

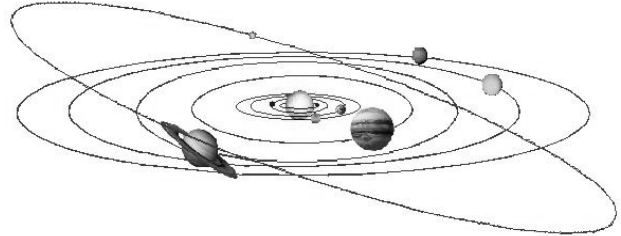


Earth-Sun Geometry

The Basics

The sun is the center of our solar system, and the planets in our solar system revolve around the sun. Earth is the third planet from the sun.

The planets orbit the sun in elliptical paths. The "elliptic-ness" of an orbit is called eccentricity and varies from planet to planet.

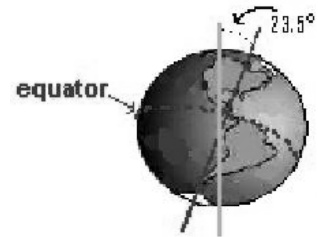


The earth's elliptical orbit changes from an ellipse to a more circular shape and back again over a cycle of 90,000 to 100,000 years.

Because earth's path is elliptical, there are times when the earth is closer to the sun and times when it is further from the sun. But this difference in distance is not the reason we experience seasons, as many people believe. *Even though the earth is closest to the sun on January 5 (it is 147 million km away), and farthest from the sun on July 5 (it is 152 million km away), the distance does **not alter effect of the seasons in a significant way.*** The time when the earth is closest to the sun is referred to as **perihelion**; when it is farthest away is called **aphelion**.

Reasons for the Seasons

It is not distance from the sun, but tilt of the earth that causes the seasons. Earth rotates counterclockwise (from an "above" view) on an imaginary axis that extends from the North Pole to the South Pole. This pole is not oriented straight up and down but is tilted about 23.5 degrees from straight up and down, as the diagram to the right illustrates.

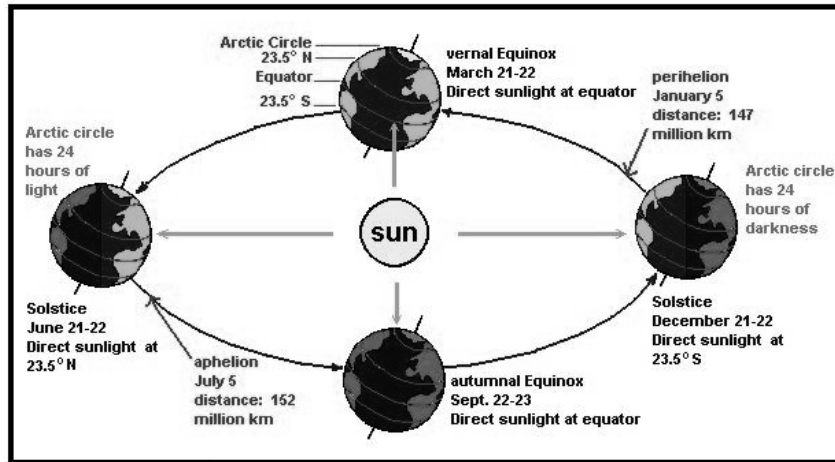


The tilt causes the seasons because it allows the sun's rays to shine more directly and for longer periods of time on some locations certain times of the year than others. The sun shines in parallel rays towards the earth, and this directness of the sun's rays upon the surface of the earth is what warms the surface. Recall that the Northern hemisphere refers to all latitudes located north of the equator, and the Southern hemisphere refers to all latitudes south of the equator. Because different parts of the earth are tilted towards the sun as earth revolves around the sun, the Northern and Southern hemispheres experience direct sunlight at the surface at different times of the year. Please see diagram on the next page..

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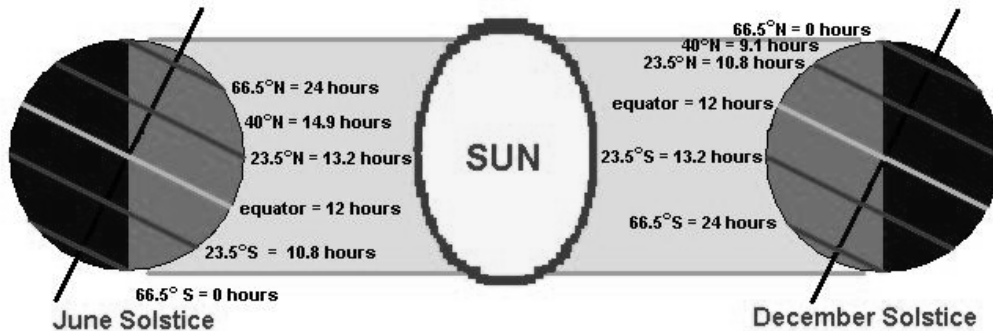
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You can see that during the June solstice, the Northern hemisphere is tilted towards the sun, while the Southern hemisphere is tilted away. The Northern Hemisphere is experiencing summer and the Southern is experiencing winter. As earth continues to revolve around the sun throughout the year, we see that at the December solstice, the Northern hemisphere is tilted away from the sun, and the Southern hemisphere is tilted toward it. The December solstice represents the beginning of winter for the Northern Hemisphere and the beginning of summer for the Southern.

Day length

The amount of daylight we experience will be greater in the Northern hemisphere in June, but will be less in the Southern hemisphere. In December, the Southern hemisphere will have the longer days. The following diagram illustrates hours of daylight that correspond to each hemisphere and each solstice:



Between the June and December solstices, there is a time that the sun's rays shine directly at the equator, and the tilt of the earth does not expose the Northern or Southern hemisphere to more or less radiation. These times are called equinoxes, and at an equinox all locations on earth receive an equal amount of sunlight, 12 hours. The vernal Equinox occurs on March 21-22 marking the beginning of spring in the Northern hemisphere, and the autumnal Equinox occurs on September 22-23 marking the beginning of fall.

The following table illustrates the differing hours of sunlight latitudes experience over the course of the earth's revolution around the sun.

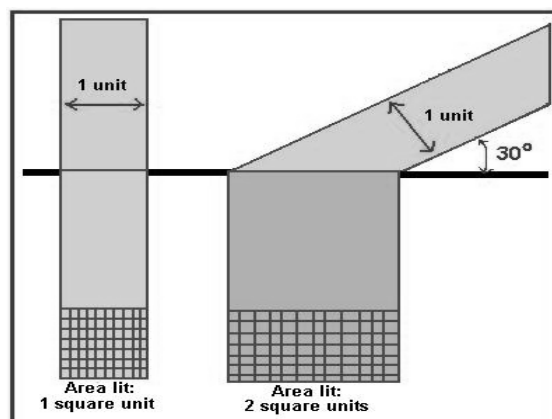
TABLE 3.1 >> Length of Time from Sunrise to Sunset for Various Latitudes on Different Dates				
Northern Hemisphere (Read Down)				
Latitude	March 20	June 21	Sept. 22	Dec. 21
0°	12 hr	12.0 hr	12 hr	12.0 hr
10°	12 hr	12.6 hr	12 hr	11.4 hr
20°	12 hr	13.2 hr	12 hr	10.8 hr
30°	12 hr	13.9 hr	12 hr	10.1 hr
40°	12 hr	14.9 hr	12 hr	9.1 hr
50°	12 hr	16.3 hr	12 hr	7.7 hr
60°	12 hr	18.4 hr	12 hr	5.6 hr
70°	12 hr	2 months	12 hr	0 hr
80°	12 hr	4 months	12 hr	0 hr
90°	12 hr	6 months	12 hr	0 hr
Southern Hemisphere (Read Up)				
Latitude	Sept 22	Dec. 21	March. 20	June 21

(table courtesy <http://www.colby.edu/sci.tech/st215/3.2view/sld008.htm>)

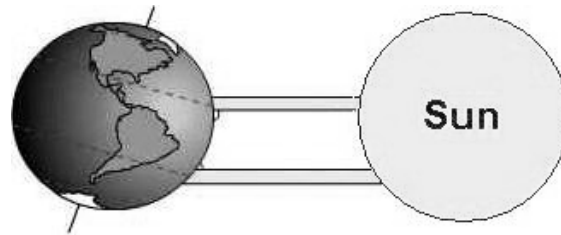
Sunlight Intensity

Not only does the number of daylight hours a location receives change as earth revolves around the sun, but also the intensity of the sunlight received. Think about it: if you were to shine a flashlight straight at a piece of paper, a very intense circle of light would light up a small area. If you were to tilt the flashlight so the light shone on the paper at an angle, the "circle" of light would not be a circle, but an ellipse. The ellipse would be larger in area than the circle. Because the amount of light shining from the flashlight had not changed, but area lit up had increased, the ellipse would be less bright than the circle. The earth's surface is affected by the sun's rays in the same way. The sun's rays shine on earth with an intensity of about 1370 Watts per square meter. Even though the sun's rays hit the earth in parallel beams, the tilt of the earth towards the sun causes the beams to hit more directly in some places than others.

The following image helps explain the relationship between beam angle, area covered, and intensity:



Notice that it is the same amount of sunlight hitting the surface, but the angle of the sunlight is what changes the way that sunlight is spread out. Because the earth is round, we can see the different angles that sunlight makes as it hits the earth.



The angle of incidence is the angle formed between the sun's rays and the earth's surface. The further from the equator North or South one travels, the smaller the angle of incidence becomes, the more surface area is lit by the sun, and the less intense the sunlight is as it is spread over more area.

Notice in the above diagram that the Earth is receiving sunlight at a 90 degree angle at about 23.5 degrees North in latitude. What time of year is this diagram showing? What would this picture look like if it were showing the vernal or autumnal equinox?

Questions to Answer

Use complete sentences. Answer on a sheet of notebook paper.

1. What day is the earth farthest from the sun?
2. In the Southern hemisphere, during which season is the earth closest?
3. About how many hours of daylight does Havana, Cuba receive around December 21?
4. About how many hours of daylight does Boulder, Colorado receive around June 21?
5. About how many hours of daylight does Sydney, Australia receive on March 21?
6. Which city receives more intense sunlight in June: Santiago, Chile or Toronto, Canada?
7. At what latitudes will there be 24 hours of daylight on December 21?
8. If there is 24 hours of daylight, explain why the temperature is still very cold at the location you identified in #7.
9. What would happen to the seasons if the earth were tilted 40 degrees instead of 23.5 degrees from straight up and down?
10. What would happen to the seasons if the earth were tilted 23.5 degrees in the other direction?