Module 3: How does the Sun affect the Earth?

Activity A: Sun-Earth Interactions

Overview

Do you know what causes the seasons on Earth? If you live in the mid-latitudes on the planet, such as in the US, you experience four seasons each year. Why are the days longer and hotter in the summer and shorter and colder in the winter? What do equinoxes and solstices have to do with seasons? By gaining an accurate understanding of Earth's place in Space, you will gain knowledge as to why there are seasonal changes in temperature on Earth over the course of a year.

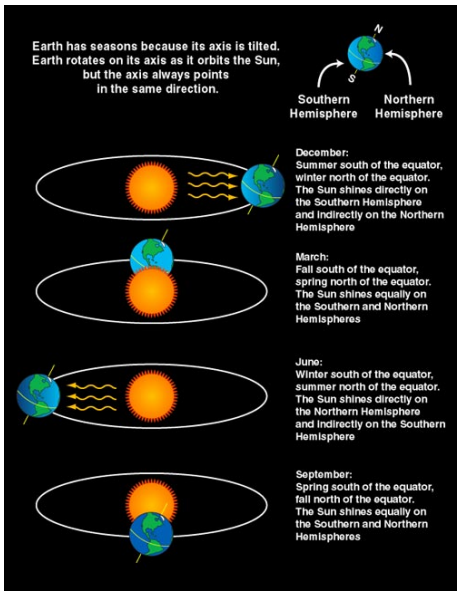


Image: NASA

First let's clear up a MAJOR misconception (false information) as to why there are seasons on Earth. Earth's seasons are NOT caused by changes in the distance the Earth is from the Sun during the year (the Earth is NOT closer to the Sun in summer and further from the Sun in winter)! The cause of Earth's seasons is due to the tilt of our planet on its axis. The Earth has an average tilt of 23.5 degrees from perpendicular. This means that the Earth's axis is not straight up and down, which explains why a globe (model of the Earth) is on an angle. Also, the tilt of Earth's axis always points in the same direction.

Teacher Overview

The focus of Module 3A is to provide an opportunity for students to create a hands-on model that accurately explains seasonal changes on Earth, and for teams to develop knowledge of the Sun-Earth system. The cause of seasons on Earth is one of the major misconceptions that exist in peoples' understanding of natural phenomena and scientific knowledge.

In the "Reason for Seasons" activity, teams create a 3-D model to demonstrate Earth's place in Space in relation to the Sun. The activity takes a constructivist approach to help students visualize a correct understanding of the causes of seasons on Earth. The four seasonal equinoxes and solstices act as "sign posts" that mark the start of seasons along Earth's orbit around the Sun. Also, the tilt of Earth's axis always points towards the North Star, Polaris, which is why this star remains in a relatively constant place in the night sky throughout the year. The 3-D model can also help to demonstrate how changes in the angle of the Sun's rays on the Earth's surface affect both seasonal and climate zone temperatures on our planet.

Objectives

Students will be able to:

- Create a model that accurately represents Earth's seasonal positions on its annular orbit around the Sun.
- Explain how the tilt of the Earth is responsible for causing seasonal changes on Earth.
- Evaluate the connection between seasonal equinoxes and solstices with the progression of

The four seasons – spring, summer, autumn, and winter – divide the year into four 3-month periods of time that are each approximately 91 days long (leap year every four years takes care of the extra quarter day per year). Latitude and the length of daylight affect seasonal temperatures. Daylight is longer during the summer months and at the Equator, and at lower latitudes sunlight is more concentrated, so temperatures are hotter. Daylight is shorter during the winter months, and at higher latitudes sunlight is spread over a wider area, so temperatures are colder. The Earth takes a day, 24 hours, to spin once on its axis (Earth rotates at 1000 miles/hour or about 1600 km/h!). While the Earth is rotating it is also orbiting (revolving) around the Sun. One orbit (revolution) of the Earth around the Sun equals a year (365.26 days to orbit means the Earth is revolving about 67,000 miles/hour or over 107,000 km/h!)!

Team Goal

Your goal is to create a 3-D model that represents Earth's orbit around the Sun to explain the four seasons on Earth.

Materials

- Small Styrofoam globes
- Fine point Sharpie
- 1 large ball or index card labeled "The Sun"
- 9 index cards labeled "Spring Equinox", "Fall Equinox", "Summer Solstice", "Winter Solstice", "September 21", "June 21", March 21", "December 21", and "North Star (Polaris)"
- 8 toothpicks
- Lump of modeling clay

Essential Vocabulary

- Revolution
- Rotation
- Orbit
- Equinox
- Solstice
- Hemisphere
- Equator
- Pole

Module Lesson

Time: 1 block period/ 2 class periods

Materials: per team

- 4 small Styrofoam globes
- Fine point Sharpie
- 1 large ball or index card labeled "The Sun"
- 9 index cards labeled "Spring Equinox", "Fall Equinox", "Summer Solstice", "Winter Solstice", "September 21", "June 21", March 21", "December 21", and "North Star (Polaris)"
- 8 toothpicks
- Lump of modeling clay

Teacher Prep:

- Obtain and prepare activity materials
- Prepare one "Earth" model for students to use as a guide
- iPad/video camera ready
- Make copies of "Reason for Seasons" activity sheets

Engage & Explore!

1. BUILD Knowledge:

Earth-Sun Interactions

As a team, watch these NASA eClips videos to see evidence of the Sun's effects on Earth. (Note: Click on the links below, type in the name of the video into the NASA eClips Search window, then scroll through the "Related Resources" to find and play your video.)

Our World: Sunsets and Atmosphere
Launchpad: Aurora Lights
Real World: Monitoring Earth's Energy Budget

2. APPLY Learning:

What Causes Earth's Seasons?

What effect does the invisible tilt of Earth's axis have on our planet? Everyone who experiences the four seasons knows from first hand observations that temperatures are colder in winter than in summer. What causes this difference in temperature and why are the daylight hours longer in summer than in winter? Click on these three Sun|Trek visualizations to learn about seasonal changes on Earth:

What is the tilt of Earth's Axis?
Why are days longer in the summer?
Why are days hotter in the summer?

Image: NASA

Student Engage/Explore Activity

1. BUILD Knowledge:

Earth-Sun Interactions

Teams watch these NASA videos to see natural evidence of the Sun's effects on Earth:

Our World: Sunsets and Atmosphere
Launchpad: Aurora Lights
Real World: Monitoring Earth's Energy Budget

2. APPLY Learning:

What Causes Earth's Seasons?

Students watch these three Sun|Trek visualizations to explain the connection between the tilt of Earth's axis and the length of seasonal daylight hours and temperatures.

What is the tilt of Earth's Axis?
Why are days longer in the summer?
Why are days hotter in the summer?

3. DEMONSTRATE Ability:

Reason for Seasons 3-D Model

Procedure:

The latitude of the region where you live on Earth determines its length and intensity of sunlight, and thus your area's climate and seasonal patterns. If you live in the Northern Hemisphere, you notice each night that the North Star, Polaris, shines almost in the same place throughout the year but the constellations appear to move as the night and year progresses. This is due the Earth's constant tilt in the same direction, which is towards the North Star. This explains why Polaris remains in a relatively constant place in the night sky throughout the year. Your team's goal is to create a 3-D model that scientifically explains how the tilt of Earth's axis causes seasons on Earth. Read and follow the instructions for the "Reasons for Seasons" activity.

After your team completes the activity, check the scientific accuracy of your "Reason for Seasons" 3-D model and diagram. Click on the link to watch a visualization that explains why Earth has four seasons. Which direction is the North Star located in the visualization?

Why are there four seasons on Earth?

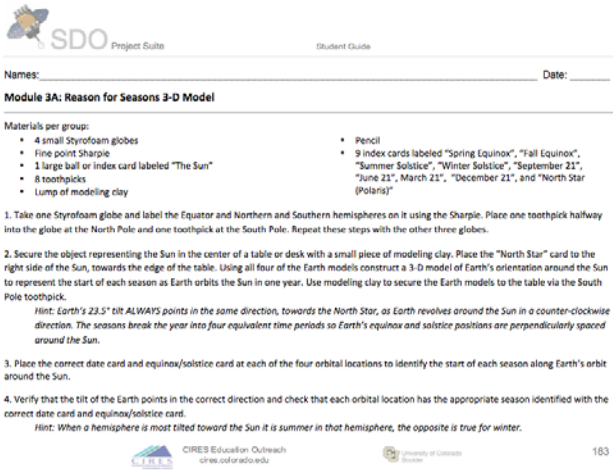
After your team has verified that your 3-D model and diagram of "Reasons for Seasons" is correct (or, if it is not correct, that your team has made changes to correct your activity diagram), you will film a short scientific "infomercial" to explain the reason for seasons on Earth. In your explanation, use your model to explain how the tilt of Earth's axis at each of the four equinox and solstice positions causes seasonal differences in temperature and daylight hours over the course of a year. Your team's 3-D "Reason for Seasons" model and this short video will be part of your Module 4 SDO Exploration Museum 3-D Solar Exhibit. Check out the NASA link below to reinforce your understanding of the reason for the seasons!

What causes the seasons?

Sensational, now you know about the relationship between the Earth and the Sun that causes seasons on our planet!

Student Engage/Explore Activity
3. DEMONSTRATE Ability:
Reason for Seasons 3-D Model
Next, student teams work together to create a 3-D model that correctly and scientifically explains why the tilt of Earth's axis causes seasons on Earth. Seasonal differences are observed in the amount of daylight hours and temperatures on Earth.
Students check the scientific accuracy of their seasonal 3-D models and diagrams by viewing the Sun|Trek visualization. They also determine which direction the North Star (Polaris) would be located in the visualization, which reinforces the concept that Earth's axis always points in the same direction- towards the North Star (Polaris).
Why are there four seasons on Earth?

After confirming that their "Reason for Seasons" model is correct (or making corrections, as needed, in their activity model and diagram), students then film a short scientific "infomercial" to explain the reason for seasons on Earth. Teams explain and demonstrate why the tilt of Earth's axis, at each of the four seasonal equinox and solstice locations, causes differences in temperature and daylight hours over the course of a year. Each team's 3-D "Reason for Seasons" model and their short video is an artifact that their team will use for the Module 4 SDO Exploration Museum 3-D Solar Exhibit. Check out the NASA link below to reinforce your understanding of the reason for the seasons! What causes the seasons?



SDO Project Suite Student Guide

Names: _____ Date: _____

Module 3A: Reason for Seasons 3-D Model

Materials per group:

- 4 small Styrofoam globes
- Fine point Sharpie
- 1 large ball or index card labeled "The Sun"
- 8 toothpicks
- Lump of modeling clay
- Pencil
- 9 index cards labeled "Spring Equinox", "Fall Equinox", "Summer Solstice", "Winter Solstice", "September 21", "June 21", March 21", "December 21", and "North Star (Polaris)"

1. Take one Styrofoam globe and label the Equator and Northern and Southern hemispheres on it using the Sharpie. Place one toothpick halfway into the globe at the North Pole and one toothpick at the South Pole. Repeat these steps with the other three globes.

2. Secure the object representing the Sun in the center of a table or desk with a small piece of modeling clay. Place the "North Star" card to the right side of the Sun, towards the edge of the table. Using all four of the Earth models construct a 3-D model of Earth's orientation around the Sun to represent the start of each season as Earth orbits the Sun in one year. Use modeling clay to secure the Earth models to the table via the South Pole toothpick.

Hint: Earth's 23.5° tilt ALWAYS points in the same direction, towards the North Star, as Earth revolves around the Sun in a counter-clockwise direction. The seasons break the year into four equivalent time periods so Earth's equinox and solstice positions are perpendicularly spaced around the Sun.

3. Place the correct date card and equinox/solstice card at each of the four orbital locations to identify the start of each season along Earth's orbit around the Sun.

4. Verify that the tilt of the Earth points in the correct direction and check that each orbital location has the appropriate season identified with the correct date card and equinox/solstice card.

Hint: When a hemisphere is most tilted toward the Sun it is summer in that hemisphere, the opposite is true for winter.

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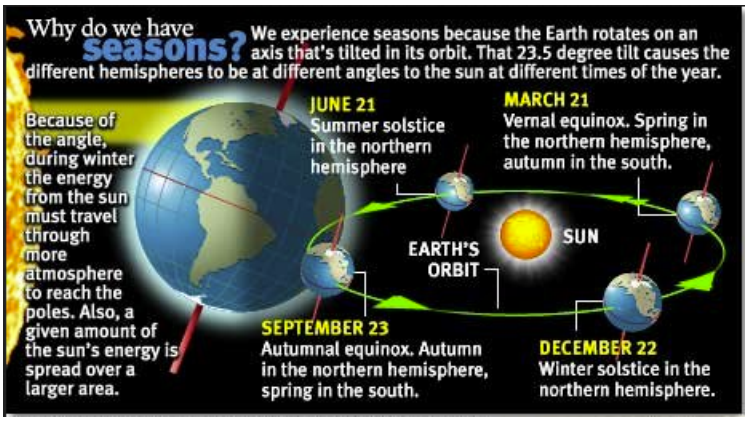

Image: NASA

Differentiation/Extension

- Climate Zones on Earth: Teams can further explore and explain the relationship between the Earth and Sun in terms of climate zones on the planet. Students demonstrate how the Sun's rays are more direct and concentrated at the Equator and are more indirect and less concentrated at the Poles to explain the why climate zones vary with latitude. Using their 3-D "Reason for Seasons" models, teams place a small graph paper grid at the equator and one at the North Pole. Next, they quantify the surface area of the grid illuminated at the Equator and North Pole using a flashlight shone from the Sun's position onto Earth. Repeat this procedure for each of the equinox and solstice positions along the path of Earth's orbit. Compare the seasonal and latitude results of surface illumination (more surface area illuminated on Earth=more indirect Sun rays and cooler temperatures, less surface area illuminated on Earth=more direct Sun rays and hotter temperatures).
- Seasons Misconception Trial: Teams carry out research to provide factual, scientifically-supported evidence to disprove the erroneous accusation that the reason Earth has seasons is because the Earth is closer to the Sun during summer and farther from the Sun during winter. Teams present their evidence in a written statement supported with illustrations, which can be recorded as a short video.
- Kinesthetic Astronomy Seasons Play: Teams act out how the Earth, with its tilt towards the North Star, orbits around the Sun to cause seasons on our planet. Students write the play's dialogue to explain the reason for the seasons as Earth passes through each of the two equinoxes and two solstices that occur over the course of Earth's one-year orbit around the Sun. Teams can add their creativity as long as it is scientifically accurate!

- NASA Solar Math
  Grade Level 3-5, p. 12
  Grade Level 6-8, p. 47
  Grade Level 9-12, p. 61

Internet Resources

The Sun, Space Weather, and Aurora Video
NASA Space Weather Media Viewer: Images "The Sun" and "Auroras"
NASA Space Weather Media Viewer: Illustrations "The Dynamic Sun" and "Auroras"
NASA Space Weather Media Viewer: Visualizations "The Sun" and "Auroras"
NASA Space Weather Media Viewer: Videos "Aurora #1-8" and "Heliosphere #1-6"
Sun|Trek Earth & Beyond
Sun|Trek Sun-Earth Interaction Videos
Space Weather Center
Space Science Institute Kinesthetic Astronomy
The Sun & Earth Relationship
Aurora Flip Chart & Auroras Collection Sheet
NASA Think Scientifically (Book 2): Adventure in the Attic
Lunar and Planetary Institute - Seasons
Nat Geo Solar Power Video
Stanford Solar Center Solar The Sun on Earth
Stanford Solar Center Effects of the Sun on Earth Labs