Name: ____________________ Laboratory Section: ____________________

Date: ____________________ Score/Grade: ____________________

Video
Exercise 5
Pre-Lab Video

LAB EXERCISE

Scan to view the Pre-Lab video

http://goo.gl/8yj0IS

5

Earth–Sun Relationships and Daylength

For more than 4.6 billion years, solar energy has traveled across interplanetary space to Earth, where a small portion of the solar output is intercepted. Because of Earth's curvature, the arriving energy is unevenly distributed at the top of the atmosphere, creating energy imbalances over Earth's surface. Also, the annual pulse of seasonal change varies the distribution of energy during the year.

Earth's distinct seasons are produced by interactions of revolution (annual orbit about the Sun) and rotation (Earth's turning on its axis), Earth's axial tilt (at about 23.5° from a perpendicular to the plane of the ecliptic), axial parallelism (the parallel alignment of the axis throughout the year), and sphericity. As Earth rotates, the boundary that divides daylight and darkness is the **circle of illumination**.

Earth rotates about its axis, an imaginary line extending through the planet from the geographic North Pole to the South Pole. The Tropic of Cancer and Tropic of Capricorn mark the farthest north and south the subsolar point migrates during the year, about 23.5°N and 23.5°S latitude. The **solstices** occur when the Sun is directly over the tropics, and the **equinoxes** occur when the Sun is directly over the equator. The **march of the seasons** refers to the procession of the March equinox, June solstice, September equinox, and the December solstice.

Daylength, the interval between sunrise and sunset, varies during the year, depending on latitude. The equator always receives equal hours of day and night. At 50°N or S latitude, people experience almost 8 hours of annual daylength variation.

At the North and South Poles, the range of daylength is extreme, with a 6-month period of no insolation, beginning with weeks of twilight, then darkness, then weeks of predawn. Following sunrise, daylight lasts for a 6-month period of continuous 24-hour insolation—literally, the poles experience one long day and one long night each year! Lab Exercise 5 has two sections.

Key Terms and Concepts

circle of illumination
daylength
equinox
march of the seasons
solstice
subsolar point

KEY LEARNING concepts

After completion of this lab, you should be able to:

1. *Label* diagrams representing Earth–Sun relations in the annual march of the seasons.
2. *Calculate* daylength for selected locations for the solstices and equinoxes and *analyze* the relationship between latitude and seasonality.

Materials/Sources Needed

pencil
calculator
color pencils
ruler

Lab Exercise and Activities

SECTION 1

Earth–Sun Relations—Seasonality

Because Earth is spherical, its curved surface presents a continually varying angle to the incoming parallel rays of insolation. Differences in the angle of solar rays at each latitude result in an uneven distribution of insolation and heating. The place receiving maximum insolation is the point where insolation rays are perpendicular to the surface (radiating from directly overhead), called the **subsolar point**. All other places receive insolation at less than a 90° angle and thus experience more diffuse energy receipts.

Solar beam angles become more pronounced at higher latitudes. As a result, during a year's time, the top of the atmosphere above the equatorial region receives 2.5 times more insolation than that received above the poles.

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1. On the accompanying diagrams in Figure 5.1, complete the following items. June has been started for you. Also, you may want to consult your physical geography text for reference.

   a) Extend the Sun's rays until they *intersect* (pass through) or are *tangent* to Earth's surface (touch at only one point). (See the Earth profile diagram for examples.)

   b) Where the rays intersect or are tangent to Earth's surface, draw a short line tangent to the surface, indicating the angle at which the Sun's rays are intercepted.

   c) Label the rays with the appropriate term—*vertical ray* (striking Earth at a 90° angle), *oblique ray* (striking Earth at less than a 90° angle), or *tangent ray* (parallel to Earth)—and mark and label the *subsolar point.*

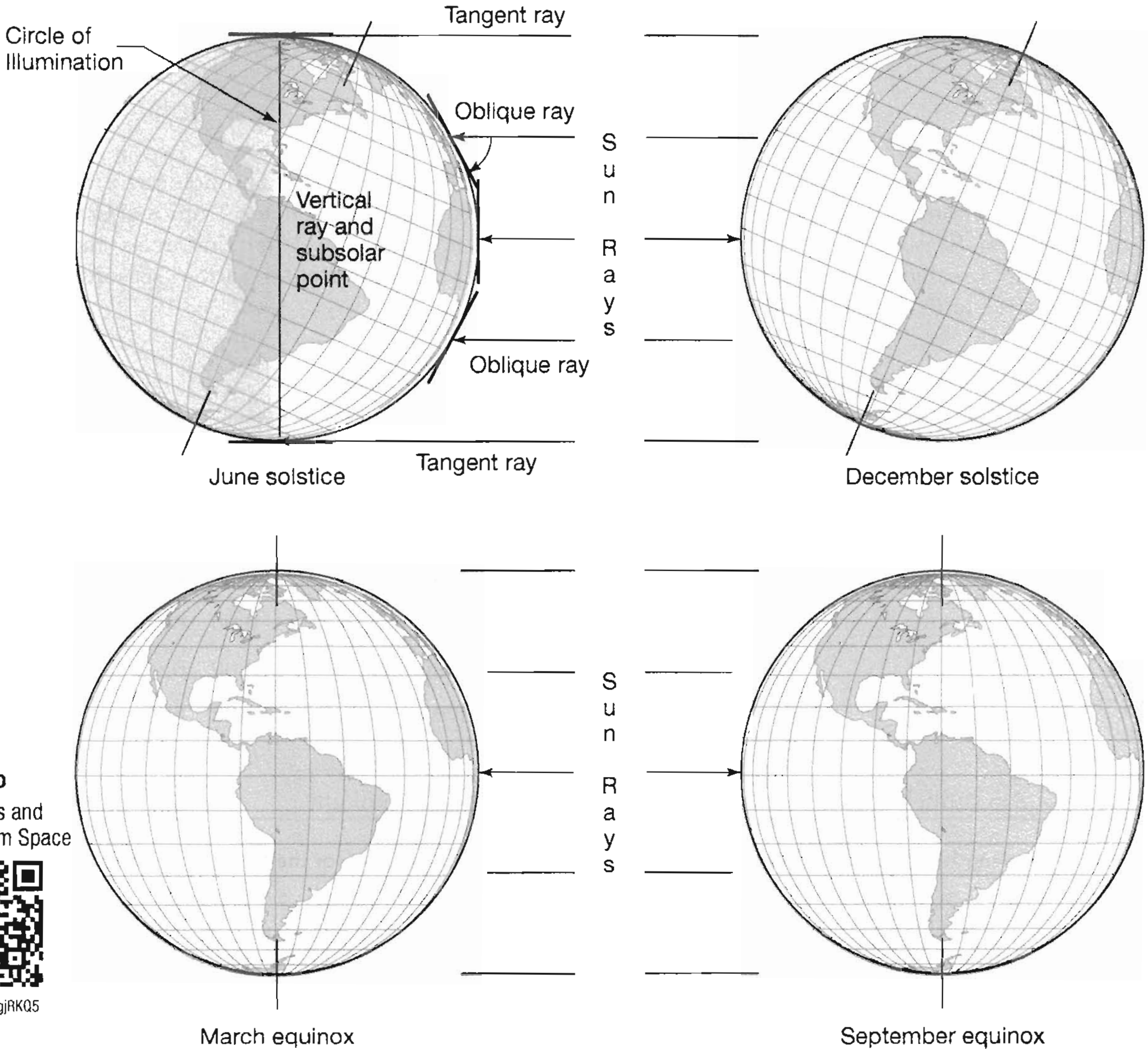
   d) Draw the following on the Earth profiles and label:

      North and South Poles
      Equator
      Tropics of Cancer and Capricorn
      Circle of Illumination
      Arctic and Antarctic Circles

   e) Lightly shade the portion of Earth that is experiencing night, or the night half of the circle of illumination. Half of Earth is in sunlight and half is in darkness at any moment. The traveling boundary that divides daylight and darkness is called the circle of illumination—it is the day–night dividing circle.

2. Describe the changing position of the subsolar point and vertical rays throughout the four key seasonal positions of Earth.

3. On the **equinoxes**, the subsolar point is at the equator. Which latitudes does the circle of illumination run through on the equinoxes? On the June **solstice**, the subsolar point is at the Tropic of Cancer. Which latitudes does the circle of illumination pass through on the June solstice? On February 26 the subsolar point is at 9°S. Which latitudes does the circle of illumination pass through on this date?



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▲ Figure 5.1 **Earth–Sun relationships**

4. What is the relationship between the location of the subsolar point and the circle of illumination?

SECTION 2

Daylength

The length of daylight hours, the time between sunrise and sunset, varies both with latitude and the season of the year. Seasonal shifting of the subsolar point results in a realignment of the **circle of illumination** relative to the poles. See the diagrams in Section 1 of this exercise and note the proportions of each latitude line (equator, Tropics of Cancer and Capricorn, Arctic and Antarctic Circles) that are in daylight vs. darkness at the various seasons.

1. Complete Table 5.1 (below), filling in the daylength at selected latitudes.

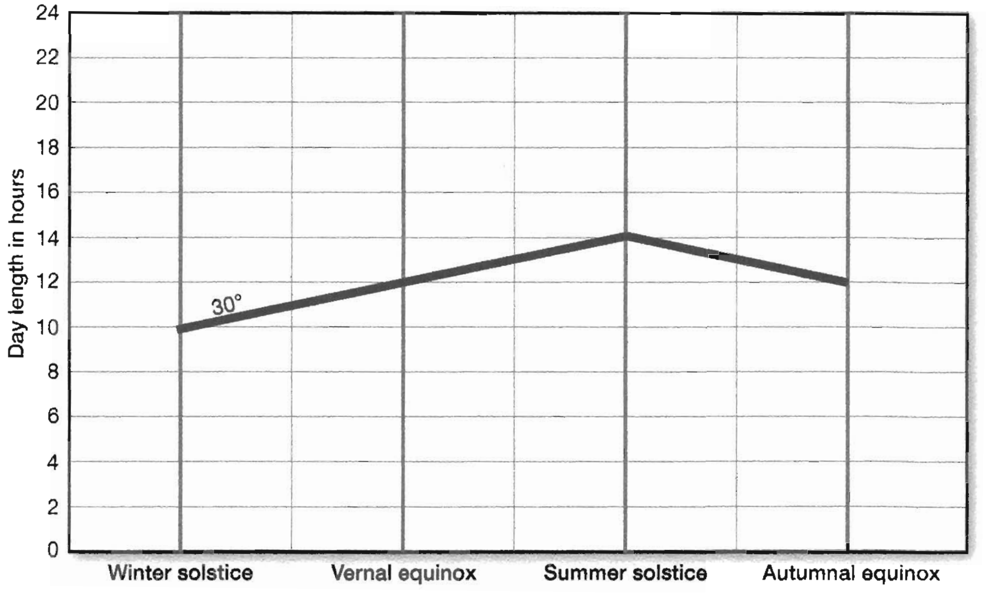
	Winter Solstice (December Solstice) December 21–22			Vernal Equinox (March Equinox) March 20–21			Summer Solstice (June Solstice) June 20–21			Autumnal Equinox (September Equinox) September 22–23		
	A.M.	P.M.	Daylength	A.M.	P.M.	Daylength	A.M.	P.M.	Daylength	A.M.	P.M.	Daylength
0°	6:00	6:00	______	6:00	6:00	______	6:00	6:00	______	6:00	6:00	______
30°	6:58	5:02	______	6:00	6:00	______	5:02	6:58	______	6:00	6:00	______
40°	7:26	4:34	______	6:00	6:00	______	4:34	7:26	______	6:00	6:00	______
50°	8:05	3:55	______	6:00	6:00	______	3:55	8:05	______	6:00	6:00	______
60°	9:15	2:45	______	6:00	6:00	______	2:45	9:15	______	6:00	6:00	______
90°		No sunlight			Rising Sun		Continuous sunlight				Setting Sun	

▲Table 5.1 **Daylength—the time between sunrise and sunset—at selected latitudes for the Northern Hemisphere**

2. Explain how changes in the Sun's altitude (angle above the horizon) and daylength vary with the seasons at the equator, 30°, 60°, and 90°.

3. Estimate the approximate length of daylight for the following locations:
   - **a)** Dawson, Yukon Territory, Canada (64° N), on December 21 ______
   - **b)** Adelaide, South Australia (35° S), on June 21 ______
   - **c)** Bangkok, Thailand (14° N), on March 20 ______
   - **d)** Your location on June 21 ______
   - **e)** Your location on December 21 ______

4. Complete the following graph, using the values for daylength calculated in question #1 for the following latitudes: 0°, 30°, 40°, 50°, 60°, and 90°. Use a different color for each latitude. The line for 30° has already been done for you.



▲ Figure 5.2 **Daylength and latitude**

5. What is the relationship between seasonal changes in daylength and latitude?