OMSI
Everyday Encounters with Science

Kendall Planetarium

Perfect Little Planet

Planetarium Show – Teacher's Guide

PROGRAM OUTLINE

***Description**:* Imagine the ultimate space vacation! Discover our Solar System through a new set of eyes – a family from another star system seeking the perfect vacation spot. Fly over the surface of Pluto, our best known Dwarf Planet. Dive over the ice cliffs of Miranda, a moon of Uranus. Sail through the rings of Saturn. Feel the lightning storms of Jupiter. And walk on the surface of Mars. Which destination would you choose?.

Activities: Modeling the planets' sizes; modeling distances in the Solar System; scaling the Solar System with toilet paper; seasons: the effect of the Earth's tilt and the Sun's rays; Planet Bingo; measuring the diameter of the Sun and the Moon; simulating Jupiter's motion.

LEARNING OBJECTIVES

- Planets are different sizes. *Understand the relative sizes of planets and the fact that the gas giant planets are much larger than the terrestrial planets.*
- The planets in our Solar System are arranged at different distances from each other. *Learn how the Sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, and Uranus are spread out within the Solar System.*
- The seasons on Earth are caused by the tilt of our planet's axis. *Learn how the Sun's light shines more directly or less directly on planets depending on if the planet is tilted toward or away from the Sun.*
- The Sun is much larger than all of the planets. *Measure the diameter of the Sun and compare this value to the diameter of the Earth.*
- Different constellations are visible at different times of the year, because of the Earth's motion around the Sun. *Demonstrate how our view of the stars changes throughout the year.*

Process Skills Focus: Inquiry, observation and communication.

Topics: The Solar System, planets, seasons, constellations.

OREGON STANDARDS

Scientific Inquiry Standards:

- K.3S.1 Explore questions about living and non-living things and events in the natural world.
- K.3S.2 Make observations about the natural world.
- 1.3S.2 Record observations with pictures, numbers, or written statements.
- 1.3S.3 Describe why recording accurate observations is important in science.
- 2.3S.2 Make predictions about living and non-living things and events in the environment based on observed patterns.

Engineering Design Standards:

- 1.4D.3 Show how tools are used to complete tasks every day.
- 2.4D.3 Describe an engineering design that is used to solve a problem or address a need.

Earth and Space Science Content Standards:

- K.2E.1 Identify changes in things seen in the sky.
- H.2E.3 Describe how the universe, galaxies, stars, and planets evolve over time.

Physical Science Content Standards:

- K.2P.1 Examine the different ways things move.

NEXT GENERATION SCIENCE STANDARDS

Practices

2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
7. Engaging in argument from evidence

Crosscutting Concepts

1. Patterns
2. Cause and effect
4. Systems and system models

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a	✓		n/a		✓	✓	
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design								

DCI Grade Band Endpoints

ESS1.A *Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (By end of grade 2).*

The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (By end of grade 5).

Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (By end of grade 8).

Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (By end of grade 8).

ESS1.B *Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (By end of grade 2).*

The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause *observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (By end of grade 5).*

The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (By end of grade 8).

This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (By end of grade 8).

Performance Expectations

1-ESS1-1.	*Use observations of the sun, moon, and stars to describe patterns that can be predicted.*
1-ESS1-2.	*Make observations at different times of year to relate the amount of daylight to the time of year.*
5-ESS1-1.	*Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.*
5-ESS1-2.	*Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.*
MS-ESS1-1.	*Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.*
MS-ESS1-2.	*Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.*
MS-ESS1-3.	*Analyze and interpret data to determine scale properties of objects in the solar system.*

GLOSSARY

Asteroid: Small rocky or metallic bodies in the Solar System.

Asteroid Belt: The region between Mars and Jupiter containing numerous rocky asteroids.

Dwarf planet: A classification of a minor body which is neither a planet nor a satellite of a planet (i.e., a moon). Dwarf planets in our Solar System include Pluto and Ceres, where Ceres is located in the asteroid belt.

Eccentricity: A measure of how much an object's orbit differs from a perfect circle. An eccentricity of 0 means that the orbit is circular while a larger eccentricity indicates that the orbit is non-circular. Bodies in our Solar System have eccentricities varying from 0.007 (Venus) to 0.248 (Pluto).

Equinox: Two specific times of the year when the path of the Sun intersects the celestial equator. At these times, the tilt of the Earth's axis is neither away from nor toward the Sun. The vernal (spring) equinox is around March 20th and the autumnal equinox is around September 22nd.

Moon: A satellite orbiting a planet.

Orbit: **(noun)** The path of a body through space. **(verb)** The action of moving through space.

Period of Revolution: The time that it takes for a body to revolve around another object. The Earth's period of revolution around the Sun is approximately 365 days.

Planet: A body orbiting a star. Planets must be massive enough to be roughly spherical in shape but not massive enough to undergo thermonuclear fusion in their cores like a star.

Retrograde: The apparent backwards motion of a body. Planets can show retrograde motion relative to one another: as seen from Earth, Jupiter briefly appears to move backwards relative to the background stars when Earth overtakes Jupiter in its orbit around the Sun.

Rotation Period: The time that it takes for a body to rotate on its axis. The Earth has a rotation period of roughly 24 hours.

Solar System: The arrangement of eight planets orbiting around the Sun. The asteroid belt between Mars and Jupiter is also part of the Solar System.

Solstice: Two specific times of the year when the path of the Sun is at its highest or lowest point relative to the celestial equator. At these times, the tilt of the Earth's axis is oriented the most steeply toward or away from the Sun. The summer solstice is around June 21^{st} and the winter solstice is around December 21^{st}.

Sun: Our nearest star, located approximately 93 million miles from Earth.

Zodiac constellation: One of 12 constellations that the Sun appears to pass through during the course of the year: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces.

POST-VISIT QUIZ

Check your comprehension of the planetarium show!

1) **What are the three types of planets in the Solar System?**

2) **Is it possible to land a space ship on a gas giant planet? Why or why not?**

3) **Which planet is tipped over on its side as it orbits the Sun?**

4) **Saturn's rings are actually lots of little moons made of ___________, ___________, and ____________.**

5) **Choose the true statement:**
    a. **Jupiter has more than 60 moons.**
    b. **Jupiter has fewer than 60 moons.**

6) **The Great Red Spot on Jupiter is a giant ______________________.**

7) **Olympus Mons is the name of an enormous volcano on the planet ____________.**

8) **Where is frozen water found on Mars's surface?**

9) **Why is Venus the hottest planet in the Solar System?**

10) **Because Mercury has been hit by many asteroids, there are lots of ____________ visible on its surface.**

11) **What two planets in the Solar System have no moons?**

SUGGESTED CLASSROOM ACTIVITIES

Model the Planets' Relative Sizes

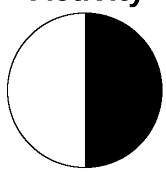
Description: In this activity, students become familiar with the relative sizes of the planets in the Solar System.

TIME REQUIRED

Advance Preparation

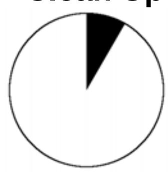
5 minutes

Activity



30 minutes

Clean Up



5 minutes

SUPPLIES

- Construction paper
- Rulers
- Scissors
- Compasses to draw circles (one for each student or group)
- Tape

ACTIVITY

- Students should work in groups. Measure, draw, and cut construction paper circles of appropriate diameters to demonstrate the general appearances and relative sizes of each planet. Display the model planets in the classroom. They may be able to be hung from the ceiling or taped to the walls. Be sure students understand that, while the relative sizes of the planets are to scale, the distances between the planets will not be.

- The paper should be cut to the following sizes, depending on the planet. Paper colors are also suggested.

Object	Paper Diameter	Paper Color
Sun	109”	Yellow
Mercury	½”	Gray
Venus	1”	Yellow
Earth	1”	Blue
Earth’s moon	¼”	White
Mars	½”	Red
Jupiter	11”	Tan
Saturn	9”	Tan
Uranus	4”	Green
Neptune	4”	Neptune
Pluto	¼”	Gray

This activity can be expanded for older students to include the moons of the planets. Have the students determine the scaling factor for the model by finding the actual diameters of the planets and comparing that with the diameters in the model. After looking up the actual diameters for the moons of the other planets, they can calculate the model size for each moon using the equation below.

$$\frac{\text{(planet's model size)}}{\text{(planet's actual size)}} = \frac{\text{(moon's model size)}}{\text{(moon's actual size)}}$$

Modeling Distance in the Solar System

Description: These two activities present complementary ways of discussing the distances between planets in the Solar System. The first activity requires a large outdoor space (1030 yards) while the second activity can be accomplished in less space (37 yards).

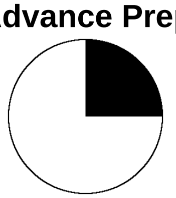
The first activity, "**The Thousand and Thirty-Yard Solar System**," requires a large area but is preferable to the second activity as it allows students to compare the sizes of the planets to the space between them and better demonstrates the hugeness of space. The second activity, "**Scaling the Solar System with Toilet Paper**," has the advantage of requiring less room. On its scale, however, the planets would be tiny. This means that this activity doesn't allow students to easily visualize the sizes of the planets relative to each other or to the space between them. It has been included as a second-choice activity in case the amount of space needed for **"The Thousand and Thirty-Yard Solar System"** is impossible to find.

In both activities, Pluto is included as a planet. Even though Pluto is technically classified as a dwarf planet, we have included it here to emphasize the enormous distances between bodies in the Solar System.

The Thousand and Thirty-Yard Solar System

TIME REQUIRED

Advance Preparation

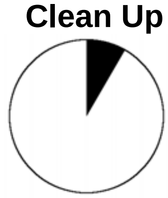


15 minutes

Activity

60 minutes

Clean Up



5 minutes

SUPPLIES

- 10 index cards

- Tape

Objects to represent the Sun and the planets:

- Sun – any ball, diameter 8 inches (a standard bowling ball is about 8 inches across. Inflatable balls of about the right size are also fairly easy to find).
- Mercury – a pinhead, diameter 0.03 inch
- Venus – a peppercorn, diameter 0.08 inch
- Earth – a second peppercorn
- Mars – a second pinhead
- Jupiter – a chestnut or a pecan, diameter 0.90 inch
- Saturn – a hazelnut or an acorn, diameter 0.70 inch
- Uranus – a peanut or coffee bean, diameter 0.30 inch
- Neptune – a second peanut or coffee bean
- Pluto – a third pinhead

Note:
Using distinct objects, such as peanuts and pins, is helpful because students associate sizes with the objects. This method helps them remember the relative sizes of the planets and their tiny size relative to the space around them.

ADVANCE PREPARATION

- Stick each pin through an index card; this technique makes the pins easier to see. Tape the other objects to index cards. Label each card appropriately. This helps keep the planets straight and makes the items harder to lose.

ACTIVITY

- Place all the objects on a table. Let the students examine them and have the students place the planets in the correct order (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto) next to the Sun.

- Once the objects are in the correct order, ask the students how much space they think you will need to make a model of the solar system using these objects. Young students may guess that the tabletop will be enough. Older students may guess the length of the room or the hallway will suffice.

- Introduce the idea of scale. You can take this discussion to various levels depending on the age of your students. For young students, a common example of scaling is probably sufficient. Here is one you can use: if an automobile is 5 meters (500 cm) long and your model car is 10 cm long, then the scaling factor is 500 cm ÷ 10 cm = 50.

- Point out that in our model the tiny peppercorn represents the entire Earth that we live on! In the real Solar System, the Earth is 8,000 miles in diameter. In our model, the peppercorn is about 8/100 of an inch in diameter. *So, in our model, 1 inch represents 100,000 miles.* The distance between the Earth and the Sun is 93,000,000 miles, or 930 inches in our model. That's about 26 yards, or 26 steps for an adult human. To emphasize how far this is try to take 26 paces across the room. You will probably hit the opposite wall! To complete your model, it will be necessary to go outside.

- Calculate the scaled distances between each planet, using the real distance to each planet and the conversion factor of 1 inch = 100,000 miles in our model. The values are listed below.

Planet	**Real distance from the Sun (miles)**	**Model distance from the Sun (yards)**
Mercury	36,000,000	10
Venus	67,000,000	19
Earth	93,000,000	26
Mars	142,000,000	39
Jupiter	483,000,000	134
Saturn	885,000,000	246
Uranus	1,787,000,000	496
Neptune	2,800,000,000	778
Pluto	3,700,000,000	1028

- Hand one planet to each group of students and go outside to the beginning of the 1,030 yard route you have chosen.

- Start by placing the Sun ball on the ground. Walk 10 yards (about 10 steps) and have the student holding the pinpoint labeled Mercury set the planet down. It's another 9 paces to Venus and another 7 to Earth. When you get to Earth, turn around and look back at the Sun and the other planets. The distance and tiny size of the planets might seem astonishing! The Sun warms the tiny peppercorn Earth from this far away. We can see Venus when it is "near" the setting Sun on our horizon. And yet there is so much space between the Sun and these inner planets.

- Continue on your journey, placing each planet on the ground when you come to the appropriate distance. You may need to place rocks on the cards to keep them from blowing away.

- If the distances between the Sun and the terrestrial planets don't surprise students, the distance to the gas giants should. From Mars to Jupiter you must walk 95 yards; that's more than two times further than you've walked so far!

- When you finish the activity, you will have walked over half a mile. (One mile is 1,760 yards.) Now, look back now towards the Sun. You can't see it. You won't even be able to see it with binoculars! Now look down at the pinhead that is Pluto. You may begin to feel the enormous size of our solar system.

- Turn your class around and retrace your steps. Re-counting the paces between the planets gives them a chance to learn them and looking for the little objects reemphasizes how lost they are in space.

- Have the student who retrieves each planet write on the card a brief description of where it was - "At 9th Street," "In front of the public library", etc. When you get back to the classroom, you can hang the objects on the wall or from the ceiling to remind the students of their journey.

Scaling the Solar System with Toilet Paper

TIME REQUIRED

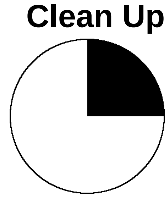
Advance Preparation

5 minutes

Activity

30 minutes

Clean Up



15 minutes

SUPPLIES

- 10 index cards
- Two rolls of 500-sheet toilet paper

ADVANCE PREPARATION

- Write the name of the Sun and the nine planets on the index cards, one object per card.

ACTIVITY

- Spread the index cards on a table and have the students arrange them in the correct order (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto).

- If you want to include learning about each planet in this lesson, see if the students can tell you something about each planet. If they can't, help them out. Here are examples of what you might tell them:

Mercury is a barren rock. It orbits the Sun in just 88 days. The side facing the Sun can reach temperatures around 700 degrees Fahrenheit, while the side away from the Sun has temperatures of about -330 degrees Fahrenheit.

Venus has thick clouds of sulfur that trap the Sun's heat and make it the hottest planet in the Solar System. It also rotates in the opposite direction as most of the other planets. Of all the planets, only Mercury and Venus do not have moons.

Earth is our home and is the only planet we know of (so far) in the whole universe that has life. About 70 percent of Earth is covered in oceans.

Mars is a red planet with very little atmosphere. It is a cold desert with a volcano the size of Oregon and a canyon that would stretch across the entire United States. It has ice caps at its poles.

Jupiter is the largest planet and the first of the Gas Giants. It is home to the Great Red Spot, a storm that is so large that the four terrestrial planets could fit inside. Jupiter also has the most moons of any planet (more than 60!).

Saturn is the second largest planet. It has bright rings of rock and dust around it. These rings can be seen through a telescope from Earth. Saturn is also the least dense of the planets. If you could make a cup of hot chocolate large enough to put Saturn in, Saturn would float like a marshmallow!

Uranus orbits the Sun tipped over on its side and rotates backwards. Like Saturn, it has rings made of particles ranging from 10 meters in diameter to tiny pieces of dust. However, unlike Saturn, Uranus's rings are dark and very difficult to see.

Neptune has the fastest winds of any planet in the Solar System. The winds of this gas giant can reach 1,200 miles per hour.

Pluto is a small and cold dwarf planet. Like Uranus, Pluto orbits on its side.

- The distance between the Sun and the Earth is 93 million (93,000,000) miles. In our model, we will represent this distance with 0.93 meters of toilet paper. *So, in this model, 1 meter = 100,000,000 miles.*

- Have your students calculate the scaled distances from the Sun to each planet, using the conversion that 100,000,000 miles of actual distance is equal to 1 meter in the model. You could also have them calculate the diameters of the Sun and planets on this scale. (They will be very small! Only the Sun would be wider than 1 cm in diameter. Jupiter, the largest planet, would only be 0.8 cm across). The values are listed below.

Planet	**Real distance from the Sun (miles)**	**Model distance from the Sun (number of toilet paper sheets)**
Mercury	36,000,000	3.6
Venus	67,000,000	6.7
Earth	93,000,000	9.3
Mars	142,000,000	14.2
Jupiter	483,000,000	48.3
Saturn	885,000,000	88.5
Uranus	1,787,000,000	178.7
Neptune	2,800,000,000	280.0
Pluto	3,700,000,000	369.9

- Take the toilet paper rolls and the index cards to the beginning of a route 37 meters long (37 meters is roughly the length of 370 sheets of toilet paper, the distance between the Sun and Pluto). Place the index card Sun on the ground. Unroll the toilet paper, laying the index cards with the appropriate planet names on it at the appropriate distances from the Sun.

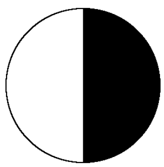
- After building the model, remind students that the planets, even the gas giants, would be smaller than a centimeter on this scale. Have the students compare the distances between the planets and reflect on how far away each is from the Sun.

Planet Bingo

Description: This activity summarizes the properties of different planets in a fun, interactive manner.

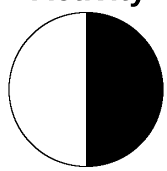
TIME REQUIRED

Advance Preparation



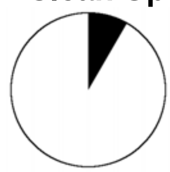
30 minutes

Activity



30 minutes

Clean Up



5 minutes

SUPPLIES

- Bingo card for each student
- 15 or more bingo markers (squares of construction paper, for example) for each student
- Bingo calling cards

ADVANCE PREPARATION

- Prepare a bingo card for each student. Each bingo card should list four or five planets and four or five general characteristics, such as distance from the Sun, size, surface, temperature, atmosphere, composition, and special features. The characteristics of the planets are listed below. Don't forget that each bingo card should be different.

ACTIVITY

- Each student should have a bingo card and at least 15 bingo markers.

- Begin by drawing a calling card from your pile. Call out the planet name first and then the feature. Allow students time to place the marker on the planet-feature combination if they have it on their card. Then, set the calling card aside. Placing the calling cards in piles by planet simplifies the process of checking a player's "Bingo" at the end of the game.

- Continue drawing until a student has a "Bingo." A player has a "Bingo" when he/she has filled in a row, column, or diagonal completely.

Categories	Mercury	Venus	Earth	Mars
Mean Distance from Sun (millions of kilometers	57.9	108.2	149.6	227.9
Period of Revolution	88 days	224.7 days	365.3 days	687 days
Equatorial Diameter (kilometers)	4,880	12,100	12,756	6,794
Atmosphere (Main Components)	Virtually None	Carbon Dioxide	Nitrogen Oxygen	Carbon Dioxide
Moons	0	0	1	2
Rings	0	0	0	0
Orbit Inclination	7˚	3.4˚	0˚	1.9˚
Eccentricity of Orbit	.206	.007	.017	.093
Rotation Period	59 days	243 days Retrograde	23 hours 56 min.	24 hours 37 min
Inclination of Axis	Near 0˚	177.2˚	23˚27'	25˚12'

Categories	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance from Sun (millions of kilometers	778.3	1,427	2,871	4,497	5,914
Period of Revolution	11.86 years	29.46 years	84 years	165 years	248 years
Equatorial Diameter (kilometers)	143,000	120,000	51,800	49,528	~2,330
Atmosphere (Main Components)	Hydrogen Helium	Hydrogen Helium	Helium Hydrogen Methane	Hydrogen Helium Methane	Methane
Moons	67	31	27	13	3
Rings	3	1,000+	11	4	0
Orbit Inclination	1.3˚	2.5˚	0.8˚	1.8˚	17.1˚
Eccentricity of Orbit	.048	.056	.046	.009	.248
Rotation Period	9 hours 55 min.	10 hours 40 min.	17.2 hours Retrograde	16 hours 7 min.	6 days 9 hours 18 min. Retrograde
Inclination of Axis	3˚5’	26˚44’	97˚55’	28˚48’	120˚

RESOURCES

NASA Education
http://www.nasa.gov/offices/education/about/index.html

Monthly Skymaps
http://www.skymaps.com/

Kinesthetic Astronomy
http://www.spacescience.org/education/extra/kinesthetic_astronomy/download.html