The Reasons

For the Seasons

Studying the effects of direct and indirect sunlight

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Title of Lesson: Reasons for the Seasons

Grade Level: 8th

Subject(s): Astronomy: Seasons

Summary:
For this lesson, which can be implemented as a station in a larger lab activity, students will measure the temperature on a globe representing the earth in different seasons, illustrating that the seasonal temperature variation has nothing to do with the distance from the earth to the sun, and everything to do with how much direct sunlight a region gets.

Time Required: 20 minutes

Group Size: Groups of 3-4 students each

Cost to implement: For the equipment available in a typical science classroom, this activy should cost less than $10 (for extra lightbulbs, string or tape).

Learning Goals:
- Students understand that seasons are not caused by the earth's orbit taking it closer to the sun and farther away from it
- Students understand that seasons are not caused because the earth tilting toward the sun means that one hemisphere is "closer" to the sun than the other
- Students understand that a region that gets more direct sunlight is hotter than a region which gets sunlight at an angle, and this is the reason for the seasons, as well as the reason the equator is hot and the poles are cold.

Level of Inquiry:
The inquiry level of this activity is generally low: Students are given a question, told the data to collect and how to collect it. Students are then lightly guided to use the evidence they have collected to form their own explanation.

Safety Issues: Students will be measuring the distance between a point on a glboe and a lightbulb, so need to take care not to burn themselves on the lightbulb.

Materials List:
For setting up:

- Construction paper
  - Cut into 2 circles and 2 arrows for each station (see attached setup)
  - Cut the shape of a person (see lesson closure)
- Tape
- Marker

Each station will need (see attached setup):

- A labeled globe
- A thermometer or temperature probe
- Tape
- String cut into uniform lengths (1-1.5 feet)
- A light fixture mounted to a pole
- A 75 Watt or higher lightbulb

Introduction / Motivation:

When showing students the lab setup, ask students: "What is wrong with this setup?" or, "In what ways is it not really representative of the earth/sun system?" You may get answers ranging from
"They're not big enough" to "The sun is made of gas", "The sun isn't hot enough", "The sun isn't bright enough", or "The sun isn't giving out light in all directions". These are all great, but the answer you are mainly looking for is "The sun is too close to the earth". (If you shrunk the earth down to the size of a globe, the sun would be located 3.5 to 5 km away, for a 12"-16" globe).
So what, you might ask? This means that for the real earth, whether it is tilted toward the sun or away from the sun, the distance from any point on earth to the sun is basically the same. Any difference is insignificant compared to the HUGE distance between the earth and the sun.

You can compare this to talking about the distance between any two of the students in the class, and Paris, France. Technically, one of the students is closer to Paris than the other, but does it matter? For that matter, does it really matter where in all of Los Angeles the student is when talking about the distance to Paris? The distance is basically the same, whether you are on the Eastside or the Westside, and no atlas would make the distinction. The size of the cities is insignificant compared to the distance between them.

This idea is really important for this lab: it means that to measure the temperature somewhere on the globe, you have to make sure that your bulb/sun is always the same distance away, so you have to keep adjusting the spacing between the earth and the sun.

Procedure:
Set up the lab station according to the attached directions

Students will follow the attached worksheet to make measurements of the temperature in Canada and the Equator in the Summer and Winter, and answer questions about their results.

Lesson Closure:
Even after the worksheet, students are often still confused about what 'direct' and 'indirect' sunlight mean, and why the angle that the sun hits should matter for the temperature.

One analogy which you can make to help students understand this is Laser Tag.

Ask students what the goal of Laser Tag is (To hit others, and to not be hit yourself). Ask them, What makes it easy to hit someone? What makes it harder?

Show students that a person who is leaning backward (or forward) at an angle is a smaller target than a person standing straight up (a small paper person cutout is a handy prop here). Compare this to the sun trying to hit the earth with its rays-- when an area of earth presents a big target (like the equator or Canada in the summer) it gets hit with more rays that an area that presents a small target (like Canada in the winter). The students should have seen this from the drawings they made of the paper circles over the Equator and Canada in each season.

Another comparison you can make is with the height of the sun in the sky. What are the hottest and coldest times of the day? Noon is hotter than sunset because the sun is hitting you from directly overhead, rather than from low in the sky. The sun is always higher in the sky near the equator, and lower near the poles, which causes their temperatures to differ accordingly.

Finally, it is useful to note that there are secondary effects that help make it hotter in the summer: the days are longer, for example. However, this is not the MAIN reason that summer is hotter than winter, for the longest days in the summer are at the North and South poles, where the Sun never sets-- yet it remains very cold there!

This lesson was inspired by a Vernier Probe lesson in their Middle School Science with Vernier lab manual. However, the lesson may be easily conducted using a thermometer in place of a temperature probe.

References:
Middle School Science With Vernier: What Causes the Seasons?
http://www.vernier.com/cmat/msv.html

CA Science Standards addressed:
This lesson is not directly related to 8th grade science standards, but addresses common misconceptions about the seasons that have been shown to persist even into adulthood.

Attachments: Worksheet for this activity, as well as a detailed description of the setup required for this activity.

Station Setup: Materials Required

75 Watt or higher light bulb

Clamp light

Thermometer

Globe

Stand

String
(cut into uniform lengths)

Tape

Station Setup: Labeling the Globe

Tape a construction paper circle (ideally, in a dark color so that it absorbs heat more quickly!) over the regions for which you want the students to make temperature measurements (suggested: Canada and the Equator)

Depending on the background of the students, and your learning goals for the lesson, you can also tape arrows at the bottom of the globe stand to help students more quickly (and correctly!) position the globe for the Northern Hemisphere seasons.

Station Setup: Instructions

Attach the clamp light to the stand.

Position the light so that it is at the midpoint of the globe (at the same level as the Tropic of Capricorn if it is Winter in the Northern Hemisphere, or at the same level as the Tropic of Cancer if it is Summer in the Northern Hemisphere)

Label the Globe with the construction paper circles, taping them where you want students to take data (Canada and the Equator) and arrows indicating the seasons, if desired.

Cut string into 1-1.5 foot lengths for each station.

Make sure that each station has

- a string
- a labeled globe
- a thermometer
- tape to attach the thermometer in place while taking measurements
- a light source, set to the correct height.

What Makes the Seasons?

DIRECTIONS:

STEP #1:

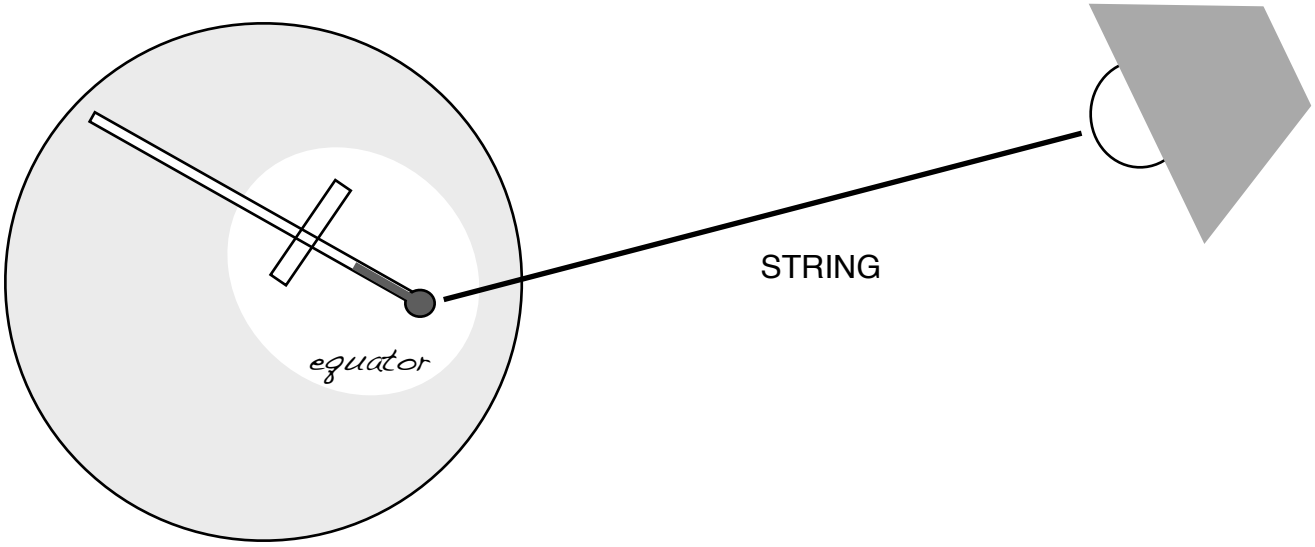
Turn the globe so that it is winter in the Northern Hemisphere, and daytime in Canada.

STEP #2:

Tape the thermometer or temperature probe onto the paper circle over Canada. **Make sure the thermometer/probe is oriented vertically (North-South).**

STEP #3:

Use your measuring string, and move the light source until one end of the string is at the end of the thermometer/probe, and the other end of the string can just reach the lightbulb. **Make sure this distance is the same for every measurement you take!**



STEP #4:

Wait for 3 minutes. Answer the questions below the data table.

STEP #5:

Record the temperature in your data table.

STEP #6:

Do steps #2 through #5 again, this time taping the thermometer/probe over the paper circle on the Equator.

STEP #7:

Do **EVERYTHING** again, but this time turn the globe so that it is summer in the Northern Hemisphere

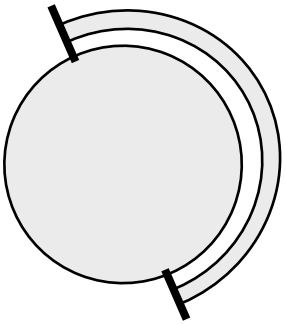
Data Table

Location	**Temperature** (degrees Celsius)	
	Winter	Summer
Canada		
Equator		

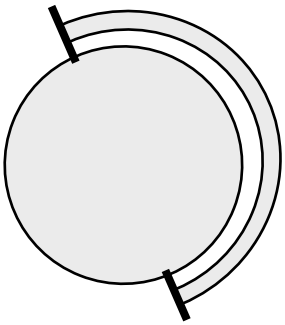
QUESTIONS:

Draw what the shape of the paper circle over Canada looks like when you stand where the sun is

In Winter:

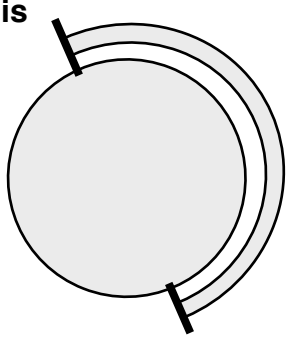


In Summer:

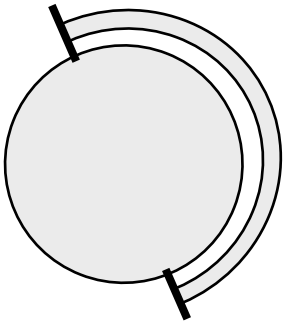


Draw what the shape of the paper circle over the Equator looks like when you stand where the sun is

In Winter:



In Summer:



How does the apparent size of the circle, which represents how much direct sunlight each location collects, change with the seasons?

Why do you think the weather near the equator is always hot and the climate is tropical?

How could you explain why the North pole and Antarctica are always cold?