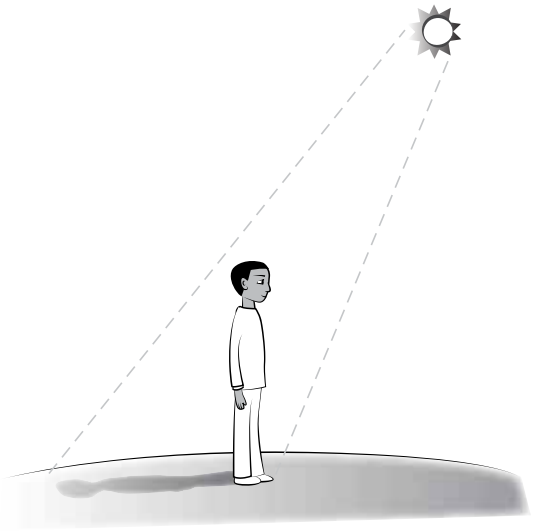
No Shadow



Four friends in New York City were wondering if there was ever a time during the day when they would have no shadow. They each had different ideas about daytime shadows. This is what they said:

Paige: "I will have no shadow when the Sun is highest in the sky."

Olive: "I will have no shadow at noon because the Sun will be directly overhead."

Kami: "It depends on the season. I will have no shadow at noon in the summer, but not in the winter."

Vince: "It depends on where you live. Only people who live near the equator will have no shadow on certain days."

Which friend do you agree with the most? _____ Explain why you agree.

_____

_____

_____

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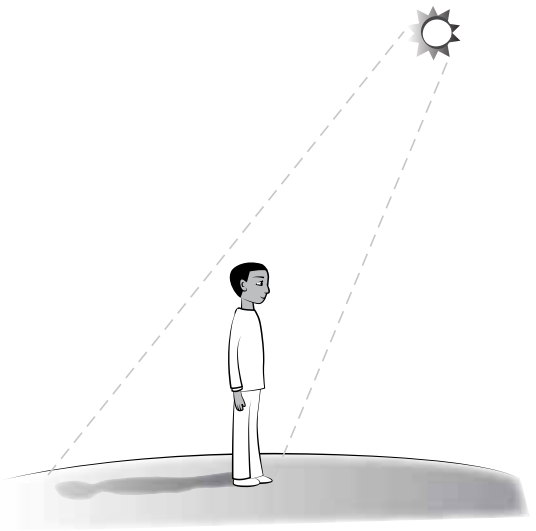
No Shadow

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about the Sun's motion during the day. The probe is designed to reveal whether students know that the Sun is never directly overhead as viewed from the continental United States. (Hawaii is the only state where the Sun is sometimes overhead at noon.)

Related Concepts

Objects in the sky
Seasons: cause
Solar system objects: spin
Sun: altitude at noon, path in the sky

Explanation

Vince has the best answer: "It depends on where you live. Only people who live near the equator will have no shadow on certain days." In order to have no shadow, the Sun needs to be directly overhead. The Sun is never directly overhead except on certain occasions for locations between the Tropic of Cancer and the Tropic of Capricorn. The only state that falls between the tropics is Hawaii. So for the continental United States and Alaska there is always a shadow whenever the Sun is visible in the sky. Paige's response reflects a common misconception that the Sun is directly overhead when it is highest in the sky. Olive expresses a widely held misconception that the Sun is overhead at noon. Kami's statement that it depends on the season would be correct if she lived in the tropics, and even then the Sun is not overhead every day.

Administering the Probe

This probe is primarily designed for students in grades 3–8. For the younger children it is important to first determine if they understand how shadows form and that the length of their shadow indicates how high the Sun is in the sky. If some children are confused about the relationship between the length of their shadow and the height of the Sun, plan some preliminary activities for students to learn

about this relationship before administering the probe. For middle school students, you can extend the probe by asking the students to explain their answer. Students can also be encouraged to draw a picture to support their explanations.

Related Ideas in *Benchmarks for Science Literacy* (AAAS 2009)

K–2 The Universe

★ The Sun, Moon, and stars all appear to move slowly across the sky.

3–5 The Earth

- The rotation of the Earth on its axis every 24 hours produces the night-and-day cycle. To people on Earth, this turning of the planet makes it seem as though the Sun, Moon, planets, and stars are orbiting the Earth once a day.

Related Ideas in *National Science Education Standards* (NRC 1996)

K–4 Objects in the Sky

- The Sun, Moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.

K–4 Changes in Earth and Sky

- Objects in the sky have patterns of movement.

Related Research

- Plummer and Krajcik (2010) interviewed 60 students—20 each in grades 1, 3, and 8—about their ideas concerning how the Sun moves in the sky during the day. None of the first-grade students and only a few of the older students (20% in third grade and 10% in eighth grade) knew that the Sun does not pass directly overhead.
- A sample item from a set of astronomy diagnostic questions asks college students, "As seen from your location, when is the Sun directly overhead at NOON (so that no shadows are cast)? " Common incorrect responses included every day; on the day of the summer solstice; on the day of the winter solstice; and at both of the equinoxes (spring and fall). Many college students failed to select the correct response: never from the latitude of your location (Zeilik, Schau, and Matter 1998).
- Students seem to have more success in locating where an object's shadow will fall in relation to a light source if the object is a person. They have more difficulty anticipating where a shadow will fall if it is a nonhuman object, such as a tree (Driver et al. 1994).
- Plummer (2008) interviewed a total of 60 children in grades 1, 3, and 8, and developed a learning progression for realistic expectations for developing students' ideas about the Sun's motions:
  - For grades K–1 the Sun rises and sets, and it is in the sky during the daytime but not at night.
  - For grades 2–3 the Sun rises, moves continuously through the sky, and sets on the opposite side of the sky.
  - For grades 4–5 the Sun is highest at noon but does not pass directly overhead. Also for grades 4–5, the length

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

of the Sun's path and its highest point in the sky changes across the seasons.

- Mant and Summers (1993) interviewed primary school teachers in England. Although most could explain the day-night cycle in scientific terms, few could relate their explanations to observations of how the Sun appears in the sky. Some appeared to work backward from their explanation to describe what must be happening in the sky. That suggests it is important to have students first observe how the Sun changes its position during the daytime before explaining why that happens from the viewpoint of a spinning Earth.

Suggestions for Instruction and Assessment

- This probe can be combined with "Me and My Shadow" in *Uncovering Student Ideas in Science, Vol. 3: Another 25 Formative Assessment Probes* (Keeley, Eberle, and Dorsey 2008).
- This probe can be used to launch into an investigation in which students measure the length of a shadow from morning through afternoon, including observations at about 15-minute intervals before and after noon. This activity can help students learn why it is colder in winter if repeated monthly throughout the year. Record the observations on a large sheet of paper and post them on a wall so students can compare the observations; they will see that as winter approaches the Sun does not go as high in the sky around noon, so their shadow is longer. As the school year turns to spring, the Sun will be higher in the sky around noon so shadows will be shorter.
- Revisit this idea at the high school level, asking students to write an explanation of the day-night cycle. Demonstrations like those mentioned above can be used if formative assessment reveals students have misconceptions about the motion of the Sun during the day.
- NSTA's Astronomy With a Stick project has several activities and suggestions for helping students develop an understanding of the changing position of the Sun throughout the day: *www.nsta.org/publications/interactive/aws-din/aws.aspx*.

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