ARM

CLIMATE RESEARCH FACILITY

Education and Outreach Lesson Plan

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Grade levels 6-8

Why is it Hotter at the Equator?

Why is it Hotter at the Equator?

Approximate Time

One hour for experiment; additional time for Student Record Sheet.

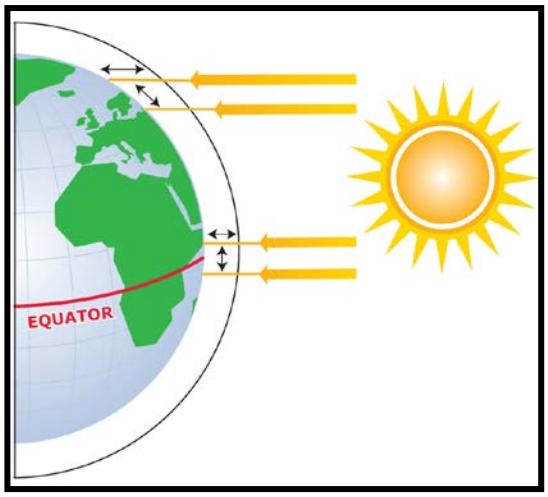
Objective

The student will investigate the different heating effects of sunlight as evidenced by observation, documentation, and explanation of how the angle of direct sunlight affects heat differential.

Key Points to Understand

- Slanted light does not heat objects as quickly as direct light.
- Because the Earth is nearly round, the equator receives direct light, and the poles receive slanted light, with a gradation in between.
- Due to the differential heating of the Earth's surface (unequal heating of all regions), it is always warmer at the equator than at the poles.

Background Information

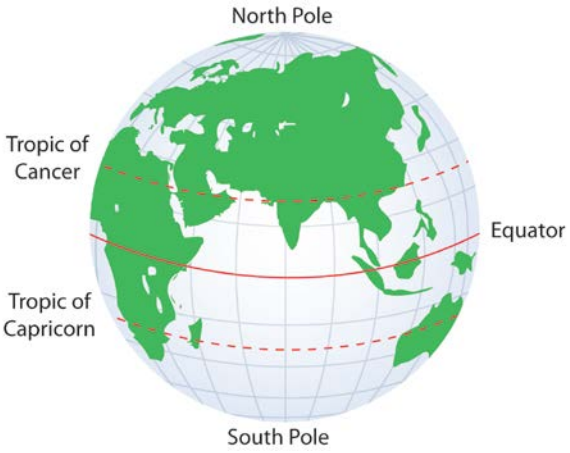


Temperatures at the equator are, on average, the hottest on the planet. It is a common misunderstanding that it is hotter at the equator because the equator is closer to the sun. Its location at the center of the Earth is what makes its average temperature warmer than any other place on Earth, because the equator always receives **direct sunlight**, whether it is summer or winter. Because of the Earth's spherical shape, sunlight hits the equator directly year-round, unlike the North and South Poles.

The sunlight is most indirect when hitting the North and South Poles; therefore, it is coldest there. Since the Earth is tilted at its axis, the poles do not consistently receive the same amount of sunlight throughout the year. In addition, extensive ice and snow at the poles reflects back to space some of the sun's energy that reaches the Earth. A beam of sunlight falling on the equator has a much more intense effect than the glancing rays spread over a much larger area of the curving surface near the poles. Therefore, it is hotter at the equator than at the North Pole because **the sun's heat is concentrated directly overhead at the equator.** The higher the sun in the sky (angle) the warmer it is.

Key Vocabulary

- **Celsius**: Also, Centigrade. A temperature scale (Celsius scale) in which 0° represents the ice point and 100° the steam point. Symbol: C
- **Equator**: The imaginary circle around the Earth's surface, equidistant from the poles and perpendicular to the Earth's axis of rotation. It divides the Earth into the Northern Hemisphere and the Southern Hemisphere.
- **Gradation**: Any process or change taking place through a series of stages, by degrees, or in a gradual manner.
- **Heat differential**: The distribution of *heat* (or variation in temperature) in a given region over time.



- **North/South Pole**: The end of the Earth's axis of rotation, marking the northernmost/southernmost point on the Earth.

Materials

- 3 identical Celsius thermometers per group of students (note: *thermometers need to be alcohol-filled*, backed with glass or metal)
- Reflector lamp with clamp and 60-watt light bulb
- Ring stand with iron ring
- Utility clamp (used to secure the ring stand)
- Black construction paper (one sheet per group of students)
- Several books to prop thermometers
- Metric ruler
- Scissors
- Stapler
- Pencil
- Student Record Sheets
- Digital timer

Preparation

Be sure that all materials are either centrally located or are already distributed to student groups. The teacher may do as much or as little preparation of materials (setting up lamps, covering thermometers) as desired. The more preparation done ahead of time, the less time will be required for the

experiment/activity, but the need for students to learn to use laboratory equipment should be considered. Use alcohol-filled thermometers for this activity. **Urge students to use caution to avoid breaking the fragile thermometers and burning themselves on the lamp.** Having a globe on hand may aid in your discussion during and after the experiment.

Procedure

1. Use black construction paper to make a cover for the bulb of each thermometer, as shown in Figure A. Cut a strip of black construction paper 5 centimeters by 10 centimeters. Fold the paper in half and staple four times, as shown in Figure A. Insert the thermometer. Make three covers and cover each thermometer.
2. Prop the thermometers, as shown in Figure B. One should be vertical (A), one slanted at about a 45-degree angle (B), and one horizontal (C). Label the thermometers. Make sure you can easily read the thermometer scales without touching them during the experiment.

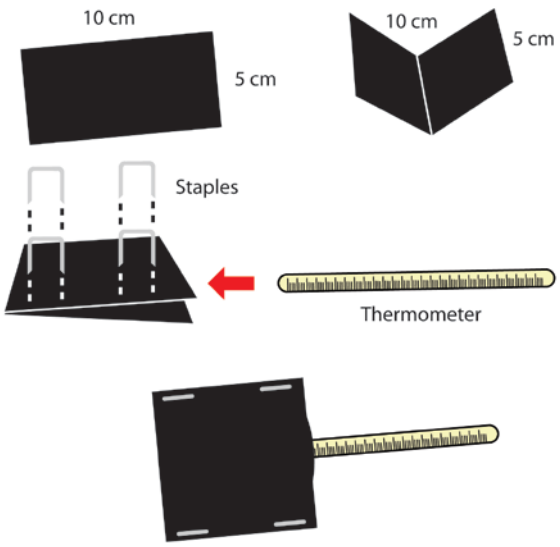


Figure A

3. Attach the lamp to a ring stand and ensure it will not move during the experiment. Use the utility clamp to secure it to the table. Adjust the lamp on the stand so that the light bulb is centered 10 centimeters above the bulbs of the thermometers.
4. Before turning on the lamp, record the temperature of all three thermometers on the student worksheet under the "0 minutes" column of the data table.
5. Turn on the lamp and record the temperatures for each thermometer every 3 minutes for 15 minutes (a total 6 samples). Do not move the thermometers when reading the temperatures. Record all temperatures on the data table on the student worksheet.
6. Using the data collected, create a graph and plot the results under time versus temperature for all three thermometers using different lines (different colors, solid, dashed, etc.) to show the results of each thermometer.

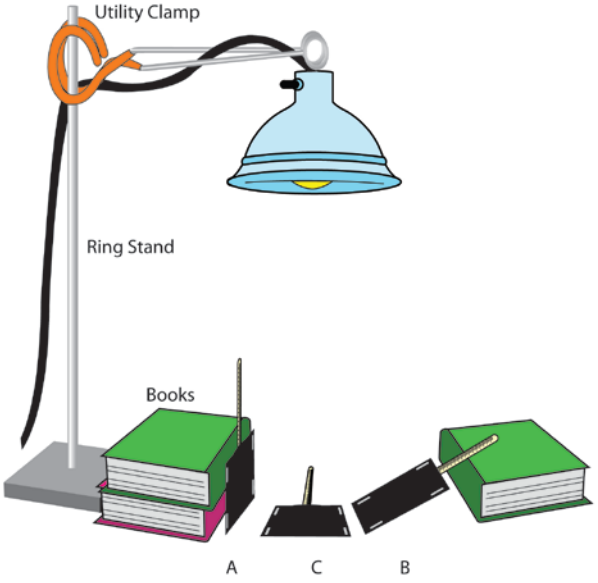


Figure B

Closure and Evaluation

Ask students:

1. Which thermometer showed the greatest temperature increase? Why do you think this one had the greatest increase?
2. Which thermometer(s) best represents the way sunlight strikes the equator?
3. Which thermometer(s) best represents the poles?
4. What parts of the globe would the third thermometer represent?
5. Draw a picture of each thermometer. Label each one with the region of the globe it represents. Be sure to draw each one with the correct angle.
6. If you were given a data table that listed the average yearly temperatures for cities as you travel from the equator towards a pole, what trend do you think you would see in the temperatures? If a trend exists, what should this trend be and why would it exist?

Students will complete a Student Record Sheet including data table, graph, and several questions. The above questions may be used as a class discussion or for individual assessment.

Suggested Follow-Up Activities

- Using what you learned on this activity, how can you explain the fact that the equator is always hotter than the poles?
- Write a paragraph using this topic sentence: **It is always hotter at the equator than at the poles or other regions of the earth.** Use information you learned in the experiment to support your explanation.
- Using either a newspaper or an internet weather site, locate the temperatures for cities located along the equator, temperate zone, and the North and South Poles. How does this information compare with your experiment results?
- Collect temperature data (as done above) once a week for a period of 4 weeks. Make a table and a graph much like the one in the experiment. Use a different color or line for one city in each of the locales mentioned above (equator, poles, temperate zone) to plot temperature by week for 16 weeks. Does this long-term data confirm or negate your findings from the experiment?
- How would knowing the proximity to the equator for a given city help a person to pack clothing for a 3-week visit? Make a list of clothing a reasonable person would take to each to the cities you plotted on your longitudinal graph above.

Name:_____

Date:_____

Title: _____

Why is it Hotter at the Equator?

Research Question: Why is it hotter at the equator?

Hypothesis

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Materials

- 3 identical Celsius thermometers
- Reflector lamp with clamp and 60-watt light bulb
- Ring stand with iron ring
- Utility clamp (used to secure the ring stand)
- Black construction paper
- Several books to prop thermometers
- Metric ruler
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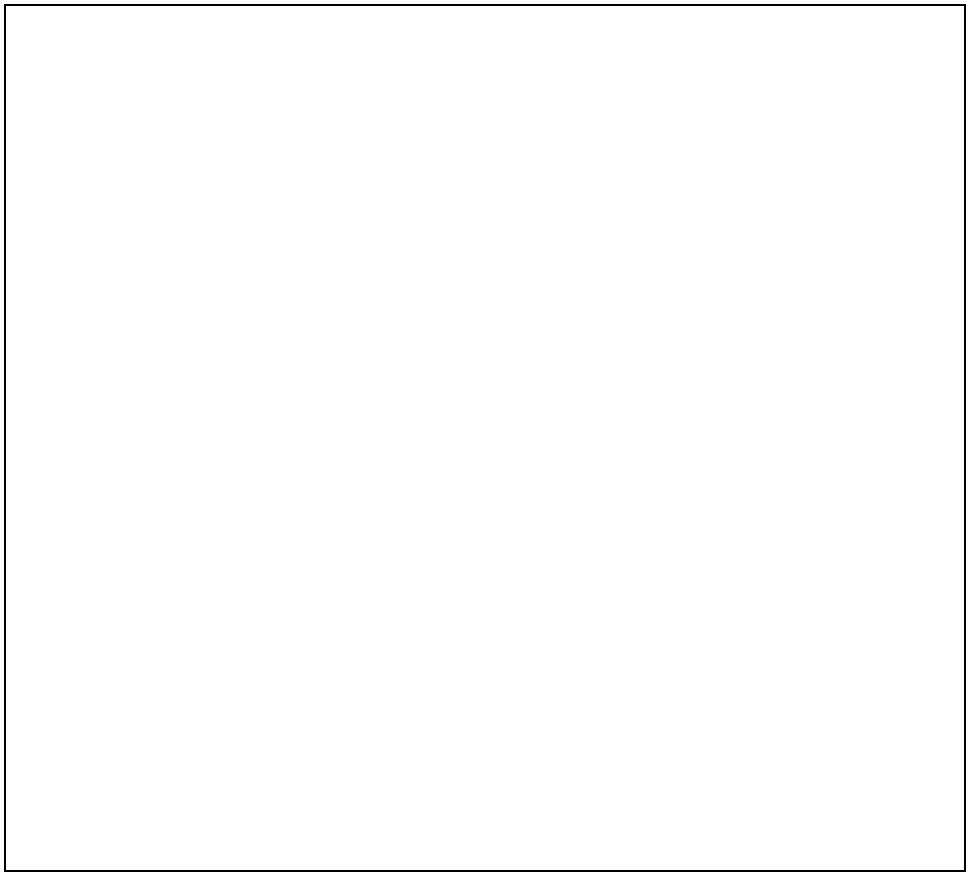
- Digital timer

Data

Temperature Differentials (due to angle of thermometer)

	0 minutes	3 minutes	6 minutes	9 minutes	12 minutes	15 minutes
Thermometer A						
Thermometer B						
Thermometer C						

Graph the data from the Temperature Differentials Table. Include: Title, labels for each axis, scale, and key.



Conclusion

Based on your hypothesis, recorded data, and findings from the experiment, write a conclusion.

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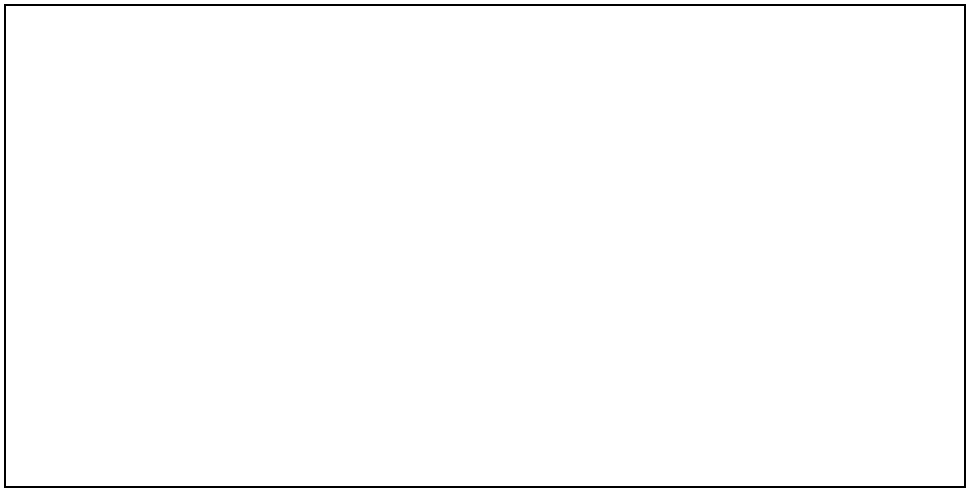
Draw a representation of sunlight hitting the Earth that illustrates your conclusion in the box below. Use labels.



Answer the following questions using the data collected.

1. Which thermometer showed the greatest temperature increase? Why do you think this one had the greatest increase?

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2. Which thermometer(s) best represents the way sunlight strikes the equator?

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3. Which thermometer(s) best represents the poles?

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4. What parts of the globe would the third thermometer represent?

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5. Draw a picture of each thermometer in the box below. Label each one with the region of the globe it represents. Be sure to draw each one with the correct angle.

6. If you were given a data table that listed the average yearly temperatures for cities as you travel from the equator toward a pole, what trend do you think you would see in the temperatures? If a trend exists, what should this trend be and why would it exist?

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