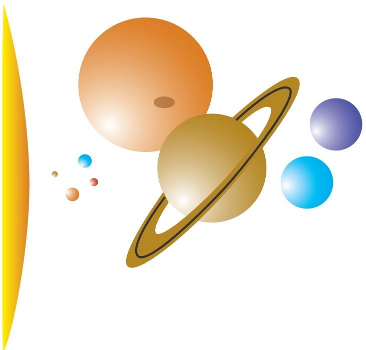


Activity 2
Where Are We in the Solar System?

Overview
During this activity, your youth:
- Experience the vastness of the solar system and the size differences among the Sun, our home planet Earth, and this unit's theme — Saturn.
- Walk a playground or other large area to create a scale model for size and distance in our solar system. A variation for an indoor model is included.
- Participate in the creation of an orbital ("radial") scale model of the solar system.
- Compare their early thoughts about the solar system to their new experience and questions once they have participated in the scale and distance exercises.
- Reflect on what it would be like to travel to Saturn.

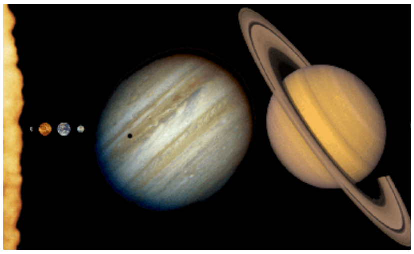
Time/number of sessions
Session 1 — 30 minutes
Sessions 2 and 3 — 40 minutes each

Activity Type
Kinesthetic and art

Space Needed
Session 1 and 3 — Classroom, cafeteria, or other space with tables, chairs, and extra floor space
Session 2 — School campus (to fit at least 247 yard-long walking paces)

Activity Goals
Youth will:
- Start to understand scale — in size and distance — in comparing the Sun, Earth, and Saturn.
- Begin to learn about Saturn and the Cassini–Huygens mission and spacecraft.
- Practice the scientific thinking skills of predicting, comparing, and relating.

Where's the Science and Engineering?



- The sizes and distances that we explore in space are far greater than those we are accustomed to on Earth. Students (and adults) may not easily grasp the enormity of space or the size difference between Earth, the Sun, and the other planets.
- Our solar system contains our star (the Sun), eight planets, dwarf planets, moons, and a variety of other objects.
- Distances in space are so vast that scientists use astronomical units (AU) for measurement. An AU is the distance from Earth to the Sun — 150 million kilometers or 93 million miles.

National Science Education Standards

K–4

Physical Science
- Position and motion of objects

Earth Science
- Objects in the sky

Equity/Leveling the Playing Field

- In this activity, youth present their work to the group. This may be more comfortable for some than others.
- Create an environment where they will feel comfortable presenting in front of the group telling them that they should think of themselves as “critical friends” who give positive constructive input.
- Explain that critical friends will give positive feedback and helpful suggestions for improvement.
- “Mirroring” is a good way to ensure this will happen, such as: “What I like about your work is...” “What you drew that is missing from my drawings is…”
- This can be followed by a “critical friends” statement, such as “What I would change about your drawing is…”
- Emphasize the idea of being supportive and helpful.

Materials

From Your Supply Closet

Session	For Leader	For Students
1	• Chart paper/white board, markers, tape	
2	• For *Chart of the Size Models* and *Walk on the Wild Size*: • Scissors, tongue depressors or Popsicle™ sticks, glue, thin cardboard or manila folder, tape • Large piece of chart paper (at least 4 feet by 4 feet square) • Yardstick, yellow highlighter, marker for writing titles	
3	• Metric measuring tape or meter ruler • Butcher paper or 4 poster boards glued/taped together to create a large square (about 2 meters on a side) • Chart paper, markers, tape • Pieces of tape to mark with the planets’ names	• Marking pens, string, scissors • Student’s *Saturn Discovery Log*

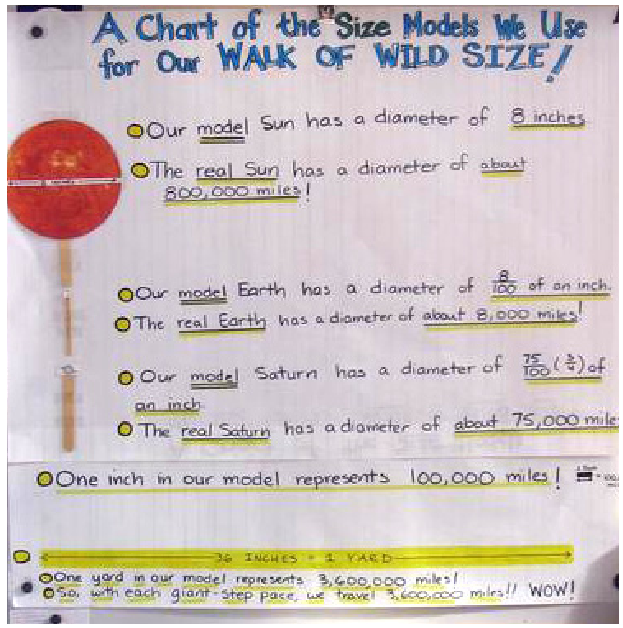
From a Photocopier/Printer

Session	For Leader	For Students
1	• Copy of the Sun, Earth, and Saturn image page, to make Sun on a stick, Earth on a stick, and Saturn on a stick • For optional Leader reading: copy of the mini-book “Introducing Saturn”: Questions, Answers, and Cool Things to Think About (from Activity 3 — “Discovering Saturn: The Real Lord of the Rings”)	
2	• Copy of Instruction Sheet *Take a Walk on the Wild Size*	• (Optional) Copy of Instruction Sheet *Take a Walk on the Wild Size* to take home

Getting Ready

For Sessions 1 and 2

- Cut out the images for the Sun on a stick, Earth on a stick, and Saturn on a stick, and glue each to a separate piece of thin cardboard or a manila folder. Tape each object to a tongue depressor or Popsicle™ stick so that students can easily hold them.
- Prepare the *Chart of the Size Models* for *Walk on the Wild Size* as shown. (Be sure to draw and label a 1-inch bar.) You will use this chart to show the students how the scale of the model compares to the actual distances in the solar system, and how much distance in space one pace represents.
- Brief yourself on the Instruction Sheet *Take a Walk on the Wild Size*, and optionally, print it out for each student to take home.
- Identify a large portion of a school campus. Because the distances in space are so big (247 yard-long paces to Saturn, 1019 paces to Pluto!), everyone will need to take a short hike to complete this model.

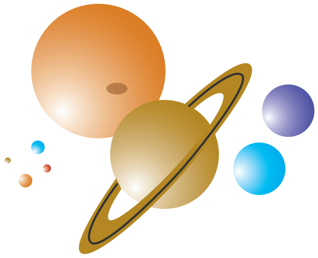


For Session 3

- Tape and/or glue butcher paper or 4 poster boards together to create a large square (about 2 meters on a side).
- Mark the center of the square, for the Sun's position in the model.
- Pre-cut a piece of string to be 80 cm or longer.
- Write the name of each planet on the right half of a separate piece of tape. (These will be used to wrap around string.) Since the inner planets are so close together, you might need to put several inner planet names in order on a single wide piece of tape, and/or cut the tape into narrower strips.
- Distribute each student's *Saturn Discovery Log* back to him or her for journaling.

Leader Tips

- Pace out the walking scale model in advance yourself to find the best location and to anticipate student questions. A very large space is required. It's impressive when done, but not every site has this kind of space. This scale was chosen to correctly model the size of the Sun to the distances to the planets at the same time. (All numbers are rounded.) See "Taking Science to the Next Step" if you need to adapt the walk for a smaller/indoor space.
- Set any ground rules you need to before taking the group outside — this could include staying with the group at all times or agreeing on a signal that it's time to stop.
- Some cities make their own permanent solar system scale models, such as the Smithsonian Institution in Washington, DC. Websites are listed in the "Internet Resource List" (see Appendix) to help you visualize representations of the solar system and Saturn's place in it.



Where Are We in the Solar System?

Student Activity

Session 1 • Wondering About and Sizing Up What's Out There

1. Lead the children in sharing their ideas about our solar system. Capture their thoughts on a white board or chart paper. (Do not worry about whether an idea is right or wrong for the moment.) Some suggested questions are:
   - What are the names of planets in our solar system?
   - What other kinds of bodies or objects are out there in the solar system?
   - What have you heard about traveling in space?
   - What questions do you have about the solar system?

2. Explain to the students that over the next few sessions, the group will learn about the planet Saturn and think about what it would be like to go that far into the solar system. Explain that they will model the size of the Sun, Earth, and Saturn, and how far they are apart, at the same time.

3. Ask the students how many stars there are in the solar system. Reveal that there is only one – our Sun. Explain that our Sun is also the largest object in our solar system — it would take 109 Earths to span the Sun's diameter. Remind students that the Sun is in the center of the solar system and the planets orbit (go around) the Sun.

4. Show the students the Sun on a stick that is approximately 8 inches in diameter, and say "This is a model of the Sun." Ask: "If this is our Sun, how big do you think Earth should be? How big do you think Saturn should be?" and have them respond.

5. Show the students the Earth on a stick and Saturn on a stick models, revealing the true size for Earth and Saturn in this model.

6. Display the *Chart of the Size Models* for *Walk on the Wild Size* you created and have the students take turns reading it out loud. Emphasize that for each "giant" (yard-long) step, they would travel 3.6 million miles (5.8 million kilometers - km) on the actual scale of the solar system! Then have them estimate some distances using this conversation guide:
    - Now that we have established the size scale for the Sun, Earth, and Saturn, how much space do you think we need to build our scale model of distances between them?
    - Let's have one volunteer come to the front of the room and be the Sun. (Have the volunteer hold the Sun stick.)
    - Let's have another volunteer be the Earth and stand next to the Sun. "Earth" will keep taking giant steps away from the Sun in a straight line and you all count them. Call out "Stop" as soon as you think that "Earth" is far enough from the "Sun." (The correct distance is 26 giant steps. If the students stop "Earth" earlier, respond "Not far enough" until they run out of room or get to the right distance.)
    - The distance between Earth and the Sun is 93 million miles (150 million km), or in our model, 26 giant steps.
    - How far apart do you think you need to stand to model the distance from the Sun and Earth to Saturn? (Have a volunteer come up to stand where the students think Saturn would be.)
    - We'll learn the right distance for Saturn in our next session, and walk the distances to the other planets. For that, we'll need to go outside!
7. Collect the Sun, Earth, and Saturn stick models.
8. (Optional) Leader Reading: Read aloud the last 2 paragraphs of page 3 from the mini-book "Introducing Saturn," showing the illustrations.

Quick Facts Reference: Size Comparison

- The Sun's diameter is about 864,337 miles (1,390,718 km).
- Earth's diameter is about 7,918 miles (12,740 km).
- Saturn's diameter is about 74,913 miles (120,535 km).
- It would take about 109 Earths to span the diameter of the Sun.
- It would take about 12 Saturns to span the diameter of the Sun.
- It would take about 9-1/2 Earths to span the diameter of Saturn at the equator.

Session 2 • Taking a Walk on the Wild Size

1. Repost the *Chart of the Size Models* for *Walk on the Wild Size* in the room.
2. Prepare the students for their walking adventure through the solar system, using this conversation guide:
    - Most of you have had some kind of experience with models. A model is a representation of something else, often something too big, too small, too far away, or too complicated to observe directly.
    - Scientists and engineers often build models to test a challenge or visualize how something will work. The model could be as simple as drawing something on a white board so that everyone sees the same thing and as complex as creating a computer program to test how their spacecraft will land on a planet. When scientists want to send a spacecraft to space, they often make a model of their destination to figure out how best to get there.
    - For our model, as we make the trip to Saturn, the distances are so big that we'll need to go outside.
    - We'll be pacing the distances from the Sun to the orbits of the planets, walking in a straight line. While this model is true for size and distance comparisons, it is not true

for the locations of planets in their orbits around the Sun. A straight line-up of the planets essentially never happens. Since models are only representations, they don't represent everything accurately.

3. Point out the facts on the *Chart of the Size Models* for *Walk on the Wild Size* and again emphasize that for each "giant" (yard-long) step, you would travel 3.6 million miles on the actual scale of the solar system!
4. Prepare the group to go outside, and make any recommendations for rules of conduct while there. Take and use the Instruction Sheet *Take a Walk on the Wild Size*.
5. Have the students line up at your selected large and/or outdoor location. Using the Instruction Sheet, begin pacing together, and read off the distances as you go, beginning at the Sun.
6. Once you have completed the walk, get their impressions:
   - What surprised you about the distance?
   - What do you notice about how the Sun looks from Saturn compared to how it looked from Earth? (The Sun is a smaller size. You cannot see as much detail on the Sun from Saturn's distance.)

Session 3 • Creating a Radial Scale Model

1. Prepare the students to think about a different kind of model, using this conversation guide:
   - Earlier we made a model to show the distance between planets and the Sun. Now we are going to make a radial model for the planets' distance from the Sun. The radial model shows the planets in their orbit around their common center — the Sun. Scientists, too, often create different models of the solar system for different purposes.
   - As we saw in the last session, because distances in space are so large, scientists have come up with different ways of measuring these distances. They use an astronomical unit (AU) for the distance from Earth to the Sun (93 million miles, or 150 million kilometers). Other measurements in space are then referred to as the number of AUs between two bodies (or the number of 93-million-mile segments).

2. Spread out the sheet of butcher paper/poster board and mark the Sun at the center.
3. For this model, every astronomical unit (AU) is about 2 centimeters (cm). Ask students to predict where they think Earth and Saturn will be, relative to the placement of the model Sun. They can also predict how many astronomical units they think this will be.

4. Measure the different distances along the string and put the piece of tape marked with each of the planets' names.
   - Mercury: 0.8 cm (0.4 AU)
   - Venus: 1.5 cm (0.7 AU)
   - Earth: 2 cm (1 AU)
   - Mars: 3 cm (1.5 AU)
   - Jupiter: 10 cm (5 AU)
   - Saturn: 19 cm (9.5 AU)
   - Uranus: 38 cm (19 AU)
   - Neptune: 60 cm (30 AU)
   - Pluto: 79 cm (39.5 AU)
5. On the large paper, attach the piece of string to the center of the Sun. Have the students mark the planets at the appropriate distance, as you rotate the string around the Sun as each planet is placed. Planets should be spread out in several directions — not lined up as they were in the earlier model.

Questions for the Youth (Informal Assessment)

Prompt a discussion about the activity with your students using this conversation guide. (Suggestions for starting/continuing the conversation are in parenthesis):

- What surprised you? (It's a lot farther between each planet and really far to Saturn.)
- What do you notice? (The radial model shows that the planets don't line up in a row.)
- What do you notice about how the Sun looks from Saturn compared to how it looked from Earth? (The Sun is a smaller size. You cannot see as much detail on the Sun from Saturn's distance.) Do you think it is colder on Saturn than Earth? (The heat from the Sun is much less because it is much farther away.)
- What problems or challenges do you think a spacecraft has to overcome in order to travel from Earth to Saturn? (The spacecraft needs enough energy to make all the instruments and cameras work during the several-year flight to Saturn.)
- What kinds of information about Saturn and Titan do you think a spacecraft could gather that we are unable to gather from Earth? (Because it is close to Saturn, it can see clouds and landscapes better. The spacecraft can take better pictures to send back to Earth)
- What questions do you have? ("I wonder…?" "What if…?")

Sharing the Findings (Informal Assessment)

Ask students to work in teams and spend a few minutes writing down everything they just discovered or learned in their *Saturn Discovery Logs*. Ask them to also list all of their new questions.

Leader Reflection/Assessment

After the activity, ask yourself the following questions:

1. Did the students show a curiosity to learn more about the solar system?
2. Did the students' discoveries indicate an understanding of the bigness of our solar system? Of how far away Saturn is?
3. Did the students understand that the planets are not lined up in a row, but in orbit around the Sun?

Glossary

- Astronomical unit (AU) — The distance from Earth to the Sun (93 million miles, or 150 million kilometers).
- Diameter — The length of a straight line through the center of an object — so, the diameter gives us the measurement of how far it is across a planet, moon, or the Sun.
- Model — A three dimensional example for imitation or comparison; a representation (sometimes in miniature) to show how something is configured or constructed.
- Radial — Radiating from, or situated around, a common center (the Sun).
- Solar system — The configuration of our Sun and planets and other bodies that revolve around the Sun.

Information for Families

Do the parents in your program have busy schedules — does working and taking care of the kids leave time to go to a museum? Is it difficult to get to museums? Use your Web browser and search for "science museum virtual tour" for locations that can be visited online or with a smart phone.

Young people today are living during the most amazing era of exploration in human history. For the first time, we are able send back pictures and information from other worlds. Encourage parents to share the adventure with their children at the SpacePlace parent's page at
spaceplace.nasa.gov/menu/parents-and-educators/

NASA Resources

Careers at NASA

What would a career exploring other worlds be like? How can you work at JPL as a student? Find out at www.jpl.nasa.gov/work

Ask students to brainstorm a new "job at NASA." What would it be? What would that person try to find out? Describe the mission that person would lead. Chart the students' responses.

Role Model Resource

Dr. Ed Stone is a professor of physics at the California Institute of Technology and the Chief Scientist for Jet Propulsion Laboratory's Voyager mission, which has traveled to the outer planets making amazing discoveries, and continued the journey beyond to the boundaries of our solar system. Since the launch of the two Voyager spacecraft in 1977, Dr. Stone has coordinated 11 teams of scientists in their investigations of Jupiter, Saturn, Uranus, and Neptune, and became nationally known as the JPL public spokesman during the planetary flybys, explaining the Voyagers' scientific discoveries to the public. He later served as the Director of JPL. He's interested in how things work — science is, after all, about understanding how nature works. He found that learning about how things work is best done by actually trying to make and build things! He also feels that to be a successful scientist, as in most aspects of life, you need to develop skills for good listening and for talking with people.

Watch a video about Ed at solarsystem.nasa.gov/multimedia/video-view.cfm?Vid_ID=1048

Learn more about the Voyager missions at voyager.jpl.nasa.gov

Resources

To help you visualize representations of the solar system and Saturn's place in it, visit:
• solarsystem.nasa.gov/yss/display.cfm?Year=2010&Month=10&Tab=Classrooms. Build your own solar system scale model and find others around the country.
• solarsystem.nasa.gov/eyes/player (requires the free 3d-Unity player download)
• voyager.jpl.nasa.gov/pdf/VoyagerPoster2010_Back.pdf. A 2-dimensional model of planetary distances on a football field.

"The planets" section of this solar system website is particularly fun for students to explore — solarsystem.nasa.gov

For child-friendly information about space travel, including quiz games and a history of space travel, see — www.jpl.nasa.gov/kids/

Additional educator resources can be found on the NASA website (www.nasa.gov). Click on "Educators" to view.

Taking Science to the Next Step

If you need a smaller space for the scale model (such as a gym or playground), divide everything by 10:

- On "photo" setting, photocopy at 10% reduction the Sun, Earth, and Saturn image page. (Your copier may require you to do two reductions at 33% each instead.) Earth will be a pinpoint at this scale.

- In the *Chart of the Size Models* for *Walk on the Wild Size*, change the model Sun's diameter to 85/100 of an inch (0.85), model Earth diameter to 8/1000 of an inch (0.008), and model Saturn diameter to 75/1000 of an inch (0.075). One inch in this model represents 1,000,000 miles (1:1,000,000).
- Divide the number of steps needed by 10 (round to the nearest whole number) before pacing.

Send home the directions for pacing the solar system, so students can do the activity again with family and friends.

Convert the size model and pacing model to metric units, which are commonly used by engineers! (As you learn more about astronomy, read different books, and visit different websites, you may find information presented in miles, kilometers, or both.) Here is an easy was to convert from miles to kilometers, and kilometers to miles — 1 mile = 1.609 kilometers.

- To convert from miles to kilometers (km), multiply by 1.609. For example, if the diameter of Saturn is 74,913 miles, multiply 74,913 miles by 1.609 km per mile = 120,535 km.
- To convert from kilometers to miles, divide by 1.609. For example, if the diameter of Saturn is 120,535 km, to find out miles, divide 120,535 km / 1.609 km per mile = 74,913 miles.

Make other models of the solar system: see the "Solar System Model Builders' Guide" on the Windows to the Universe website at www.windows2universe.org/our_solar_system/distances.html (includes directions for scaling the solar system when Earth is represented by a marble).

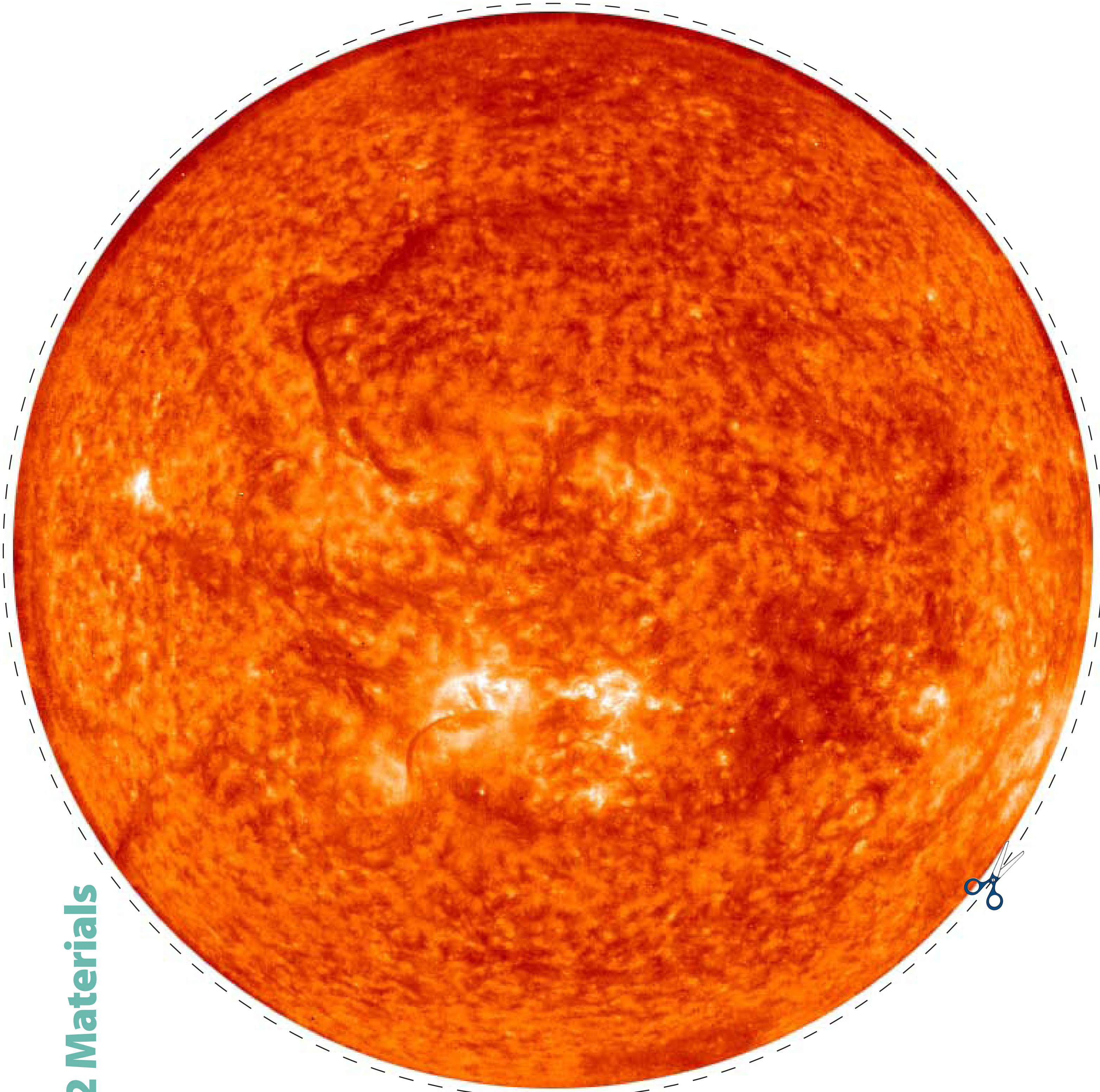
If there's enough space (for example, a football field), try pacing out the solar system but instead of lining up the planets, ask each student representing a planet to walk in a different direction and create a radial model. This way, students will understand that the planets are not "all lined up" in a straight line.

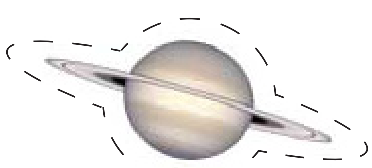
Literacy

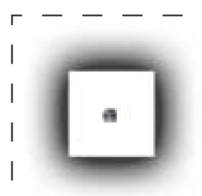
Ask the students to write a short science fiction story about going to Saturn. Tell them to include as many Saturn or space facts as possible. Include information like how far away Saturn is, or the name of its largest moon. Share the stories with the children.

- Discuss why it took Cassini seven years to get to Saturn.

Activity 2 Materials







Instruction Sheet — Take a Walk on the Wild Size

Directions for Pacing the Solar System

1. Pick a location for the Sun, and have the group start their "giant" paces from there. (The giant paces should be about 1 yard long each.) Read off the distances as you go.
2. Take 10 paces. Call out "Mercury."
3. Take 9 more paces. Call out "Venus."
4. Take 7 paces. Call out "Earth." At this point, have everyone look back at the Sun. Ask, "What do you notice?" "How big does the Sun look from Earth?" "Looking from our model Earth, does the model Sun look about the same size as we see it in the sky?" (It should.) Share fun facts:
   - Earth is 93 million miles from the Sun.
   - Astronomers give the distance from Earth to the Sun a special name — an astronomical unit.
5. Take 14 more paces. Call out "Mars." Ask everyone if they know which planet they will pass next on their journey to Saturn.
6. Take 95 paces. Call out "Jupiter." Ask the group which planet is next. Have them predict how many more paces it will be to Saturn.
7. Take 112 paces. Call out "Saturn." Saturn is 247 paces from the Sun, and 221 paces from Earth!
8. Stop at Saturn and discuss the model with the group. Ask them what they think about the size of the model they created. Are they surprised? Where do they think Earth's Moon would be located? How big does the model Sun look from the model Saturn?
   - Saturn is 890 million miles from the Sun, or 9.5 astronomical units.
   - So — Saturn is about 800 million miles from Earth, when they are both on the same side of the Sun.
   - Walking at 3 miles per hour, it would take you 30,441 years to get from Earth to Saturn.
   - Driving a racecar at 100 miles per hour, it would take you 913 years to get from Earth to Saturn.
   - Flying to Saturn in a jet plane, traveling at 600 miles per hour, it would take you 152 years to get to Saturn.
   - Flying in a rocket, traveling at 17,500 miles per hour, it would take you 5 years to get to Saturn.
   - It took the Cassini–Huygens spacecraft nearly 7 years to get to Saturn, because it did not travel directly to Saturn. It had to fly by several planets on its way, using their gravity to give it the "energy boost" needed to get all the way to Saturn. Cassini's journey covered nearly 3 billion miles.
9. If you have the space and the time, you can continue to the outer planets, and to Pluto!
   - It is 249 paces from Saturn to Uranus.
   - It is 281 paces from Uranus to Neptune.
   - It is 242 paces from Neptune to Pluto.