Afterschool Activity

The Solar System in Your Neighborhood

Overview

During this activity, your youth:

- Use familiar food items for a scale model of the size of planets in our solar system
- Make a foldable scale version of the solar system with a piece of paper
- Compare their scale version of the solar system to the neighborhood around their school
- Use science and mathematics skills of observing, communicating, predicting, gathering and organizing data, team work, using proportions

Time/number of sessions	Activity Type	Space Needed
Two to three 40-minute sessions	Hands-on, kinesthetic	Tables and chairs

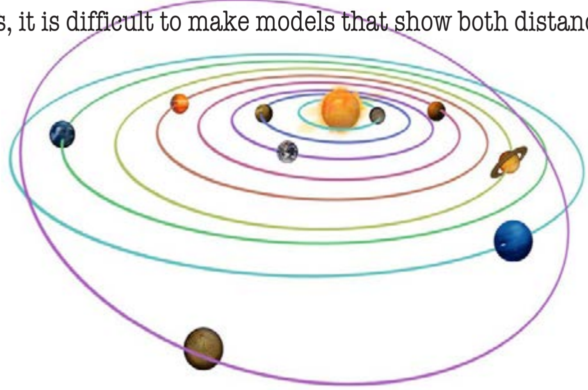
Activity Goals

Youth will:

- Understand the importance of using models for representations of larger or more complex objects
- Gain appreciation for the vastness of the solar system by comparing to something familiar – a piece of paper, a map, the neighborhood
- Observe that the solar system is mostly empty space, and that the outer planets are much further part than the inner planets
- Kinesthetically experience planetary sizes

Where's the Science and Engineering?

- Scientists use measurement and scale calculations on an everyday basis. It's important because they can help visualize answers to questions about the solar system.
- Engineers also depend on measurement and scale calculations for planning and building spacecraft, calculating the trajectory of a spacecraft's flight path, and many other important steps for a mission into the solar system.
- Both scientists and engineers need to be very familiar with the locations of planets and other bodies in the solar system - the distance from Earth, distance between them.
- Our solar system is made up of the Sun, eight planets, many Kuiper Belt objects and dwarf planets including Pluto, over 140 moons, millions of small asteroids, and countless comets. Most of the mass in the solar system is concentrated in the Sun, which is a medium-sized star. (Jupiter, the largest planet, has a mass just 1/100 that of the Sun.) However, most of the solar system is empty of any large bodies – the planets orbit the Sun at distances that are thousands of times larger than their planetary diameters. Because of this, it is difficult to make models that show both distances and sizes together.



Next Generation Science Standards (NGSS)

Space Systems
MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.

Science and Engineering
5.. Support an argument with evidence, data, or a model

Crosscutting Concept: Scale, Proportion and Quantity
5. Natural objects exist from the very small to the very large
MS. Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small

Common Core Mathematics
MP4. Model with Mathematics

Equity/Leveling the Playing Field

- This activity introduces mathematics in an enjoyable way. Help them to understand that making these math concepts will to let them compare the solar system to their own surroundings.

Materials

From Your Supply Closet

Session	For Leader	For Students
1	From the grocery store – substitute as needed (approximate diameters given): • Small cantaloupe or large round squash (11 cm or 4 ½") • Grapefruit (9 ½ cm or 3 ¾") • Small lime (4 cm width or 1 ½") • Large strawberry (just under 4 cm width) • Green grape (1 cm width or 3/8") • Blueberry (1 cm or 3/8") • 2 Peppercorns (1/2 cm or 3/16") • 1 grain of rice (2 mm or 1/16")	For each student team of 4-5: • Pencils
2	• Chart paper/ whiteboard/ chalkboard and markers/chalk	Colored pencils or thin markers (white board markers are too thick)

From a Photocopier/Printer

Session	For Leader	For Students
1	*Solar System Scale Model – Planetary Sizes* Answer Key	For each student team of 4-5: • *Solar System Scale Model – Planetary Sizes Student Handout*
2	*Copy of map of school neighborhood on legal (8 ½" x 14"), or regular (8 ½" x 11"), sized copy paper (See Getting Ready for instructions)*	*Copy of map of school neighborhood on legal (8 ½" x 14"), or regular (8 ½" x 11"), sized copy paper*

Getting Ready

For Session 1

- Gather fruit, grains, and other items to represent the planets and dwarf planet Pluto in our solar system
- If you use any substitutions for the food items, be sure to note it on your *Solar System Scale Model – Planetary Sizes* Answer Key.
- Familiarize yourself with the *Solar System Scale Model – Planetary Sizes* Answer Key so that you can help guide the students.

For Session 2

- If you have legal sized copy paper (8 ½" x 14"), it will be easier for the students to make all the folds. 8 ½" x 11" will work, but some students may need extra help making the folds for the inner planets.
- You can use a photocopy of a map of the local neighborhood around your school, or a map or satellite view from an on-line map website (the latter may help the area be more recognizable to your students). Having the paper with the short edges on the left and right (8 ½" side), choose an enlargement that puts your school at the far left of the paper and covers the neighborhood in one direction away from the school. Showing an area covering a few blocks works well, but you can choose the area you want to cover
- A map image handout of the National Mall in Washington DC is included if you don't have a different map to use.
- You may want to choose one street that runs the across the length of the page. This allows students or families to observe the solar system model on a continuous route through the neighborhood.
- The Sun's location will be represented on the far left of the page, and Pluto's location on the far right.
- Trim the short sides to the actual photocopied/printed edges where the Sun and Pluto will be.

Leader Tips

Session 1

- Point out to the group that these are "scale" models that don't come close to representing the actual size of any or distance of the planets. They can tell that by looking at the model of Earth.

Session 2

- If you don't have access to maps, you can still do this activity and use the paper folds as a model for the planetary distances.

Glossary

Diameter — the length of a straight line through the center of an object. The diameter gives us the measurement of how far it is straight through the middle of a planet, dwarf planet, moon, or the Sun.

Kuiper Belt (KYE – per) — the region of the solar system beyond the gas giants (beyond the orbit of Neptune from about 30 to 55 AU) and is probably populated with hundreds of thousands of icy bodies larger than 100 kilometers (62 miles) across.

Model — a three dimensional example for imitation or comparison; a representation (sometimes in miniature) to show how something is configured or constructed

Scale factor — A number used to multiply or divide a quantity when converting from one system of units to another and sizing for a particular model representation

Solar System — the configuration of a sun with planets and other bodies that revolve around it

The Solar System in Your Neighborhood

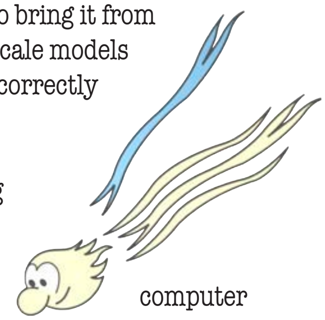
Student Activity

Session 1 • Scale the Size of Planets with Foods

1. Divide students into teams of 4 – 5, each sitting at separate tables. (9 teams are ideal, so have smaller teams if needed.) Then introduce the activity with the following conversation guide:

- Think about all the planets in our solar system, and imagine you wanted to show your friends and family how big they are, or how far away from each other they are. How could you do it? (Let them brainstorm for some answers.)

- You would need a scale model. To scale something is to use math to bring it from one size to another in the proper proportion. You may have seen scale models of planes or buildings. They are much smaller in size but they are correctly proportioned to the actual thing.



- Scientists and engineers often build models to visualize something that is too big, too small, too far away, or too complicated to observe directly. Their model could be as simple as drawing something on a white board, or as complex as creating a computer program. Using mathematics to determine the size and scale of bodies in the solar system and the distances between them is critical to scientists and engineers because they are sending spacecraft that must navigate these planets.

- But models can't represent everything about the actual thing (otherwise, they'd be a copy!). We must pick and choose and communicate the key things we can easily represent with our model. Some traits of the original we won't be able to represent accurately.

2. Tell them that today, using food items, they will make a scale model of the size of planets in the solar system (including dwarf planet Pluto), and put them in order in the proper part of the solar system. Let them know that each team will be asked to investigate and represent a planet or dwarf planet. They will have three jobs – to choose the food that best represents the size of their planet, decide which part of our solar system it belongs (inner, outer, or beyond) by learning about what it's made of, and put it in order of their distance away from the Sun.

3. Give them some background and hints using this conversation guide.

- One of the ways scientists classify the parts of our solar system is by the type of planets that are there and what they are made of. While our solar system was forming, near to the Sun its heat and radiation removed most of the gases and ice that were originally there, leaving behind solid rocky materials and metal which planets could be made from. The outer planets, being further away from the Sun, kept much of their gasses and so they became the major part of those planets. Their gasses turn to liquid much deeper in the planet, due to increased pressure.

- From this, we get the identification of our "rocky inner planets" and our "outer gas giants". This gives you a clue to the general order of placement for them in our model. Another clue is that the outer gas giants – Jupiter, Saturn, Uranus, and Neptune – are much larger (or giant) than the inner rocky planets. The inner planets – Mercury, Venus, Earth and Mars – are made of rock and metal and have solid surfaces. Pluto doesn't seem to fit into its location furthest from the Sun and scientists have had a lot of discussion about its being - not a planet - but a dwarf planet, one of a number found in what's called the "Kuiper Belt" (pronounced K"EYE" - per) out beyond the gas giants.

4. Have students take a look at the items on the table while you name each food. (Use the food name, not the planet name.)

5. Hand each team a copy of the *Solar System Scale Model – Planetary Sizes* student handout. Explain that they are to do the things below and record their answers in the corresponding column of the handout. (If the session time is limited, you may want to have each team look at a different planet/dwarf planet and only fill in those corresponding columns.)

- Decide which food represents which planet (fill in the "Food Model" column)

- Using the "Percent Rock, Metal, or Gas" columns, decide on which part of the solar system the planet belongs (fill in the "Part of Solar System" column with one of "Inner/Rocky", "Outer/Gas Giants", or "Kuiper Belt")

- Order the planets/dwarf planet from closest to the Sun to furthest away from the Sun (use a number from 1-9 to fill in the "Order from Sun" column)

6. Pass among the tables and answer questions, but encourage them to use the data on diameter and percent of rock, metal, or gas to make their decisions.

7. When the students have completed their tables, have them select one planet they want to represent. Make sure all planets and Pluto are represented. Have each team send one member forward and pick up the food item they believe represents their planet.

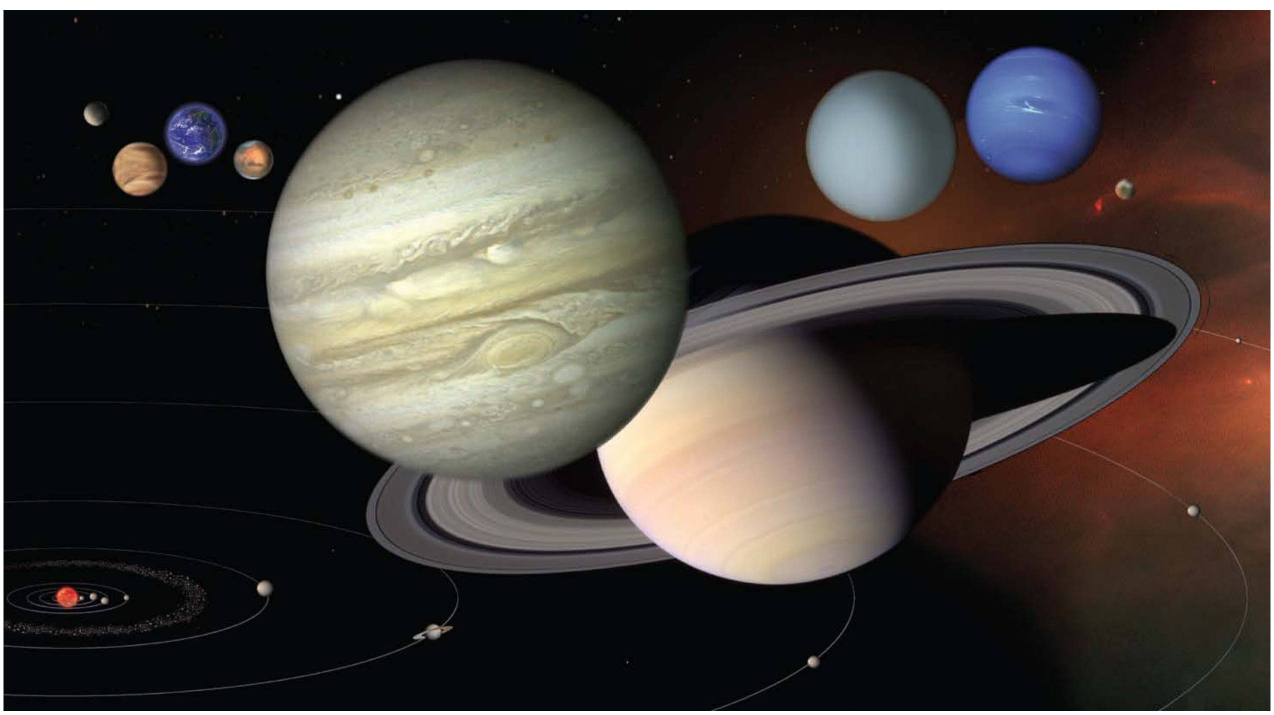
8. Next, finish this model of the solar system by having the representatives put themselves in order they think is their planet's distance from the Sun. (You can use the Solar System Scale Model – Planetary Sizes Answer Key.) If there are any disagreements, ask them to discuss why they chose that particular food item or order. If they had a good reason for their selection, correct it, but applaud that they used data to make their decisions. Make the point that the planets are not this close to each other in space, but since this model is not about proper distance between planets, they can stand right next to each other.

9. Once everyone has the correct food item and order for this model, ask the students where they would divide the food between the rocky inner planets and the outer gas giants (Answer: between Jupiter and Mars). What is the area where dwarf planet Pluto is? (Kuiper Belt)

10. As a fun exercise, tell them that the Sun is 109 times bigger across (in diameter) than the Earth. What could we use to represent the Sun in our model? (Suggestions: on this scale, the Sun =109 cm (about 3 ½ feet), the height and arm span of a typical kindergartener, or a 1000 pound pumpkin).

11. You can give them this easy saying to remember the order of their planets, which includes dwarf planet Pluto: "**M**y **v**ery **e**legant **m**other **j**ust **s**erved **u**s **n**ine **p**izzas – Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto

12. Have the students return to their seats.



Session 2 • Solar System Map Scaled to the School Neighborhood

1. In this Session, students will make a scale model of the solar system by matching locations on a map of the neighborhood around their school to the orbits of the planets in the solar system, including dwarf planet Pluto.

2. Remind them about the previous model they made on the schoolyard, and ask them to recall what surprised them about the distances of the planets in the last session. Ask what about that scale model was represented accurately. What didn't the model represent well? Chart their responses.

3. Tell them that today they are using a map of an even much bigger area to form their model of distance in the solar system - the amazing thing is that they will be able to take a copy of a map or satellite picture of their school neighborhood and fold it to places that represent the approximate distance from the Sun of the planets and Pluto! (We might call it Planetary Origami!) They will be able to help their friends and family learn the scale the solar system, too, right around their school.

4. Hand each student a copy of the map, and orient them to what they are seeing. Show them where the school is on the map and help them locate other buildings and street names nearby.

5. Demonstrate each fold as you give the students these instructions. Walk among the tables to check that the folds are being properly made.

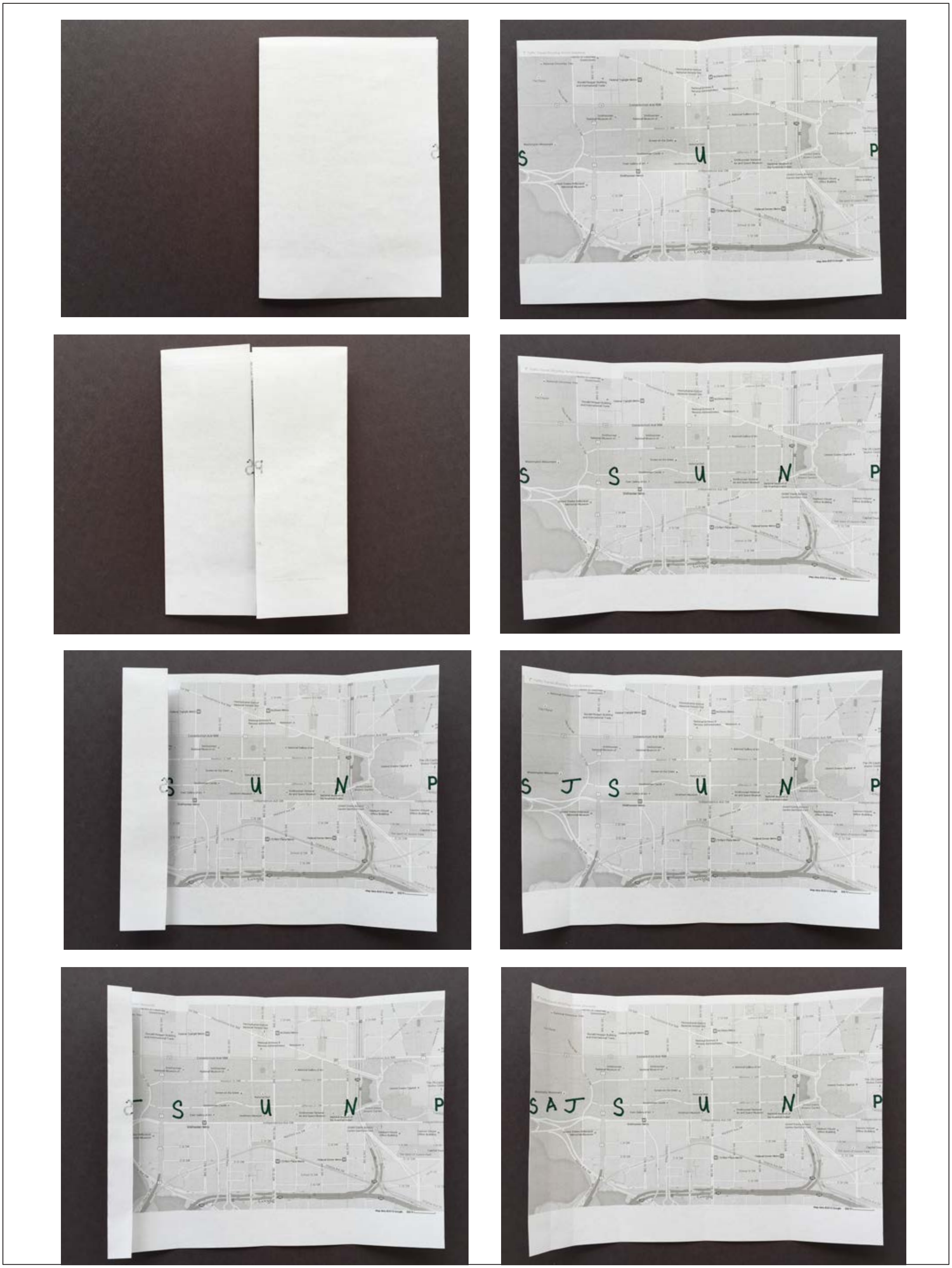
- Lay your paper on the table with the short edges on the left and right. Write "Sun" (or "S") in small letters along the left edge of the paper. (Students might do better writing along the crease vertically.) Write "Pluto/Kuiper Belt" (or "P") along the right edge. All the rest of the planets are going to be fit to scale between these two.

- Now fold your paper by making the two short edges meet (bring the "S" and "P") together. Crease the paper. Then unfold it, face up. Write "Uranus" (or "U") along the crease. Uranus' orbit is half-way to Pluto!

- Again take one of the short edges, but instead fold it half-way by bringing the edge to the center crease, where Uranus is marked. Crease the paper at this fold. Take the other edge and bring it to the center crease, too. Unfold both sides. Write "Saturn" (or "S") on the new crease on the left, and write "Neptune" (or "N") on the new crease on the right.

- Now, take only the left edge and fold it to the crease marked "Saturn". Unfold and write "Jupiter" (or "J") on this newest crease.

- Wow! What parts of the solar system do we have represented so far? (Answer: The outer solar system and the edge of the Kuiper Belt.) We now have all the gas giants placed on our model. But what about the inner solar system – how much room is left for that? (Answer: 1/8 of the page, the part to the left of the last fold.)


S U P
S S U N P
S U N P
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- So we aren't done yet! We're going to add something new here, which is the Asteroid Belt where small rocky remnants left from the formation of the solar system orbit the sun. Fold the left edge to the crease marked "Jupiter". Unfold and write "Asteroid Belt" (or "AB") on the new crease.

- And now, for the inner planets! We need two more folds! First, fold the left edge to the "Asteroid Belt" and crease. Unfold and write "Mars" (or "M") just to the right of the crease, and write "Earth" (or "E") just to the left of the crease.

- The paper to fold is getting really small now. (You might need to help the students particularly for this fold.) One more time, fold the left edge to the previous crease (in between Earth and Mars). Unfold. If there is room, write "Venus" on the right of the crease, and "Mercury" on the left.

- You now have the Sun, all eight planets, and the dwarf planet Pluto.

- Open your paper completely and discuss your findings with your team.

6. Close by asking them what is accurately modeled with this paper model (answer: distances between the planets and the Sun), and what is not represented well (suggestion: in reality, the planets are not in a straight line). Suggest this is a solar system model the students can talk about with family and friends at school, or show people when they are passing by.

Questions for the Youth (Informal Assessment)

- Were there surprises about the difference in scale size among the planets? What were they?
- What surprised you most about the size of the solar system and the position of the planets within it? (Chart answers)

Sharing the Findings (Informal Assessment)

- What do you think about Pluto being re-assigned from a planet to a dwarf planet now that you know more about its composition, size and distance from the Sun? (You can remind them of some of Pluto's characteristics from their data sheets if they have forgotten).
- Do you think that scientists should be able to change the designation of a planet or other body in the solar system once it is established? Why or why not?
- Who do you think might enjoy learning the scale model of the solar system with fruits? Who could we share it with and how would we do that?

Leader Reflection/Assessment

Did students seem to understand the difference between rocky inner planets and outer gas/ice giants in terms of their placement and composition?

Information for Families

Have students take home the list of food items for the planetary sizes scale model, and encourage them to plan a demonstration of the scale, followed by a side of fruit salad made from some of the same fruits!

NASA Resources

Careers at NASA

Putting a probe into space around another planet takes a team of dedicated scientists, engineers, and others at NASA working together. Learn about some of the people who make space exploration possible.

http://www-robotics.jpl.nasa.gov/people/index.cfm

Role Model Resource

When Eugene Chiang was 12 he would haul his telescope out at night on Long Island, New York, only to find his view wrecked by city lights or tall trees. On many nights, the cold drove him inside. "It was hard to find a good patch of sky that was really open," Chiang remembers with a laugh. "That's why I became a theorist" instead of an observing astronomer.

Chiang is now a university professor who has worked on a team using powerful telescopes to search for giant chunks of ice and rock - the fossils of our solar system - in the Kuiper Belt, that are just about at the edge of what a telescope can detect, using predicted paths of these mysterious objects.

Chiang is happy to leave most of the actual observing to his colleagues. One trip to a telescope high atop a dormant volcano in Hawaii reminded him of his chilly introduction to stargazing. The theoretical world is much warmer. "I prefer to sit in my sunny office and think," he said. Chiang credits his love of physics to role models both real and fictional. He grew up watching real-life scientist Carl Sagan's Cosmos and the British science fiction series *Dr. Who* on television. "I remember telling my mom I couldn't decide who I admired most," Chiang said. "Carl was real. But science fiction interested me, too, because it is about the future possibilities of physics. As far as I could tell, *Dr. Who* used physics to save the universe every week. It wasn't magic. It was physics."

Taking the Science to the Next Step

Give your students more experience with scales in the solar system with the NASA Space Math activity "Earth and Moon to Scale". Students create a scale model of the Earth-Moon system and compare with artistic renditions and actual NASA spacecraft images.
http://spacemath.gsfc.nasa.gov/Grade35/5Page23.pdf

In "Planets, Fractions, and Scales", students work with fractions of planetary sizes to determine the actual sizes of the planets, given the diameter of the Earth.

http://spacemath.gsfc.nasa.gov/Grade35/5Page24.pdf

In "Planetary Conjunctions", students study a simple solar system with three planets and use geometry and patterns to work out how often the planets will "line up".

http://spacemath.gsfc.nasa.gov/Grade35/6Page42.pdf

Literacy

Ask the students to write a short science fiction story about space travel. Tell them to include as many facts as possible. Which planet would they go to? How long would it take to get there? What would they expect to find? Include information like how far away the planet is, or the name of its largest moon. Share the stories with the group.

Want to know more about the planets? Learn the words to the rap song "Planetary Posse", from NASA's Space School Musical
http://discovery.nasa.gov/musical/index.cfml

Activity Mate ials

Solar System Scale Model – Planetary Sizes **Student Handout**

Solar System Scale Model – Planetary Sizes **ANSWER KEY**

Map of National Mall in Washington DC – Washington Monument to the US Capitol

Order from Sun	Planet & Diameter	Kilo-meters	Miles	Food Model	% Rock	% Metal	% Gas/ Liquid	Solar System Location
	Earth	12,756	7,926		55	45		
	Jupiter	142,984	88,846		15		85	
	Mars	6,794	4,222		91	9		
	Mercury	4,880	3,032		58	42		
	Neptune	49,528	30,766		9		91	
	Pluto (dwarf)	2,360	1,466		42		58	
	Saturn	120,536	74,898				100	
	Uranus	51,118	31,764				100	
	Venus	12,104	7,520		61	39		

Order from Sun	Planet & Diameter	Kilo-meters	Miles	Food Model	% Rock	% Metal	% Gas/ Liquid	Solar System Location
3	Earth	12,756	7,926	Green grape	55	45		Inner/rocky
5	Jupiter	142,984	88,846	Cantaloupe	15		85	Outer/gas giant
4	Mars	6,794	4,222	Peppercorn	91	9		Inner/rocky
1	Mercury	4,880	3,032	Peppercorn	58	42		Inner/rocky
8	Neptune	49,528	30,766	Strawberry	9		91	Outer/icy giant
9	Pluto (dwarf)	2,360	1,466	Rice grain	42		58	Kuiper Belt
6	Saturn	120,536	74,898	Grapefruit			100	Outer/gas giant
7	Uranus	51,118	31,764	Small lime			100	Outer/icy giant
2	Venus	12,104	7,520	Blueberry	61	39		Inner/rocky

Map of National Mall in Washington DC – Washington Monument to the US Capitol