3-D Constellations

Activity F7

Grade Level: 4–12

Source: Adapted with permission from the activity "Building Three-Dimensional Models of the Constellations" in *Project STAR: The Universe in Your Hands*, © 1993, 2001 by the President and Fellows of Harvard College, published by Kendall/Hunt Publishing, Dubuque, IA. Adapted by Anna Hurst for the Astronomy from the Ground Up project at the Astronomical Society of the Pacific. Updated 2010 by Andrew Fraknoi. This version was produced in 2010 by the Astronomical Society of the Pacific. http://www.astrosociety.org

What's This Activity About?

Because the stars in the best known star patterns, such as the constellation figure of Orion the hunter, and the asterism of the Big Dipper, look (after much association in our minds) like they belong together, many students actually believe that the stars in these sky figures are associated. Yet most stars in a bright constellation pattern are at quite different distances from us and only happen to lie in the same part of our sky. This activity helps students realize that the sky is a three-dimensional place and things that look like they are together on the "dome of the sky" can actually be far apart.

What Will Students Do?

Students use string and everyday materials, as well as a photograph of the star patterns of Orion and the Big Dipper to make a 3-D model, using the distances given in the activity.

Tips and Suggestions

- The table in this activity already calculates the conversion of the distances in light years to the length of the string needed (in centimeters and inches). Older students who need math practice can do this conversion on their own.
- Note that some of the stars in the Big Dipper turn out to be at about the same distance from us, since they are part of a moving group of stars that were probably born together. This collection of stars is called the Ursa Major Moving Group and its central part is about 80 light years away. Thus, if you are trying to make the point that most stars in a constellation are NOT related, it's probably best to start by doing Orion. Later, let the students think about why the distances of five (or six, if you count Mizar and Alcor separately) of the stars in the Dipper are at roughly the same distance.
- Since the materials for making these models are easy to lose, it's probably best to buy more than the students will need.

What Will Students Learn?

Concepts

- Constellations
- 3-D nature of the sky

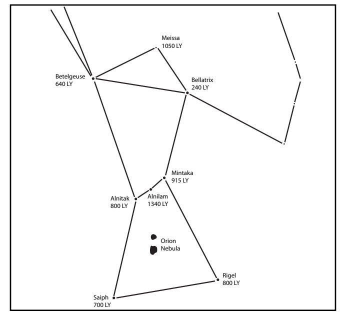
Inquiry Skills

- Ordering
- Measuring
- Visualizing
- Modeling

Big Ideas

- Patterns of change
- Modeling and simulations
- Scale

3-D Constellations



Type of Activity:	Indoor classroom or drop-in station, facilitated
Set up Time:	30–45 minutes
Time to Do:	30 minutes
Audience age:	8 years and older
Group size:	various

What's This Activity About?

The stars appear to be painted on the dome of the sky above our heads. Those that make up the Big Dipper, Orion and other well-known star patterns appear close to each other in space — but are they really close together? This activity demonstrates that the pattern we see in the sky is just an accident of our place in space. The stars in a constellation can actually be quite distant from each other, so that the same constellation would thus look much different from a different part of the Galaxy.

Materials

For each constellation model:

- Copies of constellation photographs
- Copies of constellation charts (see pages 5–6)
- Meter stick
- Thick sewing needle or ballpoint pen (with long, exposed writing point)
- Steel washer
- Piece of corrugated cardboard about 30 cm x 30 cm (1 ft. x 1 ft.)
- Pony beads (number equal to number of stars in constellation)
- 1-meter long pieces of black button thread (number of pieces equal to number of stars in constellation)
- Tape

See the list of sources for materials on page 4.

Setting Up the Activity

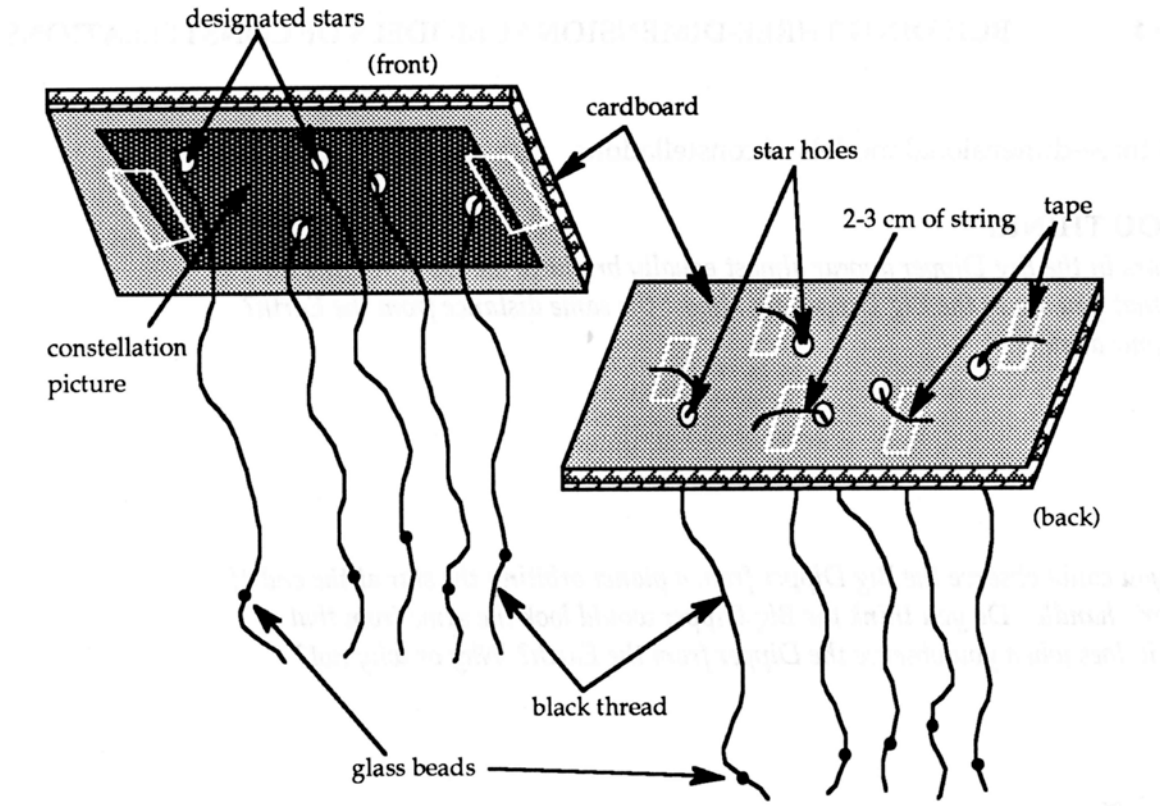
This works best with participants sitting at tables. You will need to pre-cut the lengths of thread and the pieces of cardboard. Set out one piece of cardboard, a constellation photograph, a constellation chart, a pen or needle, the appropriate number of threads and pony beads, and a ruler for each participant, as well as tape for the table to share.

Suggestions for Introducing the Activity

If possible, look at Orion and the Big Dipper, if not in the real sky, then in a planetarium or on a photograph. The stars in Orion make a clear figure of a hunter. Do you think all the bright stars are at the same distance? The stars in the Big Dipper appear almost equally bright to us. Do you think all the stars that you see in the Big Dipper are almost the same distance from Earth? Imagine you could observe the Big Dipper from a planet orbiting the star at the end of the Big Dipper's handle. Do you think the Big Dipper would look the same from that planet as it does when you observe the Dipper from Earth?

Doing the Activity

1. Participants should carefully tape the constellation photograph to the piece of cardboard.
2. They then place a bead on each string by first passing the thread through it, then around and through it again. By stringing the bead this way, they will be able to slide the bead along the length of the string, but it will stay in place when they let go.
3. Using the needle or pen, participants should punch holes through the photo and the cardboard at the position of each star which has a distance written next to it on the corresponding chart. They then slide a piece of thread through each hole, leaving about 1 inch at the



back and the rest at the front. (The front is the side with the constellation photo.) Tape the one-inch length of thread to the back of the cardboard to hold it in place. To cover up this messy side, you can tape the constellation chart over it.

4. Participants should then bring together the ends of all the strings on the front side and tie them into a tight knot around a steel washer about 56 cm (22 in) from the sheet of cardboard. Have them cut off the extra thread. This thread length is used because the camera that took the pictures of these constellations had a focal length of 56 cm. If you hold the picture at a distance of 56 cm from your eyes, the constellation will appear the same size as it does in the sky.
5. The distance to the stars on the photos is indicated on the constellation charts on pages 5 and 6. A star labeled "79 LY" is 79 light years from the Earth. A light year is the distance light travel in one year, about 10^{13} or 10 trillion kilometers.
6. To make a three-dimensional model of the constellation, participants must slide the beads along the string until they are the correct scale distance from Earth. Use a scale of 2.5 cm = 100 LY. For example, if a star is 100 LY away, slide the bead representing that star to 2.5 cm (1 inch) from the washer. If you have a star that is 830 LY away, slide that bead out 21 cm (8.3 inches) away. See the table on page 4 for the scaled distances to the stars in Orion and the Big Dipper. (Older students can do the conversion calculations themselves.) Participants can use the rulers to position their beads at their approximate scaled distances.
7. When the beads are positioned, participants should hold the washer with one hand and the photo upright with the other hand. They then stretch the strings and hold the washer next to an eye. Looking at the photo through the washer, they should be able to see the beads outlining the shape of the constellation. This may work better in pairs, with one partner holding up the cardboard so that it is easier for the other partner to view the constellation. As mentioned above, the scale of the photo is such that if you hold the cardboard 56 cm from your eye, your view of the constellation is the same as you would have at night looking at the constellation with your naked eye.

8. Next, they can hold the model so that they are looking at the constellation from the side. This is how the constellation would appear if you traveled many light years out into space and looked at it from the "side."

Wrap-up

You may want to have participants draw the constellation the way it would appear in a "side view." They could indicate the direction towards the Earth with an arrow and even create a name and story for their constellations.

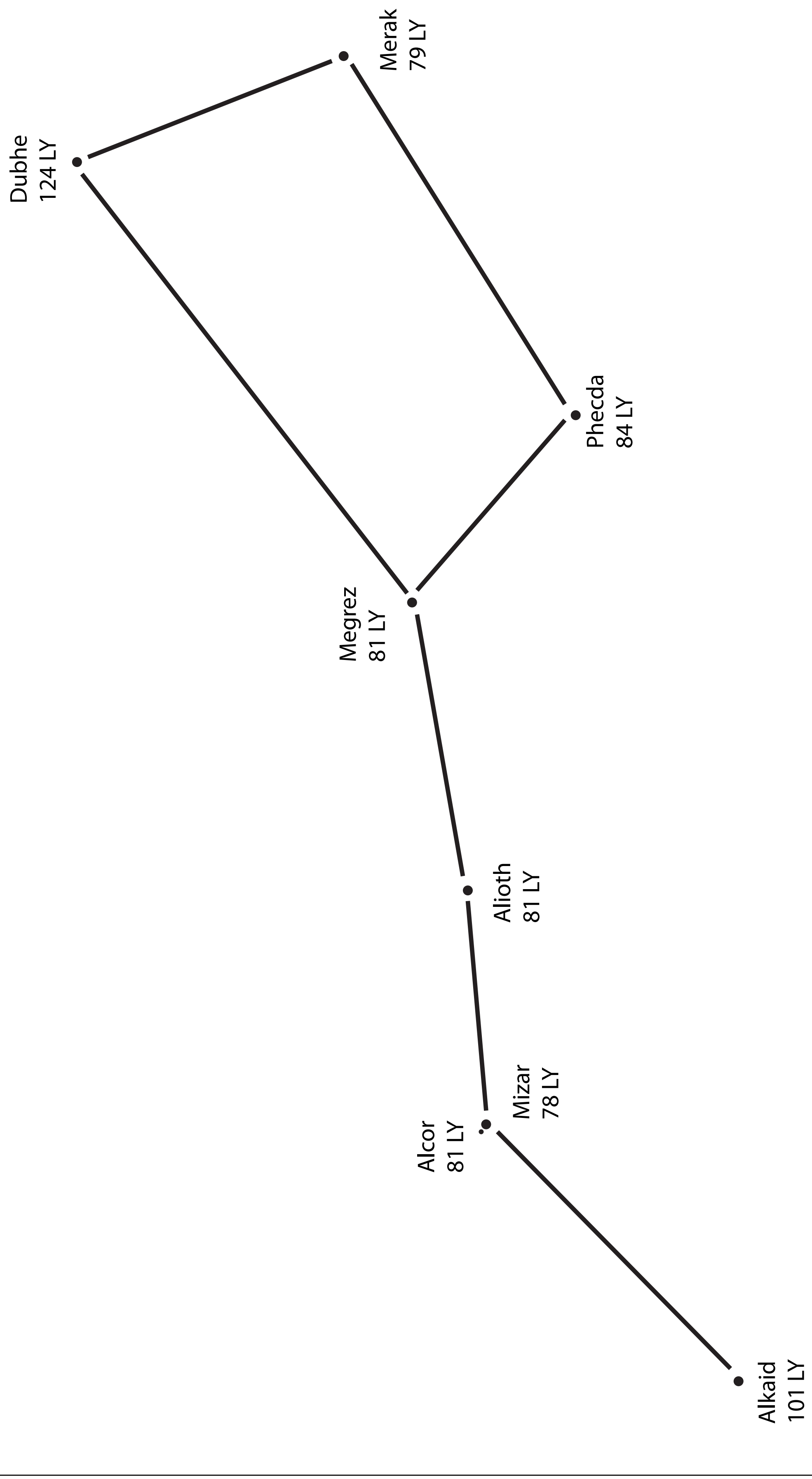
Return to your questions from the introduction. Are all the stars in Orion an equal distance from the Earth? What about the Big Dipper? Would Orion look the same from a planet orbiting the star at the end of the hunter's belt?

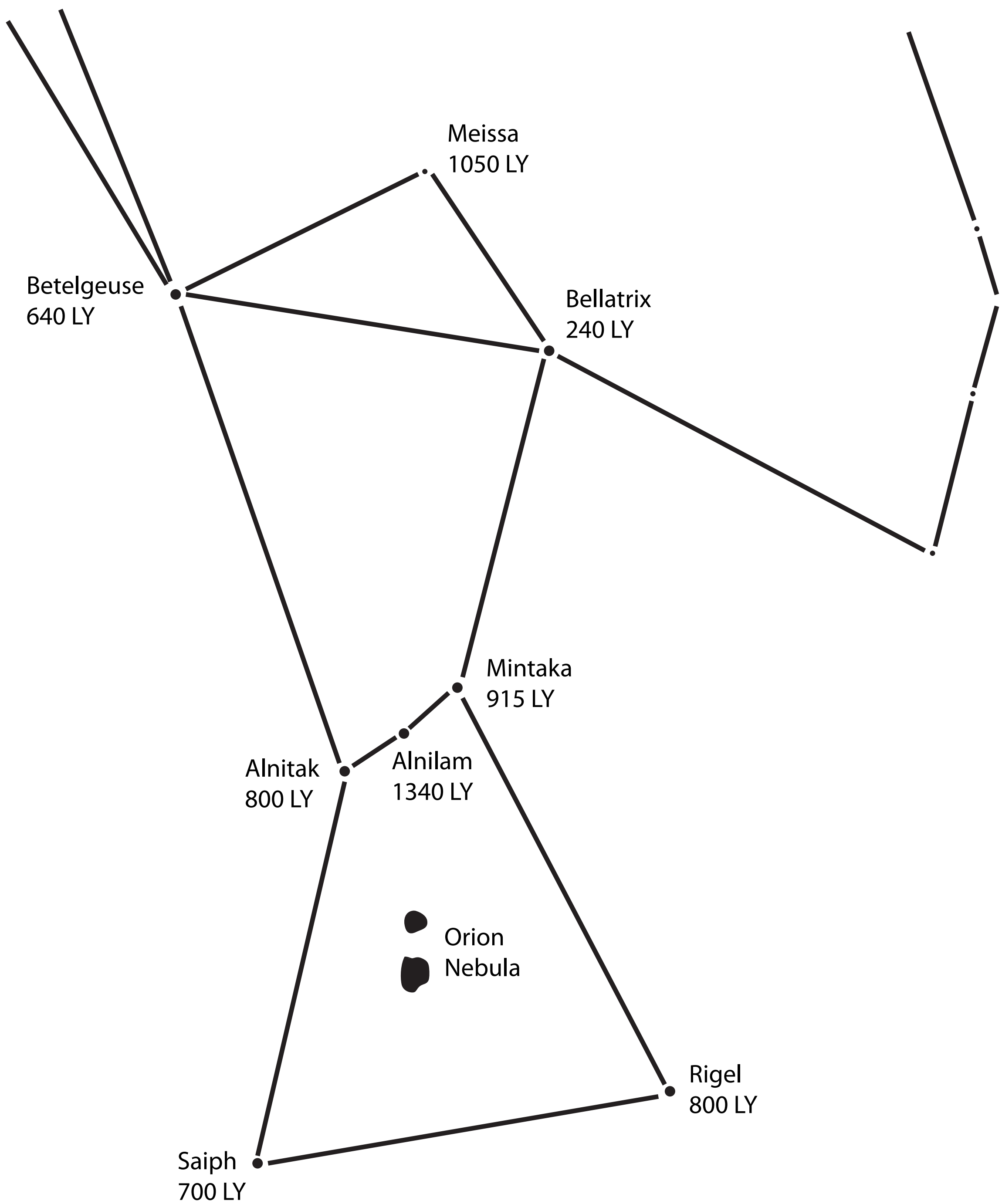
Materials sources

It is best to use button thread for this activity because it is thick and strong. Black is best, since it blends in with the background of the photographs. Button thread can be purchased at most sewing and craft supply stores, as can pony beads.

Scaled Distances to Stars

STAR PATTERN	STAR NAME	DISTANCE (LY)	SCALED DISTANCE (CM)	SCALED DISTANCE (INCHES)
Big Dipper	Alkaid	101	2.5	1
	Mizar	78	2	0.8
	Alcor	81	2	0.8
	Alioth	81	2	0.8
	Megrez	81	2	0.8
	Phecda	84	2	0.8
	Merak	79	2	0.8
	Dubhe	124	3.1	1.2
Orion	Betelgeuse	640	16.3	6.4
	Meissa	1050	26.7	10.5
	Bellatrix	240	6.1	2.4
	Alnitak	800	20.3	8
	Alnilam	1340	34	13.4
	Mintaka	915	23.2	9.2
	Saiph	700	17.8	7
	Rigel	800	20.3	8


Merak
79 LY
Dubhe
124 LY
Phecda
84 LY
Megrez
81 LY
Alioth
81 LY
Mizar
78 LY
Alcor
81 LY
Alkaid
101 LY


Meissa
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Orion
Nebula
Rigel
800 LY
Saiph
700 LY