Earth Systems
Standard 6, Objective 2

Title: Direct and Indirect Radiation Lab

Brief Description: Students will model the intensity of the sun's rays striking Earth at different places, by using a flashlight and graph paper.

Objective: Students will determine the relationship between the angle of the sun and the intensity of light. They will do this by calculating the surface area that a source of radiation covers on a piece of graph paper.

Materials needed: flashlights or other light source, colored pencils, graph paper, protractors, textbooks and tape (optional) student sheet (see below)

Background Knowledge: Students should understand latitude and longitude. They should understand solar radiation and how to use a protractor.

Time needed: 50 minutes

Safety/Security Concerns: None

Teacher procedures:
1. Assemble needed supplies and run off enough copies of the student sheets
2. Hook: Turn off all the lights in the classroom after students have arrived. Hold a flashlight under your chin and turn it on. (Like you are going to tell a ghost story. You may want to cackle or howl to get a laugh from the students.)
3. Ask for 3 brave student volunteers. Have the students come to the front of the classroom. Tell your class to watch the light on the faces of the volunteers and the volunteers reaction to the light. Shine the light on the first volunteer at a small angle (indirectly). The next volunteer should be more direct and the last volunteer shine the light directly on their face. (You may want to make sure this is a good natured student.) Most likely you will receive a wince from the last student.
4. Thank the volunteers and let them return to their seats. Turn the lights back on in the classroom.
5. Ask for students to explain to you the differences in the light on the faces of the 3 volunteers and why they responded the way they did.
6. Hopefully students will make the connection between the angle of the flashlight and the directness of the light. This should lead well into the lab.
7. Pass out the student sheets.
8. Allow students to read through the background information in their labs and complete questions in background.
9. Have students read through the lab procedures and make their predictions.
10. Clear up any questions students may have regarding the lab.
11. Allow students to complete the lab.
12. Provide time for students to answer questions.
13. Discuss questions.
Answers to Background Information:

Angle $A \approx 30$-degrees has the coldest temperatures
Angle $B \approx 60$-degrees has moderate temperatures
Angle $C \approx 90$-degrees has the warmest temperatures
Answers will vary for student explanations. Accept all answers.

Answers to Analysis Questions:

1. $90$-degrees
2. Direct
3. $0$-degrees latitude, at the equator. The temperatures would be higher because the radiation from the sun is more direct.
4. The overall energy is greater per square meter because the sunlight is more direct. Sunlight equals the energy which powers a food chain. There will be more organisms in the ecosystems at the equator because more energy is available.
5. The larger latitudes near the poles. The temperatures would be coldest because the radiation from the sun is scattered, or less direct.
6. The overall energy per square meter would be much smaller because the energy from the sun is spread out over a greater distance. There are less organisms at the poles.
7. If you change the distance of the light source you change the intensity of the light. The distance doesn't matter as long as you are consistent with each angle.
8. The climate of a region is determined by temperature and rainfall. The directness of the sun's radiation is a major factor in determining the temperature.
9. Other factors which can influence climate are elevation, proximity to a body of water, and air and water currents.
10.

The angle shown in drawing $A$ represents Utah during the winter. The angle is smaller relative to the angle shown in drawing $B$. Drawing $B$ represents Utah in the summer when the Northern Hemisphere is tilted towards the sun. This increase the angle at which the sun's rays strike the earth in the $N$-hemi. This causes the radiation to be more direct and causes the warmer temperatures.
Answers to Conclusions:

Answers will vary but should be detailed and relevant. Students should also use complete sentences.

Sample Grading Rubric:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Points Possible</th>
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</thead>
<tbody>
<tr>
<td>Background information questions</td>
<td>8</td>
</tr>
<tr>
<td>Prediction</td>
<td>2</td>
</tr>
<tr>
<td>Quantitative Data</td>
<td>3</td>
</tr>
<tr>
<td>Qualitative Data</td>
<td>3</td>
</tr>
<tr>
<td>Analysis Questions answered correctly</td>
<td>20</td>
</tr>
<tr>
<td>Conclusions valid and complete</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>45</strong></td>
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Title: Direct and Indirect Radiation Lab

Background Information:

Using your protractor, determine the angle at which the sun’s radiation strikes the earth at the latitudes indicated by letters A, B and C. Write the angle next to the letter. What are the temperature differences at the three latitudes of A, B, and C? How do you think the angle that the sun’s radiation hits the earth correlates to the relative temperatures at the latitudes of A, B and C?

Objectives: To determine the relationship between the angle of light striking a paper and the surface area on the paper that the light covers.

Materials: flashlight, 3 colored pencils, graph paper, protractor, tape (optional), textbook (optional)

Procedures:
1. Obtain all necessary materials.
2. Shine a light on a sheet of graph paper at a 90-degree angle. Outline the lighted area with a red pencil. (Hint: You may want to tape your graph paper to a textbook. It helps.)
3. Count the number of squares in the area and record it in the data table.
4. Repeat the step above but shine the light this time with the paper at a 60-degree angle. Use your protractor to help you find the correct angle. Use a different colored pencil to outline the area.
5. Repeat again, holding the paper at a 30-degree angle. Use a different colored pencil to outline the area.
6. Be sure to keep the flashlight the same distance from the paper each time.
7. Answer the analysis and conclusion questions.

Predictions: Which angle of radiation has the most concentrated light (covers the least amount of squares)?

Quantitative Data: (numerical)
<table>
<thead>
<tr>
<th>Angle</th>
<th>Number of squares in lighted area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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**Qualitative Data:** (written observations)
Describe the observed difference between the intensity of the light when the flashlight was held at each angle.

**Analysis Questions:**
1. What angle had the most concentrated radiation?

2. When the angle is at 90 degrees is the radiation direct or indirect?

3. What latitude receives the most concentrated/direct radiation?
   What can you infer about the temperatures there?

4. What, in general, can you infer about the energy per square meter at the equator?

5. What latitude receives the most indirect radiation?
   What can you infer about the temperatures there?

6. What, in general, can you infer about the energy per square meter at the poles?

7. Why was it important to keep the flashlight the same distance each time?

8. How does the angle of the sun’s radiation affect the climate of at certain latitude?

9. What other factors can influence climate?
10. How does the angle of the sun’s radiation change from season to season in Utah? Draw a diagram to help you explain your answer.

Conclusions: Please summarize 2 main ideas you learned from completing this lab. Be sure to be complete and use full sentences.