ACTIVITIES 28 & 29

The Reason for Seasons
(Sessions I and II)

BROWARD COUNTY ELEMENTARY SCIENCE BENCHMARK PLAN

Grade 5—Quarter 3
Activities 28 & 29

SC.E.1.2.1
The student knows that the tilt of Earth on its own axis as it rotates and revolves around the Sun causes changes in season, length of day, and energy available.

SC.E.1.2.3
The student knows that the Sun is a star and that its energy can be captured or concentrated to generate heat and light for work on Earth.

SC.H.1.2.2
The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

SC.H.1.2.3
The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

SC.H.1.2.4
The student knows that to compare and contrast observations and results is an essential skill in science.

SC.H.1.2.5
The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.

SC.H.2.2.1
The student knows that natural events are often predictable and logical.

SC.H.3.2.2
The student knows that data are collected and interpreted in order to explain an event or concept.

ACTIVITY ASSESSMENT OPPORTUNITIES

The following suggestions are intended to help identify major concepts covered in the activity that may need extra reinforcement. The goal is to provide opportunities to assess student progress without creating the need for a separate, formal assessment session (or activity) for each of the 39 hands-on activities at your grade.

1. **Session I—Activity 28:** Have students think about the effect of the tilt of Earth's axis on seasons at the North Pole. Ask, *What would happen to the seasons at the North Pole if the Earth's axis were tilted at an angle of 5 degrees?* (The seasonal changes would hardly be noticed.) Then ask, *What would be the effect if the axis were tilted at an angle of 50 degrees?* (The seasonal extremes would be greater than what the North Pole experiences now.)

2. **Session II—Activity 29:** Have students write a fictitious journal entry comparing three dates in the life of a vegetable farmer. Tell students to include a description of the amount of incoming solar energy and its effect on the vegetable crops on January 1, May 1, and October 1. (With less incoming solar energy on January 1, the temperatures would be lower and the crops may either die off or have diminished growing capacity; May 1 would be a better growing time; October 1 would be slightly less so, depending on the crop and its temperature sensitivity.)

3. Use the Activity Sheet(s) to assess student understanding of the major concepts in the activity.

In addition to the above assessment suggestions, the questions in bold and tasks that students perform throughout the activity provide opportunities to identify areas that may require additional review before proceeding further with the activity.

ACTIVITIES 28 & 29

The Reason for Seasons

OBJECTIVES

As a continuation of their study of Earth's orbit around the Sun, students learn how the tilt of Earth is responsible for seasonal changes.

The students

- model the tilt of Earth's axis as it orbits the Sun
- learn about solstices and equinoxes and the role they play in the Sun's apparent motion
- explore how the angle at which sunlight reaches a given location affects its concentration
- infer the causes of seasonal changes

SCHEDULE

Session I—Activity 28 About 30 minutes

Session II—Activity 29 About 40 minutes

VOCABULARY

direct sunlight
equinox
indirect sunlight
solstice

MATERIALS

For each student

1	Activity Sheet 29
1 pr	safety goggles*

For each team of four

1	battery, AA
1	globe
1	globe base
1	measuring tape
1 pc	paper, construction
1	penlight
2	push pins

For the class

2	extension cords
1	globe, inflatable
2	light bulbs
2	light sources
	marker*
8 pcs	paper, construction
	sheets, to cover windows (optional)*
	DSR *Earth, Moon, and Sun*

* provided by the teacher

PREPARATION

Session I—Activity 28

A darkened room will enhance the activity greatly. If your room has uncovered windows, you may want to collect sheets or other materials with which to cover them.

Session II—Activity 29

1. Make a copy of Activity Sheet 29 for each student.
2. Assemble the penlights and check to see that they work.
3. With a marker, make two season signs each for "Summer," "Autumn," "Winter," and "Spring" in large letters on pieces of construction paper.

BACKGROUND INFORMATION

Many people believe that summer occurs because Earth's not-quite-circular orbit veers closest to the Sun at that time. In reality, those of us in the Northern Hemisphere prepare for the cold weather of January just as Earth nears the Sun. The Sun is farthest away in July.

The dramatic weather changes that we see are actually caused by the tilt of Earth's axis. In winter, the Northern Hemisphere is tilted away from the Sun; in summer, it is tilted toward the Sun.

As a result, the apparent altitude of the Sun's course changes. When Earth's North Pole is tilted toward the Sun, the Sun appears—to those in the Northern Hemisphere—to rise higher in the sky. This higher path means that the Sun stays above our horizon longer on summer days. When Earth's Northern Hemisphere tilts away from the Sun, the Sun appears—to those in the Northern Hemisphere—lower. It disappears sooner so days are shorter. Longer days mean that more heat is absorbed by Earth. Shorter days mean less heat is absorbed. This difference in the amount of sunlight absorbed by a particular area at different times of the year is the first major factor producing seasons.

The second major factor producing seasons is the angle of the Sun's rays hitting Earth—also a result of the Earth's tilt. When the Sun is high in the sky, its rays reach the Earth at an angle that is almost perpendicular to its surface. Perpendicular rays are called ***direct sunlight.***

Direct sunlight is concentrated when it reaches Earth's surface. (See Figure 29-2.) For this reason, direct sunlight packs a considerable amount of energy per square meter. This concentrated energy is the cause of summer's more intense heat.

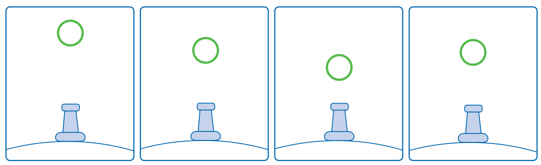
When the Sun is low in the sky, its rays reach us at a lesser angle with respect to Earth's surface. Low rays, known as ***indirect sunlight,*** spread out along Earth's surface. The energy per square meter from indirect sunlight is much lower than that from direct sunlight. As a result, Earth's surface receives less total energy and temperatures are lower.

The length of daylight and the concentration of the rays hitting Earth are the two major factors controlling our annual cycle of seasons.

▼ **Activity Sheet 29**

The Reason for Seasons

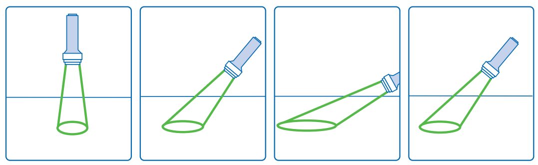
1. Draw the Sun where it would appear from the perspective of your push pin each season.



2. Beside each season, write the distance the observer traveled on the globe during daylight and during night.

Season	Distance Traveled	
	Day	Night
summer		
autumn		
winter		
spring		

3. Draw the shape and size of the area lit by the penlight at the equinoxes and solstices.



Guiding the Activity

Additional Information

Session I—Activity 28

1 Place one light source near the center of the room on a desk or table. Divide the class into teams of four. Then distribute a globe and two push pins to each team. Have teams insert a push pin at each pole on their globe.

You may want to do this yourself because the poles on the model globe have hard plastic caps that will resist the pins. If you have students insert their own pins, tell them to use extra caution.

Gather teams in a large circle around the light source. Darken the room enough that the light source appears bright, but students still can see you. Then stand inside the circle, and demonstrate with the inflatable globe as teams model Earth's movements with their globes.

Ask, **In which direction does Earth move around the Sun?**

Students should recall that Earth moves in a counterclockwise direction.

Inform students that the light source in the center of the room represents the Sun. Have teams begin revolving around it. Model how to hold the globe level with the Sun as you revolve.

For this model, students need not rotate Earth as they move.

Ask, **How long does Earth take to revolve around the Sun?**

Students should realize that a year is, by definition, the length of time Earth requires to revolve around the Sun.

As teams continue to revolve, explain that the orbit of Earth is circular. Have teams revolve along a circular orbit.

Although Earth does not travel in a perfect circle, the change in radius is not significant.

2 Hold the inflatable globe upright and continue moving with teams around the Sun. Ask, **Is Earth upright like this when it revolves around the Sun?**

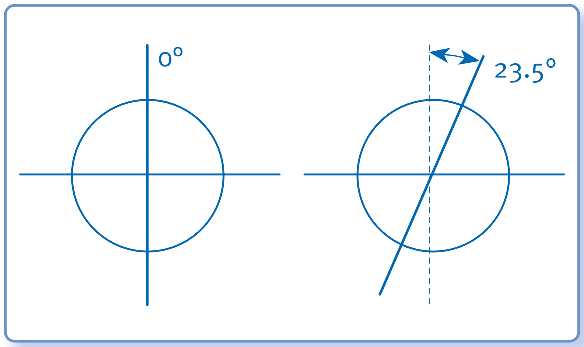
Most teams probably are holding their globes with the axis of rotation straight up and down. The actual angle is 23.5° from the vertical. (See Figure 28-1.)

Instruct teams to hold their globes vertically and indicate what a vertical axis of rotation would look like with the inflatable globe. Then ask, **What would the globe look like if it were tilted 23.5° from the vertical?**

Draw Figure 28-1 on the board to demonstrate a 23.5° angle.

Guiding the Activity

Additional Information



▲ *Figure 28-1. The tilt of the Earth with respect to the vertical.*

Model how to tilt the globe approximately 23.5° toward the front wall of the classroom. Explain that as they revolve, they must keep the globes tilted toward the front of the classroom. Have teams continue their revolution, this time with globes tilted.

Watch carefully to make sure that globes remain level with the Sun and tilted toward the front of the classroom as they revolve. Students tend to want to maintain the tilt in reference to the Sun rather than to a fixed point in space like the front wall.

Model how to rotate the inflatable globe through several days, maintaining the angle of rotation at 23.5° toward the front wall. Ask, **Does rotating the globe change its angle to the Sun?**

Sometimes students are confused by the fact that Earth rotates and think that its rotation affects its tilt toward the Sun. This demonstration shows that rotation has no effect on tilt.

As appropriate, read or review pages 11 and 12 from the Delta Science Reader *Earth, Moon, and Sun*.

3 Have teams stop rotating and complete a year's revolution around the Sun.

Then ask, **What is it about this revolution over the course of a year that causes the seasons?**

Students may respond that seasons result from the proximity of Earth to the Sun and that the seasons vary as Earth's orbital distance varies. If so, explain that this is not the case. Point out that the variation in Earth's orbit is not sufficient to cause any noticeable seasons on Earth.

Ask, **If the variation in distance does not cause the seasons, what does?**

Students may offer a variety of answers including the possibility that Earth's tilt is a factor.

Guiding the Activity

Additional Information

Ask, **What is different about the way sunlight strikes your globe when it is near the front of the classroom and when it is near the back?**

Students should be able to observe that the globes near the front of the classroom have more light shining on the Southern Hemisphere while those in the back are better illuminated on the Northern Hemisphere.

Lead students to realize that this change in Earth's illumination is what causes the seasons.

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4 Revolve from the front of the classroom until you are holding the inflatable globe one-quarter of the distance around the room. If you have held the tilt steady, then Earth should be tilted neither toward nor away from the Sun. Explain that this is Earth's orientation at the start of spring in the Northern Hemisphere.

Continue around the room until Earth is on the opposite side of the room from where you started and the North Pole points more toward the Sun.

Ask, **Which season is occurring in the Northern Hemisphere now?**

Students should see that the Sun now shines directly on the Northern Hemisphere, which creates summer for northerners.

Then ask, **Does the Southern Hemisphere receive much light during this time of year? Which season are residents there experiencing?**

Students should observe that the Southern Hemisphere receives less light, so it is winter there.

Complete the revolution with the inflatable globe, having students identify the seasons experienced by Northern and Southern Hemispheres at three-quarters of the way around the room and at the starting point.

At three-quarters of the way around, Earth is again tilting neither toward nor away from the Sun. Its position marks the start of autumn in the Northern Hemisphere and spring in the Southern. Back at the starting point, the Northern Hemisphere tilts away from the Sun, so it experiences winter while the Southern Hemisphere experiences summer.

Turn on the lights. Raise or remove window coverings. Remove push pins from the globes and return all materials to the kit.

Guiding the Activity

Additional Information

Session II—Activity 29

5 Arrange both light sources in the room so that half of the teams can work around each one. Distribute a copy of **Activity Sheet 29** to each student and a measuring tape, push pins, a globe, and a globe base to each team.

Tell teams to set their globe on their globe base. Have them pinpoint their own location on Earth with one of the push pins and insert the pin at that spot. Inform students that the push pins represent them, standing on the surface of the Earth at that point. The top of the push pin is the top of their head.

Make sure students insert the pin at a right angle to the surface of the globe.

Have one team from each group stand between their light source and the front wall. On the floor beside each of the two teams, lay a "Winter" sign. Moving counterclockwise, position another team from each group to stand between their light source and the side wall. Beside each of those teams, lay a "Spring" sign. Continue around the circle, laying "Summer" beside the teams toward the back of the room and "Autumn" beside the teams toward the fourth wall.

Darken the room. Have teams revolve with their globes around the light source Sun, observing the angle of the push pin with respect to the Sun. Remind students to keep the Earth's tilt toward the front of the room, but to rotate the globe so that the push pin always faces the Sun. At each of the season signs, they should stop and complete the appropriate part of Step 1 on the activity sheet.

Correct any team that is not holding its Earth at about a 23.5° tilt pointing toward the front of the room. The globe base should help them maintain the correct angle.

Encourage students to imagine that they are the push pin looking at the Sun. (See Figure 29-1.) The more directly the top of the push pin faces the Sun, the higher in the sky the Sun would appear to them. Conversely, the larger the angle between the top of the push pin and the Sun, the lower in the sky the Sun would appear to be to them.

Guiding the Activity

Additional Information

▲ ***Figure 29-1.*** *Imagining the position of the Sun on the horizon from the viewpoint of a push pin.*

6 Ask, **How does the push pin's view of the Sun change as Earth revolves?**

Allow students time to consider the question. Suggest that they repeat a few more orbits to help them see what is happening. Ultimately, lead them to realize that from the push pin's "point of view," the Sun is nearly overhead in the sky when Earth tips toward the Sun. When Earth tips away from the Sun, the Sun appears to the push pin to be low in the sky. When Earth is tipped neither toward nor away from the Sun, the Sun appears to the push pin to be midway between these two extremes.

Then challenge students to use their models and measuring tapes to demonstrate how this change in the relative position of the Sun will affect the amount of daylight the push pin receives in a day. Have them remove the push pin for a moment and stick it through a centimeter mark on the measuring tape. Then replace it in the globe.

At each season sign, one teammate should hold the globe at the proper tilt, starting with the push pin at the sunrise position (the western edge of the sunny side). As a second teammate holds the measuring tape at a constant latitude, have the first teammate rotate the globe until it reaches the sunset position (the eastern edge of the sunny side).

You need not introduce the term latitude *at this point in time. Just demonstrate to teams how to keep their measuring tapes along the same line as the globe is rotated.*

Guiding the Activity

Additional Information

Then teams can measure the length of the pin's daytime path and record it in Step 2 of the activity sheet. Next, students should measure the length of the pin's nightly path—from the western to the eastern edge of the dark side of the globe.

Have them record this number on the activity sheet as well.

Ask, **Does the push pin spend more time in daylight or night during the summer? during the winter? What about spring and autumn?**

It should become obvious that the tilt strongly influences the amount of daylight seen by the observer. In summer, when Earth tilts toward the Sun, the push pin is in the light considerably longer than it is in the dark. In winter, when Earth tilts away from the Sun, the exact opposite is true. Finally, in autumn and spring, when there is no tilt in relation to the Sun, the push pin rotates through the same amount of light and darkness.

Write the words *solstice* and *equinox* on the board. Explain that students just demonstrated solstices and equinoxes. Challenge students to identify the positions of the globe that represent solstices and equinoxes.

Solstice *is from the Latin for "stop Sun" and refers to the date on which the Sun stops its apparent motion up (summer solstice) or down (winter solstice) in the sky.* ***Equinox*** *is from the Latin for "equal night" and refers to the dates halfway between solstices when day and night are equal.*

7 **Based on your observations, what would you now say is the cause of the seasons?** Inform students that the fact that Earth's surface absorbs different amounts of sunlight depending upon the length of the day is not the only reason for seasons.

Students should be able to explain that the Sun is higher in the sky and days are longer during summer. During winter the Sun is lower and days are shorter. Students may realize that because the Sun shines longer on a summer day, Earth absorbs more heat.

8 Turn on the lights temporarily and distribute a sheet of construction paper and a penlight to each team. Have them draw a small dot in the center of the construction paper and place it on a desk top. Tell students that the paper represents the surface of Earth, the dot represents an observer, and the penlight represents the Sun.

Guiding the Activity

Additional Information

Darken the room once more and have students shine the penlight onto the dot as if it were summer solstice. Have them draw the shape of the lighted area in Step 3 on their activity sheets.

The penlight should be held about 15 cm (6 in.) from the paper and directly over Earth's surface (the paper) to simulate summer solstice (see Step 3, "summer solstice," on the activity sheet). The resulting illuminated area is a brightly lit circle. If necessary, have teams use their globes again to model how light from the Sun hits Earth at different times of the year.

Next, have teams simulate the equinoxes and winter solstice with their penlights.

Refer students to Step 1 of the activity sheet if they have forgotten that the Sun appears low in the sky during winter and about halfway between the position of the two solstices at equinox. When students hold the penlight about 15 cm (6 in.) away and shine it toward the circle from a 45° angle (equinox) and then from a very low angle (winter solstice), it will light a duller, more extended oval as the angle decreases.

Have students copy the shape of the lit area for the equinoxes and winter solstice onto their activity sheets. Then write *direct sunlight* and *indirect sunlight* on the board.

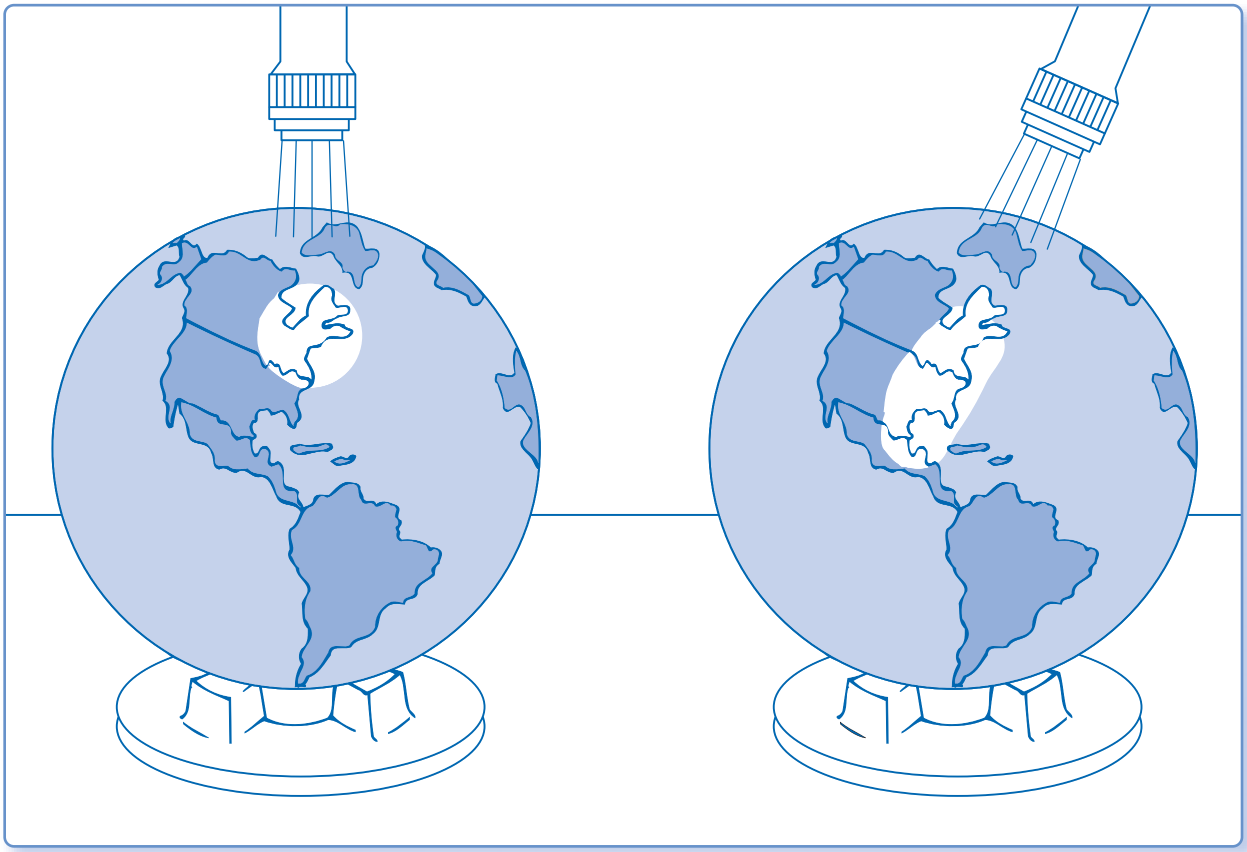
Explain that during the summer solstice the Northern Hemisphere receives more **direct sunlight** because the Sun is directly overhead. During the winter solstice, the Northern Hemisphere receives **indirect sunlight** because sunlight hits Earth from a low angle.

Have students compare direct and indirect sunlight with their models or in the drawings on their activity sheets. Ask, **How do you think the angle at which sunlight hits Earth affects the seasons?**

Students may offer a variety of answers. Use the discussion to point out the following: In each case the penlight, simulating the amount of sunlight falling on one area of the globe, is producing the same amount of light, which is heat energy. However, the light is distributed over very different sized areas. At the summer solstice, a given amount of direct sunlight—containing a given amount of heat energy—is concentrated into a small area. At winter solstice, the same amount of heat energy, or sunlight, is distributed over a large area, so that each spot receives much less heat.

Guiding the Activity

Additional Information



▲ *Figure 29-2. Summer's direct sunlight concentrates its heat more than winter's indirect sunlight.*

Tell students to shine the penlight onto the globe to demonstrate the angle of sunlight during solstices and equinoxes (Figure 29-2). Finally, ask, **What are the two major causes of the seasons on Earth?**

Students should be able to synthesize their observations to see that the tilt of Earth as it orbits the Sun causes changes in the length of day, which determines the amount of sunlight an area absorbs. The tilt of Earth also changes the angle at which the Sun's rays strike it, thereby varying the concentration of heat energy that falls on it.

Reinforcement

Direct students to place a second push pin somewhere in the Southern Hemisphere. Invite them to repeat their modeling to see how the seasons are reversed in the Southern Hemisphere compared with the Northern Hemisphere.

Assessment Opportunity

This Reinforcement also may be used as an ongoing assessment of students' understanding of science concepts and skills.

Science Notebooks

Have students place their completed activity sheets in their science notebooks.

Cleanup

Return all materials to the kit.

Connections

Science Extension

Have students model the axial tilt of Earth to match the data that they have collected in their Solar Journals from Activity 26. How in its orbit is Earth positioned in relation to the Sun today?

Science and the Arts

Play a recording of Vivaldi's *The Four Seasons* for students. Can students identify the season without being told? How does the composer achieve the feeling of each season: through instrumentation, tempo, major or minor key, and so on?

Afterward, have students describe or record sounds they associate with a season, such as the whine of a lawnmower, the scrape of a rake, the chirp of crickets, or the crunch of snow. What feelings do each of these sounds evoke?

Science and Health

Ask a doctor or other health care professional to talk with the class about the effects of sunlight on health. For instance, staring at the Sun can cause blind spots in the eye. Too much sunlight—particularly direct sunlight—can cause skin cancer. (Why might Australia have the highest rate of skin cancer of any nation?) Yet, too little sunlight—such as occurs in northern climes during February—can cause such depression and malaise that some people find it necessary to spend time under special lights that are high in certain spectra found in sunlight.

Science and Math

Ask the class to analyze the data from their Solar Journals. Begin by calculating the length of each day and night. Are days growing longer or shorter? How can they tell from the length of the days and nights whether they have experienced a solstice or equinox?

Help students find any solstices by looking for the maximum and minimum day length. If the maxima or minima are in the middle of their data instead of at the beginning or end, that means the data indicate a solstice. A day and night of equal length indicate an equinox.

Can students write a computer program that analyzes a database of day and night lengths in order to determine which days are solstices or which days are equinoxes?

Science and Social Studies

The solstices and equinoxes have been a consideration in religious architecture throughout the centuries. Stonehenge, the pyramids of Cheops and Chephren, and Chartres Cathedral were all positioned so that the Sun would shine on a central point at summer solstice. Buildings as much as a thousand years old in countries as distant as Mexico, Ireland, and China all have been sited so that the Sun shines through a particular notch or passage at equinox or solstice.

Have students make models of some structures such as Stonehenge that include the Sun at its apparent position during solstices and equinoxes.