



Bear's Shadow

Children listen to the story *Moonbear's Shadow* and then recreate scenes from the picture book, using a Bear figure and a flashlight (to represent the Sun). Children explore how the position of the light affects the size, shape, and position of the shadow.

 30–45 minutes

 Workshop/camp
Drop-in station (see page 3)

 3–4 children per adult



Content Learning Goals

Children begin to understand:

- A shadow is created when an object blocks light from a light source.
- Changing the position of the light source changes the position, size, and shape of the shadow.
- The Sun appears to move across the sky each day from morning until sunset.

Science Practices

- Children **model** how the Sun casts shadows.
- They **observe** the shadows cast by the flashlight and **compare** their observations as they change the position of the light.
- They **make claims** about how to make the shadows longer, shorter, or in front of /behind the bear figure.

Materials

- Book: *Moonbear's Shadow* by Frank Asch
- For each station:
 - Green mat with blue pond and fish
 - Bear figure
 - Tree (small model or stand-up paper cutout — see image)
 - Flashlight with Sun cutout attached
 - Set of challenge cards (separate file)
- Optional — various props for discussing shadows:
 - Extra light sources: flashlight, lamp, candles, etc.
 - Objects: three-dimensional/flat; opaque/translucent; variety of sizes and shapes

SET-UP

- Create a circle area for reading *Moonbear's Shadow*.
- If you also want to demonstrate and discuss shadows during circle time, make sure that you can darken the room and can access your various light sources.
- Set up a station for each child or family:
 - Place the Bear figure and the tree onto the pond scene.
 - Slide the Sun cutout over the end of the flashlight.
 - Lay out a set of challenge cards.
- Check ahead of time to be sure the shadows cast by the flashlights will be visible with the lighting in your space. Switching off the lights is not strictly necessary.

ACTIVITY DESCRIPTION

1. Read *Moonbear's Shadow* by Frank Asch (10–15 minutes)

This is a story about Bear trying to lose his shadow after it scares away the fish he was trying to catch. He tries out various creative ideas, but his shadow always reappears. Although not explicitly discussed in the narrative, the illustrations depict the Sun's apparent motion across the sky, as well as the changing size, shape, and position of Bear's shadow throughout the course of the day. You can use the following questions to focus the children's attention as you read the story:



- Ask children to help you find the Sun and Bear's shadow in each illustration. Use your finger to trace a line from the Sun, to Bear, and then to his shadow.
- Ask children to make predictions about the story. For example: Do you think Bear's shadow will stay nailed to the ground when he walks away? Bear's shadow disappeared when he stepped into the shade of the tree — where did it go?
- Review how the position of the Sun in the sky changed throughout the story, over the course of the day. Motion with your arm, and have children practice the same motion: "The Sun started low on one side of the sky, and then climbed higher as it moved across the sky. It was at its highest at noontime, when Bear took a nap. Then it continued across the sky, getting lower. Bear's shadow changed as the Sun moved higher and then lower across the sky."

Shadows at noontime:

In the book, Bear's shadow disappears at noon, but this would actually only happen in the tropics. For more details, see the explanation on page 7.

2. Discuss light and shadows (optional, 5–15 minutes — see page 2)

3. Experiment with making Bear's shadow (10–15 minutes)

Invite each child to a station so that they can recreate scenes from the book and try to make Bear's shadow change. If families are participating, encourage them to work together. If it's just children, you should plan for one facilitator for every three or four children.

Encourage children to try switching the flashlight on and off, and using it to make the shadow of the Bear figure, then experiment moving the light and the objects to recreate scenes from the book as depicted on the challenge cards:



- ☉ Move the Sun across the sky, from sunrise to sunset. What happens to Bear's shadow as the Sun moves?
- ☉ Shine the light straight down on Bear from above his head. Where is his shadow?
- ☉ Try to make Bear's shadow appear in front of him/behind him.
- ☉ Try to make Bear's shadow long/short.
- ☉ Bear wants to hide in the shade of the tree. Can you help him?
- ☉ In the story, Bear's shadow scared the big fish away. Try to make Bear's shadow touch the fish in the pond.

This activity allows children to **model** the phenomenon of how the Sun casts shadows outside. Use the question prompts to help children investigate how changing the flashlight's position changes the size, length, and position of the shadows. As children test different positions of the flashlight, ask them to **compare their observations** and encourage them use their observations to **make claims** about how to make the shadows longer, shorter, or in front of/ behind the Bear figure. Children can make claims either verbally or by demonstrating with their model.

Optional discussion of light and shadows

As time permits before or after reading the book, have a discussion about light and shadows. In the story, Bear didn't seem to realize that as long as he had a light (the Sun) shining on him, he'd have a shadow. This is a discovery that you can help the children make. Here are some questions and ideas you might explore, and if possible, demonstrate:

- Tell me about your shadow.
- When do you see your own shadow? Do you see your shadow on a cloudy day? Do you have a shadow when it's dark?
- Does your shadow always look the same? Why do you think that your shadow changes?



- What do we need to make a shadow? Encourage the children to share their ideas. Sum up by identifying three things that we need to make a shadow: a light source, an object to block the light, and a surface for the shadow to appear upon.
- You might darken the room and demonstrate making a shadow that the children can see on the floor. Emphasize that:
 - The Sun, light bulbs, candles, and flashlights are examples of sources of light.
 - When an object blocks the path of light, a shadow is made.
 - We can see the shadow on some kind of surface — e.g. the floor or wall.

If you have the time, switch off the lights and let the children freely experiment making shadows with different light sources and objects. You could use flashlights, lamps, and battery-operated flameless candles. Compare shadows of different objects, and then the same object with different light source. Observe what happens when you change the position of the light source. If possible, give each child a flashlight to make shadows, observing how the light travels in a straight line, and how a shadow is formed when an object blocks that line of light.

AS A DROP-IN ACTIVITY

Though designed as a workshop activity, *Bear's Shadow* can also be adapted as a drop-in station for children and accompanying adults. You'll need a space in which the lighting will allow for shadows of the Bear figure (it does not need to be completely dark). Set up the stations in the same way, with a pond scene, Bear figure, tree, and flashlight with a Sun cutout slipped over the end. Lay out the challenge cards and the *Moonbear's Shadow* book. Encourage families to experiment with the flashlight to make shadows, try out the challenges on the cards, and discuss how and why our shadows change throughout the day as the Sun appears to move across the sky. The challenge cards have discussion questions on the back if they want to go further.

EXTENSIONS

- Make shadow puppets by cutting shapes from construction paper and gluing them to craft sticks. Hold them up behind a screen that is lit from behind.
- Trace children's own shadows on a sunny day using sidewalk chalk. They might even wear headbands with ears so that they can pretend to be Bear from the story. Mark the locations of their feet. Have them stand in the same locations later in the day, and trace their shadows again. How have the shadows changed? Be sure to choose a location that will still be in sunlight when you return for the second tracing, e.g. think ahead to avoid shadows of buildings.

DEVELOPMENTALLY APPROPRIATE STRATEGIES

Children have probably noticed their shadows before, but it may be their first time reflecting on or articulating about what makes a shadow. Likewise, this may be the first time using a flashlight for some children. Allow them time to experiment with how it works and delight in the experience. They will likely practice switching it on and off, and try shining it on each other, on different objects, at the ceiling, at the wall across the room, etc. Discourage shining the lights in each other's faces.

The challenges on the cards will indeed be challenging for many children. Give children time to try out different solutions. When children seem ready for additional support, try some of these developmentally appropriate strategies:

- **Acknowledge** what children are doing by describing their actions and the results (e.g., *You're pointing the flashlight down on Bear's head.*). Avoid evaluative statements (e.g., "good job") by giving **specific feedback** (e.g., "You made Bear's Shadow disappear!")
- **Ask questions** to provoke children's thinking (e.g., *Show me how you can make Bear's shadow really short. What happens if we shine the light straight down on Bear from above? What do you notice about Bear's Shadow when you shine the flashlight over there?*)
- **Give assistance** in the form of a hint or **demonstration** that will help children think of solutions to the challenges (e.g., *I see you're trying really hard to make Bear's shadow touch the fish in the pond. I'm going to try holding the flashlight behind him over here. Where do you see his shadow? Look! It's in the pond. How should we move it so it touches the fish?)*
- **Provide information** to help children extend their conceptual understandings and enrich their vocabularies (e.g., *I see you are holding the flashlight high up in the sky and Bear has a very short shadow. The time of day when the Sun is highest in the sky and our shadows are shortest is called noon. Noon is the time when we eat our lunch!*)



Note: Make sure to pause between questions or statements to allow children ample time to comment and respond back. If they do not reply immediately, allow a bit more time to pass before asking another question. This respects their discovery process.

For more developmentally appropriate strategies, see: <http://www.naeyc.org/dap/10-effective-dap-teaching-strategies>

BACKGROUND INFORMATION

The following information about the learning sciences and astronomy is intended for the educator who will facilitate the Bear's Shadow activity. The activity is a developmentally appropriate first step toward the children eventually understanding the concepts explained below, perhaps years later. We do not intend the educator to cover most of these concepts with the children during the activity. This information is provided to give the educator a good basic understanding of the scientific concepts that the activity is moving toward and how many children think about these topics, and preparation to answer questions from very curious children or adults.

LEARNING SCIENCES: HOW CHILDREN UNDERSTAND LIGHT, SHADOWS, AND THE MOTION OF THE SUN

Light and Shadows

Whereas Piaget claimed that preschool-aged children were too young to understand light and shadows, more recent research on learning and development has shown that young children can begin to develop an understanding of these concepts. The new research has also helped us to better understand the challenges that children face in trying to understand how shadows work. Other recent research has demonstrated that very young children can begin to understand and reason about shadows with the help of certain teaching interventions or engaging hands-on activities.¹ For example, young children in one study were likely to show understanding of shadows after having opportunities to explore the conflicting dimensions of size of object and distance from light source².

Sun's Motion

One of the My Sky Tonight research partners, Dr. Julia Plummer, has found that even in first grade (6–7 years), most children were not aware of the Sun's apparent path from one side of the sky to the other. Instead, most either described this motion as a straight up-and-down pattern or they described Sun as staying at the top of the sky all day long³. In addition, research studies conducted by My Sky Tonight researcher Dr. Jennifer Jipson as part of the My Sky Tonight project have found that preschool aged children also report that the Sun only moves up and down. While the Sun only passes directly overhead in the tropics, most children believe this is the typical path of the Sun regardless of their actual location or the season. Research has also suggested that when preschool aged children are exposed to and use a variety of spatial language, their spatial thinking skills improve. Combining the use of spatial words with gestures can further refine understanding of the concepts being explored^{4,5}. For example, Plummer found that engaging first and second grade children with a combination of words, images, and gestures (tracing the Sun's path across the sky) during a planetarium show improved their understanding of how the Sun appears to move⁶.

¹ Hadzigeorgiou, Y. (2015). Young children's ideas about physical science concepts (Chapter 4). In K.C. Trundle & M. Sackes (Eds.), *Research in Early Childhood Science Education*. New York, NY: Springer.

² Newcombe, N.S. (2010). Picture this: Increasing math and science learning by improving spatial skills. *American Educator*, 34, 29–43.

³ Plummer, J.D. (2009). A cross-age study of children's knowledge of apparent celestial motion. *International Journal of Science Education*, 31 (12), 1571–1605.

⁴ Newcombe, N.S. (2010). Picture this: Increasing math and science learning by improving spatial skills. *American Educator*, 34, 29–43.

⁵ Pruden, S., Levine, S., & Huttenlocher, J. (2011). Children's spatial thinking: Does talk about the spatial world matter? *Developmental Science*, 14(6), 1417–1430.

⁶ Plummer, J.D. (2009). Early elementary students' development of astronomy concepts in the planetarium. *Journal of Research in Science Teaching*, 46, 192–209.





ASTRONOMICAL SCIENCE BACKGROUND: SHADOWS AND THE APPARENT MOTION OF THE SUN

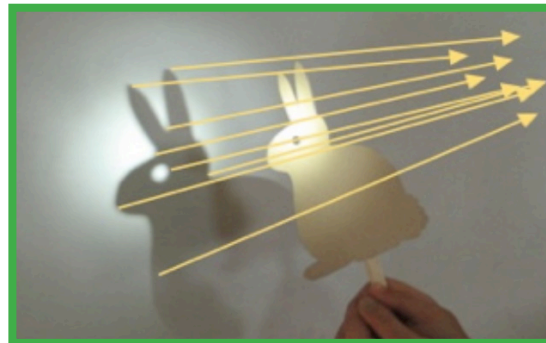
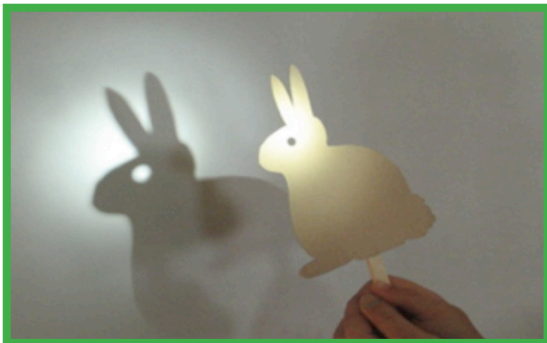
What elements do you need to make a shadow?

We need three elements to see a shadow:

- ☀ Source of *light*
- ☀ *Object* to block the light
- ☀ *Surface* for the shadow to fall upon



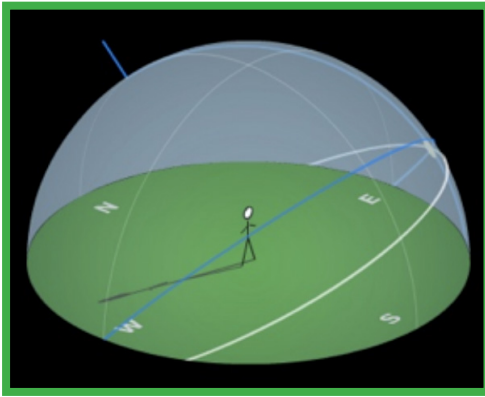
In the picture above, we see the children as the objects and the ground as the surface that their shadows are falling on, but don't see the light source. In the picture below, we have the wall as the surface, the bunny cutout as the object, and once again, a light source that is not seen. From the two things that we can see, we can trace back to figure out where the light source is — the Sun shining on the children from high up above, like that cartoon Sun at the top of this page; and the flashlight shining on the bunny from over the person's shoulder.



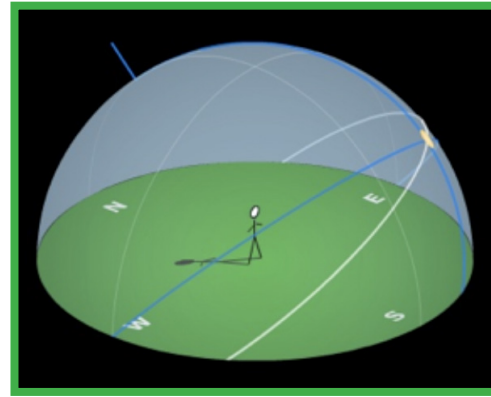
Changing shadows cast by the Sun

When we are outside on a sunny day, we can see our shadows cast by the Sun, just like Bear in the story. The shadow will change throughout the day as the Sun appears to move across the sky, and the shadow will look different at different times of year when the Sun appears higher or lower in the sky. The shadow will appear opposite the direction of the Sun, so, for example, if the Sun is in the east, the shadow will point to the west. The shadow will be longer when the Sun appears low in the sky, such as at sunrise and sunset; and the shadow will be shorter when the Sun appears high in the sky, such as at noontime.

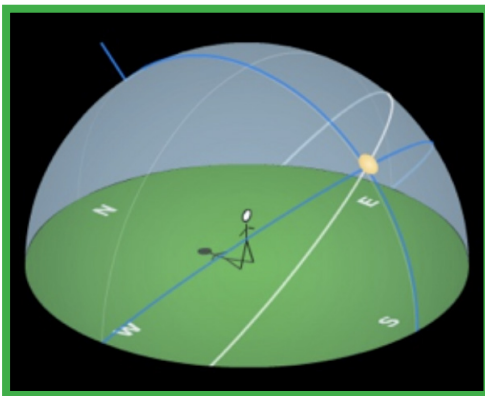
The following descriptions are for the Northern Hemisphere:



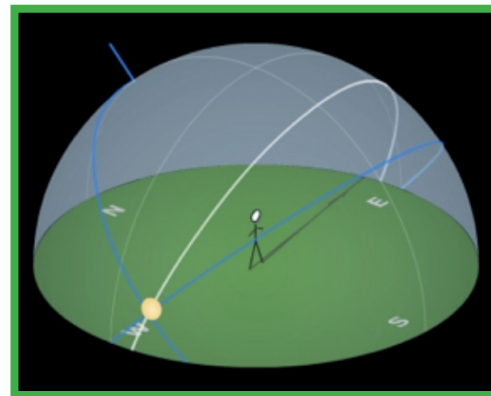
Sunrise: The Sun appears to rise in the east, starting out low near the horizon, casting long shadows that point to the west.



Morning: Throughout the morning, the Sun appears to climb higher and toward the south, casting shadows that become shorter and point northwest.



Noon: At solar noon, the time when the Sun has reached its highest position in the sky to the south, the shadows will be at their shortest, pointing north.



Afternoon & sunset: Throughout the afternoon, the Sun appears to sink lower in the southern sky toward the west, casting shadows that become longer and point northeast. The Sun then appears to set in the west, casting long shadows that point to the east.

The Sun appears to rise higher in the sky in summer months, and remains lower in winter months, so shadows will be shorter in the summer and longer in the winter, while still varying over the course of a day as described above.

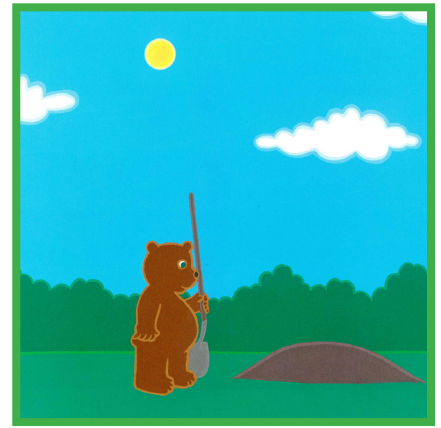
The illustrations above were made using the *Motions of the Sun Simulator* from the University of Nebraska-Lincoln. Find it at the link below to explore how the Sun's apparent position in the sky varies throughout the day and year, and for different locations on the Earth, and how this affects the position and length of shadows cast by the Sun.

<http://astro.unl.edu/naap/motion3/animations/sunmotions.html>

Shadows at noontime

Solar noon is the time when the Sun appears at its highest point in the sky for the day. This may vary from noon as shown on your clock due to variations across a time zone, as well as Daylight Savings Time. Solar noon is when shadows will be at their shortest and pointing directly north in the Northern Hemisphere or directly south in the Southern Hemisphere.

In the book, Bear's shadow disappears at noon. The assumption is that the Sun is directly overhead, and thus his shadow is directly underneath him. This phenomenon actually only occurs in the tropics, a region that extends a certain 23.5 degrees north and south of the Earth's equator, and only on certain days of the year. At the equator, the Sun will be directly overhead at noon on the equinoxes (March 20 and September 22). At other locations in the tropics, this will occur on just one day of the year, which will vary with latitude. In the continental U.S., which is not a part of this region, solar noon is when our shadows are at their shortest, but they will never completely disappear.



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