the list of subphyla with fairly obscure creatures called Lancelets and Tunicates, respectively.

All told, this familiar phylum includes 45,000 species of which you are just one.

Joint-Legs (*Arthropoda*)




If your animal has jointed legs and no spine, you can find it in the *Arthropoda* phylum. This includes most, if not all, of the animals we commonly call "bugs" as well as the crustaceans. Scientists have described 500,000 species of arthropods and believe that up to 10,000,000 species are alive today.

The classes of this phylum include -- in the order pictured above -- the six-legged Insects (***Insecta***); the eight-legged Arachnids (***Arachnida***) including spiders (pictured), scorpions, and ticks; the hard-bodied Crustaceans (***Crustacea***) including crabs (pictured), shrimp, and barnacles; and ***Malacostraca***, which includes the sowbug or pillbug.

Other Arthropod classes are: ***Merostomata* --** home of the Horseshoe crab; Millipedes (***Diplopoda***); and Centipedes (***Chilopoda***)

Soft Bodies = Mollusks (*Mollusca*)



Mollusks are so named because of their soft bodies (Greek: *mollis* = soft). The soft bodies of many of the 110,000 Mollusk species are protected by a hard shell, however. Even those without this protection, such as slugs, still have vestigial traces of a shell.

The most common classes are: ***Polyplacophora*** characterized by a shell composed of 8 overlapping plates, such as the Lined Chiton (*Tonicella lineata*), above; ***Gastropoda*** commonly known as slugs and snails **--** including the Banana Slug, above; ***Bivalvia*** or Bivalves, such as clams and mussels (above); and ***Cephalopoda***, comprising octopus and squid, as well as the Nautilus.

Other classes are ***Monoplacophora***, ***Scaphoda*** (tooth shells).

Spiny-skinned (*Echinodermata*)


These animals are *radially symmetrical* -- they have no distinct front and back, only a top and a bottom. The 6,000 species are usually found in tide pools along the seashore.

The classes are: ***Asteroidea* -- starfish** such as the Six-rayed Star above (*Leptasterias hexactis*); ***Ophiuroidea*** **--** brittle stars; ***Echinoidea*** including sea urchins (pictured) and sand dollars; ***Holothuroidea*** **--** sea cucumbers; and ***Crinoidea***.

[Marine] Stingers (*Cnidaria*)

There are some 9,500 species of these water creatures, which are sometimes called *Coelenterates*.

These animals are radially symmetrical and have tentacles with stinging cells. The more familiar types include jelly fish, sea anemones (pictured), corals, medusas, and hydras.

Other Phyla containing species that may be familiar to the amateur include:

- Sponges (*Porifera*, 10,000 species)
- Segmented Worms (*Annelida*, 8,800 species including the common earthworm and leeches),
- Lamp shells (*Brachiopoda*, 350 species)
- Comb Jellies (*Ctenophora*, 90 species)
- Nematodes (*Nematoda*, 80,000 species)
- Horsehair worms (*Nematomorpha*, 240 species)

Page 30 of 38

Annotated Bibliography

Margulis, Lynn, Karlene Schwartz, *Five Kingdoms: An Illustrated Guide to the Phyla of Life on Earth (2nd edition)*, W. H. Freeman and Company, New York, 1988

An overview of the highest levels of Taxonomy. I have chosen the authors' nomenclature where available. Names, however, are constantly changing in the field of Taxonomy, and no doubt many of these names are disputed or have changed since 1988.

Margulis, Lynn, *Diversity of Life: The Five Kingdoms*, Enslow Publishers, Inc., New Jersey, 1992

Although billed as a children's book, this book is quite appropriate for the adult amateur. Dr. Margulis strikes an excellent balance between detail and brevity in this fact-filled book.

Milani, Jean P., et. al. *Biological Science: An Ecological Approach (6th edition)*, Kendall/Hunt Publishing Company, Iowa, 1987

A high school textbook that devotes several chapters to Taxonomy and the diversity of life on our planet. The Appendix titled: *A Catalog of Living Things* illustrates the phyla as well as many classes and families within the five kingdoms.

This site produced and maintained by Ari Kornfeld, email: (ari@perspective.com)

Please take a moment to provide your feedback on this site.

Credits:

Collaboration and inspiration thanks to Susan Kornfeld

PhotoCD scans by Alpha CD Imaging, Menlo Park, CA

Special thanks to Claire Doyle for scanning some early photos

Internet service by Humboldt Internet

Vermont Weathervane

Due to our current redesign,

the Time of Falling Leaves page has moved.

Click on the title to go to its new location.

VERMONT WEATHERVANE

The Time of Falling Leaves

by Mary Lou Healy

October closes the autumn season in spectacular fashion with nature's annual show of pyrotechnics, the explosion of red and gold that blazes across hill and valley. Lenape Indians called it the "time of falling leaves."

It's easy to develop a split personality in October. There's a love-hate ambivalence connected to it. We love it. Summer's heat has been tempered by crisp fall air. We welcome pilgrims from afar to the annual foliage viewing. With them, we immerse ourselves in the last great display of the year, the silent song of the leaves.

I remember how happily we brought them to school and learned to preserve them in waxed paper...the red of sumac, the yellow of birch, ginko, ash and hickory, the salmon-pink of sassafras, the russet and burgundy of oak and, always, the glory of multi-hued maples: scarlet, orange, vermilion, gold and even purple.

I always preferred to believe that Jack Frost painted the trees for my delight until some spoil-sport had to explain more than I ever wanted to know about the process...how the warm, bright days encourage sugar production, while the cold nights trap it in the leaves, causing red pigmentation. Did I need to know that the decrease in chlorophyll meant less green as anthocyanin flamed the leaves?

I much prefer the explanation given in an old Indian legend. Many, many moons ago, when sky-hunters roamed the Milky Way, they chanced upon the Great Bear. They fired shooting stars into the constellation and killed him. As he lay dying, his red blood dripped onto the green forests below.

Then the hunters, hungry from their journey, cut up the Great Bear and threw him into the Big Dipper to cook. But the pot boiled over and the rich, yellow fat spilled downward from heaven and colored other leaves in shades of gold. And now, each autumn, the land remembers and turns color to honor the Great Bear.

I enjoy one other bonus of nature in autumn. The Franklinia tree that I planted some years ago delights me with its late blooming habit. Among the red and bronze of its leaves glisten pure white blossoms with saffron hearts. It's a thing of wonder before the silver season of November drains all the color away.

* * * * *

But all that is the UP side of October. The day of reckoning...or rakin' in...is the down side. The falling-down side? Time to gather and dispose of the dull brown remnants of glory.

When I was an innocent, carefree child, blessedly ignorant of workaday things, I was taught a little ditty. "Come, little leaves, said the wind one day. Come o'er the meadow with me and play...." Educators should have been preparing me for the real world. Never mind darling little leaves dancing. We should have had the facts straight from the leaf pile: when the dance is done, we're the ones who clean up the dance floor! As one neighborhood wag put it one Saturday afternoon, "The family that rakes together, aches together!"

The sight of leaves spiraling downward often inspires me to visions of innovative, if bizarre, disposal methods. Perhaps a sneaky way with a wind machine, revved up in the dead of night, to blow all my leaves into someone else's territory. But would I do that? Of coooourse not!

Another thought, which I'll donate to any inventor who cares to tinker with it, is that there must be some way to spray a very fine glue onto the trees, which would then hold leaves in place throughout the year.

Fallen leaves have their uses, I suppose. Thrifty New Englanders once, and sometimes still, put their leaves in bags placed around their house foundations, as added insulation against the winter-to-come. It's called "banking the house" and can be surprisingly effective at reducing floor-level drafts.

Then there are compost heaps. Compost heaps are a dull business, really. Occasionally I see a well-tended heap going about its job of rotting into a compound over which a gardener,

Feedback

Write Us:
weathervane@ruralvermont.com
We welcome your comments, suggestions, and questions.

or call: 802-645-9631
RD 1, Box 680
West Pawlet, VT 05775

some future day, will gloat as he enriches his soil. For a moment, I might feel a twinge of envy but never a strong enough twinge to go and do likewise. I think I'm more into instant gratification.

Strong-minded individuals simply refuse to acknowledge the existence of leaves once they hit the ground. They just ignore the little rustlers until they either blow away down the avenue or rot where they lie. I've also read of a homeowner who will not mow his lawn. He prefers the "natural look." Perhaps back-to-nature enthusiasts like non-mowers and non-rakers have the right idea.

Poet Joyce Kilmer rhapsodized about how he'd "never see a poem as lovely as a tree." You can figure Kilmer probably never had to rake leaves! He had a gardener. Or lived in a penthouse apartment. A friend of mine considers Kilmer's lyric poem, "Trees," the greatest ever. She was devastated to learn that it was not one of his favorite verses. Perhaps he had a change of heart after writing it. Or perhaps someone gave him a leaf rake on his birthday.

* * * * *

Yes, October, time of falling leaves is here, the month of leaves dancing. But April is a month of leaves, too, with its softly shimmering flutter of tender green. So is July, with canopies of dark, rich emerald under whose cool shade we seek refuge from the noonday sun. And December comes, when dark branches are outlined against a pale, cold sky, devoid of leaves but wearing stars instead.

The pageantry of autumn is soon finished but hold this thought that someone once expressed - One of the nicest things about October is that November isn't here yet.

Mary Lou Healy, an "umpteenth generation" New Englander, writes regularly for our journal, most likely as an excuse to avoid raking leaves.

Walton Hall Nature Trail, what's on September/October

We are now moving into autumn, the season of mellow fruitfulness. Blackberries, rosehips, haws and crab apples are ripening, and indeed many of the hazelnuts have already been eaten. The weather at this time of year can be rather variable, one frost can cut short many plants and insects but in recent years there have been a number of 'Indian summers', periods of warm settled weather which have allowed some butterflies and tender plants to survive almost until Christmas. If on the other hand its miserable outside try summer sounds - a [400k] recording of bumblebees and house martins made in one of the OU courtyards.

Plants Walking along the river at this time of year you can't miss the pink flowered Indian balsam (*Impatiens glandulifera*). It grows 2m tall, smells of balsam and has explosive seeds - just try squeezing one of the pods and see what happens! The species originally came from the Himalayas but is now widespread across Europe especially in damp habitats.

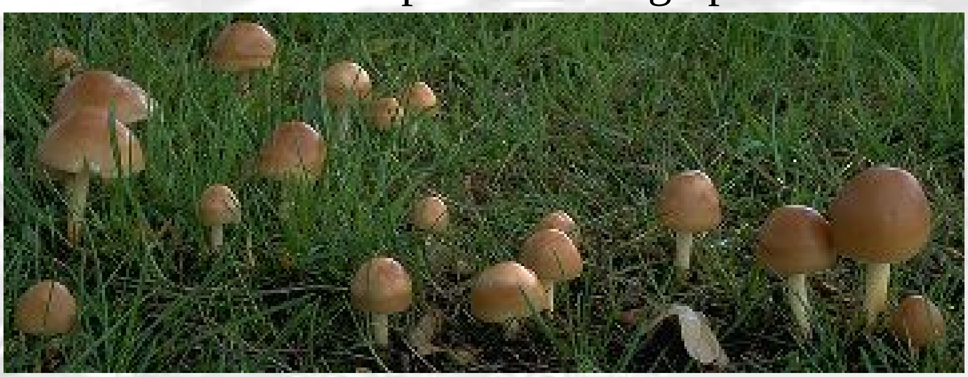
Brambles are again producing a good crop of berries this year although some of the bushes round Walton Lake look slightly orange from a distance. This is due to infection with the rust fungus *Phragmidium violaceum* which produces spots on the upper side of the leaf and pustules underneath. Spores of this species have a rather curious shape.

Birds This is the time of year for migration. The house martins generally leave their nests and flock together round the OU buildings before heading south so look out for this as you won't see them again for another 6 months. On the other hand species such as redwings and fieldfares should be arriving soon from Scandinavia to escape the more severe winters and eat all our berries. There is also a chance of seeing a rare migrant such as redstart, pied flycatcher or ring ousel all of which have been seen in this area in the past

Herons [picture right] are common throughout the year especially in Walton Lake. When not feeding they may roost together in a traditional 'standing ground', I have seen groups of 5 or more together in the fields behind Fenny lock but they will have to move on as this area is about to be built on.

Insects Grasshoppers and bush crickets are very common at this time of year. Males are often heard stridulating (singing) in the long grass round Walton Lake. Bush crickets are generally larger than grasshoppers and have very long antennae. The males of some species fly well and may be attracted indoors to lights. Females are fearsome looking beasts often with a sabre-like ovipositor, they can give a painful bite if handled.

Fungi Any periods of damp weather now are liable to bring on crops of fungi. Fairy ring champignon (*Marasmius oreades*) [below] is common round the OU campus. The tiny birds nest fungus (*Cyathus olla*) is also common on the pulverised bark path by the river. It is unlikely that the two rare species that appeared last year (*Boletus impolitus* and *Hygrophoropsis fuscosquamula*) will be here again as both areas where they grew have been disturbed but with 3000 UK fungi to choose from I expect there will be at least a few unusual species turning up.



Back to Nature Trail overview

Natural Perspective

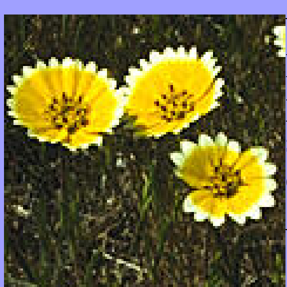
A Farewell To Spring (July 1996)

(Last modified: 24 July 1997)

Spring has drawn to a close here in the San Francisco Bay Area. The rainy season is definitely over; the delicate herbs of Spring are all but gone. Pink Clarkias -- aptly named Farewell-to-Spring -- now provide a final burst of color among the dried grasses (*above*).

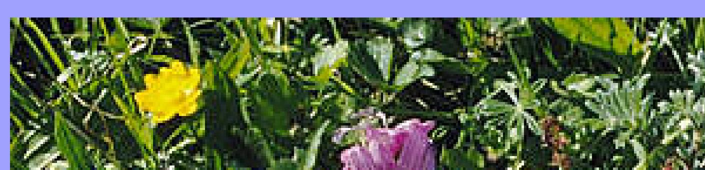
This was truly a wonderful year for Spring: the rain and climate cooperated perfectly to encourage plants to grow. Spring had slipped in by late-January and built up to a crescendo of blossoms (accompanied by Cicada song) that lasted through May.

A lovely bouquet of flowers in the Pea and Carrot, Aster and Geranium families framed both the season and its flowers. Acacia trees of the Pea family were among the earliest to flower but other family members including the brooms, clover, lupine, and vetch followed in a steady procession. The Carrot family conducted its own procession, beginning with the beautiful Footsteps-of-Spring, followed by Sanicles, Cow Parsnip and other fragrant relatives. As Summer approaches, the Carrot family still reigns, with tall Poison Hemlock and Angelica plants still in bloom.



Wild members of the Geranium family, with tiny purple-to-pink flowers, seemed to dot the landscape everywhere -- even between chinks in the pavement. The Asters, later to start, painted entire hillsides and meadows with gold. The palette included tiny Goldfields; substantial Mule's Ear; dainty Tidy-tips (*left*); and bevies of confoundingly similar dandelion species.

Within the lattice formed by these plants, a myriad of other beautiful flowers flourished this Spring: Suncups, Cat's-ears, Checkerblooms, Blue-eyed Grass, tiny California Plantain, owlish Purple Owl's Clover, Bluedicks, Shooting Star, Baby Blue-eyes, Douglas Iris and the glorious California Poppy to name but a few. Meanwhile the shady woodlands nurtured their own bouquet with Trillium, Forget-Me-Not, Hound's-tongue, Starflower, Violets, and a wonderful variety of fungi.



Nowhere was the feeling of Spring better represented than at Chimney Rock, Pt. Reyes. The place deserves its reputation for breathtaking profusion of wildflowers. We took the short walk from the parking lot to Chimney Rock (perhaps a mile each way & less than a quarter mile wide) and found it carpeted with showy wildflowers, most of them less than a foot high. (*Right: a tiny sampling of the plants Chimney Rock -- 6 species with a Checkerbloom in the center*)

One trail guide claims that over 60 species of wildflowers grow along this path. We counted around 35 that day -- half of them new to me -- but the number of species doesn't do justice to the beauty of the place. It doesn't indicate the sheer density of colorful blooms and how they intermingle with each other. Nor does it portray the beautiful backdrop. Here gentle hills converge to terminate in a seaside cliff -- a protected bay on one side, the ocean on the other -- with flocks of birds flying overhead. One bold Song Sparrow perched on a trailside rock and repeated its beautiful melodies over and over much to the delight of all passers-by.

After maturing in the lowlands, Spring slowly crept up the mountain sides following the receding blanket of melting snow-pack. By the end of April, Springtime had extended up a mile in elevation (1.5 km) and with it came the delights of Morel hunting.

During one trip to the Sierra, we had pretty much given up on finding Morels and just settled back to enjoy the hike through a Sequoia grove. Around halfway into the trail, a lumpy "rock" caught my attention. We almost passed it without further note, but something called me back. Much to our delight the rock had turned into Black Morel! From there we kept our eyes peeled and found enough mushrooms to fill two sandwich bags. Not a huge take but enough, and even more welcome as we had already abandoned the hope of finding any edible mushrooms.

Snowplants, Manzanita and Giant Trillium were in full bloom along the trail that day. What beautiful plants, each in its own way. Once again, we were thankful to the fungi, without which the former two plants would die of starvation.

A month later we journeyed to Colorado for Memorial Day Weekend. We found Spring once again, now barely reaching 8-9,000 feet (2.5-3 km) in altitude. Although we spent one day hiking in snowfall, we found beautiful Calypso Orchids, Bearberry Shrubs, Columbines (*right*), Pasqueflowers and many of the other ephemeral flowers for which the Rockies are famous.

Having enjoyed so many beginnings of Spring this year, Summer came upon us all too quickly. Summer has it own joys, however: hardy shrubs and vines that just now are turning to fruit. Rose-family berries such as Blackberry and Thimbleberry are ripening. Our favorite Heath berry, the Huckleberry, will follow in due time. And the Soap-plant has started its beautiful afternoon display of flowers. Spring is still just a day trip away to the higher elevations.

One more Spring has come to a close in the lowlands of San Francisco; one more Summer has taken its place. We have again reveled in Nature's rebirth, drunk in her beauty, and marveled at her complexity. Along the way we discovered new delights, delighted in the familiar, and enjoyed a cornucopia of smell, sight, taste, touch, and sound.

-Ari & Susan

This site produced and maintained by Ari Kornfeld, email: (ari@perspective.com)

Please take a moment to provide your feedback on this site.

Credits:

Collaboration and inspiration thanks to Susan Kornfeld

PhotoCD scans by Alpha CD Imaging, Menlo Park, CA

Special thanks to Claire Doyle for scanning some early photos

Internet service by Humboldt Internet

Word Lore

Origins of Words from the Threads of Inquiry

This is a document designed to explore certain words we use a lot in the Threads of Inquiry. Here we learn about how ancient and modern cultures use the following words and from where the origin of the word has come. Since it is always a difficult decision whether or not to introduce new vocabulary words to students when they are trying to experience concepts without them, this page may offer a teacher an interesting approach to teaching certain words to the class. A brief note: This document assumes students are from the United States, however, the information gathered here can be adapted for any country.

Contents

Introduction

Selected Words from the Threads of Inquiry

- Night
- Time
- Spring
- Fall
- Summer
- Winter

Language Links

For Further Reading

About Our Language

What language are we speaking? It is *English*. Why is it called that? It is the language which is spoken by English people who live in England. Even though we are not English, our language is still called English because it is very similar to the language that English people speak in England.

In fact, American English is slightly different from British English. Hundreds of years ago, the first English speaking people came to America from England. Since that time, the English language has been spoken both in America and in England, but it has changed just a little bit--and in different ways--in both countries. Now there is enough of a difference between the languages spoken in America and England that sometimes people call the English spoken in American American English and the English spoken in England British English.

Over long periods of time, the language a people speaks changes very slowly. Usually, these changes take place so gradually that the people speaking the language probably won't notice the changes. But after hundreds of years, the changes become apparent--just has they have with British English and American English. Eventually a language can change so much that it can't really be called the same language anymore. Perhaps one day American English will be so different from British English that we won't call the language spoken in America "English" anymore.

Even before there was a special kind of English spoken in America, the English language in England had been slowly changing for a very long time indeed--over a thousand years! If we had a time machine that would allow us to meet and talk with people who lived in England six hundred (600) years ago, we might have a lot of trouble understanding them. Today we call their kind of English Middle English. If we used our time machine and went back to talk to people who spoke English one thousand (1000) years ago years ago, their English would be so much different from ours that we could hardly understand them at all. We call their kind of English Old English, and you can listen to what it might have sounded like here. Before that time, the language was so different that we don't even call it English.

Any language can change so much that it needs a new name. Sometimes a language will change differently in different places, and it will need two or more new names. It is possible to draw a picture like a family tree showing how languages change. This link shows a tree with the English language on it. This language family tree shows the Germanic languages. About two thousand (2000) years ago there was a language we call Germanic. It was spoken a little differently in different places, and slowly turned into a number of different languages, including English. Just as English is descended from Germanic, Germanic is descended from another language we call Indo-European. Indo-European was spoken perhaps six thousand (6000) years ago, and here is another language family tree showing it. Germanic and English are both shown on this family tree diagram.

We can learn many different things by looking at how a language changes. Below are a number of terms and vocabulary words taken from the Threads of Inquiry, each of which has a brief discussion about its history and the folklore associated with it. By introducing such concepts, we find that the subjects we investigate are all interconnected.

Brief Pronunciation Notes

For the purposes of comparing similar words in different languages, spelling is often enough. However, the students may have fun learning how to pronounce some of these words--doing so also gives additional insights on how languages change, since spelling does not always reflect pronunciation (especially in English!). There are samples of so many different languages on this page that it would be difficult to provide information on how to pronounce them all (and, in fact, the author has very little idea about how to pronounce some of them!). In some cases, links from this page will take you to other sites with more information on individual languages, including pronunciation guides. However, it is possible to briefly note a few important points without undue oversimplification.

Unlike modern English, most languages (including Old and Middle English) have few or no "silent letters". Thus the Norwegian word *time* is not pronounced at all like the English word "time"--the Norwegian word is pronounced something like "TEE-meh".

The letter **i** is usually pronounced "ih", although in the North Germanic languages **í** and **i** are often pronounced "ee". In general, **e** is pronounced "eh" in most of the sample languages, and **a** is pronounced generally closer to as in English "father" while **o** is pronounced generally closer to as in English "b**o**x"--though "long o" (**ó** or **ô**) is pronounced as in English "n**o**te". On the other hand, "o umlaut" (**ö**) and "slashed o" (**ø**) are pronounced like the "ea" sound in English "**ea**rn". The letter **y** is often pronounced with one's mouth in position to say "oo" (as in "b**oo**t"), but then trying to make an "ee" sound without changing the position of one's lips (similar to German **ü**).

Some letters or letter combinations have special sounds. The **ch** sound as in Scottish "lo**ch**" or the name of the composer "Ba**ch**" is represented by the following letter combinations:

- Old English/Gothic: **h**
- Middle English: **gh**
- Frisian/German/Dutch/Afrikaans: **ch**

Thus Old English "liht", Middle English "light", and High German "Licht" are all pronounced in very much the same way ("lih**ch**t").

In Old English, **sc** was pronounced like modern English "sh"--Dutch and German **sch** are pronounced the same way. In every Germanic language except English, **j** is pronounced like the consonant "y" in "**y**ellow" "(except in Dutch **ij** which sounds like "ee"). In High German, **s** is pronounced like English "z", and **w** like English "v", while High German **ei** sounds like the English word "eye". Italian **ce** and Spanish **che** sound something like "chay".

SUN

"Sun" is a very old word. This is because people have always needed a word to describe that big, fiery thing that appears to move across the sky.

People who spoke Indo-European six thousand (6000) years ago might have used a couple of different words for "Sun". Even then, language had changed enough in different places where Indo-European was spoken that we can't find just one word for "Sun"! Some people might have said something like "suen", while other people said something like "sáwel". Both these words start with similar sounds (su-/saw-), but have very different endings (-n or -l).

Both these words for sun were still used in Germanic, about two thousand years ago. People who spoke Germanic might have said something like "sunnón" or "suól". English (and other West Germanic languages) are descended from the language used by Germanic-speaking people who said "sunnón". One thousand (1000) years ago, the people who spoke Old English said "sunne". Other Germanic languages descended from those used by Germanic speakers who said "sunnón" (mostly West Germanic languages) have words for "Sun" which look a lot like the English word "Sun":

- West Frisian: sinne
- Dutch: zon
- Afrikaans: son
- Low German: sunne
- High German: Sonne
- Gothic: sunnô

Languages descended from those used by Indo-European speakers who said "sáwel" (and from Germanic speakers who said "suól" (mostly North Germanic languages) have words for "Sun" which look like these:

- Gothic: sauil
- Icelandic: sól
- Danish: sol

- Norwegian: sol
- Swedish: sol
- Latin: sol
- Spanish: sol
- Portugese: sol
- Italian: sole
- French: soleil
- Occitan: solèlh

Today we usually think of the sun as an "it". Sometimes people might refer to the sun as if it were a person, and often they will speak of it as if it were male (as in, "The sun is shining, and his rays are very warm."). However, people thought of the Sun as "she" for a very long time--up until the 1500s, about five hundred years ago.

SHADE AND SHADOW

Look at the words "shade" and "shadow". What do you notice about them? One thing students might notice is that they start with the same letters: shad-. They might also notice they have similar meanings: casting a shadow makes shade. If they think these words are related, they are right!

A thousand (1000) years ago, people who spoke Old English said "sceadu". This word basically meant "shade". Six hundred (600) years ago the people who spoke Middle English used the word "schade" which eventually turned into our word "shade".

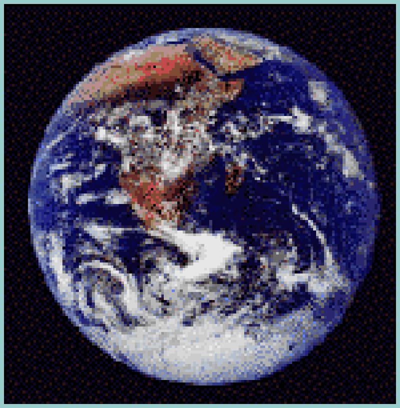
There were other forms of Old English "sceadu", though, including the oblique case form "sceadwe". [1] This eventually turned into our word "shadow". Since both "shade" and "shadow" come from one word (Old English "sceadu"), their meanings are very, very similar. In fact, you can try making sentences using only one of the words, and then try substituting in the other to see if the sentence still makes sense. Most of the time it will make sense, although it might sometimes sound a little funny. People tend to use "shade" and "shadow" slightly differently even though they mean almost the same thing. See if the students can figure out how they use both words.

About two thousand (2000) years ago, people who spoke Germanic might have said "skaðwoz" or "skadwaz" to mean "shade" (or "shadow"). [2] About six thousand (6000) years ago people who spoke Indo-European might have said "skotwós" or "skotos". This turned into words with related meanings in different later languages; the Greek word for "darkness" is very similar: "skotos". Here are words meaning "shade" or "shadow" in other Germanic languages--most only have one word for "shade" and "shadow":

- West Frisian: skaed
- Dutch: schaduw

- Afrikaans: skadu
- Low German: schadde
- High German: Schatten
- Gothic: shadus
- Irish: scáth
- Breton: scod
- Cornish: scod
- Welsh: cy-sgod

WORLD

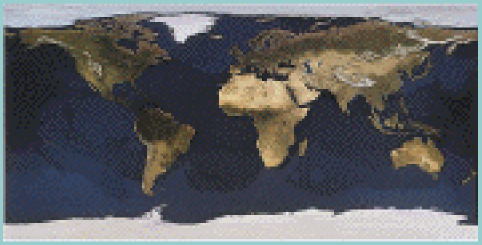


What in the world does the word "world" mean? In these Threads we mostly use it to refer to the planet Earth, which we live on. But sometimes we can use the word world with slightly different meanings. We might use it to refer not only to the planet Earth, but to include the people who live on it, or the plants and animals who live on it, or even inanimate things like lakes, rivers, and oceans. The word "world" exists only in the Germanic languages. The reason for this is that is actually the combination of two words. The first part of the word is "wer-", from Germanic "weraz" or "wiraz" which means "man"--this same element gives us the "were-" in "werewolf", which means "man-wolf". The second part of the word was from "alda", which means "old" or "age". So, when put together in Germanic, as it might have been used two thousand (2000) years ago, "werald" means "the age (or life) or man". Eventually the word came to mean "things that have to do with humanity" and the original meaning began to become less important. Later, it eventually came to refer to the planet Earth and everything in it. People who spoke Old English one thousand (1000) years ago might have said "weorold" or "worold". Here is how the old Germanic word "werald" turned out in other Germanic languages:

- East Frisian: warld
- Dutch: wereld
- Afrikaans: wêreld
- Low German: werld
- High German: Welt
- Icelandic: veröld
- Swedish: verld
- Danish: verden
- Norwegian: verden

There are many words in modern English that are made up of combinations of two other words, just like "world" (weraz + alda) and "werewolf" (were [man] + wolf) are. Perhaps the students can think of some of these. Far in the future, maybe some of the compound words will have merged so fully (like world) that it will be difficult to see what two words the originally came from. Perhaps the students can make guesses about how some of these words might one day look like. Maybe some of these words will also change somewhat in meaning (like "world" did). What might their new, but related, meanings be?

EARTH

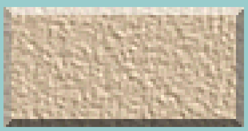


Where on Earth does the word "earth" come from? "Earth" is another word which is found almost exclusively in the Germanic languages. Probably people speaking Germanic about two thousand (2000) years ago said something like "erþó" or "erþâ". [3] This word already meant "earth" even then, and no one has any certain ideas what the word might have been like earlier or what it meant. About one thousand (1000) years ago people speaking Old English might have said "eorðe".

The word "earth" can be used to mean a number of different things. It can simply mean "dirt". This may have been one of the earliest meanings. What do we stand on? If you are inside you are probably standing on a floor, but if you are standing outside you are often standing on dirt. Perhaps, people came to think of the whole area they were standing on as "dirt" or "earth". By the time people were speaking Old English, about one thousand (1000) years ago, "earth" could already mean the world on which people live. It took longer for "earth" to come to mean "Planet Earth"--until around 1400 CE or so. Here is how the old Germanic word ""erþó"" turned out in other Germanic languages:

- Frisian: ierde
- Dutch: aarde
- Afrikaans: aarde
- High German: Erde
- Gothic: aírþa
- Icelandic: jörð
- Swedish: jord
- Danish: jord
- Norwegian: jord

LIGHT



"Light" is another word common to all the Germanic languages. About six thousand years (6000) ago, people who spoke Indo-European all used words having to do with shining or being white-colored that began with the sound "leuk-", although in different areas they may have used different endings for the word--already at that time the word was changing! People speaking Germanic about two thousand (2000) years ago probably said something either like "leuktom" or "leuksa" which meant "light". People speaking West Germanic used "leuktom", and by about one thousand (1000) years ago, people speaking Old English had changed this word to "léoht". This word slowly changed to "leht", then "liht", and finally to Middle English "light", which was spelled the same way as our word "light". Here is how "leuktom" turned out in other West Germanic languages:

- Frisian: ljocht
- Dutch: licht
- Afrikaans: lig
- Low German: licht
- High German: Licht

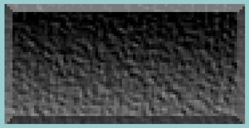
Here is how "leuksa" turned out in the North Germanic languages:

- Icelandic: ljós
- Swedish: ljus
- Danish: lys

Here is how the Indo-European basic sound "leuk-" turned out in other non-Germanic languages:

- Latin: lux
- Spanish: luz
- Portugese: luz
- Italian: luce
- Occitan: lutz

DARK

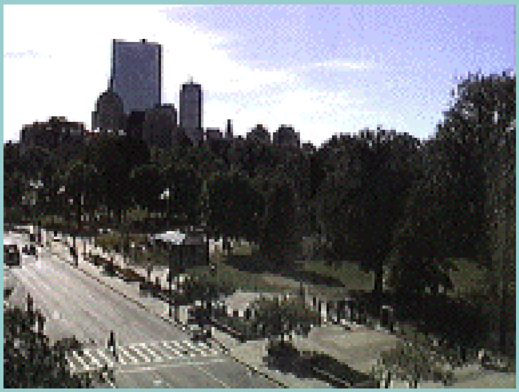


"Dark" is a strange and rare word for such a common concept. Everyone needs a word to describe the absence of light, but there are a number of different words in the Indo-European languages to describe this concept! Sometimes people make special words to describe concepts which are frightening or disturbing. Perhaps some students will admit to being afraid of the dark--such feelings may have been quite common long ago, before electric lighting allowed us to reduce the amount of dark so easily. [4]

In any case, about five hundred (500) years ago people who spoke Middle English said "derk", which was changed from the word "deorc" used by speakers of Old English about one thousand (1000) years ago.

No one knows exactly where the Old English word "deorc" came from. There is a similar word found only in Old High German (which was spoken in southern Germany about one thousand years ago) "tarchanjan", meaning "to hide" or "to conceal". You can see how the start of this word, tarch-, is similar to "dark". Perhaps speakers of Old English described the absence of light as that which hid things or concealed them. It is possible that both "tarchanjan" and our word "dark" come from a West Germanic word like "darknjan" which was used two thousand (2000) years ago.

DAY



How do we know when it is day? When the Sun is visible in the sky. This explains the origin of our word day, which seems to have come from an Indo-European form "dhegh-" or "dhegwh" which had to do with heat, burning, and times when it was warm. For example, the Sanskrit word "dah" means "to burn" and Albanian "djek" means "burnt, while Lithuanian "dagas" means "hot season".

About two thousand years (2000) ago, people speaking Germanic said "dagoz", meaning "day". People speaking Old English about one thousand (1000) years ago said "dæg". There were many different forms of this word used by speakers of Middle English about six hundred (600) years ago, including "dag", "daw" "daig", and "dai". Eventually these were simplified into our word "day". Here is how the Germanic word "dagoz" turned out in other Germanic languages:

- Frisian: dei
- Dutch: dag
- Afrikaans: dag
- Low German: dag
- High German: Tag
- Gothic: dags
- Icelandic: dagur
- Swedish: dag
- Danish: dag
- Norwegian: dag

Some other Indo-European languages have a word for "day" which sounds similar to our English word "day". Actually, these other words are unrelated to English "day", and the similarity is merely a coincidence.

- Latin: dies
- Spanish: día
- Portugese: dia

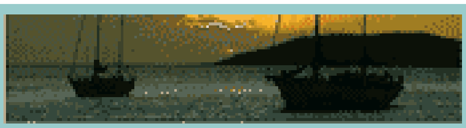
NIGHT

Compared with the word "dark", the word "night" is a surprisingly common one. Words very much like "night" appear in many Indo-European languages. Six thousand years ago, people who spoke Indo-European may have used a word like "nokt". By the time people were speaking Old English one thousand years ago, this word had only changed a little, to "neaht" or "niht". People speaking Middle English (about six hundred (600) years ago had changed the word to "nyght", which is very similar to our word "night". Here is how the Indo-European "nokt" turned out in various Germanic and non-Germanic Indo-European languages:

- Frisian: nacht
- Dutch: nacht
- Afrikaans: nacht
- Low German:
- High German: Nacht
- Gothic: nahts
- Icelandic: nótt
- Swedish: natt
- Danish: nat
- Norwegian: natt/nott
- Latin: nox
- Spanish: noche
- Portugese: noite
- Italian: notte
- French: nuit
- Occitan: nuèch
- Russian: noch'

TIME (& TIDE)

What is time? It's a thing which is so basic to our existence, that it is very hard to describe well! We all know time as the thing which a clock measures the passing of, but what it is, really? Perhaps the simplest way of describing time is to call it the system of sequential relations between events. We might also call time a period of continued existence.



Meanings like these have to do with dividing up a sequence of events into sections. Not surprisingly our word for "time" goes back to an ancient Indo-European form used about six thousand (6000) years ago: "dai-". By the time people were speaking Germanic, about two thousand years ago, "dai-" was being used in two Germanic words: "tídiz" (meaning "a division of time", and "tímon" (meaning something like "an appropriate time [at which to do something]").

The "tídiz" word became Old English "tíd" and our word "tide". In our modern English we usually use "tide" to mean the way the ocean rises and falls over periods of time (as in "high tide" and "low tide"). See how this meaning is linked to the concept of time? One thousand (1000) years ago, Old English had no one word for the ocean's tide--instead people referred to "flód" (flood or high tide) and "ebba" (ebb or low tide). A few centuries later, during the time people in England were speaking Middle English, northern Germany (where people then spoke Middle Low German) was an important center for sailors, shipping, and nautical technology. There was a Middle Low German word "getîde" which had acquired meanings which originally belonged to the ancient Germanic word "tímon" : "fixed time, proper time, opportunity". Middle Low German "getîde" also came to refer to times of the ocean's tides (which happened at fixed times, and were opportunities to use their power to help move a ship). This new meaning was borrowed for the regular Middle English word "tide" (meaning "time") in the early 1300s, when "tide" in English could refer to the *time* at which the ocean's tides took place. Within the next hundred years, by the 1430s, the English word "tide" had come to mean the tidal motions of the ocean themselves, rather than merely the times associated with these tidal motions. Middle Low German "getîde" led to modern Low German ""tîde" and Dutch "tij", both referring to the ocean's tides.

The word "tide" however, did not entirely lose all its old associations with time, even after receiving this new meaning. Even now, some old-fashioned expressions use "tide" to mean "time", like "Yuletide" or "eventide". "Tide" also survives in the slightly archaic word "tidings" (as in "glad tidings we bring") which means "news" (in the sense of "timely information"). This modern English word "tiding" (Middle English "tídung") seems to have been borrowed almost a thousand (1000) years ago from the Old Norse word "tíðendi", which meant "events". This word "tíðendi", comes originally from the ancient Germanic "tídiz" word. It is interesting to note that words related to "tiding" appear in other Germanic languages with similar meanings, such as Swedish "tidning" and High German "Zeitung", both meaning "newspaper".

Most other Germanic languages use a word that changed from "tídiz" to mean "time":

- West Frisian: tiid
- Dutch: tijd
- Afrikaans: tyd
- Low German: tid
- High German: Zeit
- Icelandic: tíð
- Swedish: tid
- Danish: tid
- Norwegian: tid

By the time people were speaking Old English, about one thousand (1000) years ago, the old Germanic word "tímon" had changed to "tíma", which could mean "time" or "opportunity". About six hundred (600) years ago, when people were speaking Middle English, this word had changed to "tyme", which is very similar to our spelling of "time".

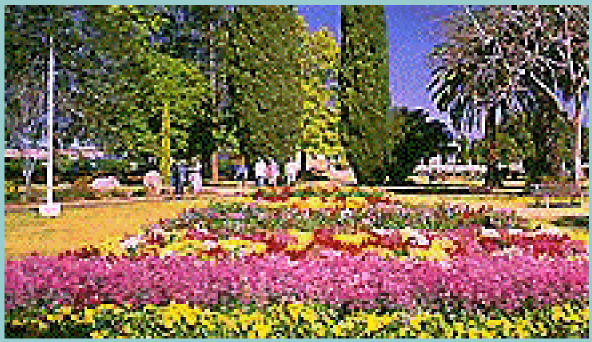
The North Germanic languages do have a word that changed from "tímon", as did our word "time". They, however, do not mean "time", but have a meaning that is related to the concept of time:

- Icelandic: tími (meaning "hour", OR "appropriate time", "lucky time" or "prosperity")
- Swedish: timme (meaning "hour")
- Danish: time (meaning "hour")
- Norwegian: time (meaning "hour")

All the North Germanic languages have changed the meaning of their word descended from Germanic "tímon" to "hour"--only in Icelandic preserves a alternate meaning very similar to the original meaning of Germanic "tímon". [5] Why? Originally, the Scandinavians (who are the people who speak the North Germanic languages) had their own system of measuring time. They did not use hours, but instead used three-hour divisions of time called eyktar or ættir. After the Scandinavians were converted to Christianity, the Roman system of time-keeping, as used my the Christian Church, was introduced to their culture. The Romans system, which used 24-hour days, is the basis of our modern system of time-keeping. The Scandinavians needed a new word for the concept of an "hour", and instead of borrowing the Latin word (as English did: Latin "hora", through Old French "oure") they altered their word which meant "appropriate time" to mean "hour" (in the sense that when it is a certain hour, that is an appropriate time for a given event). The Roman/Church method of time-keeping, however, was the high-class, learned method, and as is often the case in such situations, the older native method of time-keeping persisted side-by-side with the Roman/Church method in rural areas of Scandinavia for centuries.

On the other hand, English speakers expanded the meaning of their word "tíma" into a general word for time. It's older sense of "appropriate time" only survives in expressions like "It is **time** to go," or "It is **time** for lunch" (meaning that it is the appropriate time to go or to have lunch). When people were speaking Middle English, about six hundred (600) years ago, they sometimes used "time" to mean "hour" (as Swedish/Danish/Norwegian do) but "time" could also sometimes mean "year". [6]

SPRING



What do we call the season that follows Winter? It is Spring. Why do we call this season "Spring". Can the word "spring" have other meanings? What other meanings can the word "spring" have? It can mean "to jump" or "to leap". It can mean "a place where water comes up out of the ground" (in other words, the water *springs*, or jumps, out of the ground). It can mean "a bouncy piece of coiled metal" (in other words, the because of its shape and elasticity, the metal can *spring*, or jump, back into shape after pressure has been applied to it).

All these meanings have to do with jumping, or vigorous sudden activity of some kind. Can you guess the season following Winter is named Spring? What kind of things happen in Spring? What happens in nature? Plants begin growing quickly once the cold of winter has ended. One might say the new growing is practically *springing* up. And that is why we call this season Spring!

"Spring" is an old word, and appears in many Germanic languages with a meaning like "to jump" or "to run". About two thousand (2000) years ago, the basic Germanic form was "spreng-" and by about one thousand (1000) years ago, when Old English was spoken, the word had changed to "spryng" or "spring" and has not changed significantly since then! However, the word "spring" was only began to be used to name the season following Winter in the 1500s (about five hundred (500) years ago). People had been using expressions like "spring of the leaf" and "spring time of the year" to describe the new growth of this season, and it seems likely that the season name "Spring" was formed from such expressions.

So what did people call this season before they called it "Spring"? In fact, the common Old English word naming the season following winter was "lencten", "lengten" or "lenten". This word is related to our word "long", perhaps coming from a Germanic form something like "langiton" used about two thousand (2000) years ago. Possibly, the word was used for the season following Winter because this was the time when the Sun's path was noticeably higher in the sky and the time of daylight lengthened--you can see how similar the modern English word "lengthen" is to the Old English word "lengten"! This word survives in our Modern English "Lenten" or "Lent". This word is now most commonly associated with the Christian Lent holidays which take place in the Spring. Lenten originally was just the season name, however, and only began acquiring its Christian associations after the Anglo-Saxons (which is the name we give to the Germanic inhabitants of England who spoke Old English between about 600 and 1100 CE) were converted to Christianity. In fact, the earliest use of it in a Christian context is from around 1020 CE.

English is the only Germanic language in which a word related to "Lenten" has a Christian religious association. It was used as a common name for the Spring season which followed Winter in several other West Germanic languages: Middle Dutch "lentin" and Old High German "lengizin/lenzin". Middle Low German and Modern Dutch "lente" are closely related forms also.

However, the various modern Germanic languages use a wide variety of words for the season "Spring", many of which are related neither to "Spring" nor "Lenten"--for example, modern High German "Frühling" and Swedish "vår". This much variation in names for the same season is very surprising when compared to words for Summer or Winter, most of which are nearly the same in the Germanic languages. This suggests that the season we call Spring may not have been as important as Summer or Winter. In fact, some old Germanic cultures only counted two seasons in the year--Summer and Winter--and didn't count Spring or Fall at all.

AUTUMN & FALL

What do we call the season which follows Summer? It can have two names: "Autumn" or "Fall". Which one do the students use most often? Nowadays, the name "Fall" is probably used most often in American English, though "Autumn" is used as well. In British English, however, the word "Autumn" is used almost exclusively--British English used the word "Fall" for this season quite often, though now it is only sometimes found in some dialects of British English.

Why do you think this season might be called "Fall". What happens in the natural world during this season? The leaves on many trees die and *fall* to the ground. About five hundred (500) years ago, when Middle English was spoken, expressions like "fall of the leaf" and "fall of the year" were quite common, and the season name "Fall" comes from them. It is interesting to note that although Old English, spoken about one thousand (1000) years ago, had a word "fiæll" (or "fyll")--meaning "fall" as in "a falling from a height"--this word not only did not mean "the season following Summer", but did not even change into our modern English word "fall"! Instead our word comes from the Old Norse word "fall" which, like Old English "fyll", also meant "a falling from a height". However, during the period after the Scandinavians (who spoke Old Norse) settled in England (between 800 and 1100 CE) their word "fall" was borrowed into English and replaced the Old English word "fyll". There are many other Old Norse which were borrowed into English at this time. But the word "fall" only came to refer to the season "Fall" in the 1500s.

Before the 1500s, this season was often called "Harvest". In fact, the name "Harvest" was used for this season quite commonly up until the end of the 1700s, after which the word "harvest" began to apply more specifically of the gathering of crops. Before the 1700s, most English-speaking people had occupations which had to do with farming, and "Harvest" was quite an appropriate name for this season when the crops were gathered in. However, after the Industrial Revolution beginning in the 1700s, fewer people were working on and around farms--in our times, most English-speaking people do not work in farming. So it is easy to see why the word "harvest" became less popular as a season name. "Harvest" comes from a Germanic word something like "harbistoz" or "harbustoz", used about two thousand (2000) years ago--this may have come from an older Indo-European root "harb-", used in words perhaps four thousand (4000) years ago, and meaning something to do with crops or fruit, or with plucking. By around one thousand (1000) years ago, the Germanic word "harbistoz" had turned into the Old English word "hærfest". By the time people spoke Middle English, about five hundred (500) years ago, people were already using our word "harvest". Here is how the Germanic word "harbistoz" turned out in other Germanic languages:

- Dutch: herfst
- Afrikaans: herfs
- High German: Herbst
- Icelandic: haust
- Swedish: höst
- Danish: høst
- Norwegian: høst/haust

The word "Autumn" is a little more mysterious. It comes ultimately from Latin "autumnus", which itself is of uncertain origin. In Middle English, spoken about five hundred (500) years ago, it was spelled "autompne" having been borrowed from Old French "autompne" (found in modern French as "automne". Middle English "autompne" was sometimes used as early as the 1300s, but only became common during the 1500s.

SUMMER

What is Summer? It is when school is out! It is also the warm and sunny season of the year, when sun is up more than at other times of the year and doesn't set until late in the evening. Not surprisingly, people have needed a word for summer for a very long time. In fact, of all the words for seasons used by the people who spoke Indo-European about six thousand (6000) years ago, only one of them is still used in English: summer. The Indo-Europeans used a basic word that started "sem-". By about two thousand (2000) years ago, people speaking Germanic had taken this basic start and turned it into "sumaraz". People who spoke Old English about one thousand (1000) years ago said "sumor". People who spoke Middle English about six hundred (600) years ago used a word like "sumer" or "sommer", which has become our word "summer". Here is how the Germanic word "sumaraz" turned out in other Germanic languages:

- West Frisian: sommer
- Dutch: zomer
- Afrikaans: somer
- Low German: sommer
- High German: Sommer
- Icelandic: sumar

- Swedish: sommar
- Danish: sommer

WINTER

What is winter? It is the cold season, the snowy season--and if it isn't quite cold enough for snow it can be the wet season as well! In fact, our word "winter" is related to our words "wet", "water", and "wash". All these words come from an Indo-European basic form "wed-". People speaking Germanic, about two thousand (2000) years ago, used a word "wentruz" to mean "winter" (or "wet season"--for comparison, the Germanic word for "water" was "watar"). By about one thousand (1000) years ago, people speaking Old English had changed this word to "winter"--just like the modern word! Although it was sometimes spelled slightly differently (wynter, wintir, wintur, etc.), the word has scarcely changed at all in the past millennium. One might almost say that it had *frozen* (ha ha!).

Anyway, here is how the Germanic word "wintruz" turned out in other Germanic languages (and you can see many of them have words which are very similar to the English word "winter"!):

- Frisian: winter
- Dutch: winter
- Afrikaans: winter
- Low German: winter
- High German: Winter
- Gothic: wintrus
- Icelandic: vetur
- Swedish: vinter
- Danish: vinter
- Norwegian: vetter

However, many of us don't necessarily think of winter primarily as a wet season. Nevertheless, in some places (both in North America and elsewhere in the world) the most noticeable thing about the winter season is that it is wet! The words people use for seasons and their folklore about those seasons can vary depending on what the local weather is like. Perhaps the students can think of other names for our seasons that describe various weather or natural events that characterize those seasons.

Language Links

Here are some links about the history of English and other interesting linguistic matters:

- A Brief Look at the History of English
- History of the English Language Home Page:
- Instant Old English
- Lowlands-L
- The Early History of Indo-European Languages
- Indo-European and the Comparative Method
- Foreign Language Learning Resources
- Universal Survey of Languages
- Learn to Speak Italian (Sort of an oddball link, but entertaining enough that I couldn't leave it out!)

For Futher Reading

- Arlotto, Anthony, *Introduction to Historical Linguistics* (New York: University Press of America, 1971; repr. 1981).
- Baldi, Philip, *An Introduction to the Indo-European Languages*, (Carbondale, IL: Southern Illinois University Press, 1983).
- Buck, Carl D., *A Dictionary of Selected Synoynms in the Principal Indo-European Langauges* (Chicago: University of Chicago Press, 1949; repr. 1988).
- Burrow, J. A. and Thorlac Turville-Petre, *A Book of Middle English*, 2nd edn (Cambridge, MA: Blackwell, 1996).
- Gamkrelidze, Thomas V. and V. V. Ivanov, "The Early History of Indo-European Languages", *Scientific American*, March 1990, 110-116.
- Graddol, David, Dick Leith and Joan Swann, eds, *English: History, Diversity and Change* (New York: Routledge, 1996).
- McCrum, Robert, William Cran and Robert McNeil, *The Story of English* (New York: Viking, 1986).
- Mitchell, B. and Basil Blackwell, *An Invitation to Old English and Anglo-Saxon England* (Cambridge, MA: Blackwell, 1995). Mitchell, B. and F. C. Robinson, *A Guide to Old English* (Cambridge, MA: Blackwell, 1992).
- Robinson, Orrin W., *Old English and Its Closest Relatives: A Survey of the Earliest Germanic Languages* (Stanford: Stanford University Press, 1992).
- Watkins, Calvert, ed, *The American Heritage Dictionary of Indo-European Roots* (Boston: Houghton Mifflin, 1985).

Footnotes

[1] On the oblique case, see the Lexicon of Linguistics. Concepts like grammatical case might be a bit beyond many elementary school students, unless they are already learning a language that still uses cases like Latin or German. Suffice it to say that in Old English, people used different forms of a word depending on where they appeared in the sentence, and as time went on and the language became simpler these different forms sometimes became confused. Back to text

[2] The fourth character in "ska**ð**woz" should look like a bent-stem lower-case "d" with a bent stem which has been crossed like a lower-case "t". If you are viewing this document on a DOS/Windows machine it should look like that without trouble. If you are using a Macintosh, it may look wrong (sort of like a ">"). Macintoshes need a special font (such as Times OE) to display this and other special non-English characters. This character is pronounced like the "th" in words such as "**th**is" or "ba**th**e". It was originally invented by Anglo Saxon scribes for writing Old English, but eventually fell out of use in English writing. Back to text

[3] The third character in both "er**þ**ó" and "er**þ**â" should look like a lower-case "b" combined with a lower-case "p". If you are viewing this document on a DOS/Windows machine it should look like that without trouble. If you are using a Macintosh, it may look wrong (sort of like an "fl"). Macintoshes need a special font (such as Times OE) to display this and other special non-English characters. This character is pronounced like the "th" in words such as "Thursday" or "think". It was originally borrowed from the Germanic runic characters by Anglo-Saxon scribes for writing Old English, but eventually fell out of use in English writing. Though few realize it, the letter **þ** survives as *y* in phrases like "**Y**e Old Toy Shop". During the period when Middle English was written, the way in which people wrote **þ** slowly changed to look similar to the way in which they wrote *y*. Eventually, the distinction was forgotten! Back to text

[4] Sometimes something is considered so special--either frightening, or holy, or powerful, etc.--that people are uncomfortable talking directly about it. Often they will make a new word to describe it, and not use the old one anymore. In such cases, the old, uncomfortable word is known as a "taboo word". Something is "taboo" if people are uncomfortable referring directly to it. Many words which we now consider common began as replacements for taboo words describing special things. The word "bear", for example, is related to the Indo-European word for "brown", rather than the original Indo-European word for "bear" ("rtko-", which survives in southern European words, like Latin "ursus"). Bears were considered very special and powerful creatures and it is thought that in the northern European languages, people made a new word for them because the original word was too powerful to be used regularly.
It is not sure whether "dark" is such a word, but it might be. It makes a good introduction to talking about what people consider powerful or frightening and how they deal with it. Such concepts are often central to a culture's folklore. Back to text

[5] Although Icelandic "tími" can be used to mean "hour", the word "stund" or "klukkustund" is also common. "Klukka" means "bell", and is related to the English word "clock". Back to text

[6] The use of the word "time" to mean "year" was the result of overly literal biblical translations. It was, however, used in this fashion on occasion into the early 1800s. Back to text

---

ECT Home Page | Table of Contents |

Author Carl Anderson
Last updated August 18, 1998

GYLFAGINNING (The Deluding of Gylfi)

The Astronomical Material

by Snorri Sturluson

translated by Carl E. Anderson

Introduction | The Translation | Storybook Adaptation

The Introduction

The myths and legends of the ancient Scandinavians survive better than those of any other Germanic people. This is largely thanks to the Icelanders, who, not long after they were converted to Christianity, developed the most extensive vernacular literature of any medieval society. At first their writings were largely concerned with Christian religious materials, but in time they became interested in writing about their own culture and history as well.

The most famous medieval Icelandic writer was Snorri Sturluson (1179-1241). He wrote a number of books, including one best known as the *Prose Edda*, which contains a great deal of Scandinavian mythological material. Snorri was a great poet as well as a great writer, and he preferred an old-fashioned kind of poetry that made much use of the pre-Christian Scandinavian mythological material. During Snorri's times, however, the Christian Church strongly discouraged anything that was connected with the heathen past. Partially because of this, the kind of poetry Snorri liked was becoming unpopular and was being replaced by new styles of poetry.

Snorri wrote the *Prose Edda* as an instruction manual on how to write the kind of old-fashioned poetry he liked. He included lots of the old myths and stories so that people would know how to use them in the poetry. As a Christian himself, Snorri did not want to present the myths as if he believed them. So he started the *Prose Edda* with a story of his own about a king of Sweden called Gylfi who disguised himself as a traveler called Gangleri and went on a journey to visit the Æsir and gain knowledge from them. The Æsir were the old Scandinavian gods, but Christian Snorri described them simply as very powerful men. When Gylfi/Gangleri found the Æsir, he asked them many questions about the creation of the world and the beings who lived in it. The Æsir responded with many myths and stories. Snorri writes that the Æsir were trying to trick Gylfi/Gangleri into believing these stories--in this way he can write all about the old heathen myths without getting into trouble with the Christian Church. This is why the first section of the *Prose Edda* is called "The Deluding of Gylfi" (or, in Old Norse, *Gylfaginning*).

Snorri explains the mythological material by having Gylfi/Gangleri ask a question of the Æsir, and having one of the Æsir answer with a long story or some other mythological information. The Æsir whom Gylfi/Gangleri asks his questions of are called High One, Just-as-High, and Third.

It is difficult to tell how genuine the myths Snorri wrote about are. By the time Snorri was writing, Icelander had been Christian for over two hundred years and many of the old stories may have been forgotten or changed. Snorri probably tried to piece many bits and pieces of myths together as best he could. Snorri, however, was very learned in Biblical and classical (Greek and Roman) studies and this knowledge may have affect the way he rebuilt the myths. He may even have made some things up! Because of this, we need to keep in mind, when reading his material, that the myths we are reading may not be exactly the same as the myths told by pre-Christian Scandinavians.

Since *Gylfaginning* is very long, only sections about the Sun, Moon, and seasons are translated below. Explanatory notes are included to explain the material more fully.

The Translation of *Gylfaginning*

[The Æsir have told Gylfi that three brothers--Óðinn, Vili, and Vé--killed an enormous giant called Ymir. They took various pieces of Ymir's body and made the world out of them. Below, Third tells Gylfi about how the three brothers created the sky and the astronomical bodies in it.]

Then Third says: They [Óðinn, Vili, and Vé] took his [Ymir's] skull and made the sky from it and set it up over the earth with four corners, and under each corner they set a dwarf. These are called so: Austri, Vestri, Nordri, Sudri. Then they took the embers and sparks that flew loose and had been cast from Muspell's World[1] and set them in the midst of Mighty Space[2], both above and below, to light the sky and Earth. They gave places to all fires, to some in heaven; some flew loose under the sky and yet they set their places and shaped their paths. So is it said in old poems that from this were the days and the year-count reckoned, as it says in Völuspá:[3]

> The Sun knew not
> where she had her halls.
> The Moon knew not
> what might he owned
> The stars knew not
> where their places were.

So it was above the Earth before this took place.

[...]

Then says Gangleri: It seems to me that they had then accomplished much when earth and the sky were made, and the sun and heavenly bodies were set, and the days divided--and from where came the men who inhabit the world?

Then answers High One:

[High One talks for a while about how humans were created. Then he talks about some of the gods, and where they lived. Below he talks about the Sun and Moon.]

N&oumlrfi or Narfi was the name of a giant who lived in Giantland[4]. He had a daughter who is called Night.[5] She was swarthy and dark, like her relatives. She was married to a man who is called Naglfari.[6] Their son is called Auðr. Next she was married to someone called Other.[7] Their daughter is called Earth.[8] Last she wedded Shining One, who was related to the Æsir.[9] Their son was Day.[10] He was bright and fair like his father. Then the All-father[11] took Night and her son Day and gave them two horses and two chariots and set them up in the sky so that they should ride around the world every two half-days. Night rides in front with the horse who is called Frosty-Mane[12], and at morning every day he bedews the earth with drops of foam from his bit. That horse whom Day owns is named Shining-Mane[13], and light is shed over all the air and the earth by his mane.

Then says Gangleri:

How does he steer the path of the sun and moon?

High One says:

A certain man who was called Mundilfari had two children. They were so fair and beautiful that he called one of them Moon but the other, his daughter, Sun, and married her to that man who is named Glenr. But the gods were angered by that arrogance and took the siblings and set them up in the sky, they made Sun drive that horse who drew the sun's chariot which the gods had shaped to light the world from an ember which flew from Muspell's World. Those horses are named like so: Early-Waker and All-Strong. But under the the horses' shoulders the gods set two bellows to cool them, but in some sources these are called "iron-coal".[14] Moon steers the moon's course and controls its waxing and waning. He took two children from the earth, who are so named: Bil and Hjúki, when they were going from the spring which is named Byrgir, and were bearing on their shoulders the tub which is named Sœgr, and the pole Simul. Their father is named Viðfinnr. These children follow Moon, as may be seen from earth.

***

Then says Gangleri: The sun moves fast, and almost as if she were afraid, and she could not speed her course even if she feared death.

Then answers High One: It is not surprising that she goes at a great speed: that one who seeks her follows closely. And she has no way out except to run away.

Then says Gangleri: Who is it that makes her this trouble?

High One says:

There are two wolves, and the one which is after her is named Sköll. He frightens her and he will catch her, but the one which runs in front of her is named Hati Hróðvitnisson, and he wants to catch the moon, and so must it be.[15]

[...]

Then says Gangleri: Why is there such a great difference, that summer should be hot but winter cold?

High One says:

A well-informed man would not ask this, because this is known by all, but if you alone have become so lacking in knowledge that you have never heard this, then I think it better that you ask unknowingly once than that you should be ignorant any longer of something which it is proper to know about. He is named Agreeable, who is Summer's father, and he is so fortunate in life that that which is pleasant is so named from him. But Winter's father is either called Wind-Bringer [16] or Wind-Cool.[17] He is Damp-Cold's son, and these kinsmen were grim and cold-hearted, and Winter has their character.

[Gangleri/Gylfi goes on to ask High One, Just-as-High, and Third many things about the nature of the universe and the gods and heroes of Scandinavian mythology. In the end, High One, Just-as-High, and Third tell Gangleri/Gylfi about the way in which the universe will be destroyed--but they also tell him how it will be renewed. Above, they told him about the wolf chasing Sun, and how it will catch her at the time when the universe is being destroyed. But High One goes on to tell Gangleri/Gylfi this:]

And you will seem strange to you but that the sun will have a daughter no less fair than herself, and she will travel in in her mother's path, as it says here:

> Elf-glory[18] bares a daugher
> before Fenrir catches her.
> The maid shall ride,
> when the powers die,
> the mother's road.

But now if you can ask anything more, then I do not know from where an answer will come, because I never heard any man tell at greater length the story of the universe. And now use it as you can.

Footnotes:

1 Snorri has Third describe Muspellsheimr (or Muspell) in this way: "It is light and hot and that region flames and burns so that those who do not belong to it and whose native land it is not, cannot endure it." Back to Text

2 Ginnungahimin (or Ginnungagap) was the name for the primal, undifferentiated cosmos that existed before everything else and was the source for all things. *Ginnunga* means something like "magical, mighty" and *himin* literally means "heaven". Back to Text

3 *Völuspá* ("The Sibyl's Prophecy")was poem describing the beginning and end of the world. It is part of a collection of mythological and legendary poems called the *Poetic Edda*. Although it describes Scandinavian myths, many scholars believe its material was influenced by Christianity. Back to Text

4 Jötunheimr. Back to Text

5 Nótt. Back to Text

6 Old Norse *nagl* means "nail", but this is may be a folk etymology for a form related to Latin *necare* (meaning "to kill"). Back to Text

7 The name Annarr seems to be the same as the word *annarr*, meaning "other, second". Back to Text

8 Jörð. Back to Text

9 The Æsir are one of the families of the Scandinavian gods. Back to Text

10 Dagr. Back to Text

11 All-father is a name for Óðinn. Back to Text

12 Hrímfaxi, literally "Rime-Mane". Back to Text

13 Skinfaxi. Back to Text

14 Old Norse *Ísarnkol*. This is sometimes simply translated as "bellows". The meaning seems to stem from the understanding of bellows as tools from a blacksmith's forge. Some experts think that "iron-coal" may be a mistake in the original text of the story for "iron-cold". Back to Text

15 The poem *Völuspá* describes the destruction of the world when the sun and moon are devoured by these wolves. Back to Text

16 A possible meaning of the name Vindlóni. Back to Text

17 Vindsvalr. Back to Text

18 A name for the Sun. Back to Text

The Storybook Adaptation

Gangleri: A King's Search for Answers

by Tania Ruiz

Based on a translation from the *Prose Edda*

A very very long time ago, there was a king named Gylfi. Gylfi was a king of Sweden, and he lived among his people there happily for many years. The Swedish people trusted their king and expected him to know answers to all questions. But Gylfi soon found that the questions his people asked of him were becoming too diificult for him to answer himself. The people wanted to know where the Sun came from, why it got so cold in the winter, and what will happen to the world in the future. Gylfi did not know the answers to these questions, and felt he could not be a good king for his people until he knew all things. Isn't it sad that Gylfi should feel this way?

So, one night, Gylfi secretly left his home in his kingdom and went on a long journey. He was going to see the gods called the Aesir. Gylfi said to himself as he walked, "They would know the answers. They will help me to be a better king." Gylfi was a bit worried about going to see the Aesir. He was afraid that if they found out he, a king, did not know so many things, they would punish him or take away his kingdom. So, Gylfi decided to call himself Gangleri instead. He trekked on with his new name, practicing all of the questions he would ask the Aesir. Soon he reached the hall of the gods.

Three Aesir greeted him when he arrived, and he told them his new name, but not his real name. Their names were High-One, Just-as-High, and Third. "We greet you, Gangleri. You have traveled far to see us. What is it that you need from us?" High-One said.

Gylfi was very excited, these Aesir seemed rather friendly, and blurted right out, "I would like to know how the world began!"

The Aesir looked at him strangely, and then Just-as-High told Gangleri of the three mighty brothers, Odinn, Vili, and Ve: "It was once that the universe was cold, all ice and snow, and the ruler of this place was an enormous giant named Ymir. Ymir was also the universe, do you understand?"

Gylfi frowned for bit. He thought maybe he understood, but was not sure. High-One raised an eyebrow and grinned, saying, "You are still confused. The whole universe was a cold giant named Ymir. Because he was the universe, he ruled it, see?"

Gylfi's frown flatted until he smiled, "Yes, I see. Yes..."

Third sniggered a bit. Gylfi heard this, and blushed. It is not very nice to make fun of people who do not understand.

Just-as-High continued, "There was only ice to eat, so a giant cow fed Ymir milk all day to keep him alive."

Gylfi interrupted, "What did that poor cow eat, if there was only ice?"

Third smirked, and whispered something to Just-as-High. Gylfi was more nervous than ever, and began to wring his hands a little. It was a good question, really.

High-One cleared his throat and said, "Well she licked the ice, see?"

Gylfi nodded with furrowed brow. His hands were all sweaty.

Just-as-High began again, this time speaking in a very slow way, "She found people in the ice when she licked it."

Just-as-High stopped, looked at Gylfi. Gylfi motioned for Just-as-High to continue. He completely understood that a cow could like people free from ice. Why just the other day...he began to think to himself, but Just-as-High went on, "The grandchildren of these people were three boys named Odinn, Vili, and Ve. They were so very powerful that we, as gods you know, decided that these boys should rule over the universe."

Gylfi was concerned, "Uh, what about Ymir, the giant?"

High-One widened his eyes, and clapped Gylfi on the shoulder, "Good question, Gangleri! Very good question. When these three boys grew to be men, they decided to kill the giant."

"Oh," Glyfi said, thinking that was a rather rude thing to do to the giant who spent all of his life lying in the cold snow and having only milk for food.

Third began, sensing Gylfi's unhappiness with Odinn's choice, "Well, they needed to do this, Gangleri. Imagine being a man like Odinn or his brothers and trying to live in a universe made of a huge frozen giant who drinks milk all day."

"You've got a point there," said Gylfi. High-One and Just-as-High shook their heads in agreement.

Third continued, "Well, Odinn and Vili and Ve had to use the giant's body to make the whole world, since there was little in the universe but him. They took his huge skull and made the sky. To keep the sky hanging above the earth, they made four dwarfs stand at the corners. The dwarfs were called Austri, Vestri, Nordri, Sudri."

"East, West, North, and South...oh, yes, I see..." mumbled Gylfi.

"Odinn and his brothers took embers from distant very hot and fiery lands and put them up into Mighty Space so they could exist over the sky and the Earth. A chariot called Sun was made of embers and sent across the sky to measure a day. A chariot called Moon also raced across the sky. In the time before Odinn:

> The Sun knew not where she had her halls.
> The Moon knew not what might he owned.
> The stars knew not where their places were.

Now, the length of a day and the count of the year was found from the hard work of Odinn, Vili, and Ve! This is why they are rulers and gods, and not the lazy Ymir!"

Gylfi smiled proudly, for he himself and his people were all great-great-great grandchildren of the resourceful brothers. He was standing there for some time, smiling, when he realized that Third had stopped talking. Gylfi looked up to see the three great Aesir staring at him expectedly.

He remembered his other questions. "Uh, well, I am wondering what happened to the universe after Odinn created it? And then where did light and dark come from?" Gylfi asked.

High-One spoke long about how humans were created and where the gods came to live. He got to the part about the Day and Night, and Gylfi listened very carefully.

"Narfi was the name of a very dark giant who lived in Giantland. He had a daughter whose name was Night, and she was also very lovely and dark. She was married to a man called Naglfari. They had a son called Audr. Her second husband was called Other, and together they too have a daughter, named Earth. Her last husband was called Shining One, a relative of ours, actually," High-One smirked proudly, and continued, "and they had a son called Day."

Gylfi tried to keep track of all of the children and husbands.

High-One then said, "Odinn took Night and her son, Day, and gave them each a horse and chariot. He set them in the sky and told them to ride around every two half-days. Night was to ride in her chariot at the front with her horse Frosty-Mane. Every morning the foam Frosty-Mane makes from chewing his bit falls to the earth and makes the morning dew."

"Yuck," said Gylfi, and promised he would never walk barefoot in the morning grass ever again.

Third giggled, and Just-as-High thumped him in the chest.

"Day rides behind in his chariot with his horse called Shining-Mane. His glowing mane sheds light over the air and Earth." High-One finished.

Gylfi was then wondering about the gods of Sun and the Moon, and how they fit in with all of the horses and chariots and embers and things.

High-One answered again, "A certain man who was called Mundilfari had two children. They were fair and beautiful. He called them Moon and Sun. The gods were angry with Mundilfari because he called his children after the names Odinn had given to the ember chariots! As punishment, the gods took Muldilfari's children and made them work in the sky. Sun was made to drive the speedy horses of the Sun chariot, which was very difficult, since the chariot was very hot, filled with embers! So the gods kept the horses, named Early-Waker and All-Strong, cool by putting bellows underneath them. Poor Moon was made to steer the Moon's course across the sky and control its shape."

Gylfi wondered about poor Sun driving those horses, keeping them so cool at the same time. He knew the Sun could move very fast across the sky. He was so curious, he finally asked, "Why does the Sun move so fast?"

Third and Just-as-High seemed alarmed at this question. High-One laughed, and said, a bit sarcastically, "Well, it is not surprising she goes so fast, considering who is following her so closely! She has no way out except to run away!

Gylfi felt very very stupid, but he had to know, "Who is it that makes her this trouble?"

Third fell off of his seat laughing and excused himself. Just-as-High sighed deeply.

"Ahem, Gangleri, everyone knows that there are two wolves surrounding her. The one who is behind her is Skoll. He frightens her and he will eventually catch her, when the world ends. The one in front of her is Hati Hrodvitnisson, and he is running after the moon. He will catch it, of course, when the world ends. It is so in the Great Poem, Gangleri."

Gylfi was so very nervous. He knew about the wolves, really. He didn't realize that they were chasing Sun and Moon all of this time. He thought they only showed up at the end of the world, when they eat Sun and Moon. He looked down at his feet and shivered a bit, thinking about the end of the world always made him cold. Cold....winter was coming soon to his kingdom, and the people would ask him again why it was so very cold.

Third returned from wherever he had wandered off, and sat back down, wiping his eyes a bit and coughing. Just-as-High nudged him a bit.

Gylfi swallowed very hard and thought about all he had learned. There was a lot of warmth coming from the embers, so much that the horses carrying the chariot had to be cooled! So why should it get so cold on Earth in the winter with all of that heat driving about in the sky? He had to ask this last question of the Aesir. He had to know not just for his people.

Gylfi took a deep breath, closed his eyes so he could not see them smile, and asked, "Why is there such a great difference that summer should be hot but winter cold?"

When they heard this, the Aesir were very surprised. Third laughed so hard he nearly choked to death. Just-as-High sat in his chair with his mouth open so wide that Gylfi could see all of his teeth. Even the High-One seemed annoyed and shocked.

Gylfi felt about three inches tall and slumped. He wanted to crawl away and leave this place. To Gylfi these gods seemed to find his lack of knowledge amusing. But how is one ever to know a thing if one does not search for the answer or ask for one?

However, eventually High-One said to Gylfi, "A well-informed man would not ask this, because this is known by everyone. But if you alone have come so lacking in knowledge that you have never ever heard this, then I think it is better that you ask just this once than forever not know this."

Gylfi shook his head in agreement, that's why he was here: to learn not to be tested. He listened carefully.

"Summer's father, named Agreeable, is so fortunate in life that his name is used to describe everything in the world which is nice and pleasant. So Summer grew up to be this way. But Winter's father is grim and mean, and he is called Wind-Bringer or Cold-Wind. That's why Winter himself is so nasty and grim."

Gylfi didn't think this really answered his question. He was about to open his mouth, but High-One said, "If you can ask anything more, then I do not know from where an answer will come. I have never heard any man tell more about the universe than I just have. Go, Gangleri, and use this as you can."

Third made shoo-shoo gestures towards Gylfi, and Just-as-High still sat with his mouth gaping. High-One waved cheerily to Glyfi, and the three Aesir disappeared. Gylfi was left in an empty room. He found the door and headed back home to his people with all of the new information he had found. It all sounded so fanstastic, so many fathers and children and horses and things. But at least he had decided to seek answers, and he would have lots to tell his people when next they asked.

Everyday Classroom Tools Home Page | Table of Contents

Native American Lore Index Page

Below are links to several stories of Native American Indian Lore from several Tribes across Turtle Island. If you have a story of Native Indian Lore you would like to have posted here, send it to me with as much information about the Lore that you can, and I will post it with others found here. Help me to make this site the best Lore site on the Web .

Id like to extend a warm welcome to all those visiting from either Discovery School Magazine project or Animal Planet. Osiyo Oginalii, Ulihelisdi Owenvsv.... Cherokee for Greetings Friend, welcome home.

Our site has been selected as a valuable Internet resource for Discovery Channel School's Discover Magazine theme for fall 1997

01. Buffalo and the Mouse
02. Origin of the Buffalo Dance Blackfoot
03. Comrades
04. The Raccoon and the Bee-Tree
05. Big Long Mans Corn Patch
06. How Coyote Stole Fire
07. The Frog and the Crane
08. The Falcon and the Duck
09. How Fly Saved the River Anishnabeg
10. Geow-lud-mo-sis-eg : Little People Maliseet
11. How Glooskap Found the Summer
12. The Origin of Light Inuit
13. The Magic Arrows
14. The Runnaways
15. The Legend of Wountie Squamish

136. **Origin of Tobacco Crow and Hidatsa**
137. **THE PET DONKEY Sioux**
138. **THE FORGOTTEN EAR OF CORN Sioux**
139. **THE HERMIT, OR THE GIFT OF CORN Sioux**
140. **Legend of the Cedar Tree Cherokee**
141. **The Wolf Dance**
142. **Hero with the Horned Snakes Cherokee**
143. **Return of Ice Man Cherokee**
144. **A LITTLE BRAVE AND THE MEDICINE WOMAN Sioux**
145. **STORY OF THE LOST WIFE Sioux**
146. **THE ARTICHOKE AND THE MUSKRAT Sioux**
147. **THE STORY OF THE PET CRANE Sioux**
148. **The Origin of Strawberries Cherokee**
149. **THE MYSTERIOUS BUTTE Sioux**
150. **UNKTOMI AND THE ARROWHEADS Sioux**

---

back to Fall Color

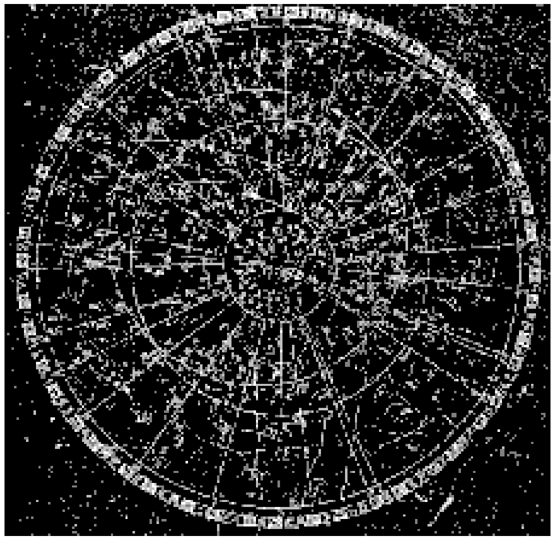
North Carolina Traditional Weather Lore

Back in the early days, when plants and animals were first made, they were told to fast and stay awake for seven days to gain spirit power. All were anxious to gain power so they tried to do as instructed and most were able to stay awake through the first night. The next night some started to fall asleep, and by the third night many of them were asleep. By the seventh night, only a few of the animals were awake. The panther, the owl and one or two others managed to stay awake and as their reward they were given the power to see and go about in the dark. Many of the plants also fell asleep and of the trees, only the cedar, the spruce, the pine, the holly, and the laurel were able to stay awake. As their reward, these were allowed to be always green, while the others must lose their leaves in the fall.

James Mooney, in his important work,
History, Myths, and Sacred Formulas of the Cherokee,
relates the Cherokee's explanation for fall.

These are some of the more popular North Carolina folk sayings about autumn and the weather. Many variations exist and have been reported in numerous sources, including the *Old Farmer's Almanac*, the *Foxfire* series, and the collections of the NC Folklore Society. All of them are guaranteed to be true (sometimes).

- A warm November is the sign of a bad winter.
- Thunder in the fall foretells a cold winter.
- If animals have an especially thick coat of fur, it will be a cold winter.
- When squirrels bury their nuts early, it will be a hard winter
- If the woolly worms head is more black than colored, the coldest part of the winter will come in the first months of winter.
- The more black than brown a wooly worm has, and/or the wider the black stripe, the worse the winter.
- If fruit trees bloom in the fall, the weather will be severe the following winter.
- If berries or nuts are plentiful, it will be a hard winter.
- A cold winter is succeeded by a warm winter and vice versa.
- If the first snow falls on unfrozen ground, expect a mild winter.
- It will be a bad winter if trees keep their leaves until late in the fall
- Hornets nest built in the tops of trees point to a mild winter.
- The first twelve days of the year are thought to foretell the weather for each of the next twelve months. The variant is the 12 days from new Christmas (Dec. 25) to old Christmas (Jan. 5) determine the weather.
- If an owl hoots on the east side of a mountain it denotes bad weather.



Star Charts and Moon Stations

By Steve Renshaw and Saori Ihara

Revised June, 1998

Until the Meiji Restoration, charting of the heavens in Japan (like most astronomical observation) was closely tied to divination and calendar reckoning for astrological purposes. While there were some variations in choice of stars, delineation of asterisms by Japanese chart makers closely followed traditions and developments in China. For ancient Chinese and later Korean and Japanese cartographers, four talismanic animals marked the four seasons and four cardinal directions... the Azure Dragon of the East (Spring), the Red Bird of the South (Summer), the White Tiger of the West (Fall), and the "Genbu" (Black Tortoise) of the North (Winter) [actually there were five, the other "direction" being "center"... earth]. Corresponding to each of the celestial "palaces" were seven "stations" of the moon. Moon "stations" or "lodges" were of course, based on the daily (or nightly) position of the moon among the stars. Origins of these associations are somewhat obscure and even controversial. In China, they appear to be at least 3500 years old, some estimates dating much earlier. In Japan, their first confirmed "existence" is found in the 7th century (probable dating) Takamatsu Zuka Kofun (Pine Tree Burial Mound) and the recently explored Kitora Tomb.

Determination of the talismanic animals and associated star "palaces" together with the associated 28 *sei shuku* or moon stations represent some of the most complex aspects of Asian "astronomy". The associations have not only been adapted over the centuries but are also tied to the astrology of each culture. Cultures using these associations were/are located in the Northern hemisphere for the most part. An apparent anomalie is the fact that the actual positional path of the sun seems to move in a direction opposite the seasonal associations of Spring and Fall. While "Genbu" (translated as the black tortoise of winter, a name which fails to really convey the fearsome nature of this snakelike shelled "creature") and the red bird of summer have the sun nicely positioned in them during their respective seasons, the white tiger of autumn and blue dragon of spring lie "opposite" the sun's actual perceived path. While Staal (1984) argues that this is due to the animals and moon stations being created some 17 to 18 millennia ago (precession creating the anomaly), there is actually little archaeological and certainly no written evidence to indicate that this kind of system was in use at such an early time; this also does not really explain the apparent "backward" motion of the sun through seasons. More likely, moon stations may have been among the first delineated constellations and were perhaps used as markers for seasonal change; they were subsequently incorporated into a more complex mathematical division of the "heavens" (months, principle and sectional terms, etc.). They quite possibly were used in conjunction with the direction to which the handle of the big dipper (often called the "North Seven Stars" in China, Korea, and Japan) pointed at the equinoxes and solstices. In other words, the "North Seven Stars" were probably used as an actual "time piece" for determination of season. Before the Christian Era, when the *sei shuku* were created, the "North Seven Stars" did not appear to "set" (with precession, they had a relatively "higher" position than now). Thus, they could be seen and used in conjunction with the *sei shuku* as such a seasonal "time piece" year round (see Yoke, 1985, for further explanation in English). Looking toward the North, the handle of the "North Seven Stars", when viewed each evening at an ideal time, appeared to rotate in a counterclockwise manner through the year, apparently in opposite direction to the sun's movement through the ecliptic and moon stations. The reader may find some visual explanation of this anomaly by looking at the charts accompanying the links to seasonal animals. At any rate, with precession, their function probably took on more and more of an astrological function as centuries progressed, and this was certainly their primary "function" as they found their way to Japan in the early centuries A.D. (see Nivison's 1989 article for an excellent discussion in English of various aspects and "problems" related to the origin and development of the *sei shuku*).

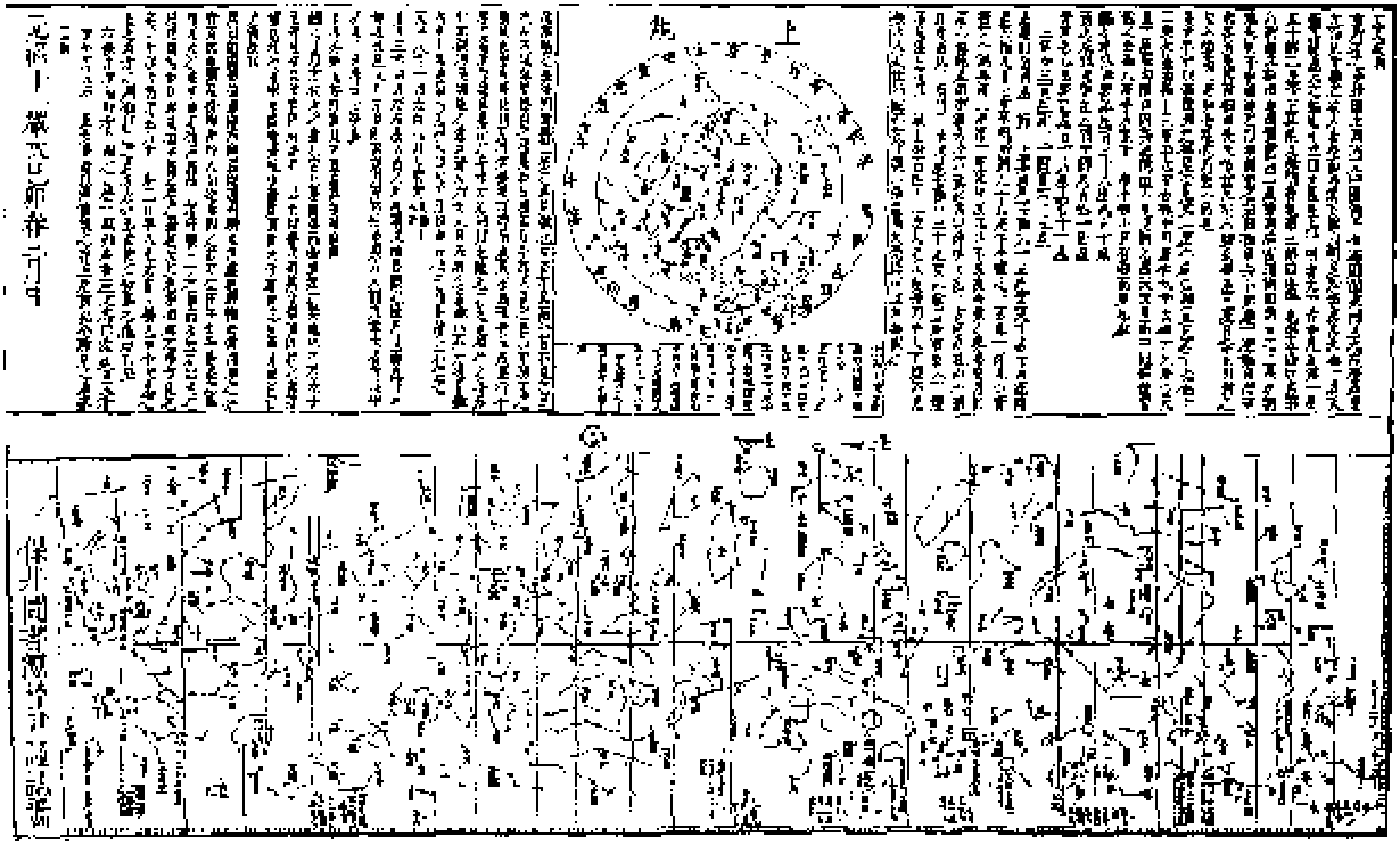
In many ways, these associations reflect the mirror or "shadow" relation of earth to sky... human to nature... nature to cosmos... that was so prominent in pre-scientific cosmologies in this part of Asia. At times we are looking at earth from the perspective of the emperor; that is, we are in the North, South is opposite, East is to the left, and West is to the right. At other times, we are looking toward the North, from the earth, and reading the signs of stars relative to our previously defined "earthly" directions.

Like myths and traditions in Western cultures, these views still wield influence in the daily life of people in China, Korea, and Japan... this despite quite prominent scientific literacy. However, it should be pointed out that astrological divination in China, Korea and Japan was and is rather complex. It took and still takes into account many "elements" of sky **and** earth, an elaborate geomancy including but certainly not limited to the position of some celestial body within a given constellation at a person's birth. It is difficult to argue that the system is not intellectually rich, and it no doubt had pragmatic use in both affairs of state and "common" person. However, it is somewhat sad that in the long history of China, not to mention the curious but rather isolated Japan, such concentration on astrological matters held attention much longer than in the West, thus retarding at times significant scientific advances in astronomy (see Calendar Reform in Japan). Many gifted minds were and perhaps still are wasted in such divination.

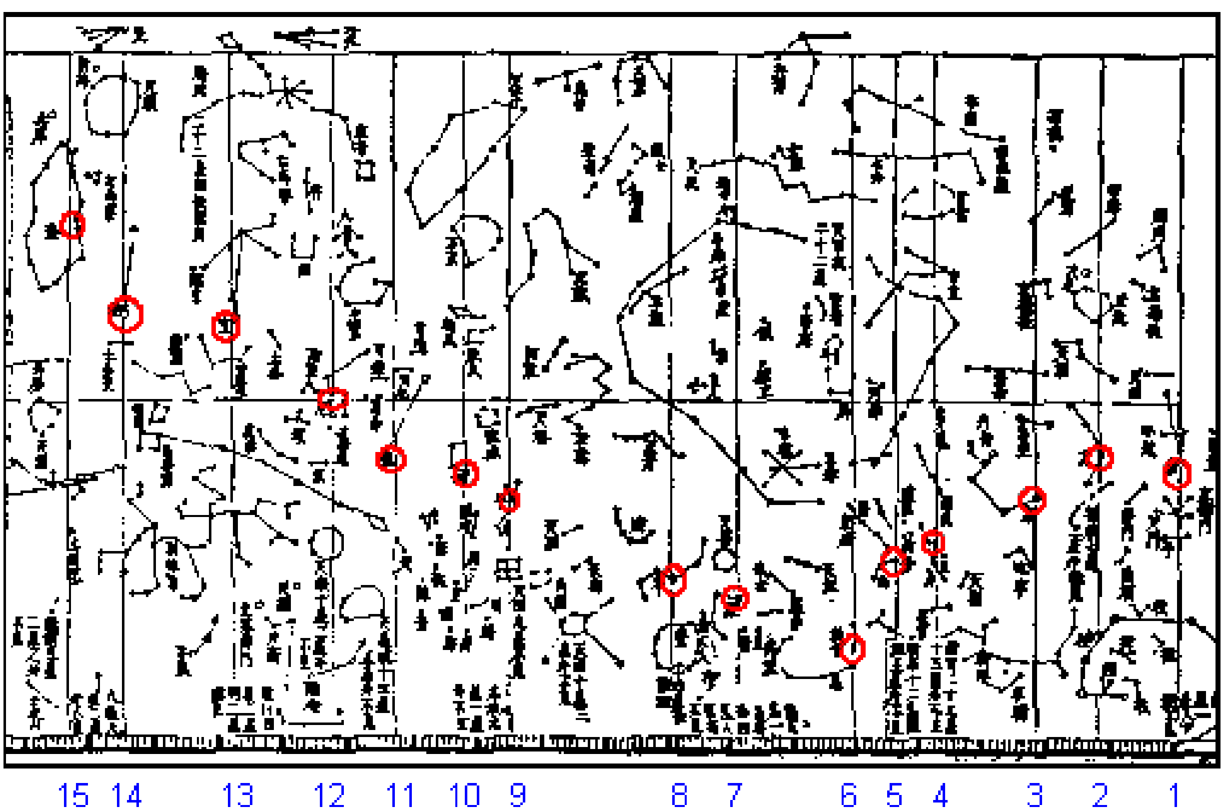
That said, lore related to moon stations is one of the most interesting aspects of Asian Ethnoastronomy. Somewhat similar to Chinese but perhaps even more, Japanese interpretations of these associations tended to revolve around agricultural needs and animistic views of nature. Unlike many Western myths and traditions, there were few if any perceptions in the myths of "active" god(s) creating or wreaking good or bad on the cosmos and/or humankind. Rather, especially in Japan with its Shinto base, gods like the talismanic animals were seen as manifestations of nature... stars and celestial events were signs of change in season, life, politics, etc... perhaps most often portending "bad" but sometimes "good" as well.

Below is an example of a star chart from Edo Era Japan. Also linked from this page are charts generated from ***The Sky*** which show the stations and associated key stars more clearly for each of the four talismanic animals. Kanji, meaning, and Japanese name are also provided. While there is an abundance of national and local Japanese lore associated with the *sei shuku*, many of the origins of Japanese names have been lost. There is no way we can do justice to this complex system (especially with regard to its Chinese roots) in a web page article. Readers who are interested in more information in English about origins as well as views of all Chinese constellations associated with the segments of moon stations might want to look at the Nivison work referenced above and the work of Yoke (1985). While Staal (1984) does an admirable job of relating Chinese constellation lore, his speculations and interpretations should be viewed cautiously, especially with regard to origin and meaning of Chinese characters.

Example Old Chart with Moon Stations



A 1699 Star Chart by Harumi Yasui



Close-Up of Yasui's Map Showing the First 15 Moon Stations

The "KyoSei" or key star for each Moon Station is circled in red. The key star for Station 1 is Alpha Vir (Spica).

Charts of Seasonal Animals with Moon Stations

The Azure Dragon of the East (Spring)

The "Genbu" (Black Tortoise) of the North (Winter)

The White Tiger of the West (Fall)

The Red Bird of the South (Summer)

References

Hara, M. (1980) ***Seiza no Shinwa***. (The Mythology of Constellations). Kouseisha Kouseikaku Co. Ltd., Tokyo.

Hirose, H. (1972) ***Nihonjin no Tenmonkan***. (The Japanese Astronomical View). NHK Books, Tokyo.

Izuru, S. (Ed.) (1994) ***Koujien***. (Japanese Etymological Dictionary). Iwanami Shoten, Tokyo.

Nakano, S. (1995) ***Hyoujun Seizu 2000*** (Standard Star Atlas 2000). Chijin Shokan, Tokyo.

North, J. (1995) ***The Norton History of Astronomy and Cosmology***. W.W. Norton and Co., New York.

Ootawara, A. (1995) ***Tentai Kansoku Hando Bukku*** (Astronomical Observer's Handbook). Seibunsha, Tokyo.

Ozaki, U. *et al*(Eds.) (1993) ***Dai Ji Gen*** (Great Origins of Words). Kodokawa Shoten, Tokyo.

Nakayama, S. (1969) ***A History of Japanese Astronomy; Chinese Background and Western Impact***. Harvard University Press, Cambridge, Mass.

Nivison, D.S. (1989) The origin of the Chinese lunar lodge system. In Aveni, A.F. (Ed.) ***World Archaeoastronomy***. Press Syndicate of the University of Cambridge, New York, pp. 203-18.

Pannekoek, A. (1961) ***A History of Astronomy***. Interscience Publishers, Inc., New York.

Staal, J.D.W. (1984) ***Stars of Jade: Calendar Lore, Mythology, Legends and Star Stories of Ancient China***. Writ Press, Decatur, Georgia.

Shunichi, U. *et al* (Eds.) (1991) ***Nihon Zenshi; Japan Chronik***. Kodansha, Tokyo.

Watanabe, T. (1987) ***Kinsei Nihon Tenmon Gakushi; Vol II: Kansatsu Gijutsu Shi***. (A View of Japanese History of Astronomy in Modern Times; Vol II: Techniques of Observation). Koseisha Kosaikaku, Tokyo.

Yoke, H.P. (1985) ***Li, Qi, and Shu; An Introduction to Science and Civilization in China***. Hong Kong University Press, Hong Kong.

Zhentao, X., K.K.C. Yau, and F.R. Stephenson (1989) Astronomical Records on the Shang Dynasty Oracle Bones. ***Archaeoastronomy***, Number 14; Supplement to ***Journal for the History of Astronomy***, Volume 20, pp. S61-S72.

Please send comments to

Steven L. Renshaw

Return to Astronomy in Japan Home Page

明けましておめでとうございます

The Sun, the Moon, and Happy New Year in Japan

Steve Renshaw and Saori Ihara

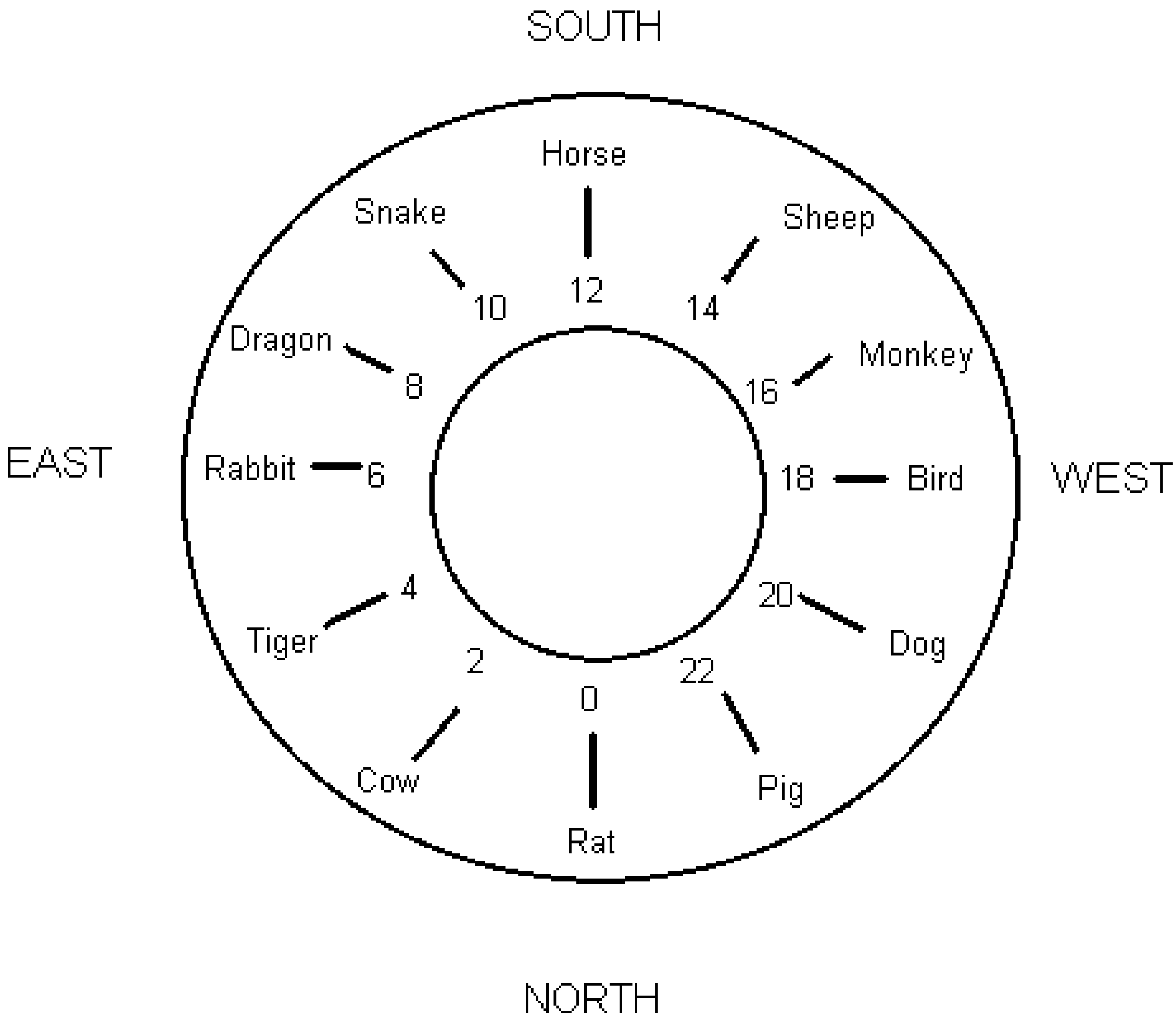
Revised January, 2004

[Based on an article which appeared in ***Appulse; Bulletin for the Philippine Astronomical Society***, Vol. 9, #12, December, 1996.]

2004 is the year of the monkey ("Saru Doshi" in Japanese).

Image of Monkey (Saru) from Chiba Shrine

Visually understanding the 12 year cycle of the Chinese lunar calendar may be aided by the following diagram:



This system was used not only for naming months, but also the hours of the day and other aspects of "time". Note that "everything" is mirrored relative to the manner in which directions are viewed in the "West". Starting at the bottom of the diagram, 1996 was the year of the "mouse" or "rat". It began a new cycle. Proceeding in a "clockwise" fashion, 1997 was the year of the cow, 1998 the year of the tiger, etc. You may also note that the 24 hours of the day also correspond to these "animals".

The New Year is always an important holiday in Japan and other East Asian nations. Christmas is celebrated in Japan in much the same way it is in the West, but "New Years" is by far the more significant holiday. Before the Meiji Restoration, the New Year was celebrated according to the Chinese lunar calendar (January 22 for the year 2004). These days, though the calendar still has great influence on festivals and celebrations, the Gregorian calendar change is celebrated by most people as the "official" New Year.

In Japan, people busily prepare for the New Year by cleaning house and buying/cooking food to welcome the "god of new life". At this time, the Post Office is flooded by New Years' cards which each person sends to friends, relatives, and associates. Rail and air terminals are jammed with people trying to get back to their home towns to spend the New Year's "night" and "daybreak" with their relatives.

Japanese express wishes for the New Year by saying "Akemashite Omedetou Gozaimasu!" (pronounced ah-keh-mah-shteh oh-meh-deh-toe go-zah-ee-mahss). Only one Kanji (Chinese character) is found in this phrase (within the first word). This Kanji is a combination of the characters for sun and moon, and among other ancient meanings, it has to do with the sun and the moon getting together and becoming "bright". It entails "changing" and "opening"... "dawning"...

明 "sun" + "moon" = "bright"... "change"... "dawn"

Interestingly, this Kanji is also sometimes used in a name for the planet Venus [usually called "Kinsei" (gold star), but in this case (similar to Western naming) "Myou Jyou" (bright dawning star)]. In ancient lore (under the lunar calendar), the New Year was seen in relation to change in both the sun and moon as well as the symbolism of their luminance. The meaning(s) of the phrase "Akemashite Omedetou Gozaimasu" may be somewhat complicated, but (roughly translated) may include the following: "The year is changing... darkness gives way to light... new life begins... Congratulations!" Following tradition, many Japanese on New Year's morning brave the cold to find places with unobstructed views of the Eastern Horizon and eagerly await the rising sun... the break of day... the symbol of new life... the first day of the New Year. The sun is making its journey back to the North, and in these latitudes, the Vernal Equinox is eagerly awaited.

The New Year of 1996 was special in that it began another 12 year cycle of the Chinese calendar [based on positions of Jupiter with its 12 year orbit (and consequent position about the ecliptic); also associated with 12 clockwise geocentric directions (beginning with North) and named after animals as seen above]. While the lunar calendar is no longer "officially" used in Japan, the tradition of using animal names for the 12 directions and associated years is popularly maintained in the "New Style". In 1996, things turned around once more to the direction of "ne" (mouse), the North... to the direction of the star sometimes called "Ne no Boshi" (mouse star) but also called "Shin Boshi", the "Heart" star, the "soul of the Heavens" (Polaris) [See Cornering the Bear for more lore about the "North"]. 1996 began the clockwise cycle again [moving from N to NNE (1997, "ushi"=cow) to ENE (1998, "tora"=tiger) to E (1999, "usagi"=rabbit) etc.]. 2000 as the year of the dragon brought not only Y2K concerns as in most parts of the world but also the traditional New Year's cards mentioned above (as well as special stamps issued by the post office) all of which sported various stylistic images of this, the only imaginary animal in the East Asian Zodiac. Cards for 2004 have, of course, various renderings of monkeys.

Like Christmas in the West, celebration of the New Year in China and Japan is somewhat complex, and this is seen in the mix of astronomical phenomena and the pragmatic need for an "efficient" calendar with tradition, religion, and lore. Saori and I hope that darkness continues to give way to light for you in the New Year...

AKEMASHITE OMEDETOU GOZAIMASU!

Please send comments to

Steven L. Renshaw

Return to Astronomy in Japan Home Page

Through Thick and Thin

Resources for Teachers and Students

Internet Sites | Children's Books | Folklore & Mythology

Internet Sites

The Science Behind It

- **Temperature and Thermometers** - A great site all about how thermometers work, about the temperature scales, and weather.
- **Build your own Thermometer** - Simple instructions and good questions about a water thermometer.
- **Bill Nye the Science Guy- Episode: The Sun** - Here is a site which has a fun experiment you can do about the heat of the Sun.
- **Bill Nye the Science Guy-Episode: Reptiles** - Find out how reptiles deal with the heat of the Sun.
- **Bill Nye the Science Guy-Episode: Energy** - Some experiments and discussions about energy.
- **Reflectivity and Absorption** - Experiment for students about differences in reflectivity and it's effects on temperature.

Heat and the World

- **Heat Wave** - All you wanted to know about the facts and figures of heat waves. Provides indications of how much is too much, and what to do to avoid and/or treat symptoms of heat disorder.
- **Tree Heat Syndrome** - How trees are dying in the heat in Georgia. An interesting example of how heat can be harmful.

- **The Arctic Circle** - Natural resources, history and culture; social equity and environmental justice in the Arctic Circle. There are presentations of textual materials, art, photographic exhibits, and in the future, sound and short video recordings
- **Solar Energy and Environment** - Here's a site to help you make your house warm and snug in the winter and cooler in the summer using the Sun!
- **Ancient Climates** - A site describing recent finds about the climates of the past.
- **Why are there Ice Ages?** - A rather impressive document which describes in detail the processes and examples of making Ice Ages on our world.
- **Climatology: Ice ages** - More student-oriented page on Ice ages, part of the University of Oregon's Electronic Universe Project.

Children's  Books

---

- **Under the Sun** by Ellen Kandorian. Dodd, 1987.
- **Musicians of the Sun** by Gerald McDermott. Simon and Schuster, 1997. How the Wind God must find the four musicians of the Sun to bring life and color to the Earth.
- **How the Sun Made a Promise and Kept It: A Canadian Indian Myth** by Margery Bernstein. Scribners, 1976. by . , 19. by . , 19.

Folklore  Mythology

---

Carl's Lessons

- **Word Lore** - Carl's lessons on exploring words we use in this curriculum, such as where did the word "Sun" come from, or what is the difference between "daylight" and "day"?

Math and Folk Ways

- **Magic Squares** - Great way of talking about multiplication and the fun of numbers. This should be reserved for the most advanced students.

Seasonal Holidays and Seasonal Lore

- **Celebrating the Seasons: Pagan Holidays** - Selena Fox's site desribing the Pagan holidays. She also includes some activities you can do on these holidays which are very much like those done by families in the past.

Ice and Heat Lore

- **The Origin of Summer and Winter** - An Acoma/Laguna tale about why there are extreme seasons.
- **Origin of Fire** - Native American Tale of the origin of fire.
- **The First Fire** - A Cherokee Tale about a spider carrying fire to her people.
- **The Warm Wind Brothers vs. the Cold Wind Brothers** - A Native American tale explaining the winters and ice ages and other heat related events on the Earth.

Through Thick and Thin | Table of Contents | ECT Home Page

WebMaster Tania Ruiz
Last updated October 1, 1997

Irish/Celtic Seasonal Celebrations

Directory of The Seasons

ST. John's Eve June 23	Easter	Christmas	Wren Day St.Stephen's	St.Patrick	St.Briget
Summer	Samhain	Home	Feedback	Orange Day July12	May Day

Samhain

Learn how to make the Parshell or Samhain Cross
Learn how to make a Samhain Turnip Head

Holiday Checklist

1. Do not eat blighted blackberries and other fruit which have been spat upon by the P`uca. lest the blight affect you too. (frost damage=blight)

2. Children should not touch the fruit.

3. The fairies were let loose to visit all the plants and blast berries with their breath.

4. Leave some fruits outside for the fairies to ensure a good crop in the next year.

5. Sprinkle the animals with holy water.

6.Give church offering for Holy Souls.

7. Light candles on the night after Nov. 1, one for each deceased relative, at a window in the room where death occurred.

8. Place a lighted candle in the window if it faces the graveyard.

9. Place a candle in a lantern left lit all night on the grave of a loved one.

10. Meet your lost friends at the graveyard gate at night.

11.Watch out, you may meet those you have injured.

12 .Place beans and nuts in the fire and watch them jump

13. Melt lead through a key to form shapes suggestive of destiny in the water. Shapes formed will indicate vocation.

14. Place your shift or shirt in front of the fire to see who turns it.

15. Throw a reel of thread into a lime kiln to find out who would wind it up again.

16. Place a snail in the hollow between two plates and watch for the slime trail to see a meaningful shape.

17. Eat a salt herring in three bites to see the future husband in a dream.

18. Play Snap apple: suspend a cord with a cross stick with apple at one point and a lighted candle at the other. Twirl the stick and try to catch the apple, not the candle, in the mouth. In the case of children or lack of nerve substitute a dirty potato for the candle!

19. Duck for apples and coins in a tub

20. Eat cream pancakes, stampy, apple cakes, nuts and black berry pie.

21. Find a ring in your cake or champ and you will be next married. Other things to put into the cake: a pea, a silver coin, a piece of matchstick, thimble, religious metal, button, rag. Wrap them in greaseproof paper and put them into the barm brack .(see recipes below) The thimble signifies spinserhood, matchstick means your husband will beat you. Pea is for poverty, bean is for wealth.The religious medal indicates religious orders. The button is for bachelorhood. The rag is for poverty.

22. Find a little boat and be blessed with a journey to Skellig rocks.

23. On the way to and from the gathering play tricks- take the wheels off of carts and place them on roof tops. Take Cabbages. Paint a man sleeping by the roadside.

24. Place a stake at the junction of two streams upright. Look at it on Nov.1 to forecast the winter weather.

25. Look at the moon on the 31st also to determine the weather

26. Beware of the Fairies in their forts.

27. Put up a wood cross in the thatch or a Parshell

28. Sprinkle holy water on the door.

29. Spit on the animals to settle them down and remove the Sprite

30. Crawl through a briar rooted at both ends, making your request for the help of evil spirits

31. Provide a feast for the poor

32. Do not eat meat on the vigil- the 31st

33. Eat Colcannon-(potatoes and cabbage and onion).
    Recipe for Colcannon:

Colcannon for 6
1 1/4 lbs. Kale or green Cabbage, 2 cups water, 1 tablespoon olive oil, 1 1/4 pounds peeled and quartered potatoes, 1 tablespoon chopped parsley, 1 cup cleaned and chopped leeks (white part only), 1 cup milk, pinch of ground mace, salt and ground pepper to taste,
1/2 cup melted butter (use real butter)
1.Simmer kale or cabbage in 2 cups water and oil for 10 minutes , drain , chop fine.
2.Boil potatoes and water, simmer till tender.
3.Simmer the leeks in milk for ten minutes till tender. 4.drain and puree the potatoes.
5.Add leeks and their milk and cooked kale. 6.mix. add mace, salt and pepper.
7.Mound on a plate and pour on the melted butter.Garnish with parsley.

34. Make stampy cakes from grated raw potato and sugar caraway and cream, boxty, oatcakes, dumplings.

Recipe for Boxty:
Boxty Cakes:
Ingredients:
1/2 pound hot cooked potatoes, 1/2 pound grated raw potatoes, 2 cups flour,
1 teaspoon baking soda,
1 1/2 cups buttermilk, butter for frying, salt and pepper.
1.Drain, peel and mash the hot potatoes.
2.Stir in the raw potatoes, flour and baking soda.
3.Add salt and pepper to taste.
4.Mix well with enough buttermilk to make a stiff batter.
5.Shape into 3 inch patties about 1/4 inch thick.
6.Fry on hot greased griddle until crispy and golden on both sides. Makes 12

35. No Hollantide without a pudding. So….Make a pudding!

36. Give children apples and nuts.

37. Burn nutshells and foretell the future of a couple-place a nut for the boy next to the nut for the girl into the hearth. If one jumps from the other as they burn so will it be in life.

39. Hang an apple from a rope. Place a chair or box under it. With stick in hand and other hand on box or chair run as fast as possible around the chair under the apple. Then when done 7 times try to strike the apple with the stick.

40. Store crops and livestock for the cold season.

41.Get turf and wood for fires ready, including the bog deal or pine found when digging turf.

42. Everyone has debts at Hallow E'en - pay workers, pay rents, settle debts.

43. Have a fair-to spend the money collected!

44. Carry a blackhandled knife and have a steel needle stuck in the coat collar or sleeve. In case of fairies you can turn your coat inside out and so disguised escape.

45. When throwing out water on the night call out Seachain (beware) or Chughaibh an t-uisce (water towards you) to warn the gosts and fairies to step aside.

46. Listen for revelry from within ringforts.

47. Light a fire, preferably at the crossroads (include in it tires and whatever you have that burns)

48. Put crackers on the roadside to explode under cars

49. Go door to door masked (a guiser) and ask for funds for the Halloween party.You may take clubs and sticks and invoke the name of Colum Kill saying: "lay aside the fatted calf and bring forth the black sheep" Blow horns to announce that you are coming Disguise your voice and chant your request.

50.Give the guisers white bread and butter and milk, or money

51. Have a procession led by a person in a white sheet- the Lair Bhan "the white mare" -the messengers of the Muck Olla-you can also exact donations from merchants.

52. Play traditional wake games. (See O' Suilleabhain's study of Wake Amusements) .

53. Hollow out a great big turnip. Carve into it a face. Light it with a candle and suspend it from a wire or rope and walk from place to place. (see instructions below!)

54.Consult all of the many divinations.

55. Make Barm Brack and hide a ring or other object in it with the resultant luck being given to the finder. (see 21. above for charms to include)

Recipes! Take your pick:
Quick Barm Brack #1

1/2 lb. brown sugar

1 lb. sultanas
1 tsp. mixed spice
1 tsp. ground cloves

Soak the above ingredients overnight in a cupful of strong tea.
Add to the mixture:

1 well-beaten egg
1/2 lb. self-rising flour

Put into a well-oiled loaf tin and bake at 350 Deg. F. one hour and ten minutes.

Yeast Barm Brack #2

This recipe is for a traditional current bread in the shape of a round cake.

1/2 cup lukewarm milk
1 tsp. sugar
1 tsp. yeast
2 cups plain flour
1 tsp. mixed spice
pinch of salt
1 egg, beaten
3 Tbsp. butter
2 cups mixed dried fruit (currants, sultanas, raisins, candied peel)
2 Tbsp. sugar

Instructions:

Soak the dried fruit in strong black tea before use, at least two hours.
Set oven to 400 deg. F. Mix the yeast and the teaspoon of sugar and combine into the milk. Allow to rise. Sift the flour with the 2 Tbsp. sugar and the spices and rub in the butter. Make a well in the center and add the yeast and the egg. Beat with a wooden spoon for about ten minutes until a dough forms. The fruit and salt is now worked in by hand, and the whole should be kneaded. Put the bowl of dough in a warm place (covered with a cloth) for about an hour until the mixture rises and doubles in size. Knead lightly and place in greased 7 inch diameter cake pan. Allow a further 30 minutes rising. Bake near the top of the oven for 45 minutes

Back To Seasons

May Day

A landmark day as the first day of Summer. It was a gale day when land tenancy began or ended or when a half-year's rent was due. It was a day for change and marketing of ones skills by taking a tool symbolic of one's occupation to the fair. The cattle sheltered in the Winter and Spring were taken to the Summer pastures or: "Buaile".The fields scheduled for harvesting were carefully protected and cleared of stones. Turf cutting begins.

May day is a day for the housewife to demonstrate her skill at making the food last over the

Winter and Spring. A formal meal was made with the good food which was left.

May Day was also a day for watching the weather which will help predict the end of frost and success for the summer months. One should not dig whitewash or bathe or sail on May Day.

Summer was welcomed in many ways: A May bush ws set up,flowers (especially yellow ones) were gathered into small bouquets which were hung up in the house-these must be picked before dawn of May Day. Horses bridles were also decorated with flowers. Generally flowers were tied to everything-cows, churns etc... as protective elements. In some areas branches of newly leafed trees were collected. The Sycamore being a favorite "May bough" in Cork. While the flowers were beautiful the main reason for their cutting and distribution was to ward off evil and bring good. The May Bush was extremely important in this regard in many parts. It was set up by the family on May Eve in front of the house door and was decorated carefuly with flowers and the colored egg shells carefully saved since Easter. Ribbons were also aded together with bits of candles. These candles were lit and a dance was held in honor of the Blessed Virgin Maryat dusk at May day eve.Children going door to door would chant:

"Long life and a pretty wife, and a candle for the May bush"

-of course they were looking for money as well!

Bonfires were also lit and sports competitions lead to the worst fighting of the year. May bushes became in some areas May poles. Stealing the bushes also was a source of great fighting and led to some famous rhymes:

"We'll wallab a mosey down Meadstreet in tune
Ri rigdi ri ri dum dee,
And not leave a weaver alive on de Combe
Buyt rip up his tripe-bag, and burn his loom!
Ri rigidi dum dee!"

The custom of young newly married couples giving new and decorated hurling balls:"May Balls" to the young men of the town also lead to great festivities and often violence as drink money was also given out with the balls.

Of many charms and omens for May Day the collection of May dew was the most well known. This was carefully decanted and collected to use as a medicine and for beauty. The man who washed his hands in the May dew would be good with knots and nets. There are many things you should not do on May day one of which is to pick up anything left in the roadway.Back to Seasons

---

Irish Easter Customs

1.Clean house thoroughly Inside and out-whitewash applied.

2.Obtain New clothes.

3.Good Friday-do no work on the land just in the house.

4.Fast More than is Required on Good Friday.

5.Good Friday- Plant a small amount of crop seed to bring blessing on it all.

6.Shed no blood on Good Friday,work no wood,hammer no nail .

7.Maintain quiet on good Friday from Noon till three P.M.

8.Visit church-take off shoes-good Friday.Visit holy wells and graveyards.

9.Do not fish with nets or lines on Good Friday no fishing boat puts out to sea alternatively gather bia tragha-shore food-seaweed and shellfish for the Main meal.

10.Cut your hair on good Friday to prevent headaches in the year to come-trim finger and toe nails.

11.Water from the holy well will have curative properties on Good Friday.

12.A child born on Good Friday and baptized on Easter Sunday had gift of healing. (if a boy he should go into the ministry) die on good Friday go right the heaven.

13.Eggs laid on Good Friday-Mark with cross and each eat one on Easter Sunday.Eggs Hatching on that day will produce healthy chicks.

Easter Saturday

1.Have Holy water blessed.

2.Drink three sips of holy water each for health.Sprinkle on everything for good luck.

3.Bring cinders from the Paschal fire to be blessed.

Easter Sunday

1.Butchers have mock funeral for a herring symbolizing end to abstinence.-whip the herring,have a procession involving the herring-

2.Go to church and then herring procession.

3.Go up at sunrise to view the sun dancing with joy.

4,View the reflection of the sun in a pail of water and move it so the sun appears to dance.

5.Do something with eggs.Give them,color them

6.Have a Cludog or cluideog ritual-children collect and cook eggs and other food in a structure which they make on the edge of the farm-roasted eggs.

7.Brightly dressed Tobies go from place to place to demand the eggs of Easter Singing, dancing dressed in bright colored rags.

8.Keep shells of Easter eggs for the May bush. 9.Roll eggs to race them.-may be Presbyterian custom.

10.Have feast on Easter-Kill a cow if you can-

11.Take down the Spoilin meith na hlnide-little piece of meat pinned up at lent and burn it giving house a rich smell

12.Have a a Cake Dance. Cake being the prize for best dancer.Easter cake dance-a pruthog

13.Go to a "Sunday's" well-have a bonfire.

Back to Seasons

Saint Patrick's Day March 17

In Irish Gaelic:
Lá Fhéile Pádraig (LAW AY-luh PAW-rihg) = St. Patrick's Day
Beannachtaí na Féile Pádraig oraibh! (BAN-uhkh-tee nuh FAY-luh PAW-rihg O-rihv) = Happy St. Patrick's Day to You All!

Visit the Ulitmate St. Patrick Page!To Patrick!
Make a St. Patrick's Cross and be Prepared -Go to the St. Patrick's Cross Craft Page
For Poetry and Writing of the Saint go to:Pat's Verse!

Traditional customs for the proper celebration of the day-and Yes we know that Ireland has tried its best to discard its historic culture in favor of progress,industrialization and American commercialism-but customs are important to give meaning to life and joy to the soul so here they are:
1.Wear an emblem in honor of the saint-a custom which dates from as early as 1681-and the account of Thomas Dinely. Generally a green ribbon the shamrock or a saint patricks cross(circle or square of paper decorated with green ribbon and bits of priests vestments by girls and small children-for boys a paper cross in the style of the Celtic illuminations carefully decorated)

2. Go to work and demand the "Patrick's Groat" take leave of your capitalistic master and go to town and spend it all.(very few of the zealous should be found sober at night account(Dinely 1681!). 3.Men should make a cross of a twig of wild sallow and pin it to the thatch inside the house or above the door.

4.You may also wear a harp shaped badge

5.Wear the "Trifolium repens"-white clover (Identified as such by Caleb Threlkeld in 1727)

6.After church go to the pub to drink the "pota Pa/draig"-St. Patricks pot. Many acts of devotion should be followed by an equal number of acts of copious libation...

7.Say this quaint line when doing so:

Ordain a Statute to be Drunk

And burn Tobacco free as Spunk

And (fat shall never be forgot"

In Usquebah,St. Patrick's Pot

(Farewell 1689)

8.Actually it is doubtful if anyone knows what a shamrock is(Early 20th century-Nathaniel Colgan asked around Ireland and found that it could be-Trifolium repens,(white clover), Folium minus-(leser trefoil),Trifolium pratense(purple clover),Medicagio Lupulina(Black Medick) So take your pick!

9.Give treats and gifts to friends and children.

10.Put shamrock which has been worn on the day into the last glass of drink-then toast to the health of all and pick the wet drowned shamrock out of the glass and toss it over the left shoulder.

11.Using a burnt stick make a cross on the sleeve of each member of the household

12.You have to eat meat and you do not need any special dispensation to do so. Jocelin notes that as early as 1100 AD people ate meat in Lent due to an account of St.Patrick doing so and then being forgiven the meat turning to fish in the boiling water.

17.You must begin your planting soon after St. Patrick's day-(peas are best planted on the day. (Source-Kevin Danaher- The Year in Ireland Mercier Press Cork,1972)

Saint Patrick's Breastplate

The prayer used by St. Patrick to protect his followers from the King-He prayed and the whole group changed into deer and ran past the warriors to the hall of the king where he

successfully did a battle of words with the Druids.
I bind me to-day
Gods might to direct me
Gods Power to protect me
Gods wisdom for learning
Gods eye for discerning
Gods ear for my hearing
Gods Word for my clearing

Gods hand for my cover
Gods path to pass over
Gods buckler to guard me
Gods army to ward me
Against snares of the devil
Against vices temptation
Against wrong inclination
Against men who plot evil
Near or afar with many or few

Christ near
Christ here
Christ be with me
Christ beneath me
Christ within me
Christ behind me
Christ be o er me
Christ Before me

Christ in the left and the right
Christ hither and thither
Christ in the sight
Of each eye that shall seek me
In each ear that shall hear
In each mouth that shall speak me
Christ not the less
In each heart I address
I bind me to-day on the Triune I call
With faith in the Trinity-unity
God over all.

(trans. Sigerson)

Back to Seasons

Saint Brigid a.k.a. The Mary of the Gael

To The Main St. Briget Page

Her day: February 1 First Day of Spring -New Year's day for the Farmers
the beginning of Imbolc: Season of light (alternate spellings- Brighid, Brigid)
Brigid means Fiery Arrow
She is patroness of cattle and of dairy work-ale.

1. A day to look for weather signs-a hedgehog a good weather sign if he stays out of his burrow.

2. Do only essential work on the day and go to the local shrine to pray.

3. Take stock of the household supplies-will it last till harvest?

4. Clean the house.

5. Make a special dinner for St. Brighids Eve.

6. Make a Bairin-breac-yeast cake with fruit (aka barm brack) for the eve and invite the neighbors in.

7. Make fresh butter - Brigid is closely associated with the dairy.

8. A day for the wealthy to give food to the poor.

9. St. Brigid traveled the countryside, blessing households, with her white red-eared cow.

10. You need to show her welcome: place bread and fresh butter on the window sill outside, also put out a sheaf of corn for the cow, put out rushes for her to kneel on to bless the household, set the table in the kitchen on the eve.

11. Make the cros Bride or bogha Bride (St. Brigids Cross). These crosses are made of rushes-but vary in materials and somewhat in design from region to region (main page for cross link).

12.The cross should be hung in the thatch roof of the house or above the door, and if you dont have a roof-apartment-on the inside of the front door.

13. Cross material should be blessed.Crosses are left in place for a full year to be renewed on the day.

14. A large oat bread cake, a Strone,Strohn, or Brigid's Bread (See main page food links) in the shape of a wheat sheaf or cross is made, blessed by the priest and eaten.

15. Often a door ceremony is held with a person, usually the eldest daughter, representing the saint knocking and asking to be let in. She says - Go on your knees, open your eyes, and let Brighid in. Answered by from within: Greeting,greeting to the noble woman.

16.After perhaps Mary, Brigid is the most common name for girls in Ireland - it is shortened to Bridie (pronounced bri dee). (Bride in English however comes from the German; although many think otherwise, the linguists insist on a German root.)

17. On the eve the Bridie Boys go out with an effigy of the saint called the Brideog - a doll dressed in white. They pick up the offerings of bread and of butter left out. (In some areas the Brideog was the most pure girl of the village.)

18. A piece of white cloth is hung outside the front door.

19.Those coming around would say something like this: Something for poor Biddy! Her clothes are torn
Her shoes are worn
Something for poor Biddy

or Here is Briget dressed in white
Give her a penny for her night
She is deaf, she is dumb
She cannot talk without a tongue.
or Here comes Brigid dressed in white
Giver her something for the night
She is deaf, she is dumb
For Gods sake give her some.

20. A silk ribbon is left out for the Saint to bless; it is used to cure illness. It is called the ribin Brighid - St.Brigids Ribbon. 21. To say over the cross:

Brighids Girdle is my girdle,
The Girdle with the four crosses.
Arise housewife
And go out three times.
May whoever goes through my girdle
Be seven times better a year from now

. 22.The leftover materials from the cross were used to bless the animals as bedding and feed.

23. On St Brigids day the lark was a good omen of Spring.

24. The dandelion is spoken of as Brigids Flower.

25. Hoar frost(thick frost) gathered specially on the day can be used to cure headache.

26. There are many wells dedicated to the saint from which water is drawn and used for blessings on the day.

27. Brigid is famous for brewing ale and for distributing it -so ale is a part of the celebration

28.The farm animals should be especially well taken care of on the day.

For foods of the day see the recipes section-
SOURCE:Danaher,Kevin.The Year In Ireland. Back to Seasons

Irish Christmas Customs

1. Prepare spiritually. From the beginning of advent add prayers to usual devotions.

2. Children should say additional Paters and Aves and to count them (counts of 5,000 are cited)

3. Be especially sure to be "a hardy annual" and be sure to go to church.

4.Many days before the festival clean house and farmyard thoroughly.

5. Men clean outbuildings and yard entrances passageways and surroundings. White-wash all buildings inside and out.

5. Women sweep,wash and clean the house.

6. Do major laundering- include everything.

7. Clean tables and chairs with sand. Clean pots and pans.

8. Children survey the countryside for holly, ivy, bay and other evergreens for later cutting.

9.Holly with berries is especially prized. Make Ivy garlands. Whiten ivy berries with whiting or starch.

10.Cut colored paper scraps into adornment and use needle and thread to string loose holly onto linen in patterns or seasonal mottoes.

11.Purchase decorations from a peddler or traveling person.

12.Make a small cross of holly sprigs or crossed pieces of wood.

13.Where mistletoe is found you can decorate with it and the girl kissed under it receives a gift from the boy.

14.Just before Christmas go to the town to "bring home the Christmas"- go to the Christmas market for this purpose (the Margadh M/or or big market).

15.Receive a gift from a shopkeeper- a "Christmas box".

16. Country country people give produce from the farm to townspeople.

17. Town Folks give town goods to country folks.

18. Prosperous farmers give portions of a slaughtered animal and other donations of food to their friends,poor and workpeople.

19. Make poitin. Make sure you have at least a quart available.

20. Lay in a good supply of fuel for heating.

21. Obtain a special log- bogdeal, the "bloc na Nollag".

22. Clean the Chimney using a prickly bush pulled up and down.

23. Purchase a chance on a mutton.

24.Hold a "join". Every man contributing a small sum-toward liquid refreshments and have a pleasant evening of talk,song, and storytelling.

25. Make Christmas Cake- Note - this needs to be don in advance!

Irish Christmas Cake

Citron 1 lb.
Candied orange and lemon peel, combined, 1/2 lb.
Dates, 1/2 lb.
Glace cherries, 1/2 lb.
Raisins, 3 3/4 Cup.
Currants, 2 3/4 Cup.
Almonds and pecans, combined, coarsely chopped, 1 lb.
Brandy, 3/4 Cup
Brown sugar, 1 lb.
Butter, softened, 1 lb.
Egg yolks, beaten until thick, 15
All-purpose flour, sifted, 4 Cups
Cinnamon, 1 Tbsp.
Cloves, 1 Tbsp.
Allspice, 1 Tbsp.
Nutmeg, 1 Tbsp.
Mace, 1 1/2 tsp.
Egg whites, beaten until stiff, 15

Chop the citron, orange and lemon peels, dates and cherries. (Reserve a few cherry halves for decoration.) Add the raisins, currants, almonds,

and pecans. (Reserve a few nut halves for decoration.) Pour on the brandy and let the fruits marinate while preparing the rest of the ingredients. Cream the sugar and butter until light and fluffy. Add

the

beaten egg yolks gradually, beating constantly. reserve 1 cup of the

flour

and sift the remaining 3 cups with the spices. Add the sifted

ingredients

gradually to the butter mixture, beating well after each addition. Fold

in

the egg whites carefully. Sprinkle the fruits with the reserved 1 cup

of

flour and mix well. Fold the fruits into the batter. Oil and line a

12-inch

springform pan with waxed paper. Place batter in pan and bake in

300

degree F. oven with pans of hot water in bottom of the oven, for 2

1/2

hours. Cool the cake and wrap in cheesecloth that has been soaked in brandy. Place in airtight container and store until ready to use. Every

3

weeks, re-dip the cheesecloth wrapper in brandy.

Before decorating, glaze the top and sides of the cake with either

apricot

jam, thinned with a little water or red currant jelly. This will help the marzipan to adhere to the cake sides.

Almond Paste

3 (9 oz.) cans almond paste

Form 2 cans of the almond paste into a ball. Place on lightly sugared

or

floured board and roll into a rectangle 1/8 inch thick. (The width of

the

rectangle should match the height of the sides of the cake. The

length

should match the circumference.) Circle the cake with the almond

paste

and trim the edges to fit perfectly. Roll the remaining paste into a

circle

the size of the top of the cake. Place the circle on the cake and trim.

Let

the almond paste dry overnight.
Ice with Royal Icing

Royal Icing

egg whites, 2
Lemon juice, 1 Tbsp.
Confectioners' sugar, 1 lb.

Beat the egg whites with the lemon juice until they are the consistency of cream. Beat in the sugar a little at a time. Continue beating, scraping the sides of the bowl occasionally, until the icing is smooth and shiny. It will be very stiff. Cover the bowl with a damp cloth if the icing is not to be used immediately. Cover the almond paste with a thin layer of icing. Dip the knife in hot water if the icing is difficult to spread. To decorate the cake, form peaks on the sides and edges of the top of the cake with the remaining icing using the tip of a knife.

Christmas Eve

1.Return home for Christmas.-to the parents house on Christmas eve.

2.Finish work by midday on the Eve and get home before night-fall.

3.Bring presents to father and mother and to younger brothers and sisters.

4. Send an "American Letter" to your family in Ireland containing cash.

5.Finish the last preparations- the final sweeping and cleaning and preparations from festive food.

6.Prepare the most elaborate dinner of the year for Christmas.

7.Roast of Boiled beef- the most popular dish:spiced beef.

8. Boiled Ox head was the favorite dish in Armagh,Tyrone, Monaghan and other places in the north.

9. Wealthy farmers of Leinster and Munster prepare fowl: chicken or goose, bacon and mutton,cakes, puddings, and pies.

10. Prepare puddings on Christmas Eve for final cooking on Christmas Day.

11.Make Cutlin pudding in County Wexford.- a porridge of wheaten meal and sugar dried fruits and spices are added. Make this into a ball as big or bigger than a football and wrap it for boiling.

12.Make a Christmas pie in the shape of cradle decorated with strips of pastry to represent the manger in Donegal.

13.Light Christmas candles at night on Christmas eve. With a prayer.

14. Place large candles into sconces made from a turnip or piggin filled with bran or flour. One for house holder , one for wife and one each for the grandparents. Little colored candles for the children .

15. Decorate all candles with holly.

16. Let candles burn all night extinguishing them just before the first mass.

17.One big candle: coinneal M/or na Nollag can be displayed.

18.Candles are lighted at 6 0'clock and the angelus is said.

19.Light three candles in honor of the Holy Family-or a three branched candle.

20.Have the youngest person light the principal candle.

21.If the principal candle goes out for some reason it is a bad omen.-possibly of the death of the head of he household.

22.Candles are lighted to show the way to Joseph and Mary.

23.Leave doors open on Christmas eve.

24.Have a candle in every window.

25.Leave the table set for three persons.

26. Leave a bowl of water out to be blessed by the travellers-this water will be used for cures.

27.Put on a good fire before bed.

28.Sweep the floor.

29.Put bread on the table.

30Leave a candle for each of the family who has died since last Christmas-to welcome them in.

31.Take the children to a high place to show them all the candles.

32.Observe Christmas Eve as a fast day. If you eat it should be stockfish-hake,cod or ling with white sauce and potatoes.

33.End fast after candles are lit well before midnight.

34.Cut the Christmas cake and make tea,punch and other beverages.

35. Give sweets and apples to the children.

36.Gather the family around the fire.

37. Remind children that an angel stood on every spike of holly leaves this night and all nights.

38.No prayer will be unanswered on Christmas eve.

39. If you die on Christmas Eve you will go right into heaven.

40.Place a small wreath of holly yew or other evergreens on family graves especially on the grave of one who had just died.

41.Fire a salute from a shotgun at noon on Christmas Eve. A "grussenschuss".

42.At midnight leave the cows and donkeys to kneel in adoration of the Christ.

43. Feed animals sheaf corn or branmash.

44. Decorate byre and stable with evergreens and provide a special lantern there.

45.Children tie sprigs of holly on cow's horns.

46. The cock will crow on unusual times -to hear him crow at midnight will be a good omen.

47.Cold weather with frost or snow will indicate a mild spring with absence of illness.

48. A green Christmas makes a fat churchyard.

49. When it snowed on Christmas Eve. Geese were being plucked in heaven.

50. A new moon on Christmas Eve was very lucky.

Christmas Day

1.Spend it at home.

2.Have a quiet Christmas.

3.Stay away from the homes of others.

4.Go to church-early mass if possible-before dawn.

5.Take a wisp of straw from the crib to bring luck and blessing.

6.Women cook Christmas dinner after church.

7.Men and boys remain outside out of the way busy with sport-hurling-a big village match. The match can be begun at the church gate -bring hurleys to church.

8.Use a specially made hurling ball with a small tin box of loose shot inside for a louder sound.

9.Hunt hares with greyhounds or harriers.

10.Have a shooting match.

11.Drink three sips of salted water before dinner for good health.

12.Sit around the fire after dinner with song and story.

13.Listen for a cricket on the hob and have a sign of good fortune.

14. In the North East of Ireland some Scottish Puritans do not celebrate Christmas.

15.Listen to the waits called "good morrow,good morrow,good morrow,past twelve o'clock;a fine frosty morning" view the performances and reward the performers.

16.Go to a hill and blow a loud salute for Christmas Morning using cows horns.

17. Sing carols.

Source: Danaher,Kevin, The Year in Ireland.,The Mercier Press,Cork,1972.

Another Great Christmas Resource:

The Irish Christmas Book,John Killen ,ed. Blackstaff,Belfast,1992. Back to Seasons

Source:

Danaher,Kevin,The Year in Ireland,The Mercier Press,Cork,1972.
Back to Seasons

Directory of The Irish Studies Page

Halloween on the Net | Holidays on the Net | Additional Holiday Celebrations

The Story of Halloween

Halloween is one of the oldest holidays with origins going back thousands of years. The holiday we know as Halloween has had many influences from many cultures over the centuries. From the Roman's Pomona Day, to the Celtic festival of Samhain, to the Christian holidays of All Saints and All Souls Days.

Hundreds of years ago in what is now Great Britain and Northern France, lived the Celts. The Celts worshipped nature and had many gods, with the sun god as their favorite. It was "he" who commanded their work and their rest times, and who made the earth beautiful and the crops grow.

The Celts celebrated their New Year on November 1st. It was celebrated every year with a festival and marked the end of the "season of the sun" and the beginning of "the season of darkness and cold."

On October 31st after the crops were all harvested and stored for the long winter the cooking fires in the homes would be extinguished. The Druids, the Celtic priests, would meet in the hilltop in the dark oak forest (oak trees were considered sacred). The Druids would light new fires and offer sacrifices of crops and animals. As they danced around the the fires, the season of the sun passed and the season of darkness would begin.

When the morning arrived the Druids would give an ember from their fires to each family who would then take them home to start new cooking fires. These fires would keep the homes warm and free from evil spirits.

The November 1st festival was called Samhain (pronounced "sow-en"). The festival would last for 3 days. Many people would parade in costumes made from the skins and heads of their animals. This festival would become the first Halloween.

During the first century the Romans invaded Britain. They brought with them many of their festivals and customs. One of these was the festival know as Pomona Day, named for their goddess of fruits and gardens. It was also celebrated around the 1st of November. After hundreds of years of Roman rule the customs of the Celtic's Samhain festival and the Roman Pomona Day mixed becoming 1 major fall holiday.

The next influence came with the spread of the new Christian religion throughout Europe and Britain. In the year 835 AD the Roman Catholic Church would make November 1st a church holiday to honor all the saints. This day was called All Saint's Day, or Hallowmas, or All Hallows. Years later the Church would make November

2nd a holy day. It was called All Souls Day and was to honor the dead. It was celebrated with big bonfires, parades, and people dressing up as saints, angels and devils.

But the spread of Christianity did not make people forget their early customs. On the eve of All Hallows, Oct. 31, people continued to celebrate the festivals of Samhain and Pomona Day. Over the years the customs from all these holidays mixed. October 31st became known as All Hallow Even, eventually All Hallow's Eve, Hallowe'en, and then - Halloween.

The Halloween we celebrate today includes all of these influences, Pomona Day's apples, nuts, and harvest, the Festival of Samhain's black cats, magic, evil spirits and death, and the ghosts, skeletons and skulls from All Saint's Day and All Soul's Day.

Holiday Music

Clicking will launch a new window and music (midi format) will play
Make sure to turn the speakers on!
Internet Explorer users need to do nothing. Netscape or another browser click for plug-in instructions

celebration. Easily search Amazon.com's selections.

Tell-a-Friend

Enjoying yourself? Then tell your friends and family about our holiday celebration. Easily send them an email invitation to visit our website and join in the fun

Join our Mailing List

We'll keep you informed of future Holidays on the Net Celebrations

[HOME] [DAYS OF DEAD] [PUMPKIN PATCH] [WITCHES]
[TRICK'O'TREAT] [CARDS] [GOODIES] [RECIPES] [CRAFTS]
[SIGN GUESTBOOK] [READ GUESTBOOK]

A Production Of

HOLIDAYS on the net

Holiday Celebrations on the World Wide Web

Visit Our Other Holiday Celebrations

Join Our Emailing List

Thanksgiving on the Net | Holidays on the Net | Additional Holiday Celebrations

Welcome to
Thanksgiving on the Net

A Celebration of America's First Thanksgiving

Thanksgiving Day in America is a time to offer thanks, of family gatherings and holiday meals. A time of turkeys, stuffing, and pumpkin pie. A time for Indian corn, holiday parades and giant balloons

So here for your entertainment are some fun Holiday things for you and your family. We've got stories of the Pilgrims and the first Thanksgiving, turkeys to take home, holiday pictures for the kids to print and color, tasty holiday recipes and e-greeting cards to send your friends and family. We hope you find something you like!

Thanksgiving is celebrated on the *4th Thursday of November*,

which this year (2004) is November 25th.

So bring your kids and tell your friends. And please stop by again. Don't forget to sign our Guestbook before you leave.

The Story of Thanksgiving
Throughout history mankind has celebrated the harvest with thanksgiving ceremonies

America's Thanksgiving
The Pilgrims and America's First Thanksgiving

The Thanksgiving Turkey
Yum Yum Yum!

Thanksgiving Proclamation
US President George W. Bush's Thanksgiving Proclamation
Also Thanksgiving Proclamations of 2001, 1999, 1998 and 1996

National Day of Mourning
Focusing attention on past injustices to the Native American Peoples

Goodies
We've Got Lotsa Holiday Goodies
Take a (Virtual) Turkey Home
Get out the crayons and print these pictures for the kids

Thanksgiving Crafts
Fun and entertaining craft projects to help celebrate your Thanksgiving

Holiday Home Decorations
Make an elegant Fall/Thanksgiving Garland for your home

Website Search
Easily Search our Website or the Web for the Holiday information

you need

Search Website | Search the Web

Thanksgiving Recipes

Some fun and tasty Thanksgiving recipes to help celebrate the holiday

Thanksgiving Greeting Cards

Send your friends and family FREE Thanksgiving Email Greeting cards

Holiday Music

Turn up the Speakers and enjoy the holiday spirit

Clicking will launch a new window and music (midi format) will play

If music does not begin click for plug-in instructions

Holiday Books, Music, and Videos

IN ASSOCIATION WITH amazon.com

Holidays on the Net has joined with Amazon.com to offer you and your family books, music CDs, DVDs, videos and more to enjoy your holiday celebration. Easily search Amazon.com's selections.

Sign our Guestbook

Let us know what you think about our celebration

(Have you seen or head about us in the press? Let us know!)

Read the Guestbook

Read what our other visitors have said

Join our Mailing List

We'll keep you informed of future Holidays on the Net Celebrations

Website Awards

"You like us, You like us, you really like us!"

[HOME] [STORY] [PILGRIMS] [TURKEYS] [GOODIES] [CARDS] [RECIPES]
[GIFTS] [SIGN GUESTBOOK] [READ GUESTBOOK]

A Production Of

Holiday Celebrations on the World Wide Web

Visit Our Other Holiday Celebrations

Join Our Emailing List

Sponsored by

Studio Melizo

Web Design and Maintenance

Questions, Problems, or Comments?

holidayboss@holidays.net

regiTOUR
Festival of Malaysia

HARVEST FESTIVAL

Celebrated by the Kadazan of Sabah each May with thanksgiving dedicated to the rice gods. Agricultural shows, exhibitions, cultural programmes, buffalo races, and other traditional games are held. There is much merrymaking and feasting with rice wine flowing freely throughout the festivities.

REGIT

To Seek or Not to Seek?

Purpose

In this Thread, we will begin our experience with the tools of scientific inquiry. We will be observing our world, inside and outside of the classroom, looking for changes, perspectives, and patterns. We will begin to use measuring tools as simple as our feet and fists and move on to more complex devices such as microscopes and scales. This is the first step in our journey to build learning from direct experiences.

The National Science Education Standards stress that students of all ages should be learning science from an inquiry-based approach. The passing of the seasons and the characteristics of the natural world should be observed and known, as well as how a changing environment affects life on the Earth. Students should become familiar with the history and nature of science. The Standards also stress that recording data and measuring specimens from nature are crucial for the science student. The vocabulary which can be used to help us talk about our experiences are words such as observe, experience, curious, theory, pattern, change, detail, evidence, data, nature, science as inquiry, sight, hearing, touch, smell, and taste.

> You will need: journals, pencils and crayons, plastic sample bags, microscopes, scales, and rulers.
>
> The visits outside or around the school will vary according to the ages of the students. We recommend that there is enough time during a session for each student to draw a certain aspect of his observations and/or write a short description of the area he viewed (or even a list of the relevant features observed). Repeat visits to the sites need to be made at intervals of about three weeks. Additional time will be spent talking about what change the class has seen between visits. Gathering materials for this Thread should not be difficult, as most of the equipment should be available at the school.

Teacher Background

Ultimately, the purpose of this adventure is to watch Autumn happen, although we don't want to say that from the start! We want to invite inquiry into the classroom by leaving the classroom! Looking around outside will reveal many interesting things about the world around us. The trees will soon change, relying on their sap and ground water to survive during the cold months. This process can be seen during the next few months as the leaves change from green to brown and then detach from the tree entirely. The colder temperatures and decreased sunlight will cause many plants to die altogether. Most plants will develop seed pods which will fall and provide a new generation of plants in the spring. Over time, certain insects will become active while others will disappear. The fur on some critters gets thicker, while other animals go into hibernation.

Having students make observations on this first day is key. There is no book telling us what the outside of our school looks like. We must explore it ourselves. We must look around with care, draw what we see, describe what we see, and keep a neat record of this world outside our classroom. When we bring the students out again in a few weeks, we need to be able to return to these same spots outside and observe again. There will be some changes, and we will find as many of them as we can. If your school is surrounded by asphalt, a walk to a park or garden will work quite well.

Collecting samples to bring back to the classroom will, hopefully, also bring the inquiring mind into the classroom. Using tools such as microscopes and scales to measure and record what we have found will allow us to keep more than just pictures and words from our observations. We can use this empirical evidence later when we compare our first finds to those we pick up on later visits. Bringing data inside also is a good way of demonstrating that observation is more than just looking around; it is learning about something which is in front of you in any manner which is possible: touching it and smelling it, as well as weighing it and measuring it.

The skills of good record keeping also should be introduced with this exploration, perhaps not on the first trip out, but on the second. We may think, "If only I had made a better record, I would know what had changed." Find moments during the investigations to ask your students these questions: Why should we date our records? Could we record in which direction we were looking? Does the time of day make a difference in what we see?

For the teacher, it is important also to realize that here we are asking things of the students which may have never been asked of them before. There is an atmosphere we create in inquiry-based learning which is most likely unfamiliar to them, and we should be sensitive to that. We are asking our students to do most of the talking, instead of us, and we also are not giving many answers -- they will find them. We are only collecting data and comparing it with what we gathered before. We are learning how to observe the world around us and make some inferences about what we see. We need to make students comfortable with this, instill some confidence in their ability to observe, gather data, and make connections. Students in this age group will not be used to having this much control over the learning process, and we need to understand that it will take time before they grow assured enough to begin probing deeper into patterns and predictions.

Within two months after the beginning of school, autumn's changes will become readily apparent in the world outside the classroom. By then, we should have established a comfortable environment for inquiry and students should be at ease with exploring everything they encounter, from math to moths, using the tools of scientific inquiry.

Contents
Download
Internet Resources
Children's Books
Folklore & Mythology Connections
To K-2nd Grade Thread
To 2nd-4th Grade Thread
To 4th-6th Grade Thread

Kindergarten through Second Grade

Developmental Issues

This Thread resonates with kindergarten through second graders in many ways. It invites observation of change, a concept that fits well with students' own explorations. They have been growing and changing a great deal themselves, and this activity invites a natural extension of noticing such patterns into a broader world. There are also natural links to using all of our senses, as well as learning how to frame questions.

Children in this age group are often capable of and interested in using their emerging understandings of logic and order in helping them make sense of the world. For example, they often enjoy sorting objects into sizes or classifications and watching cause and effect. They may enjoy starting elaborate collections of things. This Thread offers opportunities for them to do all of these things within the framework of learning to observe their world and record what they find. It will provide ways for them to build their increasing knowledge of words and numbers along with the skills of scientific inquiry.

In this activity, this age group will find out that they observe many patterns that they cannot easily explain. There will be many unanswered questions after this investigation. Beginning the process of experimentation without knowing all of the answers is an important lesson in learning to think as scientists do.

Teachers will need to help children consider the difference between cause and effect and correlation in concrete instances. For instance, some children might think that it is the leaves turning color that makes them fall from the tree. What are the key causal factors and what are correlational ones? The Everyday Classroom Tools Project can help all students think deeply about key causal factors (the tilt of the Earth resulting in shorter daylight time thus less warmth) and the multitude of correlated effects (birds flying south, leaves dropping, plants making seed pods). It is unlikely that the youngest children will be able to make all of these connections, but their teachers can help them see particular instances when a pattern is correlational as opposed to causal (i.e. The leaves turning color will not "make" the birds fly South, the increasing cold causes both.)

Inquiry Introduction

Many of us have questions about our world. What makes a day happen? What are the stars? How do birds fly? Why is the sky blue? Where do we usually go for answers? Many students will say their parents. Where do parents go for answers? Many will say to books or TV. Where did books and TV get their answers? And so on until we realize that someone somewhere - and some when -

discovered those answers because he or she had the same questions. If there can be a someone who had the same questions as us, doesn't it follow that if he found the answers, so can we? All we'd have to do is think of a plan for finding that answer. It would probably start with observing the richness of the world.

Inquiry Investigation

What does it mean to look at something? How many students in the classroom could tell you what the sky looked like when they got to school this morning? Why is the number so few? Is it important to observe the world around us? Why do we only do so when there may be danger, such as crossing the street? Let's pick a question such as what does our world look like right now and go answer it. How do we start? Well, first we go outside!

Outside the classroom is a wealth of information. Where do we begin? As explained in the background information, we want the students' data to show the real changes as we go from summer to fall. So, once outside, you may want to encourage the students to look at their world closely, giving examples of the trees and plants as good things to draw or record. They should feel free to observe whatever they wish, as long as the plant life is examined along with other objects.

What does the sky look like today? Is it a nice day? What colors can we see around us? How big is a tree compared to a grass blade or to us? What things could we pick up and which things are too heavy? Are there bits of our world which we could bring back to the classroom? What might we be able to learn from them? What tools could we use to learn more about them? It's a good time to gather objects. Plastic lunch baggies for collection should be handed out with journals and pencils, and students should be encouraged to record their observations in whatever manner they understand.

In the classroom, break the students into groups seated at different tables. Let's spill the contents of our baggies on our group's table and look at what we've got. In what ways could we sort these objects? What things about them are the same or different? Size, color, dryness, function, and shape are all good ideas for categories.

Encourage students to try all different ways of sorting. Older students could record the number of objects which fit into each group or fit each category. Younger students could show you what they have done once they have sorted in one way, and then you might suggest they try to find yet another way to sort their collections.

What is change? Does the world outside of our classroom change at all and, if so, in what ways? How would we see those changes? How could we know for sure that things had changed? Would asking our parents about our observation site in the school yard give us any answers? Why not? The answer is that they are not here and it was our observation not theirs. Hopefully, students will see that they would need to go back outside and check to see if things change.

The next time you take students outside, bring them to the same spot they went to before. Ask them very specific questions, such as "Were there that many leaves on the ground last time?" and "Did that plant have seed pods?" They probably will not have made a very careful record of their first visit and may not be able to answer definitively.

Here is where we can discuss the importance of recording. This is not to say we need be boringly precise in our drawings and text. This is just to point out that had our questions been very explicit, our records should have been as well. However, our questions were broad, and so were our discoveries. But what if we had wanted to know the answer to a question such as "What will happen to the trees?" Where would we start?

We could pick a tree which we could watch all year. We would make careful records of it when we came outside. We could even name our tree and collect leaves from it. We should never fail to observe the world around the tree. Observing just a tiny piece of our view makes it difficult to talk about the whole view. We should recognize that there is more to observing than just looking at tiny bits. Choosing some good times to repeat this Investigation, such as the first snow or the coming of spring, would be beneficial for getting a good chronology of the changes taking place outside.

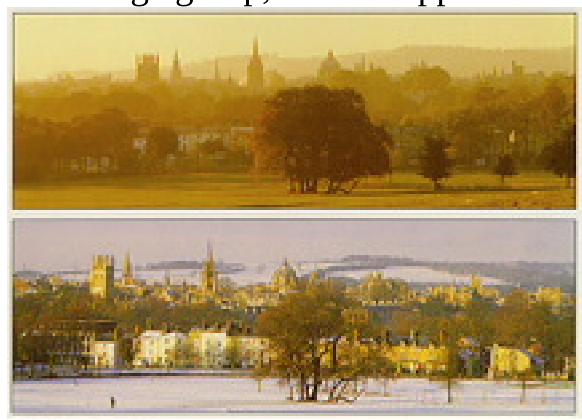
Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To K-2nd Grade Thread

Second Grade through Fourth Grade

Developmental Issues

Students in this age group are growing increasingly able to think about abstractions. Inferring abstract patterns from concrete instances, as called for in this Thread, fits well with their developing reasoning skills. They can reflect on their thinking and can consider whether their reasoning follows from the evidence that they have collected. While second to fourth graders have the skills to answer more of their questions than younger children, they will find that science is a continuing process of seeking answers, an important lesson for all learners! Teachers can help students of this age make a distinction between cause and effect and correlation (i.e. The leaves turning doesn't make the birds fly South. Instead, these are correlated and the increasing cold causes both). Teachers can introduce the words, "causal" and "correlational" to help students think about how events are related.

Often children at this age want to be given "real" and "grown-up" things to do. Beyond this, their growing cognitive capacity enables them to hold many possibilities in their minds at once and to consider alternative explanations and scenarios. Therefore, for this age group, we will approach this Thread very seriously and talk more about mysteries and puzzles -- the answers for some even we do not know! We will tell them we are stepping back to explore their questions with the tools we have available to us. Consider having the students work in groups for investigation. Exploring the ideas of others is an important source of learning and capitalizes upon this age group's budding social interests.



Inquiry Introduction

Close the window shades or drapes (or whatever) and ask the students some questions. How many of you students can tell me what the sky looks like right now without peeking outdoors? How many of you think it is cloudy? `Those who say "yes" should all meet at one place in the room. What about sunny? They should go to another part of the room.`

`Address each group in turn.` What clues or evidence did your group use to make this claim? Did you guess? Is it OK to guess? Sure, but it is best if we made an educated guess or one based on clues we put together. Making an educated guess means we are thinking and puzzling. How could we know for sure what the sky looks like right now? Look at it, of course! `Open the shades.` Who was right? What is the evidence?

`Close the shades once more. Ask students to tell you something about the ground near a big tree or other obvious object in the yard. How are we supposed to know that? you may hear.` Well, the shades were open and the world was there to see. But you asked us about the sky! Here is another key element about observing our world. So often we simply look at the one thing which is immediately important but neglect to view the rest. For example, we look both ways at a cross street, because we don't want to get hit by a car or bicycle. This is a very good reason to look around, but why not just look around because the world is pretty cool?

Inquiry Investigation

Outside, what things can we see that are alive? What things are not alive? What things may change in a year or a week? What could we watch through the year that might go through some clear and obvious changes? Trees are a good choice. We could even take a photograph or draw a picture of what it looks like now. How long do we think it might take before we see some kind change? And what kind of change might that be?

What things can we find on the ground? Seeds? Dead leaves? Weeds and flowers? Will these be here in a week? In a month? Why or why not? Have the groups collect those things on the ground around the tree, keeping a record in a journal. How do these things relate to the tree, if at all?

What other things in this school yard could we watch? What about the wildlife, if there is any? What kinds of critters seem to live around this tree? What do these critters do in the yard? Bees which gather pollen and help flowers grow are an example. Will bees be around when the flowers are gone?

Return to the outside area around the tree (or wherever you started) and repeat the gathering of data by collecting bags of samples and making pictures of the area. In the classroom, create stations with scales and rulers. Allow teams with their data collection bags to analyze what they have in terms of weight, size, color -- whatever they decide are characteristics. They should keep this data in their journals, maybe even staple or tape their baggies on to pages of the journal. Have students explain their findings to the other teams.

How might these findings change over time? Let's plan to go outside again and test some theories about what we think may happen out there.

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To 2nd-4th Grade Thread

Fourth Grade through Sixth Grade

Developmental Issues

This Thread may seem like a silly exercise to students at this age; they do not like to look stupid or take risks, especially in the sixth grade. At this age, students are establishing their individuality and gaining a sense of who they are. An important message this lesson can convey to them is that multiple perspectives and observations help us to have a fuller, increasingly objective account of what is happening. Stressing the importance of different kinds of perspectives and observations increases the level of engagement of all students and suggests to them that it is okay to be yourself. Therefore, this investigation should not seem like a race or a contest. However, as this is the very first introduction to Inquiry-based learning for many of them, encouraging independent thinking within a group situation is key.

These students also are becoming increasingly introspective. This is a good age to do related writing activities focused on topics, such as how one feels about the changing seasons. Perhaps letting them go out with a journal is a more private means of letting them explore. Talking about what is written is often easier than asking them to call out. As students grow more accustomed to inquiry-based approaches, their verbal participation should increase. For teachers who already use inquiry-based approaches, it's likely that your students are less reticent than others.

Inquiry Introduction

What was the sky like yesterday? How many birds live in the tree across the yard? How many cars were parked in the lot when you got to school? How are we supposed to know that? What was the Moon like four days ago? When will a hurricane hit Florida? How do cancer cells grow? What is a tadpole? All of these things require observation.

`In teams, have the students pick one of these questions above and brainstorm about the things one would need to do to answer them.` The key to answering these puzzles is knowing that all of them require watching something for a period of time. For example, if you looked in a pond and saw a bunch of tadpoles, you would think they were the local critters in the pond. If you looked again in three months and they were gone, you might be very confused. Where did they go? If you looked and found them nowhere, you would be alarmed, perhaps, especially since there are now a bunch of frogs hanging around. Did the frogs come in and eat the tadpoles? Of course not. Everyone knows that tadpoles are baby frogs, but how did someone ever learn that?

You need to watch carefully and repeatedly the changes that happen around you and be aware of cause and effect. You also need to isolate the important details from the fluff. What things do you need to watch in order to discover if a hurricane is going to hit Florida? Do you need to watch soap bubbles in your sink? No, you would need to watch the weather reports and storm fronts. What if you wanted to watch the seasons turn from summer to fall? Would you watch a shoe? What would you watch? What kind of data could you gather?

Inquiry Investigation

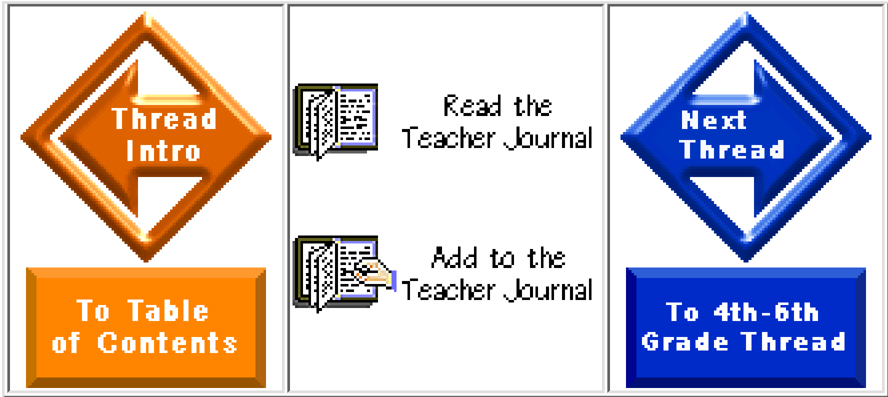
With journals and plastic bags, let's begin exploring the world outside the classroom. What are the things out here which could change first? Which things probably will not change until later? Are there things which may never change in our life times? What could we collect as evidence of what we are seeing out here? What are we seeing out here anyway? In your journals, write some thoughts about the world out here. Pick a spot you want to watch for a while during the year that you think will change fairly impressively. Draw it as you see it and gather some bits from the area that represent what you see. Do you have any predictions about which parts will change and which will not? Why? Why not?

Why is it important to pay attention to things in our world? What if you never looked both ways when you crossed a street? What might happen to you? How about if you never checked the weather from a window or door before you went out? There are some practical aspects of keeping an eye out on the world, aren't there? Are there things you have watched grow for your own pleasure? Are there things you have checked in on every once in a while to see how they are doing, like a chicken's nest, tadpoles, a sleeping baby sister, or crystals?

On what scales do things change? Is change always obvious to our unaided eye? Does the Sun change? Do the wings on a gnat change? What tools would we need to observe these kinds of changes? Using a microscope for tiny specimens is possible in an elementary school. Using a telescope for more distant changes may not be. Inviting an astronomer with a telescope and sun filter would be a good means of watching the Sun. However, do not try to do this without an expert. Looking at the Sun through a telescope will instantly, painfully, and permanently blind the observer!

Talk to the students about what the tools of inquiry are: Asking questions like these to fuel understanding, being curious and using science to guide you to answers, is known as the Spirit of Inquiry. There are many things we could ask here about the world outside, such as how do trees survive the winter or where do the birds really go and when? Let us make some lists of questions we would like answered about changes in the world. For how many of these do we really think we might find answers?

How do people find answers to questions? Many people ask other people or read books. Others look on the Internet or watch a television program about it. And still others, scientists, create ways of discovering answers by careful observation. We will be scientists, by going outside and experiencing things for ourselves, so that when we do find answers, they are our own. We must be able to think about things and not be afraid to ask questions about them. Without a question, there is no inquiry. Without inquiry, there is only reading someone else's data from books.


Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To 4th-6th Grade Thread

To correspond with the investigations of Day and Night, we have collected a set of web sites which will show you live pictures of different places around the world. Although we cannot fly everyone to these sites, we can at least go there by way of the Internet.

- **Day/Night Globe.** **This is a picture of the whole Earth that you can click on to zoom in on. It is shaded according to which part of the world is having night and which is having day. You can also change your viewpoint from a plain world map to what the Earth looks like from the Sun or Moon. You can get weather features on the map as well as other features.**

- **World Map.** **This is a site with a world map marked with red dots where there are live cameras.**

  Here are some selected sites:

  What time of day is it? What season is it? Where is it on the Earth?

  Cambridge, England

  Mt. Fuji, Japan

  Sydney, Australia

  Fairbanks, Alaska

- **Around the World in 80 Clicks.** **A guided tour around the world through 80 live cameras.**

Back to the ECT Home Page

Author/WebMaster Tania Ruiz
Last updated January 22, 1999

lesson title: solar observation = primary grades

---

concept / process goals: students will . . .

---

exploration lesson

*** students mark the hourly position of a shadow**

processes that make up the exploration lesson

- **observe:**

  * shadows of a meter stick
  * their own shadows
  * shadows of other objects
- **observe:** students play shadow tag -- stepping on another person's shadow
- **observe:** that some shadow edges are sharp (distinct) while others are fuzzy.
- **observe:** the sun seems to move to the "right" when facing south as the day goes on.
- **communicate:** students put numbers on the shadow to agree with the time of day (9 a.m. --- 10 a.m.)
- **measure:** cut a piece of paper the length of the shadow each hour of the day. They do not use units (inches / cm)
- **measure:** define noon as the time of the shortest shadow
- **gather data / predict:** after seeing the change in shadows for three one hour periods, students predict the position of a shadow in one hour. They put bottle caps down to mark their prediction.

---

concept introduction

- shorter / longer / lighter / darker / left / right / position
- compass directions:

  * east is the position where the sun is seen in the morning
  * south is the position where the sun is seen at noon
  * west is the position where the sun is seen at day's end
- the edges of short shadows are sharp (distinct)
- the edges of long shadows are fuzzy

---

concept application

- students continue to make weekly observations to note --

- the sun seems to be in the same spot at the same time each day
- check the accuracy of their sundial
- shadow length and position do not change (much) from day to day
- shadow tag: determine which time of the day would be the best to
- play if --
  * they were "it" -- trying to "catch" other people
  * they were trying not to be caught

Misc: materials needed; synectic / STS possibilities; safety

- **safety:** students will not look directly at the sun.
- **health:** sts: skin care - the sun can be harmful
- **materials:** masking tape; meter stick; support; chalk

9 / 20w / 95

lesson title: solar observation = intermediate grades

---

concept / process goals: students will . .

---

exploration lesson

*** mark the hourly position of a shadow on the sidewalk**
*** mark the hourly positon of the sun on a "sun globe"**
*** mark the position of the rising sun on an east window**

processes that make up the exploration lesson

- **observe:**

  * shadows of a meter stick
  * their own shadows
  * shadows of other objects
- **observe:** students play shadow tag -- stepping on another person's shadow
- **observe:** that some shadow edges are sharp (distinct) while others are fuzzy.
- **observe:** when facing south notice that the sun seems to move to the "right" as the day goes on.
- **communicate:** students put numbers on the shadow to agree with the time of day (9 a.m. 10 a.m.)
- **measure / gather data / graph -- linear data:** record the hourly shadow lengths in cm & plot them on a graph
- **measure / gather data / graph -- angular data:** determine the hourly angular change in the sun's position
- **communicate:** use their computer and art class time to make posters that will be displayed in the halls and inform others (and be updated) about this year long project.
- **measure:** define noon as the time of the shortest shadow
- **interpret data:** compare wrist-watch noon to solar noon
- **gather data / predict:** after noting the change in shadows for three one hour periods, students predict the position of a shadow one hour later. They mark their prediction bottle caps.

---

concept introduction

- compass directions:

  * east is the position where the sun is seen in the morning
  * south is the position where the sun is seen at noon
  * west is the position where the sun is seen at day's end

- the edges of short shadows are sharp (distinct)
- the edges of long shadows are fuzzy
- zenith angle = the angle that separates the sun from being directly overhead
- the larger the zenith angle, the longer the shadow

---

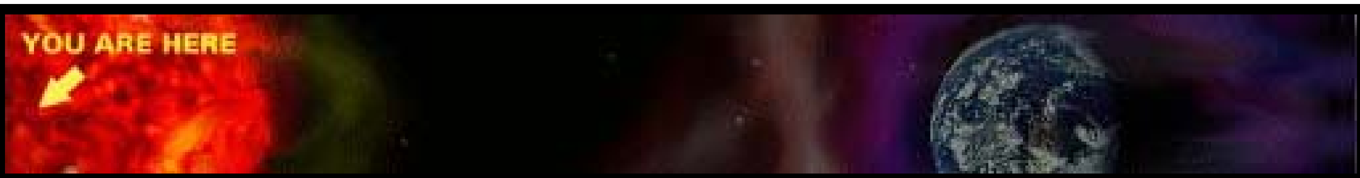
concept application

- students continue to make weekly observations to note the position of "sunsight" and "sunclipse" changes with the seasons
- check the accuracy of their sundial
  * shadow length and position do not change (much) from day to day
  * shadow tag: determine which time of the day (and season) would be the best to play if --
  * they were "it" -- trying to "catch" other people
  * they were trying not to be caught

Misc:

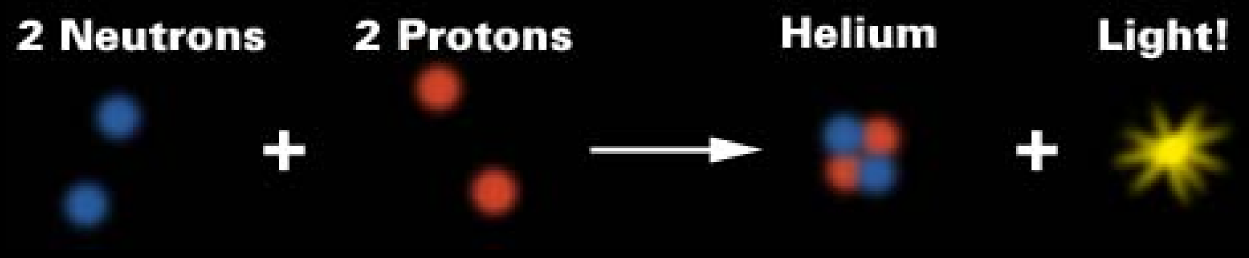
- safety: students will not look directly at the sun.
- health: sts: skin care - the sun can be harmful
- materials: masking tape; meter stick; support; chalk

9 / 20w / 95



The center of the Sun

The center of the sun is very hot (about 15 million degrees Celsius) and the pressure is immense (about 100 billion times the airpressure here on Earth).
Because of that, atoms come so close to eachother that they *fuse*.



In every second, the Sun spends 700 billion tons of protons (or: Hydrogen) in this way. And only a small fraction (0.7 percent) is turned into light.

Right now, about half of the amount of Hydrogen in the core of the Sun has been fused into Helium. This took the sun about 4,5 billion years.

File Not Found

The page you requested 'http://www.phys.uidaho.edu/~pbickers/Courses/310/Notes/book/node11.html' was not found on this server.

Click here to go to the home page for this requested page's website.

Telling Time without a Clock:

Scandinavian Daymarks

Introduction

How would we measure time without a clock? We know that the Sun moves across the sky during the day. Can we tell what time it is by looking at the position of the Sun?

In modern times, precise time measurement is very important. So many people depend on knowing the "right time" to go about their daily business. Industrialized societies need accurate regular time measurement to function. Does everyone on Earth live in such a society? No, in some parts of the world people still live much as they did thousands of years ago. Even our industrialized societies are fairly new when compared to most of human existence. Only a few hundred years ago telling time exactly wasn't so important. But it was still helpful to get a rough idea of what time it was.

Pointing at the Sun

Probably the simplest way to tell time is by knowing the path of the Sun across the sky and how long it takes the Sun to move. Where on Earth is this method easiest? If the Sun rises high in the sky and its path doesn't change much from season to season, it is pretty easy to tell time from the position of the Sun. The Sun behaves more like this the closer to the equator one gets. Many pre-industrial peoples in the tropics used this method of telling time, even into this century. Many African peoples--such as the Cross River, Caffres, Waporogo, and Wagogo peoples--would indicate time by pointing to a place in the sky where the Sun would stand at the time they wished to indicate. The same method was used in other parts of the world, such as the New Hebrides, Dutch East Indies, and Sarawak.

Hours of Day, Hours of Night

What about telling the time of the Sun in regions farther north or south of the equator? The Sun's path changes much more over the course of the year as one moves farther from the equator. In winter the Sun might be very low while in summer it might be much higher.

One simple way to tell time was to divide the daylight time and the night time into segments. Many cultures did this, using different numbers of segments. For example, the Chinese divided one sun-cycle into 12 sections and the Hindus into 60. Very early on, the Egyptians divided the period between sunrise and sunset into 10 sections, an d then added two more sections for the periods of twilight at dawn and nightfall--making 12 sections of daylight time. They then divided the night into 12 sections also. This made a division of the sun-cycle into 24 sections, very much like the 24 hours that we divide the sun circle into. The Babylonians used a similar system, and this is in fact where our modern 24-hour day has its origin. [1]

However, there was an important difference between the hours we use and the "hours" of the Babylonians and the Egyptians. Their "hours" changed length, depending on what time of the year it was! They divided both daylight and nighttime into 12 sections each. When the daylight lasted a long time during the summer, their daylight "hours" could be as long as 75 minutes, while the nighttime "hours" were only 45 minutes long. In winter, however, when the Sun was not up as long, their "hours" might shrink to as short as about 55 minutes during the day, while at night they were about 70 minutes. Only on the equinoxes were their "hours" 60 minutes, both day and night, just like our modern hours. You can imagine what trouble using a system like this would cause in the modern world, as the length of the hours changed slightly each day of the year!

The ancient Greeks had borrowed the Babylonian/Egyptian system of counting hours, but in the late second century BCE, over 2100 years ago, a Greek astronomer called Hipparchos suggested that the "equinoctal hours" of 60 minutes each for use at all times of the year. This is where our modern system ultimately comes from, but it was a long time before it became widely used. The Greeks (and Romans) continued using the Babylonian/Egyptian system of "temporal hours" which changed length through the year for thousands of years, and many European peoples adopted this usage as well. In 725 CE, the English monk Bede wrote a highly influential book on time-keeping. Most importantly, it helped popularize the modern Western system of counting years (AD/CE and BC/BCE), but in it Bede also argued for dividing the sun-cycle into 24 equal hours at all times of the year. Nevertheless, it was not until mechanical clocks started to become common during the 1300s that the "equal hours" began to replace the "temporal hours" for good.

Scandinavian Daymarks

The Egyptians, Babylonians, Greeks, and Romans all lived far enough north of the equator that they could not rely on a fairly constant Sun-path over the year, as people in the tropics did, but they were not so far from the equator that the differing lengths of day and night made it difficult for them to use their "temporal hours", even though their lengths changed somewhat over the course of the year.

Very far north (or south) of the equator, however, the difference between the length of daylight time in the summer is very much greater than in the winter. In parts of Scandinavia above the Arctic Circle (at a latitude of 66.5° North) the Sun does not set at all for part of the summer--it is daylight all the time. On the other hand, for part of the winter the Sun does not rise in these same areas. Obviously there is no point in dividing the daytime or nighttime into twelve sections if they are not taking place! Even if the Sun sets for only three of our modern hours in the summer, if one is dividing the daytime and nighttime into Babylonian/Egyptian-style "temporal hours", the nighttime hours will be so short compared to the daytime hours that there is hardly any point in making the divisions.

However, even very far north (or south), no matter where the Sun rises or sets, the middle of its path is above about the same part of the horizon. That means you can always tell when the middle of the day is if you know above which point on the horizon the highest point of the Sun's path is. Also, no matter how high the Sun is above the horizon, it always passes over the same points on the horizon after the same interval of time. Using these facts, the people living in Scandinavia developed a system of time-keeping quite different than the Babylonian/Egyptian system.

As said earlier, our modern system of time-keeping divides each sun-cycle into twenty-four hours, each of which is 60 minutes long. The Scandinavians divided each sun-cycle (*sólarhringr*, "sun-ring" in their language) into eight sections. [2] They did this by dividing the horizon into eight sections (north, northeast, east, southeast, south, southwest, west, and northwest). Each of these sections was called an **eighth** (*átt* or *eykt*). [3] A place on the horizon which lay dead center in any of these eight directions (due north, due northeast, etc.) was called a **daymark** (*dagmark*). [4] The identified the time by noting when the Sun stood over one of these daymark-points on the horizon.

The Midday Daymark

What do you think the most important daymark was? It was the daymark beneath the highest part of the Sun's path, since the Sun reaches the highest part of its path above the same part of the horizon every day of the year. This central daymark was named Highday or **Midday** (*hádegi* or *middag*). That was the name of the time, just as we would say "twelve o'clock" or "noon". The position of the Sun at this time had its own related name: **Midday Place** (*hádegistað* or *middagsstad*). [5]

Many, perhaps most, Scandinavians lived in isolated farms or villages in earlier times. They used geographical features located on the horizon (as viewed from near their homes) as guides to the daymarks. Often they would name a feature, usually a mountain, after the daymarks. Since Midday was the most important daymark, there were many mountains named after it: Middagsfjället, Middagshorn, Middagshaugen, Middagsnib, Middagsberg, and Middagsfjeld are all mountain names in Norway--similarly Sweden has Middagsberget and Middagshognan, while Iceland has a Hádegisbrekkur. All of these names are made by taking the Scandinavian words for Midday (or Highday) and adding a Scandinavian word meaning "mountain". They are like saying "Mount Midday" or "Midday Mountain" in English.

The Other Daymarks

Midday was the most important daymark, since it divided the Sun's path in half, but there were seven other daymarks in all, and each of these had names, too. Some of these daymarks took place during the night when the Sun was below the horizon. Because Scandinavia was so far north, during the winter the Sun could be below the horizon most of the time! But when the Sun is not very far under the horizon and the weather is clear, it is still possible to see it's light showing where the daymark is on the horizon.

What is the opposite of Midday? It is Midnight. Just as we have a name for the middle of the night in English, the Scandinavian's had a name for the daymark in the middle of the night: *miðnætti*. It is very easy to find a Midnight daymark in the summer in Scandinavia. Although the Sun often does set for a while at night, the twilight is often bright enough to mark the spot on the horizon which the Sun is beneath. In some parts of Scandinavia the Sun simply does not set in the middle of summer! Then one need only look for the lowest point in the Sun's path, and mark the spot on the horizon beneath it. Just as the Sun reaches its highest point (Midday) at due south, it reaches its lowest point (Midnight) at due north.

Between Midday and Midnight are three more daymarks. The first is called **Undorn** or simply *eykt*. The names for this daymark are hard to translate into English. Their origins were lost long ago, and even the ancient Scandinavians may not have known exactly where the names came from--only that they referred to this time of day in the afternoon. [6] After the Scandinavians were converted to Christianity, they sometimes used the name *nón* for this time, borrowed from the Latin term *hora nona*, which means *ninth hour*--the Roman people, who spoke Latin, had considered the ninth hour of the day to happen in the afternoon (clearly they started counting their hours at a different time (6 a.m.) than we do now!). [7]

After *undorn*eykt (or *nón*) comes **Mid-Evening** (*miðr aptann*). At Mid-Evening, the Sun is approximately due west--or halfway between the Midday (south) and Midnight (north) daymarks. On the equinoxes the Sun would set right at the Mid-Evening daymark. Before Midnight, there was one more daymark called **Night-Measure** (*náttmál*). [8]

Between Midnight and Midday there are three more daymarks, making eight in all. Midnight was followed by **Ótta**. This name comes from an very ancient Germanic root-word, **uhtwón*, and designated the time of night before daybreak, which was thought the deepest and most frightening time of night. [9] Even during summer, the sky would darken a little at this time in many parts of Scandinavia. In winter, Ótta must have seemed very dark indeed!

Mid-Morning (*miðr morgun*) took place when people woke up in the morning. [10] Most of the daymarks were determined by events in daily life like this. Since the Sun rose so early in summer, it might have been light long before people finished sleeping. On the other hand, in winter, the Sun might not rise until long after people woke up. In a way similar to that of Mid-Evening, the Sun at Rise-Measure is approximately due west, halfway between the Midnight (north) and Midday (south) daymarks. On the equinoxes the Sun would rise right at the Rise-Measure daymark. Before Midday there was one more daymark called **Day-Measure** (*dagmál*)--just as Night-Measure came before Midnight.

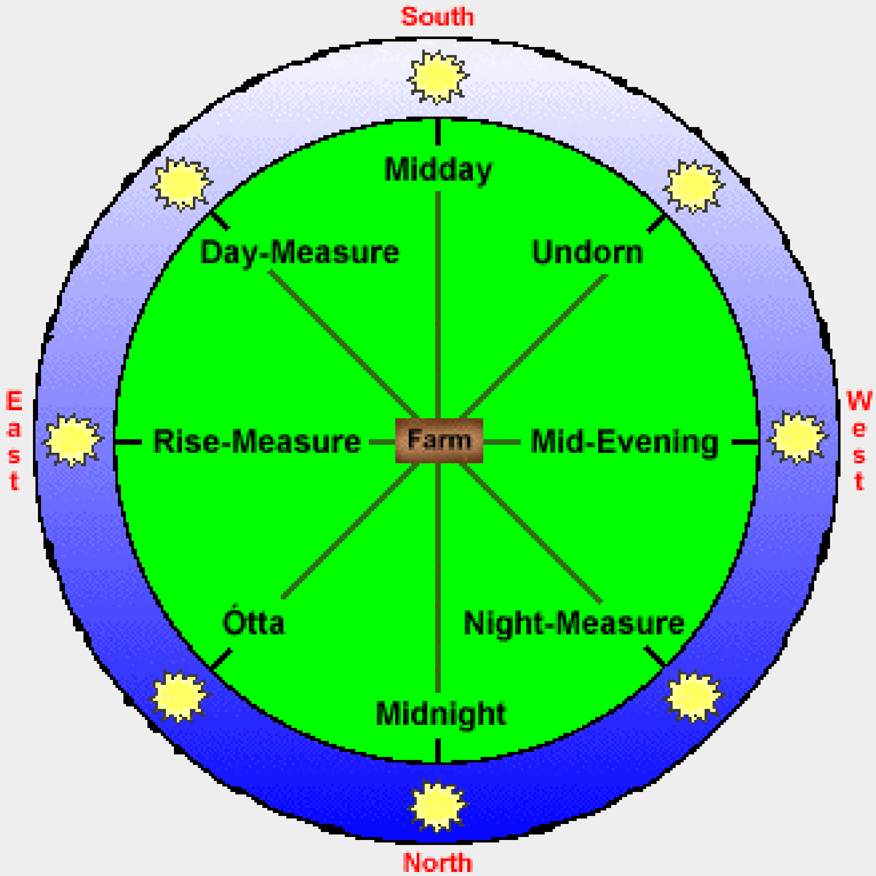
These other daymarks did not seem to be as important as Midday, but sometimes we find geographical features named after these daymarks, just as we found them named after the Midday daymark: in Norway we find Rismaalsfjeld and Nonsfjeld, in Sweden we find Nonsberget and Nonsknätten. In Iceland are Dagmálahóll, Eyktargnipa, Nónfell, Miðaptansdrangur, and Undornsfell. Around a thousand years ago many Scandinavians settled in England, and they used some of these same naming traditions at their new English farms. Thus, there are some more daymark-type place names in the parts of England where they settled.

How Daymarks Work

On the right is a view of a Scandinavian farm from above. In the center is the farm house, and around it are imaginary lines and labels showing in which direction the various daymarks are. The edge of the green circle represents the horizon. Beyond it the Sun is shown standing at the eight daymark points on the horizon. Would the Sun always be visible at these daymarks? No, sometimes it would be below the horizon and not visible. But even when we cannot see the Sun it is still below the daymark, underneath the horizon at night.

In the summer, when the Sun is up almost all of the time, the Sun appears to travel around the circle in a clockwise fashion. Even at midnight, there may be enough twilight lingering in the north to show where on the horizon the Sun would be. If the farm were far enough north, the Sun might even be visible above the horizon at midnight during the middle of the summer.

In our modern system of telling time, if the time is halfway between one hour and the next--between 2 p.m. and 3 p.m. for example--we might say it was "half past two". The Scandinavians used a similar system when the Sun stood halfway between two daymarks. In such a case, they would say it was "evenly near both" (*jafn nærri bá ðu*) daymarks. So if the Sun



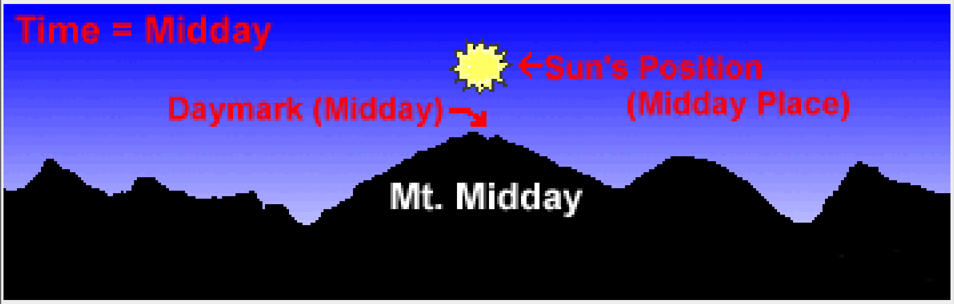
View of a Scandinavian farm from above, showing showing the directions in which the daymarks lie.

were between the Midday and Undorn daymarks, they would say, "It's evenly near both Midday and Undorn."

Daymarks on the Horizon

This diagram, on the right, shows a view south from the same Scandinavian farm, with mountains on the horizon drawn in black.. It shows how the daymarks work, using the Midday daymark as an example. The people living on this farm could watch the Sun's path everyday and find where its highest point was--and in this diagram the Sun is shown at the highest point in its path. What did the Scandinavians call this place in the Sun's path? They called it **Midday's Place** (*hádegistað* or *middagsstad*).

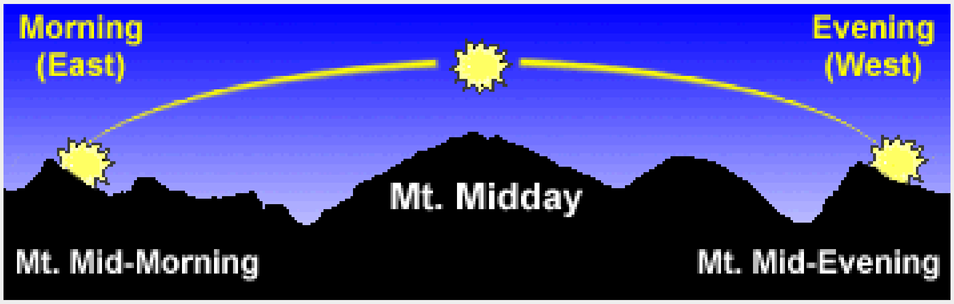
Conveniently for the people on this farm, there is a large mountain directly beneath Midday's Place which they can use as a daymark. Which daymark is it? It is the **Midday** daymark. They might name the mountain under the Midday daymark something like "**Mount Midday**". Then they will know that whenever the see the Sun over Mt. Midday, that the time is "Midday".



When the Sun is in Midday Place, it is above the Midday daymark. This means the time is "Midday".

On the right is a diagram showing a view from the same imaginary Scandinavian farm. This view shows the Sun's path on the equinoxes, either autumn or spring. The Sun is shown its positions at **Rise-Measure's Place** (sunrise), **Midday's Place**, and **Mid-Evening's Place** (sunset). The Sun's path is drawn in yellow.

The mountain which marks the Midday daymark is named Mt. Midday. On some farms, the people might find mountains for the other daymarks and name them, too--or they might use other features, like passes, waterfalls, etc. In this diagram, there are mountains named after the Rise-Measure and Mid-Evening daymarks, and

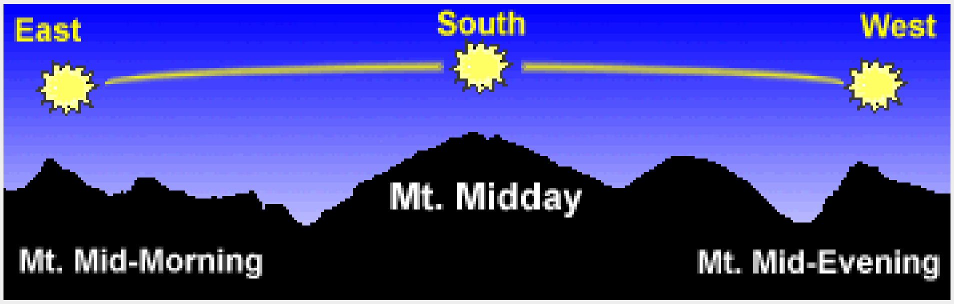


Equinoctal View of the South Horizon from a Scandinavian Farm

their names are in brackets.

Summer and Winter and the Daymarks

Now look at the view from the same farm in summer. Where is the Sun's path now? The Sun is very high in the sky, even when it is over the Rising-Measure and Mid-Evening daymarks! During the summer the Sun's path is longer than it is at the equinoxes and much, much longer than it is during the winter. But no matter how high or low the Sun is in the sky, it still arrives over the daymarks at the same time. This means when the Sun is at its highest point in the winter it is still over the same daymark as in the summer. So when the Sun is over Mt. Midday it means that the time is Midday, whether it is winter or summer. It's highest point during the



Summer View of the South Horizon from a Scandinavian Farm

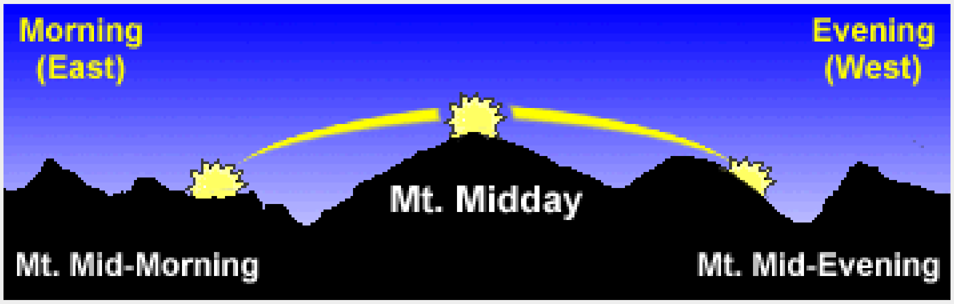
winter is not as high as its highest point during the summer.

During the summer in Scandinavia, the Sun scarcely ever sets--particularly in the northernmost sections. The diagram on the right shows what a view north from the same Scandinavian farm might look like at Midnight in the middle of the summer. The twilight glow of the Sun is still visible, even though the Sun is below the horizon. This is the lowest part of the Sun's path. At the Midnight daymark on the northern horizon there is a pass--a gap in the mountains--which the people living on the farm might name after the daymark. Perhaps they might call it Midnight Pass, just like they called the mountain to their south Mt. Midday, after the Midday daymark

Summer View of the North Horizon from a Scandinavian Farm

On the right is a diagram showing a view from the same imaginary Scandinavian farm, except that this view show's the Sun's path during the winter. What is different about the Sun's path now? It is shorter. The Sun rises and sets closer to the middle of its path than it does in the equinoctal diagram above. The Sun is also lower in the sky. But is the Midday Place in the winter still the same as the summer Midday Place? It is. No matter what time of year it is, the Sun is always highest in the sky over the same spot on the horizon (due south).

Is this also true for the other daymarks? It is. Even if the people on the farm cannot see the Sun because it is below the horizon, the daymarks remain at the same place (and same time). However there is a problem! If during the winter the Sun is only above the horizon around Midday, then no one



can tell what daymark it is at. This seems like a big problem. However, during the winter it was so dark and cold outside that people spent most of the time indoors, resting, entertaining themselves, or doing indoor tasks. In such cases it wasn't so important to know what time it was. On the other hand, in the summer, there was a lot of activity--and luckily the Sun would be up most of the time, so that it would be very easy to tell what time it was.

However, if any daymark would be visible in winter, it would be the Midday daymark. Why is this? It is because Midday occurs when the Sun is at the highest point in its path. Perhaps this is why there are more mountains named after Midday than any other daymark.

Winter View of the South Horizon from a Scandinavian Farm

Daymarks and Day Sections among Other Peoples

The Scandinavians were not the only people to use the surroundings to help them tell the time. In the area around Antananarivo in Madagascar people where the Sun stood in the sky in relation to different parts of their houses. For example, when the Sun was over the ridge of the roof, it was midday. They could do this because they always built their houses in the same way, with the length running north and south.

Many, many peoples around the world divided their day up into sections which, like the Scandinavian daymarks, would change in length at different times of the year. This is because these people, like the Scandinavians, were farmers who were more interested in using the sunlight than having hours of the same length like we are! The Native American Natchez people of Louisiana, USA divided up the day-light time into four sections, just like the Scandinavians. Many other Native American tribes did the same.

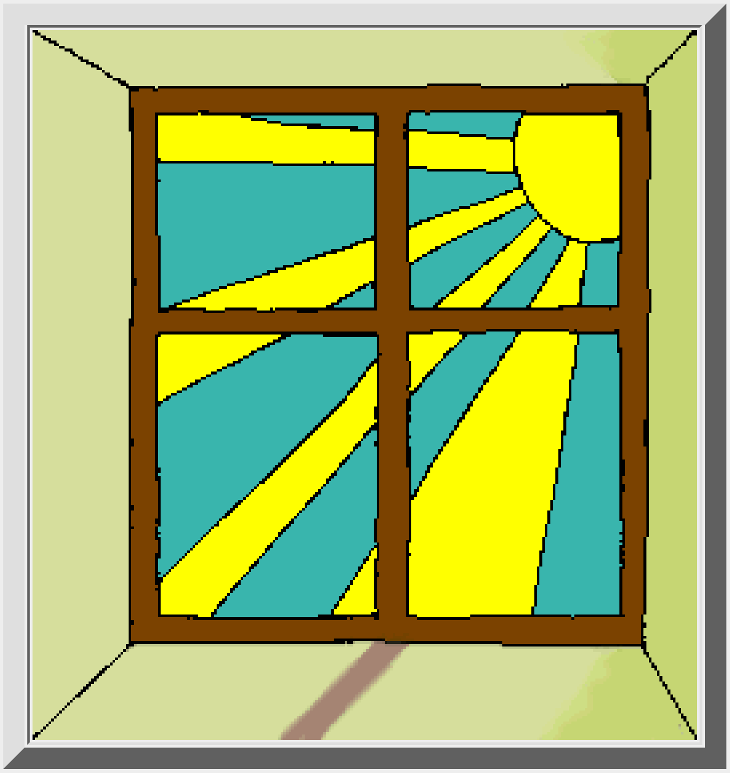
Class Projects

Schoolyard Daymarks

You might try having the class calculate measurements of "temporal hours" for their hometown. Depending on the time of the year, it might be possible for them to observe sunrise or sunset directly, either at school or at home. If they cannot record these measurements directly, one possibility would be providing them with a set of sunrise and sunset times over the year and having them make the calculations (if their math skills have reached this level) of dividing daytime and nighttime into 12 sections each. This, however, would not provide the students with the experience of direct observation that is at the heart of the Threads of Inquiry. Instead, you could choose other ways of splitting up the day. Suppose they divided the amount of time they were at school into twelve "school hours" and the time they were at home into twelve "home hours". The "school hours" would be much shorter than the "home hours". What would happen in the summer? There would be no "school hours" at all! Perhaps this system would not work so well over the whole year.

You might also have the students experiment with a daymark-system. They don't need to live on Scandinavian farms, they can try them out at their own houses or at school.

First they will need to observe the path of the Sun to find the highest point in the Sun's path. Go outside in the hours around 12 noon for several days to find this time. During **Hello, Sun!** (and later more mathematically in **This is a Stick-Up**), the class found out how to record the Sun's path and to find out when it was highest in the sky. All they need do now is find what is on the horizon beneath the Sun when it is in Midday Place at its highest point. There need not be a mountain there--a building, a tree, anything to mark



the spot will do. When the ancient Scandinavians didn't have a natural feature to mark the spot for them they would often build a little pile of stones out towards their horizon. Perhaps you can mark the spot with a pole or with colored ribbons. If nothing else, you might have the students draw a large panoramic view of the horizon and draw the Sun's positions on it, marking the Midday daymark.

If you can, have the students note the positions of the Sun at the beginning and end of the school day (probably easier than sunrise and sunset!) at different times during the school year. Perhaps you can find or make various daymarks for the other "eights". You can even have them invent names for times of day which are meaningful to them: School-Start for the morning and Go-Home for the afternoon, perhaps. Have them see how the daymarks for these times can change over the year, while the Midday daymark stays steady. The same experiments can be done at the students' own homes as well.

Class Noon-Line Project

Another project could be making a window **Noon Line**. This was a device used by farmers in Skåne, Sweden to mark Midday. Find a south-facing window which has several panes of glass. Notice how the solid framework between the panes casts shadows onto the window sill. When the Sun is at its highest point (at Midday) you can mark the line of the shadow cast by the pane frame with masking tape. This effectively turns the window into a simple sundial. Whenever the shadow of the pane frame matches the line of tape, that means it is Midday.

Footnotes

[1] The English word "hour" comes from Middle English *houre/oure/ure*. These forms were borrowed from Anglo-Norman *ure*, itself related to Old French *ore* or *oure* (Modern French *heure*) stemming ultimately from Latin *hora*. Late Latin *h* had become a silent letter, explaining why it does not appear in the older English or French words for "hour"--it was only added back in modern times, modeled on the classical spelling of Latin *hora*. The Latin word stems back to a very ancient Indo-European root, *jér-* or *jór-*, which had to do with units of time. This same root lead ultimately to the word "year", through a different developmental path. Back to text

[2] For convenience, all Scandinavian terms are given in Old Norse (or Old Icelandic), the medieval language from which the modern Scandinavian languages are descended. The equivalent terms in the modern Scandinavian languages have changed very little. Geographical names, however, are written in the language of the named feature's region. Back to text

[3] As a translation of *átt*, a word like "octant" or "octet" might be more appropriate than "eighth". Since the relation of these words to the number eight (8) might not be immediately apparent to students, "eighth" is probably better. It might be mentioned that sometimes this word is spelled *ætt*, which means "family" (used in the sense that the different directions may be grouped into a "family of directions". It is unsure which term is more correct, but *átt* and "eighth" are used in this document.
Eykt has a totally different meaning. It is related to the English word "yoke" (Old Norse *eykr*), as in the device used in harnessing draft horses or oxen. Draft animals could only be harnessed for a certain length of time before they needed to be rested. Thus, people divided the time of day into segments according to when their animals were yoked. Eventually the *eykt* referred directly to the unit of time, rather than an actual yoking-period. [Jan de Vries, *Altnordisches etymologisches Wörterbuch* (Leiden: Brill, 1961).] Back to text

[4] An alternate name is *eyktarmark*, very commonly used in Iceland. English-speaking students, however, may have an easier time remembering *dagmark* and its clear relation to English "daymark". Back to text

[5] The last character in *stað* should look like a bent-stem lower-case "d" with a bent stem which has been crossed like a lower-case "t". If you are viewing this document on a DOS/Windows machine it should look like that without trouble. If you are using a Macintosh, it may look wrong (like a ">"). Macintoshes need a special font (such as Times OE) to display this and other special non-English characters. This character is pronounced like the "th" in words such as "this" or "bathe". It was originally invented by English scribes and was used in writing Old English. It was later adopted by Scandinavian scribes, but eventually fell out of use in English writing. Back to text

[6] For a discussion of *eykt*, see note 2 above. The Norwegian word *ykt* or *økt* (which is descended from *eykt*) is often used to refer to lunchtime meal eaten at this time; perhaps if this time of day was a popular lunch break, the general term *eykt* stuck as a special name for this time.
The term *undorn* may have also referred to a meal. There was once a term "undern" in English, though the word largely fell out of use after the 1400s. Strangely, it could mean either a time in the morning or (like the Scandinavian *undorn*) mid-afternoon. Variants survived in northern British English dialects (in forms like "oanders", "aunders", and "andrum") meaning "afternoon meal" into the late 1800s. In teaching this material, "undern" could be used in place of the Scandinavian word *undorn*, if desired. Back to text

[7] The English word "noon" has a similar origin, but its time has been transposed to

midday! The same shift has happened to Dutch *noen* and French *none* (a somewhat archaic term in French, now generally limited to use in certain French dialects). These words also come from Latin *nona* and originally indicated a time around 3 p.m., but now mean Midday. Back to text

8 The Old Norse word *mál* is translated here as "measure". It was a word which could be used with a variety meanings, mostly having to with the measuring out of a certain thing. It is related directly to the English word "meal" (as in a time for eating, or food eaten) and can be used in that sense. Back to text

9 There is an English version of the Scandinavian word *ótta*: ughten. It is obsolete, having largely dropped out of usage after the 1300s. A Scots dialect version of it, "oachenin" was still being used in Caithness, Scotland around 1900. In teaching this material, it could be used in place of the Scandinavian word *ótta*, however. Back to text

10 Another name often used for Mid-Morning was *rismál* meaning "Rise-Measure", a name formed like Day-Measure and Night-Measure. Back to text

---

Sources Consulted

- Andersson, Christer, Onsala Space Observatory, Chalmers University of Technology, Onsala, Sweden, personal correspondence (25 August 1997).
- Borst, Arno, *The Ordering of Time: From the Ancient Computus to the Modern Computer*, trans. by Andrew Winnard (Cambridge: Polity Press, 1993).
- Hastrup, Kirsten, *Culture and History in Medieval Iceland: An Anthropological Analysis of Structure and Change* (Oxford: Clarendon, 1985).
- *An Icelandic-English Dictionary* , prep. by Richard Cleasby, Gudbrand Vigfusson, William A. Craigie, 2nd edn (Oxford: Clarendon Press, 1957).
- Nilsson, Martin P., *Primitive Time-Reckoning: A Study in the Origins and First Development of the Art of Counting Time among the Primitive and Early Culture Peoples*, Skrifter Utgivna av Humanistiska Vetenskapssamfundet i Lund, I (Lund: Gleerup, 1920).
- O'Neill, W.M., *Time and the Calendars* (Sydney: Sydney University, 1975).
- *The Oxford English Dictionary*, prep. by J.A. Simpson and E.S.C. Weiner, 2nd edn, (Oxford: Clarendon Press 1989).
- de Vries, Jan, *Altnordisches etymologisches Wörterbuch* (Leiden: Brill, 1961).
- Thorsteinn Vilhjálmsson, Professor in History of Science and in Physics, The Science Institute, University of Iceland, personal correspondence (26 August 1997).

Author Carl Anderson
Last updated August 18, 1998

Windows to the Universe

Beginner | Intermediate | Advanced

Spanish English

MYTHOLOGY

Windows to the Universe

Beginner | Intermediate | Advanced

Spanish English

MYTHOLOGY

Windows to the Universe

Beginner | Intermediate | Advanced

Spanish English

MYTHOLOGY

For thousands of years people have associated objects in the sky, the Earth, and aspects of their physical world with the gods and goddesses of their cultures. Through these pages, find out about the gods and goddesses of different cultures around the world, and the works of art people have created to give them expression.

- Sun
- Earth
- Moon
- The Solar System
- Sky, Constellations, and Stars
- Classical Mythology
- Family Trees
- World Mythology
- Mythology Hangman NEW
- Mythology's Web NEW

Last modified prior to September, 2000 by the Windows Team and disclaimer

MYTHOLOGY

For thousands of years people have associated objects in the sky, the Earth, and aspects of their physical world with the gods and goddesses of their cultures. Through these pages, find out about the gods and goddesses of different cultures around the world, and the works of art people have created to give them expression.

Last modified prior to September, 2000 by the Windows Team

Solar Folklore

For centuries, humans have attempted to explain the Sun in terms of their own worldviews. The Sun can be a god, a demon, a mischievous spirit, an omnipotent creator or a ruthless taker of life. Whatever role it plays, most cultures have recognized the significance of the Sun as prime controller of all life on Earth.

As you read these, remember they were not stories created to entertain, nor were they written for children. These myths, legends and tales represent their culture's worldview, a peoples' attempt to explain, understand, and come to grips with nature's phenomena. To the people who tell them, these stories are as relevant and true, as deeply meaningful and spiritually important, as any scientific explanations.

Indigenous American

North American

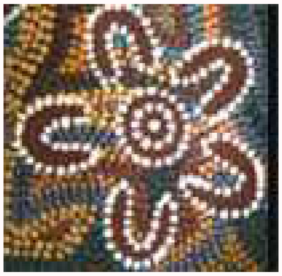
- Why There is Day and Night (As told by Lynn Moroney)
- Raven and the Sun
- Raven and the Sun
- Three-legged Rabbit
- Coyote and Eagle Steal the Sun and Moon
- Boy and the Sun
- Sun and Her Daughter

- Spider and the Sun
- Little Brother Snares the Sun
- One Who Walks all Over the Sky
- Fifth World
- Tsohanoai

For more Indigenous American starlore, see Starlore of Native America.

Mezo & South American

- Huitzilopochtli (Aztec)
- Inti (Incan)



Australian Aborigine

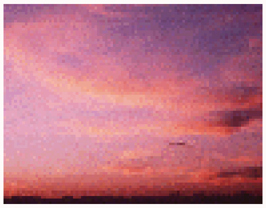
No one knows what the earliest humans thought about the sky, for no records exist. However, the culture of the Australian Aborigines, which has been passed down via legends, songs, and dances for more than 40,000 years, gives us a glimpse of how these earliest known astronomers interpreted the Sun and stars.

The Aborigines represent the world's oldest and most long-lived culture, a heritage rich in wisdom and insight. The Aborigines are at one with the Earth, nature, and the sky. Their view of the cosmos is based on their concept of the Dreaming -- a distance past when the Spirit Ancestors created the world. Aborigine songs, dances, and tales convey how, long ago, the Spirit Ancestors created the natural world and entwined the people into a close inter-relationship with nature and the sky.

- Aborigines' View of the Sun

Mesopotamia

- Gilgamesh and the Sun
- Shamash



Judeo-Christian

- The Creation
- Joshua Halts the Sun

Others

Ancient Egypt

- Horus

African Cultures

- Liza

China

- Ten Suns

Classical Greece and Rome

- Apollo

Inuit (Greenland)

- Malina

Japan

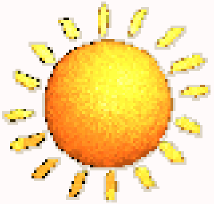
- Amaterasu

Norse

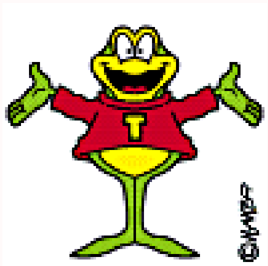
- Freyr

Ancient Astronomers

- Newgrange and Newgrange Photographs -- world's oldest astronomically-oriented structure!
- The Sundagger -- Anasazi (Native American) marker for solar and lunar cycles
- The Big Horn Medicine Wheel -- Native American pointer to sun and stars
- Stonehenge -- ancient astronomical site
- Aztec "Sun Stone" or Calendar
- Maya Astronomy
- Native American Astronomy
- Ancient Astronomy in India (and Egypt)
- Ancient Japanese Astronomy
- Rock Art



A Modern Sunwheel



Great Quotes

"The Sun is a mass of fiery stone, a little larger than Greece." --Anaxagoras 434 BC "Turn your face to the sun and the shadows fall behind you." --Maori proverb "The Universe is populated by innumerable suns, innumerable earths, and perhaps, innumerable forms of life. That thought expresses the essence of the Copernican revolution. No revelation more striking has ever come from the scientific mind." --Robert Jastrow 1989 "To the best of our knowledge, our Sun is the only star proven to grow vegetables." --Philip Scherrer 1973 "The purpose of life is the investigation of the Sun, the Moon, and the heavens." --Anaxagoras 459 BC "The cosmos is all there is, all there ever was, and all there ever will be." --Carl Sagan Some people can tell what time it is by looking at the sun. But I have never been able to make out the numbers. --5/6th grader "Anyone who has lived through an English winter can see the point of building Stonehenge to make the Sun come back." --Alison Jolly 1988 "One astronomer set up his equipment in an empty chicken coop to protect his instruments from the wind, and then spent most of the eclipse trying to shoo away the chickens, who dutifully reported to the roost when darkness fell." --Wm. Hartmann 1978 "Dew is formed on leaves when the sun shines down on them and makes them perspire." -- 11-year old, on a science exam "Mankind will not remain on Earth forever, but in its quest for light and space will at first timidly penetrate beyond the confines of the atmosphere, and later will conquer for itself all the space near the Sun." --Konstantin E. Tsiolkovsky "I'm astounded by people who want to know the Universe. It's hard enough to find your way around Chinatown." --Woody Allen "In the Universe the difficult things are done as if they were easy." --Lao Tzu "Those bright spots you see are Solar Rays. Each of those gas bubbles is the size of the Earth! NASA hopes this video will help us understand other stars in our Solar System." -- Reporter for Bay Area Channel 7 News (1997) Did you realize that 4.5 pounds of sunlight hit the earth each second? -- Mike Rushford "Red sky in morning, sailors take warning. Red sky at night, sailors delight." --Old Sailor's Adage "Nature uses only the longest threads to weave her patterns, so each small piece of her fabric

Quotations extracted from collections by Brad Snowder, Western Washington University Physics Club, and Amara Graps.

Highlights

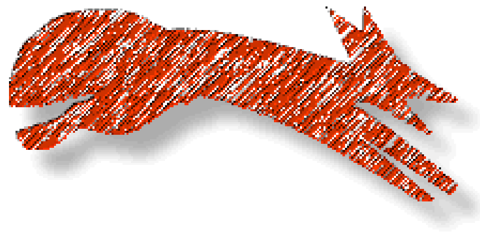
SOLAR Center Homepage | Activities | Ask a Solar Physicist | About the Sun | Glossary | Related Sites

Solar Oscillations Investigations at Stanford | Solar and Heliospheric Observatory SOHO

Sign Our Guest Book | Comments | Credits | Copyrights

This page is http://solar-center.stanford.edu/folklore/folklore.html
Created by Deborah Scherrer in May 1997
Last Modified by DKS on 1 December 1997

I can be contacted for written work and for voice-overs and personal appearances as a storyteller via my publishing company: *Dancing Fox Productions*. 18 High Street, Twerton on Avon. Bath. Somerset. BA2 1BZ. England. Tel: (01225) 330879.



The moon spirit and Coyote Woman

(Why coyotes howl at the moon)

(A sort of modern folk myth in the Tanais the Fox series written by Clive Grace)

It was midnight and Tanais the fox was walking alone, deep in thought. It was a beautiful night, a full moon shone high in the sky and he could hear waves crashing against the distant shoreline. He felt a need to look out at the sea, so he decided to walk by himself in the moonlight for a while and maybe smoke his pipe a little. He didn't know *why* he felt this need to be alone, only that he needed it every now and then. Hoping he would feel a lot happier with the sound of waves and the smell of salt, he sniffed expectantly at the sea air to catch his bearings and started on his journey.

Leaving a long trail of paw prints behind him, Tanais walked the entire length of the beach occasionally puffing on his pipe. At one point he came across a walking stick tossed upon the sand. It was actually a short length of tree branch or a thick twig that had been discarded by the ocean; a few tiny barnacles had attached themselves to one end and it was still quite damp from floating in the sea, but it would dry out eventually, so he picked it up, brushed some seaweed off of it and continued on his journey, propping the stick on one shoulder.

Tanais especially liked to walk along the shoreline and watch the waves as they crashed against the rocks in the distance. It wasa strangely magical night; at one point he thought he heard the sound of fluttering wings somewhere deep in the darkness. Stopping to look around, he saw no-one, so he shrugged - snuggling deeper into a scarf he had brought along for the night - continuing on his midnight walk.

Eventually he came upon a rocky cove; it was a favourite haunt of his and he found it ideal as a place of quiet contemplation - a place where he could get some thinking done at times like this.

Finding his favourite spot in the cove, Tanais stared for a long while at the moon reflecting off the surface of the sea and felt a pang of loneliness. He felt this every now and then and indeed had come to live with it and accept it. He knew that the life of a wanderer is sometimes like that, but he wouldn't have it any other way.

The fox sat down on a smooth rock jutting out over a shallow pool of water; every now and then he puffed on his pipe, sending plumes of smoke into the cold air. Apart from the occasional crash of waves in the distance, all was quiet around him.

Watching the shadows of rocks made by the moon's reflection, Tanais quietly pondered how different everything looked at night; in the daytime the pool was home to tiny sea creatures caught in the low tide, but at night it became something quite different and enchanting. Tanais watched the water in the pool as it caught the moon's reflection, bathing nearby rocks and stones in a shimmering silver light. It was one of the most beautiful places Tanais knew of and he would often return there when he felt sad, lonely or just a little thoughtful.

As he puffed on his pipe Tanais remembered a story he had been told as a cub, a story about the moon and the sea and many other things besides. The moment was perfect for the telling of this particular tale, but there was no one around to hear it! So he sat with his head resting in both paws and looked out at the sea and at the moon's reflection, pondering what to do with the story.

After a while, Tanais shrugged a little and looked thoughtfully at the moon. Try as hard as he might he couldn't get the tale out of his head. Suddenly an idea crossed his mind and he paused for a few moments, pondered quietly on his idea before turning his muzzle skywards where he addressed the moon with a smile. "Then I think I shall tell it to you, my friend. You know, I've never told a story to the moon before - I hope you like it." Shifting into a more comfortable position, Tanais paused only to push his scarf a little higher onto his shoulders and he began his tale:

"This story happened years ago," began Tanais a little uncertainly. "It happened many years before I, or anyone I know was born - at a time when this land was still quite young and when there were many places filled with wild magic."

Tanais reached for the stick he had found on the beach and started to draw shapes in the sand in front of him. "Of all the creatures, the most popular, and certainly the most prolific was the coyote." he said, his sketching rapidly turning into the outline of a coyote.

"Some legends say that the coyotes were the first of the creatures to be made for the new land and that they were told by the creator to look after the land whilst he went off and made the rest of us." Tanais laughed a little. "Others say that the coyote was put here so that none of us would have an easy life." The fox's laugh trailed off into a wistful sigh. "I guess we shall never know exactly for sure," he said as he continued drawing. "Back in those days, people just lived by the fact that the sun always followed the moon and that Winter always followed Summer. They didn't have any need for clocks or calendars, choosing to sleep when they were tired and waking when the sun came up." With a flourish, Tanais finished his drawing and stopped for a moment to admire the likeness.

With a satisfied nod, Tanais looked back up at the moon. "This story is about one tribe of coyotes in particular," he said. "The other coyote tribes had dispersed throughout the land and had fallen into fights and squabbles with each other - mainly over land or food, but this tribe was different. Theirs was a peaceful tribe, working hard and quietly living off the land in their own way."

Becoming more elaborate with his drawing, Tanais started to sketch out some more coyotes in the sand; some were ploughing the land, others were harvesting fields or pulling fishing nets in small boats on the sea. Dotted around his picture were small tepee-like tents - out of which poked the faces and noses of coyote mothers with their cubs.

As Tanais drew each coyote he explained to the moon what each one was doing. "None of them were warriors. They lived a peaceful life in spite of their warring cousins," he concluded as he put the stick down. "Some were farmers, others herded cattle or rode horses, whereas a few would catch fish in the ocean."

Tanais brushed some sand off of his paws. "The other tribes lived far away and would fight and squabble amongst each other, fouling and spoiling wherever they went. The tribe by the sea was, by contrast, the smallest of all the coyote tribes and their peacefulness didn't interest the others. As they never went attacking or plundering anyone, they never got attacked themselves. After a while they had been all but completely forgotten by the other tribes."

Tanais picked up the stick again and started to very carefully adapt the picture of the first coyote he drew. "Not very far away from the tribe lived a coyote woman," Tanais said. "She was very beautiful and wore a green and purple cape and the feather necklace of a medicine woman. Known only as *Why-ay-looh'*, or `Coyote Woman', she loved to take long walks by herself in the plains, searching for herbs and roots that she would later turn into powerful medicines.

"One of her favourite places was a rocky cove; called Medicine Cove, it was shielded on all three sides by a sheer wall of rocks, accessible by a secret path that only she knew about. Coyote Woman would often spend many hours sitting in her cove, looking at the moon as it rose over the ocean. Sometimes she would sing to herself or devise new magic and medicine, sometimes she would braid colourful beads into her long golden fur or prepare her herbs. In the centre of the cove was a pool of water that she would often use to look into and think about things when she wanted to be by herself and not be disturbed.

"One night, Coyote Woman went to her cove and sat on an outcropping of rocks that looked over the pool. As she sat, braiding beads into her hair and humming a song to herself, she looked into the pool and saw to her surprise what looked like a face smiling up at her in the reflection of the moon. With a startled yelp, she jumped back and looked up at the moon shining high in the sky but saw nothing unusual there. Shaking her head, she looked back at the pool and stared into the water."

Tanais looked down into the pool and saw his reflection looking up at him. The reflection of the moon had slid a little further into the pool and shone behind him, lighting the outline of his ears with an eerie glow. He thought about playing with his reflection using the stick he had just been drawing with, but he thought better of it. He paused to remember where he was in the story, then continued.

"At first she thought it must have been some sort of illusion - that the reflection in the moon was her *own* face looking up at herself from the pool - so she peered a little closer. Although the face was indistinct and shimmered slightly as it rippled in the water, Coyote Woman found that if she squinted her eyes as she looked into the pool, she could quite clearly see the image of a pure white coyote staring up at her with his deep blue eyes.

"Nothing like this had ever happened before! She had acknowledged long ago that this was a very magical place but knowing about magic and coming face to face with it are two very different things."

Tanais looked into the pool again. As he told the story he noticed that the reflection of the moon had slid further into the centre of the pool, bathing even more of the surroundings in its eerie light. This made the rocks appear as if they were formed from glass and made the wet sand glisten with an icy blue radiance as the waves crashed and then drew back from the shoreline in a foaming silver-white carpet.

Although entranced by the beauty of the moment, Tanais remembered his audience; hard as it might be, once a story is started, it should always be finished. He took a refreshing gulp of sea air to bring him back to his story and continued.

"If Coyote Woman was surprised at what she saw from within the pool she was completely unprepared for what followed," said Tanais, looking around him. "The face in the pool became more *real* and more solid with each passing moment until after a minute or so *Hah-ah'* - a moon spirit - was shimmering in the pool, looking up at her with his blue eyes."

Tanais paused for a moment; the hairs on the back of his neck and all along his tail were bristling with excitement. The cool sea air had suddenly become as sharp as a razor's edge and seemed to fill the cove with an almost electrifying energy - like the moment just before a thunderstorm. Tanais waited with bated breath for something to happen; he half-expected the Coyote Woman or the spirit from the pool to appear at any moment, but the moment passed and nothing appeared - so he gathered his thoughts together and continued a little more cautiously, his whiskers twitching and one ear cocked to catch the slightest change around him.

"The story is a little unclear around this point..." said Tanais, scratching at an ear as he observed the pattern of rocks shimmering and glowing under the moon's light, "...but the version of the story *I* prefer tells of the coyote woman and the moon spirit falling in love with each other." Smiling, the fox continued. "You see, the moon spirit loved to look down on this pool from where he lived on one of the moon's highest mountains. When the moon was full and at her most powerful, the moon coyote would shine down on the pool, spreading his magic into the rocks and sand.

"Some say that magic attracts more magic and as the cove was one of the few places still left where wild magic was still very much alive, he naturally felt an affinity with the place. The fact that a beautiful Coyote Woman also loved this place merely added to his insistence that he should appear in front of her.

"Without a word, the moon spirit started to lift himself up out of the pool. First a pink nose pushed through the water, followed by a muzzle and then a pair of milky white ears. The moon coyote was pushing very hard against something as he slowly heaved more and more of his body out of the pool, pausing every now and then to catch his breath. Water didn't drip off of him, rather the water seemed to solidify and *become* part of him, drawing out into long strands of silver-white hair.

"Coyote Woman stood and watched breathless as Moon Coyote lifted more and more of himself out of the pool. Fighting with all his might, he strained against the water that seemed to cling to him. It was as if it wanted to drag the moon coyote back down, but he continued, straining and pulling with every muscle in his body until he finally leapt free of the pool and stood triumphant in the moonlight.

"The next morning, Coyote Woman and Moon Coyote went into the village. Seeing their medicine woman walking into the village with a stranger, the tribe immediately stopped what they were doing and came rushing to see who her strange new companion was. She padded to the chief of the tribe's tent and knelt as the Chief of the tribe who was called *Le-ee'-oo* came out to see what was going on.

"`*Le-ee'-oo*!' said Coyote Woman, holding her head down, `this is *Hah-ah''*, pointing at Moon Coyote. `He came to me last night from out of the pool in Medicine Cove. I wish to marry him,' she said rather matter-of-factly. There was gasp from the villagers as she said this because the medicine woman normally didn't marry and when they did, they certainly didn't marry at such a young age.

"The Chief just nodded and looked at Moon Coyote as he slowly walked around him. Every now and then he sniffed and prodded at Moon Coyote and muttered to himself and exchanged words with his advisers. Everyone fell silent as he did this until finally the Chief looked deeply into the his eyes, snorted to himself and nodded again.

"Turning to Coyote Woman, he looked at her and said rather gruffly, `Medicine woman, *Hah-ah'* is a spirit, a moon coyote, he is not from this land. Why do you wish to marry him?'

"`Because I love him!' she said, still kneeling `...and because he loves me'.

"*Le-ee'-oo* snorted again, but this seemed to be what he wanted to hear, so he looked back at the moon coyote and asked,

`...and do you love her *Hah-ah'*? Will you stay with her for as long as you live?'

The moon coyote nodded and padded over to Coyote Woman and gently lifted her up off the ground. `I do.' he said, `I will love your medicine woman even after I die'.

"`Then let it be so', said the Chief. Turning to the villagers the Chief proclaimed in a loud and very formal voice, `Our medicine woman has a husband. He is *Hah-ah'* of the moon tribe. From now on he shall be known as `Moon Coyote'. With a nod and a gentle smile at the couple, *Le-ee'-oo* walked back into his tent, followed by his advisers. Coyote Woman and Moon Coyote were married."

Tanais frowned a little to himself. Had he ended the story there, it would have been a good place to stop, but even he would be the first to admit that nothing much happened and there was more. "...And I suspect you know there's more to the story don't you?" said Tanais, eyeing the moon suspiciously as he sat down on his rock again. Looking at the shoreline and noticing the water was slowly crawling up the beach towards the pool, the fox reckoned that he would have just enough time to finish telling his tale without getting trapped by the rising tide, so settling down to finish the rest of his story, Tanais took one last puff from his pipe and continued:

"Of course Coyote Woman and Moon Coyote were very happy together; they went back to their home by the sea and watched the waves beating against the shore. Throughout the day they were visited by villagers and friends - bearing gifts and blessings for the newly-weds. Later in the afternoon, they decided to explore the beach and the Coyote Woman showed her husband the places she liked to go and things she liked to see. Together they laughed and skipped in the sand, chasing each other up and down the beach as they played games with each other.

"In the evening, Coyote Woman went down to the beach and took her beads and herbs with her. Her husband had gone hunting with his new friends and tribe members, so she thought it would be a good time to sit by herself and contemplate how different her life had suddenly become. She thought lovingly about her husband and soon her thoughts drifted towards raising a family together."

Tanais sighed to himself as he pictured the image in his mind. "For the first time in her life Coyote Woman was truly contented."

Tanais stopped and shrugged as he remembered the story. "Coyote Woman was lost in her own dreams and braiding her hair when, all of a sudden, she heard the distant sound of a yelp followed by a cry of pain. Someone was hurt, and it wasn't far away by the sound of it. She rushed to the top of a sandy hillock to see better and, to her horror, saw her husband in the distance lying on the floor twitching."

"As he was the newest member of the tribe and because he had just been married, it was agreed that the hunters were to go on an expedition and that Moon Coyote was to have the first try at pulling down a bison." explained Tanais, tapping the ashes from his pipe into the sand. "Moon Coyote had never hunted one of these before - being something of a rarity where he came from - and it came as no surprise that he had badly miscalculated. As he chased after his prey, it swerved madly in front of him, trampling him under its powerful hooves, lifting him into the air with its short, but nonetheless lethal horns before dashing him on the floor with a sickening crack of bones.

"Seeing her husband lying there, Coyote Woman didn't hesitate, she grabbed her herbs and ran as fast as she could to his side. By the time she arrived, Moon Coyote was barely alive. He was unconscious and his breath was rasping - a thick pool of blood had soaked into the sand and the rear half of his body lay twisted on the floor. You didn't have to be a medicine woman to realise that his back had been broken.

"Nevertheless, Coyote Woman tried to help her husband; she applied her strongest and most powerful medicines - but everything she did to try and heal him was in vain. Moon Coyote's beautiful white coat was now a dull grey and was caked with blood where the bison had tossed him into the air. His deep blue eyes had started to mist over and his rasping breath got fainter with every passing breath. Coyote Woman's instincts told her that he was dying.

"She thought desperately of possible remedies and cures, but this was far beyond her healing capabilities. Eventually, and with tear filled eyes, she admitted defeat and turned away from her husband to howl a cry so painful and so desperate that everyone for miles around stopped in their tracks and listened with dread at the pain in Coyote Woman's voice.

There was nothing else to do but to look on helpless as her Moon Coyote's breath faded. She applied what little medicine she could to ease the pain away and just sat, watching Moon Coyote slowly die - lit by the moon as it rose slowly over the sea. Never before had she felt so helpless, if only there was something she could do!

"All of a sudden she had an idea! It was crazy and desperate, but then she *was* desperate. Lifting Moon Coyote's dying body in her paws, she ran down to Medicine Cove. The moon coyote was already so far gone that he only moaned pitifully and his breath started to rasp and become more ragged again.

"When she finally arrived, Coyote Woman spread her dying husband out in the shallow pool. Propping his head gently on her robes, she watched helpless as his life seemed to ebb from his body into the pool.

"Pointing her muzzle towards the moon, the Coyote Woman howled again, a lonely, broken howl. Moon Coyote sagged as the life finally left his body and he breathed his last. Coyote Woman looked on with baited breath, waiting for something to happen, but the moon just carried on its upward ascent into the night sky, shining down on the cove, the moon coyote and his disconsolately sobbing widow."

Tanais stared into the pool and sniffed. "The Moon felt that Moon Coyote's death was unfair and although she hadn't the power to bring Coyote Woman's husband back to life, she *was,* nevertheless, an important part of the wild magic - a magic that was in existence long before death came into the world. She looked down sadly on the sobbing Coyote Woman and decided to do something about it.

"After Coyote Woman had cried herself out, she looked miserably at where her husband lay in the pool and saw, to her astonishment, the ghostly apparition of her husband floating above his body. The moon's silver light was shining down on the pool - stronger and brighter than it had ever been before - and his body was still lying in the shallow pool, but the huge ugly blood stain in his side had been washed away by the pool. The spirit of her husband looked down on his body and sniffed at it before looking at his wife and, to her amazement, smiled at her."

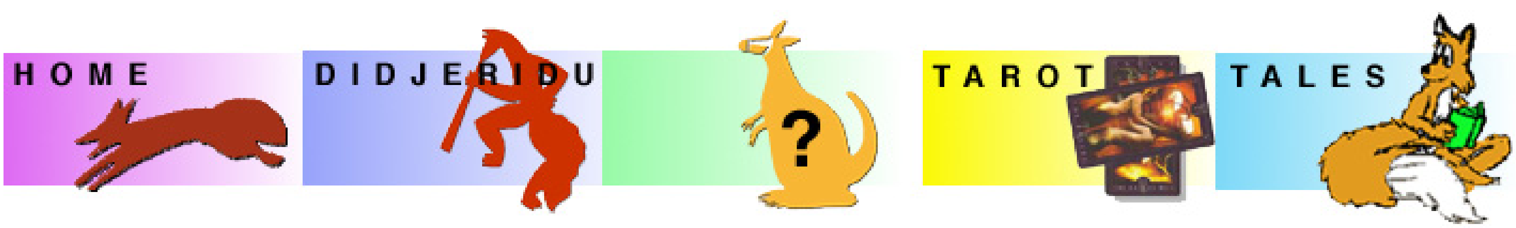
Tanais stopped. Picking up his stick, he looked at the moon and frowned "No one really knows what happened as the story ends there. The next day the other tribe members eventually found their way into Medicine Cove and discovered Coyote Woman's drowned body laying next to her husband in the pool.

"Some stories say that Coyote Woman died of a broken heart," Tanais looked carefully at the rising tide, "others say that she had drowned - too heartbroken to notice, or to care - I guess we shall never know," and he kicked a little at the sand. "But the stories all agree on one thing however. On the night they died, a star appeared next to the moon. It's one of the brightest stars in the sky and is the first to come out in the summer evenings. If you look at it very carefully, you'll see that it appears as if it is two stars joined closely together.

Tanais picked up his hat and looked at his drawings in the sand as the waves crawled closer up the shoreline. The cove was nearly filled with water now and he would have to hurry in order to get out and not get his paws wet. Soon his pictures would be gone - washed away as if they were never there. "Nothing's permanent." muttered the fox as he quickly gathered his belongings together and started on his journey home, his spirit strangely lifted by the telling of such a sad story.

As he turned to walk home, he took one last look at the water rolling relentlessly into the cove. The waves were much heavier now and the water was much higher than before. Nodding his head and sniffing the air one last time, Tanais raised his hat to the moon and walked off.

Had he been a little closer to the pool, Tanais would have seen the faces of two shimmering Coyotes - one white, the other golden - holding each other and looking at him as the water washed over them.



Info Thanks

The tales of Tanais the Fox...

Tanais and the Spirit Wolf

The Fox and Old Lady Crow

The Moon spirit & Coyote woman

The fledgling & Grandfather Fox

Tanais and the Dracon Cub

Innkeeper Badger's Journey

Hello, Sun!

Purpose

In this Thread, we will examine the passage of time by watching the world change outside of our classroom. The Sun will seem to move across the sky in a steady manner throughout the day. This will allow us to begin thinking about the movement of either the Sun or the Earth as well as the shape of the Earth so that the motions make sense. The National Science Education Standards call for students to become comfortable with objects' properties of size and movement, an example being the Sun. Students should learn that the Sun appears to move around the Earth, but in fact it is the Earth spinning around on its axis while the Sun remains stationary. This Investigation allows students to explore what the NSES refers to as "technological design". The vocabulary that can be integrated into this Thread are words such as Sun, Earth, day, night, spin, axis, arc, model, angle, sphere, and degree. For a new approach to learning some of these vocabulary words, visit Word Lore, an appendix dedicated to exploring the history of words pertaining to this curriculum.

Teacher Background

The easiest way to see time passing is with a clock, but what made us aware of passing time before clocks? The motion of the Sun is the key here, and most students do not know what that motion looks like.

You will need chalk or wipe board and chalk/markers, easel, roll paper for easel, pencils, journals, crayons, adhesive yellow dots or BINGO markers.

The class will initially need a sunny day for this and will need to repeat measurements from the earliest time possible in the morning until school lets out in the afternoon, at one hour intervals. You will need to locate the direction South outside in the yard. In the classroom, you may want to spend several class periods spanned over a week thinking about the data you've collected. There are few tools required, so materials gathering for the investigation is minimal.

We know that we are a small planet shaped like a ball in orbit around a huge star 93 million miles away. This star we call the Sun, and it is an enormous ball of very hot gas. This star is so large, that even from this far away, its light can reach our planet. Sunlight is radiated from the Sun in all directions, and we are only a tiny planet in the way of a tiny bit of that sunlight. Therefore, we get light from what appears in the sky as a small disc in a certain direction. If we were very close to the Sun, that orb would seem larger. Why do we feel warmth all over the land during the day? Well, that is because we have a lovely atmosphere to keep us warm like a blanket. Why then do we feel cold in the winter? That will be explored in a later Thread.

In some respects, it appears that the Sun circles the Earth. Greek philosophers speculated about our world and its geometry and decided that it is the Earth which is turning on its own, making things appear to swing past it, outside of it. This is similar to being on a carousel and watching your family rush around you, even though it is you who are moving. To prepare ourselves to model the Sun, it would be good to first explore some alternative approaches to looking at the world around us. This requires thinking flexibly. Now would be a good time to introduce puzzles, riddles and optical illusions, to help us think about the importance of opening up our minds to different ways of seeing the same thing.

The movement of our Earth is very uniform, making the Sun rise, arc overhead, and set at the same speed everyday. This speed is our spin time, or day, of 24 hours. For students, the term "day" is more like the daylight time. Confusion between "days getting longer" but "days are always 24 hours long" can happen. Begin to refer to these times as daylight time and spin time, to ease communication among your students. In fact, perhaps we should consider inventing our own terminology for these two concepts in class.

As part of the ECT curriculum, we offer some lessons about how ancient and historical cultures used observations similar to those the students will make in the Threads. For Hello, Sun!, We've included background information and classroom activities in the Appendix relating to how Scandinavians one thousand years ago used the Sun to tell time. We call it Telling Time Without a Clock. [Note: The Daymarks project is also relevant for the Thread called This is a Stickup!]

Contents
Download
Internet Resources
Children's Books
Folklore & Mythology Connections
To K-2nd Grade Thread
To 2nd-4th Grade Thread
To 4th-6th Grade Thread

Kindergarten through Second Grade

Developmental Issues

The purpose of this Thread for this age group is to emphasize the joys of wondering about our world and learning to look for change and patterns carefully. It introduces the skills of question asking, communicating ideas in speech and drawings, and manipulating objects. Students will learn about the Sun as our light and heat source and about our world as having a regular time pattern, which can be observed from the simple motion of the Sun.

This Thread is not intended to impose on students of this age the model of a turning spherical

Earth past a distant steady Sun. Research shows that the average five year old is just learning how to envision images in his or her mind and to manipulate those images (for instance, thinking about how to walk to school and then reversing the route in one's mind). However, constructing images that require shifts that the child has never experienced, thinking about positions of objects in the future (beyond yesterday, today, tomorrow), and holding a dynamic model in one's head to reason about it, is challenging for students of this age.

It is important to realize that experience with models and analogies helps children learn to understand them. Teachers should not shy entirely away from presenting concepts that are slightly beyond the developmental level of their students, but that they should support the students' developing understanding with other paths to grasping the concept.

Inquiry Introduction

What is a day? Why is it that we know when a day has passed, or what time of the day it is? What are the things we look for to tell us about the time of day? Or when we are tired? Hungry? Cold? Are there things which always happen at a certain time of the day? Students may want to draw a day (allow yourself time to write a brief narration for each drawing based on their verbal description.) Are they thinking only about daylight time? Do any of them describe a day as more related to the spin time perspective?

Is there any way we can think of to tell that a day is passing? Many students will suggest the clock. Tell them this is the modern way, but what about when people didn't have clocks or watches? Does anything change during the daytime which isn't a clock? If no one suggests the Sun, lead them to think about the world outside the classroom. When it is day, what does it look like? This question will seem odd to the students without a contrasting frame of reference. Ask them what the night looks like, then return to thinking about the day. The Sun will enter the discussion now, if it had not already. You should now ask again what happens during the day to make it become night. Can we see that happen? What would we need to do first? Go outside!

Inquiry Investigation

Outside, you should bring an easel with paper and a marker. Without mentioning the direction South, you need to make everyone face South (or North if you are in the Southern Hemisphere). This is important for the observations. While you are doing this, you might want to talk about why it is important that everyone face the same direction (without talking about South) when you are all observing the same object. Facing south is important because in the continental United States, the Sun is in the south at all times. You should not mention this fact at this time. What is important is that everyone should be able to talk about the same viewpoint. Otherwise, imagine trying to talk about a pillow on your bed if everyone else is looking at your door. It will be hard to do unless you have everyone looking at your bed first.

You should then draw the view ahead of you on the paper on the easel. Ask everyone if the details are correct. If not, what should be changed or added? It is the morning during this first observation, and the Sun will be over everyone's left shoulder. Our shadows will be to the right of our bodies. Just noticing that they have a shadow is fun for this age group. Later Threads will provide more time for your students to explore this further.

Ask the students some questions. Where is the Sun? How high is it in the sky? Can everyone think about tree heights or house heights? How about where the Sun should be in the picture? Could we tell from other clues? Some will feel the Sun on their left cheek, and say that is a clue. Few may make the connection between the shadow on their right and the Sun on their left. (This is a great connection which will be explored deeply in later Threads.) Draw the Sun on the easel.

We could, out here in the warmth, talk about our Sun and the heat and light it gives us. How far away do we think it is? What is it made of? How big is it? We don't need to know the real answers for this. We should just be thinking about this great Sun of ours and how much it can affect our world down here.

Return with the easel to the classroom and try to ask where they think the Sun might be in an hour. There will be wild guesses, and that is part of the fun of asking questions in a wondering scientific spirit! They could mark their guesses with mini sticky notes or dots, if you wish.

Return with them every hour to make another drawing. Maybe they can take turns helping you draw the Sun into the easel drawing. How did the guesses turn out? Does anyone have a theory about the movement? Where is the Sun going? What happened to the shadows?

After a few more observations, a definite shape is appearing in the movement of the Sun. This shape is known as an arc, but for the purposes of this younger age group, you can call it whatever you wish. In fact, it would be a good time to compare this shape to other shapes around their world. Some classes in the past called this shape a rainbow, a frown, a big belly, and a bridge. What do they see in this shape? Could they take this shape and draw it in their journals? What do they see? What else can they make from that shape?

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To K-2nd Grade Thread

Second Grade through Fourth Grade

Developmental Issues

Second to fourth-grade age children are better able to reason more time-related concepts, consider two or more variables in thinking about a problem, and begin to plan things for the future. Their skills in dynamic imagery are developing as well as their ability to hold more information in their heads. This makes it possible for them to hold and manipulate the position of images in their minds. This is key to concepts such as predicting from observation or thinking about the movement of two objects, the Earth and the Sun. This Thread will focus on these ideas as directed by our observations. Since students at this age are able and enthusiastic when it comes to reading and writing, an emphasis will be placed on recording data and sharing it with others. On a social level, this age group is typically interested in teams and other social groupings. You may want to consider allowing for this in the investigation, creating teams of illustrators, time keepers, or instructors. It may help students become comfortable with the atmosphere of inquiry-based learning.

Experience with models and analogies helps children learn to understand them. Teachers of students at this level should introduce them and should not shy entirely away from presenting concepts that are slightly beyond the developmental level of their students. Look for ways to support the students' developing understanding with a number of alternative paths to grasping the concept as well.

Inquiry Introduction

Where does the Sun go in the evening? Why does it seem to rise in the morning? What is happening? What is a day for us? We should think more about the outside world and how it knows about a day. Without a clock, what could we look at to know about a day? How could you plan such an experiment? What are the important things to plan when you are about to observe something? How long would it take to get a good idea about what was happening? How would we keep a record of what we saw outside?

Inquiry Investigation

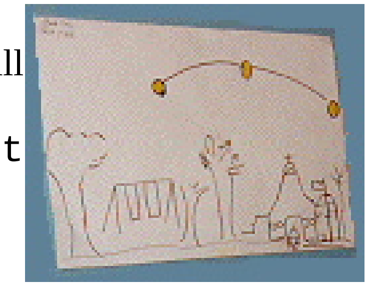
Outside, you should bring an easel with paper and a fresh marker. You also may want students to bring journals. Without mentioning the direction South, you need to make everyone face South (if you are in the continental United States). This is important for the observations. While you are doing this, you might want to talk about why it is important that everyone face the same direction (without talking about South) when you are all observing the same object. Facing South is important because in the continental United States, the Sun is in the south at all times. You should not mention this fact at this time. Children at this age should be comfortable with left and right, and can use these words to think about the direction of the Sun. What is important is that everyone should be able to talk about the same viewpoint. Otherwise, imagine trying to talk about a pillow on your bed if everyone else is looking at your door. It will be hard to do unless you have everyone looking at your bed first.

What needs to be drawn on the paper? Why should we be so careful about getting our view on the paper? We should think about the fact that we are all about to have an experience outside, and if we want to share it with other people, we should really make sure we've got a good recording of our experience.

Should we look at the Sun directly? No, this will harm our eyes. Even glances are not very healthy. How else could we describe where the Sun is? Some will feel the Sun on their left cheek, and say that is a clue. Others might make the connection between the shadow on their right and the Sun on their left. (This is a great connection which will be explored deeply in later Threads.) Where is it with respect to our bodies? To the school? To that tree over there? How does it feel on our faces or arms?

Now, let us leap into another arena of thinking and ask where on the two-dimensional drawing of our view would we put the Sun? We need to make the connections between the representation of objects on the drawing and the actual objects themselves which are outside in the world. Does everyone have a thought about this, and can they explain it to others? Draw the Sun where everyone agrees it should appear in the picture. Drawing in journals also might be a good idea. Return to the classroom.

In the classroom, talking about what a model is would be a good way to link these two experiences. In the real world, we saw a Sun with respect to our position out in the world, and with respect to the positions of other things out in the same world. The drawing, however, contains our viewpoint, without us in the picture. It is a model of the world around us, and we are not in it because it is what we saw around us. What is the shape of this model compared to the shape of our world? Is it still an OK picture of what we saw? When we were outside, it sure looked like our view. How is our drawing different from the real view? Think about the three dimensions of the world around us and how paper limits us.



What will happen in one hour? Anything? What will our view look like? Will we need to draw a different picture of the school yard? If not, what will be different in the picture, if anything? Perhaps here the class could break into brainstorming teams to think about where the Sun might be in one hour and why. They should prepare an explanation for the other teams.

Return with them every hour to make another drawing. Maybe here is where teams might help keep records and draw the Sun on the easel view. How did their predictions turn out? Does anyone have a theory about the movement? Where is the Sun going? What happened to their shadows? Can those same teams back in the classroom think some more about the movement they have now seen and how it might be reinterpreted?

After a few more observations, a definite shape is appearing in the movement of the Sun. This shape is known as an arc, but you can call it whatever you wish. Children at this age are really broadening their creative skills, and having them think up their own name for this shape would be fun for them. Some classes in the past called this shape a rainbow, a frown, a big belly, and a bridge. What do your students see in this shape? Could they take this shape and draw it in their journals? What shapes can be made from it, half-circles, circles?

What reasons can we think of to explain why the Sun is making this shape? Do we think that the Sun is really moving around the Earth? Many will come to your class already having been told about the spinning of the Earth, but they will not be able to explain it well. Ask them if they could explain the movement of the Sun with a spinning Earth. Is it important right now that everyone believe the Earth is spinning? No, not really. It is important only that they have had this day-long observation and been able to model it in the classroom on paper. You could ask them to try to get up with a group and recreate their observations in a play, where one person (the Sun) walks around another (the Earth) during the day and also where the Sun person is still and the Earth person slowly spins.

So, where does the Sun go in the evening? Could we draw it or write about it somewhere? Could we interview other classrooms who have not had the same experiences as us and see what they think? What about classes who have had the same experiences as we did outside? What do they think? Many will say the Sun goes to the other side of the world. Ask them then what it is like for people on the other side of the world when it is day for us? Can anyone point to a place on the globe which is having night right now? The Internet has a database of live cameras set around the world. Finding the country your students chose and looking at a "live" picture will help solidify their theory and strengthen their resolve. See the resources page for a list of good Internet sites with live cameras.

Another way of enforcing this experience is to make a Noon Line in your school: either in your own classroom, if we face South, or in a friend's classroom across the hall. For instructions, please see the Appendix for Time Keeping without a Clock.

Thread Intro | Read the Teacher Journal | Next Thread
To Table of Contents | Add to the Teacher Journal | To 2nd-4th Grade Thread

---

Fourth Grade through Sixth Grade

Developmental Issues

Fourth through sixth graders are increasingly able to abstract, reflect, and put one's self into another situation. They are able to reason about time more flexibly. They can manipulate images in their minds and can coordinate the dynamics of more than one image. They also can entertain the possibility of future events and think about hypothetical outcomes. These students are also making connections between what they are experiencing and how it affects their lives; how situations in general can affect lives in general. They also can consider different scenarios and envision whether these fit with their observations. This combination allows us now to explore the passing of the day with respect to objects in motion in a three-dimensional world outside of planet Earth and also to think about experiences happening for people in different places. Also, the level of math acquired by this age lets us talk about our experiences in another language, the language of geometry and numbers. This Thread will present the two theories of the Sun's motion debated by the geocentricists (who believe in an Earth centered Solar System) and heliocentricists (who believe in a Sun centered Solar System). Using the different positions of the Sun during the day as they relate to different positions in time and space, we will probe the data for theories and make models of what we have postulated.

Inquiry Introduction

The passing of a day has long been known and measured to be what? 24 hours. But what does 24 hours represent? How could we watch that happen without a clock? What is happening outside which plots the length of day and night?

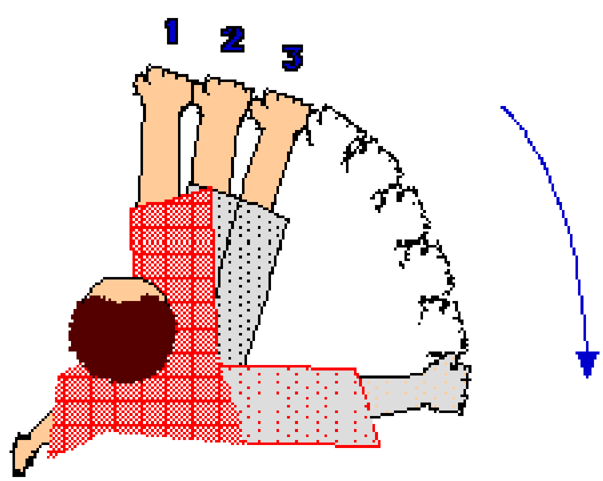
Inquiry Investigation

Outside, you should bring an easel with paper and a marker. Students should bring their journals. Also bring a navigational compass (or enough compasses for the whole class). What time of day is it? Without having already known it was morning, are there any clues around you that might tell you the same thing? How far around the world can we see with our eyes without turning our head?

Ask the students some questions. Which way is North? How could we find out for sure? If a certain direction is North, which way is East? We always learn East is to the right of North. If everyone faces North, East will be on our right hand. This will help ease the perspective problem. The question is, how easily can we see the Sun when facing the North? Have everyone face the South. Which way is South? Is it easier to see the Sun in our view now? OK. We will face South, then. Could we draw that view? Having everyone bring out their journals is a good exercise here. They can all draw what they are seeing. Ask them what they have done by drawing the world. Is our drawing truly the real world? It is a flat model. How does it compare to the world around us? Is it a good representation of the world? Would someone from another school be able to recognize trees and houses as such in our drawing? Also, draw this view on the easel paper.

Should we look at the Sun directly? No, this will harm our eyes. Glances are not even very healthy. How else could we describe where the Sun is? Some will feel the Sun on their left cheek, and say that is a clue. Others might make the connection between the shadow on their right and the Sun on their left. (This is a great connection which will be deeply explored in later Threads.) Where is the Sun with respect to our bodies? To the school? To that tree over there? How does it feel on our faces or arms?

How high is the Sun? How could we measure that? With a ruler? There is a very easy technique called "fist measuring" which can help us without having to use anything but our own bodies. All you need to know is that 90° is the angle difference between holding your arm straight out to the side and straight out in front of you. All you need to do is stand still and put your arm out in front of you at eye level, with your hand in a fist. Close one eye. Carefully begin moving your arm stiffly, watching and counting how many fists you can line up side by side until your arm is 90° away from where you started, or straight out to your side. Use things around the yard as guides to help you count those imaginary fists. The figure helps you see what we are describing. Dividing 90° by the number of fists you counted will give you how many degrees your fist covers! (Hint: In case you are not sure of your answer, an average fist covers 10° on the sky. Your value should be close to this.) Similarly, you can try to calibrate your finger! Try this outside (your finger held at arm's length will cover 1° on the sky.)



Now, let us imagine where on the two-dimensional drawing of our view would we put the Sun?

We need to make the connections between the representation of objects on the drawing and the actual objects themselves which are outside in the world. Does everyone have an idea, and can they explain it to others? `Draw the Sun where everyone agrees it should appear in the picture. Use the fist measurement tool to relate the Sun's position to the horizon, to nearby buildings and trees, and perhaps to due south. Return to the classroom.`

How would we go about making some good observations of the Sun to understand what is happening in a day? `Most students will tell you to go out every so often and check.` Why? What might change? Does our world change? How has it changed since spring? How will it change in four months? How will it change in five hours? How have we changed in a year? The changing world means we need to keep an eye on it. What is the scale for watching the Sun move in a day? `If no one else does, suggest that observations be made every hour. Have the students devise a plan for carrying the easel and markers and making sure journals get collected for observing outside.` Does anyone have a clue about where the Sun might be next? Let's all make some predictions with accompanying reasons in our journals.

`Return with them every hour to make another observation and drawing.` Where is the Sun now? Is it noticeably different? How many fists up in the sky is it? Maybe they can help you draw the Sun in. How did their predictions turn out? Does anyone have a theory about the movement? Where is the Sun going? What happened to their shadows? `Many will come to your class already able to tell you that the Earth spins, but they will not be able to explain it well. Ask them if they could explain the apparent movement of the Sun with a spinning Earth. Is it important right now that everyone believe the Earth is spinning? No, not really. It is important only that they have had this day-long observation and been able to model it in the classroom on paper and then later on the board as a geometrical model. We can then talk about our experiences back in the classroom and think of some good explanations for what we saw.`

So, where does the Sun go in the evening? We could interview other classrooms who have not had the same experiences as us and see what they think. What about classes who have had the same experiences as we did outside? What do they think? Many will say the Sun goes to the other side of the world. What is it like for people on the other side of the world when it is day for us? Can anyone point to a place on the globe which is having night right now? `The Internet has a database of live cameras set around the world. If you are able, access a site and find the country your students chose. Looking at a real picture "live" from that place will help solidify their theory and strengthen their resolve.` `See page 61 for a list of Internet sites with live cameras.`

`After a few more observations, a definite shape is appearing in the movement of the Sun, if you use each Sun plot as a dot in an outlined shape.` What shape is emerging to describe the movement of the Sun? This shape is known as an arc. How might we extend this shape into a bigger shape? `Draw this arc` high on the board, leaving room on the sides and the bottom for thoughts about the larger shape of this arc. Ask them if this is the shape they saw the Sun moving in. Students will see a semi-circle and a full circle, some may even be silly and make some squiggle. Perhaps they should put their bigger shape in their journals and give it a name.

Can anyone think of a reason why the Sun is making this shape? Is the Sun moving? Do we think the Sun is moving around the Earth in this shape? Where in our drawing on the board is the Earth? If this is too hard to think about, where then were we in the picture? If the shape were a semi-circle, what would happen to us? Would the Sun go right through us? What about the other side of the Earth. Do people live there? What would happen to their day if the Sun just went zipping past in a straight line like that? Do they think this is probable? What might be a more likely shape for this situation? A circle!

What do we know that is special about a circle? How many degrees are in a circle? How many hours are there in a day? Could we figure out some things about where the Sun might be shining in one hour? What about in five hours? Where will the Sun be? On a globe, we could try to guess this place and look on the Internet. (The Thread, Time Warp, begins some thoughts on Time Zones.) England is five hours from Eastern Standard Time, and there is a great Internet site for Cambridge, England, where a live camera takes a wide angle shot of the University there every few minutes. This visual proof can be turned around in such a way: Thinking about a circle seems very mathematical and not related to our world very much. However, if we recall that we made a circle from the motion of the Sun in our experience, then it must be said that what can be predicted from a circle can be applied to the apparent motion of the Sun.

Does that circle mean that the Sun is moving around the Earth? Could there be another way of seeing the Sun do what we've just seen it do? Here is the challenge of perspective, and this will be the most difficult of all. Imagine you were born and lived on a spinning carousel. You've never known the ground. What would your view be like? All around you the world would be spinning past, but the things on the carousel would stay in place. How easy it would be to believe that you are standing still and everything else is moving, if you've never been off of the carousel.

Place a bright light source or even a student at the front of the room. Have the students stand such that their left shoulders are pointing to the light source in the same way their shoulders had pointed to the Sun. Ask the students to then say where in their vision does the light source lie. Give them a blank piece of paper. They should say or even draw the light at the very left of their view or paper. Just drawing where the light source is in their view might be superior to drawing the room and the light source. The reason for this is, as they are spinning about past the light source, the room is also appearing to spin. Thus, the idea of the light source appearing to move becomes moot, because the entire room will appear to move. This is not what we saw when we watched the Sun all day long. We saw the Sun appear to move past the scenery. So, perhaps saying that they should draw where the light source is instead of what they are seeing will help them develop a better mental model of what is happening.

Ask them to turn counter-clockwise until they are facing the light source. Have them again say or draw where the light is in their field of vision. The view will be that there is a room with a light source in the middle. Then ask them to turn again so that the light source is on their right shoulder. Have them tell you about or draw this final view. This time, the room should appear to be filling their view except for the very right side, where there is a light source. They may want to glue or staple the drawings into their journals later.

Putting the pictures in the order of their movement, does anyone see a pattern? Put the easel and its drawing in the front of the room. Does anyone see a connection? What two types of motion do we now know can cause the pattern we have observed? If the light source were the Sun, what time of day would the first drawing represent? Where is mid-day? What would happen if we spin around past the point where the light source was at our right shoulder? Our backs would be to the light source. Is this what happens at night? Ask the students if everyone on the Earth gets sunlight sometime. This will lead into the question of what kind of spinning shape allows that to happen.

Now the big challenge is to find out what the students think this motion means. The light source "Sun" was always at the front of the room, but on the drawing of our turning, we saw it move across our field of view. Is it possible then that the Earth might be the thing that is moving while the Sun actually stands still?

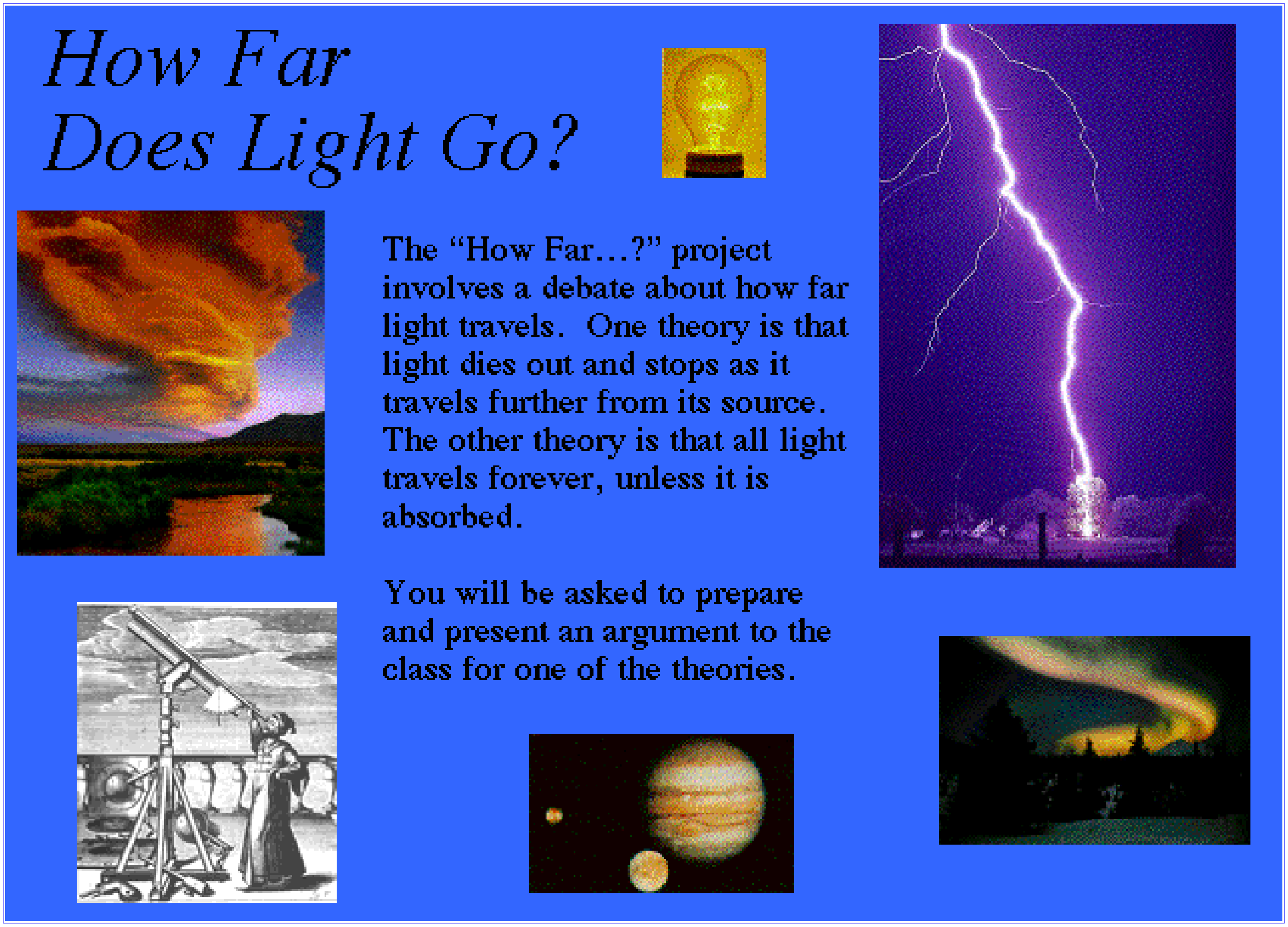
At some point, it would be good to discuss with your students why you had them face South when they were outside. What would happen if we all had faced the other way? Could we go out and see that? We could explore the school's Daymarks by using the Appendix, Telling Time Without a Clock. What objects around the school could help us to keep track of time without a watch?

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To 4th-6th Grade Thread

The How Far Does Light Go? Debate

(IF POSSIBLE, MAKE YOUR BROWSER WINDOW AT LEAST AS WIDE AS THE PICTURE SHOWN BELOW)

Read the text below about the project and then click to begin

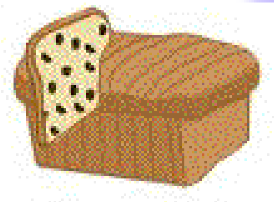


(There is also Teacher Information available for using this project in your classroom.)

KIE Wired Project. UC-Berkeley. Send inquiries to kie_info@kie.berkeley.edu.

Projecting Shadows

How can you get a picture of a slice of something without cutting it apart?



To keep it simple at first, think about this: what can we learn about the shape of something just by looking at shadows? Let's shine spotlights on some different shapes and look at the shadows they make:

Click on the spotlights to turn them on and off.
Choose different shapes from the menu.

(**By the way...** There's something not quite right with the lights and shadows here. Do you know what it is? Did you notice it before?
If you can't spot it, here is the answer.)

I can't tell a whole lot, except for how wide the shape is in the direction the light is shining on it.

That's a start. Try this:

1. Turn on *only* the left and bottom lights; make sure the diagonal light is off.

2. Pick 'Square' from the menu, and look at the two shadows carefully.
3. Now pick 'Circle' from the menu, and compare the shadows. You may want to switch back and forth a few times. Notice how the shadows are the same?
4. Now turn the diagonal light on, and compare the shadows from the square and circle again.

Oh, I get it. Each direction we look at the shadow tells us something more. Does that mean that the more ways we look at it, the more we know about it?

Exactly. That's why real CAT scan machines go around in a circle: so they can take x-rays from all sides.

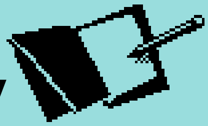
Um...wouldn't it be easier to just spin the shape and watch the shadow change?

It would give us identical results. Of course, the most we could ever learn using plain old visible light is what the outside contours of something are. But x-rays enable us to do a similar trick on the **inside**.

Previous | Next
Table of Contents | E-Mail Us!

KIE Evidence

Solar Thermal Energy



by
Philip Bell Jim Slotta
KIE Developer

Pictures linked from the CREST Solstice web site.

It is possible to get energy from sunlight in several ways. First of all, sunlight can be used to warm your house directly -- especially if you paint it a dark color or use some fancy architectural tricks. There are also "solar panels" which convert sunlight directly into electricity, using some sophisticated scientific technology.

Finally, there is a method known as "solar thermal heating", where sunlight is reflected from many mirrors onto a central point. At this central point, the heat from sunlight is so intense that it can bring water to a boil, creating steam. This steam can be used to turn motors which generate electricity.

There is a place on the Web where solar thermal energy is described, including some examples of solar thermal power plants!

Before you get started...

To focus your attention:

This is a long, complicated web-site with many pages of information. You should look at just a few of the pages, and try to form some good questions about light and heat. Follow the links we provide below, and then follow one or two links from each of those pages. How can sunlight be used to heat up water? How do we get energy from light?

To challenge your thinking:

This Web site talks about "solar radiation" as if it is the same thing as "sunlight" Do you think they are the same? See if you can understand how sunlight warms up an object. If there isn't enough information on the page to help you understand completely, try to make your questions focus on what is missing, or what is not clear.

- History of Solar Thermal Energy

- About Sunlight...
- How it works...
- An example of a solar thermal electricity plant.

Evidence Information

KEYWORDS	Solar, Energy, Sunlight, Power, Thermal
SUBMITTER	Jim Slotta

You Light Up My Life

Purpose

Next, we want to determine the behavior of sunlight from observations outside and inside the classroom. We will learn about how light travels by using mirrors, prisms, and shadow makers. The National Science Education Standards state that the nature of light is an important topic to be learned in this age group, and the manipulation of tools is crucial. The vocabulary which can be introduced to help talk about our experiences are light, shadow, shade, opaque, transparent, translucent, waves, colors, mirror, rainbow, spectrum, and ray. For a new approach to learning some of these vocabulary words, visit Word Lore, an appendix dedicated to exploring the history of words pertaining to this curriculum.

Teacher Background

> You will need white paper and masking tape, pencils, crayons, mirrors, prisms, objects of differing transparency, garden hose or spray bottle, flashlights, overhead projector, water and clipboards.
>
> A few sunny days would be good for experiencing this topic. Students will be developing theories about light and need a few chances to test them in the outdoors. Only a few periods of class time are required. (This Thread leads to another Thread about shadows which will take longer to explore fully but supports the same developing understandings.) Gathering materials will take time, as equipment may need to be reserved or ordered.

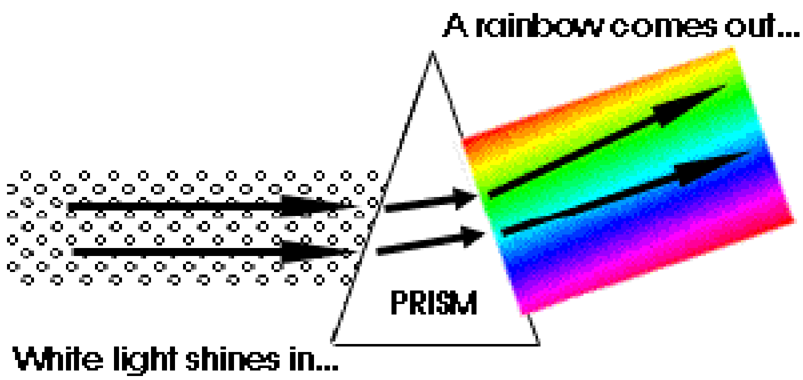
Light is a very odd thing, but a very special thing. It travels faster than everything else in the Universe. It defines how we measure everything we do, for it travels around, hitting objects and bouncing their images to our eyes. When the images of objects reach us, they allow us to judge the positions of those objects. In that way it is our only good means of determining time. If something moves from one minute to the next, we are most likely to notice this if we can see its image. We can only see its image, if light is bouncing around. Therefore, light can tell us about the world and its changes.

Our current scientific knowledge suggests that light can act in ways that are wave-like and ways that are particle-like. That light acts as a wave means it bounces off things or interacts with other lights similar to the way that waves in water do. That light acts as a particle means that when it bounces off things, it carries with it energy that can be transferred to the things it hits. An example of this is a sunburn, where sunlight has hit and been absorbed into the skin, burning the cells.

This wave particle thing called light travels in a very straight way, in rays, from its source. Anything in the path of the light ray will block the ray to some degree. If the object is very dense and dark, preventing the light from passing beyond it, it is called opaque. Beyond this object, then, on the side farthest from the light source, is what is know as a shadow - where there is an absence of the bright light. You can usually still see things in the shadow because there is other light scattered or bounced about the room or yard hitting that area indirectly. Some transparent objects like glass even let light travel almost completely through them. Objects which may allow only a little light to pass through, like colored plastics, are called translucent. However, the translucent materials often distort the light they let through. This is because light is a strange thing itself.

White light, or the common light from the Sun, is a tight tangle of all visible colors of light. The colors travel together all mixed up in a way that makes our eyes see the combination as bright whiteness. This combination can be untangled out if you somehow crack open that tight mixture with a light bending tool. Thick clear things like glass and water are very good at this, but plain glass or water is not enough. They have to be in a shape which makes it tough for the tight light package to get through without breaking apart.

A prism is a piece of glass shaped like a triangular solid, or a triangle stretched upwards to make a three-dimensional shape. The light travels into the triangle from a face of the triangle at a certain angle. Whenever light goes from one medium (air) to another (glass) the different colors of light bend slightly differently. The pencil in the glass of water trick is an example of this. Usually, through a flat medium like a pane of glass, the light enters, colors bend by a specific amount, and then bend back into one another going out the other flat side. But the prism, because it is not flat but triangular, doesn't allow the colors to bend back into one another. Instead, it encourages more bending by the angle it has on its other side. So, the white light enters the glass and the colors bend and take different paths through the prism. When they reach the other side, instead of meeting up again with each other passing back into air, each color splits even more from the pack by the same angle again and takes a slightly different path out of the prism. We see the colors break open in the beam. A spray of water will also make this happen as the little droplet shapes of water work like miniature prisms. You get a misty rainbow in the droplets as the white light package gets ripped open in the spray -- exactly as it happens in the sky with real rainbows.



Contents

Download

Internet Resources

Children's Books

Folklore & Mythology Connections

To K-2nd Grade Thread

To 2nd-4th Grade Thread

To 4th-6th Grade Thread

Kindergarten through Second Grade

Developmental Issues

This Thread will focus our experiences of shadows on what light is doing. The students will explore the direction of light and how it always makes a shadow behind an object. We will make it into a game called Sun/Blocker/Shadow which hopefully will root important scientific concepts in a fun game. Five- to eight-year-olds are not very adept at grasping the nature of light. Most undergraduate physics students have difficulty with the concept! However, being comfortable with the way light works is crucial for understanding shadows. Make sure that children understand that when someone says "there is no light" that it's different from how we talk about dark in everyday language. If a room is slightly darkened but they can still see, it is because there is light available! Providing the concrete experiences offered in this Thread helps children develop a strong base for the complete concepts they will learn when they're older.

Inquiry Introduction

What are shadows? Where do they come from? How do you make one? What things do you need to make a shadow? Could we make a shadow outside? Inside? In a dark room or at night? Under water?

Inquiry Investigation

Outside, the Sun lights up the world. But what happens when things get in the way of the sunlight? Does everything make a shadow? Where are our shadows? Can I walk up to someone and step on her shadow? Playing a game of shadow tag would be fun here. After the energy is released from play, gather the students around again.

Let's face the Sun and try to find our shadows. Are they in front of us? They are behind us. Let's face our shadows. Where is the Sun? It is behind us now. So, where are shadows going to be when the Sun is over there (point to the left)? Let's face that way. Our shadows would be behind us again, on the other side. So, where do shadows form? On the side of us away from the Sun. Is this true for any light? Can both the Sun and shadow ever be on the same side of us? Could we face the Sun and face our shadows at the same time? Why or why not? What is it about the Sun's light that is not making that happen?

The overhead projector in the classroom gives off a nice light. Turn it on and ask someone to stand in front of it with his eyes covered (otherwise it will hurt). Where is his shadow? He can't see it, but the class can see it behind him. Where should he move to see his own shadow? He turns around and there it is.

What is the Sun? What is the light? Are there things in our classroom which give off light? What are they? Could we think about the sunlight as we do the classroom light? Are there such things as portable lights? Could we use them to think more about light and blockers of light?

What about with flashlights? Could we shine a flashlight on something and make a shadow behind it? In pairs in the classroom, have students shine a flashlight on objects they have in front of them. You could give them wooden shapes and other things. Where are the shadows? Can they change the shape of the shadow or the size?

There seems to be some kind of lining up that has to happen: Sun, blocker of Sun, and the shadow. Could we find a tree and see if it works with a tree? Find a nearby tree and see if the same is true. What about a car or the school? Where is the Sun? Where is the shadow?

Emphasize "Sun/Blocker/Shadow" while pointing to each of these elements in the set-up. Move the flashlight to another spot and show again the different pieces of the Sun/Blocker/Shadow. Let them quiz each other with teams at their own desks. For the youngest grades this may require supervision. You may just want them to play with the flashlights, see if they can tell someone else one special thing they found out about the light and shadows.

A short assessment handout is included that you could use tomorrow to see how many have experienced this fact of light: Light travels in straight lines, so that shadows are directly away from the light source.This handout was created by a first grade teacher as part of the Everyday Classroom Tools curriculum. She had great success with it, and used it repeatedly to reinforce the ideas.

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To K-2nd Grade Thread

Second Grade through Fourth Grade

Developmental Issues This Thread allows teachers to direct questions towards the nature of light through repeated experiences with it and objects which block it. These students can juggle ideas such as the seen and the unseen. This will help us to get a firm enough grasp of what light is doing that we will be able to predict some things about both it and shadows. Try getting them to notice the world around them, especially things that don't seem to make sense. Encourage them to take the next step in problem solving by coming up with the kinds of questions they would ask to solve the mysteries. Be aware: they will come up with questions that they may not be able to completely answer! Encourage your students to write their questions down in a journal where they could call upon them as they gain further understandings.

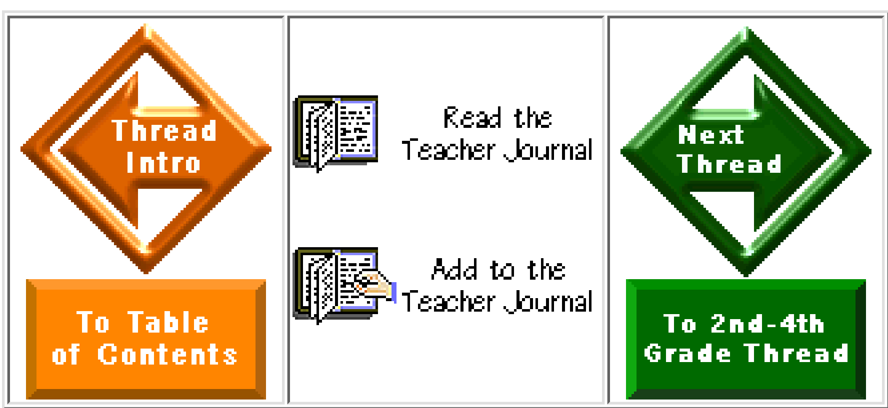
Inquiry Introduction What are shadows? What is shade? Are they the same? What is light? Where does it come from? How is it made? Let's go outside and think more about this. Grab stuff you want to see shadows of and maybe some paper if you want to draw shadows to show people later. Does anybody think there is something which does not make a shadow? Bring it along.

Inquiry Investigation `Outside, find a place where there is space to spread out clipboards and people without overlapping shadows. It may be better to do this closer to mid-day when the shadows are shorter. Have everyone place their test objects on the paper.` What do we see? Which objects make really good shadows? Which make weirdly colored shadows? Why might this be so?

In all of this, where is the Sun? Look again at the shadows. Which way do they point in relation to the Sun? Is there anything we could do to change that? Trace the shadow there right now. Then try to find some way to make the shadow look different on the paper. Some will move the object, some will move their position on the ground, others will twist their paper a bit. Draw the shadow again. Whose shadow looks different? Why? What happens when you move the object itself? How did the shadow change? Is it pointing in a different direction? Where is the Sun? What about when you move to a different place? Where and how did you move? How might that have affected the way your shadow looks? Where is the Sun? What about those of you who twisted the paper? Where is your new shadow? Is it still pointing away from the Sun? But where is it on the paper? The paper moved and not the Sun, right?

Why are shadows always pointing away from the Sun? How is light working to do that? How does the Sun know the wooden block is there? Light is somehow hitting the block and making that shadow. What is that area behind the block and away from the Sun? Is there light in there? Not as much as there is around it. So, when light hit the block, did it go through the block? A shadow must be the area behind an object facing the Sun which can get no direct light.

Why is it cooler in the shade? Is the Sun warm? What happens in the shade? It is not getting the light and so is not as warm. Cool. Exactly.



Fourth Grade through Sixth Grade

Developmental Issues

This Thread offers fourth through sixth grades the opportunity to tackle the theory of light through different and more serious experiences outdoors. They are ready to ask and be asked some deep questions which will hopefully open their analytical minds to the possibilities of even deeper questions for real understanding. Providing them with tools and time is all we need for them to create a fairly good theory of the nature of light. Even if they don't come up with the same theory that scientists currently hold, they are learning about theory generation, how we come up with the best explanations that we can until we learn something new to help us generate a better explanation.

Inquiry Introduction

Why can we see the world around us? What outside conditions cause us to see worse or better? Students will mention the weather and amount of light. Why does the weather affect our view? It will become obvious that the weather can block light, such as on a cloudy or rainy day. So, really, the only factor is light. What is this light stuff? Where does it come from? Does it only come from the Sun? What other things give off light? Fire and friction are good examples, friction being what causes light bulb filaments to glow. (This may be new to this age group. If so, it would be useful to have all of the class rub their hands together and tell you what happens to the temperature. Can they think of other familiar objects that produce heat in this way?) Phosphorescence is another way of making light, but a very confusing way at that. How does that little sky spot of the Sun make the whole town light up? What is light doing? How might we figure out more about it?

Have the class make strategies for learning more about the Sun. Brainstorm about ways to test theories. For example, one hypothesis might be that the sunlight glows in the air. How could we test that? Is there a way? One way might be to get a clear container of air and shine a light in it, then turn the lights off. If the air is still glowing inside, that could be interpreted as evidence for the theory. What other thoughts might they have about how light works? Now might be good time to talk about reflection.

Inquiry Investigation

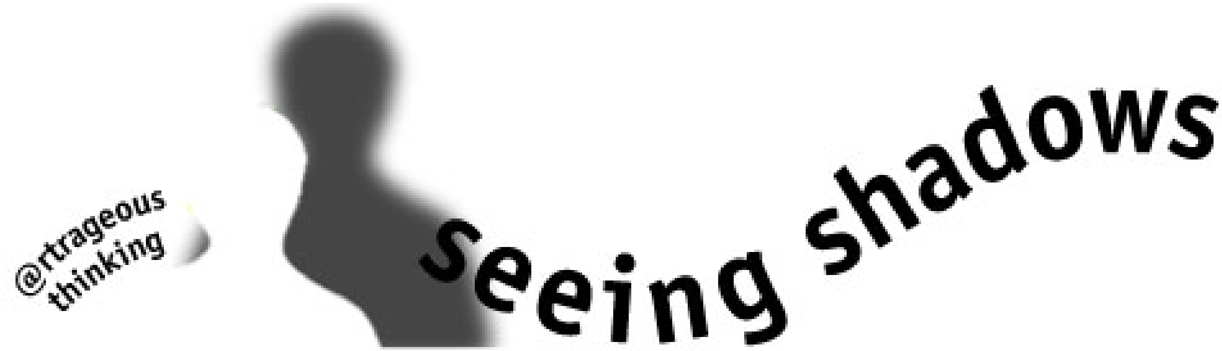
Bring outside (on flat ground or pavement with paper) all of the things they might need to discover properties of light. We suggest you bring mirrors, objects of varying opacity, closed boxes, flashlights, paper, tape, etc. (Please note: It is an unfortunate fact that children outside with mirrors often will try to aim the bright sunlight into the faces of others. You should consider using mirrors indoors with flashlights, which are weaker, or mentioning that mirrors will be taken away if students cannot behave properly with them.) Encourage your class to build devices for trapping or analyzing light.

Why are shadows on only one side of an object outside? Do they ever move? Why or why not? Most will say that the Sun is shining and hitting the object on one side of it, and the shadow forms because the light can't get through to the other side of the object, so there's no light there. Trace the shadow on the paper. Twist the paper. Where is the shadow on the paper? Where is the Sun? Is the shadow still pointing away from the Sun? But where is it on the paper? Did the Sun move? But the shadow changed because what we were measuring it on moved. Keep this in mind when we do the Sun stick measurements.

Why can you still see the pavement in that shadow? Surely there must be some light coming from somewhere? What is happening? What happened to the light that hit the block? Did it get sucked into the block? Did it bounce off the block? How can light bounce? What other things can bounce like that? Many will say playground balls or something like that. Is light made of little balls of bright stuff? If so, what could we do to test that? Here is where the mirrors come in.

It is hard to see the light bouncing from the block, but easy to detect light which is being bounced from a mirror. Can we bounce light around the yard? How far can we get before it is difficult to catch the beam of light? If light can bounce so well off mirrors, might it not bounce around off other things, but not as well? Probably. That is why it still gets around the whole yard, even the pavement inside a shadow, when the Sun is in one place in the sky. This is why it gets bright out in the morning even before the Sun rises, and that it is still light just after the Sun sets. Light indeed travels in very straight lines, but light itself can bounce though it still travels in straight lines from object to object.

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To 4th-6th Grade Thread



People usually don't pay much attention to the things they see everyday. A key to being a good artist, however, is noticing things that other people often miss.

Take shadows. Most people don't bother to look at shadows. But, once you start looking for shadows, you'll discover them all around you. Looking at shadows might seem strange at first. Yet, it's a good way to focus your vision and reacquaint yourself with your surroundings. It's also fun!

Materials You Need: a flashlight, a camera, and a roll of film.

What To Do: Begin by studying the shadows of things in your room. Take a strong flashlight and shine it on an object. Notice how the position of the light source determines the size and shape of the shadow.

Go outside on a sunny day and concentrate on shadows. Watch the shadows of things moving around you. Notice how much detail you can see in shadows. If it's late afternoon, notice how the shadows stretch out on the ground. For fun, play with your own shadow for awhile.

Want To Do More? Take a camera and shoot pictures of the shadows you see in your surroundings. Look for both familiar shadows and unusual shadows to record. Have your film developed and select your "best" shadow picture to frame and hang in your room.

| @rtrageous thinking |

Thinking Fountain

Shadowville

The poetry and illustrations make this book fun to read out loud. -Wendy

- Light
- Sun
- Shadows
- Night

Shadowville
by Michael Bartalos
Published by The Penguin Group
ISBN 0-670-86161-8

Summary:
When night falls, shadows of all kinds flock to their private world where they play, eat, and rest.

For more literature and science connections browse through other Books you can use.

that makes me think

Put on a shadow play with your friends. How could shadows turn different colors? What are the ingredients for a shadow? What objects can you identify by looking at its' shadow?

- **Can you see through this one?**
- **Build your own light island**
- **Shadow puppetry**

Gathered by topic Connected together Index of ideas Try something new

---

Me and My Shadow

In this Thread, we will become familiar with the orientation of shadows, their size in relation to the object casting them, and how the alignment of the Sun, the object, and the shadow tells us much about how shadows work. The National Science Education Standards stress that geometry and light should be integrated into curricula as tools for learning about three dimensional objects. Vocabulary words which can be used to help talk about our experiences are alignment, casting, angle, and light source.

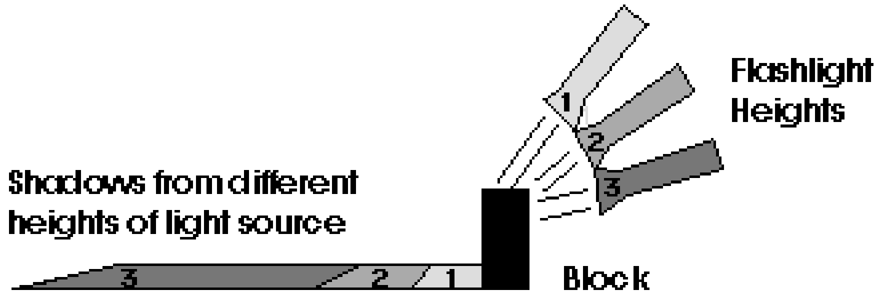
The height of a tilted light source (in other words, the angle between the light source and the ground) and the size of the object it is illuminating determine the length of the shadow that the object casts. The object blocks the light coming from the source so that nothing behind the object gets any direct light. The length of the shadow is a result of how high above or below the top of the object the light source is. Imagine if the light source were directly above the top of the object. Would there be a shadow? No, not one that would be visible around the object. Twist the light source a little down from the top, and a shadow appears behind the object, but is very short. This is because as the light source moves down, the shadow is being created by the small area of the object blocking the light. Imagine straight lines coming down from the light and hitting the object. The higher the light, the less light lines get blocked by the object and hence the less shadow. Thus, the lower the light source is aimed at the object, the more the object blocks the lines, or rays, of light.

You will need enough pebbles, coins, marbles or counting blocks for the entire class, a box of chalk, chalk/wipe board and markers, overhead projector or lamp.

This requires one class session outside in the sunlight. Another class session or two inside is enough time to really think about our outdoor experiences. Materials gathering is quite minimal.

The key to understanding shadows is to realize that the light source and object must be lined up in order to make a shadow appear. In fact, if the object is placed anywhere along that line, it will produce a shadow of the same length behind the object. It is only when you change the orientation of the light source that the shadow changes. That makes sense in one order: light hits an object and casts a shadow. But experiencing the connection of these fundamentals in a different arrangement is good for rooting our experiences more firmly. In other words, trying to predict where to place an object to cast a shadow at a specific location: essentially trying to locate the path of the light.

We've made a brief page about solar eclipses. Solar eclipses are excellent examples of light and shadow.



Contents

Download

Internet Resources

Children's Books

Folklore & Mythology Connections

To K-2nd Grade Thread

To 2nd-4th Grade Thread

To 4th-6th Grade Thread

Kindergarten through Second Grade

Developmental Issues

This Thread invites Kindergartners through second graders to continue to think about light and shadow while using their bodies to make observations. This roots our experiences by relating them to ourselves, which is fitting for this age group. It engages students in manipulating objects with a focus in mind as well as exercising balance and movement skills which are good for this age group. Teachers of second graders should consider using the grade 2-4 version of this Thread.

Inquiry Introduction

Remember the game Sun/Blocker/Shadow? Why does it work? What other game could we devise to play with the way light works? Everyone grab a marble or cube. `(Don't call the cubes "blocks" or it will confuse the game.)`

Inquiry Investigation

Together, let's go outside and find a place to spread out on an area of asphalt or concrete, etc. Where are our shadows? Can everyone find his or her own shadow? Where is it? Is everyone's shadow visible? Can the teacher come and step on someone's shadow? Does it hurt to step on a shadow? How far away from the person is the teacher who is stepping on the shadow? Is it hard to reach the person from where the teacher is standing? Why are shadows so far away from their makers?

Play Shadow Tag again, this time with some questions afterward. Was it hard to play this game? We had to be careful to watch our shadows and the person who was "It" very carefully. When was it hardest to be careful: when running towards the Sun or away from it? Why? How are shadows made, then?

Now it is time to reverse our thinking. Everyone, drop your cube somewhere. Where is your shadow? Can you move your shadow so that the shadow of your hand can cover the little cube on the ground? `This will at first seem quite difficult, but soon they will begin to cry out that they have done it. Helping is definitely OK.`

How did you knew where to put your fingers? `They will begin to vocalize in their own ways an important fact: that the sunlight is in straight lines to their hands and they need only line themselves up with the Sun and the cube to cast a shadow on it. In this way, they have figured out that one can determine the position of the light source from the angle of a shadow they can cast.` Can anyone think of a way to play this game in the classroom?

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To K-2nd Grade Thread

Second Grade through Fourth Grade

Developmental Issues

This Thread will examine the orientation of the Sun, ourselves, and shadows from the reverse way around. It will seem like a tricky game, but once the idea of the linear nature of light travel is experienced, we can talk more about light in the next Thread. To do so, again we will exploit this age group's fascination with mystery, team learning, and the ability to string two or more variables together into a model. Second grade teachers should consider choosing this version of the Thread over the version intended for younger (K-2) students.

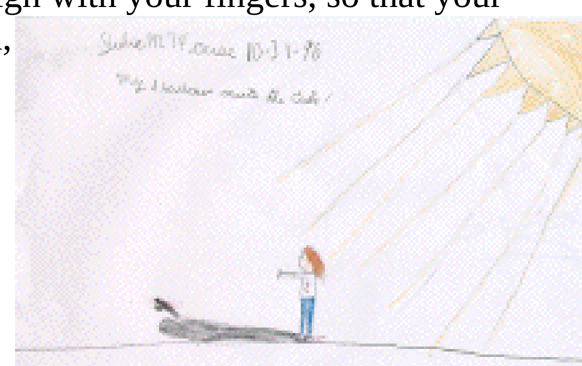
Inquiry Introduction

What has to happen before we can see a shadow of ourselves? There must be light. There is light and us, but there is something else we need to actually see the shadow. We need something for the shadow to land on. So, three things are required for shadows: a light, an object, and a surface. Is there any guideline for where the shadow should land when we are standing in the light? Does it matter where we put the light? What about in outer space?

Inquiry Investigation

Everyone should grab one small shiny object like a new penny or an interlocking math cube, a pink eraser or a marble. Let's go outside. Find an asphalt or concrete area with a lot of space, enough that the entire class can spread out and be bathed in sunlight. Is there enough room for their shadows? `You might consider timing this for between 11 a.m. and 1 p.m., when the shadows are shorter but not so short as to make this impossible.`

Everyone should spread out enough that they can twirl in place and not hit anyone. Next, everyone should drop their shiny object somewhere about 4-5 feet from them in any direction. Now find your own shadows and stick your arms out. Make an OK sign with your fingers, so that your shadows show a little ring or circle for your hands. Can you, without squatting, move your shadow ring so that it encircles the shiny object on the ground?



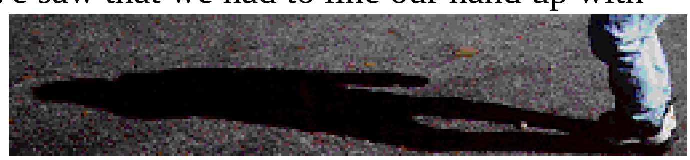
`They will mock this as easy at first, until they find it is very difficult. There is some kind of trick to doing this, and it will be fun watching them catch on.` What has to happen before the shadow can line up with the object? What else is needed to make a shadow besides the surface (shiny object) and the thing making the shadow? The Sun. `See how many can incorporate this into their struggle. There has to be an alignment of the three crucial items needed in making a shadow happen.`

Soon, (it takes about 3-4 minutes), they will begin crying out that they have figured it out, one by one. Ask them what they did, and they will try to explain they made things line up or they looked back to where the Sun was. It is the lining up of these objects which is so crucial to learning about how light and shadows work. If someone has managed to ring the object by luck, ask about the positions of the things needed to make a shadow. Is there any pattern? Can we shuffle from side to side and still make the shadow happen on the object? Can we shuffle forward and backward and still make the shadow happen on the object? How? Where must the Sun be in order for this to work? Directly behind our hand. Where must the object be in order for this to work? Directly in front of our hand.

Where is the Sun? Where is our shadow? Have them face the Sun. Where is our shadow? Turn to the left. Where is the Sun? Where is our shadow? Is there a pattern here? What if the Sun were over there (point to the left)? Where would our shadows be? What is true then about shadows and the Sun? Shadows point away from the Sun. Do shadows point away from a lamp as well? We can play with this back in the classroom.

They will want to play more with this trick once they all have caught on. You can ask them if they can get two people to circle the object at once from different positions. Break into teams of shadow makers. Can anyone make other shapes with your body to circle the object? Does everyone have to stand at the same distance from the object to ring it? How many people can you line up who are casting a shadow around the object but are standing apart from each other?

Back in the classroom, let's pool what we've seen. We saw that we had to line our hand up with the Sun to make a shadow, but we also had to line that shadow up with the shiny object. We had to move our entire bodies so that the Sun was at our back to get the OK sign over the object. We found that we could also move towards it and away from it and still keep the OK ring around the object by moving our hand only slightly.



Draw on the board a Sun, a person with her hand out, and the object, but do not line them up in the proper was for the person's shadow to hit the object. Will this person's shadow hit the object? Why or why not? Students should gather in the same teams that they were in outside. They should think about the question on the board and then come up with an answer. Ask the teams in turn what they think. They will hopefully mostly say no, this cannot happen. Why not? They will talk about things not being lined up. You could prod them some more by asking them if they mean you can't draw a straight line which connects them all.

Draw a line that connects the three items, first asking what the order is. Sun, object, shadow....It should be a terrible looking line, with connections between points not meeting at a 180 degree angle. In other words, not a straight line. Where would I need to put the person to make the line straight? Teams can confer and answer you in rotation. Have them come up to the board and place an X where they think the person's hand should be. Different colored chalk would work well for different teams, otherwise numbers will suffice. Does everyone agree? If not, more examples like this could be done.

Is this what we experienced outside? We had to line up everything to make it work! Why? What must be true about sunlight or any other light source? It travels in straight lines.

Thread Intro	Read the Teacher Journal	Next Thread
To Table of Contents	Add to the Teacher Journal	To 2nd-4th Grade Thread

---

Fourth Grade through Sixth Grade

Developmental Issues

For this age group, this Thread involves a quick investigation outside to exercise our powers of perception. Although this is probably a little easy for them, it is still a good idea for them to be familiar with every aspect of the shadow making process.

Inquiry Introduction

What makes a shadow? Most will know that shadows are caused by the Sun or other light hitting an object and blocking the path of light behind the object. This is easy, right? You can make a shadow fairly easily and determine where the light source is from just looking carefully at a shadow. But can you aim a shadow at an object? Huh?

Inquiry Investigation

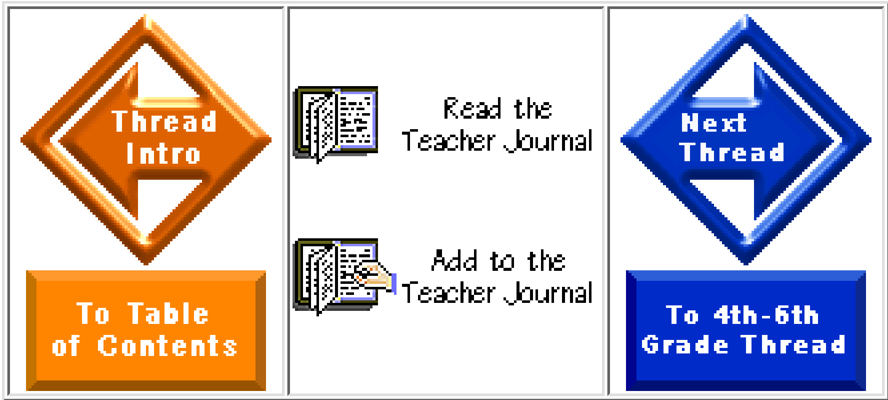
Everyone should grab one small shiny object like a new penny, interlocking math cube, a pink eraser or a marble. Let's go outside. Find an asphalt or concrete area with a lot of space, enough that the entire class can spread out and be bathed in sunlight. Is there enough room for their shadows? (You might consider timing this for 11 a.m. or 1 p.m., when the shadows are shorter.)

Everyone should spread out enough that they can twirl in place and not hit anyone. Next, everyone should drop their shiny object somewhere about 4-5 feet from them in any direction.Now find your own shadows. Make an OK sign with your fingers, so that your shadows show a little ring or circle for your hands. Can you, without squatting, move your shadow ring so that it encircles the shiny object on the ground?

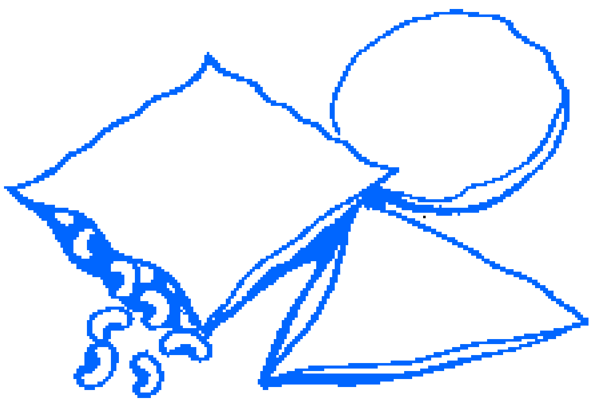
They will mock this as easy at first, until they find it is difficult. There is a trick to doing this, and it will be fun watching them catch on. What has to happen before the shadow can line up with the object? What else is needed to make a shadow besides the surface (shiny object) and the thing making the shadow? The Sun. See how many can incorporate this into their struggle. There has to be an alignment of the three crucial items needed in making a shadow happen.

Soon, (it takes about 1-2 minutes), they will begin calling out that they have figured it out, one by one. Ask them what they did, and they will try to explain they made things line up or they looked back to where the Sun was. It is the lining up of these objects which is so crucial to learning about how light and shadows work. If someone has managed to ring the object by luck, ask about the positions of the things needed to make a shadow. Is there any pattern? Can we shuffle from side to side and still make the shadow happen on the object? Can we shuffle forward and backward and still make the shadow happen on the object?

How? Where must the Sun be in order for this to work? Directly behind our hand. Where must the object be in order for this to work? Directly in front of our hand.



bag it



skill

Differentiate between size and shape

materials

Bean bags in different shapes: circle, square, triangle (teacher made), tape (colored masking tape is great)

teacher input

Use tape to make a big face on the floor. Gather children and explain the game. We're going to take turns tossing our little bean bags into the big shape that matches the shape of the bag. **Å** Review familiar shapes around the room, then model one round of tossing. Transition to centers.

procedure

With a small group, three to five children, begin the game. Provide two or three lines on the floor for the tosser to stand on. Allow choice. Other children stand behind tosser. **Å** Give child a bag of each shape and observe what happens. Note if child tries for shape space that matches bag shape. Ask child questions about the size and shape of his bag relative to those on the floor. Accept all responses. Rotate groups.

independent play centers

ART: Sponge painting with different shaped sponges.
BLOCKS: Use blocks to build a large shape space. Fill it with blocks (smaller) of like shape.
LANGUAGE: Use stamp pads and rubber shapes (these can be made out of erasers) to make shape designs.

extension ideas

MATH: Use the shape bag toss idea for a variety of shapes: diamond, heart, rectangle, hexagon, pentagon.
LANGUAGE: Cut out center of paper plates in a shape. Use to trace. Provide stickers or bits of paper in matching shapes to glue on plates.
ART: Cut out paper in various shapes for painting. Use matching sponges.
MOVEMENT: Make a body shape. Use a friend if you need to.

Previous Page | Table of Contents | Next Page

GEOMETRY UNIT

Grade 4

by Amy DeMitry

5/21/96

Unit Objective : Children explore the world around them before they are able to walk. Fitting shapes into appropriate holes and building block towers all help develop a child's sense of geometry. In this unit students will be given the opportunity to experiment with geometry once again through the use of hands on activities. The end result of this unit will be a deeper understanding of the world of geometry that surrounds them as well an appreciation of the use of geometric principles in real world applications.

Lesson #1 : ***Classification of Shapes***

Time: 45 min

Objective : Relying on their past experiences students will draw shapes which they envision as they listen to a poem. Given an introduction to classification, students will classify various geometric shapes using their own scheme and explain in writing why each shape belongs in its particular category.
.

Overview: After reading Shel Silverstien's "Shapes" students will be asked to draw what they envisioned as they listened to the poem. This focus activity is followed by an introduction to classification and the classification of geometric shapes. Lesson Plan 1

Lesson #2 : ***Angles***

Time: 45 min

Objective : Students will identify right angles and will determine whether an angle is less than or greater than a right angle.

Overview : Students will create their own right angles and then, working in groups, determine whether or not given shapes have right angles. Then they will create an angle adjuster which will be used to examine angles smaller or larger than 90 degrees Lesson Plan 2

Lesson #3: Quadrilaterals

Time: 45 min

Objective: As a result of this lesson, students will be able to recognize various types of quadrilaterals and group them accordingly.

Overview : Working in groups, students will classify given quadrilaterals. Each group will describe their classification scheme in writing and report their findings to the class. With the time that remains students will play a game of guess my shape. Lesson Plan 3

Lesson #4 : ***Lines and Polygons***

Time: 45 min

Objective: Students will create both parallel, perpendicular, and intersecting lines. They will then create polygons made up of these type of lines.

Overview: Working in groups of four, students will create a polygon using a large cord. Once they have created the polygon, they will be asked to point out things such as sides and vertices. They will create intersecting, parallel, and perpendicular lines.These concepts will be reinforced by using geoboards.
Lesson Plan 4

Lesson #5 : ***Tangrams***

Time: 45 min

Objective : As a result of this lesson, students will become more familiar with geometric shapes and understand how they can be combined to create more shapes.

Overview : I will begin the lesson by reading *Grandfather Tang's Story* to the class to introduce the idea of tangrams. I will then pass out special tangram pieces to the class, as well as a worksheet which the students will follow to create various pictures and shapes by combining the different shapes.
Lesson Plan 5

Lesson #6 : ***Clues Leading to Shapes***

Time: 45 min

Objective : Given various clues containing information about shapes, lines, angles, and size, students will work together to recreate the object described. Students will then create their own figure and write clues for classmates to follow in order to recreate their original shape.

Overview : Each group of students will be given various clues. The students will work together to create the figure described in the clues. Once the group successfully recreates the shape they will create their own figure and write detailed clues for their classmates to follow in an effort to create their original figure. The groups will then draw their original figure to use as an answer key. Finally the groups will trade riddles and try to create each others figures.
Lesson Plan 6

Lesson #7 : ***Perimeter***

Time: 45 min

Objective: As a result of this lesson, students will discover how to compute perimeter and use this discovery to calculate the perimeter of various shapes.

Overview : Each group of students will be given a number of different shapes all having equal perimeters. The students will be asked to discover how to find these perimeters. Once they have devised a method to calculate perimeters, I will ask them to use their new formula to determine the perimeters of various other geometric figures.
Lesson Plan 7

Lesson #8 : ***Evaluating Area***

Time : 45 min

Objective : As a result of this lesson, students will be able to calculate the area of various shapes, as well as to create shapes with a specific area using square inch paper. They will appreciate the use of area measurement.

Overview : Each group of students will be given various shapes drawn on paper and centimenter blocks. The students will use these blocks to cover the shapes and experiment with finding the area of these figures. Once they understand the concept of area, I will ask them to create their own shapes given only the area. How many different shapes can you construct with the same area? Do they have equal perimeters?
Lesson Plan 8

Lesson 9 : ***The Creation of a Park***

Time : 4 hours

Objective : Given instructions and basic guidelines of a plan to build the "perfect park", students will use their learned knowledge of geometry and processes of trial and error to create and construct a park that best fits the criteria specified.

Overview : Each student will be placed in a group. The groups will all receive a set of instructions and guidelines about creating the park. The students will then be given the opportunity to ask any questions. At this point it is up to the students to map out their ideas of the park until they come across what they think is the perfect park according to the instructions provided. Once they have devised a plan, they must construct the park and label all of the dimensions. Finally the group will present their project to the class and explain why they feel their model best represents the perfect park. Lesson Plan 9

Shapes (Geometric)

Violet M. Nash
7417 South Wabash
Chicago IL 60619-1625
(312) 994-8731

Spencer Math and Science Academy
214 North Lavergne
Chicago IL 60644
(312) 534-6150

Objective:

The student will be able to identify geometric shapes using colors and math problems. Designed for second grade.

Materials Needed:

Magic Marker (black or navy)
Neon Construction Paper (five colors)
Index Cards
Magnetic Tape
Scissors
Name and Diagram of eight geometric shapes:
- Circle
- Square
- Diamond
- Rectangle
- Triangle
- Hexagon
- Octagon
- Pentagon

Strategy:

Cut out each of the above shapes in five different colors (40 shapes).
Cut one extra set of shapes with the proper name that correctly identifies that shape and use for demonstration.
Write primary math problems (using four operations) on index cards, select four exact answers per problem, and tape a card to back side of neon paper.
Using magnetic tape, scatter 40 designs and attach to magnetic board.
Divide class into two equal teams, one captain per team, and designate playing area for each team.
Place demonstration shapes beside (for reference) scattered shapes.

Activity:

Alternate one player from each team to call the color and shape (e.g. yellow hexagon and blue pentagon) and the captain of that player's team will turn the cards over to show math problems. Player must state the problems and the answers. If the answers are a match (e.g. 5+5=10 and 20-10=10), that player continues to play until no match is made. As the first player moves to the end of their team's line, play begins with the next person in line on the opposite team. Points may be assigned by giving a number value for every match obtained. The team with the highest number of matches or the most points is the winner.

Return to Mathematics Index

in partnership with QuiltersVillage.com The online home of your favorite quilting magazines.

Quilting

with Susan C. Druding
Your Guide to one of hundreds of sites

Quilting with Children
Inspiration & Ideas for teachers and parents

Sharing your quilting knowledge with children or teens can be more fun than you can imagine. Seeing the faces of the students in some of the pictures you'll see linked from this article as they hold up their creations will make you smile and want to have some of these snapshots in your album of memories as a quilter! Whether you are a teacher, a scout leader, a camp counselor -- or, you just want to have fun with your own children, grandchildren and their friends -- think about doing a group quilt project. This article will lead you to some free quilting patterns, projects and excellent advice and inspiration on a great collection of Web sites.

Heddi (Thompson) Craft is the kind of teacher we all want for our kids - and her Web pages are a perfect place to start exploring how to teach quilting. Spend some time really exploring her pages. She starts them with understanding the way a block is designed, then goes into clear detail on how to teach handsewing and includes good diagrams. The picture of the "Fifty States Quilt" is great, don't miss the lower picture on the page of the 6th grade artists proudly holding their quilt for the camera.

Heddi's also collected stories and photos from other teachers from around the USA on her pages. This "California Here We Come" quilt is from a class of 4th graders in Belmont, CA. Karen Cutter (an avid quilter) is the library/media specialist at the school and helps any teacher who wants to do a class project. These students used Pentel's Fabric Crayons for their blocks. Amy Henbest shows a class project done with fabric crayons.

Internat'l Quilt
Quilt Equipment
Holiday
Fun Humor
GuildsAssociations
Young Quilters
Fabrics Online
Quilt Books
Materials & Safety
Museums
Personalities

Subject Library

All articles on this topic

Heddi has added some good tips on quick turn finishing a quilt to her pages. These are fast techniques for turning, binding, etc. Also see her page on Simple Patterns for children to do.

- Quilting in the Classroom has ideas for classroom ideas at the Gilbert Linkous Elementary School.
- The American Quilt Getaway has a list of K-12 Lesson Plan sites using quilts that has lots of ideas.
- The Apple Barrel's Quilt Unit - a beautifully done Web site by Debbie Meyer with lots of ideas for using quilts to teach children math, history, art, and more. Whether you are a teacher or a person wanting to introduce quilting to children you will enjoy these Web pages.
- Sweet Clara & the Freedom Quilt - A lesson plan that could be used to introduce other lessons or discussions on migration and the different reasons people have for moving.
- Julia Pferdehirt shares classroom ideas for making Underground Railroad inspired quilts.

Scott Carles is an inspiringly creative 5th grade teacher in Millville, UT. He explains his, "Who Am I" quilting project this way: [Note: Scott Carles' site is not available currently, I don't want to remove the links in case it returns. July 2002]

> "The idea behind this quilt was exploring the question, "Who am I?" I wanted students to realize that history is the story of individual lives. It is also the overlapping of many individual lives making a rich tapestry of collective lives. I wanted students to realize they have an individual history that makes them who they are at any given point in their life. So to start the year I had them write papers on "Who am I?" This assignment was the focal point of each individual quilt block making up our collective quilt."

He has shared excellent information on fictional books on quilts and quilting (which students read to the class while others were working on the quilt) and a Curriculum written out to show how he used the quilt theme for teaching math, writing and more via the quilt theme.

Older children also express themselves in quilting. A project at The Adolescent Quilting Project at the Children's Medical Center of the University of Virginia shows some real personal expression in quilts by both girls and boys. Math teachers love to use quilting -

what could be more clear to show geometry than a quilt block?

Mary Beth Martin shares a detailed Integrated Unit for 1/2 grades using quilting. She includes math, history, social sciences, etc.

Here are some Web sites especially focused on math uses of quilts for teaching:

> The Math Studio: Harnessing the Power of the Arts discussion
> Escher page with information and lots of links
> Geometer's Sketchpad: software for Euclidian geometry.
> Discussion thread from Geometry newsgroup has some ideas, too.
> Search on the word 'quilt' and check categories 'Art, Math, Social Studies' on Global SchoolNet for ideas for projects

If you don't have time or can't actually make quilts with a group you can use existing quilts to promote discussions and ideas.

Faith Ringgold as inspiration: Even younger children can have quilts as inspiration "Dream quilt, Children express wishes through art" project was for children 3-5 years old. Faith Ringold's "Tar Beach" was used as the book for starting them on their Dream Quilt. Another 3/4 grade class project using Tar Beach is here. . Ringgold's sequel book, Aunt Harriet's Underground Railroad in the Sky, is another of this painter-quilter-artist's book with quilting in the story. Faith Ringgold is on the faculty at UC-San Diego. Faith Ringold's Home Page is Here. A large gallery of her work is Here keep clicking 'more' at the bottom of the page to see more images.

Also, see my previous feature article on MOLAS for a class project linked there as well.

Two more quilting book lists for children on the Web are the very thorough list by Betty Reynold's and a FAQ on Children's Quilting Books from QuiltNet. You may want to print these out to take to the library with you.

I hope this article has inspired you to think about a children's project. You do not have to be an expert quilter for this, in fact, you can learn right along with the children! Most of the quilting areas on the Web have quilters who will be happy to share information and advice. Our Quilting Forum is a good place to start, lots of helpful quilters visit there.

Susan Druding
Your Quilting at About.com Guide

Articles Indexed by Date	Articles Indexed by Topic	Quilt Resource Lists on this Site

Email this page | Sign up for a Newsletter |

Explore More

Most Popular Articles

- A free applique pattern - a spring kite scene
- Bold Quilt Block - with several methods to make the quilt bl...
- easy baby quilt or lap quilt project - a free quilting patte...
- Free quilt blocks - applique
- Free Easy Log Cabin Quilt Block Pattern: log cabin in severa...
- Useful basic quilt block - easy and fast to make for quick q...
- Mystery Quilt 3 - fast & easy fat quarter free mystery quilt...

What's Hot Now

- Quilt words - a glossary of quilting terms, definitions and ...
- Free Baby Quilt Pattern : Little Mittens
- A free quilt pattern - Deco-Whirl Quilt - a paper foundation...
- How To Make a Quilt Greeting Card
- Bold Quilt Block - how to make with paper foundation piecing
- A Free Applique Pattern - a sports training shoe in the shoe...
- Quilt Greeting Card - easy small gift

About Us | **Advertise on This Site** | **User Agreement** | **Privacy Policy** | **Kids' Privacy Policy** | **Help**

SimpleNet
MAKING THE WEB SIMPLE

World-class data center solutions

HOME | ORDER | LOGIN | ABOUT US | SERVICES | DATA CENTER | SUPPORT | CONTACT US

Welcome

24/7 Sales & Support 619-243-3212

Finances
Debt Consolidation, Refinance Mortgage, Refinance Home, Refinance, Cash Advance, Personal Loan, Bankruptcies, Credit Reports, Repair Credit, Unsecured Loan

Online Gambling
Online Casinos, Poker, Wagering, Video Poker, Online Betting, Slots, Black Jack, Monte Carlo, Sports Betting, Vegas

Insurance
Car Insurance, Health Insurance, Life Insurance, Home Insurance, Dental Insurance, Travel Insurance, Business Insurance

Homes
Refinance, Home Equity Loans, Air Purifiers, Home Insurance, Renters Insurance, Home Mortgages, Air Conditioning, Movers, Real Estate

Business
Home Based Business Incorporate, Incorporate Online, Merchant Accounts, Merchant Account, Fundraising, Business Opportunities, Online Training, Business Credit Cards, Business School

Internet
Cheap ISP, DSL ISP, Affiliate Programs, Internet Businesses, Wireless ISP, Internet Access, ISP, Spam Filter, ISP Provider, Internet Services

Health
HGH, Viagra, Health Insurance, Phentermine, Lipitor, Diet Patch, Contact Lens, Contacts, Weight Loss, Pharmacies

Travel
Carnival Cruise, Caribbean Cruise, Car Rentals, Timeshare, Honeymoons, Cruises, Vacation Rentals, Vegas, Hotels, Air Travel

Online Shopping
Flowers, Cigars, Promotional Products, Contact Lens, Pens, Contacts, Cigarettes, Perfumes, Bracelets, Office Supplies

Top Nine Searches:
Debt Consolidation
Online Casinos
Refinance Mortgage
Refinance Home
Refinance
Cash Advance
Poker
Home Based Business
Home Equity Loans
Incorporate

Lesson #1 : ***Classification of Shapes***

Time: 45 min

Objective : Given an introduction to classification, students will classify various geometric shapes using their own scheme and explain in writing why each shape belongs in its particular category.
.

Materials:
"Shapes" by Shel Silver stein
cut outs of various shapes

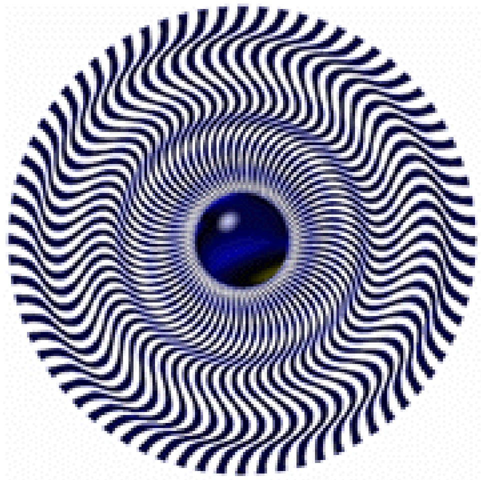
Motivation: Students will listen to a reading of a poem and draw what they envisioned after listening to the poem.

Instruction:
1. I will begin the lesson with a reading of Shel Silverstein's "Shapes".
2. Students will be asked to draw a picture of what they envisioned after hearing the poem.
3. The class will share their pictures and discuss the activity.
4. I will then group the students into various groups according to things such as hair color, sex, shoes, etc and ask them if they can guess how the group was created.
5. We will then discuss what classification is.
6. The students will classify themselves and I will attempt to discover their means of classification.
7. Each group of students will be presented with a number of shapes, all of different sizes and colors.
8. Each group will classify the shapes and write their method of classification of a separate piece of paper.
9. Each group will share their scheme of classification with the class.

Summary
The class will compare and discuss the various ways of classifying shapes.

Evaluation:
1. Observation of group work, technique of classification, and use of geometry language.

FANTASTIC Optical Illusions!!!



These are some great illusions that we found on the net and decided to include in our pages. We did not create these illusions. If you see any more illusions on the WWW, please let us know. We are always looking to add to our site. Again, these illusions are just for amusement. We do not have a copyright on these illusions so if you would like to, you can copy them from us.

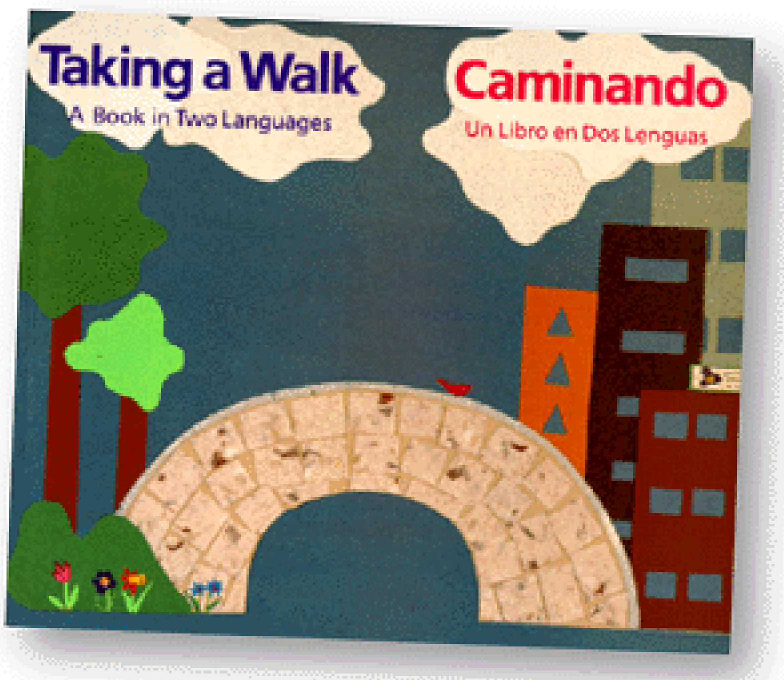
Thank you,
The Web Staff
info@ads-online.on.ca

back to:

Toronto's Services & Attractions

Thinking Fountain

Taking A Walk



This book is good to read before taking a shape walk -Karen

- Shapes
- Spanish language
- English Language

Taking A Walk
by Rebecca Emberley
Published by Little, Brown & Co., Ltd.
ISBN 0-316-23471-0

Summary:
Labeled illustrations and Spanish and English text introduce the things a child sees while on a walk.

For more literature and science connections browse through other Books you can use.

That makes me think

Walk around your neighborhood and draw a picture of what you find, then label the parts. Make bilingual signs of things in your room and put them up.

Searching for shapes

- **Changing shape**
- **Can you spot 'em?**

---

theme clusters
Gathered by topic

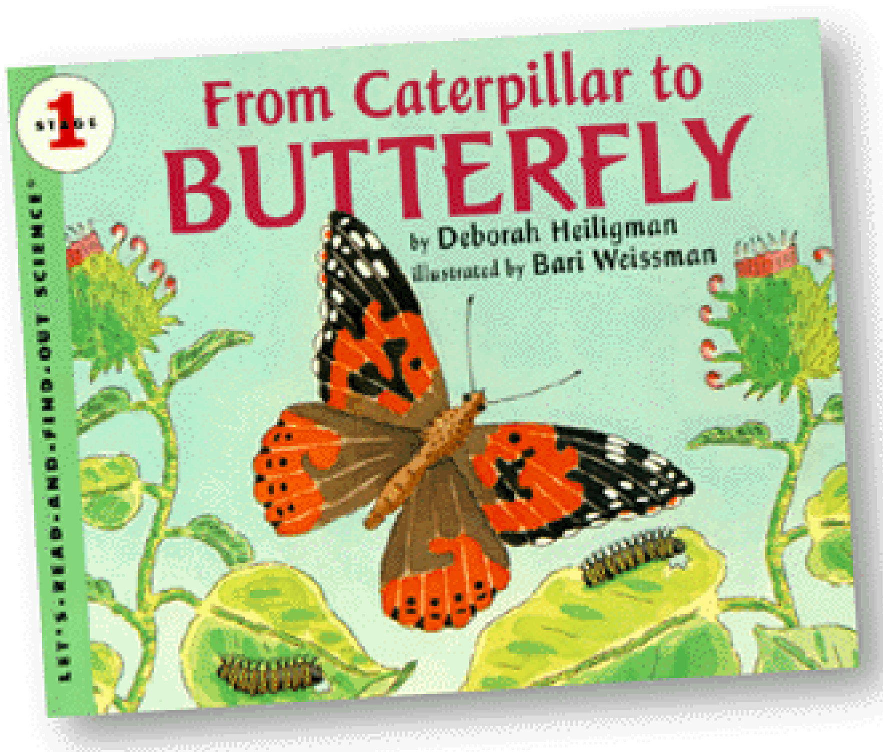
mind maps
Connected together

A to Z
Index of ideas

search
Try something new

Thinking Fountain

From Caterpillar to Butterfly



This is a great story to read while raising butterflies -Karen

- Butterflies
- Caterpillars
- Life Cycle
- Symmetry

From Caterpillar to Butterfly
by Deborah Heiligmam
Published by HarperCollins Publishers
ISBN 0-06-445129-1

Summary:
From the time a caterpillar first hatches, it eats so fast that its skin can't keep up. It sheds its skin several times as it grows bigger and bigger. Eventually it forms a chrysalis and one day splits open and a beautiful butterfly emerges. What a magical metamorphosis!

For more literature and science connections browse through other Books you can use.

BOOKS you can use

that makes me think

Try to name all of the parts of a butterfly. In what countries are butterflies found? What other insects go through a metamorphosis?

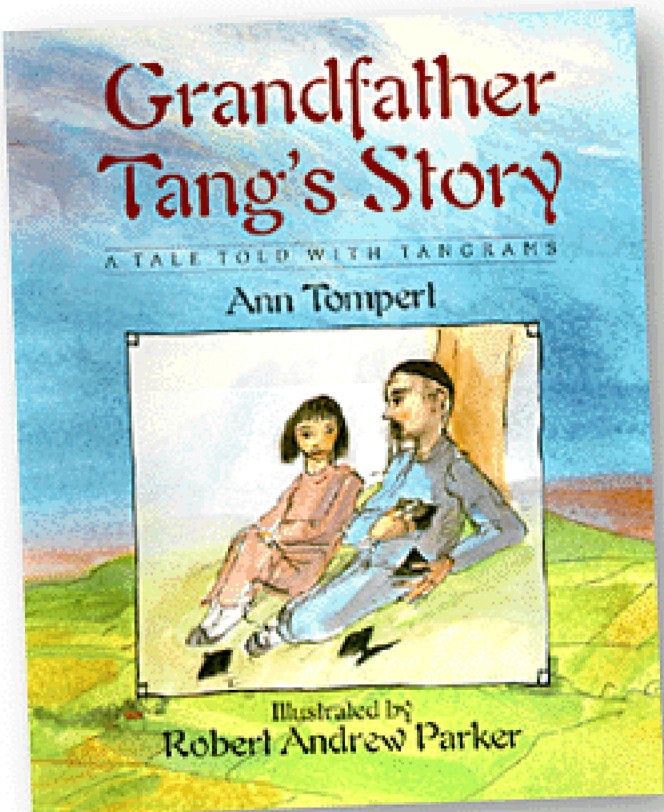
- **Butterfly Collection**
- **Symmetry**
- **Can you see it?**

---

theme clusters
Gathered by topic
mind maps
Connected together
A to Z
Index of ideas
search
Try something new

Thinking Fountain

Grandfather Tang's Story



This book is a perfect way to introduce Tangrams. -Mike

- Folklore
- Animals
- Shapes
- Tangrams

Grandfather Tang's Story
by Ann Tompert
Published by Crown Publishers, Inc..
ISBN 0-517-57272-9

Summary:
Grandfather tells a story about shape-changing fox faries who try to best each other until a hunter brings danger to both of them.

For more literature and science connections browse through other Books you can use.

BOOKS you can use

that makes me think

Try to act out the different characters in this story. Make your own characters out of Tangrams and write a story for them. How would your characters change if you used two sets of Tangrams?

- **You'll find a few here**
- **What shapes do you see around you?**
- **Putting shapes to work**

Gathered by topic | Connected together | Index of ideas | Try something new

Science Learning Network / ©1996 Science Museum of Minnesota

Guess My Shape

Purpose

Understanding how light hits things of different shape and form necessitates an understanding of shape and form. Becoming familiar with the shapes around us and having a language to talk about them helps us when we describe other things which are happening in our world. The National Science Education Standards suggest introducing the rectangular solids in elementary school and the manipulation of shapes and perspectives throughout the school year. Older students will benefit from the application of math skills to shape and structure. Vocabulary words which can be introduced to help us talk about our experiences are shapes, edges, sides, cylinder, sphere, triangular solid, rectangular solid, cone, pyramid, and cube.

Teacher Background

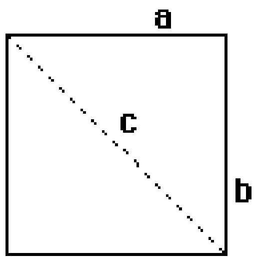
There are several basic shapes in our world which show up time and again. We call these the regular solids because their construction is from simple shapes like circles, triangles, and rectangles. To make one of these shapes is to imagine a triangle, say, sitting flat on the table as if cut out from a piece of paper. Flat as it is, it is nearly two-dimensional. What if you could give it height? Imagine being able to grab hold of the three sides and stretch them upwards. From above, it would still look like a triangle, but from the sides, it would look like a building with three sides. This is called a triangular solid. The same technique is used to make a cube or cylinder. These shapes are often called "prisms", but are quite unlike rainbow prisms, so we should not refer to these shapes as such. Instead, they are rectangular solids, because a shadow cast from the long side is always a rectangle.

You will need: buckets of wooden solids, overhead projector, flashlights, paper, pencils. K-2 will need paper plates, ball, clay or a clay substitute and drawing materials. 2-4 will need a cardboard shield constructed ahead of time, and 4-6 needs pipe cleaners and tape.

Depending upon the level of your students, you may need more or less time to talk about shapes. However, a few class periods is probably sufficient, although referring to shapes throughout the year is a fine way of keeping the topic alive. The amount of time needed to collect materials is minimal, unless you need to order the wooden solids.

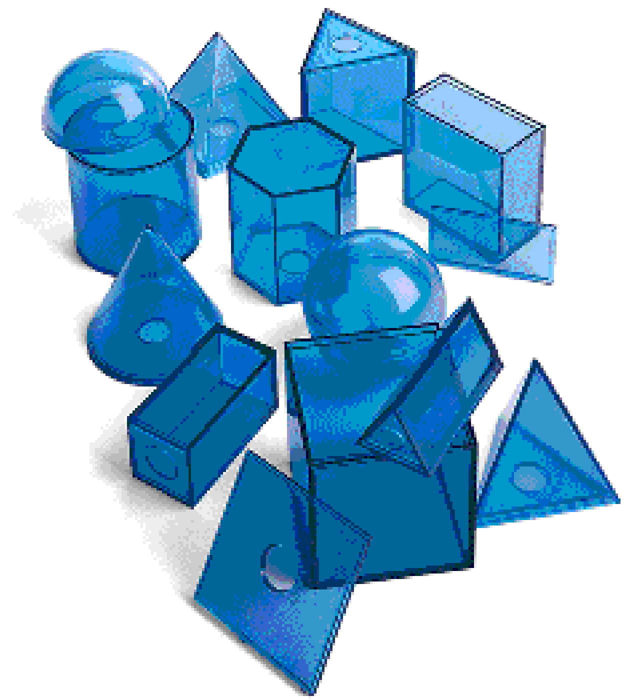
To make something like a pyramid or cone, you must imagine a similar procedure. Instead of stretching the sides up to make the solid, you imagine that you pull them up and together to a point at the top. Or imagine you cut paper into smaller and smaller versions of the flat shape and place them on top of one another until you have cut out a single point, which is the very top. So, a four sided pyramid is a square onto which is placed a smaller square and so on. The sides slope as the size of the square shrinks. The same with a cone, but you start with a circle as the flat shape and build up on that.

Pulling shapes through a third dimension means that light shining on these shapes can fool the eye when looking at their shadows. The shadow cast by a light shining on the face of a triangular solid will produce a rectangle. If you knocked the triangular solid on to one of its long sides and cast a shadow from a light shining at one of its ends, you would see a triangle. This is the nature of the regular solids. They have the capacity to fool you when seen only in shadow.



$$c^2 = a^2 + b^2$$

Thinking about the way light hits objects is a good way of thinking about the geometry of these solids. In math, we say that the length of the diagonal cut across the face of a square, let's call it "c", is equal to the square root of the squared lengths of the two sides, a and b. This means that the diagonal is longer than the sides by a little bit. You can find this out yourself with shadows cast on a rectangular solid. If the light is aimed at a side of the solid, the shadow will be a certain width. However, if the solid is turned slightly so that the light is aimed at a corner, the shape of the shadow will still be slightly wider than before. This is the nature of the projection effect of shadows cast from different angles of a rectangular solid.



The ability to roll is something only the circle-based solids have. We cannot talk about corners with these shapes, as there are none. There are edges and surfaces, but no corners. A corner is a point where in flat space, two sides would meet. In three-dimensional space, it is where 3 or more edges meet. An edge is a meeting of two sides, or faces, like the spine of a book or the sharp lines down the cube.

Kindergarten through Second Grade

Developmental Issues

For Kindergarten through second grade, this Thread focuses on manipulating shapes and sorting objects. This is a great exercise for this age group. They are quite capable of sorting by size and are learning about classification. Geometrical classification by shadow casting may be a bit too complex for them, because children at this age tend to find hierarchical categories confusing. In part because, they tend to assume that categories are mutually exclusive! Superordinate categories create the most difficulty.

Inquiry Introduction

Let's play with shapes in the light to get a feel for shadows of shapes.What is a cube? Which of these shapes are round in some way? How could you sort these objects into groups? What are some things about these shapes that make them different from other shapes? What names would you give for these shapes?

Inquiry Investigation

`A tabletop full of geometric solids and their flat counterparts is a good visual. If there are enough shapes, one set at each group table would be great. How could we sort this group? Students may find links between the triangle and the pyramid or the cone and the pyramid.` Can anyone explain why they made the grouping that they did? What does the group look like when placed on the overhead projector? Is there a way of making a group on the overhead projector whose shadows look alike?

How do some shapes when put together look like other shapes? What kinds of pictures can we make from just moving these shapes around? Where have we seen these shapes in the world? Why aren't tires made from cubes? Why aren't ice cream cones made from box shapes?

What is the shape of our world? `They will likely say round. What is round? Have them draw the world as seen from a rocket in space.` What colors did you use? What sizes would you see? How many of you put more planets in or made a crescent moon? `Have them talk to you and the class about their drawing. Most every child will have drawn a circle Earth.`

`Hold up a paper plate and a ball. Which one of these is round? They will say both are, but the world is like the ball.` How do they know that? What would be true, then? Could you walk all around it? Could you sail around it? Could you dig through it? What if the world were like the plate? Could you travel around it, or might you fall off the edge?

`Have them make clay or clay substitute planet Earths.` What kinds of things are on the Earth? Water, land, ice, clouds, air? What does light look like when it hits the world shape? Make a mark for where you are on your world. Face your mark towards the light of the projector. What time of the day is it for you? Is there someone on your world having night? Where? Make your mark on your world have night. Are there other people on your world having day while you have night? How much of your world is having night with you? Is this how it works on the big world?

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To K-2nd Grade Thread

Second Grade through Fourth Grade

Developmental Issues This age group can think about multiple variables and is capable of imagining other viewpoints and places. For this age level the Thread is focused on speculating about projection of a shape before jumping right into shadow images of them. It engages students in thinking about the function of edges, sides, and corners.

Inquiry Introduction What is a three-sided shape? What is a four sided shape? what is the shape of our world?

Gather the sets of rectangular solids into groups and give them out to teams of students at desks. Have them list the different groups of shapes in their pile: which have sharp edges, which can roll around, which have four sides, five sides, etc. They will find many different ways of classifying their shapes. Have them talk to the class about their shapes and the groups they made from them.

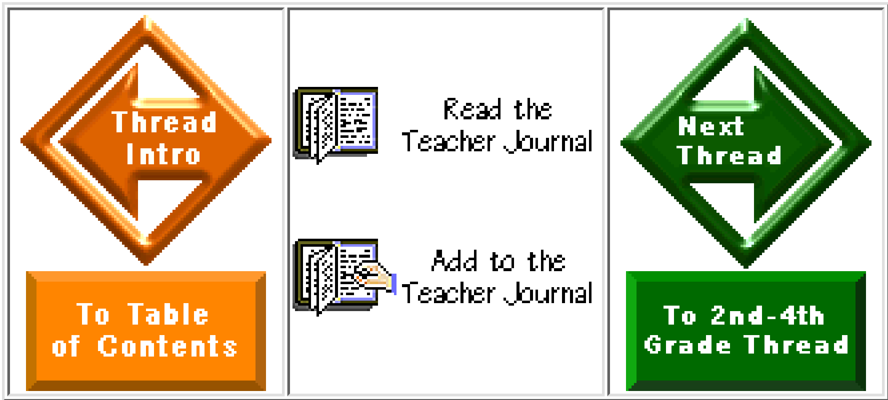
Inquiry Investigation What do shadows of these shapes look like? What if the shapes were not sitting on the paper and were instead floating in space? What would the shape of the shadow of our world look like? It is in space with a big light source shining on it. Shouldn't the Earth have a big shadow behind it?

Block the overhead projector from the class with a cardboard shield so that they can't see what sits on the projector but can see the projection. Put a shape on the table of the projector and have them try to guess the s hape that is sitting there from the projection. It may be hard to figure it out because of how sometime two very different shapes can make similar shadows. Ask them which shape this could be and why. For example, a triangular solid sitting lengthwise on the projector table will look like a rectangle. Ask them what they could do to be really sure of what the shape was, besides moving the blocking screen you have constructed? They will hopefully say to rotate the object or turn it over on the projector table. A triangle will show up, and then it is obvious. Lift the shape so everyone sees it and go to the next.

Play around with these shapes, asking if this is the shape of the world. Keep the sphere last. When you put the sphere on, ask them which shape this is. It is the sphere or ball shape. This is the shape of the world, so what does that mean about its shadow as cast behind it through space? Let's be sure. No matter how you rotate the sphere, it always casts a circular shadow. So, if the Earth's shadow were to hit anything, it would be a circle-shape, and that would let us know we were right about the shape of the world. Are there any other shapes that can make a circle shadow? Put a quarter coin or other larger circle shape on the projector table. You see a circle. How can you be sure? You will have to turn it or rotate it. It is then a thin line.

Does the world ever turn around? What would that mean about its shadow? If it were a flat circle, then its shadow will change from a circle to a line. But if it is a sphere, its shadow should always be a circle. Is there anything in space the Earth's shadow would hit? Is there anything that is somewhere close by us in space? The Moon is the closest object to us in space. Does it ever get in line with the Earth's shadow? (Please note: that many models of the Solar System show the planets' orbits all in line with the Earth's as well as cramming all of the planets very close together. These models have confused and misinformed students and teachers alike for decades.)

If there is a lunar eclipse soon, this obviously would be a great introduction to it. Otherwise, locate pictures of past eclipses. What is the shadow's edge shape? It is definitely circular. What does that mean about the shape of our world? Cool. We have provided supplementary material about moon phases as well, to show they are not caused by the Earth's shadow.



Fourth Grade through Sixth Grade

Developmental Issues

We will approach this Thread from the geometry of the light/solids interaction. Projection from two dimensions to three or vice versa is possible with this age group, as is trying to relate this to how light "sees" objects in the third dimension. Manipulation of rulers and pencils and working carefully in groups is easier for this age group as well.

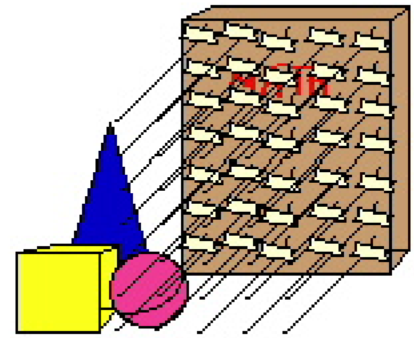
Inquiry Introduction

What are shapes? What makes a shape three-dimensional? Why are shadows the outlines of objects? Why do they seem to sometimes not quite look like the object they are hitting? When light travels past an object, it catches the edges of the object. Is there a way we could make "shadows" just by thinking about the outlines of objects?

Inquiry Investigation

Draw a square on the board. How can I make this square look like it is three-dimensional? Hopefully they will say you need to give it some kind of depth. Extend its sides outward and then connect them again in a square until you have a cube. What is this shape called? Hold up a wooden cube block and orient it to the drawing. Draw a triangle and repeat the depth idea until there is a triangular solid. Hold up a wooden triangular solid and orient it to the drawing. What would these shapes look like if we were looking at them from here, in front of a face of the cube or triangular solid? Many should be able to see it would just be a square or triangle.

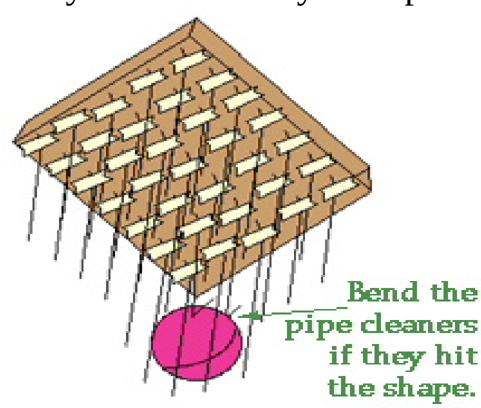
Encourage everyone to try making three dimensional shapes on paper in front of them. How does light see three dimensional shapes? Can we even try to model that?



Have teams of three or more people pick a large and solid shape from a selection of shapes. Give these instructions to the students. Place the blocks on big sheets of paper and trace their position. (Note: This can lead into or follow a multiplication exercise.) Take 35 pipe cleaners, tape each one by an end to the front of a covered textbook, forming a neat 5 x 7 grid pattern. An array of pipe cleaners should now be sticking straight out from the textbook, making the book look like a big hairbrush. Have one student aim the pipe cleaners on the book from some angle above and to the side of the block. They may want to measure the height of the book above the desk top.

What is this representing? What are the pipe cleaners supposed to be? Have them move the book along in the direction the pipe cleaners point until they hit the paper and the block. Any pipe cleaners that hit the block can be bent back out of the way, while the other pipe cleaners reach past the block to the paper. Tape the pipe cleaner ends to the paper or block where they hit. Move around the class to make sure every team and/or student understands the procedure. One student should carefully trace and darken the area where there are no pipe cleaners touching the paper. What is this area called? What is the shape? Teams with triangular solids, for example, will find that their pipe cleaner shadows are very rectangular. Why is this?

Can any of the groups explain what they are seeing happening here? Urge them to think about what the shape "looks like" to light. Can you close one eye and peer at the shapes and see the projection effect? If light really does travel in straight lines, then these shadows are correct. How could we be sure? Get a bright portable lamp and place it at the same height the book was. Don't turn it on yet. Slide the lamp in front of the block, still at the same height as the book. What shadow did it make? Is it the same shape shadow as the pipe cleaners made?



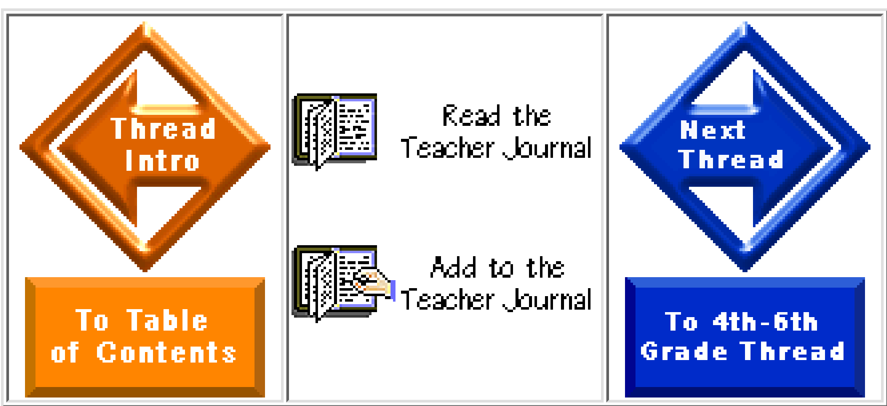
What if the light were coming from directly on top of the block? Move the lamp above it. They will see there is little to no shadow. Where is the shadow? Does anyone lift the block to see the shadow below? Remember, to have a shadow, you need a light, a blocker, and something to cast the shadow on.

What is the shape of the world? Hold up a sphere. What kind of shadow would this make? When light rays hit it, what shape do they make? Students should be able to see they make a circular shadow. Move the ball to a different orientation, which won't look very different. Now what kind of shadow will be made? The same.

What about in space? Is there anything the shadows can land on? Does the Earth have a shadow? Is there a light, the Sun? Is there a blocker, the Earth? Where could the shadow fall? What else is out there? Many will suggest the Moon or other planets. So, the Earth makes a circular shadow. If this is true, the world would make a circular shadow on the Moon sometimes.

If there is a lunar eclipse happening soon, this would be a great introduction to eclipses. Otherwise, locate eclipse photographs to show them some pictures of a real eclipse. What is the shape? It is definitely circular. How long does an eclipse take? Hours. What does the Earth do in a few hours of time? It spins. So, if the Earth were a flat circle that spins, would it always cast a round shadow during the eclipse. What does that mean about the shape of our world? Cool.

There is a diagram showing how the phases of the Moon occur. It is important to know that they are not caused by the Earth's shadow.



Lesson #2 : ***Angles***

Time : 45 min

Objective : As a result of this lesson, students will be able to identify right angles as well as determine whether an angle is less than or greater than a right angle.

Materials:
paper
various objects
strips of paper
brass fasteners
cut out shapes
worksheet

Motivation: Students will be asked to take out a piece of scrap paper and make two folds to create a right angle.

Instruction:
1. After discussing what a right angle is, students will examine various items with their group to determine if they contain right angles.
2. Student will share their findings with the class.
3. Students will be given two strips of paper and a brass fastener to create and angle adjuster.
4. Students will use their creation to look at angles larger and smaller than 90 degrees.
5. Student will be given a worksheet and cut out shapes and asked to determine the angles that make up the various shapes.

Summary: The students will discuss the discoveries they made on the worksheet. Can a shape be made up of different types of angles? Are any shapes made up of only one type of angle?

Evaluation:
1. Observation of students understanding of new information, vocabulary usage, and ability to correctly identify the different types of angles.
2. Visual evaluation of students ability to work in a group setting.

The Maryland Virtual High School of Science and Mathematics

SUN DATA OFFERS A VARIETY OF COMPUTATIONAL SCIENCE POSSIBILITIES

Maryland Virtual High School teachers have found that one collaborative project often leads to new questions which offer additional opportunities for further experimentation, data analysis and computer modeling. This article considers additonal ideas related to the Eratosthenes Project, a simple collaborative opportunity to approximate the circumference of the Earth using a method designed over two thousand years ago. Eratosthenes observed that at noon on the first day of summer, the sun cast no shadow in Syrene. So, he sent a slave to Alexandria to measure the shadow cast by a tall tower there; and using ratios (see diagram on the left), he was able to calculate the circumference of the Earth.

Educators around the world have adapted this method to the Spring or Fall Equinox when their students are in school. Last spring, MVHS teachers had teams of students stand a meter-stick vertically on a flat surface within one day of the Equinox and plot the shadow tip position over some time spanning midday. Using the shortest shadow length and simple trigonometry, each team determined the angle of declination for its site. By sharing this information with other schools, a simple ratio (see diagram on the right) was used to find the circumference of the earth.

Although a school could work in isolation using the Equator as a known reference point (declination of 0), using collaborative data provides an opportunity to discuss how limited data affects accuracy: if two sites with little difference in latitude are compared (as is the case in Maryland), obtaining a reasonable approximation is difficult.

Solving problems associated with acquiring precise experimental data are a valuable part of the project experience: setting up a "vertical" stick (called a gnomon) on a "flat" surface, deciding how to mark a fuzzy shadow tip, dealing with weather conditions, handling variations in measurements among different teams at a particular site, deciding how long to monitor the experiment. These collaborative issues must be resolved in choosing the data to report for the school. In pondering how to improve the project, however, several flaws have occurred to the "design team". Repeating the Eratosthenes calculation may have limited inherent interest. The basic activity is hardly a genuine scientific experiment. Using latitude explicitly or implicitly to find the distance between comparison-sites assumes a known measurement of the circumference. This smacks of "cheating". Cloudy days at the time of the Equinox reduces "personal involvement" a great deal. Therefore, new extensions of the project are being investigated.

MVHS believes that there is great educational value in the collaborative analysis of data associated with the periodic changes in the position of the Sun at various locations around the globe. Measurements of shadow tip position and shadow length at different times of the year, different times of the day, and at different latitudes provide valuable information about the position of the sun in the sky. Longitude may also be a factor since the sun is at a slightly different position at a given clock time in the same time zone. The "design team" has accumulated many good questions but only a limited bank of concrete answers and understandings. Hopefully this is a source of intrigue and encouragement!

Topics might appeal to different classes based on individual interests, abilities, and logistics. We have organized related topics together and assigned each one a code. The first letter indicates (I)ndividual or (C)ollaborative. Collaborative projects rely on sharing data among schools. The second letter indicates the time commitment for the project: (S)ingle Measurement, (D)ay Long, or (E)xtended. In addition to experimental data collection, data can be gathered through the library and Internet. Certainly this does not detract from the scientific value of the analytic process. There are a number of web sites rich in solar and other geophysical data; these would be great sources of confirmation for experimental results. Projects that might rely on such sites are noted as (R)esearch.

We also hope that the range of topics allows teachers to participate based on their schedule and the logistics of network and computer use at their school. One school might collect data that will be analyzed by a partner school. Classroom time can be saved if students collect data over lunch or during the weekend.

For more information, links to valuable web sites, and to the the main page at Arundel High School for data collection see the main Shadows '97 page.

Part of the spirit of MVHS lies in a challenge to more clearly define computational science and its applications across a broad range of secondary school experience levels. We think that the range of suggested topics fits this goal and provides an opportunity to invite interdisciplinary collaboration between mathematics and science departments. Consider: 1) Curve fitting and the meaningful uses of graphical analysis techniques to educate our intuition. 2) Comparison of theory with experimental measurements. 3) Meaningful scientific collaboration. 4) The opportunity to use spread sheets, MATLAB, or STELLA in modeling daily and seasonal changes.

Declination and Altitude of the Sun

1. Measure shortest shadow length on the Equinox. The fact that the sun's declination at local noon on the Equinox is equal to the latitude of the observer can be used to verify the students determination of shortest shadow length. Students might draw a diagram explaining why the declination angle is equal to their latitude.
2. Share data to calculate circumference of the earth as described above. (CS)
3. What effect does latitude have on altitude or declination on an arbitrary day? Find out using

data collected from various latitudes. (CS)

4. Plot altitude at local noon throughout the year. What kind of curve results? (IE)
5. How does the shape of the daily altitude curve change over an extended period? This is especially meaningful as the season progresses from one of the solstices. (IE)
6. Compare these curves with those created at other latitudes. (CE)

Shadow Length

1. Share data between various locations to plot shadow length at a commonly determined time and day vs latitude. Does the data fit the expected tangent? (CS)
2. Plot the **length** of the shadow vs time and fit the best curve to the data. What kind of curve is this? How is error related to the amount of data available? (ID)
   9) Determine the rate at which the shadow **length** changes over a day. Can you relate this to the speed of rotation of the Earth at your latitude? (ID)
3. Compare the curve of **length** vs time for other latitudes and/or longitudes. Is there a detectable difference in the equation of the curve? What does it mean? (CD)
4. Compare the rate of change of shadow **length** for different locations. Can you relate rate-differences to variations in latitude? (CD)

Shadow Path

1. Track the **path** of the tip of the gnomon's shadow over an extended period of time during a day. What can you say about its shape? (ID)
2. Compare the shape of your shadow **path** with those drawn for other latitudes and/or longitudes. (CD)
3. If you mark the position of the tip of a fixed gnomon's shadow at local noon over a year, the track will be an elongated figure eight (or propeller shape), with one lobe larger than the other. The pattern is called an analemma. How does the size ratio of these lobes relate to latitude? What is the reason behind this pattern? (IE)
4. Compare analemmas for different locations. Is the proportionate size of the lobes a predictor of the analemma's latitude? (CE)

Magnetic Variation

1. On any sunny day during the year, locate the magnetic compass direction of the shadow at local noon. Since that shadow aligns with a True North-South line, we can subtract to find the local "magnetic variation" (sometimes called "magnetic declination" which is measured in degrees east or west of True North. (IS)
2. Share and plot magnetic variation data as a function of latitude and/or longitude, perhaps in polar coordinates to locate the Magnetic North Pole. Share research on how magnetic variation relates to other magnetic phenomena. (CS)

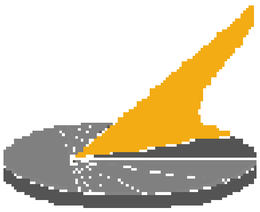
Position of Sunrise and Sunset

1. Determine the exact position of sunrise and sunset. What does it really mean to say "the Sun rises in the East and sets in the West"? (ID)
2. Compare the positions of sunrise and/or sunset over an extended period of time. What is the angular difference in range between the solstices? (IE)
3. Compare results with other latitudes (CE)

Sunrise/Sunset Times and Length of Day

1. Calculate the Earth's tangential rotational velocity using times of sunrise, sunset, or local noon for two places on a given day. Find the horizontal distance between the sites. Divide by the difference in Universal Times. How does rotational velocity relate to latitude? (linear, parabolic, trigonometric)? (R)
2. Compare times of sunrise and sunset at various locations and plot as a function of latitude. Is longitude a factor in sunrise or sunset times? (R)
3. Plot length of day at various locations as a function of latitude. For a given winter day, predict the lowest latitude where the Sun stays below the horizon. (R)
4. Plot sunrise, sunset, or length of day over part of a year. Extrapolate. (R)

Search MVHS | **Home** | MVHS Contacts
News and Views | Classroom Projects | CoreModels Program | NCSA-PACI Collaboration | Additional Initiatives
MVHS Central | MVHS North | MVHS West



For more information visit the North American Sundial Society:

Sundials

Time and the Sun

For most of history, man's days and years were governed by the sun and stars. Even after clocks and watches were invented, they were set by the sun so that they read noon when the sun was at its zenith. Time is now delivered to us by the radio and television and told by the digital watch.

Morning is when the alarm goes off. Summer is when you need the air conditioner. We know about satellites, galaxies, planets and black holes, but have lost touch with the logic and rhythm of sunrise, sunset, summer and winter.

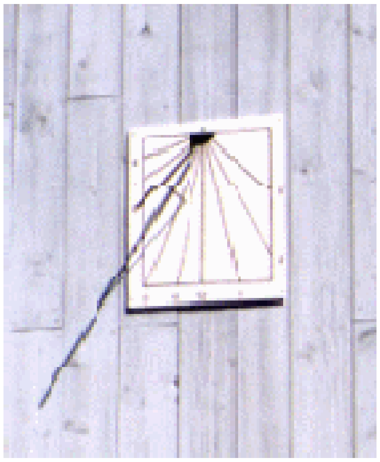
These things used to be understood intuitively by everybody, and their rules and special terminology were a part of the intellectual baggage of all well-educated people. Midsummer's day was celebrated at the summer solstice on June 21. Christmas is close to the Winter solstice on December 22. The vernal and autumnal equinoxes mark the beginning of Spring and Fall when the sun moves into Cancer and Capricorn, respectively. It is instructive to learn how a sundial works and watch its shadow advance through the day and vary with the seasons. In this way we can come to a better understanding of these natural phenomena and relearn the meanings of those half-understood, half forgotten names like "gnomon", "ecliptic" and "zodiac."

Until the end of the 19th century, all time was local and related to the sun. Noon in Boston was not the same time as noon in New York. With the development of railroads and telegraphs widely spaced locations became linked to each other more closely in time and, there was a need to standardize time areas. In 1884 an international convention in Washington D.C. agreed on a worldwide system of time zones of 15° each. Local adjustments were allowed, as necessary, to keep political subdivisions in a single zone.

Dials

A sundial consists of the dial plate marked out with hour lines, and a "gnomon", the raised projection that casts the shadow. The inclined edge of the gnomon, called the "style", produces the working edge of the shadow that is used to tell the time. It is oriented parallel to the earth's axis, pointing toward the point in the sky around which the (imaginary) celestial sphere rotates once every 24 hours, which is very close to the location of Polaris, the pole star visible at night. There are many different types of sundials, including vertical dials and tilted dials. Virtually anything casting a shadow can be made into a sundial; the trick is to calculate the proper placement of the time marks. The most straightforward type of dial is the "polar" dial. It has marks placed at equal intervals. Its disadvantage, however, is that it has to be angled to face up toward the north pole. Vertical dials on public buildings used to be widespread. Now, the type of dial seen most often is the horizontal dial, generally used as a decorative element in gardens. Sundials sold in garden shops will not generally tell accurate time, however, except by coincidence.

Vertical Declining Dial **Horizontal Dial**

Placement

To be accurate, a sundial must be specially designed for the spot it is to be used in and must also be pointed in the right direction. The two dials pictured above were made for a specific location in Maine. Note that the times on the vertical dial are asymmetrical. This is necessary because the dial "declines" from true north by about 20°. The barn was built using a compass but at this point on the earth's surface, magnetic north is about 20° east of true north.

The angle made by the style with respect to the earth's surface -- or with the plate in the case of a horizontal dial -- must be equal to the local latitude, which will point it to the proper elevation. The time lines are also a function of local latitude; they must be arrayed around the center of the dial differently in different places. Finally, the dial must be oriented so that the gnomon lies on a true north-south axis to insure that it points to the north pole of the sky. When these alignments are all correct, the edge of the gnomon whose shadow marks out the time will be exactly parallel to the axis on which the sky's imaginary globe is turning. When the sun is at its zenith, the gnomon's shadow will fall on the line representing solar noon.

A garden sundial can be set to tell the right time if it was correctly constructed for some point on the earth's surface. Assuming that the hour lines were drawn correctly to match the elevation of the gnomon at a given latitude the sundial will be accurate if the whole thing, including the plate, is tilted so it sits at the angle of the earth's surface at its "home location" or in other words if the gnomon points to the north celestial pole. If you are at latitude 42° at washington and the gnomon makes an angle of 39° with the plate, simply tip the plate by 3°.

Construction of a vertical declining dial

Vertical declining dials are those attached to walls that do not face directly north, south, east or west. Although this is not the most straightforward type of sundial, it is probably the best kind to construct oneself as a project, since it can be put on the side of a house, barn or garage and executed using easily available materials including wood, paint, and pre-made numbers for the dial itself and dowels, pipes, or rods to construct the gnomon-pointer. The following procedure shows how to lay out the angles for the gnomon and the hour lines on paper using a standard geometric methods (straightedge and compass). A protractor will also be necessary to establish the lines dependent on latitude. The drawing should be laid out on a large sheet of pa per and subsequently transferred to the wall. If you are actually going to do this, you will obviously want to send this page to your printer so you can refer to it.

Since you generally do not have the option of reorienting your garage to line up with the compass, it will probably be necessary for the dial to "decline" from the cardinal points. First, you have to ascertain which of the four categories (shown in figur e 1) your building or wall falls into.

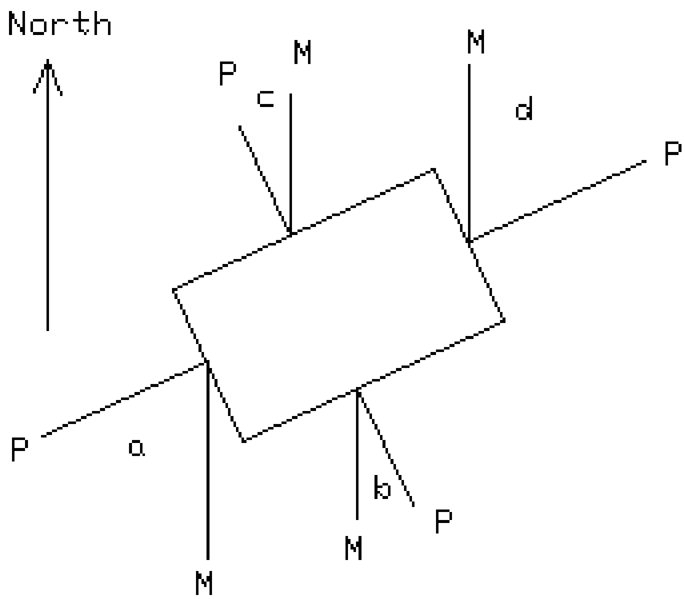
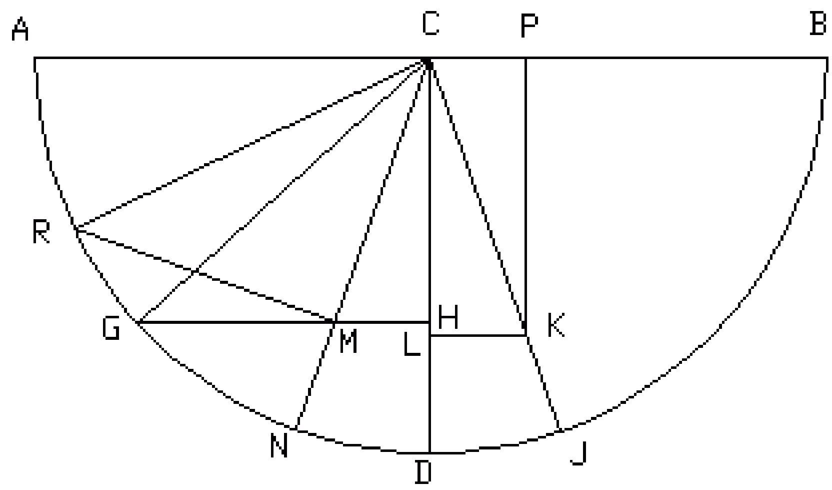


Figure 1. Measuring the declination of a wall. In each case P is perpendicular to the wall and M lies in the meridian
In the example, 'b' is our wall facing somewhat south, declining east
The declension is angle MP

Before we can design the sundial, we must know the latitude (as with all dials) and also the amount of the walls declination. In this example, we will assume that the dial will be going on the wall facing southeast which declines S 24° E, which means that it starting from the south has been twisted around through the east through an angle of 24°. We will also assume the dial is at latitude 40 degrees north.

The first step is to find the substyle line, which is the line on the dial plate on which the gnomon is to be erected perpendicular to the dial plate -- or in this case, the wall. In a more typical dial, the gnomon would follow the 12-o'clock line, but w ith vertical decliners this is no longer the case. In all vertical dials the 12-o'clock line is vertical, but with declining dials the line on which the gnomon is placed (called the substyle) is twisted out of the vertical, lying to the right or east of the 12-o'clock vertical line and thus among the afternoon hour lines if the dial declines toward the west of south or to the left or west among the morning hour lines with the southeast decliners. (As with the example.) The angle between the vertical 12 -o'clock line and the substyle is called the substyle distance, or SD. To find this substyle graphically we proceed as follows using figure 2.



The substyle line

1. Draw AB as the horizontal line.
2. At C, near the center of AB, draw CD perpendicular to AB
3. With any convenient radius draw the semi-circle ADB centered at C.
4. Draw CG making angle DCG equal to the colatitude. The colatitude is the difference 90° minus the local latitude, here 50°. Since our dial declines toward the east, we place CG to the left of CD.
5. From G draw GH parallel to AB, cutting CD at H.
6. On the side of CD opposite CG draw CJ with angle DCJ equal to the dial's declination (here 24 degrees).
7. On CJ lay off CK equal to GH.
8. Draw KL parallel to AB intersecting CD at L.
9. On HG lay off HM equal to KL.
10. Draw CMN. This is the substyle line, and the angle DCN is the substyle distance, SD. This ends our first step.

The substyle height:

Having found the substyle on which the gnomon will be placed, we next find the style height, SH, which is the angle the style plate makes with the dial plate. Continuing with figure 2,

1. Draw KP parallel to CD
2. Find point R on the semi-circle so that MR = KP.
3. Draw CR. This represents the style, and angle NCR is the required height of the style, SH.

The hour lines:

The hour lines could be added to figure 2, but because of increasing clutter, we will transfer the essential lines to figure 3. AB, CD, CR, and CN are all carried over from the preceding figure.

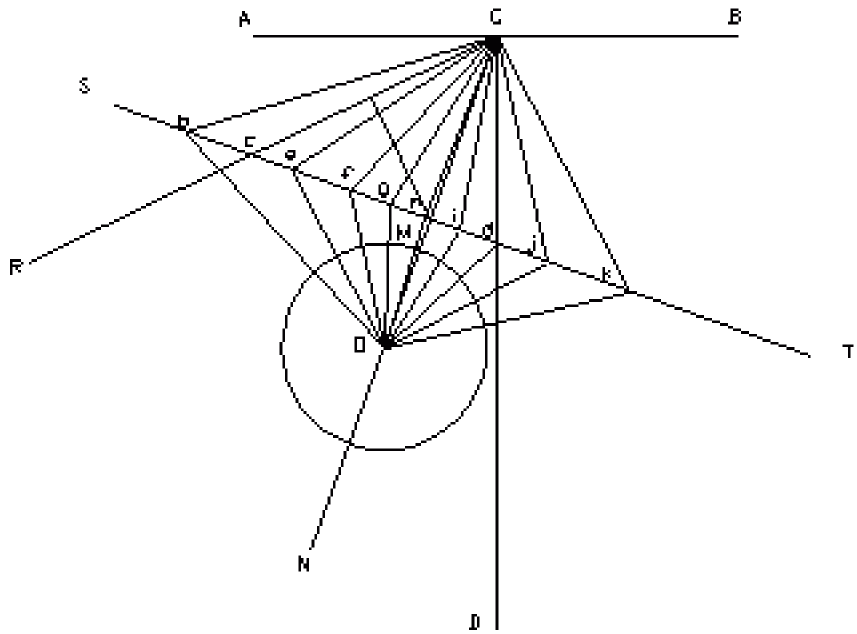


Figure 3: Lines AB, CD, CN and CR are taken from Fig 2

1. At any convenient point on CN (as at M) draw SMT perpendicular to CN. The distance taken for CM will determine the scale of the final diagram.
2. Draw ME perpendicular to CR
3. On CN lay off MO equal to ME.
4. With O as center draw a circle of any desired radius. In Figure 3, the radius has been taken equal to OM.
5. Call the intersection of ST and CD "d." Draw Od.
6. Divide the circle into 15° arcs starting from Od.
7. Draw lines from O through the 15° divisions on the circle and continue these radii until they intersect ST at the points indicated by lower case letters.
8. Draw lines from C to the points just found on ST. These are the hour lines and are numbered counterclockwise with CdD the 12-o'clock line.

These lines are to be transferred from the worksheet to the dial plate or perhaps directly to the wall, remembering that the 12-o'clock line will be vertical. You will also need the substyle line to attach the gnomon perpendicular to the dial plate.

Finding true north

In principle, north can be located by using a magnetic compass and making an appropriate the correction. Magnetic north is substantially off from true north -- the exact amount varies by location. But there are better ways. Polaris, the north star, can be used, but this is inconvenient -- you have to wait for a clear night -- and not entirely accurate either. The most accurate way to find a true north south orientation is by using the sun itself to find the direction of a shadow cast by a vertical object when the sun is at its zenith. This is easier than it sounds, and can be done by measuring the length of the shadow cast by the upright before and after noon. Set up a vertical pole (or a use a rope with a weight) to cast a shadow on the ground. If you use a rope you will need to make the reference point somewhere near the top cast a visible shadow -- like a stick knotted into the rope) The base of the shadow will be the first point for your south-north axis and the reference point or top of the pole will trace the second point. At some time in the morning, mark the spot on the ground where the reference point casts its shadow. Measure the length from the base to the end of the shadow, and using a string of that length, trace out a semi-circle on the ground with the base of the shadow as its center point. As the sun rises higher in the sky, the shadow will first shorten as noon approaches, and and then will lengthen. At some in the afternoon it will reach the semi-circle you traced in the morning. Note the spot when it crosses the arc the second time. The midway point between the morning and afternoon points, will be directly north of the base point of vertical object.

Adjusting for clock time

The north "noon" line cast by the sun at its zenith will not correspond to noon clock time. Two adjustments are necessary. The first of these has to do with local placement within the time zone and is different for every longitude; the second is a function of the day of the year and can be found with an Analemma.

Time Zones

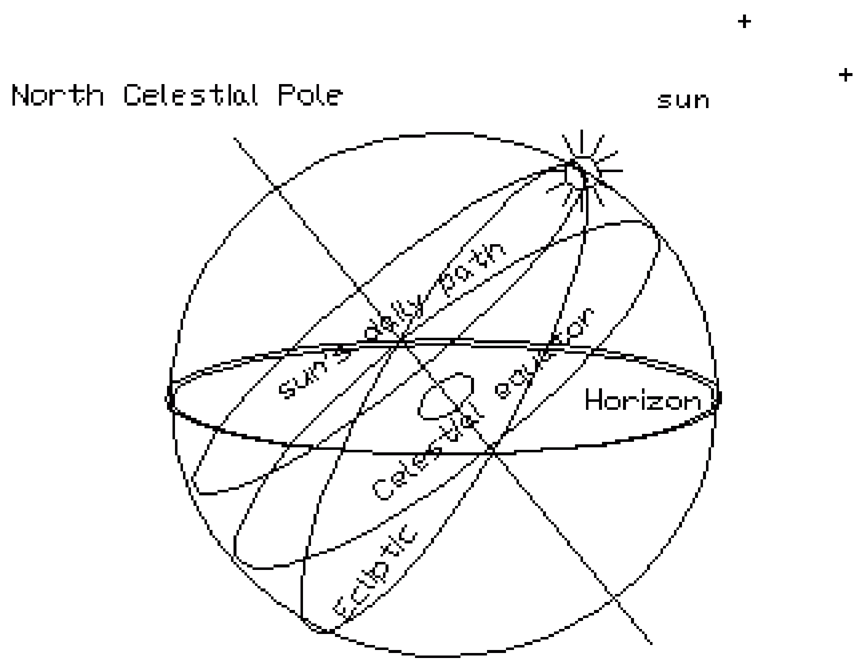
Since there are 360° in a circle and the earth makes one rotation in 24 hours, each time zone covers 15° (15 X 24 = 360). Time zones are counted in 15° increments from Greenwich, England, the point of reference, so that the "center" of each time zone (i.e. the point where solar time is the same as clock time) lies on 15° increments moving west from Greenwich. Eastern Standard Time is set to noon when the sun crosses over the 75th meridian (5 hour increments west of Greenwich) which falls near Philadelphia. Since each° represents 1/15 of an hour, it counts for 4 minutes of time, and it is necessary to subtract or add 4 minutes for each° of difference from the center of the time zone. For Eastern standard time, when it is noon by the clock, it is exactly 8 minutes earlier by the sun at the Capitol building in Washington at 77° longitude -- two° west of the 75 meridian line at Philadelphia.

The Equation of Time

The second adjustment is more complex and is captured in what is by tradition called "the equation of time." This results from the fact that the apparent motion of the sun across a spherical sky is a fiction; the earth actually orbits around the sun in an elliptical path. Therefore the sun's apparent motion across the sky is not uniform throughout the year and can run almost 15 minutes fast or slow. For practical purposes, however, it is important that the hour-unit of time be kept constant and the days divided into 24 equal sized hours, regardless of the season. This means that for clock time it is necessary to create a "mean sun" -- an imaginary sun that moves across the sky at a constant rate. The equation of time is is the sum of two curves, one caused by the earth's eliptical orbit; the other caused by its inclination. The equation has long ago been worked out with great precision and incorporated in tables. If plotted against the days of the year, it looks like an irregular pattern with four peaks and four troughs. It is commonly represented graphically on old globes and sundials by the "Analemma," a figure-8 shaped device that shows the number of minutes that must be added or subtracted from solar time at each date in the year.

The Seasons

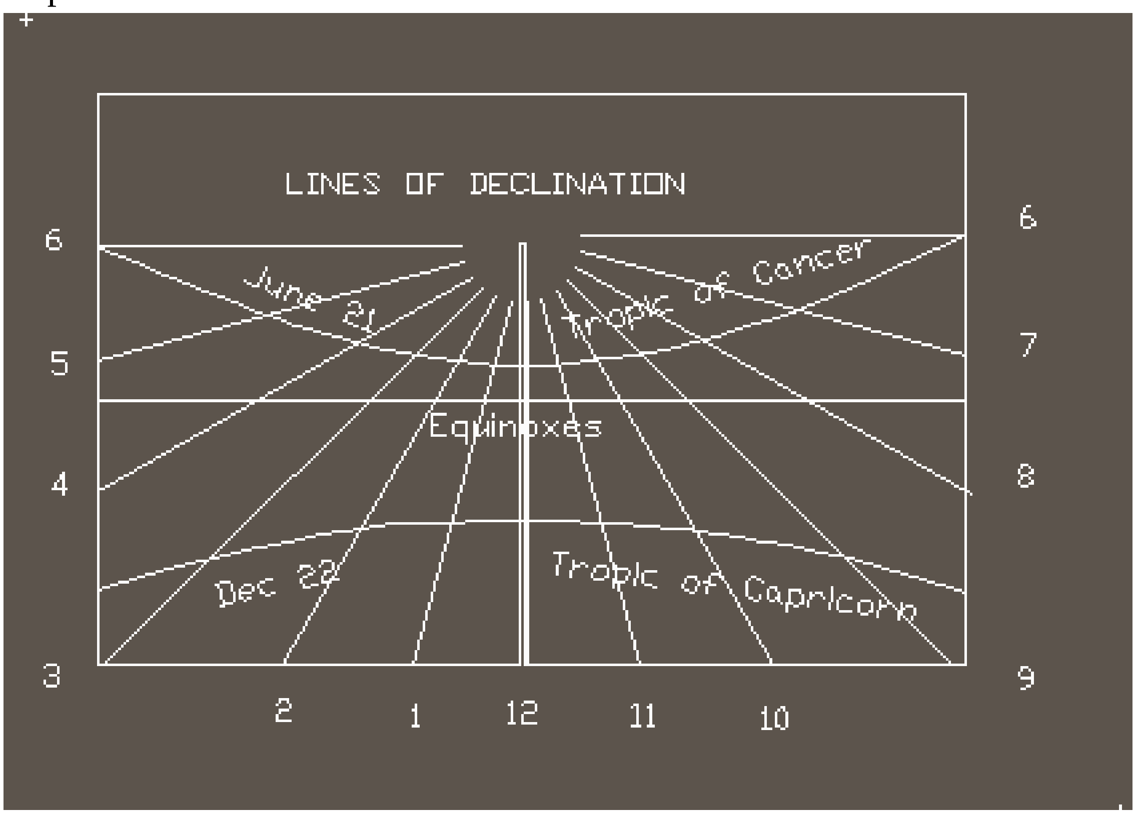
A line traced around the center of the celestial sphere perpendicular to the pole it rotates around is called the celestial equator. This line is not directly overhead, but is tilted as a function of the observer's local latitude. In the northern hemisphere it angles toward the south. In the Washington DC area, it makes an angle with the horizon of 52 degrees. Through the course of a year, the sun migrates around the celestial sphere. If it moved along the equator, there would be no seasons. But because the earth's axis is tilted with respect to its orbit around the sun, this requires another imaginary line on the imaginary celestial sphere, known as the ecliptic. On the longest day of the year (the summer solstice), the ecliptic is 23.4° higher than the equator so that the sun reaches 75.4° at high noon. At the winter solstice, the year's shortest day, the sun only reaches 28.6° above the horizon. At the vernal and autumnal equinoxes when days and nights are equal, the sun's path along the ecliptic coincides with the celestial equator and the sun reaches 52° elevation above south at the latitude of Washington.



This is confusing and difficult to visualize. It may help to bear in mind that the equator line is related to the sky's daily rotation, while the sun moves on the ecliptic by only a short distance every day. The sun therefore moves across the sky on a path (almost) parallel each day to the equator, but displaced from it by a distance that varies slowly throughout the year. In this figure, which is meant to represent the sky, the sun is at its high point, the summer solstice. It rotates in one day on the axis of the pole, parallel to the celestial equator. It does not rise in the east and set in the west, but cuts the horizon quite far north side of an east-west line, The sun's motion along the ecliptic takes a year to complete. When it has moved to the opposite side as shown in the diagram, its path will be very low and it will rise and set south of an east-west line through the horizon.

The Tropics: Cancer and Capricorn

The word "tropic" has an older meaning from which the present use is derived. What we call "the tropics" lies between two lines, the tropics of Cancer and Capricorn that when drawn on the surface of the earth represent the northernmost and southernmost points at which the sun can be found overhead on the longest day. The words derive from the lines drawn on a sundial (at any latitude) which represent the longest (and shortest) days of the year. The length of the shadow cast at a given time by a sundial's gnomon -- or any other shadow-- is a function of the season. It is longer in winter than in summer. The line that is traced out on the ground by the tip of a shadow from dawn to dusk has a different shape depending on the season and is called the "line of declination". If, on the summer solstice you were to plot the sun's shadow cast by the tip of the style (the nodus) on a sundial at short intervals over a full day, the line traced out crossing the hour lines would form a parabola. Similarly, the line traced out by the shorter series of shadows on December 21 is also a parabola, but faces in the opposite direction. These two lines were called "tropics" and on old dials are sometimes labelled the tropics of Cancer and Capricorn. These names come from the fact that they are traced out at the times of year when the sun is in the respective constellation.

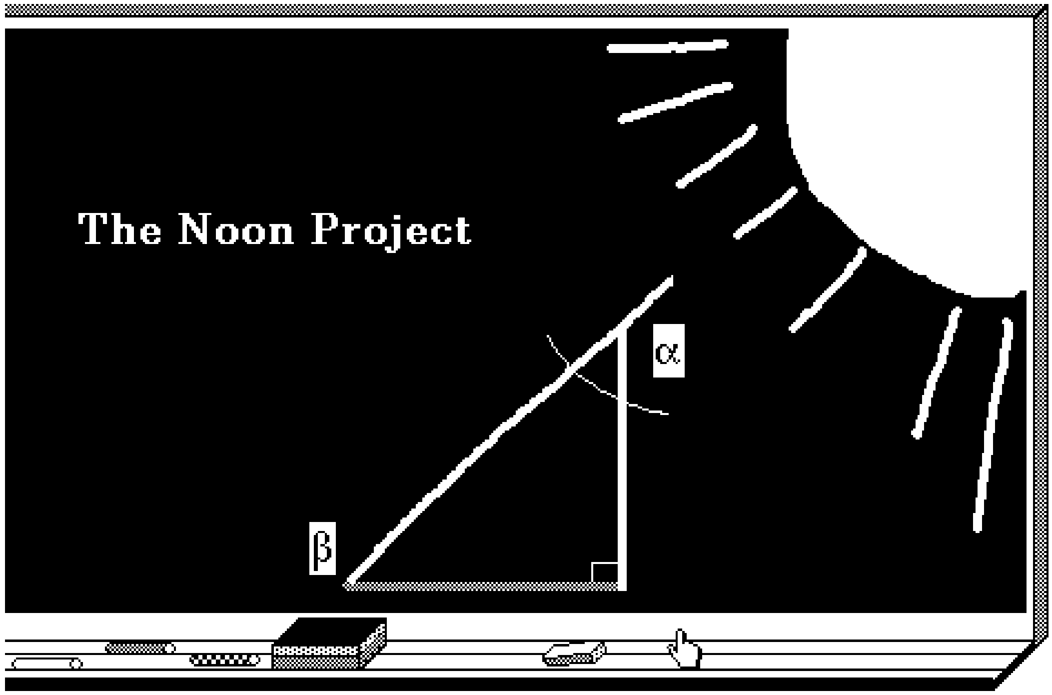


The Zodiac

During the day, the stars lying along the ecliptic cannot be seen, but they are nevertheless there. The constellations near the ecliptic have a special status. There are 12 of them, which collectively make up the zodiac, which aside from their use in the newspaper astrology column, represent traditional star patterns in the night sky and hold official sway over 15° of arc each. At the summer solstice the sun enters the constellation Cancer. When it sets in the evening of June 21 along with (then invisible) Cancer, the constellation on the opposite side of the zodiac, Capricorn, will be rising into view. At the winter solstice, the sun is in Capricorn. The shadow traced by the nodus is the tropic of Capricorn, and as Capricorn sets at dusk, Cancer will be rising in the night sky. On the two equinoxes, March 21 and September 21, the nodus traces out a straight line.

The Noon Observation Project

Thursday, March 18 through Tuesday, March 23, 1999



- What is the Noon Observation Project?
  The Noon Observation Project is a joint effort among interested schools worldwide in accurately estimating the circumference of the earth.
- Introductory message describing the project organization
- What can we learn from this Project?
  The learning process is enhanced through mathematics, geography, as well as introducing the Internet, and of course, just having fun!
- How to compute local noon at your location, so that you know when to schedule your observations.
- A form for submitting your Noon Observations (created by Kenneth Cole)
- The results of the Noon Observations (created by Kenneth Cole)
- An explanation of the formulas for computing the Earth's circumference from the shadow lengths
- Eras??? Who???
  You know. The ancient Greek!
- Who was involved in the 1996 Noon Observation Project?
- Who was involved in the 1995 Noon Observation Project?
- How do I become involved with the Project?,
  A brief summary of the Project and what you need to do to become involved.
- A description of the original network-based Noon Project done in 1988, which is part of an article by Levin, Rogers, Waugh & Smith that appeared in *The Computing Teacher*

- Pictures of students from Lindfield Primary School (Sydney, Australia) measuring the noon shadow in 1997.
- Faubion Middle School's Spread Sheet Calculations (McKinney, Texas)

- Pictures of students from Central High School (Champaign, Illinois) measuring the noon shadow in 1996.
- Pictures of students from Walkersville High School (Walkersville, MD) measuring the noon shadow in 1996.
- Acknowledgements

If you have any suggestions, questions or comments, please send mail to: smithka@knight.cmi.k12.il.us

The Sundial Gallery: This is our finished sundial exhibition page, including pictures of the completed sculptures, student journal entries and even some QTVR movies!

Linking Science and Art: Learning about the scientific aspects of sundials was a key part of this project. This page is our spin on the science involved in making and understanding sundials.

The Challenge: Urbana High School art students were linked with Adler Planetarium, who provided us with lots of help in making the connection between science and art. To visit the entire Adler Planetarium project site, click here.

Other Links: Here is a list of the online resources we found useful in our search for information about sundials.

Marking the Noon Hour

A "Sun Clock" at Kochi Castle, Japan

By Steve Renshaw and Saori Ihara

March, 1997

As with many buildings which are considered national treasures in Japan, entrance to the west door of the main "house" on the citadel of Kochi Castle requires removal of ones shoes. Near this entry area, in a small yard, a "sun clock" made in the Edo Era (1603-1867) can be seen. Most visitors, both local and foreign, pass the little "instrument" without notice; yet at one time, this simple string gnomon and stone arrangement had more impact on the lives of Kochi citizens than anyone could imagine.

"Sun Clock" in front of Kochi Castle; moved during a period of repairs in the late 1940's, the linear depression in the middle of the stone is aligned with magnetic north. The angle of the "gnomon" is about 40 degrees.

A sun "dial" consists of two major components: a gnomon and a set of incremental markings generally called a "dial". To be a relatively accurate measure of time throughout the year, the alignment direction and angle of the gnomon should be such that it always points at celestial north. The angle of the gnomon should thus equal the latitude of the location of the instrument. The "sun clock" at Kochi Castle, similar to ones which can be found throughout Japan, looks somewhat different from sun "dials" we usually see in the West. However, its basic function was similar.

Instead of the solid gnomon we are used to seeing, the gnomon of the castle's "sun clock" is composed of a post at the northern end of the stone with a string attached to its top and stretched to the southern base. Instead of a "dial", the "sun clock" has but one indented line in the middle parallel (lengthwise) with the stone.

The angle of the gnomon (string to stone base) is about 40 degrees. The actual latitude of Kochi is a bit over 33 degrees, so the gnomon of the clock is obviously not parallel with the earth's axis. The indented north-south "line" of the stone is aligned at present with magnetic north, thus placing it out of alignment with "true" celestial north. At best, the instrument gives a somewhat inaccurate indication of the noon hour. What then, in a culture known throughout its history for precise engineering, was the function of this rather crude instrument?

As in every culture, knowledge of time was an important aspect of day-to-day life throughout the history of Japan. While records are scarce regarding means of determination prior to influences from China and Korea, there is evidence that by the latter part of the 7th century, a clepsydra (water clock) based on Chinese principles of time keeping was in use for "knowing the hours" in the Yamato (present Nara/Asuka region) of Japan. [It should be noted that from early times of Chinese influence, hours were based on a system of Chinese Geomancy. In East Asian countries influenced by China, one hour was equal to what would be considered two hours in the West. Hours were also named according to the familiar animals of the Chinese Zodiac rather than on a numerical basis. For more on this, see The Sun, the Moon, and Happy New Year in Japan.]

Despite virtual isolation from the outside world during the Edo era, mechanical time pieces (such as pendulum clocks) were in use in much of Japan at least by the 18th century. However, for many centuries (even until the late 19th when time pieces were common), arrangements for meetings, appointments, and social gatherings were sometimes based on a relatively loose interpretation of coincidence of celestial phenomena with geophysical landmarks. For example, people might decide to meet "tomorrow when the sun has reached the top of that mountain in the southeast", or lovers might decide to meet "when Subaru is at the position of the horse" [meaning the asterism Subaru's transit overhead at night]. Obviously, such means of determining times for engagement fulfilled many informal needs, but the Shogunate along with daimyos from the various feudal domains of the Edo Era saw the need to have a more standardized method for setting and coordinating functions of time pieces as they became more available to citizens in each domain.

While it is possible that the "sun clock" at Kochi Castle was an educational or amateur instrument of the daimyo or one of his children, it is more probable that it was the instrument used to determine the "official" noon hour for Kochi City in Edo times. As in the West, determination of standard time was pretty much a local matter up until latter parts of the 19th century. No standard such as that established in Greenwich with its time ball in the early 1800's was instituted by the Tokugawa Shogunate in Tokyo, and virtually every feudal domain had to develop its own standard for determining "correct" time. Most likely, given its place on the castle grounds, the "sun clock" was the instrument used to provide citizens of Kochi with a standard for adjusting their time pieces. At the moment when the string's shadow was perceived to be exactly coincident with the linear groove in the stone, on signal, temple bells were probably sounded to alert citizens that the hour of noon was "at hand". Before the present era, Kochi was known as Tosa. Thus, the stone probably functioned to establish "Tosa Standard Time"... TST.

Photo of the "sun clock" taken at noon; note the shadow of the string roughly coincides with the linear marking on the stone.

The style of "sun clock" seen at Kochi Castle was introduced to Japan by Shihei Hayashi at the end of the 18th century and was in widespread use throughout the country in latter Edo times. We really do not know what the original alignment of the stone or angle of its gnomon was. There certainly were calendar scholars in Kochi throughout the Edo Era, and it is clear that they not only had a relatively precise measure of the city's latitude, but could also easily determine alignment with celestial north. Whether or not one of them assisted in the original placement of the stone and angular "setting" is not known. Given the generally accepted attitude of the shogunate and respective daimyo of the time, it seems likely that such precision was not seen as necessary. Rather, the simple establishment of a standard that the daimyo could "rely on" was sufficient for regulating the temporal affairs of the city. The Meiji Era, of course, saw the demise of shogunate rule and a movement to follow GMT as a base for time standardization throughout Japan.

References

Aston, W.G. trans. (1972) ***Nihongi; Chronicles of Japan from the Earliest Times to A.D. 697***. Charles E. Tuttle Co. Ltd., Tokyo.

Okamura, K. (1995) ***Tosa Tenmon Sanpo***. (Tosa Astronomical Promenade). Kochi Shinbun Co. Ltd., Kochi, Japan.

Sansom, G.B. (1931) ***Japan; A Short Cultural History***. Charles E. Tuttle Co. Ltd., Tokyo. Revised 1993.

Schutte, K. (1975) *Modern Sundials*. In G.D. Roth (Ed.) and A. Beer (Trans.) ***Astronomy; A Handbook***. Springer-Verlag, New York; Sky Pub. Corp., Cambridge, Mass.

Sugimoto, M. and D.L. Swain (1989) ***Science and Culture in Traditional Japan***. Charles E. Tuttle Co. Ltd., Tokyo.

Uchida, M. (1975) ***Koyomi to Nihonjin*** (The Calendar and Japanese). Yuzankaku, Tokyo.

Uno, S. et al (1991) ***Nihon Zenshi*** (Japan Chronik). Kodansha, Tokyo.

Walters, D. (1989) ***Chinese Geomancy***. Element Books Ltd., Longmead, Shafttesbury, Dorset.

Whitrow, G.J. (1988) ***Time in History; Views of Time from Prehistory to the Present Day***. Oxford University Press, Oxford.

Please send comments to

Steven L. Renshaw

Return to Astronomy in Japan Home Page

Sundials on the Internet

For a full overview click here

Mottoes on sundials - a minor art form in themselves

Mottoes on sundials are a minor art form in themselves. Many of them perhaps look on the more pessimistic side of life, but there are plenty of others to suit every temperament. This list - in no particular order - is given for your information and amusement; you are encouraged to send an E-mail if you would like to add others. Please give some indication of the source if at all possible.

Among those sent in recently are

20 April 2001 (Rachel Sarda)

"Light and shadow by turns, but love always"

7 July 1999 (Kathleen M Broadhead)

Time and Tide Wait For No Man

10 June 1999 (Piers Nicholson)

Aim Higher than the Mark (on the new sundial at Ashby)

5 May 1999 (Pete Bliss)

The shadow of my finger cast
Divides the future from the past;
Before it stands the unborn hour
In darkness and beyond thy power;
Behind its unreturning line
The vanished hour no longer thine;
One hour alone is in thy hand,
The now on which the shadow stands.

28 April 1999 (Sandy Brown)

Slow comes the hour
Its passing speed how great

The assortment following is from a collection of more than 2000 mottoes collected by sundial maker James Stewart, who worked in Invercargill, New Zealand up until his death in 1933. (James Stewart was the great great grandfather of Bruce Christie, of the Plant Science Department, Massey University, Palmerston North, New Zealand. (Phone 64-6-3504253 Fax 64-6-3505614) who kindly supplied this collection.

1. A day may prime thee, improve this hour.
2. Moved by the light.
3. A stick in time saves mine.
4. On this moment hangs eternity.
5. To thee that mourn the hours are slow
   But with joyful swiftly go.
6. The gliding hour flies on its fitful wings.
7. Come boys now's the hour.
8. Learn ze, years pass by like running water.

9. Snatch the present hour, fear the last.
10. As a shadow such is life.
11. Look at me and pass on.
12. By the shadow shall I mark time.
13. Be thankful, watch, pray and work.
14. The sun who guides the heavenly bodies produces the shade.
15. Come light visit me.
16. Count all the hours lost which are not accompanied by some worthy deed.
17. With the shadow nothing, without the shadow nothing.
18. To God alone be the glory.
19. Learn to live and die well.
20. The Lord is my light.
21. Perhaps the last.
22. Go your way into His courts with thanksgiving.
23. Let the slight shadow teach thee wisdom
24. Evil be to him who thinks evil thereof.
25. I count bright hours only.
26. I tell only sunny hours.
27. I am a shadow, so art thou,
I mark the time, dost thou?
28. Amidst the flowers I tell the hours.
29. The clock the time may wrongly tell,
I never if the sun shines well.
30. Time flies, eternity draws near.
31. Lead kindly light.
32. Let not the sun go down on your wrath.
33. Let others tell of storms and showers,
I tell only sunny hours.
34. Light is the shadow of God.
35. Night comes when no man can work.
36. Like a true fireman, I am always ready.
37. He hath made his choice aright,
who counted but the hours of light.
38. Till the day dawn and the shadows flee away.
39. My time is in thy hand.
40. Man wants but little here below,
nor wants that little wrong.
41. Only as I abide in the light of heaven
do I fulfil the will of my maker.
42. They pass by and are scorned.
43. So passes the glory of the world.
44. The sun guides me the shadows gone.
45. Tak tent o'time, ere time be tint.
46. Time passes as a shadow.
47. Time flies, death urges, knells call, heaven invites.
48. With warning hand I mark times rapid flight,
From life's glad morning to its solemn night.
Yet through the dear God's love, I also show,
There's light above me by the shade below.
49. When thou dost look upon my face,

To learn the time of day:
Think how my shadow keeps its pace,
As thy life flies away.
Take, mortal this advice from me
And so resolve to spend
They life on earth, that heaven shall be
Thy home when time shall end.

50. I stand amid the summer flowers
To tell the passage of the hours.
When winter steals the flowers away
I tell the passing of their day.
Man whose flesh is but as grass
Like summer flowers thy life shall pass
While time is thine lay up in store
And thou shalt live for evermore.

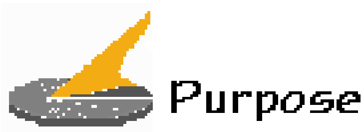
To end up in the wrong direction, these verses by Hilaire Belloc have probably not been used on actual sundials, but express some of the problems and indeed pathos of the sundials!

- *In soft deluding lies let foools delight.*
  A shadow marks our days, which end in Night
- *How slow the Shadow creeps; but when 'tis past*
  How fast the Shadows fall. How fast! How fast!
- *Loss and Possession, Death and Life are one.*
  There falls no shadow where there shines no sun.
- *Stealthy the silent hours advance, and still;*
  And each may wound you, and the last shall kill.
- *Here in a lonely glade, forgotten, I*
  Mark the tremendous process of the sky.
  So does your inmost soul, forgotten, mark
  The Dawn, the Noon, the coming of the Dark.
- *I that sitll point to one enduring star*
  Abandoned am, as all the Constant are.
- *Save on the rare occasions when the Sun*
  Is shining, I am only here for fun
- *I am a sundial, and I make a botch*
  Of what is done far better by a watch.
- *I am a sundial, turned the wrong way round.*
  I cost my foolish mistress fifty pounds

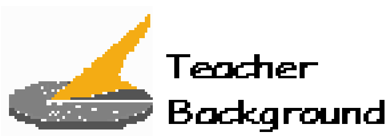
For a full overview of Sundials on the Internet click here

This site designed and maintained by Inter*net*works Ltd of Epsom, England
last revision
Comments/ suggestions/ problems, please get in touch with the Webmaster

This is a Stickup!



In this Thread, we are continuing to examine the passage of time from observations we can make about the outside world. In Hello, Sun!, we saw that the Sun appears to jog across the sky during the school day. It looks like a nice and smooth motion. By using the shadow of the Sun during the day, we may make safe and accurate measurements of that motion. The National Standards require that students be learning what causes light, heat and shadow, and how time passes, how to use rulers and other measuring tools. The vocabulary words which can be introduced to help us talk about our experiences are line, length, angle, sphere, straight, and model.



We have already explored the way the Sun moves in the sky during the day. The next step is to try and see that motion from another perspective. Some classes may have been able to determine the height of the Sun in fists and found that the Sun first gets higher then lower in the sky. Did students also notice that their shadows got shorter and then longer again? Do they have a record of that? As we saw from the Thread, **Me and My Shadow**, the height of a light source changes the lengths and orientations of shadows. Using a standard stick with careful measurements can give us a better record of the changing shadow lengths outside in the Sun and also good data for exploring deeper.

If we measure shadow lengths during the day using a standard stick, the shadow pattern will look like a fan of lines, first long, then shorter, then long again. This fan will begin with its first shadow line on the left of the stick, if you are looking from South of the stick This fan pattern will then proceed with lines moving ever more to the right and at steeper angles to the edge of the paper. This is because the Sun rises in the East, or to the right of the stick. A light source on the right will cast a shadow of an object to the left. The angle of the Sun above the horizon determines the length of the shadows it causes behind objects. The higher the Sun is, the shorter the shadow. This is why the fan gets shorter at mid-day. In fact, if the Earth did not tilt on its axis 23.5° as it does, then the Sun's height at mid-day would be the same every day of the year. The Thread called **Latitudes and Attitudes** will let us explore this further.

You will need pencils, construction paper flags, flashlights, paper, and either a 12-inch stick/ruler or half-meter stick; 2-4 additional: chalk or wipe board, chalk/markers, big roll white paper, coffee can filled with sand, tape, flashlights/toothpicks/clay/paper enough for half the class number; 4-6 additional: easel, protractors, yarn or string, a calculator with trigonometry functions (tangent/cotangent).

The class will initially need a sunny day for this with repeated measurements throughout the day every hour, starting with the earliest hour in the school day. You will need to have previously located South in the school yard. Materials gathering time is minimal since most of the materials are common in the classroom.

In the classroom, you will want to spend several class periods over a week or more exploring your data and what it means. The older your grade level, the more time you will want to spend. There is a lot of good math which can be introduced in this Thread and taught simultaneously. The procedure described in the Investigation portion of this Thread should be repeated at least three more times during the year.

At one point in the investigation, you will talk about the relationship between angles and sides of a right triangle. A right triangle is one which has a 90° angle in it. In such a triangle, the tangent of an angle is defined as the length of the side opposite the angle divided by the length of the side next to the angle. The hypotenuse, or longest side, is not used in finding the tangent. In the sunstick investigation, the tangent of the angles use the "sides" made by the length of the stick and the length of the shadow. So, depending on which angle you are trying to find, you will divide one by the other. In a calculator or using a table of tangents, you can find the angle. In the upper grades, you will use a protractor and some string to measure the angles directly as well as finding them with the tangent.

If you are interested in making sundials with your class, please check out this pattern for a simple design for a sundial.

Contents	Download Internet Resources Children's Books Folklore & Mythology Connections	To K-2nd Grade Thread To 2nd-4th Grade Thread To 4th-6th Grade Thread

Kindergarten through Second Grade

Developmental Issues This age group cannot yet manage the precision required for the Investigation in this Thread. They will not be able to make good measurements nor understand their importance. What we want them to learn from this adventure is that as it moves across the sky, the Sun's light changes the stick's shadow, something which they should remember from Me and My Shadow. However, we can emphasize using the Sun as a clock in this Thread. It is suggested that instead of employing the measuring stick and paper that you instead use a sapling or pole in the school yard and bright marking objects or flags. This way we can express the same basic concept in a very big and personal way, using first our bodies to mark where the shadows are and then special flags we place to make semi-permanent records of the shadows. Decorating personal flags would be a fine integration of art into this Thread for this age group.

Inquiry Introduction What is happening to the Sun outside during the day? Is it staying in one place? Does it seem to move? What happens to our shadows if the light moves? Do you think our sunlight shadows could move, too? What if we move? Do our shadows move with us? Does the Sun/Blocker/Shadow game work if we move? How could we try it out? How long would it take before we noticed any movement? Can we actually see the Sun moving? How long did it take in **Hello, Sun!** before we noticed the motion?

Inquiry Investigation Arrange ahead of time for your observation place to be undisturbed by students during the day and recess. Perhaps alerting your principal about the activity will help. Outside, let's pick a short tree or pole (or use a standard stick) on which the school's shadow does not fall anytime during the day. It would be best if this object were near the place where we all did **Hello, Sun!** so similar horizon landmarks are around us. This will help us understand what is going on.

What time is it? Where is the shadow of our tree? Can we all go run to the shadow and stand on it? How long is the shadow? Could someone go stand at the very end of the shadow? Place a little class flag there with the time written on it. Who thinks the shadow will be somewhere else in an hour? Where? Stand on the spot you think it will be. With our names on our own flags (of a different color than the class flag), let's each place a flag down where each of us thinks the shadow will be in one hour. Pick random students' flags and ask them why they chose that spot. Could they relate their decision to the Sun at all? Where do we think the Sun will be in one hour?

In one hour, go outside again. Where is the end of the shadow? Mark this with another class flag. Who was closest? Which way did the shadow move? What is changing? Where is the Sun? Did the tree shrink or grow? Let's retrieve our personal flags. Where might the shadow be next hour? This time students may begin to see that a pattern might be forming, and many will put their flag to the right of the second class flag. Again, ask them why and if they can relate it to the Sun.

By the third hour out, it should be clear what is happening to the pattern of the shadow. It is moving to the right. The length of the shadow is not going to make much sense to them, since it involves the height of the Sun; pointing out the correlation will be difficult. However, with flashlights inside, repeating the You Light Up my Life investigation may allow more modeling of the situation. Consider this if you feel your students might gain insight. Otherwise, it is not crucial at this age group. These are understandings they can build as they get older.

Which way did the Sun go today? Which way did the shadow go? Did the tree move at all during the day? No ... so what happened? Play the Sun/Blocker/Shadow game again inside with a flashlight, some object, and paper. Model the experience from outside with everyone. Ask them every step of the way if this is where the Sun was and this is where the tree or pole was. Which way did the shadow go? Is the Sun going that way? Does it happen like that for everyone in the whole world?

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To K-2nd Grade Thread

Second Grade through Fourth Grade

Developmental Issues This is a good Thread for this age group. They are beginning to learn about numbers and how to use measuring tools. At this age they are extra keen not to make mistakes, since they are desperate to fit in and avoid looking stupid. And they want to be given real tasks to do. These characteristics make a subset of this Thread perfect for your students. We will not delve into this situation's geometry with these students, but we will let them participate in some serious observing, building, and modeling in a way which we hope will satisfy their intellectual desires.

Inquiry Introduction How does the Sun seem to move during the day? From where to where? Recall the **Hello, Sun!** blackboard drawings? Could anyone draw them on the board? So, since we were facing South, the Sun moved from left to right. What happens to shadows made by the Sun during the day, then? How could we observe them and be able to take them inside to look at? Can we take somebody else's shadows inside? How could we do this? Gather suggestions from them. Many will recall that we were able to take the Hello, Sun! data indoors because we made a record of it. How could we make a record of the shadows? They will suggest putting paper on the ground, perhaps, or taking pictures. Will one picture be able to show us all of the shadows from a whole day? No. A piece of paper would work, if it had all of the shadows on it. How big a piece of paper? How long are shadows? And what should we use as a shadow maker?

Look around the room and find a standard stick. How could we keep this stick from falling over? A can with junk in it to keep the stick still is a good idea: things like clay and rocks, a Styrofoam plant basket block and stones, or a coffee can filled with sand are good ideas. Paper from a big roll and masking tape will be good for the record keeping. And a nice new marker.

Inquiry Investigation

Time the observations to coincide with the times we all went out for Hello, Sun! Bring all of the materials outside. Find the location from **Hello, Sun!** and put your equipment down there. Pull out a large sheet (about four feet long and as wide as the paper itself) and lay it down with one corner pointing towards south. (Human symmetry ideals would want you to put it square with a side facing south. Don't give in. Since the shadows at morning will be longer than those in mid-day, you will need to account for this in the orientation of your paper.) Tape the paper very firmly down. You may want to mark where the edges of the paper are in case it blows out of position. Put the can down in the corner. Make a careful circle around the bottom of the can so that you always know where it is supposed to go.

So that we don't all crowd the paper with our shadows, let's stand on the north side of the paper. (There is no need to call things north and south with this age group. They will get all fuddled up with the vocabulary. You might say, "Let's stand at the top of the paper.")

What time is it? Someone look at a watch. Where is the shadow here? Trace the shadow line carefully with a dark marker. Write the time at the shadow's end. (Do this for every shadow observation today. Putting the date down near the bottom of the paper is probably a good idea.) The shadow is to our right. Where is the Sun? It is to our left. How long is this shadow? Where do we think the shadow will be in one hour? Does anyone recall Hello, Sun! and what we learned about how the Sun moved in the course of one hour? What might that do to the shadow? Will the Sun be higher in the sky? What might that do to the shadow? The students may want to place stones on the paper marking where they think the next shadow will be. If they think the shadow might change size, they should place their stone where they think the end of the shadow will be.

Back outside again in one hour ... where did the shadow move? How many things outside in our set-up could be changing? Let them decide if the stick could have changed size. Could the paper have changed size? What else is changing? Where is the Sun? (Remember not to look at directly at the Sun, as that may cause permanent damamge to the eye's retina.) Is

there a connection? How long is the shadow? Where in the sky is the Sun?

Back in the classroom, retrieve the Hello, Sun! easel drawing. Leave it in view during this day as a reference guide for students. What time did we make this last observation? Can anyone find it on the Hello, Sun! drawing? How high is the Sun now as compared to one hour ago? Did anything happen to the shadow during this last hour? What might be the link? They may or may not see the height and length relationship right away, so encourage more thinking until they propose the idea. When they do, ask them when they think the shadow might be the shortest today, or when it will be the longest. If they do not see the connection yet, revisit this line of questioning after each observation outside until they do.

After a completed sun stick record has been made (i.e. at the end of the day) tape the record up in the classroom. Tomorrow we will be thinking more about this day and building our own models of it.

The next day, set aside a table for the flashlight/toothpick/clay/paper materials and begin talking with the class about our experiences from the previous day. What did we do yesterday and what do we think we have discovered? We think we discovered that as the Sun moved across the sky and up and down in the sky, the shadows moved across the paper and got longer or shorter. How could we try to model that inside the classroom? We would need a Sun, right? What if we wanted everyone to have his own Sun? What could we use instead of a Sun? What is the Sun anyway? They should hopefully recall their experiences with You Light Up My Life well enough to know that light is light, whatever its source, and that objects in the path of flashlights will cast shadows just as they do in the path of sunlight. What else do we need? We need some kind of little stick stuck into something. A toothpick in clay works well. And we need paper and markers. No problem.

In teams of two, have them gather one set of materials and bring them to a desk or table. Can they recreate what happened outside? Give them plenty of time to fiddle with the materials. They will want desperately to play with the flashlights at first, but not as badly as they did in You Light Up My Life. Ask them to focus on recreating the events of yesterday. What must they do with the flashlight to get their toothpick shadows looking like those on yesterday's record taped to the wall? Have them tell you why they built their model the way they did and how they constructed it. Perhaps teams could later come to the front and explain their models to the rest of the class.

What can we see here? Grab someone's flashlight and aim it down from above the very top of the toothpick. What kinds of things would happen to the shadows if we did this? There would be no shadow. Does this happen on the Earth anywhere? What about if we really lowered the flashlight (aim it at the side of the toothpick and very low). The shadows would be very long. Does this ever happen on the Earth? Gather their suggestions. Ask that they write up their experiences from the past few days, especially what they think they learned and what more they might want to learn about how shadows work on the Earth.

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To 2nd-4th Grade Thread

Fourth Grade through Sixth Grade

Developmental Issues

These students are ready to make some serious observations about their world. This age group is able to record data and comprehend the need for careful observation. They are responsible and eager to master skills. The onset of puberty often hampers a child's desire to take risks. The simplicity of the observations and the obvious results as they come in provide a student with a comfortable experience in which to make some important predictions. The journal keeping is a very personal thing and can be a safe, private place also to record their ideas. Modeling our investigation in this Thread will help make some connections between the math we are doing and what it shows about the world around us. At this age group, most curricula are introducing basic geometry: triangles, circles, and some simple concepts associated with them. This Thread uses degrees, fractions, angles and triangles to explore the spin speed of the Earth, the height of the Sun, and later in the year, the tilt of the Earth. It is fairly important that the students be familiar with the protractor before this Investigation. By the time protractors are used in this Investigation, you and your class will be involved in some serious thinking and connection building. It will distract from the cognitive process to stop and learn about the protractor in the middle of the thread.

Inquiry Introduction

When the Sun moves across the sky, how could we really record its exact position? It is extremely dangerous to look directly at the Sun. How else could we possibly try to record themotion? Let's hope they are thinking about the Sun as a light source and that they know an awful lot about the characteristics of light sources now. If not, ask them if the Sun is a light. What do they know about light sources? What can lights do? What results occur when we put something in the way of the light? Is there anything important about the light we can learn from what happens to the shadow of the object in its way? We can tell how bright it is, sometimes, by the darkness of the shadow if the object is very opaque. What about the height of the light? If light travels in straight lines, what happens to a shadow if the light comes from up here? Aim a pretend flashlight up high above someone's head. This may not be obvious to everyone. Good. That means it is time to go outside and experience this all for ourselves.

Let's bring something outside which we know a lot about. Here's a piece of wood (the 12 inch dowel rod or ruler, or the half-meter stick). How long is it? How could we know for sure? Have them suggest and implement the act of measuring it with a ruler. OK, so we know it is a foot long. Let's stick this outside and watch its shadows all day and measure them as well. If they did this kind of thing last year, they may pipe up and say so. Ask them if they ever measured the shadows they made then or if they discovered the speed of the Sun's movement? Well, no. OK, then. Time to roll.

Inquiry Investigation

Bring the easel and paper out again. Outside, with the materials set up in a good sunny spot, have them carefully pin down the paper somewhere safe where it won't be trampled. You might ask them which way is South. Suggest they point a corner of the big paper to the South and put the can with the upright dowel near that corner. What happens if the can slips? What could we do to make sure we always know where the can goes? What happens if the paper slips? What could we do to make sure we know where the corners of the paper were? Taping the corners down and chalking the outline of the paper seems to work well. Outline the can on the paper itself. If it is windy, weights on the corners of the paper should be used.

What time is it? Where is the shadow? Have someone trace the shadow with dark marker very very carefully. Why so carefully? When we measure, we need to have a good record. Mark the time of the traced shadow at the top of the traced line. We might all make some guesses as to where we think the shadow might be next time we come out to check our set-up by placing rocks or sticks on the paper.

Where is the Sun? Have a team draw the horizon on the easel as seen from the spot in front of the stick (i.e. the sky's southern hemisphere). In that case, what might we want to know about where we are standing with the easel? Have them make some mark on the ground so that they can stand in the same place again after one hour. Ask them to draw the Sun in, using the "fists" technique from Hello, Sun! Where will the Sun be in an hour? They will point to some spot on the paper. Let's keep this drawing going along with the sun stick record. So, where might the shadow be after the Sun has moved for an hour? And the length of the shadow? Longer, shorter, or the same? Why? Gather ideas but don't encourage any one over another. We'll soon see in an hour!

In one hour, revisit the set-up. Before we trace the shadow, what might we want to do? Check that everything is in its place. Then have someone trace the shadow carefully, marking the time at the top of the shadow line again. So, what happened here? Tell me about how the new shadow is changed from the last one. Someone will tell you that it moved and that it got shorter. Why did it do this? Did the stick move or get shorter? What is the only thing that can change the shadow? The light. So, the light moved in some way. Where is the Sun now? Have the Sun keepers stand in their spot and draw the Sun in on the easel. Is there a connection? If no one sees that when the Sun moves to the right, the shadow moves to the left, that is fine. We can just keep saying these things. Also, how many "fists" high is the Sun? How long is the shadow? What is happening here?

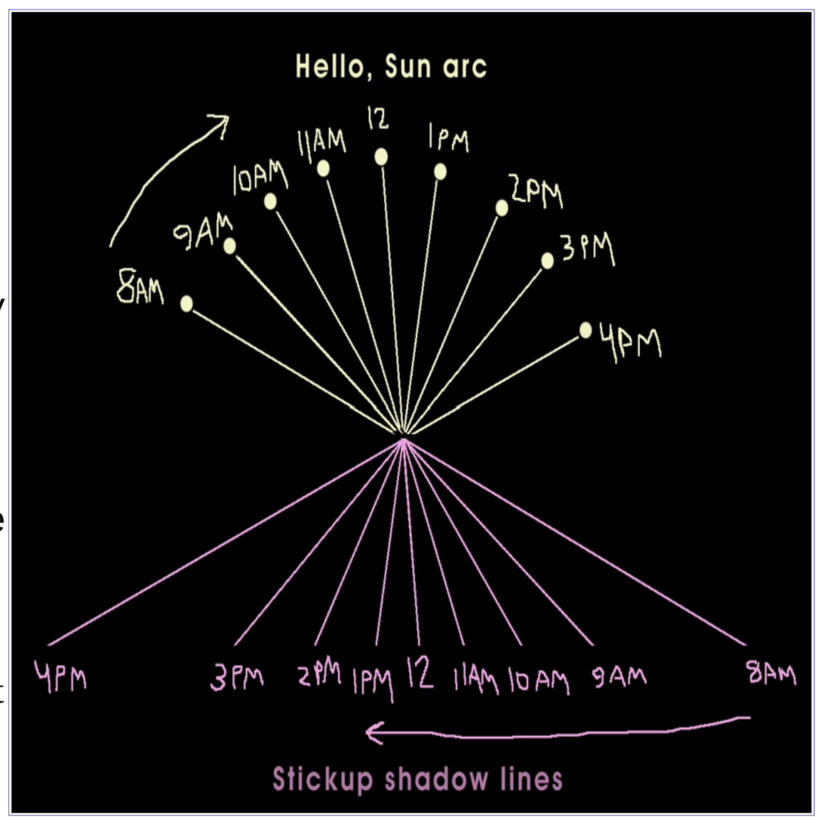
Each successive visit outside will become less interesting to them until past midday (when the Sun reached its highest point in the sky) when the shadows get longer again. Why is this happening? Do we now make the connection? How could we model that inside the classroom? They should think about this for tomorrow, for we will be building our own models then and discovering some things about the world from them. For homework, you may have them write in their journals what they think happens during the day to shadows and the Earth and Sun. Can they imagine what shadows would be like somewhere else on the Earth? Before they arrive for the next day, tape the easel drawings to the wall above the sun stick drawing (in the diamond orientation).

The next day, ask them what happened yesterday and what they think they now know. Show them that you put up the drawings we made so that they are just like they were when we saw them on the ground. Have them think about (but not call out) the two positions the drawings have been in.

Break the students into teams of four people, hand out the sets of sun-stick models (flashlight/toothpick/clay/paper) and have the teams rebuild the set-ups. How can we recreate the scene with flashlights? Where did the Sun come up this morning? Where did it go and how high? When were the shadows the longest? The shortest? What is the real connection? Have them tell you what they think is happening. They will say things like, "When the Sun is highest, the shadows are shortest." Ask them why. Does it have to do with the nature of light? Can anyone draw what is happening in their model or outside on the board?

Help by drawing the stick in the middle and put the Sun on the far left. Ask someone to come up and draw how the light is coming to the stick. Ask the class where the shadow is. They will want to come up and point or draw it in. Extend the sunlight lines past the very tip top of the stick line (if they are not past it already) so that they reach beyond and mark the end of the shadow. Ask them about shadows again and what they learned from You Light Up my Life if they wonder why you are asking that. Flashbacks are no problem, and are always encouraged. When everyone understands, draw the Sun higher and over more to the right. Have someone else come up and draw how the light is coming to the stick. Where is the shadow now? And so on.

Tape to the board next to the chalk drawings (but higher up) the easel drawing of the Sun. Underneath this, tape the sun stick drawings for comparison. Is this what we saw? Yes. What has happened is that we have experienced something and set it aside. We then modeled it and thought about it in lines and direction, and set this next to our first experience. What was true for one is true for the other, and vice versa. Since these two experiences support each other, each view is as valid as the other. The next step is taking a trip to the third realm of experience: the mathematical one. How could we communicate our experience in terms of mathematical models?



Isolate one section of the chalk drawing on the board (by either erasing the rest or re-drawing the key parts) so that it looks like a little triangle formed from the sunlight line zooming past the top of the stick, the sun stick itself, and the line marking where the shadow was cast. What shape is this? A triangle. What do you know about triangles? What does the word itself say to you? Tri = Three, angle = some height measured in degrees. Point back to the drawing on the board. Which angle opens up and points to the Sun's position?

Draw a Sun high on the board. Ask some class members where the stick's shadow would be on their model if this Sun could give off light? How could we test this? Hopefully, they will use the flashlight in their hands and move them so that they are in line with the Sun mark without leaving their desks. So, how high is the flashlight or the Sun mark above the paper in degrees? Trace the line from the Sun to the end of the shadow--but with what?

It would be good to trace the length of the shadow with a pencil first. Then, have one person hold the flashlight while another holds a string to the flashlight near the lens. A third person should pull the string until the other free end reaches the tip of the shadow drawn on the paper. What is the shape made by the string, the toothpick, and the paper shadow outline? The fourth person should be able to see this shape by viewing the whole construction from the side. What does the string represent? It points to the Sun. It follows that an angle formed at the corner by the string and the paper "ground", represents the "Sun's" angle above the ground. Can the fourth person see how this is possible by tracing with his or her eye the line made by the string up to the "Sun"? Can she explain it to everyone else in the group?

Have the fourth person in each group take a protractor and measure the height of the Sun (or the string line, in this case) in degrees. How high is our Sun in degrees above the paper? How long was the shadow? Let's record these numbers on the bottom of the paper somewhere. Erase the first Sun and draw another significantly lower on the board and redo this entire procedure for that new height. What does this triangle look like? How is it different from the first one? What is the height of our Sun? What is the length of the shadow?

What is happening here? There must be some relationship between the height of the Sun and the length of shadow it makes, but we knew this from our experiences outside. There also seems to be some mathematical relation between that angle of the triangle and the length of the triangle's bottom side. Did the size of the toothpick ever change? No. This makes a steady length for one side of the triangle. Maybe we could think about that some more. Is there a fraction we could think about that might change as the small angle changes? How about the toothpick length divided by the shadow length? What is the number? Is it greater than one here (for the first set of numbers, write them on the easel as a fraction.) How big was the angle? And what about for the other set? Write them on the easel also (if there is any room left, that is!). How big was its angle? We seem to find that the bigger the angle, the bigger the fraction. Cool. Do we have any other data we can check? Let's gather all of our data in one place so we can look for patterns, if there are any!

Start a table on a new sheet on the easel. The table should have room enough for 7 columns, with **Time** and **Length of Shadow** and **Length of Stick** as headers for columns 1-3. Obviously, the third column will not change! Let's think about how we have gotten data so far. The first column we know because we were careful to write down the time each time we took a measurement. The second column we had to measure ourselves with a ruler. The third column we knew already, because we had measured the stick. What else have we been talking about that we can figure out about this system of three lines, stick, shadow, and ray of sunlight? They should continue thinking about the idea of the triangle and that fraction.

How might we really find the angles we want to know about? Does anyone suggest using the string idea on the real setup? Set up the stick and paper on the floor. Let students use string to connect the top of the stick to the end of the first shadow. Someone can then measure the angle made at the paper with the string and write this into a **measured angle** column. They should do this for all of the shadow lengths.

Look only at the sun stick drawings, not the Hello, Sun! set. How long was our stick? It was one foot, or 12 inches, or if you used a half-meter stick, it was 50 centimeters. What are the lengths of these shadows? A group should measure the lines and record the lengths in the table (using centimeters is just as valid as using feet or inches). Can they make a fifth column for the **fraction** and fill it in? If not, you might consider using a calculator and giving them fractional values for the numbers they call out. Is there a pattern? Could we make some guesses based on the sizes of the fractions as to what the angles might have been for those times?

We are so close to being able to find an angle from this information, even though we have one we think we measured correctly. If this relationship is so simple, is there a table somewhere? Producing a table of tangents might be cool. It is not possible to expect these students to read the table very well, nor is it reasonable to expect them to understand radians of a circle. So, it is suggested that you instead tell them the calculator has the table built in. Yes, really. And for each fraction we find, we can find the angle that goes with it. Do this for each tangent fraction and write the **calculated angle** in on the easel in a sixth column.

The trick here is, if they have not suggested it already, is that the Hello, Sun! drawing has fists drawn in to indicate height. Since a fist is about 10 degrees, we can see how the angles match. If someone can call out the fist measurement, the rest should be able to tell you the degrees. Write **fist degrees** into the seventh and final column. The two last columns will not be perfectly matched, but they will be close. Ask them which measurement do they think is the less accurate and why? The fists, obviously, because the variables are the measurer's accuracy and hand size. Those who recorded the Hello, Sun! drawing should not be made fun of at this point, but should be reminded that if their eyesight was as perfect as the math, they would be in the Guinness Book of World Records! Human error is a fact of life. How could we have made mistakes in the math? The way we typed data into the calculator, the way we measured the shadow length, or the wiggling of the sun stick outside in the first place.

What are we looking to find out from this work, anyway? Probe the class for what ideas they might be having about why we are doing this today. Some may think about the height of the Sun changing, because they can see from the **Hello, Sun!** data that it is. Some may think we are trying to learn more about triangles and angles. Others may think this is a load of malarkey. OK, two out of three isn't bad. The gist is to see if we can use three different means of finding the same answer, to prove that if the logic is correct, the method is irrelevant in finding the answer. So many times we discourage children from using their own problem solving techniques because we ourselves have not internalized their method enough to comprehend if it is sound. Hopefully, after this investigation, students will see that a few minutes of thought can create three separate means of finding the same value for the Sun's angle.

Encourage your class to think about how each method was different in terms of accuracy, levels of math and observation, and simplicity.

The last thing to think about with this single data set is the time it took for the Sun to zip across the sky or the shadows to zip across the paper during the day. The pattern of shadows makes a big fan on the paper. How would you use the protractors to find out things about the pattern? Are there any places where you would want to measure angles? Let them measure for a while. Then ask what the is biggest angle they can find. It will be the angle between the first and last shadows. What is this angle? What does it represent about the Sun itself? How long did it take the Sun to travel that far? Subtracting the times listed on the shadows, it is (if you measured from, say, 9 a.m until 2 p.m.) five hours. So, the Sun moved so many degrees (ends up being 75) in five hours.

How many degrees is it around the Earth? It is 360 degrees, because the Earth is a ball. So how far around the Earth did the Sun appear to scoot in five hours? (Of course, it is the Earth spinning around like a top past a steady Sun.) Give them time to puzzle with this. Some will ignore the 360 degrees and use the 5 instead, knowing a day is twenty-four hours. They can divide 24 hours by 5 hours and discover that 5 hours goes into 24 hours almost 5 times. So, the Earth almost went one-fifth of the way around on its axis past the Sun. Others will divide the degrees traveled in five hours into the degrees around the Earth and also give you a fraction of almost one fifth. Are both answers right? Of course they are.

How could we find out how many miles of Earth spun past the Sun in five hours? We'd need to know how many miles around the Earth is. Is there any way to find that out without looking it up? No, not yet. We need another measurement from Latitudes and Attitudes.

Measure again around the time of the winter solstice (about December 22), recreating the steps they did for the autumn equinox. After they have also observed and measured the spring equinox (about March 21) shadow lines, begin the discussions for the end of the coming Thread **Tilt-A-World**.

A note about the autumn equinox (about September 22): Since you are likely to have read this entire package ahead of time, here's a note for you. If your class has not reached this Investigation before the autumn equinox, please attempt to build and make your own record of the sun stick shadows on that day. If there are other teachers in your school who are participating in this curriculum, they could help you keep up the observations or at least watch your classroom while you run out to make these records on the equinox. You should try to measure the fist height of the Sun each time you go out, just as the kids will do. No need to measure your lines; they can do that themselves when they do the others. Curious students will want to know what you are doing, and you can tell them that soon they will be doing it as well. If it is really impossible for you to get autumn equinox data, then what is there to do? You will have two sets of data to use and not three for the next Thread.

Thread Intro
To Table of Contents
Read the Teacher Journal
Add to the Teacher Journal
Next Thread
To 4th-6th Grade Thread

Eras??? Who???

Erastothenes was a man who lived in Alexandria in Anciet Egypt about 300 B.C. His interests varied widely from astronomy to theater critic. He was also in charge of the great library in Alexandria...and just what does the head librarian do on his lunch break? Of course, eat pizza and read a good book!

While thumbing through a book one day, he ran across a passage that read, on the longest day of the year, the sun cast no shadow in Syene, a city to the south of Alexandria. As he read on, he found that the sun's reflection could also be seen in a deep well. "Well!" he thought to himself, "everyone knows the earth is flat! How then, could there be no shadow in Syene when there is a definite shadow in Alexandria?"

A graphics file , showing a flat earth will be here

Erastothenes hired a friend of his to walk from Alexandria to Syene to mark the distance.

His friend found the distance between the two places to be about 500 miles. With this information and his knowledge of geometry, Erastothenes determined the circumference of the earth to be approximately 25,000 miles. And we all know what has a circumference? Yes!! He proved that the earth was round. Erastosthenes had changed the world forever with his discovery, for this led many seafaring explorers to set sail in search of new and exciting trade routes. And we all know what happened after that.

Return to the Noon Project Homepage

AUTHENTICATION

Z Number:

Passcode:

Sign In

This LANL network authentication allows access to most LANL Web applications.

Need Help/Problems?

NOTICE:
Information from this server resides on a computer system funded by the U.S. Department of Energy. Anyone using this system consents to monitoring of this use by system or security personnel. For complete conditions of use see Disclaimer/Privacy.