Lab Activity on the Causes of the Seasons

Objectives

When you have completed this lab you should be able to show how the tilt of Earth's axis and Earth's revolution around the sun causes seasonal variations in…

• temperature

• day length

• height of the noonday sun

Lab Activity #1:
Eliciting <u>Your</u> Understanding of the Causes of the Seasons

Introduction: We have just figured out why the equator is warmer than the poles. But, as you well know, our weather is not the same all year round. It is warmer in the summer than in the winter. The purpose of this activity is for you to realize exactly what you know (or at least what you think) about the causes of the seasons.

Materials: glowing light bulb (to represent the sun)
Polystyrene ball with a stick through it (the stick represents Earth's axis)

Activity: Within your group, take turns expressing your ideas about the causes of the seasons. Use the lamp and small globe as props for your explanations. Don't try to be "correct;" try to express what you REALLY believe. One piece of IMPORTANT information: Earth and all the other planets orbit the sun in a flat plane; Earth is never significantly "above" or "below" the level of the sun. Keep this in mind when you demonstrate your ideas; i.e. as you demonstrate Earth's orbit, keep the model Earth at the same height as the model sun (the light bulb).

Questions: Try to reach consensus within your group and construct a new group model that explains Earth's seasons. Describe and illustrate this model below.

Lab Activity #2: Testing, Refining and Applying Your Model
of the Causes of the Seasons

Introduction: Part of the scientific process is to constantly test models to see if they can account for all observations. If they do not, we modify them. During this activity, you will be testing your model and modifying it (or starting over) as necessary in order to account for all the observations listed below.

Materials: Glowing light bulb (to represent the sun)
        Polystyrene ball with a stick through it (the stick represents Earth's axis)

Activity: For each observation below, use the materials above to explain the cause of each observation. If your model is not compatible with a particular observation, refine, add to or change your model as necessary.

A. The Shape of Earth's Orbital Path: The table on p. 1 of this lab noted the **average** distance of Earth from the sun. The actual distance varies during the year because Earth's orbit isn't perfectly circular[1]. The table below provides Earth's average distance from the sun during selected months of the year.[2]

Month	Average Earth-Sun Distance[3]
January	147,000,000 km
March	149,000,000 km
June	153,000,000 km
July	153,000,000 km
September	150,000,000 km
December	148,000,000 km

1. When is Earth closest to the sun? _____

    When is Earth farthest from the sun? _____

2. Can the distance between Earth and the sun account for the seasons? _____
    Explain the reasoning behind your answer.

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[1]Note: Earth's orbit around the sun is nearly a perfect circle; it is off by only 4%. Astronomers have calculated the resulting difference in incoming solar radiation: it is only 7%.

[2]For those who are curious, astronomers calculate these distances from the size of the sun as seen from Earth (objects look bigger when they're closer and smaller when they're farther away).

[3]Source: Fraknoi, A. (ed.), 1995, The Universe at Your Fingertips: An Astronomy Activity and Resource Notebook: San Francisco, Astronomical Society of the Pacific. This is an EXCELLENT resource for teaching astronomy.

B. <u>The North Star Stands Still</u>: At any particular latitude of the northern hemisphere, the north star is always in the same place in the sky (always straight north, always the same distance from the horizon); no matter what time of day you look or what day of the year it is.

Does your current working model "predict" this result? If so, use the polystyrene ball and the light to show how your model explains why the north star "stands still." If your group model does not predict this result, construct a new model that does and describe how this new model can explain why the North Star stands still.

C. <u>Timing of the Seasons in the Northern and Southern Hemispheres</u>: When it is summer in California (northern hemisphere), it is winter in Argentina (southern hemisphere) and visa versa.

Does your current working model "predict" this result? If so, use the polystyrene ball and the light to show how your model explains why summer and winter are reversed in the northern and southern hemispheres. If your group model does not predict this result, construct a new model that does and describe how this new model can explain why the North Star stands still.

D. Lengths of Days and Nights
   • At the equator, where it is almost always warm, days and nights each last exactly 12 hours all
     year round.

   • Everywhere other than the equator, days are longer in summer than in winter. The longest day
     for us in the northern hemisphere is on the summer solstice (around June 21); the longest day
     for the southern hemisphere is on the winter solstice (around December 21). For example, in
     Chico the days are almost 15 hours long on June 21, but they are less than 9 1/2 hours long
     on December 21. The closer you get to the poles, the more pronounced this difference is. For
     example, in Anchorage, Alaska, the days are 18 1/2 hours long on June 21, but they are only 5
     1/2 hours long on December 21.

   • At the north pole, it is dark from the autumnal equinox (around September 21) through the
     vernal equinox (around March 21) and light from the vernal equinox to the autumnal equinox.
     When it is light at the north pole, it is dark at the south pole and visa versa.

   • At all locations on Earth other than the poles, there are exactly 12 hours between sunrise and
     sunset on the dates of the equinoxes.

   Activity: Draw a dot on your polystyrene ball to represent Chico. Place the polystyrene ball in
             the appropriate positions relative to the light to represent the solstices and equinoxes.
             Note that you can easily see the *circle of illumination* (the line between day and
             night) on the ball. At each position, spin the ball on its axis to model Earth's rotation.
             Notice how long Chico is in the light and how long it is in the dark at each position.

   Questions:
   1. Can your model for the cause of the seasons "predict" this change in the length of the day
       with the seasons? If so, explain how. If not, refine your model as needed so that it will
       "predict" the changes described above.

   2. Can the change in the # of hours of daylight over the course of a year **help** (it doesn't have
       to be the only factor) explain the differences in temperature between summer and winter? If
       so, explain how. If not, explain why not.

E. Attributes of the Tropics of Cancer and Capricorn:
   • At 23.5° North latitude (the Tropic of Cancer), the sun is directly overhead at noon on the summer solstice (around June 21).

   • At 23.5° South latitude (the Tropic of Capricorn), the sun is directly overhead at noon on the winter solstice (around December 21).

   Activity: Draw two circles on your polystyrene ball in the appropriate positions to represent the Tropic of Cancer and the Tropic of Capricorn. Place the polystyrene ball in the appropriate positions relative to the light to represent the summer and winter solstices.

   Question: What is special about the Tropics of Cancer and Capricorn at the solstices that can account for the above observations? Use your model for the seasons to explain how.

F. Attributes of the Arctic and Antarctic Circles:

   • At 66.5° North latitude (the Arctic Circle), the sun never sets on the summer solstice (around June 21); on all other days, the sun does go down at least for a little while. Everywhere north of the Arctic Circle, there are even more days when the sun never sets in the summer (the further north you go, the more days there are with 24 hours of light--"Midnight Sun").

   • At 66.5° North latitude (the Arctic Circle), the sun never rises on the winter solstice (around December 21); on all other days, the sun does make an appearance. Everywhere north of the Arctic Circle, there are even more winter days when the sun never rises (the further north you go, the more days there are with 24 hours of darkness).

   • At 66.5° South latitude (the Antarctic Circle), the situation is similar but reversed (substitute June 21 for Dec. 21 and visa versa).

   Activity: Draw two circles on your polystyrene ball in the appropriate positions to represent the Arctic and Antarctic circles. Place the polystyrene ball in the appropriate positions relative to the light to represent the summer and winter solstices. Rotate the ball on its axis to represent Earth's rotation.

   Question: What is special about the Arctic and Antarctic Circles at the solstices that can explain the above observations? Use your model for the seasons to explain how.