Seasons

Overview

In this activity, students simulate the movement of the Earth around the sun with a light as the sun and a foam ball as the Earth. Tilting Earth's axis in relation to the plane of its orbit demonstrates how sunlight strikes the Earth differently through the year, resulting in seasonal temperature differences. Summer days are warmer partly because the days are longer, but also because the sun's rays strike more directly in that season. Throughout this guide, all information in italics is a "teacher tip."

North Carolina Essential Science Standards

6.E.1.1 Explain how the relative motion and relative position of the sun, earth and moon affect the seasons, tides, phases of the moon, and eclipses.

Background

We have already learned that we have less daylight in winter and more in summer in the Northern Hemisphere, and that at the equinoxes, day and night are about the same. Of course winter is colder partly because the sun does not shine as long at that time of year. However, winter is cooler *also* because the sun is lower in the sky. At that time, the sun's rays strike more obliquely, spreading their energy over more surface area. Summer rays come from straighter overhead, concentrating their energy in less surface area, making them feel hotter. The change in the sun's apparent angle results from Earth's changing tilt, toward and away from the sun. How could the Earth change its tilt toward the sun? The tilt changes because the direction the North Pole points *does not* change: it points to a single spot in space while the earth travels its orbit. In the northern summer, the North Pole points in the general direction of the sun. In the northern winter, the Earth has traveled halfway around the sun, putting the sun "behind" the direction the North Pole points. This lesson illustrates how Earth's tilt and movement around the sun lengthens and shortens days, and raises and lowers the sun in the sky.

Materials

Materials for the whole class

- 1 lamp with a bare bulb
- 1 extension cord
- Duct tape
- Ability to project BLM 8 and BLM 9

Materials for each student

- Student graphs from the previous activity, **Sunrise/Sunset Times For the First Day of the Month in Central North Carolina**
- 1 foam ball (3-inch diameter)
- 1 skewer
- 1 rubber band
- 1 pushpin

- *science notebook
  * *supplied by the teacher*

Preparation

1. Place the lamp in the center of the room. If you use the extension cord, tape it securely to the floor so no one can trip over it.
2. Make an 'Earth Stick' for each student, and one for yourself, by poking a skewer through the center of a foam ball.

Procedure

Ask students to describe North Carolina's weather in all four seasons, and to speculate on reasons for the changes *(they might say for example, changing hours of sunlight, or distance from the sun).* Acknowledge all answers without comment, including "incorrect" reasons such as distance from sun.

1. Ask students to take out their graph from the previous activity: **Sunrise/Sunset Times For the First Day of the Month in Central North Carolina**. Project BLM 5. Ask students to write that temperature for each month by that month on their graph.
2. Ask what students notice about average temperature for the month and length of day. *[lower temperatures during periods of shorter days and higher temperatures during periods of longer days]*.
3. *Seasons simulation:* Daylight length and temperature rise and fall together, but there is also another reason why it is warmer in summer. Give out Earth Sticks (foam balls with skewers through them), rubber bands, and push pins. With an Earth Stick, rubber band, and pushpin, demonstrate the following and ask students to follow along:
   a. Ask students to place a rubber band around the circumference of each ball to represent the equator. Imagining that the North Pole is up, ask students to mark the approximate location of North Carolina with the pushpin (about a third of the way up from the equator toward the North Pole).
   b. Darken the room and turn on the bulb. With Earth Sticks in hand, ask students to stand in a circle around the lamp, as in the Night/Day simulation, and face *away* from the lamp (the sun). Have them turn the ball so that the pushpin faces toward them and lift the ball up in front of them until their Earth is fully lit.
   c. Earth is not positioned in space with the North Pole straight up from our orbit around the sun. The pole points toward the North Star, 23½º away from straight up and down. Explain that an imaginary North Star is somewhere above the front of the room, and everyone's North Pole (stick) must remain pointed toward it throughout the activity. Point your stick toward the front of the room and have everyone copy you. Show how to get the right tilt: tilt your stick toward the front of the room halfway between horizontal and vertical (45º), then 'un-tilt' halfway back to vertical. This tilt is always the same *and* in the same direction. Each person must always tilt their Earth-stick at this angle, and always *toward the front of the room*, no matter where they are.

d. Ask someone at the front and someone at the back of the room to move around their earth to be on the same side as the light, while maintaining the correct angle and direction. Have them lift their ball above the shadow of their head and turn the ball until the pushpin faces directly toward them. Ask the student at the front and a student at the back of the room to report on how long the pushpin's shadow is. *[The shadow for the student at the front of the room will be long and the shadow for the student at the back of the room will be short.]* Explain that for both students, the pushpin (North Carolina) experiences noon (directly toward the sun). Why are the shadows different? Have the students hold these positions, and let everyone look and try to come up with an explanation. Take a minute to discuss this.

e. Re-form the circle, sticks pointing correctly. Ask which students' Northern Hemispheres (on top, where the pushpins are) experience summer, and which ones experience winter *["summer" Earths are at the back of the room, "winter" Earths are at the front]*. Ask which Northern Hemispheres are more directly lit, and how they know it *[shorter shadow at noon]*.

   [Key Point to explain: When shadows are short, the sun feels hotter because the rays are more direct and concentrated. When shadows are long, the sun feels cooler because the rays come at a steeper angle. The steeper angle feels cooler because the sun's heat is spread across a larger area. With the heat spread out, each part of the area gets less heat. The steeper angle also sends rays through more atmosphere, making the sunlight feel even cooler.]

f. Remember that the Earth travels to the left (counterclockwise) in its circle around the sun. Have everyone move that way, maintaining the correct angle of the sticks. Stop periodically and ask which season everyone thinks their North Carolina experiences, and why. Ask all four quadrants of the room.

g. Continue everyone orbiting the sun, this time looking at the Southern Hemisphere. Ask:

   - Which students' Southern Hemispheres are most directly lit (summer)? *[At the front of the room] If they have trouble, ask them to move the pushpin to the Southern Hemisphere, similar position, point it directly toward the light, and look at its shadow. A short shadow means summer, a long shadow means winter]*.
   - When it is summer in the Southern Hemisphere, which season is it in the Northern Hemisphere? *[Winter]*
   - When it is winter in the Southern Hemisphere, which season is it in the Northern Hemisphere? *[Summer]*

h. At this point, the standards are met. You can stop now or continue orbiting and go deeper depending on time and how well students are doing. For example:
   - How do the seasons vary at the equator? *[very little]*
   - Who can show me midnight in North Carolina in the winter*? [student at front of the room has pushpin directly away from bulb]*
   - Who can show me sunrise in North Carolina in the spring? *[student at left of the room has pushpin turning left with the light barely striking the tip]*

Discussion

1. Project BLM 2 from the **Sun's Path Across the Sky** (earlier activity). Ask how the sun's position in the sky might relate to the temperatures in North Carolina throughout the year. Ask for thoughts about why. *[The winter sun is lower in the sky, shadows are longer, and the sun feels cooler. The summer sun is higher in the sky, shadows are shorter, and the sun feels hotter. In spring and fall, the sun's position in the sky and the shadow lengths are in-between. Temperatures are also midway between cold and hot.]*
2. What season is it in North Carolina when the sun shines more directly North of the equator? At that time, what season is it in Santiago, Chile? *[When the sun strikes the Northern Hemisphere more directly, it is summer. At that time, the strikes the Southern Hemisphere less directly, and it is winter.]*

3. What season is it in North Carolina when the sun shines more directly South of the equator? At that time, what season is it in Santiago, Chile? *[When the sun strikes the Southern Hemisphere more directly, it is summer there. At that time, the strikes the North Carolina less directly, and it is winter here.]*

4. How does the simulation of the Earth traveling around the sun relate to how we see the sun's position in the sky? *[Demonstrate with an Earth Stick tilted toward the lamp with pushpin facing the light (summer and noon on a day in the Northern Hemisphere). Imagine that the pushpin is someone looking up at the sun. Where would that person see the sun? Almost directly overhead. They would see short shadows and feel a hot sun.*

   With an Earth Stick tilted away from the lamp and pushpin facing the light (winter and noon on a day in the Northern Hemisphere), someone looking up from the pushpin at the sun would see the sun lower in the sky.

   When the North Pole points away from the sun, the sun is lower in the sky in the Northern Hemisphere, shadows are longer, and the sun feels cooler. When the North Pole points toward the sun, the sun is higher in the sky, shadows are shorter in the Northern Hemisphere, and the sun feels warmer. The same is true for South Pole and the Southern Hemisphere.]

5. Ask students to interpret their graphs with some of the following questions:

   - In the Northern Hemisphere, which three months are hottest? *[June, July, and August]* Coldest? *[December, January, and February]*

   - What season is it in the Southern Hemisphere in July? *[Winter]* In September? *[Spring]*

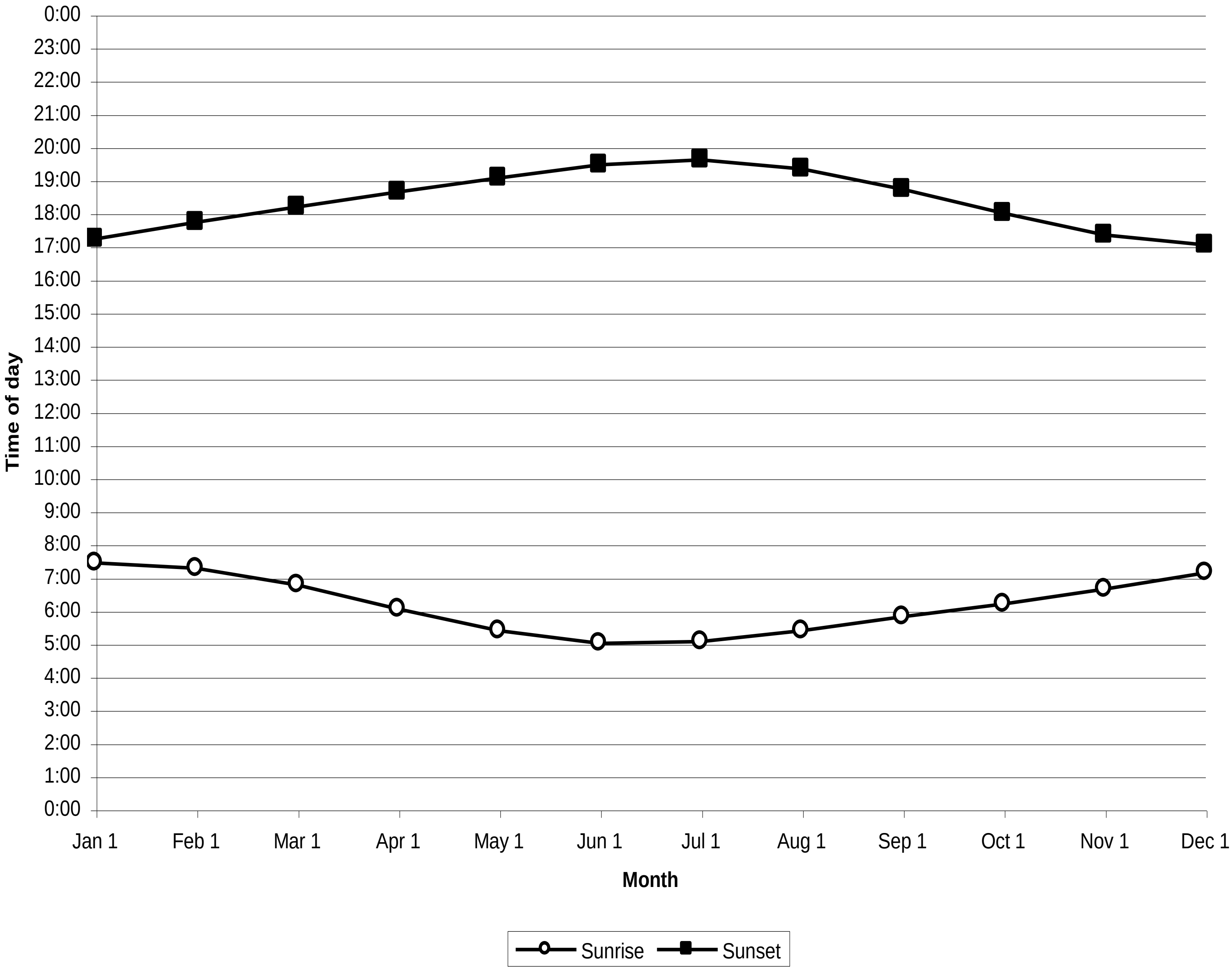
6. Based on observations during the seasons simulation, ask:

- In which months does the sun strike the Earth most directly in the Northern Hemisphere? *[June, July, August]* In the Southern Hemisphere? *[December, January, February]*

- Why is it hotter in summer than in winter? *[The sun's light hits the Earth's surface more directly in summer than in winter. Also, there are more hours of daylight to warm the Earth's surface in summer.]*

BLM 8

Graph 1 How Sunrise and Sunset Times Change Throughout the Year in North Carolina



BLM 9

30-year Average Monthly Temperatures—Durham, NC

Month	Average Monthly Daytime Temperature ˚F
January	40˚
February	42˚
March	50˚
April	58˚
May	67˚
June	75˚
July	79˚
August	77˚
September	71˚
October	60˚
November	51˚
December	42˚