**The Seasons:**

**Why Temperatures Vary at Different Latitudes**

**PURPOSE**

The purpose of this lesson is to construct a model to explain the cause of the seasons.

**ENGAGEMENT**

In the space below, make a drawing or diagram of the position of the sun and Earth for each of the four seasons and then answer the following questions.

1. Did you vary the distance of the Earth from the sun?
2. Did you change the tilt of the Earth? If so, explain how.
3. Is the Earth’s orbit more circular or more elliptical?
4. What season is the Southern Hemisphere having when the Northern Hemisphere is having spring?

 e. Why is the Northern Hemisphere polar region so cold even in the summer even though the region has 24 hours of daylight?

**EXPLORATION**

In teams of 4 – 5, you will make a model of the seasons using the craft light, Styrofoam base, four Earth models, and toothpicks. Each Earth model represents the tilt and general distance from the sun for the season.

**Procedure**

1. Place the light in the middle of the Styrofoam circular base through the cut out hole. The small craft light will represent the sun.
2. Push a toothpick into each Styrofoam ball at the North Pole so that the end comes out at the South Pole. The toothpicks represent Earth’s axis. Each ball will represent Earth at the beginning of one of the four seasons (summer, fall, winter, or spring).
3. In your team, discuss your individual drawings and construct a model that best represents the position of Earth at the beginning of each of the four seasons. To make your model, place the four Styrofoam balls in the correct positions on the Styrofoam base. The toothpick should hold the ball in place. Begin with the summer season and work your way around. You may vary the tilt and the distance. Label each season on the model and make a drawing of your team’s model.
4. Read the following “Scientists’ Explanation” to decide whether the model constructed by the team is correct. If you do not think your team’s model is correct, revise your model as you read though the explanation. Once your team has constructed the revised model, make another drawing of your team’s model.
5. Did your revised model change any from the original one?

**THE SCIENTISTS’ EXPLANATION**

At the present time, Earth is tilted on its axis of rotation by 23.5°. The direction and angle (or tilt) of Earth's axis of rotation do not change as Earth revolves around the sun. Because the direction and angle of the axis of rotation do not change, the Northern Hemisphere is tilted toward the sun during part of the year and away from the sun during another part of the year.

People often mistakenly think that the different seasons are caused by a change in Earth's distance from the sun. This is a misconception because Earth's orbit is only slightly elliptical and our planet is nearly the same distance from the sun all year long. Earth is actually a little farther from the sun when the Northern Hemisphere is having summer. The hemisphere (the Northern or Southern Hemisphere) that is tilted toward the sun receives more direct rays of sunlight (or rays that are closer to perpendicular or a 90° angle). The hemisphere (the Northern or Southern Hemisphere) that is tilted toward the sun also has more hours of daylight than the hemisphere that is tilted away from the sun. The combination of more direct rays of sunlight and more hours of daylight causes the hemisphere tilted toward the sun to receive more solar radiation and to have warmer temperatures. When the Northern Hemisphere is tilted toward the sun, latitudes between the equator and 90°N (the North Pole) are experiencing summer. At the same time, the Southern Hemisphere is tilted away from the sun and experiencing winter.

The summer season begins in the Northern Hemisphere on June 20 or 21, known as the summer solstice, when the axis of rotation is tilted a full 23.5° toward the sun. The incoming solar radiation strikes Earth directly at a perpendicular or 90° angle to the 23.5°N parallel of latitude. This 23.5°N parallel of latitude, which runs through Mexico, the Bahamas, Egypt, Saudi Arabia, India, and southern China, is known as the Tropic of Cancer. On the summer solstice, the Northern Hemisphere has the greatest number of daylight hours, whereas the Southern Hemisphere has the fewest. The angle of the sun above Earth's Northern Hemisphere is greatest on this day. Because Earth is tilted toward the sun to the maximum degree, the North Pole has 24 hours of daylight on June 20 or 21, whereas the South Pole (which is tilted away from the sun to the maximum degree) has 24 hours of darkness. After the passing of the summer solstice, the length of daylight in the Northern Hemisphere gradually decreases.

Fall or autumn in the Northern Hemisphere begins September 22 or 23. Remember that the tilt and direction of Earth's axis of rotation is the same as Earth revolves around the sun. On the first day of fall, Earth is neither tilted toward nor away from the sun, causing the length of daylight and nighttime hours to be equal (12 hours) in both hemispheres. This day is often referred to as the fall or autumn equinox. In the Southern Hemisphere, spring begins on this day. Throughout the Northern Hemisphere's fall season, the length of daylight gradually decreases until the first day of winter.

Winter in the Northern Hemisphere begins on December 21 or 22, when the axis of rotation is tilted a full 23.5° away from the sun. On this day, known as the winter solstice, the incoming solar radiation strikes Earth directly at a perpendicular or 90° angle to the 23.5°S parallel of latitude, known as the Tropic of Capricorn. Therefore, the sun's rays strike the Northern Hemisphere at the smallest angle.

On December 21 or 22, the sun appears to be at lowest point on the horizon, and the Northern Hemisphere has the fewest number of daylight hours. In the Southern Hemisphere, this is the day with the greatest number of daylight hours and the beginning of summer. The North Pole has 24 hours of darkness on December 21 or 22, whereas the South Pole has 24 hours of daylight. Throughout the winter season, the length of daylight gradually begins to increase.

Spring in the Northern Hemisphere begins on March 20 or 21 when Earth is again not tilted toward or away from the sun. On this day, known as the spring equinox, there are 12 hours of daylight and 12 hours of darkness in both hemispheres. Fall begins on March 20 or 21 in the Southern Hemisphere. The length of daylight in the Northern Hemisphere continues to increase until the first day of summer.

**EVALUATION**

1. Label the following diagram based on your model and the Scientists’ Explanation. Include the following:
* Earth’s axis, showing the tilt,
* arrows to show the movement of the Earth around the sun,
* names of the seasons, and
* the date each season begins.

1. Review your original answers to the following questions. Did your answers change?
	1. Did you vary the distance of the Earth from the sun?
	2. Did you change the tilt of the Earth? If so, explain how.
	3. Is the Earth’s orbit more circular or more elliptical?
	4. What season is the Southern Hemisphere having when the Northern Hemisphere is having spring?
2. Choose a city in Florida and a city in Alaska to compare the duration of daylight and the highest altitude of the sun on the following dates. Fill in the table below using the United States Naval Observatory Portal.
	* Use this link to determine the duration of daylight: <http://aa.usno.navy.mil/data/docs/Dur_OneYear.php>
	* Use this link to determine the highest altitude of the sun. You will need to enter the date and the time interval of 60 minutes: <http://aa.usno.navy.mil/data/docs/AltAz.php>

## City in Florida \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Latitude \_\_\_\_\_\_\_\_\_ Longitude \_\_\_\_\_\_\_\_\_

|  |  |  |
| --- | --- | --- |
| **Date** | **Duration of Daylight (hrs)** | **Highest Altitude**  |
| Fall/September 22  |  |  |
| Winter/December 21  |  |  |
| Spring/March 20 |  |  |
| Summer/June 20 |  |  |

## City in Alaska \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Latitude \_\_\_\_\_\_\_\_\_ Longitude \_\_\_\_\_\_\_\_\_

|  |  |  |
| --- | --- | --- |
| **Date**  | **Duration of Daylight** | **Highest Altitude**  |
| Fall/September 22  |  |  |
| Winter/December 21  |  |  |
| Spring/March 20 |  |  |
| Summer/June 20 |  |  |

##

For locations at higher latitudes,

a. how does the duration of daylight change on December 21st?

b. how does the duration of daylight change on June 20th?

For locations at higher latitudes,

1. how does the highest altitude of the sun change on December 21st?
2. how does the highest altitude of the sun change on June 20th?
3. Why is the Northern Hemisphere polar region so cold even in the summer even though the region has 24 hours of daylight?

**EXTENSION**

The University of Nebraska’s Seasons Simulator is an interactive animation of the seasons. You can change your latitude and angle of the sun’s rays over the course of the year.

<http://astro.unl.edu/classaction/animations/coordsmotion/eclipticsimulator.html>