

# *Physical Science*

*with Earth and  
Space Science*

## **Investigations**

*Tom Hsu, Ph.D.*

**cpo**  
science

**FIRST EDITION**

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## 27.1

## Variations in the Heating and Cooling of Earth



Question: What causes the seasons?

In this Investigation, you will:

1. Learn how Earth's orbit affects the seasonal variation of light intensity on Earth.
2. Learn how Earth's axial tilt affects the seasonal variation of light intensity on Earth.

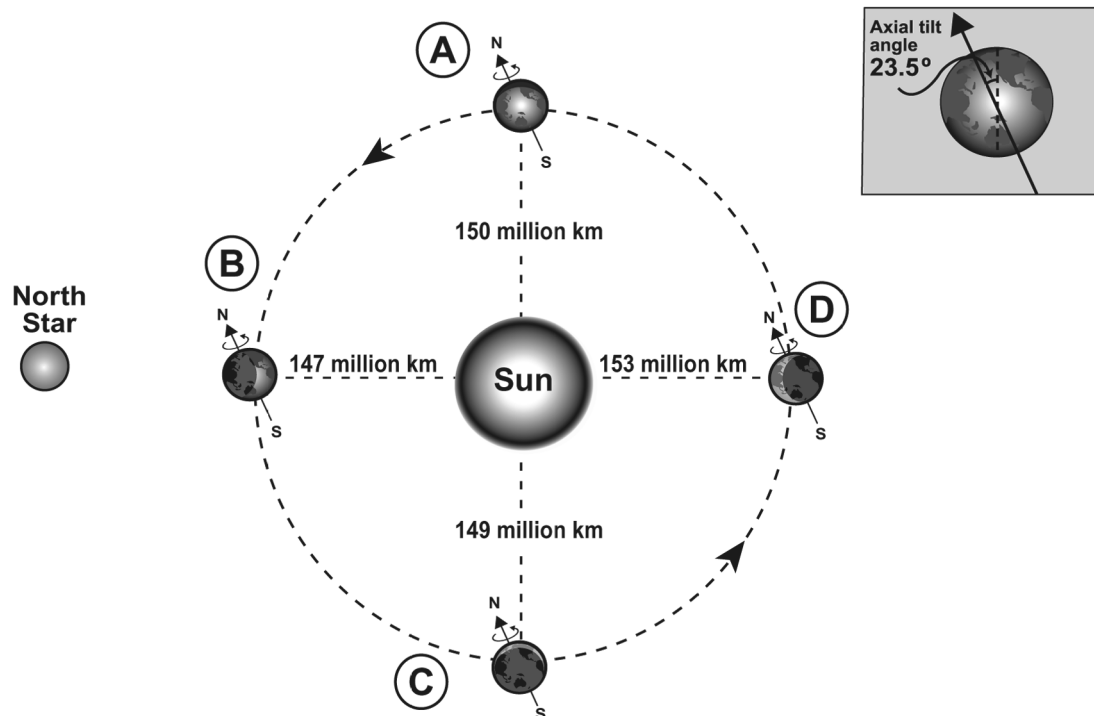
Why do the seasons occur? In the summertime, it is hotter, the days are longer, and sunlight is intense. In wintertime, it is cold, the days are shorter, and the sunlight is less intense. What causes these variations in the heating and cooling of Earth so that seasons occur?

## 1

### Developing a hypothesis about the seasons

The graphic below shows you what Earth's orbit around the sun looks like. The orbit is slightly elliptical so that at certain times of the year, Earth is a little closer to or farther from the sun than at other times. Also, Earth is tilted as it moves around the sun. Could distance or Earth's tilt be the cause of seasons?


To start the Investigation, come up with a hypothesis stating why you think the seasons occur. Do you think they are caused by Earth's distance from the sun? Do you think Earth's tilt causes the seasons? Do you think both of these factors play a role? Or do you think other factors cause the seasons?



- a. Why do seasons occur? What is your hypothesis?
- b. At which point in Earth's orbit is it summer in the northern hemisphere? Draw a diagram to answer this question. Be sure to justify your answer.

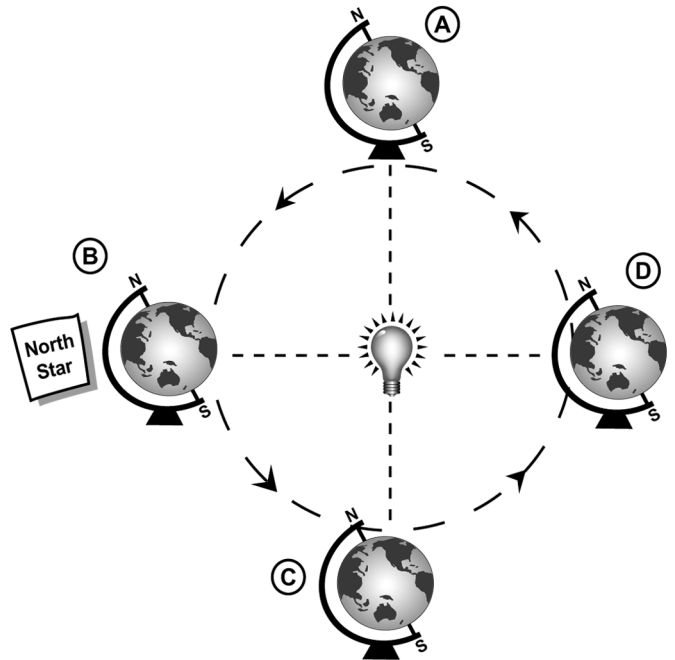
## 2

## Setting up your model of Earth's orbit around the sun

 In this Investigation, you will use an electric meter and solar cell to measure the intensity of light emitted by a light bulb that will act as the sun. The solar cell will collect the light and transform it into current that will be measured by an electric meter. Using this technique, the intensity of the light will be measured in milliamps (mA).

A light source will be placed in the center of your classroom. You will use a globe to represent Earth. You will first measure the intensity of light from the bulb at different *distances* from it. In the next part of the Investigation, you will measure the intensity of light at different *places* on the globe. Relatively low light-intensity readings will represent winter-like conditions, and relatively high light-intensity readings will represent summer-like conditions. In performing these two kinds of measurements, you will determine which factors cause the seasons.

- To get started, your teacher will place in the center of your classroom a lamp with the light bulb uncovered. This light will represent the sun. It is important that the light source emit light equally in *all* directions like the sun does.
- With your class, choose a wall in your classroom that will represent the position of the North Star (Polaris) in the night sky. Tape a sign to this wall that says “North Star.”
- One student will move the globe, in a circle, to each position (A-D) in a counterclockwise direction around the “sun.” This movement simulates *one revolution* around the sun (or one year).
- As the globe is moved from point to point, the axial tilt at the north pole of the globe is always pointing toward the North Star.
- As Earth revolves around the sun, it also spins on its axis. Note that the globe can also be spun on its axis.
- After the demonstration, obtain a globe and use it to discuss the following questions with your group.



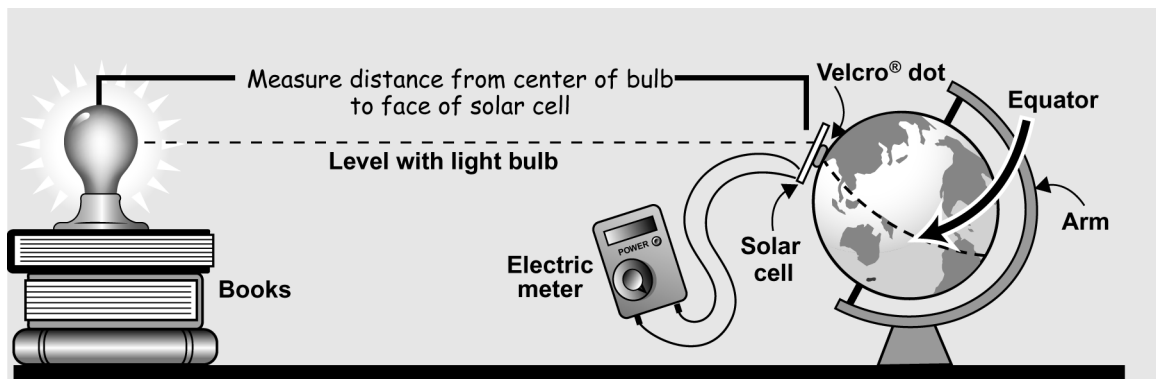
- Although the axis of Earth is always pointing in the same way, what is happening to Earth itself as it revolves around the sun?
- What does the side of the globe that faces the sun represent? What does the side of the globe that faces away from the sun represent?
- Identify the following parts of your globe: equator, northern hemisphere, southern hemisphere, and latitude lines. At what latitude are you located right now?
- In which position in the diagram is the northern hemisphere pointing towards the sun? In which position is the southern hemisphere pointing towards the sun?

## 3

## How does the distance of Earth from the sun affect its intensity?

In Part 1, you read that Earth's distance from the sun varies slightly as it revolves around the sun. In this part of the Investigation, you model the distance of Earth from the sun using a scale distance. You will then measure the amount of current produced by a light source at each scale distance.

It is impossible to measure millions of kilometers in your classroom, but you can use a *scale distance* of 1 centimeter to represent 1 million kilometers. Therefore, a distance of 150 million kilometers would be represented by 150 centimeters. Using the scale distance of 1 centimeter equals 1 million kilometers, determine the scale distance for positions B, C, and D. Write the scale distance in the third column of Table 1 below.




- Gather the following materials: Earth globe, solar cell, electric meter with leads, metric tape measure. Your teacher will have a light source set up in the middle of the room. It will be at the correct level as shown in the diagram above.  
**SAFETY NOTE: The light bulb will get very hot once it is turned on.**
- Attach the solar cell to the Velcro® dot found on the equator of the globe. Connect the leads from the electric meter to the solar cell. Set the electric meter to measure current, in milliamps (mA).
- Place the globe so the face of the solar cell is *exactly* 150 centimeters from the center of the light bulb. You will need one student to hold the end of the tape measure at the center of the light bulb and another to move the globe into the correct distance from the bulb.
- Measure the current, in milliamps, at the equator and record your measurement in the fourth column of Table 1.
- Repeat steps 3 and 4 for the remaining scale distances. NOTE: Do not move the globe to simulate Earth's orbit for each position. Vary only the *distance* from the light bulb.
- Based on your results, answer the questions below.

Position	Distance from the sun (km)	Scale distance from the sun (cm)	Light intensity (mA)
A	150,000,000	150	
B	147,000,000		
C	149,000,000		
D	153,000,000		

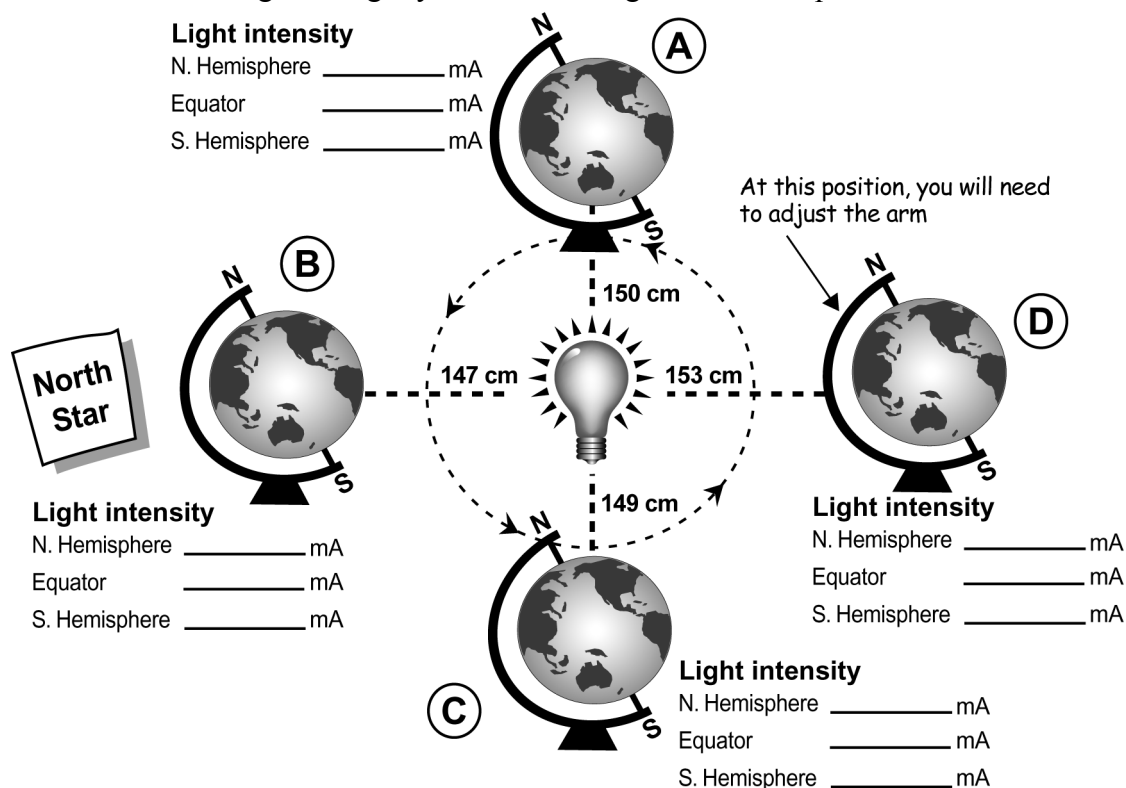
- Are there big or small differences in distance as Earth revolves around the sun?
- Based on your data, how does light intensity change as these distances change?
- Based on your results from this experiment, do you think Earth's distance from the sun over a year causes the seasons? Why or why not?

## 4

## How does Earth's tilt affect the sun's intensity?

 In this experiment you will simulate the effect that Earth's axial tilt has on the intensity of the sun's light. This time, you will model Earth's orbit around the sun, in addition to its distance at the four positions shown below.

- For the northern hemisphere measurement, you will place the solar cell at 45 degrees north latitude. For the southern hemisphere, you will place the solar cell at 45 degrees south latitude. For the equator, you will place the solar cell as you did in Part 3. Your globe has Velcro® dots attached at each of these positions.
- Measure each distance from the center of the light bulb to the surface of the solar cell, as you did in Part 3.
- At each position, make sure the north pole of the globe points **toward** the North Star. Measure light intensity in milliamps. Record your data in the blanks of the graphic. At position D, you will need to move the arm of the globe slightly to the left or right in order to place the solar cell correctly.



- What role does axial tilt play in the intensity of light on Earth?
- At which position (A, B, C, or D) and latitude (northern hemisphere, equator, and southern hemisphere) does Earth receive the most light? The least light?

## 5

## Applying your knowledge

- Of the two factors—distance from the light source and axial tilt—which plays the most significant role in causing the seasons? Was your hypothesis supported by your results?
- Based on your results, which position (A-D) represents the first day of summer in the northern hemisphere? Which position represents the first day of winter in the northern hemisphere?
- Which quarter of Earth's orbit represents summer in the northern hemisphere (from A to B, B to C, C to D, or D to A)? Explain your answer based on your results from the Investigation.

The cover colorfully combines illustrations of the forces of nature studied in the various fields of the physical sciences. Here, the “evolving tapestry of conceptual thinking” begins with water. Water droplets dance with the planets including our own watery planet and Saturn with its icy rings. Water reappears in the combustion reaction of methane, as the substance on which plants depend, as pounding waves, and, on the back cover, as the darkening clouds of a coming storm. From this cycle of water, a modern bicycle rolls into a graphical interpretation of white light split into its rainbow of wavelengths and a fiber optic. You may lose yourself in many of these images which represent hundreds of years of scientific and technological innovation. Nevertheless, that our innovations are inextricably woven into and from the natural world is illustrated by the images of Earth and the spiral connection between the DNA helix and a bicyclist ever-moving forward. On the back cover, images from physics, chemistry, and earth and space science move around a chambered nautilus seen through the windows of the Golden Rectangle. We at CPO Science with Bruce Holloway, the spirited illustrator of the cover, hope these images will inspire your interest and excitement about the discovery of science.

*The CPO Science Development Team*

Foundations of Physical Science with Earth and Space Sciences - Investigations

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CPO Science  
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Peabody, MA 01960  
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<http://www.cpo.com>

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