Background for Teachers

Carl Sagan, an astrophysicist and Pulitzer Prize–winning author often described as "the scientist who made the universe clearer to the ordinary person," was arguably the most well-known scientist of the 1970s and 1980s. His PBS television series *Cosmos: A Personal Voyage* taught hundreds of millions of people worldwide about the universe.

Sagan was born in 1934 in Brooklyn, New York. His interest in astronomy developed early in life. He studied at the University of Chicago and worked at the University of California, Berkeley; Harvard University; and the Smithsonian Astrophysical Observatory. He was a professor at Cornell University and worked with NASA on many projects, including the Voyager mission.

The Voyager 1 and Voyager 2 spacecraft were launched in 1977 and have explored the giant planets of the outer solar system: Jupiter, Saturn, Uranus, and Neptune. The spacecraft contain many instruments for collecting information, and each carries a disk known as the *Golden Record*, which contains greetings, sounds, music, pictures, and other information from Earth intended to communicate the story of our planet to extraterrestrials. Sagan chaired the committee that decided what information would be contained on the Golden Record. In 2012, Voyager 1 made history by leaving our solar system and entering interstellar space. It has traveled farther into space than anyone or anything in history. Both Voyagers are still traveling far beyond our solar system and are currently sending scientific information about their surroundings through the Deep Space Network, or DSN. (To view a real-time odometer of their distances from the Sun and Earth, go to the NASA Voyager Interstellar Mission page at *http://voyager.jpl.nasa.gov/where*.)

Sagan co-founded the Planetary Society, an international nonprofit organization focusing on space exploration. Apart from the success of *Cosmos*, he helped to popularize science by writing hundreds of articles and more than two dozen books. He even wrote a science fiction novel called *Contact*, which was made into a movie starring Jodie Foster. Sagan was also well known as a pioneer in the field of *exobiology*, the study of the possibility of extraterrestrial life. Sagan died in 1996, but he left behind a legacy of exploration and is remembered for inspiring people to search for understanding and share science with others. One of Sagan's most recognizable quotes is "Somewhere, something incredible is waiting to be known."

According to Sagan's first episode of *Cosmos*, there are more stars in the sky than there are grains of sand on all of the beaches of the world. This number is greater than anyone could ever count. Stars appear as points of light in the night sky, except for one star that outshines them all—the Sun. In this lesson, students learn that the Sun is considered a small to average-size star but appears larger because it is relatively close to Earth, a mere 93 million miles away. The next nearest star, Proxima Centauri, is nearly 25 trillion miles from Earth. Because these numbers are so large, astronomers use light-years instead of miles or kilometers to communicate astronomical distances. A *light-year* is defined as the distance light can travel in one year. Light travels at an incredible 186,000 miles per second. That makes a light-year equal to almost 6 trillion (6,000,000,000,000) miles!

A Framework for K–12 Science Education suggests that by grade 5 students learn that "The Sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth." (NRC 2012, p. 174) This disciplinary core idea (ESS1.A) is taught in the context of Carl Sagan's childhood quest to learn more about stars. Students incorporate the science and engineering practice of developing and using models by using lanterns as models of stars to compare relative size and brightness at different distances from Earth. Mathematics and the crosscutting concept of scale, proportion, and quantity are also applied as students learn to convert light-years to miles. Finally, students demonstrate their learning by creating their own episode of Sagan's *Cosmos* television show to explain why the Sun appears so much larger and brighter than other stars. That activity incorporates the science and engineering practice of engaging in argument from evidence.

2. False: The Sun is the closest star, but not the largest. Compared with many other stars, the Sun is small or average-size (p. 12).
3. False: Some stars are closer to Earth than others (p. 14).
4. True: Some stars look brighter because they are hotter, some stars look brighter because they are bigger, and some stars, such as the Sun, look brighter because they are closer to Earth (p. 16).
5. False: Stars can be red, yellow, white, or blue, depending on their temperature (p. 18).
6. True: If you watch the night sky for a few hours, the stars seem to move slowly across the sky. The stars all "rise" in the east and "set" in the west because of the direction Earth turns (pp. 24–25).

Rereading

After reviewing the anticipation guide, reread pages 16–17, which explain, "Some stars look bright because they are very, very, hot. Other stars look bright because they are very, very, big. Some stars, like our sun, look bright because they are close to Earth. This can be confusing. It means that a small, hot star that is far away can look dimmer than a cool, big star that is closer to Earth." Then, *ask*

? Which star appears largest and brightest to us? (the Sun)

? Is the Sun the largest star? (no)

? Is the Sun the hottest star? (no)

? Think back to the activity we did with the lanterns (or flashlights). Why does the Sun appear larger and brighter than all other stars? (It is much closer to Earth than any other star.)

elaborate

How Far Are the Stars?

Connecting to the Common Core
Mathematics
Measurement and Data: 5.MD.1

Rereading

Reread pages 14–15 of *Stars,* which explain how far away various stars are from Earth. Then, point out the different numbers next to the circle representing various stars. *Ask*

? What do these numbers represent? (light-years)

Explain that a *light year* is the distance light travels in one year. *Ask*

? Why do you think astronomers use light-years to represent astronomical distances such as the distance between the stars and Earth? (Answers will vary.)

? How do we measure very large distances on Earth? (miles and kilometers)

Tell students they can find out why scientists use light years instead of miles or kilometers for the distance of stars by doing some conversions. Reread the last sentence on page 14, which explains that a light-year is equal to almost 6 trillion miles. *Ask*

? How many zeros behind the six do I need to write to represent 6 trillion? (12 zeroes)

Write 6,000,000,000,000 on the board. Next, have students choose a star from pages 14–15 to convert its distance into miles. For example, the star Betelgeuse is approximately 650 light years from Earth. Demonstrate how to convert that distance to miles by multiplying 650 light years × 6,000,000,000,000 miles (using a calculator, if desired).

650 light years × 6,000,000,000,000 miles = 3,900,000,000,000,000 miles

Repeat this conversion with some of the other stars featured on pages 14–15. Then, *ask*

? Now, why do you think astronomers use light-years when discussing the distances to the stars? (The numbers are too big when using miles or kilometers, making calculations cumbersome to write and confusing to interpret. Light-years are more practical and easier to calculate and communicate.)