Voyage! of Discovery

A Scale Model of the Solar System Activity

This exciting activity is another Challenger Center Learning EdVenture, adapted from a part of the *Voyage!* Project.

The *Voyage!* Project

The *Voyage!* Project is an educational initiative dedicated to fostering a deeper understanding of the Earth's place in the Solar System, and the Sun's place among the stars. Challenger Center for Space Science Education is developing *Voyage!* to celebrate our achievements in the exploration of space, and inspire future generations to continue the journey.

At the heart of *Voyage!* are permanent outdoor exhibitions that depict the sizes and distances between the planets at one 10-billionth (1/10,000,000,000) the Solar System's actual size. The exhibitions' pedestals will display NASA color photographs, touchable model planets and moons, and encourage comparisons to Earth. Challenger Center hopes to place these exhibitions in communities around the nation. Try this activity to get a taste of things to come!

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Voyage! of Discovery Teacher Notes

Objective:
Students will explore the size and distance relationships of the Sun and planets of the Solar System, using a model of the Solar System at one ten-billionth of its actual size.

Time:
Two class periods.

Overview:
This activity has two parts. Part I looks at the sizes of the planets and takes place in the classroom. Students predict the size of Earth and Jupiter and find foods (like different cereal, gum balls, and marshmallows, etc.) that are about the size of each planet. Part II has the class go outside to walk the distances between the planets. Conclude the activity with the discussion questions listed.

National Science Standards

This activity is appropriate to use in Earth and Space Science in conjunction with

- Earth in the Solar System (Grades 5-8)
- Origin and Evolution of the Universe (Grades 9-12)

The National Science Standards considers content to be "Fundamental" if it:

- Represents phenomenon in the natural world.
- Has a rich explanatory power.
- Applies to situations and contexts common to everyday experiences.
- Can be linked to meaningful learning experiences.
- Is developmentally appropriate for students at the grade level specified.

The power of this activity lies in its use of "Unifying Concepts and Processes" [bold added]:

- Evidence, **models**, and explanation
- Change, constancy, and **measurement**

~From the National Science Education Standards by the National Research Council

To paraphrase from Benchmarks for Science Literacy by the American Association for the Advancement of Science:

- Models can be used to represent objects in the real world, so we can think about things that are too vast or too small, at a size we can handle.

Student Worksheet Answer Key:

1. D 2. Jupiter 3. B 4. Mars, Mercury, & Pluto
5. Jupiter, Uranus, Saturn, Neptune

Modeling the Size of the Planets

Mercury & Mars - Poppy Seeds
Venus & Earth - Mustard Seeds
Jupiter & Saturn - Mini Marshmallows or 1-cent gum balls, Kix, or Crunchberries
Uranus & Neptune - Popcorn Seeds or Dried Peas
Pluto - a piece of ground black pepper

6. Answers will vary.
7. Answers listed on the Teacher Question Card.
8 & 9. Answers will vary.
10. The picture at the top of the next page is a quick reference that shows the correct proportions. Using a millimeter as a pace will require students' drawings to be 3 pages long.

Key Concepts:

- Scales and models are ways to understand very large distances and sizes.
- One of the processes of science and learning is to make a prediction and test it.
- The inner planets include: Mercury, Venus, Earth, and Mars.
- The outer planets include: Jupiter, Saturn, Uranus, Neptune, and Pluto.
- The Solar System is mostly empty space.
- One of the major challenges of exploring our Solar System is the enormous distances and time such exploration takes.

Distance-Size Relationship

- The inner planets are closer together and smaller compared to the outer planets. Pluto is the exception size-wise.
- The sizes of the planets are very small compared to the distances between them.

Activity Preparation:

Part I: Exploring the Planets

- Gather materials on the Student Worksheet.
- Make copies of the Student Worksheets.
- Do NOT hand out Model Planet Cards until teams finish the first Student Worksheet.
- Prepare a master set of Model Planet Cards using correct foods under #5 of the Answer Key.

Part II: Walking the Model Solar System

- Find an area outside to walk 600 paces (600 meters or 0.4 miles) in a straight line.

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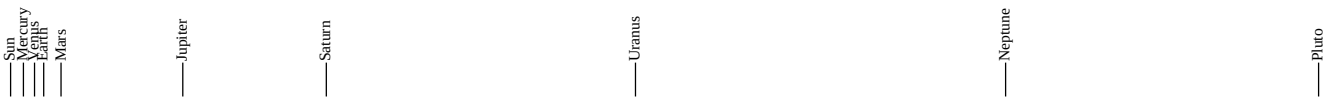

Remember: The planets never actually all line up on one side of the Sun.

Procedures

Part I: Exploring Planet Sizes

Location: classroom

1. Discuss Earth, the Solar System, and why we need models to help study them. Here is a riddle you can use: What is the biggest thing you have ever touched? Depending on where you touch it, it can be wet or dry, hot or cold, and everybody you know has touched it too. What is it?

   Earth is the biggest thing we have ever touched, but Earth is not the biggest planet in the Solar System. We cannot just look up in the sky and see the whole Solar System, and how it works. It is too big, and the planets are too far away.

   Models let us take objects that are vast—bigger than we can understand—and bring them down to a size that we can examine.

2. Explain the activity and show them the model Sun—the balloon blown up to 14 cm. (5.5 in.). Based on the size of the model Sun, students will work in teams of 4 or 5 to answer questions in Part I of the Student Worksheet.

   Instruct students to work as a team. Each group will need students to assume one of these roles:
   - Leader - keeps the group on task.
   - Materials specialist - collects items on the Materials List.
   - Recorder - writes down group answers.
   - Reporter - speaks for the team.

3. Discuss students predictions and give them the answers.

4. Pass out the Model Planet Cards. Have each team glue the cereals, marshmallow, etc. to match the size of the planet.

5. Discuss the answers to questions in Part I. Go around the room, having each team's reporter give reasons why they picked each object to use for a given planet.

6. Using the correct foods, prepare a Master set of Model Planet Cards to use in Part II. Let the glue dry and cut up cards for the walk.

Part II: Walking Planet Distances

Location: outside

1. Before taking the class outside, introduce the "pace" as the "ruler" for this model. A pace is two steps—one with each foot. One pace is about one meter.

2. Have each team predict how far away the Earth card should be from the model Sun, using paces or meters.

3. Take your class outside to walk the model length of the Solar System. Take the cut-up master Model Planet Cards you made in Part I with you outside.

4. For each planet choose a different student to be the official "pace setter" and select a "planet bearer" to fasten the planet at the correct distances. Don't forget the Teacher Question & Answer Card.

5. Fasten the Sun to the ground , tell the class the number of paces to Mercury, and have students complete the chart on their worksheets. "Walk" to Mercury, fasten the Mercury Planet Card to the ground, and repeat the process for all planets.

6. Be sure to ask students questions while walking the distances between the model planets to keep their attention focused.

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7. Back in the classroom, conclude the activity with the questions below.

Discussion Questions:

1. Were your predictions for the size of Earth and Jupiter right?
2. Were your predictions for the distance of the model Earth right?
3. What is the difference between the sizes of the inner and outer planets?
   Inner planets are small (and rocky) and most of the outer planets are much bigger (and made of gases). Pluto is the exception size-wise.
4. What conclusions can you draw about the relative distances of the inner and outer planets?
   The outer planets are much bigger and farther apart than the inner planets.
5. Why is Pluto difficult to classify as either an inner or outer planet?
   Pluto is small like the inner planets but is farther away than the outer planets.
6. What did you learn about the distances of the planets in the Solar System?
   The Solar System is mostly empty space with huge distances between the planets. Even walking a model one 10-billionth of the size of the Solar System is bigger than I thought.

*Cut out the **Card** to take walking the Model Solar System.*

Further Challenges:

1. Light from the real Sun takes 43 minutes to reach the real Jupiter. Time how long it takes to walk between the models of the Sun and Jupiter. How much faster are you traveling than the scaled speed of light? *An average walking speed is 1 meter (1 pace) per second. At that speed, students would take 78 seconds (1.3 minutes) to travel between the model Sun and the model Jupiter. That is 30 times faster than the scaled speed of light.*

$$\frac{\text{light travel time}}{\text{student's walking time}} = \frac{43 \text{ minutes}}{1.3 \text{ minutes}} \approx 30$$

2. Do you think humans will ever go to Mars? Other planets? *If humans go to another planet, it would be to Mars because Mars is the planet most like Earth. We are close to having the technology to go.*
3. Research the relationship between the distances of the planets and the length of each planet's year. *A year on a planet is how long a planet takes to complete one orbit of the Sun. The length of a year of an inner planets is shorter than that of an outer planet. This is due in part to the shorter distances around an inner orbit (think of the inner lanes of a running track) and to the fact that the inner planets move faster in their orbits than the outer planets.*

Teacher Question & Answer Card

For each planet, announce the number of paces it is away from the last planet and ask the class how many total paces or meters away the planet is from the Sun.

Model Distances Chart

Walking from:	Paces (or meters) between models	Total distance from model Sun to each planet
Sun to Mercury	6 meters	6 meters
Mercury toVenus	5 meters	11 meters
Venus to Earth	4 meters	15 meters
Earth to Mars	8 meters	23 meters
Mars to Jupiter	55 meters	78 meters
Jupiter to Saturn	65 meters	143 meters
Saturn to Uranus	144 meters	287 meters
Uranus to Neptune	163 meters	450 meters
Neptune to Pluto	142 meters	592 meters

WARNING: *The planets never actually all line up to one side of the Sun. They orbit the Sun on different paths at different speeds.* So interplanetary distances are actually GREATER than what we are walking. *Also some planets orbit in different planes.*

Inner Planet Questions

- Did the position of Mercury surprise you?
- How would the real Sun look on the real Mars compared to how we see the Sun from Earth? *Smaller and dimmer.*
- Compare the sizes of the inner and outer planets. *Inner planets are generally much smaller than the outer planets.*

Outer Planet Questions

- How have we learned so much about the planets? *Telescopes & spacecraft.*
- How fast do you think a spacecraft would travel on this model? *In our model Solar System, a spacecraft would move an average of 3 cm (1 in.) every 5 hours.*
- How do distances challenge spacecraft? *Communication over vast distances, energy supply required for many years, equipment withstanding extreme cold, etc.*
- How do these distances limit human space exploration? *Astronauts would be away from Earth for years. Need to grow food on board, have enough fuel, etc.*
- How would the real Sun look on the real Mercury vs the real Pluto? *Bigger and brighter from Mercury.*
- If we placed the model Sun in Washington DC, how far away would the model of the next star, Proxima Centauri go? *Over 4,000 km, just off the Pacific Coast near San Francisco.*

Voyage of Discovery Student Worksheet

Name_____ Date_____

Class_____

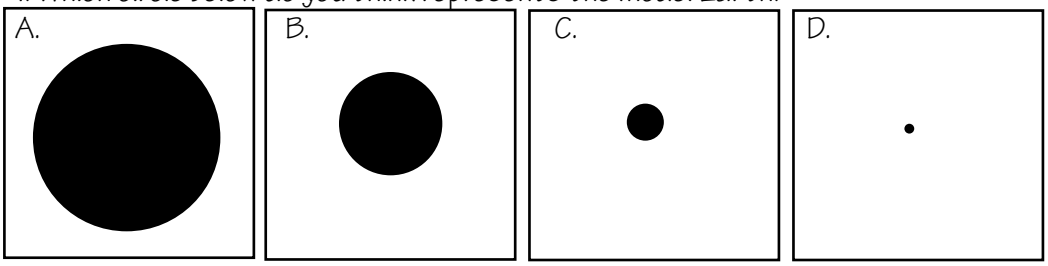
Part I: Exploring Planet Sizes

As a team decide who will take each of the following roles. Read through this page and discuss what must be done.

- Leader - keeps the group on task
- Materials specialist - collects items on the Materials List.
- Recorder - writes down group answers
- Reporter - speaks for the team

Blow the balloon to 15 centimeters in diameter. This balloon is a model Sun that is approximately ten-billionth (10,000,000,000) the size of the real Sun. The questions below show planets that use the balloon as the scale model for the Sun.

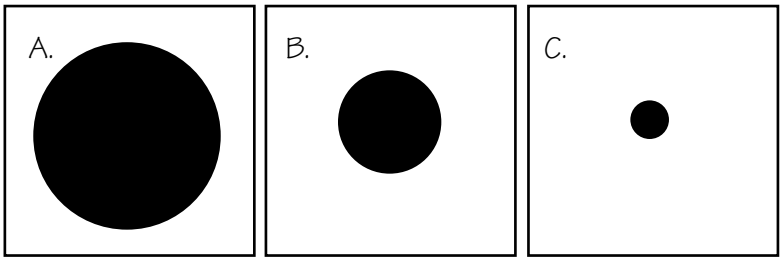
1. Which circle below do you think represents the model Earth.



2. What planet is the biggest? Circle one.

Earth Jupiter Mars Mercury Neptune Pluto Saturn Uranus Venus

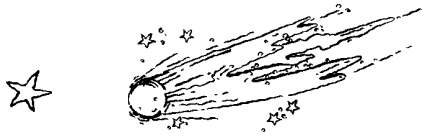
3. Which circle below do you think represents the biggest planet.



STOP HERE! Check your answers with your teacher and get a copy of the Model Planet Cards.

Voyage of Discovery Student Worksheet

4. Look at the Model Planet Cards below. What are the three smallest planets?



5. What are the four largest planets? These are called the gas giants.

Match the items on the Materials List to the size of the planets on the cards and glue them on the right cards.

Materials List:

- A metric ruler
- Mini-marshmallows
- Poppy seeds
- Mustard seeds
- Kix cereal and Crunchberries
- Popcorn kernels
- Dried peas
- 1-cent gum balls
- Black Pepper
- Glue

Mercury	Venus	Earth
Mars	Jupiter	Saturn
Uranus	Neptune	Pluto

Voyage of Discovery Student Worksheet

Part II: Walking the Model Solar System

Materials List

- This worksheet
- Round yellow balloon
- Pins or Masking tape
- Master set of Model Planet Cards
- Pencil
- Hard writing surface to take outside

6. Find your model Sun and model Earth. How far do you think the model Earth should be from the model Sun? State your answers in meters.

7. Walk the distances between the planets outside with your class and complete the chart below with your teacher's help.

Walking from:	Paces (or meters) between models	Total distance from model Sun to each planet(m)
Sun to Mercury		
Mercury to Venus		
Venus to Earth		
Earth to Mars		
Mars to Jupiter		
Jupiter to Saturn		
Saturn to Uranus		
Uranus to Neptune		
Neptune to Pluto		

WARNING: *The planets never actually all line up to one side of the Sun. They orbit the Sun on different paths at different speeds. Some planets orbit in different planes.*

8. What were you surprised to learn about the size of the planets?

9. What were you surprised to learn about the distances between the planets?

10. Draw and label a picture of your model Solar System that shows the distances of the planets on a sheet of paper. (You will need more than one.) Use a millimeter as your "ruler" instead of a "pace."

Add the following to your picture:

- a scale of 1 mm = 1 model meter = 10 billion real meters
- a note saying, "The sizes of the planets are NOT drawn to scale."
- a note saying, "Remember: The planets never actually line up on one side of the Sun."

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