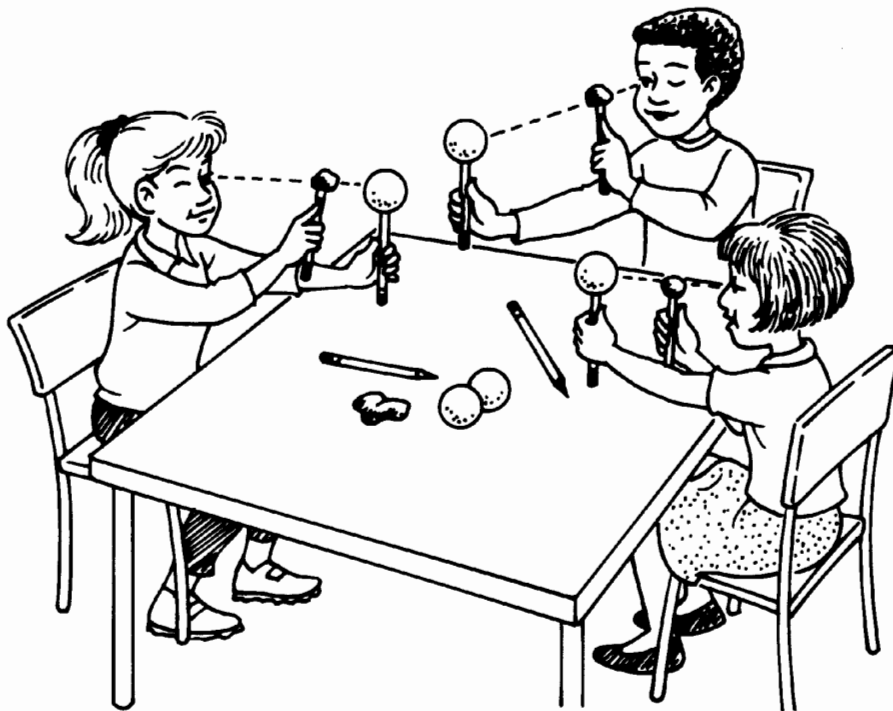
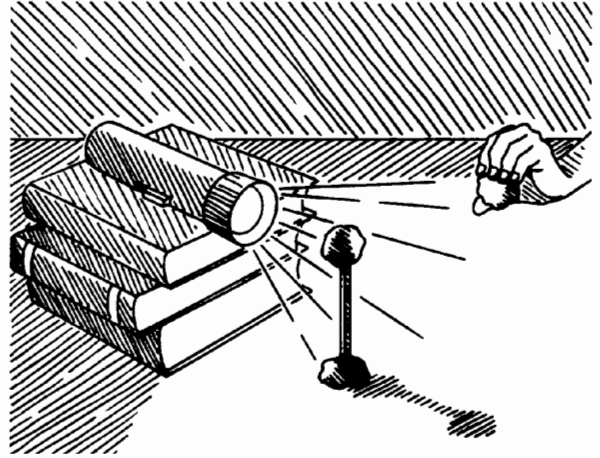
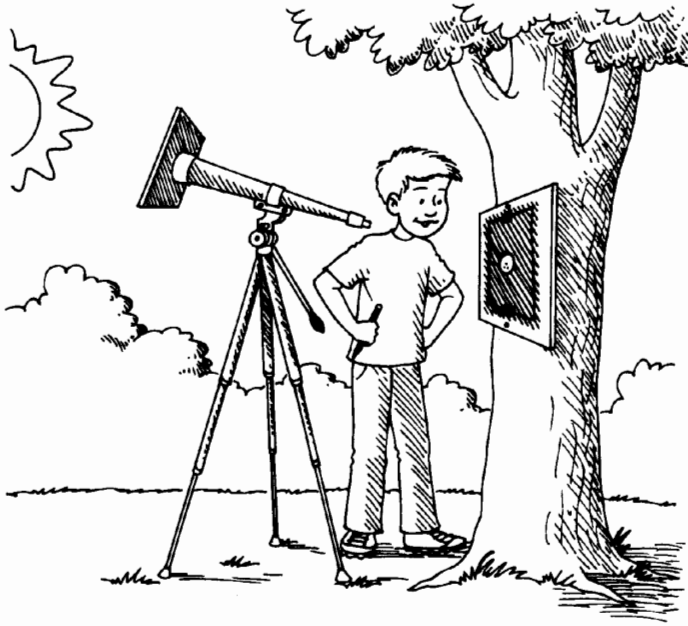


Astronomy



Brighter

PROBLEM

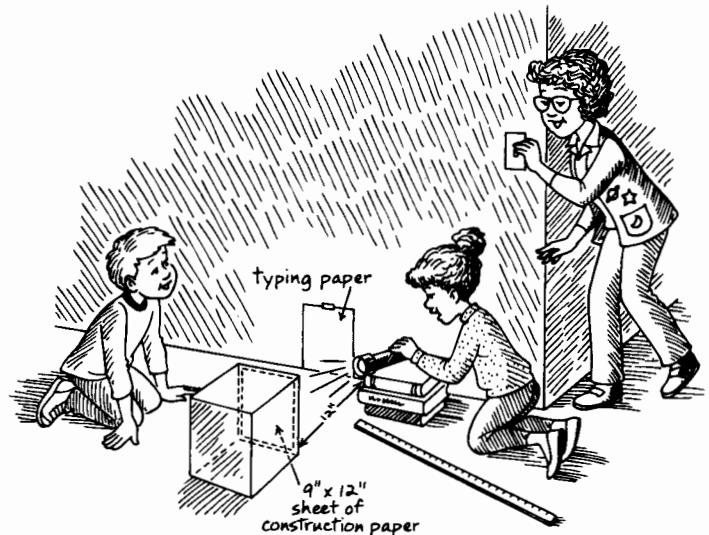
Why are planets so bright in the sky?

Materials

transparent tape
 sheet of office paper
 sheet of 9-by-12-inch (22.5-by-30-cm) white construction paper
 medium-size box with one side at least 9-by-12-inches (22.5 × 30 cm)
 yardstick (meterstick)
 3 to 4 books
 flashlight

Procedure

1. Tape the office paper to a wall so that its bottom edge rests on the floor. This paper represents the screen in a **photometer** (an instrument that measures the brightness of light) located at a point on the Earth.
2. Tape the white construction paper to one side of the box. This paper represents the surface or **atmosphere** (layer of gas surrounding a celestial body) of a planet.
3. Stand the box 12 inches (30 cm) from the screen, with the paper-covered side of the box facing the screen.
4. Use the books to raise the flashlight so that it is at an angle to the paper on the box and its light shines on the center of the construction paper.
5. Turn the flashlight on, then darken the room. Observe the brightness of the photometer screen.
6. Turn the flashlight off and again observe the brightness of the screen.



Results

The screen brightens when the flashlight is on.

Why?

The Sun and other stars are **luminous** (giving off light). But the Moon and planets, even though they shine, are not luminous. These **celestial bodies** (natural objects in the sky, such as stars, suns, moons, and planets) **reflect** (bounce back) light from the Sun to Earth, the same way the construction paper reflects the light from the flashlight to the screen. Without the Sun, the Moon and planets would not shine.

LET'S EXPLORE

1. Different planets and other celestial bodies, such as moons, each reflect different amounts of light. How does the color of a reflecting material affect the amount of light reflected? Repeat the experiment, placing the white construction paper on the box as before. Observe the brightness of the light reflected on the screen. Then,

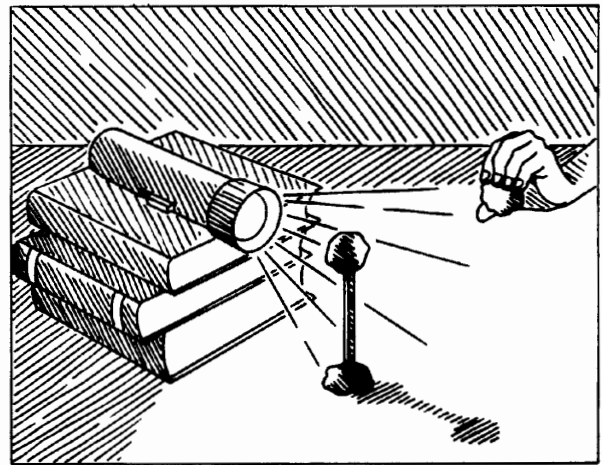
tape a different color paper, such as brown, over half of the white paper on the box. First, shine the light on the white paper, then on the brown paper, and compare the brightness of the light reflected on the screen by each paper. Repeat, using various colors, such as red, green, and black. From the results, determine how the surface or atmospheric color of a celestial body could affect its brightness in the sky.

2. How does distance affect a celestial body's **apparent brightness** (how bright a celestial body appears to be as observed from the Earth)? Repeat the original experiment, placing the box at different distances: 6 inches (15 cm), 12 inches (30 cm), and 18 inches (45 cm). Adjust the angle of the flashlight at each distance so that its light strikes the center of the construction paper on the box each time. Notice the screen's brightness at each distance. From the results, determine how distance from the Sun can affect a planet's apparent brightness.

SHOW TIME!

1. The reflecting ability of a celestial body is called its **albedo**. An albedo of 1.0 indicates 100 percent reflection. Design a table comparing the albedos of the nine planets: Earth (0.35), Jupiter (0.52), Mars (0.16), Mercury (0.1), Neptune (0.35), Pluto (0.5), Saturn (0.61), Uranus (0.35), Venus (0.76).
2. Celestial bodies not only reflect the light from the Sun, but can reflect sunlight onto other celestial bodies. Sunlight reflected off Earth is called **earthshine**. During the Moon's **crescent phase** (phase of the Moon with small lighted area resembling a segment of a ring with pointed ends), you can sometimes see the rest of the Moon's shape dimly lit as a result of earthshine.

To demonstrate the effect that earthshine has on the appearance of the Moon, divide a lemon-size piece of dark-colored clay in half and roll the two parts into balls. Stick one ball on the end of a craft stick. This ball will represent the Moon. Use the other ball to stand the Moon model on a table. Use books to raise a flashlight so that its bulb is about 2 inches (5 cm) from the backside (the side away from you) of the clay Moon. In a darkened room, observe the darkness of the front side of the Moon model. Move a cotton ball back and forth about 1 inch (2.5 cm) from the clay Moon. Observe the front side of the clay Moon as the cotton ball moves closer to it.



CHECK IT OUT!

Look at the Moon and you will see that some regions are darker than others. Early peoples imagined these shadowy areas were part of a human face, thus the saying "the man in the Moon." Find out more about the bright and dark features of the Moon. For information, see pages 6–9 in Fred Schaaf's *Seeing the Sky* (New York: Wiley, 1990).

Shadows

PROBLEM

How can the Moon block the Sun's light?

Materials

grape-size ball of clay
2 sharpened pencils
3-inch (7.5-cm) Styrofoam ball

Procedure

1. Place the ball of clay on the point of one of the pencils and the Styrofoam ball on the other pencil's point.
2. Hold the pencil with the Styrofoam ball at arm's length so that the ball is in front of your face.
3. Close one eye and hold the pencil with the clay ball in your other hand so that the ball is in front of, but not touching, your open eye. Slowly move the clay ball away from your face toward the Styrofoam ball. As you move the clay ball, observe how much of the Styrofoam ball is hidden by the clay ball at different distances.

Results

The closer the clay ball is to your face, the more it hides the Styrofoam ball.

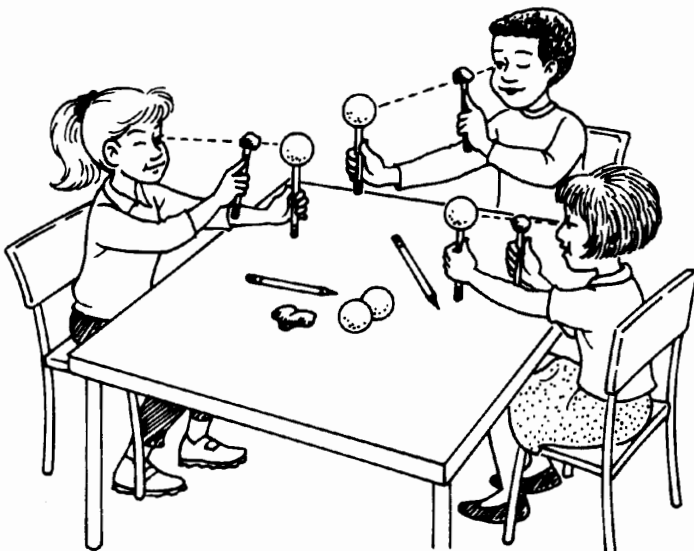
Why?

The closer an object is to your eye, the bigger it appears. The small ball of clay can totally block your view of the larger Styrofoam ball. In the same way, the Moon with a diameter of 2,173 miles (3,476 km) can block our view of the much larger Sun, which has a diameter of 870,000 miles (1,392,000 km).

When the Moon passes directly between the Sun and Earth, and all three are in a straight line, the Moon **eclipses** (passes in front of and blocks the light of) the Sun. In this position, observers on Earth see a **solar eclipse**. The Sun is about 400 times larger than the Moon, but at times during the Moon's elliptical (oval shape) orbit, the Moon is about 400 times nearer Earth. It is in this position that the Moon and Sun appear to be the same size. In a solar eclipse in which the Moon appears as large as the Sun, the Moon completely covers the Sun, blocking all of its light. This event is called a **total solar eclipse**.

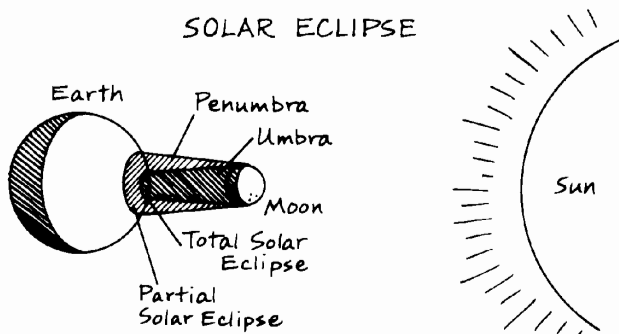
LET'S EXPLORE

When the Moon is far enough from Earth to appear smaller than the Sun, the Moon does not completely eclipse the Sun. An outer ring of the Sun's **photosphere** (bright visible surface of the Sun) is visible. This event is called an **annular eclipse**. Demonstrate an annular eclipse by repeating the experiment, slowly moving the clay ball away from your face until only a small outer ring of the Styrofoam ball is visible around the clay ball. **Science Fair Hint:** Make drawings to represent the Sun during the different types of solar eclipse.



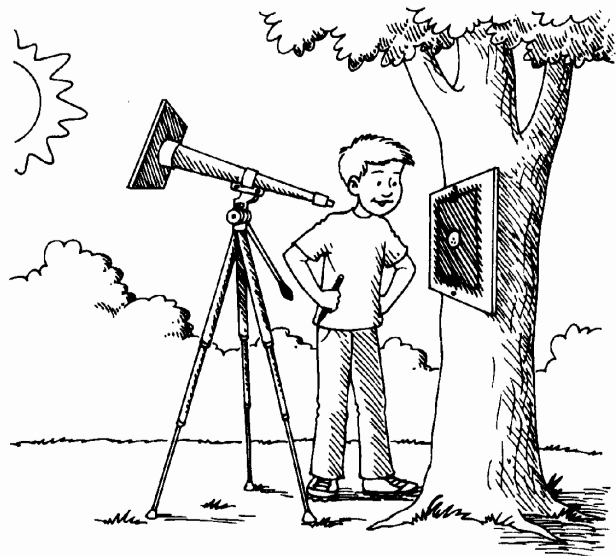
SHOW TIME!

1. Like all shadows, the Moon's shadow consists of a dark inner region called the **umbra** and a lighter outer region called the **penumbra**. Observe these parts of a shadow by positioning a desk lamp as high as possible above a sheet of paper on the desk. Hold your hand under the lamp about 1 inch (2.5 cm) above the paper. Observe the inner and outer parts of your hand's shadow.
2. During a solar eclipse, only part of the Earth is in the shadow of the Moon. Observers in the umbra see a total solar eclipse, while those in the penumbra see a **partial solar eclipse** (only part of the Sun is blocked). Observers outside the Moon's shadow see no eclipse. Design a poster of a solar eclipse, similar to the one shown here, to show why a solar eclipse is not seen by all observers on the daytime side of the Earth.



3. Never look at the Sun with your naked eye. Viewing a solar eclipse can be dangerous if not done properly. Pinhole projection is one of the safest ways to observe a solar eclipse. To demonstrate this method, ask an adult to make a small hole in the center of an index card with the point of a pencil. This is the projector card. Darken the room except for a desk lamp. Point the bulb of the light outward and stand about 6 feet (1.8 m) in front of the bulb. With your back toward the light, hold the projec-

tor card so that the light passes through the hole to a second index card (the screen). Move the projector card back and forth toward the screen until the image of the light is seen on the screen. Ask a helper to slowly move a circle of black construction paper in front of the light. The black paper should be larger than the end of the lamp so that it totally covers it. When using this method to view a solar eclipse, keep your back to the Sun and watch the shadow on the screen. For more information about viewing a solar eclipse, see pages 24–36 in Philip S. Harrington's *Eclipse!* (New York: Wiley, 1997).



CHECK IT OUT!

Because the Earth rotates, during a total solar eclipse the small umbra of the Moon's shadow sweeps across the Earth's surface. Since the umbra is only about 167 miles (267 km) wide, a total eclipse of the Sun occurs rarely in any one spot on the Earth. Scientists can predict the location of future solar eclipses. For information about the dates and sites of future eclipses, see pages 686–687 in the *National Audubon Society Field Guide to the Night Sky* (New York: Alfred A. Knopf, 1995).