SUMMER MIDNIGHT SUN

Summary
Students build a three-dimensional model of the rotation of the earth to appreciate the extremes of daylight hours at different months of the year, and make connections between available sunlight and the growth and behavior of plants of the arctic.

Grade Level
5-8; 3-4

Time Estimate
one to two class periods.

Subjects:
math, physics, geography, science

Skills:
analysis, application, comparison, problem-solving

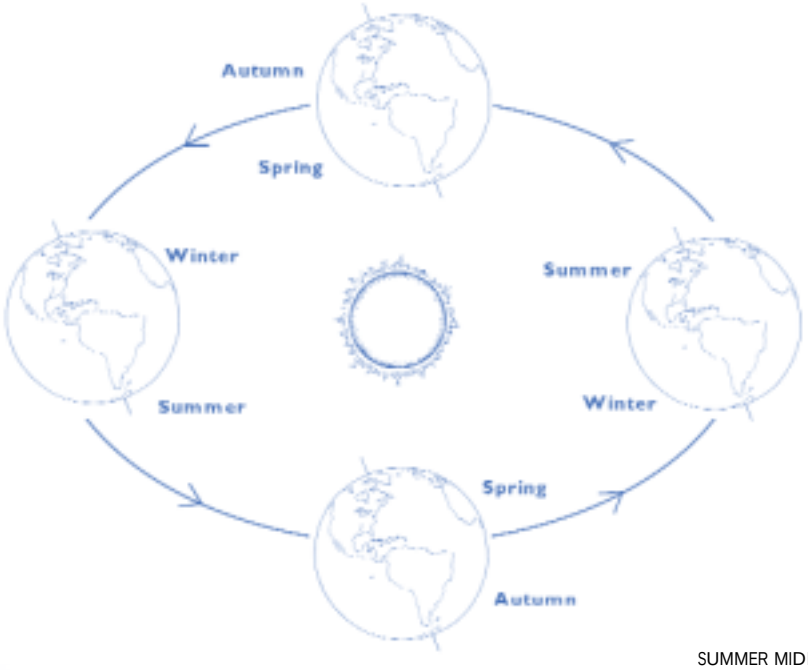
Learning Objectives
Students will be able to
- ✔ Demonstrate how the tilt of the earth and its rotation affects day length in the arctic (and seasons around the world).
- ✔ Explain how day length and available solar radiation influence survival strategies of plants native to the arctic.

Materials:
- ✔ Globe, flashlight, modeling clay, scissors, glue, Styrofoam balls and toothpicks—enough for four small and one large ball for each student and five toothpicks for each student, pencils or pens.
- ✔ Copies of student worksheets

Background

The Earth's axis is an imaginary line through its core, connecting the North and South poles. The earth revolves around this axis, one full revolution per day. The earth rotates so that during the day we face the sun, and at night we face away from the sun. Because the earth is round, parts of it are closer to the sun than others. Parts that are closer (nearer to the equator, lower latitude) experience more intense sunlight than parts that are further, such as the arctic at high latitude. To complicate matters further, the Earth's axis is at a constant tilted angle of 23.5 degrees. Over the course of a year, as the earth makes its orbit around the sun, the tilt produces variable day lengths, and the change of seasons. When the arctic is tilted away from the sun, in the winter months, it gets little or no sunlight. The sun appears to be at a very low angle on the horizon, which also means less intense light reaching the arctic. On the other hand, when the arctic is tilted toward the sun, in the summer months, it gets more intense sunlight almost around the clock.

Sunlight is critical to photosynthesis, the process by which plants produce their own food. Plants need water and sunlight in order to photosynthesize. Adequate light and thawed water are only available for 3-4 months a year in the arctic. The growing



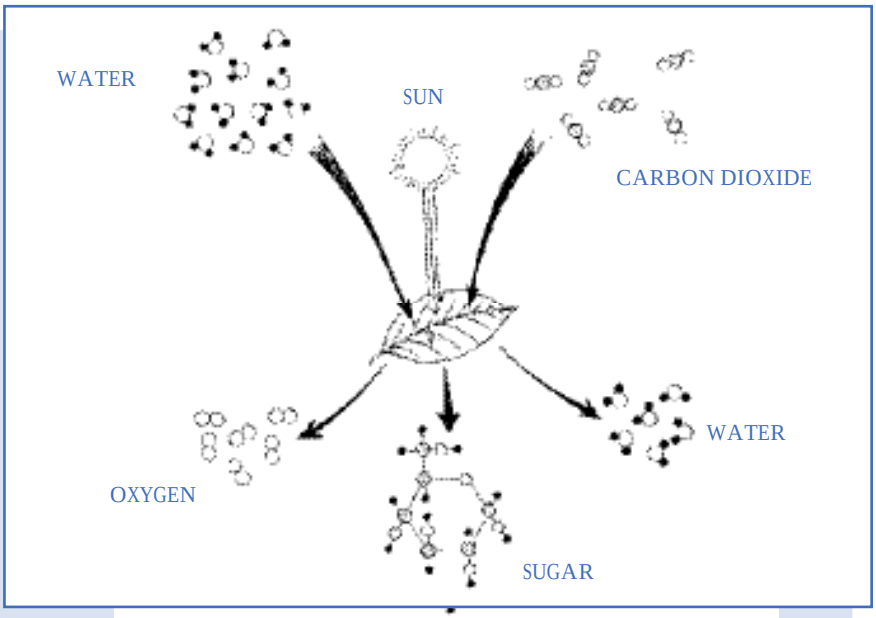
season is only about 50-60 days. Because plants are at the bottom of every food chain, sunlight is critical to all life.

Plants and animals of the arctic, where available sunlight is highly variable throughout the year, have adaptations which help them cope with this challenge. Most plants and animals hibernate or become dormant in the winter. Some animals migrate in the winter to warmer areas south of the arctic circle. Plants and animals take advantage of the summer with a burst of growth or activity during this time. For example, during the summer animals can eat throughout the day and night, helping their young ones grow as quickly as possible before winter comes and the land freezes over again and becomes dark. This period also helps many animals accumulate blubber, a layer of fat that helps keep them warm and provides them with energy reserves during the long winter months.

Emphasize to your students, that plant life all over the world is affected by both the length of light and the strength of light that reaches the earth, wherever they may be.

In this activity, your students will construct a three-dimensional model showing the position of the earth relative to the sun at four different times of the year in order to understand how this affects daylight hours and seasons in the arctic and in other parts of the world.

Photosynthesis



Procedure

1. *Why is sunlight important?* Have your students think about why plants and animals, including people, need sunlight. Discuss photosynthesis as the way plants make their own food, and note that plants need sunlight in order to photosynthesize. Arctic plants have a burst of rapid growth during the short summer, while they are dormant in the long winter. People require sunlight too. Vitamin D, essential to our bodily functions, is manufactured in the skin when it is exposed to sunlight.

2. Have students research how many growing days there are in your community. (This information may be found in a farmer's almanac.) Compare the findings to the number of growing days on the arctic tundra. *How does this difference affect the plants that grow in your area vs those that may grow in the arctic?* Have students brainstorm hypotheses and conduct

research to test their hypotheses.

3. Look at the climate data provided. *How many months of the year is the temperature above freezing in the arctic?* Make sure the class understands that this is when snow and ice thaw, making water available for plants and animals to use. In addition to sunlight, water is also necessary for plants to photosynthesize.

4. Using the data provided on Seasons Around the World worksheet and the incomplete graph provided, have students label the x and y axis and plot the average number of daylight hours per day in Alaska for each month of the year.

5. Check your local newspaper or search on the internet to find the time of sunrise and sunset and the average number of daylight hours for your town or others with a latitude between you and Alaska. *What did you discover? What does it mean?* If you find information for several places, you can graph the range of daylight hours for comparison.

6. Have students sit in a large circle representing the movement of the earth around the sun. One student, or the teacher, should sit in the center of the circle holding a flashlight, representing the sun (make sure you have turned off the classroom lights). The flashlight should be pointed directly at the globe as it is passed around the circle.

When the Arctic is tilted away from the sun, in the winter months, it gets little or no sunlight.

7. The teacher should designate four students equally spaced as the four seasonal months: January, April, July and October. Using a plastic inflatable globe, students hold the earth at its 23.5 angle of tilt and pass it around the circle, noting where the sun strikes at different seasons of the year. To be sure this activity is carried out correctly, attach a small stick to the globe at the north pole in line with the earth's axis. Tilt the globe approximately 23.5 degrees and choose a stationary object in the room (probably on the ceiling) to which the stick points. No matter which student is holding the globe, the stick should always be pointing to the stationary object. Students in the four seasonal positions can attempt rotating the globe, maintaining a constant tilt, to see where sunlight would hit over the course of one day.

8. Have students label the appropriate seasons on the worksheet.

Alternate Method

1. An alternate activity is to create a three-dimensional model to study the earth's position relative to the sun at four times of the year, each of the four seasons. Students will simulate where the sun's rays reach the earth in January, April, July, and October, taking into consideration the earth's tilt.

2. Use small round objects for the "earths," such as Styrofoam balls or

small fruit. Students should insert a toothpick through the center of each of their four earths, from "pole to pole." Using a pencil or pen, draw a circle around the North Pole to represent the Arctic Circle. Make another mark on the circle to represent the location of the arctic tundra. Use a larger Styrofoam ball to represent the sun. Insert a toothpick into the "sun" just far enough to secure the ball to the toothpick.

3. Press five pieces of modeling clay onto a piece of cardboard, one in the center for the sun, and the remaining four at equal distances away from the sun, and from each other, approximating a circle. Provide a template on which students can attach the modeling clay.

4. Position the sun onto the paper by inserting the toothpick into the clay in the middle of the paper.

5. The earth maintains a steady angle representing the 23.5° tilt. Students should angle one of their earths approximately 23.5 degrees away from the sun, and secure it into the clay at that angle, noticing the location of their arctic tundra. Holding a second earth at a 23.5° angle and not moving the paper at all, students should begin an orbit around the sun, being sure not to rotate their earth or change the angle in any way. Secure the second earth to the paper. Do the same for the third and fourth earths, again being sure not to move the paper, rotate the earths, or change the tilt in any way. When the model is complete, students should check their work by verifying that the angled toothpicks are parallel to one another, all pointing in the same direction. Students can very carefully rotate each earth without removing them from the clay, to see how much sunlight might reach their tundra in a day at that time of year. Students should notice their arctic tundra being at different locations relative to the sun throughout the year.

6. Have students refer to their graph of daylight hours and think about which angle of rotational tilt the earth would be in during each of the four seasons. Students can label the seasons on their model. Conduct a class discussion about what their models mean. *Where are the longest days in June? In December? Why does the arctic have such long days and short nights and vice versa? Why does it have such a short growing season? What do you think these events mean for*

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arctic plants? Animals? How have they adapted to this kind of situation? What kinds of adaptations do they have to help them survive in habitats with these extremes?

Modifications for Younger Students (3-4)

✔ Have students do steps 6 and 7, with your assistance. *How are the seasons and lengths of days determined by the earth's angle and rotation? What does this tell you about the temperatures you should expect at different times of the year?*

Extension

✔ Have students investigate plant hardiness zones for the North American arctic and your community. *What does "plant hardiness" mean? Which zone is your community in? What native plant species are adapted to your plant hardiness zone? To the*

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hardiness zones found in the North American arctic? Are their differences and similarities in their structures? What are they?

Assessment

✔ Have students consider: *How does day length and the rotation of the earth impact seasons in other parts of the world? Where in the world is it summer in December?* Determine this by considering the earth that the student has labeled as being in the winter position (December is a winter month in the Northern Hemisphere). Select a point on that earth appearing to get the most sunlight in one day. Notice the location of that point relative to the location of the tundra on that earth. Now go to a globe and attempt to find that same point, and the country it falls in. The student should come up with a country in the Southern Hemisphere. Students can then complete the table on the student activity sheet.

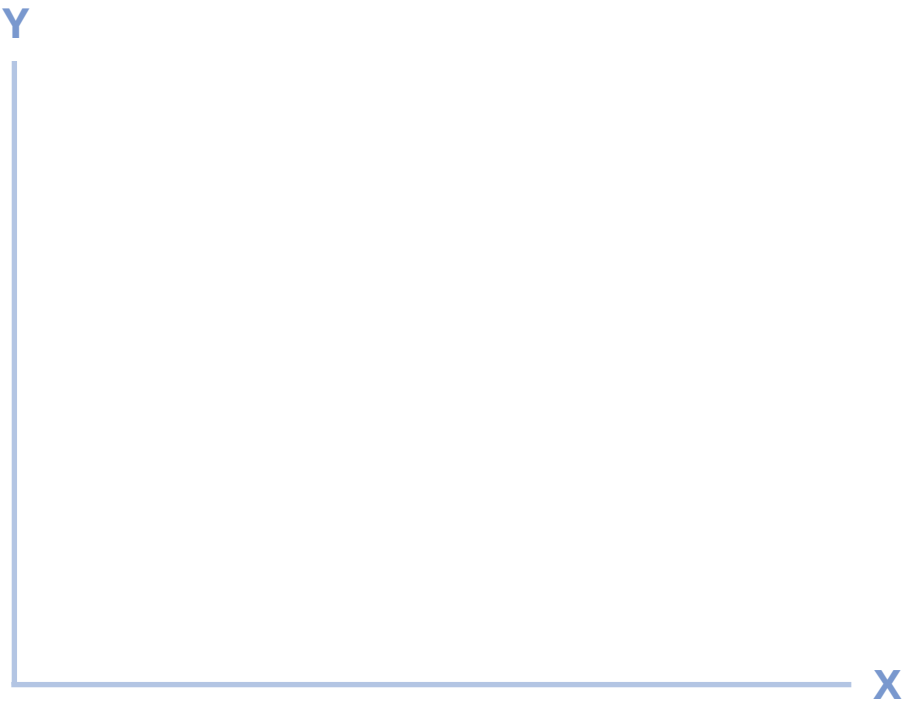
✔ Alternatively, have students propose and demonstrate a way of explaining this material to younger students, such as using a poster, sharing their own models from this activity, or doing a life-size demonstration of the earth's movement.

WORKSHEET

SEASONS AROUND THE WORLD

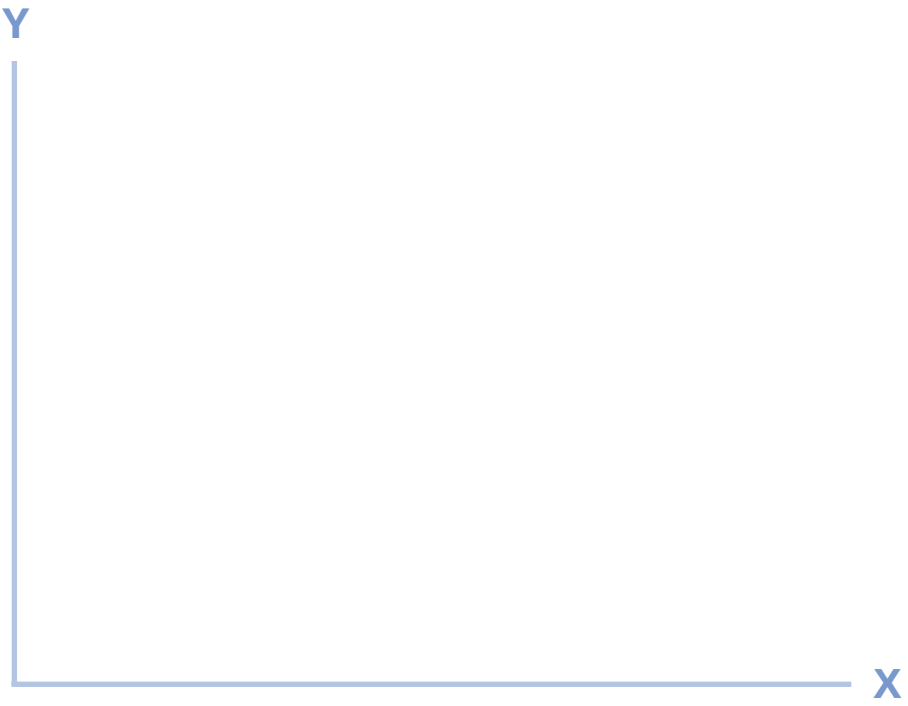
Graph the following data for average monthly daylight hours for the Alaskan tundra:

January ..... 1 hour;
February ..... 7 hours;
March ..... 12 hours;
April ..... 16 hours;
May ..... 3 hours;
June ..... 24 hours;
July ..... 24 hours;
August ..... 19 hours;
September ..... 14 hours;
October ..... 9 hours;
November ..... 3 hours;
December ..... 0 hours.



Graph the data for your region:

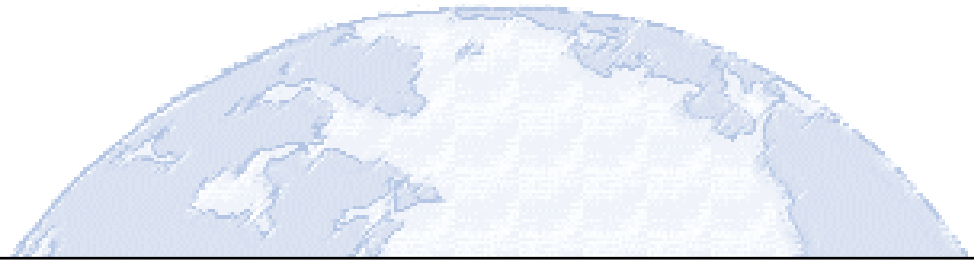
January .....
February .....
March .....
April .....
May .....
June .....
July .....
August .....
September .....
October .....
November .....
December .....



WORKSHEET

SEASONS AROUND THE WORLD

Using your model, world map, or globe, fill in the following chart to indicate what season it is in different parts of the world during the given months



MONTH/SEASON	January	April	July	October
Alaska				
Florida				
Australia				
Sweden				
Argentina				
Ecuador				
Your state: _____				

(include a graph of average monthly temperature for several Arctic locations).

Data for graph of Alaskan tundra average monthly temperatures: (degrees F)
January:-14; February:-20; March:-16; April-2; May 19; June 33; July; 39; August: 38; September: 31; october:-14; November:-1 December-13.