

## VOYAGE OF DISCOVERY

### Background

This activity has two parts. The 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 requires the class to go outside to walk the distances between the planets. Conclude the activity with the discussion questions listed at the end of the Teachers Page.

### 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.
- The sizes of the planets are very small compared to the distances between them.

### Objective

Upon completion of this activity, students will be able to:

- explore the size and distance relationships of the Sun and planets
- use a model of the Solar System at one ten-billionth of its actual size.

### Instructional Time

90 minutes

### Materials (Part 1)

Metric ruler  
Balloon  
Miniature marshmallows  
Poppy seeds  
Mustard seeds  
Kix cereal and Crunchberries  
Popcorn kernels  
Dried peas  
1-cent gum balls  
Black Pepper  
Glue

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### Procedure (Part 1)

1. Gather materials
2. Make copies of the Student Worksheet.
3. Make copies of the Model Planet Cards.
4. Prepare a set of master Model Planet Cards (for use in Part 2).
5. Discuss Earth, the Solar System, and why we need models to help study them.
  - Here is a riddle you can use:  
Q) What's 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?  
A) Earth is the biggest thing we've every 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.
6. Explain the activity and show them the model Sun – the balloon blown up to 14 cm (5.5 in.).
7. Assign students to work in teams of four or five to answer questions in Part I of the Student Worksheet.
8. Instruct students to work as a team. Each group will need students to assume one of these roles:
  - the *leader* keeps the group on task.
  - the *material specialist* collects items on the Materials List.
  - the *recorder* writes down group answers.
  - the *reporter* speaks for the team.
9. Discuss students' predictions and give them the answers.
10. Pass out the Model Planet Cards. Direct each team to glue the cereal, marshmallows, etc. to match the size of each planet.
11. 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.

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### Procedure (Part 2)

1. Find an area outside to walk 600 paces (600 meters or 0.4 miles) in a more or less straight line.
2. If the ground is soft, use pins to fasten the model planet cards; otherwise, use tape. 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.
3. Have each team predict how far away the Earth card should be from the model Sun – using paces or meters.
4. 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 and a copy of page 23.
5. 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.
6. Fasten the sun to the ground. Tell the class the number of paces to Mercury, and tell students to complete the chart on their worksheets. “Walk” to Mercury, fasten the Mercury Planet Card to the ground, and repeat the process for all planets.
7. Ask the students questions while walking the distances between the model planets (see next page), otherwise students’ attention may wander while walking the longer distances between the outer planets.
8. Back in the classroom, conclude the activity with the questions below.

### Discussion Questions: (to use after returning to the classroom.)

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 out 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 an 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 the size of the Solar System is bigger than I thought.*

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### Model Distances Chart & Questions to Ask While Walking

Walking from:	Paces (or meters) between models:	Total distance from model Sun to each Planet
Sun to Mercury	6 meters	6 meters
Mercury to Venus	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 from 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 and 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, have enough fuel, etc.*
- How would the real Sun look when viewed from the real Mercury vs. from the real Pluto? *Bigger and brighter from Mercury.*
- If we placed the model Sun in Washington D.C., 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.*

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### Part 1 Student Worksheet Answer Key

1. D
2. Jupiter
3. B
4. Mars, Mercury, and Pluto
5. Jupiter, Uranus, Saturn, Neptune
6. These are the suggestions for foods to use on the Model Planet Cards:
  - Mercury and Mars—poppy seeds
  - Jupiter and Saturn—minature marshmallows, 1-cent gum balls, Kix, or Crunchberries
  - Pluto—a piece of black pepper
  - Venus and Earth—mustard seeds
  - Uranus and Neptune—popcorn seeds or dried peas

### Part 2 Student Worksheet Answer Key

7. Answers will vary.
8. Answers listed on Model Distance Chart.
9. Answers will vary.
10. Answers will vary.
11. Using a millimeter as a pace will require students' drawings of the model to be three pages long.

### Extensions

1. Light from the real Sun takes 43 minutes to reach the real planet 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 33 times faster than the scaled speed of light.*
2. Do you think humans will ever go to Mars? To 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 the planet takes to complete one orbit of the Sun. The length of a year of an inner planet is shorter than that of an outer planet. This is due in part to the shorter distance 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 orbit than the outer planets do.*

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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.
- **Material Specialist**—collects items on the Materials List.
- **Recorder**—writes down group answers.
- **Reporter**—speaks for the team.

### Materials List

Metric ruler

Balloon

Miniature marshmallows

Poppy seeds

Mustard seeds

Kix cereal and Crunchberries

Popcorn kernels

Dried peas

1-cent gum balls

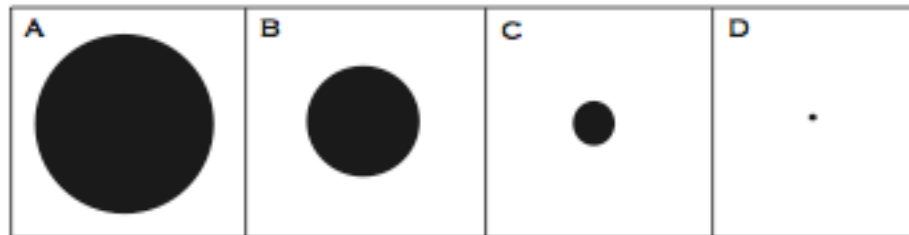
Black Pepper

Glue

### Part 1: Exploring the Planet Sizes

Directions. Blow the balloon to 15 centimeters in diameter. This balloon is a model Sun that is approximately one 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. Predict which circle below you think represents the model Earth, if the balloon is the model Sun.



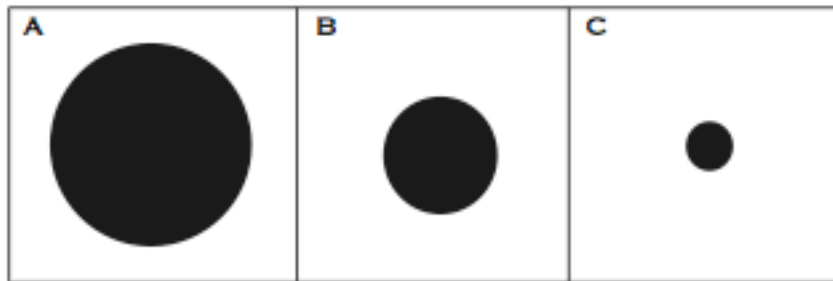
2. Which planet is the biggest? (Circle One)

Earth    Jupiter    Mars    Mercury    Neptune    Saturn    Uranus    Venus

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



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

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

6. Using the items on the Materials List, match them to the size of the planets on the cards, and glue them to the right card.

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

8. Walk the distances between the planets 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
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		

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*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.*

9. What were you surprised to learn about the size of the planets?
  
  
  
  
  
  
  
  
  
  
10. What were you surprised to learn about the distances between the planets?
  
  
  
  
  
  
  
  
  
  
11. 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  $1\text{mm} = 1\text{ model meter} = 10\text{ billion real meters}$
  - 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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## Model Planet Cards

