

Kinesthetic Astronomy: Longer Days, Shorter Nights

GRADE LEVEL	3 rd -8 th ; California Content Standards for 3 rd , 5 th , 6 th – 8 th
SUBJECTS	Earth & Space Science, Using Models
DURATION	Preparation: 20 minutes Activity: 60 minutes
SETTING	Classroom

Objectives

In this activity students will:

1. Learn that the Earth is tilted on a consistent axis
2. Know the reason why the length of days differs throughout the year.

Materials

- A lamp to represent the Sun at the center of the circle
- Twelve Zodiac Signs and Four Seasons Signs from **Kinesthetic Astronomy: Set Up**
- Painter’s tape (if you are taping these signs to chairs or walls)
- 4 globes of similar sizes
- Science Notebook (1 per student)
- 1 copy per student of the Sun’s Rays activity sheet and 1 triangle per sheet
- Dark room with minimal light pollution
- 1 copy per student of the assessment probe (optional)
- Glow-In-The-Dark Ball (optional)

Scientific Terms for Students

Orbit: the path described by one celestial body in its revolution about another

Orbital period: the time taken for a given object to make one complete orbit about another object; the Earth takes 365 days to orbit the sun.

Rotation: a single complete turn

Solar System: a sun with the celestial bodies that revolve around it in its gravitational field

Background for Educators

The Earth’s tilt causes seasons to change and daylight hours to fluctuate. This is an important concept to grasp as it affects convection currents, climate and weather on Earth. This type of lesson is typically taught as a concept for why the Earth has seasons. But for people who live in places where there is not a typical weather pattern of autumn leaves, winter snow, and summer heat, this can be a problematic concept. For example, students living in San Francisco experience summer fog, autumn heat and dry spring months. So, when a typical “Why the Earth has Seasons” lesson asks why summers are hotter, students say “there’s no heat in summer!” and they are right.

In order to better scaffold talking about the Coriolis Effect, climate, and weather, it is important to first talk about the changes in daylight throughout the year. By approaching the topic from this viewpoint, one can often avoid the confusion that comes up when talking about seasons. When asked, most people can tell you that summer has longer days and winter has shorter days. It is also common that many people can tell you that the light looks different throughout the year, with more intensity in the summer and a diluted look in the winter. All of this has to do with the tilt of our planet and the quality of light energy hitting the Earth in different places. This activity explores how light changes throughout the year.

Common Misconceptions

There are some common misconceptions about how the Earth's position in space and its tilt affect the light energy on Planet Earth. Here are some of the major ones with some suggestions on how to combat them. The best way to begin to overcome any misconception is to present a discrepant event or fact, something that surprises someone.

Misconception #1: The Earth has seasons because its distance from the sun changes.

Discrepant Fact #1: Did you know that winter in the northern hemisphere occurs when the Earth is closest to the Sun? The distance from the sun fluctuates between 91 million miles to 95 million miles away, averaging 93 million miles away from the sun. The difference in distances is relatively small and doesn't have an effect on the length of day, or the seasons. But even if it did, we would have summer in January and winter in June!

Misconception #2: The Earth's tilt brings the northern hemisphere closer to the sun in the summer.

Discrepant Event #2: Similar to the misconception above, this distance is relatively miniscule, changing the northern hemisphere's distance by a few thousand miles, which is less of a difference than when the Earth comes closer in its orbit.

Misconception #3: The Earth has longer days and shorter days, as well as different seasons, because Earth's tilt "changes" as Earth moves in orbit around the Sun.

Discrepant Fact #3: Did you know it take 26,000 years for the Earth to wobble once around? This may cause students to try to "wobble" or change the tilt of their axis as they move around the circle. This Earth's axis changes *relative to the Sun* because of its motion in orbit around it, not because of any wobbling or change in the direction Earth's axis is pointing in space.

This lesson is adapted from the Kinesthetic Astronomy program developed by the Space Science Institute, 2004.

Teacher Prep

- Follow the instructions in **Kinesthetic Astronomy: Set Up** to set up your kinesthetic circle
- Place four – six sticky dots along one meridian of the globe, spaced at equal intervals, preferably one at your location on the planet.
- Put glow in the dark ball in a dark bag, so it won't get light pollution.
- Make copies of the Sun's Rays Activity Sheets and cut up gray circle into individual triangles.

Activity Procedure

1. **Administer the Assessment Probe (optional):** Ideally, this would be done the day before you teach this class as a way of gathering information on what the class knows before you teach this activity.
2. **Science Notebooks:** Have students brainstorm ways that they have noticed daylight changing throughout the year. In their science notebooks have them draw or write why they think daylight changes. Have them share their thoughts with another student, or small group of students.
3. **Kinesthetic Movements:** Set up the kinesthetic circle. Review the meaning of a day (students turn in place to create sunrise, noon, sunset and midnight), and the meaning of a year (one trip around the sun).
4. Introduce the North Star, or "Polaris." When people are out at night in the northern hemisphere this is the star that points directly north.
5. Have your students find "Polaris" in the room and make an appropriate tilt toward it (head, or North Pole, towards the star). Have them notice which way their bodies are bending and ask the following questions:
 - a. Are there any students leaning directly away from or towards the sun? [yes, these are called "solstices."]
 - b. Are there any students in the circle who are not leaning either toward or away from the Sun?" [yes, these places are called "equinoxes"]
6. Have the students try to make one full rotation with their bodies bent on the Earth's axis.
 - a. Ask the students to ponder this question: How do you think the tilt of the Earth affects the daylight? [solstices have extremely long days and equinoxes have equally long nights and days]
7. **Science Notebooks:** Have students turn to a new page in their science notebook titled "observations of Sunlight on Earth throughout the year." Place one globe at each solstice and

equinox. Make sure that all the axes are pointed at the North Star. Turn down the lights. Have small groups of students observe the globes in different places and notice where the light shines, where it seems the brightest, and where it doesn't shine at all. Have them use their new page to document the differences between light on the different globes. After they have made their observations, discuss the following questions:

- a. Does the light play differently on the two hemispheres? [the light shining on the hemisphere leaning toward the light has a greater intensity, and the light patch on the hemisphere leaning away is more spread out.]
 - b. Have students try spinning the globe, comparing light in the northern hemisphere to light in the southern hemisphere.
 - c. How do you think the light affects the temperature of different places on the planet? [when brighter light shines longer on a specific area of the Earth, the seasons become warmer]
 - d. It is important for students to note that the tilt of the Earth does not change- it remains constant.
8. Explain that when the Sun is higher in the sky, the Sun's rays shine down on us more directly, and for a longer period of time throughout the day. Therefore, we receive a greater intensity of sunlight. On the other hand, when the Sun is lower in the sky, the rays come in at a lower angle and are spread out over a larger area so that we feel less intense sunlight. In winter, the Sun appears to follow an arc that is very low in the sky during daylight hours. This means that the intensity of sunlight is much less in winter compared to summer when the Sun follows an arc that is much higher in the sky.
9. **Diagram of the Sun's Rays:** Give them a copy of the Earth printout with the gray triangle.
- a. Students should position the triangle so that the curved edge lines up with the curved surface of the Earth on the diagram. Have them count the number of rays hitting the Earth along the edge of the triangle. They should repeat this with the triangle positioned at different points.
 - b. Ask what they observe. [the number of rays striking the edge of the triangle is different at different points on the globe.]
 - c. Optional Addition: Use a flashlight to demonstrate the effect of the Sun's rays at higher or lower angles. Ask students to compare the patch of light resulting from shining a flashlight on the floor from almost directly overhead to the patch of light that results from shining the flashlight from lower angles. At lower angles (like the Sun being lower in the sky), the light is dispersed over a greater area and so it is less intense than the more concentrated patch of light resulting from higher angles of incidence (like the Sun being higher in the sky).

10. **Glow in the dark ball:** Turn down the lights and have one student hold the ball tilted at an angle, like the Earth, and spin the ball while another student shines a flashlight on it. Then, turn off all of the lights and have students make observations of where the ball glows the most. [You should see a clear bright band on the ball, with less intense light at the edges.]
11. Restore the lights and introduce a rhyming jingle:
*“Seasons are the length of days and angle of rays...
They have nothing to do with how far away!”*
12. **Science Notebooks & Post- Assessment:** Have students draw a diagram and/or write an explanation of why light changes throughout the year. Compare that to the first drawing to see how their understanding has changed and to assess whether or not the activity had the desired learning outcomes.

Extensions

- How do you think having more or less sunlight throughout the year affects life on Earth? How does it affect you?
- If more sunlight = more heat, how do you think that affects our weather and climate?

California Science Content Standards

Grade Three

Physical Sciences

1. a. Students know energy comes from the Sun to Earth in the form of light.

Earth Sciences

4. e. Objects in the sky move in regular and predictable patterns. As a basis for understanding this concept students know the position of the Sun in the sky changes during the course of the day and from season to season.

Grade 5

Earth Sciences

4. a. Energy from the Sun heats Earth unevenly, causing air movements that result in changing weather patterns. As a basis for understanding this concept students know uneven heating of Earth causes air movements (convection currents).

Grade 6

Earth Sciences

4. a. Many phenomena on Earth’s surface are affected by the transfer of energy through radiation and convection currents. As a basis for understanding this concept students know the sun is the major

source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle.

4. b. Students know solar energy reaches Earth through radiation, mostly in the form of visible light.

Next Generation Science Standards

Fifth Grade

5-ESS1-1: Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.

5-ESS1-2: Represent data in graphical display to reveals patterns of daily changes in length and direction of shadow, day and night, and seasonal appearance of some stars in the night sky.

Middle School

MS-ESS2-4: Develop a model to describe the cycling of water through Earth's system driven by energy from the sun and force of gravity.

MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the earth cause patterns of atmospheric and oceanic circulation that determine regional climates.