Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Student Exploration:** **Seasons: Why do we have them?**

**Vocabulary:** direct sunlight, Earth’s axis, equator, indirect sunlight, northern hemisphere, North Pole, season, solstice, southern hemisphere, South Pole, summer solstice, winter solstice

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

1. At what time of day is sunlight strongest – in the early morning (when the Sun has just risen) or at noon (when the Sun reaches its highest point)? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. At what time of year does the noon Sun rise highest in the sky? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Based on your answers, why is it warmer in summer than in winter? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Gizmo Warm-up**

The reasons for **seasons** have a lot to do with the angle at which the Sun’s rays hit Earth. To see why, select the PLATE tab on the *Seasons: Why do we have them?* Gizmo. The image shows a solar panel (**Plate M**) facing the Sun. Check that the ***Axis angle*** is set to 0˚.

1. Click **Fire** to release 100 “rays” of sunlight. Look next to “Number of hits” below the plate.

How many of these rays hit **Plate M**? \_\_\_\_\_\_\_\_\_\_\_\_\_

1. Click **Reset**. Change the **Axis angle** to 40˚, and click **Fire**. How many rays hit **Plate M** now? \_\_\_\_\_\_\_\_\_\_\_\_\_
2. Which do you think will warm up the plate more quickly? (Circle one.)
	* + 1. **Direct sunlight** (sunlight that hits the plate at a 90° angle)
			2. **Indirect sunlight** (sunlight that hits the plate at an angle of less than 90°)

|  |  |  |
| --- | --- | --- |
| **Activity A:** **Sunlight on a plate** | Get the Gizmo ready: * Click **Reset**.
 | 407SE2 |

**Question: How does the angle of sunlight affect the amount of energy that is absorbed?**

1. Form hypothesis: How do you think the angle of the plate will affect how much sunlight hits the plate? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Collect data: Set the **Axis angle**to -80° and click **Fire**. Record the **Number of hits**. Repeat for each angle and fill in the tables below. You can use the slider or type the number into the text field directly and click **Enter** on your keyboard. (Note that “0°” appears in both tables.)

|  |  |
| --- | --- |
| **Axis angle** | **Hits** |
| -80° |  |
| -60° |  |
| -40° |  |
| -20° |  |
| 0° |  |

|  |  |
| --- | --- |
| **Axis angle** | **Hits** |
| 0° |  |
| 20° |  |
| 40° |  |
| 60° |  |
| 80° |  |

1. Analyze: What is the relationship between the axis angle and the number of solar rays that hit the plate? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Interpret: Select the GRAPH tab. What does the graph show? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Apply: At what angle will the plate get the hottest? \_\_\_\_\_\_\_\_\_

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1. Extend your thinking: The plate is a model for how sunlight hits Earth’s surface.
	* 1. Which parts of Earth are most similar to the plate with an axis angle of 0°? Explain.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* + 1. Which parts of Earth are most similar to the plate with an axis angle of 80°? \_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| **Activity B:** **Sunlight on Earth** | Get the Gizmo ready: * Select the EARTH tab on the left and the DESCRIPTION tab on the right.
* Check that the **Axis angle**is set to 0 degrees.
 | 407SE3 |

**Question: What causes seasons on Earth?**

1. Predict: Look at the image of Earth (not to scale). Plate **A** is located at the **North Pole**, and plate **G** is located at the **South Pole**. Plates **D** and **J** are located at the **equator**.
	* 1. Of the plates that are facing the Sun (plates A through G), which ones will receive the most solar energy? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
		2. Which of plates A through G will receive the least? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Check: Click **Fire**. Select the TABLE tab to see how many rays hit each plate.
3. Which plate got the most sunlight? \_\_\_\_\_\_\_\_\_\_\_\_\_\_ The least? \_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Why is it colder at the poles than at the equator? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Set up Gizmo: Click **Reset**, and turn on **Show axis**. **Earth’s axis** is an imaginary line that connects the North Pole to the South Pole. Earth spins around its axis, which is tilted relative to Earth’s orbit. Click **Earth axis angle** to set the axis angle to a realistic 23°.
2. Collect data: On the DESCRIPTION pane, check that **Time A** is selected. Click **Fire**. Select the TABLE pane to see the results, and fill in the left table below. Click **Reset**, and on the DESCRIPTION pane select **Time A + 6 months**. Click **Fire** and fill in the right table.

**Time A Time A + 6 months**

|  |  |  |
| --- | --- | --- |
| **Plate** | **Angle** | **Hits** |
| A |  |  |
| B |  |  |
| C |  |  |
| D |  |  |
| E |  |  |
| F |  |  |
| G |  |  |

|  |  |  |
| --- | --- | --- |
| **Plate** | **Angle** | **Hits** |
| A |  |  |
| B |  |  |
| C |  |  |
| D |  |  |
| E |  |  |
| F |  |  |
| G |  |  |

**(Activity B continued on next page)**

**Activity B (continued from previous page)**

1. Analyze: Plates **A**, **B**, and **C** all lie in the **northern hemisphere**, the half of Earth north of the equator. Plates **E**, **F**, and **G** all lie in the **southern hemisphere**, south of the equator.
	* 1. Which hemisphere gets more direct sunlight at **Time A**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
		2. Which hemisphere gets more sunlight at **Time A + 6 months**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Interpret: Plate **B** is a typical northern hemisphere location, and plate **F** is a typical southern hemisphere location. Circle the answer to each question below.
	* 1. On plate **B**, which season is **Time A**? Start of summer Start of winter
		2. On **B**, which season is **Time A + 6 months**? Start of summer Start of winter
		3. On **F**, which season is **Time A**? Start of summer Start of winter
		4. On **F**, which season is **Time A + 6 months**? Start of summer Start of winter
		5. In general, how are seasons in the northern hemisphere related to seasons in the southern hemisphere? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Apply: December 21 and June 21 are important dates called **solstices**. The **winter solstice** is the shortest day of the year. The **summer solstice** is the longest day of the year.
	* 1. Which date does **Time A** represent? June 21 December 21

This date is the winter solstice in the northern hemisphere, and the summer solstice in the southern hemisphere.

* + 1. Which date does **Time A + 6 months** represent? June 21 December 21

This date is the summer solstice in the northern hemisphere, and the winter solstice in the southern hemisphere.

1. Summarize: Based on what you have seen, what causes the seasons? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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