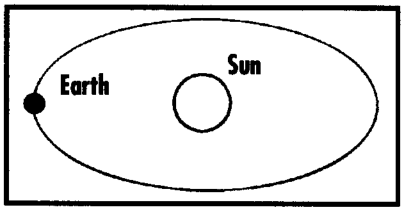
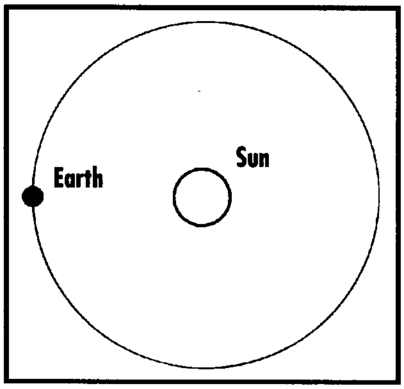
# Reason for the Seasons

The reason why Earth has four seasons—spring, summer, fall, winter—is often misunderstood. In part, this misunderstanding comes from diagrams similar to figure 1 where we try to give you a perspective on a nearly circular orbit as it would appear to a viewer almost in the plane of the orbit. From this perspective, the circular orbit looks elliptical. A similar perspective from directly above Earth's nearly circular orbit around the Sun looks like the diagram in figure 2. Having learned that Earth's orbit is actually an ellipse (although the ellipse is so round it is almost a circle), many people jump to the conclusion that diagrams like figure 1 represent the actual orbit around the Sun rather than a perspective view. This incorrect interpretation of the diagram then causes people to think that the planet is hotter in the summer because Earth is closer to the Sun than in the winter. Consider the following example. At the exact same time it is summer in the United States (the Northern Hemisphere), it is winter in Australia (the Southern Hemisphere). If Earth's distance from the Sun determines the seasons, then it should be the same season everywhere on the planet. In fact, Earth is actually farther away from the Sun during our (the Northern Hemisphere's) summer than it is during our winter.




(Not to scale)

**FIGURE 1**




(Not to scale)

**FIGURE 2**

Earth's orbit around the Sun is more accurately represented by the circle drawn in figure 2. This slightly elliptical orbit does not account for the seasons, but another of Earth's characteristics of motion does.

Earth is spinning. When a ball spins, the line around which the ball turns is called the axis of rotation. Earth's axis of rotation is tilted in relation to the plane of Earth's orbit around the Sun. Figure 3 illustrates the difference. As Earth is spinning, it is also moving around the Sun. The position of Earth in its orbit around the Sun combined with the tilt of the axis of rotation then determines the season. Figures 4 and 5 show how the orbit and axis tilt work together. In the summer the Sun's rays are striking at as close to a 90° angle to the surface as is possible for that location.

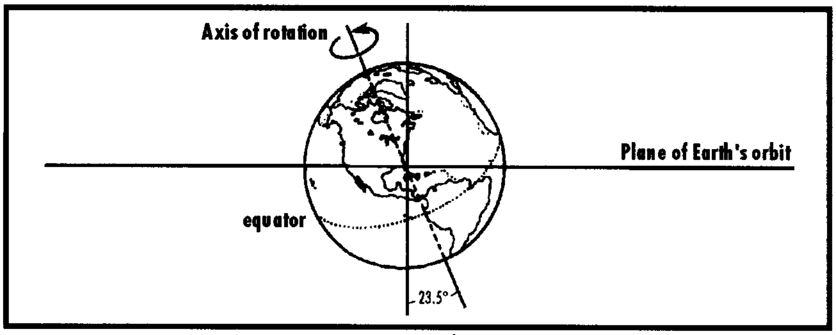



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**FIGURE 3**

Austin, TX is located at latitude 30° and Minneapolis,

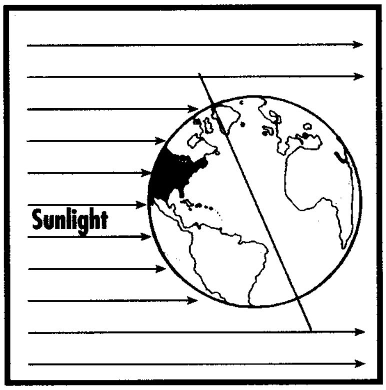


**FIGURE 4**
Summer in the Northern Hemisphere

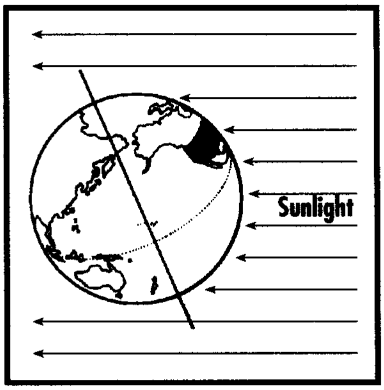


**FIGURE 5**
Winter in the Northern Hemisphere

MN is located at latitude 45°. On the longest day of the year, called the summer solstice, the Sun's rays strike Austin at 83.5° at noon and strike Minneapolis at 68.5°. During this time of year, the Sun's radiation is most intense. Figure 5 shows what happens six months later when Earth is on the other side of the Sun. On the shortest day of the year, the winter solstice, the Sun's rays strike Austin at an angle of 36.5° and strike Minneapolis at an angle of 21.5°. In this case, the Sun's rays are hitting the surface *at a greater slant* than they do during the summer, and the heating is not as efficient. It is not as efficient because the same amount of solar radiation is being spread out over a larger area. Compare figures 4 and 5. The second one represents our winter.

Figure 6 illustrates why perpendicular rays of light are more efficient at heating than slanting rays. In the picture at the top, the paper is standing vertically and the energy from the rays are concentrated in the small area ($A_1$). But when the paper is tilted back, notice that the same number of light rays, hence the same amount of energy, is now spread over a much larger area ($A_2$); therefore, it will not heat as fast.

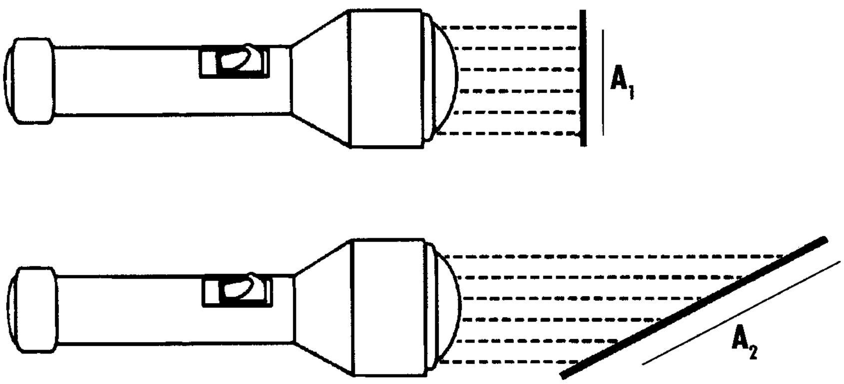


**FIGURE 6**

Similarly, when part of the surface of Earth is tilted with respect to the rays of sunlight, it will receive slanting solar rays and not heat as fast. Since Earth is round, some locations can be receiving direct sunlight while others receive it indirectly. This explains why it can be summer on one part of the planet and winter on another. In addition, because of the axis tilt, the days in summer are longer (allowing more time for solar heating) than in winter.