"Science is full of researchers working to understand nature. There's no way to tell what will help humans and our world in the years to come, but some discoveries certainly will."

—Lori Fenton, planetary scientist who studies how the wind shapes the surfaces of Earth, Venus, and Mars

Space Science Investigator

Our Solar System spreads out across space. It's much larger than you might think and the stars are even farther away than you can imagine. Venture through the Solar System and beyond, and discover that space is even bigger than you thought.

Steps

1. Model the Solar System
2. Circle the Sun
3. Discover the stars
4. Use tools to explore
5. Share your sky

Purpose

When I've earned this badge I will understand that the Earth orbits the Sun and how far away the Sun, Moon, planets, and stars are from our home planet, Earth.

Meet a Scientist: SARA SEAGER

Growing up in Toronto, Canada, Sara Seager spent a lot of time daydreaming and was always looking for new challenges. When she was 16, she went to "Astronomy Day" at the University of Toronto—and was instantly hooked.

Today, Sara is an astrophysicist, a planetary scientist, and a professor at the Massachusetts Institute of Technology (MIT). She specializes in the study of exoplanets, which are planets that orbit stars other than our Sun. She has been called an "astronomical Indiana Jones" for her important work in this field.

Every step has three choices. Do ONE choice to complete each step. Inspired? Do more!

STEP 1 Model the Solar System

Our Solar System is made up of planets, moons, asteroids, comets, and dust that orbit (move around) the Sun. The whole system is spread out through space. Make a model of celestial objects in this step.

CHOICES—DO ONE:

☐ **Make models of the planets.** Use salt dough to make tiny versions of the eight planets in our Solar System! You'll form all of the planets from a 3-pound ball of dough, but before you begin, can you predict the sizes of Earth, Mercury, and Jupiter? Draw your predictions on a piece of paper and compare them to the scale model when you're finished.

Next, make a name card for each planet and line them up in order from the Sun. If you need a reminder of their order, look at the box on page four. You're going to have a lot of small pieces so keep track of them carefully! See the instructions below.

Step 1
Divide the entire ball of dough into 5 equal parts.
- **a.** Put 3 parts onto the Jupiter paper.
- **b.** Put 1 part onto the Saturn paper.

Step 2
Cut the piece you have left from Step 1 into 10 equal parts.
- **a.** Add 7 parts to the Saturn pile.
- **b.** Put 1 part on the Neptune paper.
- **c.** Put 1 part on the Uranus paper.

Step 3
Cut the piece you have left from Step 2 into 10 equal parts.
- **a.** Add 2 parts on the Saturn pile.
- **b.** Add 4 parts on the Uranus pile.
- **c.** Add 3 parts on the Neptune pile.

Step 4
Cut the piece you have left from Step 3 into 10 equal parts.
- **a.** Add 5 parts to the Saturn pile.
- **b.** Put 2 parts onto the Earth paper.
- **c.** Put 2 parts onto the Venus paper.

Step 5
Cut the piece you have left from Step 4 into 10 equal parts.
- **a.** Add 4 parts to the Earth pile.
- **b.** Add 1 part to the Saturn pile.
- **c.** Put 1 part onto the Mercury paper.
- **d.** Put 3 parts onto the Mars paper.

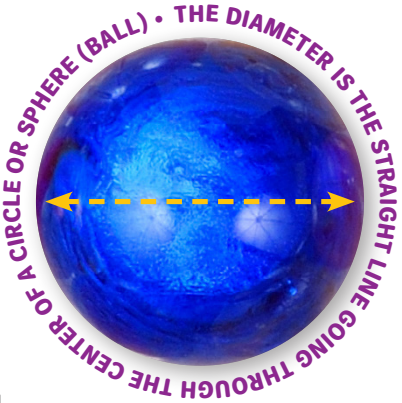
Step 6
Cut the piece you have left from Step 5 into 5 equal parts.
- **a.** Add 2 parts to the Mars pile.
- **b.** Add the last 3 parts onto the Mercury pile.

Now roll each planet into an even sphere. Compare your model to the predictions you made at the beginning. Did anything surprise you?

At this scale, Pluto would be ~one mile from the Sun and our next closest star would be ~18,000 miles!

"Model the Solar System" is based on "Worlds in Comparison" by the Pacific Science Center's Dennis Schatz and modified by the Astronomical Society of the Pacific.

OR

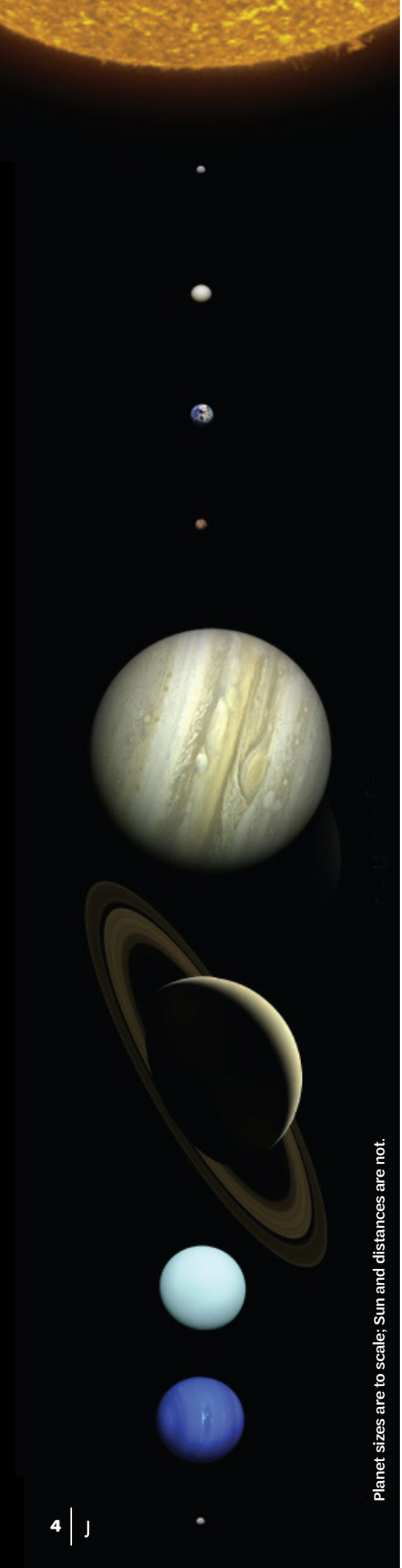


☐ **Find a scale model of the Earth-Moon system.** To make your model, use common objects like balls, beads, marbles, coins, drawings on paper, or anything you like. Find two objects, one for the Earth and one for the Moon, to make your scale model. How large do you think the Earth is in comparison to the Moon? Now check your prediction! The Earth's diameter is four times the diameter of the Moon—so you should be able to fit four "Moons" side-by-side across the object you picked for the Earth. Were you right? If not, that's ok. Find two more objects. Learning from your predictions is part of being a good scientist. Now guess how far apart the Earth and Moon should be. Once you've made a prediction, measure the diameter of the Earth and put the Moon 30 Earth-diameters away—that's the correct distance for your scale model. Are you surprised? Was your prediction correct?

FUN FACT: For a model Earth with a one-inch diameter, Pluto would be over seven miles from the Sun and it would be ~46,000 miles to our next closest star.

What is a scale model?

Scientists and engineers use models for both their research and to help communicate discoveries. A scale model is a copy of an object that is either **larger** or smaller than the original object it is "modeled" after. Each part of the object is adjusted in the same way. Architects create small scale models of the buildings they are going to build and scientists make large scale models of insects so that they can more easily study them.



Planet sizes are to scale; Sun and distances are not.

OR

☐ **Take a Solar System walk.** It is challenging to think about just how big our Solar System is. To do this walk, you will need a space that is about a half-mile long. Once you've finished your walk, you will have completed a scale model of the entire Solar System. Not enough space? Just walk to Mars and figure out neighborhood landmarks that are the same distances as the remaining planets.

To start, gather some Girl Scout friends—and an adult. Next, using the chart below, collect the objects you need for your walk. Glue or tape them each to their own sheet of paper and label them according to the planet they represent. Set up the Sun and start there. Take giant steps about 3 feet in length and start walking to the planets, using the chart to determine the number of steps you should take. Count out loud together and place each planet on a stick in the ground as you walk the Solar System. Look back at the Sun and planets as you go! What do you notice? What is surprising to you?

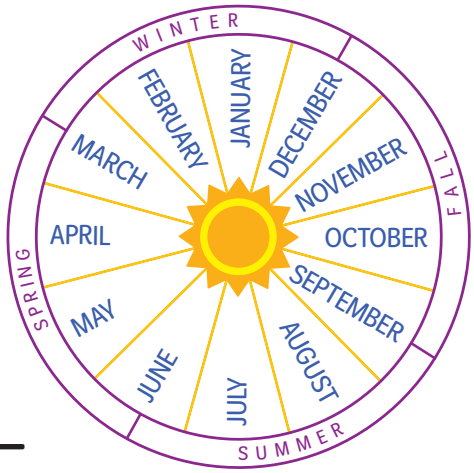
Object	Model & Size	Giant Steps (About 3 feet) to Next Planet or Dwarf Planet	Total Steps = Total Yards from the Sun	Approximate Miles from the Sun
Sun	**8-inch ball**	**0**	**0**	**0**
Mercury	**Pinhead** (0.03 inches/0.08 cm)	**10**	**10**	**36,000,000**
Venus	**Peppercorn** (0.08 inches/0.2 cm)	**9**	**19**	**67,000,000**
Earth	**Peppercorn** (0.08 inches/0.2 cm)	**7**	**26**	**93,000,000**
Mars	**Pinhead** (0.03 inches/0.08 cm)	**14**	**40**	**142,000,000**
Jupiter	**Large marble** (0.9 inches/2.3 cm)	**95**	**135**	**484,000,000**
Saturn	**Marble** (0.7 inches/1.8 cm)	**112**	**247**	**887,000,000**
Uranus	**Bead** (0.3 inches/0.8 cm)	**249**	**496**	**1,783,000,000**
Neptune	**Bead** (0.3 inches/0.8 cm)	**281**	**777**	**2,794,000,000**
Pluto	**Pinpoint or smaller**	**242**	**1,019**	**3,666,000,000**

At this scale, Pluto is ~half a mile from the model Sun and the next closest star would be over 4,000 miles!

"Take a Solar System Walk" activity is courtesy of Guy Ottewell, based on "The Thousand-Yard Model," or "Earth as a Peppercorn" (published by Universal Workshop).

STEP 2

Circle the Sun



What is a year? How do we measure a year? The Earth orbits (moves around) the Sun, and one orbit is equal to one year—actually it takes the Earth 365.24+ days. How many times have you orbited the Sun?

CHOICES—DO ONE:

☐ **Dance the Earth's year.** With a group of friends or family members, trace our planet's dance through space, using your body to mark the path of our orbit around the Sun. See instructions in the box to the right.

OR

☐ **Find your age on other planets.** Your age is the number of orbits you have taken around the Sun, but each planet is a different distance from the Sun, and they all orbit at different speeds. Today you're going to discover how old you would be on other planets by using a website such as **www.girlscouts.org/SpaceSciencePlanetAges**. How old are you on Mars? Jupiter? Did any of your discoveries surprise you?

For More FUN: Pick an age at least 10 years from now and write your future self a letter. What do you think will change once you've made more trips around the Sun?

OR

☐ **Show your years in pictures.** Make a scrapbook of your trips around the Sun. How many times have you orbited the Sun? What has changed for you? What do you want to remember? Be sure to include important days—maybe birthdays, holidays, the day you scored the winning goal in your soccer game. Be creative—you can't be wrong.

Dance the Earth's Year

You will need:

- A ball
- 16 pieces of paper
- Markers

1. Make four signs, one for each of the seasons: winter, spring, summer, and fall. What is your favorite thing to do each season? Draw it on your sign.
2. Make 12 more signs—one for each month of the year. Be creative!
3. Put the ball in the center of an open area to represent the Sun. Then, place the season and month signs around it as shown on the chart to the left.
4. Form a circle around the Sun, with everyone standing by their birthday month. What season is it? What happens to the plants, animals, and weather this time of year?
5. The seasons change as the Earth takes trips around the Sun. This trip is called an orbit. What direction do you think the Earth orbits the Sun? **Hint:** Imagine that you are the Earth. As you move around your Sun (the ball), the months and seasons should pass by in order. Try it!
6. Now take a trip around your Sun, starting and returning to your birthday month. One full orbit around the Sun means you'd be a year older. **How many trips (orbits) have you made in your life around the *real* Sun?**

Inspired by and adapted from "Kinesthetic Astronomy: The Sky Time Lesson" by Dr. Cherilynn Morrow and Mike Zawaski

STEP 3

Discover the stars

Objects in space are *very* far away. The Moon—the closest object to Earth—is about 240,000 miles away. If you could drive a car to the Moon at 60 miles per hour, it would take more than five and a half months to get there! The Sun is about 400 times farther away—roughly 93 million miles—and it's the closest star to us. Scientists measure space with a different ruler marked in "light-years." A light-year (ly) is the distance that light travels in one year at 186,000 miles per second—one light-year is about 6 trillion miles.

CHOICES—DO ONE:

☐ **Make a 3-D constellation.** Stars look tiny and faint because they are so far away. But are they all the same distance? You can make a 3-D model of the constellation Orion to see how it looks from Earth and from outer space! See the instructions on pages 10 and 11.

OR

☐ **Create your "Girl Scout Minute."** Astronomical distances are often measured in light-years. Just like inches, feet, and miles, a light-year is a unit of measurement for distance. Go outdoors with a friend to invent your own unit of measurement—a Girl Scout Minute. See the instructions in the box on the next page.

OR

☐ **Go on a night sky scavenger hunt.** You can use your eyes, a star wheel, or a smartphone app to help you identify the stars, constellations, or planets in the night sky. With an adult, use the list to the left—or make up your own! Keep in mind that not everything is visible in the sky on the same night or time of year. That's part of the fun! Just mark off what you can find, and keep going outside on different nights to search the sky.

Find Your "Girl Scout Minute"

You will need:

- A space 100 yards or meters long—like a playing field, a long sidewalk, or a long hallway
- A one-minute timer: a watch, clock, or timer on a smartphone
- Tape measure
- Calculator (optional)
- Paper and pencil to record data—a clipboard helps!

Instructions:

1. Team up with a friend and take turns. One of you will start by walking heel-to-toe in a straight line for one minute while your partner times you.

2. Help each other measure the distance you traveled and record it.

3. This is your Girl Scout Minute. Give it a name!

4. Trade places with your friend and let them take a turn.

5. How is your Girl Scout Minute like a light-year?

For More FUN: Try answering some of these questions. You might want to use a calculator!

- ☆ How far is it to your school in Girl Scout Minutes?
- ☆ How far is it to your friend's home in Girl Scout Minutes?
- ☆ How far is it to the grocery store in Girl Scout Minutes?

HINT: Divide the distance of the location (in meters) by the distance (in meters) of your Girl Scout Minute.

"Find Your Girl Scout Minute" was adapted from "Measuring a Kid Minute" by the Astronomical Society of the Pacific.

For More FUN:
Go stargazing with a family member.

STEP
4 Use tools to explore

More than 60 years ago, people launched the first spacecraft and began to explore our Solar System. Today, the planetary scientists and engineers at universities, research labs, and NASA centers explore the planets, moons, and Sun with telescopes, robotic spacecraft, and landers.

CHOICES—DO ONE:

☐ **Be a mission specialist for a planet.** Make a travel brochure for tourists on a trip to another planet in our Solar System. Be sure to use photos or drawings and some fun facts about the planet as well as the name of a robotic spacecraft or lander that has already explored there. Check out a book from the library, or team up with an adult and go online to NASA's Space Place (NASA's place for kids!) a **www.girlscouts.org/SpaceScienceSpacePlaceSolarSystem**.

OR

☐ **Make a Mars rover.** NASA is exploring Mars with rovers—robotic vehicles that explore other planets. Today, your challenge is to design the next rover to land on Mars! Think about what you'd like to discover and the tools you'd need to accomplish this. As part of your brainstorm, check out **www.girlscouts.org/SpaceScienceMarsTrek** and explore the surface of Mars. When you're finished making your model, explain how your rover works to a friend or family member. Learn more about NASA's Missions to Mars online at **www.girlscouts.org/SpaceScienceNASAMissions**.

OR

☐ **Use tools for finding your way.** Make a paper star wheel—called a planisphere—and use it to find stars and constellations. Ask an adult to download the file and then print it on heavy paper! You can find free star wheels at **www.girlscouts.org/SpaceScienceStarWheel**.

STEP

5 Share your sky

Scientists communicate with each other—they discuss questions that interest them, share their research, and demonstrate their enthusiasm for space! Now that you've learned about our place in space, it's time to connect with your community and share your knowledge—just like a scientist.

CHOICES—DO ONE:

☐ **Attend a Star Party.** Team up with an adult to find a local Night Sky Network club and ask them if they have an upcoming Star Party you can attend. Once there, share what you've learned during this badge, and ask the astronomer any questions you might have.

OR

☐ **Create a space show.** This might be a song or rap, a skit, a video, a short story, or poem. Create something that will inspire and teach others about the wonders of space science, and present or perform it for your family and friends.

OR

☐ **Share with younger Girl Scouts.** What was the most interesting thing you learned by earning this badge? Connect with Girl Scout Daisies or Brownies and share one of your favorite activities or projects from this badge. If you don't know any younger Girl Scouts, that's ok! Any younger girls will do.

For More FUN: make space-themed SWAPS or snacks with them.

The Night Sky Network

The Night Sky Network (NSN) is made up of thousands of volunteers from local astronomy clubs across the United States who love to spread the joy of viewing the night sky. To find the free club nearest you, get an adult and visit **www.girlscouts.org/SpaceScienceNSN**. Type your zip code into the search box and click on the club name closest to you to get their contact information. Look into attending an upcoming NSN event!

MAKE A 3-D CONSTELLATION

YOU WILL NEED

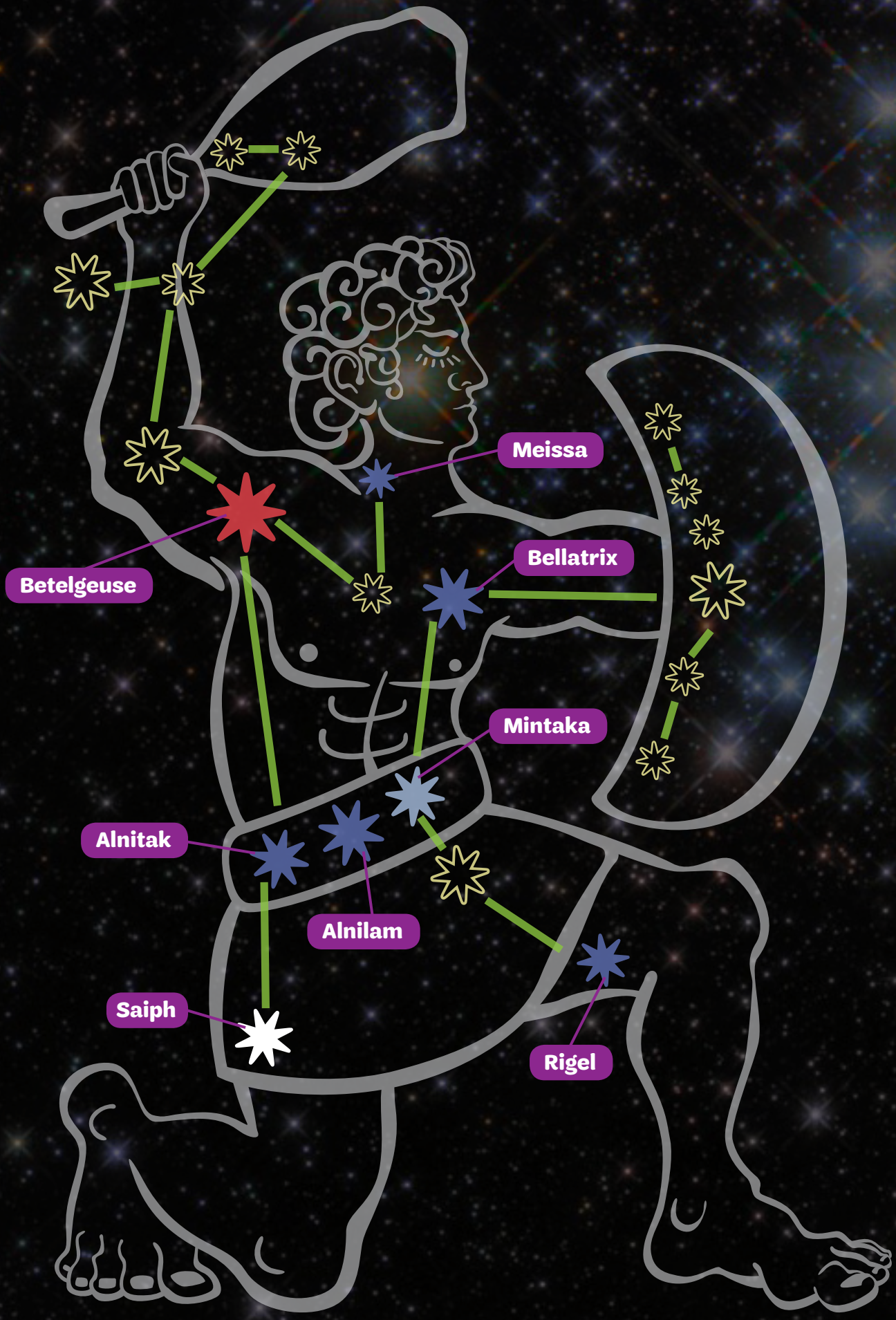
- Ruler
- Scissors
- 1 piece of Styrofoam, 30 centimeters (cm) x 30 cm (about 1 foot by 1 foot) with a 1 or 1.5-inch thickness
- 8 wooden skewers or thin dowel rods (minimum 26 cm in length)
- 6 small Styrofoam balls (1-in in diameter)
- 2 large Styrofoam balls (2-in in diameter)
- 1 copy of the Orion constellation drawing (found on the next page)
- Tape
- Paintbrush
- Red, blue, and light blue paint

INSTRUCTIONS

1. Tape the Orion constellation drawing to the piece of Styrofoam.
2. Have an adult cut each skewer to the following lengths: 26 cm, 18 cm, 16 cm, 15 cm, 15 cm, 13 cm, 10 cm, and 5 cm.
3. Paint the Styrofoam balls according to the chart.
4. Then, using the chart, insert each skewer into its corresponding star position on the drawing, which is taped to your piece of Styrofoam. You may need to measure the skewers again to make sure you're using the right ones.
5. After the paint has dried, insert the appropriate ball onto the end of each skewer (use the chart).
6. Once you've finished, have a friend hold up and tilt the Styrofoam base so that it is straight up and down. This is a 3-D version of what Orion looks like from Earth.
7. Look at the model from different angles. This is how Orion's stars would look if you could travel far out into space! Do the stars make the same constellation shape? What does this tell us about constellations? Are they flat? 3-Demensional? Do they look the same from all angles? Are stars all the same distance from us?

Star Name	Distance in Light-Years	Skewer Length (cm)	Styrofoam Ball Size	Color
Betelgeuse	640	18	Large	Red
Meissa	1,050	10	Small	Blue
Bellatrix	240	26	Small	Blue
Alnitak	800	15	Small	Blue
Alnilam	1,340	5	Small	Blue
Mintaka	915	13	Small	Light Blue
Saiph	700	16	Small	White
Rigel	800	15	Large	Blue

"Make a 3-D Constellation" is adapted from "Three-Dimensional Orion" by the Astronomical Society of the Pacific.


Meissa
Betelgeuse
Bellatrix
Mintaka
Alnitak
Alnilam
Saiph
Rigel

Going on a Journey? Do some badge work along the way.

In this badge, you explored our vast universe using a variety of scientific methodologies. Your use of scale models will offer a unique advantage as you dive into energy innovation in *Get Moving*. Apply your deeper understanding of scale models as you take action to make the world a better place.

Now that I've earned this badge, I can give service by:

- Sharing my knowledge of our vast universe with friends and family
- Taking a group of Daises stargazing and showing them how to use scientific tools
- Teaching Brownies about scale models

I'm inspired to:

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