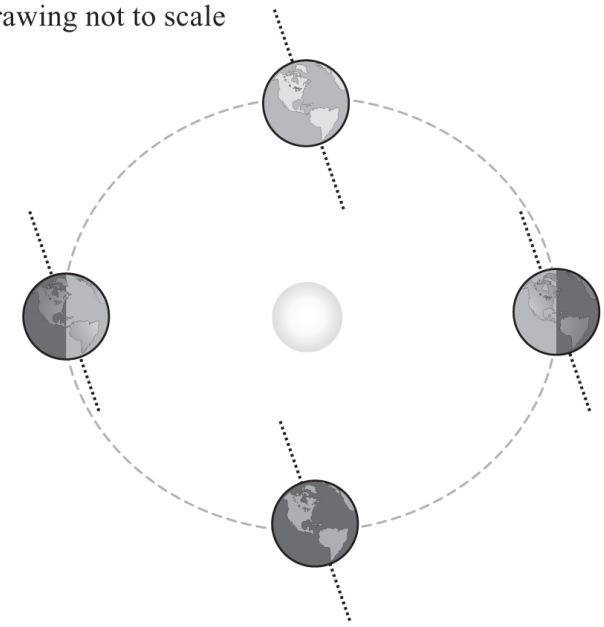
## Part I: Earth–Sun Distance

Listed below are the distances, in kilometers (km), between the Sun and Earth for four months of the year. The drawing at the right shows four different locations of Earth during its orbit around the Sun. Note that for each location drawn, Earth is correctly shown with its rotational axis tilted at an angle of 23.5°.

| Month | Earth–Sun Distance |
|---|---|
| December | 147.2 million km |
| June | 152.0 million km |
| September | 150.2 million km |
| March | 149.0 million km |

Drawing not to scale



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1) Using the information listed above, does Earth stay the same distance from the Sun throughout the year? If not, what month(s) and during which season (for the Northern Hemisphere) is Earth closest to the Sun? Farthest from the Sun?

2) Would you say the temperature stays approximately the same every month of the year at your location?

3) Are the seasons (summer or winter) the same in the Northern and Southern Hemispheres at the same time? When it is summer in the Northern Hemisphere, what season is it in the Southern Hemisphere?

4) Consider the following discussion between two students about the cause of the seasons.

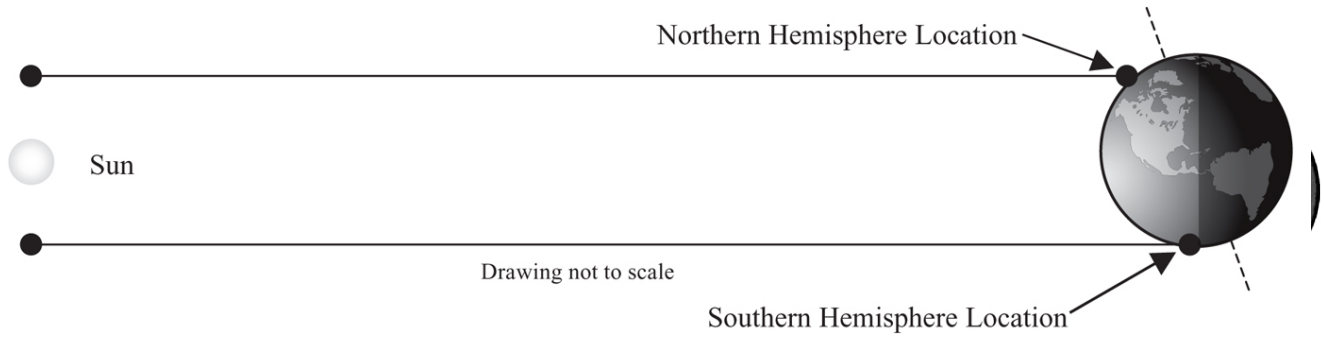
**Student 1**: *I know that it's hotter in the summer and colder in the winter, so we must be closer to the Sun in the summer than in the winter.*

**Student 2**: *I disagree. Although the distance between Earth and the Sun does change throughout the year, I don't believe that the seasons and changes in Earth's surface temperature are caused by the distance between the Sun and Earth. If the seasons were due to the Sun–Earth distance, then both hemispheres of Earth would have the same seasons at the same time.*

Do you agree or disagree with either or both of the students? Explain your reasoning.

## Seasons

At different times of the year, locations in the Northern Hemisphere can be a few thousand kilometers closer to (or farther from) the Sun than locations that are at the same latitude in the Southern Hemisphere (as shown in the drawing below). However, the distance between Earth and the Sun is, on average, about 150 million kilometers.

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5) Do you think these differences in distance between locations at the same latitude in the Northern and Southern Hemispheres are the cause of the seasons? Explain your reasoning.

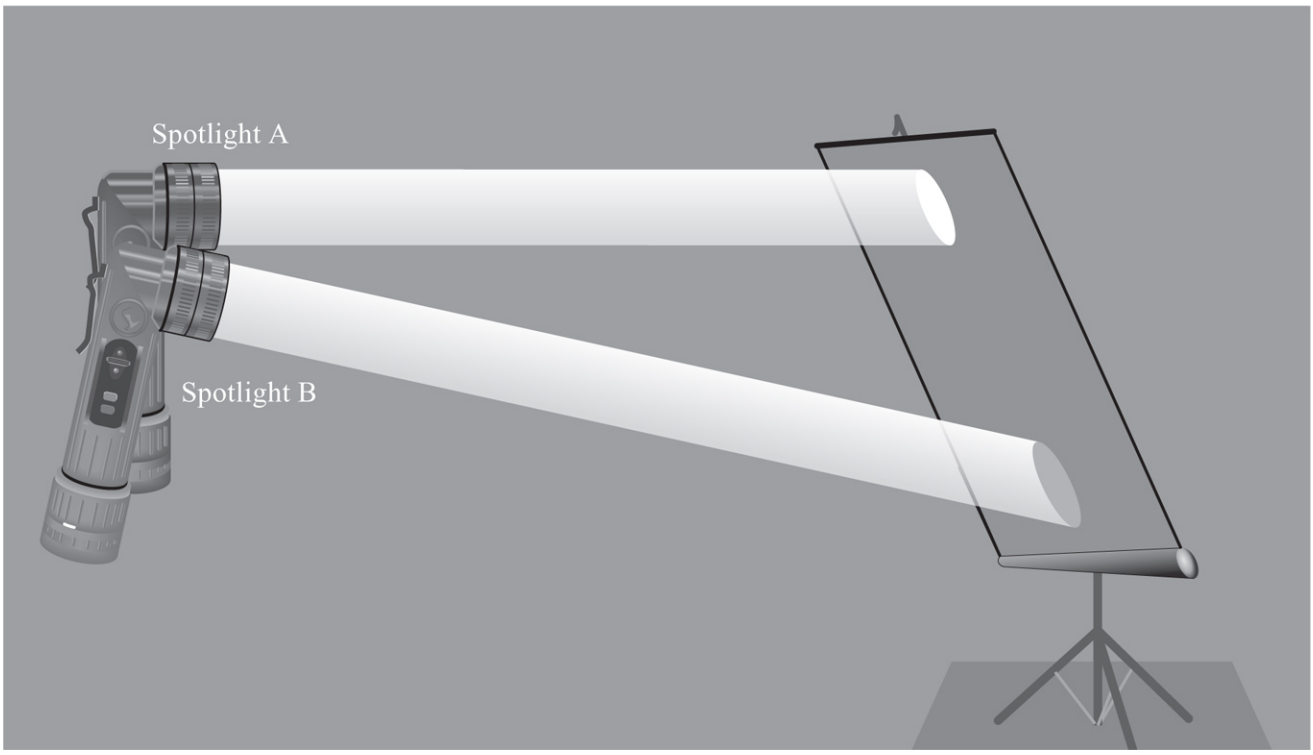
6) Consider the following discussion between two students about the cause of the seasons.

**Student 1:** *I get it. So since Earth is tilted, there are times when the northern part of Earth is closer to the Sun than the southern part. So the north has summer and the south has winter. And then later the south is tilted toward the Sun and gets closer and has summer.*

**Student 2:** *I disagree. Although the tilt does bring one hemisphere closer to the Sun, the difference in distance between the northern half and southern half of Earth is really small compared to how far away Earth is from the Sun.*

Do you agree or disagree with either or both of the students? Explain your reasoning.

## Part II: Direct Light and Tilt

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Consider the picture above in which two spotlights (A and B) are shown casting light onto a screen. Note: Each spotlight gives off the same total amount of light.

7) Which of the two lighted areas (the one created by Spotlight A or B) would appear brighter?

8) Which of the two lighted areas is smaller?

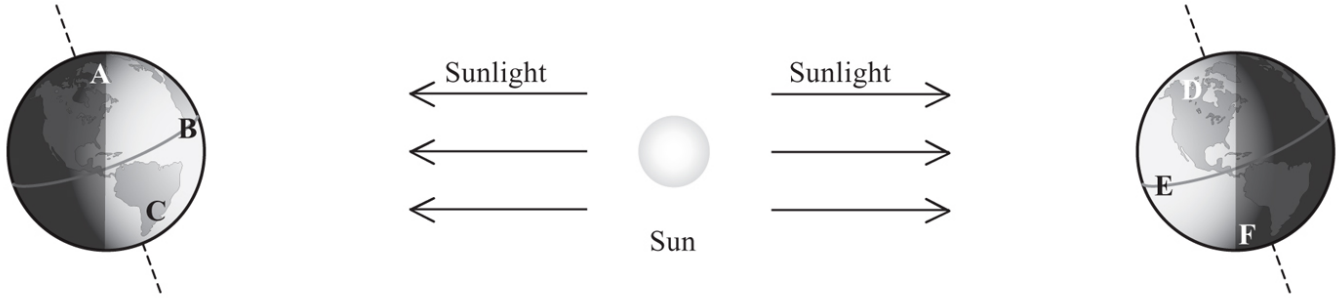
9) Which of the two lighted areas receives more direct light (amount of energy on each unit of area) from the spotlight?

10) If a thermometer were placed in each of the lighted areas, which one would read the higher temperature?

11) Which of the two positions would be similar to the way the sunlight would shine on the Southern Hemisphere of Earth during winter in the Southern Hemisphere? Explain your reasoning.

## Seasons

Consider the picture below illustrating three different regions of Earth (the Northern Hemisphere, the Southern Hemisphere, and the equatorial region) at two different times of the year, six months apart.

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Note: this drawing is not to scale. In fact you could fit more than 100 Suns between the Sun and Earth.

12) Which location(s) (A–F) correspond(s) with summer in the Northern Hemisphere? Explain your reasoning.

13) Which location(s) (A–F) correspond(s) with winter in the Southern Hemisphere? Explain your reasoning.

## Part III: Amount of Daylight

14) During which season (summer or winter) is the number of daylight hours the greatest? How many hours?

15) During which season (summer or winter) is the Sun highest in the sky at noon? Hint: Consider the drawing showing the lighted areas and the spotlights for Questions 7–11.

16) How are your answers to the previous two questions related to the time of year that your location experiences the highest average temperature? Explain your reasoning.

17) How would the number of hours of sunlight and the height of the Sun in the sky at noon change (if at all) over the course of the year for locations on the equator? Explain your reasoning.?

## IV: Applying the Model of Causes of Seasons

18) If, somehow, the number of daylight hours did not change throughout the year, but Earth was still tilted at 23.5°, would there still be seasons in the Northern and Southern Hemispheres of Earth? Would the temperature difference between the seasons still be as great? Explain your reasoning.

19) If the Northern Hemisphere were tilted 90° toward the Sun, which location would be warmer in summer: the Arctic Circle or Florida? Why?

20) Provide one piece of evidence to support the fact that the varying distance between the Sun and Earth cannot account for the seasons.

21) Which two things are most directly responsible for the cause of the seasons on Earth? Explain your reasoning.