Performance: Star light, star bright

Standard 4.4.1 Construct an explanation that differences in the apparent brightness of the Sun compared to other stars is due to the relative distance (scale) of stars from Earth. Emphasize relative distance from Earth. (ESS1.A)

Phenomenon – The Sun appears much brighter than the stars

A. ***Group Performance*: Investigate how distance affects the apparent brightness of a light source.**
    1. Explore – Compare the apparent brightness of a light when it is close to the eye and across the room.
    2. **Ask questions to obtain and evaluate information** on the **scale and relative distances** of the Sun and stars from Earth.
    3. **Construct an explanation** supported by evidence that differences in the apparent brightness of the Sun compared to other stars is due to the relative distance of stars from Earth.
    4. **Develop a model** of the Orion constellation by placing lights at the correct relative distances.

B. ***Individual Performance***
    5. Write in your journal your **argument** for why your evidence supports your group's **explanation** for the difference in relative brightness between the Sun and other stars.

C. **Group Discussion**

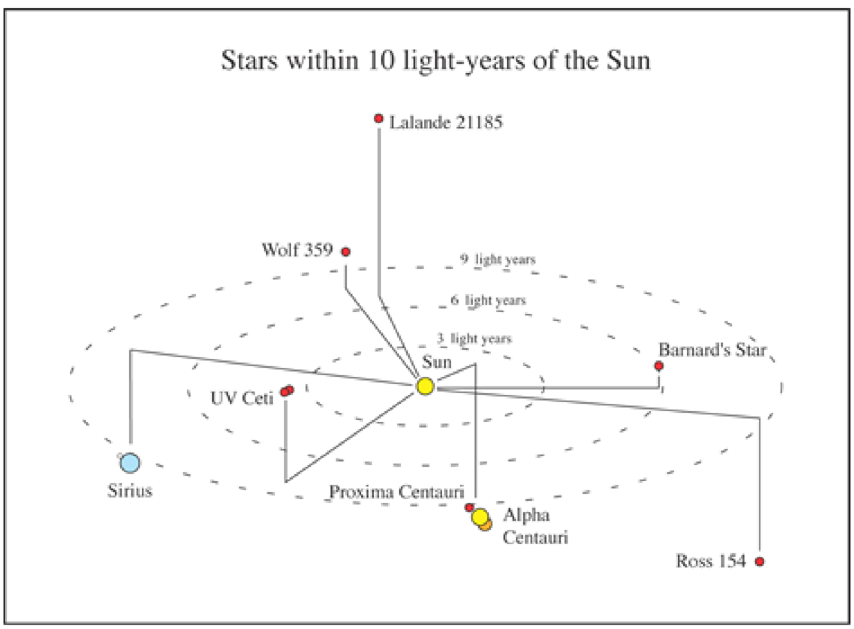
Teacher Background

The Sun is a star that appears larger and brighter than other stars because it is closer. Stars are like the Sun, some being smaller and some larger. However, they are so far away that they look like points of light. Stars range greatly in their distance from Earth. The nearest stars are hundreds of thousands of times farther away than the Sun.

When astronomers measure distances in space, units such as feet, meters, miles, and kilometers are too small to be practical. The Sun is 93,000,000 miles from Earth and nearly 25,000,000,000,000 miles away from its nearest neighboring star. Numbers this large aren't easy to work with and are hard to comprehend. A more convenient unit for measuring distances between stars is a light-year.

Although sometimes confused with a unit of time, a light-year is the *distance* light travels in one year. Light (in a vacuum) travels about 300,000 kilometers (186,000 miles) in one second. This is fast enough to travel around Earth about 7 ½ times in one second. One light-year is about 9,460,000,000,000 kilometers or 5,880,000,000,000 miles.

The nearest star to the Sun is called Proxima Centauri. It is 4.2 light-years away. The nearest star visible from Utah is Sirius, in the constellation Canis Major. It is 8.6 light-years away. Sirius is also the brightest star in the night sky. Sirius is 543,864 times farther away from Earth than the Sun.



This diagram shows stars that are within 10 light years of the Sun. Small red dots represent red dwarf stars. These stars are so small and dim that a telescope is needed to see them. The Alpha Centauri system is too far south to be visible from Utah.

One light-year is 63,240 times the distance between the Sun and Earth. By coincidence, there are 63,360 inches in one mile. We can use this coincidence to create a scale model to help better understand how big a light-year is. If Earth were 1 inch from the Sun, a light-year would be about 1 mile. So, in this scale model, the nearest star is over four miles away!

Distances to the planets in our solar system are very small compared to a light-year. In the scale model above, the distance from the Sun to the farthest planet is less than one meter. Below is the average distance of each planet (and Pluto) from the Sun in this scale model. To better visualize this scale, find each of these distances on a yardstick or tape measure.

PLANET	Distance (inches)
Mercury	3/8
Venus	3/4
Earth	1
Mars	1 ½
Jupiter	5 $^{3}/_{16}$
Saturn	9 $^{9}/_{16}$
Uranus	19 ¼
Neptune	30 $^{1}/_{8}$
Pluto	39 ½

Star Names

Most star names come from Arabic, Greek, or Latin. Some of these names were altered somewhat as they were transmitted into European languages. For example, Betelgeuse is thought to come from the Arabic phrase Ibṭ al-Jauzā', which means "armpit of the central one" or "armpit of the giant".

Here are the origins or meaning of other star names in the constellation of Orion:

- Bellatrix is from Latin for "female warrior".
- Alnitak is from Arabic for "the girdle".
- Alnilam comes from the Arabic al-niẓām, meaning, "string of pearls."
- Mintaka comes from an Arabic term for "belt".
- Saiph comes from an Arabic word for "sword" (even though Saiph is not a part of Orion's sword).
- Rigel comes from an Arabic word meaning "foot" or "leg".

The name Sirius, in the constellation of Canis Major, comes from a Greek word that means "glowing" or "scorching".

Star Distances

How do astronomers determine the distances to stars? To get an idea how this is done, try the following:

1. Close one eye.
2. Hold up your thumb and use it to block your view of some object across the room, such as a clock.
3. Without moving your thumb, close your open eye and open your closed eye.
4. Your thumb will appear to move.

This apparent movement due to a change in viewing location is called parallax. If you know the distance between your eyes and can measure the angle your thumb appeared to move, the distance to your thumb can be calculated using trigonometry. Astronomers can calculate the distance to a star by measuring how much that star appears to change its position as Earth orbits around the Sun. (https://lco.global/spacebook/distance/parallax-and-distance-measurement/)

The distances to nearby stars like Sirius can be measured very accurately. Measurement accuracy decreases with distance. The stars in Orion are far enough away that their measured distances are only approximate. The calculated distances may vary by 20% or more from the actual distances.

Activity Instructions

Materials:

LED lights (one for each student)
Orion Constellation Diagram
Measuring tape
Picture of Orion (last page in this document) or (*optional*) OrionBlackSky power point
Note: Not all images in this presentation should be used. Select the one (or two) most suitable for your students.

To turn on the LED lights:

- Separate the base of the LED light into 2 pieces by twisting the bottom half relative to the top half.
- Remove the plastic discs and store them in a location where they will not be lost. (For long term storage, replace the plastic discs into the base).
- Twist the halves back together.
- The light can then be turned off and on by twisting the two halves of the base slightly.

Engage

1. Ask students, “What does it mean for an object to be ‘bright’?” (gives off light)

2. “What is the brightest thing you can think of?” (Sun)

3. “What else gives off light?” (stars, lightning, fire, light bulbs)

4. “How bright are stars compared to the Sun?”

5. “Why do you think the Sun appears so much brighter? Is it because the Sun gives off the most light?”

Explore

6. Tell students, “You are going to conduct an investigation to explore what happens when observe lights at different distances.”

7. Demonstrate to students how to turn an LED light on and off.

8. Give each student an LED light.

9. Divide students into 2 groups, group A and group B.

10. Have each group stand on opposite sides of a room. All students should turn on their lights.

11. Have all students in group A point their lights at the students in group B.

12. Each student in group B should hold their own light about a foot in front of their face and point the light at their face.

13. Each student in group B should then compare the apparent brightness of their light with the lights across the room.

14. Have all students in group B point their lights at the students in group A.

15. Each student in group A should hold their own light about a foot in front of their face and point the light at their face.

16. Each student in group A should then compare the apparent brightness of their light with the lights across the room.

17. The groups should then move to the same location. Each student from group A should meet with a student from group B. Both students should compare the apparent brightness of both of their lights when held at the same distance.

18. All students should turn off their lights.

Explain

19. Ask students:
  a. “How bright did the light in front of your face appear to be compared to the lights across the room?’
  b. “Were the lights across the room really dimmer?
  c. “Why did your light appear to be brighter than the lights across the room?”

20. Tell students: “Stars are like the Sun. Some stars are smaller than the Sun and some are larger. The nearest stars are hundreds of thousands of times farther away than the Sun.”

21. Ask students:
  a. “Why do you think the Sun appears so much brighter than the stars?”
  b. “What evidence supports your explanation?”

22. Students should write an explanation for the differences in the apparent brightness of the Sun compared to other stars. Their explanation should include evidence that supports their conclusion.

Elaborate

Note: While this activity can be done in a classroom, it may work better in the hall or gym. The size of the space will determine the scale used (see below)

23. Tell students: “Even though stars are individual objects like the Sun, some people have tried to group stars that appear next to each other to make imaginary pictures. This is like playing connect-the-dots. We call some of these groups of stars, constellations.”

24. Tell students: “Let’s try to use seven of our LED lights to make one of these constellations called Orion.”

25. Show students a picture of Orion. [This can be done using one or more of the slides the OrionBlackSky PowerPoint presentation or printing the picture at the end of this document.]

26. Give seven students an LED light. Have them stand at least 10 feet in front of the rest of the students. These students should try to reproduce the pattern of the seven brightest stars in Orion at the front of the other students. Other students should help by giving verbal directions to adjust the positions of each LED light.

27. Ask students: "If your explanation about star brightness is correct, what does that mean for stars in constellations? Are all the stars in a constellation at the same distance?"

28. Tell students: "Let's place each of these stars at their approximate relative distances. The scale we will use is X feet for each hundred light years."

The value of X depends on the size of the space that is being used for the activity. The largest distance in the model is to the star Alnilam, which has a minimum distance of 20 feet. So, use the distance of 20 feet compared to the length of the space to determine X.

For example, if a gym with a length of 110 feet is being used, X could be as large as 4. That would place Alnilam at distance of 80 feet and still allow sufficient space at one end of the gym for the students to stand or sit that are not modeling the star distances.

29. Below is an example of distances based on 100 light years = 1 foot. This scale may work best in a classroom sized space.

Betelgeuse – 5 feet		Bellatrix – 2.5 feet
Alnitak – 7 feet	Alnilam – 20 feet	Mintaka – 7 feet
Saiph – 6 feet		Rigel – 9 feet

30. In a larger room, multiply each of the distances above by X. Using the example above of X = 4, the distances would be:

Betelgeuse – 20 feet		Bellatrix – 10 feet
Alnitak – 28 feet	Alnilam – 80 feet	Mintaka – 28 feet
Saiph – 24 feet		Rigel – 36 feet

31. With the assistance of a tape measure or ruler, have the class figure out where each student with an LED light should stand at their scaled distance to the rest of the students.

32. Ask students: "If we look at Orion in the night sky, Alnilam appears to be only a little brighter than Alnitak and Mintaka. However, Alnilam is almost three times farther away than Alnitak and Mintaka. How bright do you think it really is compared to them?"

Evaluate

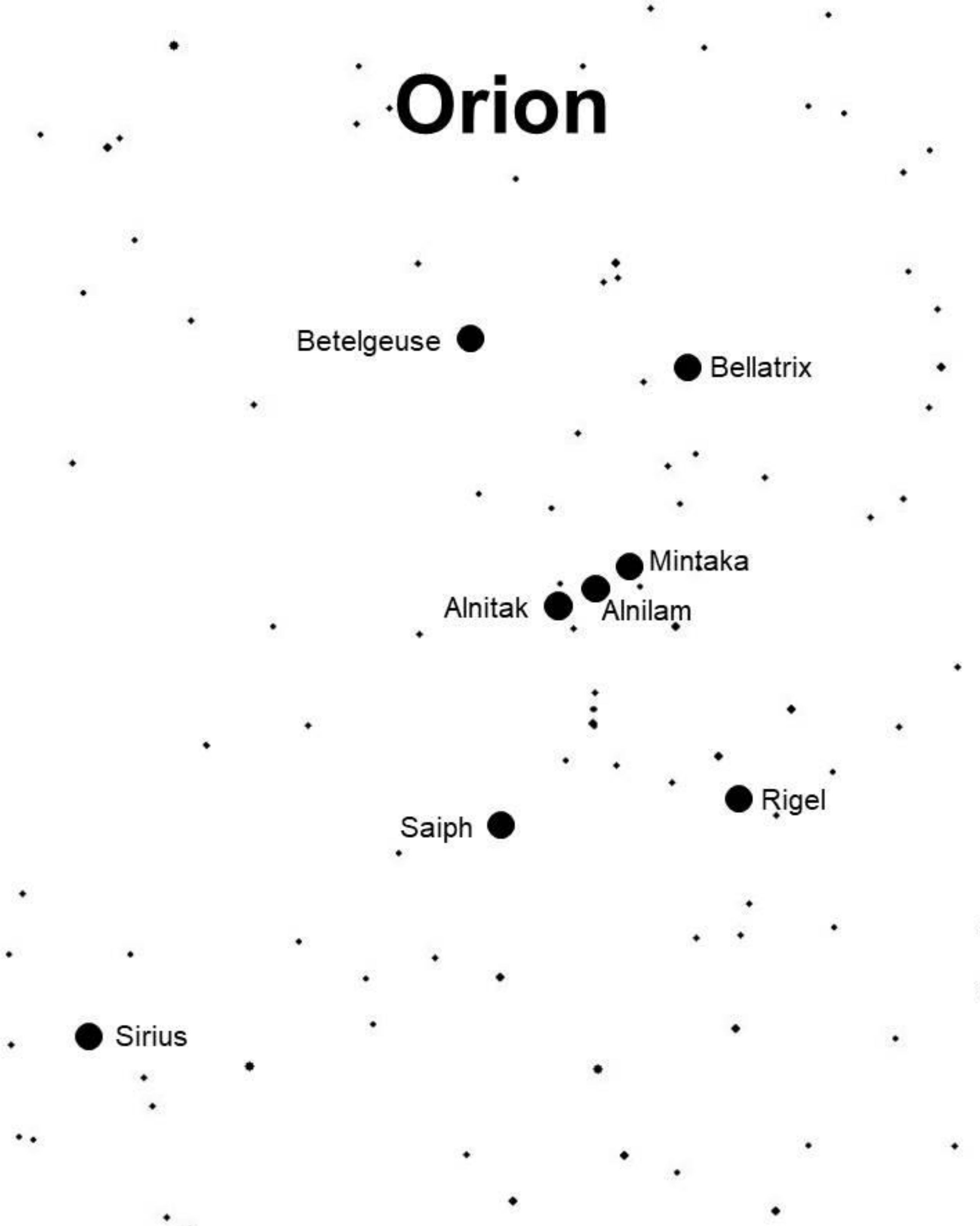
33. Ask students: “How far away would the star Sirius be on this scale?”

34. For the scale is 100 light years = 1 foot:

a. “If our scale is 100 light years = 1 foot or 12 inches, how many inches are 8.6 light years, the distance to Sirius?”
b. “We can estimate it in this way. If we round 8.6 up to 10, then the distance is about 1/10 of a foot. This is a little more than an inch. So, Sirius would be about one inch away on this scale.”

35. For other values of X, the scaled distance to Sirius would be about X inches.

Orion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