Lesson Plans: Reason for the Seasons

Objective

The objective of this activity is to understand the reasons for the seasons and to study the motion of the earth.

Materials

Each student or group of students will need the following:

- Beach ball
- Ping-pong ball
- Small, pointed bamboo stick
- Marker
- Light source

Important Points to Understand

Most of us are aware that the earth rotates around the sun. The motion of earth relative to the sun is more complex than that of a smaller sphere simply circling around a larger one, however. In fact, several characteristics of the earth's movement in space are important determinants of life. Firstly, the path, or orbit, which the earth follows as it moves around the sun is not a simple circle. Instead, it is an ellipse, or a slightly squashed circle. Secondly, in addition to orbiting around the sun, the earth also spins (rotates) on its own axis, making one complete rotation in a 24-hour period. Think of this axis as an imaginary line through earth from the North Pole to the South Pole. Thirdly, the earth's axis is tilted with respect to the plane in which it orbits. These three observations explain why we experience night and day; why the relative lengths of day and night vary from place to place and from time to time; and why we have seasons on earth. Because these simple planetary processes control the daily and seasonal variation in the reception of solar energy at all locations on the Earth's surface, they have a major effect on all manner of life on Earth.

As the earth makes its yearly elliptical orbit around the sun, it travels close to the sun on two occasions: in spring and fall. These two seasons, in late March and late September, are marked by equinoxes. An equinox, by definition, occurs when day and night are equal lengths: 12 hours each. At the equinox, despite the inclination of the earth's axis, the sun appears directly over the equator so that solar radiation is equally balanced between the two hemispheres. This does not mean that the sun will be directly overhead at midday, unless one stands at the equator itself, but at least this implies that there is an equal amount of daylight hours everywhere on the earth at this time. As the northern mid-summer (~June 21st) approaches, the inclination of the axis ensures that the northern hemisphere is tilted increasingly toward the sun. The sun's rays strike the southern hemisphere more obliquely and therefore less effectively, explaining that winter then occurs in the southern hemisphere while the northern hemisphere enjoys summer conditions. The reverse is the case at the time of the northern mid-winter. The tilt of the Earth's axis to the plane of its orbit around the Sun is about 231/2 degrees. This means that at the equator the Sun at midday is never more than 231/2 degrees from being directly overhead. Consequently there are little or no seasonal variations in the climate in locations near to the equator. Seasonal variation increases with latitude, and this is consistent with the fact that the poles experience six months daylight and six months darkness, although there is a lot of twilight to give partial compensation. Of course nothing in the physical universe is quite so simple, so that it should not be a surprise to learn that the inclination of the Earth's axis is not perfectly stable in time; in fact like a spinning top, the Earth tends to wobble in its spin, but that is perhaps too complex in principle and small in effect to warrant further discussion in the present context.

Procedure

1. Use paired small and large balls (e.g., a ping-pong and beach ball, a grape and grapefruit) to represent the earth and the sun (of course, the sun being represented by the bigger ball). If possible, mark the equator on the small ball, and label the Northern and Southern Hemispheres. Slide a bamboo barbecue skewer through the small ball to represent the earth's axis. Move the small ball to simulate earth's motion. Distinguish between rotation and orbit. Be sure that the earth's axis is tilted, and that the earth rotates around its axis rapidly relative to its elliptical orbit around the sun. Refer to the illustration below. Notice the position of the earth relative to the sun for each season.

or

In a darkened room, have a single light source to represent the sun and move the earth ball to represent the earth's orbit. It may be better with rough outline of continents marked on the ball.

2. On the board or on graph paper, draw a timeline representing one year on earth. For the Northern Hemisphere, mark the onset of the four seasons, the solstices, and the equinoxes. Mark off the length of time it takes earth to rotate once around its own axis and to travel once around the sun.