The Planets

Teacher's Guide

KENDALL
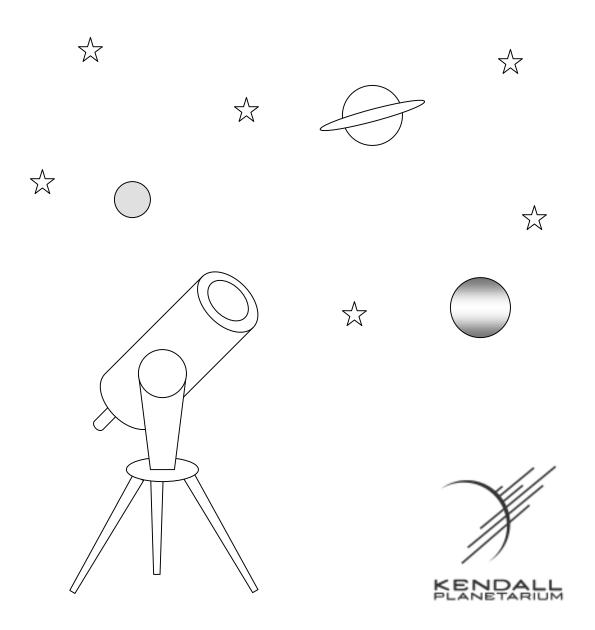PLANETARIUM

The Planets show synopsis

The Planets introduces audiences to the nine planets in our solar system. Sitting in the planetarium, visitors are whisked to the surfaces of each planet and can look in all directions to view what we know or imagine each to look like. As visitors enjoy the view, the narrator informs them of the planets' features and interesting characteristics. Between Mars and Jupiter, the narrator also pauses to supply audiences with information about the asteroids.

Before Your Visit activity suggestions

SOLAR SYSTEM: Model of the planets' relative sizes

This activity gives students an idea of the relative sizes of the planets. They will see how much larger the gas giants are to the terrestrial planets and will be able to compare all the planets to the Sun.

Familiarize students with the solar system. If they don't know it already, teach them to order of the planets. The saying "**M**y **V**ery **E**ducated **M**other **J**ust **S**howed **U**s **N**ine **P**lanets is useful in remembering the order (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto). Help the students build the following model of the planets.

Supplies needed:
    Construction paper
    Rulers
    Compasses to draw circles
        (one for each student or group if possible)
    Scissors
    Tape, and possibly string

Directions:

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. To demonstrate the relative distances between the planets, see the next two activities.

Before Your Visit activity suggestions

Below are color suggestions and the appropriate sizes for each planet:

Sun: yellow – 109 1/8"
Mercury: gray – 3/8"
Venus: yellow –15/16"
Earth: blue – 1"   Moon: white – ¼"
Mars: red – 17/32"
Jupiter: tan – 11 3/16"
Saturn & Rings: tan – 21 5/8",   Saturn only: 9 13/32"
Uranus: green –4"
Neptune: blue – 3 13/16"
Pluto: gray – 15/64"

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 and add the moons to the model.

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

MODELLING DISTANCE IN THE SOLAR SYSTEM: Two options

Students often think of the solar system as being composed of huge bodies without much space between them. The **following two activities** are designed to correct this view and to demonstrate the enormous size of our solar system, in which empty space, not planets, dominates.

The first activity, "**The Thousand and Thirty-Yard Solar System**," requires a large area (1030 yards) 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.

SOLAR SYSTEM MODEL 1: The Thousand and Thirty-Yard Solar System
(Model of the planets' relative sizes and distances)

To complete this activity, you will need to be able to go outside and walk 1,030 yards in somewhat of a straight line. Going perfectly straight isn't absolutely necessary; you can double back on yourself or go in a circle if needed. While walking this far may seem like a time consuming activity, the comprehension that students (and possibly you, yourself) will gain about the size of our solar system is well worth it.

You can compliment this activity with lessons or activities about the planets. (Some basic features of each planet are included as a part of Solar System Model 2.)

Supplies:
9 index cards
Tape
<u>Objects to represent the Sun and planets</u>:

    Sun – any ball, diameter 8 inches
        A standard bowling ball is about 8 in. 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 (or smaller item, since Pluto is the smallest planet)

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

Before Your Visit activity suggestions

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

Begin by placing all the objects on a table. Have the students examine them and place the planets in order. If they have trouble, the saying, "**M**y **V**ery **E**ducated **M**other **J**ust **S**howed **U**s **N**ine **P**lanets" can help them remember the order. (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto).

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.

To answer this question, you need to 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 or 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. The Sun is 8 hundred thousand miles wide and our ball in the model is about 8 inches wide. This means that in our model 1 inch represents 100,000 miles.

This means that 1 yard (36 inches) represents 3,600,000 miles. Take a pace. You have just crossed approximately three million six hundred thousand miles in our model. The distance between the Earth and the Sun is 93,000,000 miles. This is 26 yards in our model. To emphasize how far this is try to take 26 paces across the room. You will probably hit the opposite wall after about 15. To complete your model, it will be necessary to go outside.

If there's time before you go outside, have older students calculate the scaled distances between the planets. Below is the scale used for this model:

	Real	Model
Earth's diameter	8,000 miles	8/100 inch
Sun's diameter	800,000 miles	8 inches
Therefore	100,000 miles	1 inch
And	3,600,000 miles	36 inches or 1 yard

Before Your Visit activity suggestions

Entrust each planet to a student 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 paces (about 10 yards) 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 theses 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!

The average distances from the Sun to each planet and between the planets, both real and scaled (rounded to nearest yard), are in the table below:

Distance to:	From Sun		From previous planet	
	Real (miles)	Model (yards)	Real (miles)	Model (yards)
Mercury	36,000,000	10		
Venus	67,000,000	19	31,000,000	9
Earth	93,000,000	26	26,000,000	7
Mars	142,000,000	39	49,000,000	13
Jupiter	483,000,000	134	341,000,000	95
Saturn	885,000,000	246	402,000,000	112
Uranus	1,787,000,000	496	902,000,000	250
Neptune	2,800,000,000	778	1,013,000,000	282
Pluto	3,699,000,000	1028	899,000,000	250

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.

Before Your Visit activity suggestions

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"… 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.

SOLAR SYSTEM MODEL 2: Scaling the Solar System with Toilet Paper

For this activity you need a distance of about 37 meters, which is about the length of 4 football fields.

Supplies:
10 Index cards
2 rolls of 500 sheet toilet paper

Write the name of the Sun and the nine planets on the index cards (one object per card). Spread the index cards out on the table and have students arrange them in the correct order. If they need help, the saying, "**M**y **V**ery **E**ducated **M**other **J**ust **S**howed **U**s **N**ine **P**lanets" can help them remember the planets' order out from the Sun. (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto).

If you want to include learning about each planet in this lesson, see if students can tell you something about each one. If they can't, help them out. Here are examples of the things 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 Utah and a canyon that would stretch across the entire United States. It has ice caps at its poles.

Before Your Visit activity suggestions

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. (We know of sixty moons that orbit Jupiter.)

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 it, 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 from10 meters in diameter to tiny piece 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 mi/hr.

Pluto is the smallest, coldest planet in the solar system. It is the only one that hasn't yet been visited by a spacecraft. Most of the time Pluto is the ninth planet, however, due to the eccentricity of its orbit it sometimes comes inside the orbit of Neptune. It is closer to the Sun than Neptune for 20 years out of its 249-year orbit. Like Uranus, Pluto orbits with its poles almost in the orbital plane.

After the students have placed the planets in order and have identified some features of each, discuss the idea of scale. You can take the discussion to varying depths depending on the age of the 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 between them is 500 cm ÷ 10 cm or 50.

The scaling factor for this toilet paper model is below:

	Real	Model
Sun-Earth distance	93,000,000 mi	0.93 meters
Therefore	100,000,000 mi	1 meter

If the students are old enough and there is time, have them calculate the scaled distances from the Sun to each planet. 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.)

Take the toilet paper rolls and the index cards to the beginning of your 37 meters. 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.

Below is a table with the real and scaled distances:

Distance to:	From Sun		From previous planet	
	Real (miles)	Model (# of TP sheets)	Real (miles)	Model (# of TP sheets)
Mercury	36,000,000	3.6		
Venus	67,000,000	6.7	31,000,000	3.1
Earth	93,000,000	9.3	26,000,000	2.6
Mars	142,000,000	14.2	49,000,000	4.9
Jupiter	483,000,000	48.3	341,000,000	34.1
Saturn	885,000,000	88.5	402,000,000	40.2
Uranus	1,787,000,000	178.7	902,000,000	90.2
Neptune	2,800,000,000	280.0	1,013,000,000	101.3
Pluto	3,699,000,000	369.9	899,000,000	89.9
Total Distance Needed		**37 meters**		

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

THE SEASONS: The Effect of the Earth's tilt

The Sun has huge effects on the Earth, and other planets, as we orbit around it. One of these is effects is seasons. The reason for the seasons is something students, and adults, often have trouble understanding and remembering. (The Harvard-Smithsonian Center for Astrophysics produced a documentary, called "A Private Universe," showcasing peoples' notions concerning the reasons for the seasons. The film demonstrates that academics of all ages, ranging from middle school to college students and professors at Harvard, can have trouble correctly explaining why we have seasons.) Hopefully this activity, combined with other ways of reviewing and reinforcing, will help students understand and remember why we have seasons.

Another goal of this activity when working with older students is to build their reasoning skills. This activity walks students through a logical way to think about the seasons. The ability to use logic to arrive at the correct conclusion to a

problem is a valuable skill in science and demonstrates a greater understanding of the concepts.

<u>Supplies</u>:
Small lamp without a shade
Small Styrofoam balls (one for each student)
Pencils (one for each student)
Markers
Dark room (such as your classroom with the lights off)
Star cutout (optional)

Give each student a Styrofoam ball. This represents the Earth. Each student should do the following:

Draw a circle around the center of the ball. This is the Equator. Mark an "X" for his/her approximate location on the globe. Poke a pencil into the bottom of the ball. This will be the axis of rotation.

Place the lamp in the middle of the room on a table. This is the Sun. First, have the students hold their globes with the north and south axes straight up and down at about the same height as the lamp. Each student should be a few feet from the Sun and should do their best not to block the light for other students.
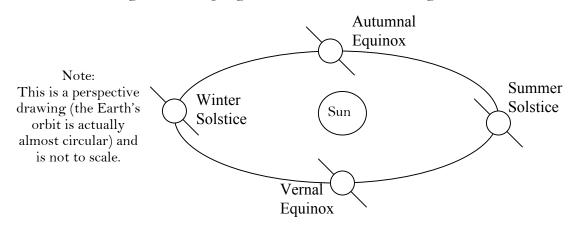
Turn off the lights so that students can clearly see the light and shadow on their globes. They should notice that half of the Earth is dark and half is light. This represents day and night. Have them rotate their globes. See if they can reason out which way to rotate the globe. If they have trouble, ask them where the Sun rises. See if they can turn the globe in the correct direction to make the Sun rise in the East from the perspective of a person standing on its surface. (Looking down on the North Pole, the Earth should rotate counterclockwise.)

Now the students should move in a circle counterclockwise around the Sun, stopping at various points and rotating their globe. What do they observe about the lengths of the days? They should notice that they are all the same length. Hopefully, when they notice this they will realize that there is something wrong with the model, because our days on Earth are not equal lengths all year long. If they don't, you can lead them in that direction until they make that conclusion.

To make the days different lengths, the Earth must be tilted on its axis. In fact, the Earth is tilted at an angle of 23.5 degrees from the upright position. Students should tilt their globes about 23 degrees. Each student should keep the axis of

his/her globe tilted and walk around the Sun as they did before. The North Pole should always point to the same spot in the room as they circle the Sun. You can hang a star cutout on the wall to symbolize Polaris, the North Star, so students can easily see where their axes should point, or you can simply choose an object in the room to represent the North Star.

The students should stop at least at the following locations around the Sun and rotate their globes, keeping the axes at the same angle.

Autumnal
Equinox

Note:
This is a perspective
drawing (the Earth's
orbit is actually
almost circular) and
is not to scale.

Winter
Solstice

Sun

Summer
Solstice

Vernal
Equinox

These four points represent the summer and winter solstices, and the vernal and autumnal equinoxes.

Notice how the length of the days changes from season to season. Also, notice the angle of the Sun's rays on each hemisphere at each season. During half of the year, the Northern Hemisphere is pointed more directly toward the Sun. During this time, the days are more than 12 hours long. This is the spring and summer. For the other half of the year, the North Pole is tilted away from the Sun. The days in the Northern Hemisphere are shorter, the nights are longer, and the sunlight falls indirectly, or at an angle less than 90 degrees, on this hemisphere. This is fall and winter for the Northern Hemisphere. Halfway between summer and winter, during the spring and fall, the Sun's rays fall directly on the Equator. These are the spring and autumnal equinoxes, dates when the day and night are of equal length in both hemispheres. In the Southern Hemisphere the seasons are the opposite. This can be easily seen in this model.

At the end of the activity, students should be able to tell you that we have seasons because of the Earth's tilt on its axis. The axis always points in the same direction in the sky (toward the North Star). As the Earth goes around the Sun, this tilt causes the changing seasons. The days are longer in the summer and shorter in the winter. The sunlight falls more directly on the Northern Hemisphere during

its summer. Both the length of the days and the angle of the sunlight affect the seasons.

If you wish, you can extend the discussion of seasons to the other planets. How would their seasons compare to ours? You will have to look at the angle of each planet's axis and at the length of its orbit to answer this.

THE SEASONS: The angle of the Sun's rays

This activity demonstrates how the angle that the sunlight hits a location on Earth affects the temperature there. As shown in the previous activity, the Northern Hemisphere is tilted toward the Sun during the spring and summer. As a result, the Sun's rays fall more directly on that hemisphere during those times. During the fall and winter, the Northern Hemisphere receives indirect light, which is light that comes in at an angle less than 90 degrees.

This activity can be done as a class or in small groups. If done in groups, each group will need the following supplies:

2 small flat boxes
2 thermometers
Sand or dry dirt
4 small blocks or bricks
Sunlight

Fill each box with an equal amount of sand and dirt. Place a thermometer in each box, with the bulb covered by the sand or dirt. Set the boxes in the sunlight. Place one box flat on two blocks so that it is off of the ground. This will keep the ground temperature from affecting the box's temperature. The sunlight should fall at an angle onto this first box. Prop the second box up so that the sunlight falls directly (at right angles) onto the dirt inside it. The other two blocks may come in handy here.

Leave the boxes in the sun for about 15 minutes. Then come back and check the temperatures. Notice that when the Sun's rays fall on the dirt at an angle, such as in the winter, the temperature is lower than when the light strikes at a right angle, as in the summer. This is because the Sun's rays are spread out over a larger area when they come in at an angle and, as a result, they don't provide as much heat. Another factor in winter (not demonstrated here) is that, because of the incident angle, the sunlight must pass through more of the Earth's

atmosphere. In the summer, the sunlight falls directly on the dirt and the Sun's energy is more concentrated over a small area. When the Sun is overhead, its light also has fewer miles of atmosphere to pass through.

SOLAR SYSTEM: Planet Bingo

Comparing the features of the planets is a good way for students to remember what they learned about our solar system in *The Planets.* A fun way to make these comparisons is Planet Bingo. Having them make their own bingo cards is an excellent means to reinforce what they learned.

Each card should have four or five planets and four or five general characteristics, such as distance from the Sun, size, surface, temperature, atmosphere, composition, and special features. An example bingo card is included after the rules of the game, as well as a table with basic information about the planets. Be sure all the students are using the same information to make their cards. You will need to make calling cards for each planet so you can call out the bingo combinations.

Another interesting discussion to have, if time, would be how the planets' features might affect the possibility of life on the planets. Also, the bingo activity can be adapted for the moons of the solar system.
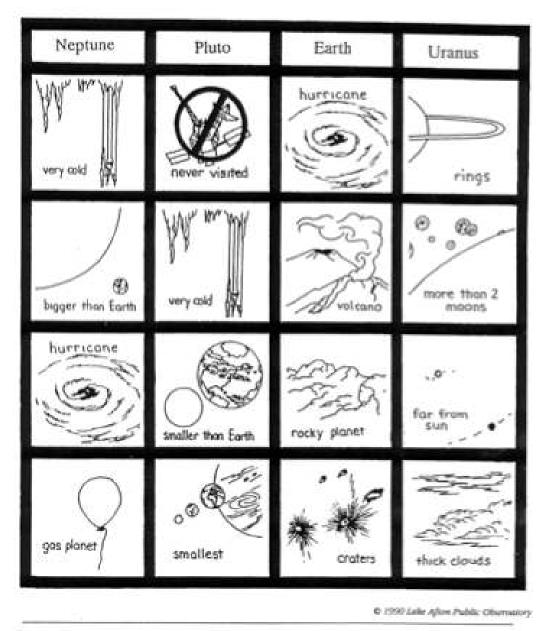
To Play the Game:

Each student should have a bingo card and at least 15 markers (these could be squares of construction paper or plastic chips from a game). Each card should be different.

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 four/five (depending on the number of planets on the cards) features in a row (up and down, across, or diagonal).

Below are a sample bingo card and a chart with some basic information about each planet. There is more information about each planet under the "Distance Model 2: Scaling the Solar System with Toilet Paper" activity.

Back in the Classroom activities to do after the museum visit

Sample Planet Bingo Card

Neptune	Pluto	Earth	Uranus
very cold	never visited	hurricane	rings
bigger than Earth	very cold	volcano	more than 2 moons
hurricane	smaller than Earth	rocky planet	far from sun
gas planet	smallest	craters	thick clouds

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Categories	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance from Sun (millions of kilometers	57.9	108.2	149.6	227.9	778.3	1,427	2,871	4,497	5,914

Period of Revolution	88 days	224.7 days	365.3 days	687 days	11.86 years	29.46 years	84 years	165 years	248 years
Equatorial Diameter (kilometers)	4,880	12,100	12,756	6,794	143,000	120,000	51,800	49,528	~2,330
Atmosphere (Main Components)	Virtually None	Carbon Dioxide	Nitrogen Oxygen	Carbon Dioxide	Hydrogen Helium	Hydrogen Helium	Helium Hydrogen Methane	Hydrogen Helium Methane	Methane + ?
Moons	0	0	1	2	60	31	27	13	3
Rings	0	0	0	0	3	1,000+	11	4	0
Inclination of Orbit Ecliptic	7°	3.4°	0°	1.9°	1.3°	2.5°	0.8°	1.8°	17.1°
Eccentricity of Orbit	.206	.007	.017	.093	.048	.056	.046	.009	.248
Rotation Period	59 days	243 days Retrograde	23 hours 56 min.	24 hours 37 min	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 *	Near 0°	177.2°	23°27'	25°12'	3°5'	26°44'	97°55'	28°48'	120°

*Inclinations greater than 90° imply retrograde rotation.

SIZE OF THE SUN: Measuring the Sun's diameter

The Sun is an enormous ball of gas about 93 million miles from Earth; it is the star of our solar system. This activity uses the Sun's image projected on a card to estimate the diameter of the Sun.

Supplies (for each group of students):
Yardstick
2 white index cards
Tape
Straight pin
Pencil
Window and a sunny day

Make a small pinhole in the center of one card. Tape this card upright to the 1-inch end of the yardstick. In the center of the other card, make two small marks ¼-inch apart. Hold the yardstick so the pinhole card close to the window. Hold the second card about 2 feet away. Adjust the yardstick so that the sunlight falls through the pinhole and makes an image on the second card. Move the second card up and down on the yardstick until the Sun image just fills the ¼-inch space

between the two marks. Record the distance between the cards. (It should be about 27 inches.)

Use the following formula to calculate the Sun's diameter:

Diameter of image of Sun
-------------------------- **x** Distance from Earth to Sun = Diameter of Sun
Distance between cards

You should get something close to 861,112 miles as the diameter of the Sun. The actual diameter is about 864,000 miles.
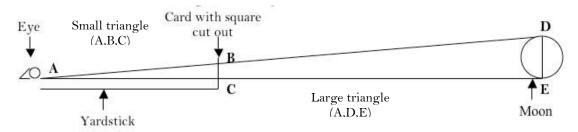
Older students can compare this with the Earth's diameter (about 7,900 miles) and the diameters of the other planets or moons. How many Earths could fit across the Sun? Is the Sun wider than the widths of all the planets combined? The Sun is a sphere. Approximately what is the Sun's volume? How many Earth's could fit inside? How many Jupiters?
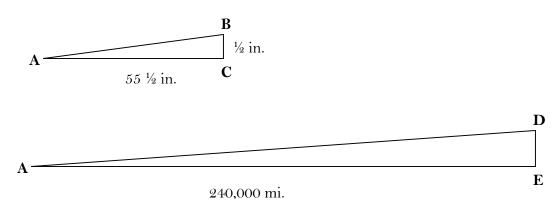
MEASURING THE MOON: Diameter

This activity works well as an at-home extension of the previous activity, "Size of the Sun," or as a stand-alone homework assignment or project.

Supplies:
Yardstick
Index card
Scissors
Ruler
Clear night with full, or near-full moon

Measure and cut a ½-inch-by-½-inch-square in the center of the index card. Tape this card to the one-inch end of the yardstick. Look out the window on a clear night at the full or near-full moon with the card near the window. Move your eye toward and away from the card, along the yardstick, until the diameter of the Moon just fills the square. Make a mark on the yardstick even with your eye. You now have two similar triangles to compare to find the diameter of the Moon.

Back in the Classroom activities to do after the museum visit

The distance between the card and the mark should be about 55 ½ inches and the opening in the card is ½ inch. The distance to the Moon is about 240,000 miles.

Comparing the triangles,

$$\frac{AC}{BC} = \frac{AE}{DE},$$

we get

AC/BC = 55 ½ in. /½ in. = 111
AE/ (AC/BC) = 240,000 mi/111 = 2162 miles

The approximate diameter of the Moon is 2162 miles.

PLANETS IN MOTION: Simulating Jupiter's Motion

The Earth rotates on its axis once in a day and orbits around the Sun once in a year. The other planets are also orbiting the Sun, though each one has a different orbital period. It can be difficult to visualize all these motions at once. This activity should help by focusing on the motion of the planet Jupiter, one of the planets that is clearly visible from Earth for much of the year.

Supplies:

Lamp without lampshade
Large open classroom
A sign for each constellation in the Zodiac (see the Zodiac map on the next page)
Tape

Before your students come into the classroom, hang the Zodiac signs around the room in the order shown on the Zodiac map. This map shows the signs in the same order they appear in the actual sky.

Move the chairs and desks to the edge of the room and place the lamp in the center of the room.
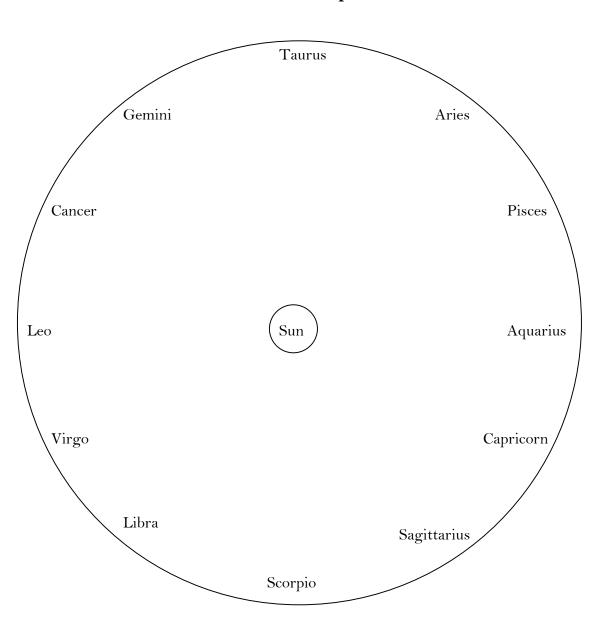
Once the students enter, have them stand in a circle, facing the Sun. Each of them represents the Earth. Have them turn counterclockwise in place to simulate the sunrise and sunset. Have them stand so that it is noon and then midnight. While standing so it is midnight, they should write down the constellation they see.

Next, the students should revolve counterclockwise around the Sun as if six months have passed. What constellation do they see now? Record this.

Now, you will represent Jupiter orbiting the Sun as they each orbit as the Earth. Stand near the wall. Jupiter orbits the Sun slower than the Earth, so you will take one step for every three the students take. The students should write down the constellation in front of which you appear to be are standing.

When you say "go" they should take three steps and you should take one. Have them record your constellation again. Do this until one year on Earth has passed. The students should observe shifts in direction and speed in your motion as they move through one year on Earth.

Back in the Classroom activities to do after the museum visit

Have the students draw a map or graph to show how you appeared to move throughout the year. Are they surprised? How did they expect you to move? How would your path have changed if you were representing Mars instead of Jupiter? What about if they were on Jupiter observing Earth's motion?

Zodiac Map

Taurus

Gemini   Aries

Cancer   Pisces

Leo   Sun   Aquarius

Virgo   Capricorn

Libra   Sagittarius

Scorpio

Back in the Classroom activities to do after the museum visit

PLANET RACE: Calculating orbital speeds

How fast are the planets moving through space? Most of us have no idea. We don't feel ourselves flying through space and yet we are. We orbit the Sun once every year. Even knowing this, most of us have no concept of how fast we have to be going. In this activity, students will calculate just how quickly we, and the other planets, are zooming around the Sun.

Supplies:
Pencils
Paper
Calculators

On an average highway, a car travels about 100 km/hr or about 60 mph. To calculate the speed of each planet, first calculate the number of Earth hours required for each planet to complete one orbit. Calculate the circumference of each orbit and use these two bits of information to calculate the speed.

In the chart below, you will find the radii of the planets' orbits and the number of Earth days needed to complete each orbit.

Planet	Orbital radius (km)	Length of orbit (Earth days)
Mercury	5.79×10^7	88
Venus	1.08×10^8	225
Earth	1.50×10^8	365
Mars	2.28×10^8	687
Jupiter	7.78×10^8	4,333
Saturn	1.43×10^9	10,759
Uranus	2.87×10^9	30,685
Neptune	4.50×10^9	60.189
Pluto	5.90×10^9	90,465

Do you see any patterns in the planets' speeds? How do these speeds compare to the speeds of familiar things such as airplanes or launching spacecraft? A mile is about 1.6 kilometers. Calculate the planets' speeds in mph.

Back in the Classroom activities to do after the museum visit

CRATERS: Size and speed of meteoroids

Several of the planets and many of the moons in the solar system have craters on their surfaces. Earth has very few while the Moon is covered with them. In this activity students will model impact craters and discover the effect of the speed and size of the meteoroid on the size of the crater.

Supplies:
3-4 pounds of white flour
Chocolate milk powder (about one container)
Newspaper
1 shallow basin that will hold about 3-5 inches of flour
Three rocks with diameters about ¼ inch, ¾ inch, and 1½ inches

Vocabulary:
meteoroid: rock or dust in space
meteor: rock or dust that enters the Earth's atmosphere
meteorite: rock from space that hits Earth's surface

First discuss what impact craters are. Ask students why we have so few craters on Earth and why there are so many on the Moon. Explain that when small meteors pass through the Earth's atmosphere, they "rub" against the air and burn up. Most small meteors don't make it to the Earth's surface. There is no atmosphere on the Moon, so the meteoroids are free to hit the surface. Also, Earth has active plate tectonics so craters that were formed millions or even billions of years ago on our planet have long since been covered up. The Moon no longer has tectonic activity. The craters that were formed long ago are still visible on the Moon's face.

Now your class will investigate how the size and speed of a meteor affects the size of the crater it makes. Pour 3-5 inches of flour into the basin. This flour represents the surface of the Moon. The rocks represent meteoroids of different sizes. Sprinkling chocolate powder on the surface of the flour makes the craters easier to see by creating contrast.

First you will investigate how the size of the rock affects the crater. Drop each of the three rocks from shoulder level. Measure the diameter of the craters each forms and record these. Repeat the experiment several times for a consistent result. Have each student record each rock size and the diameters of the craters each creates.

Back in the Classroom activities to do after the museum visit

For the next experiment you will see how the speed of the falling rocks affects the size of the crater. Choose one rock and drop it from knee level, waist level, and shoulder height. Be sure students know that falling objects speed up as they fall so that the higher the rock is when it falls, the faster it hits the ground. Record the heights from which the rock is dropped and the diameters of the craters. Repeat several times.

Now have the students look back at their data. What patterns do they see? How does size affect the size of the crater? What about speed? They should see that the larger and faster a meteor is, the larger the crater it creates upon impact. Scientists estimate that actual meteor impacts are about twenty times the diameter of the meteor itself.

RESEARCH IDEAS: A chance to learn more

Research projects can help deepen students' understanding of the topics in *The Planets*. Below are a few ideas for topics of papers, presentations, or other projects:

- Formation of the Sun and solar system
- Satellites and Telescopes for observing objects in the solar system, past, present, future. Some past/present missions include SOHO (Sun), Pathfinder (Mars), Galileo (Jupiter), Mariner flyby missions (Mercury, Venus).
- Aurora borealis (Northern lights)
- Space weather & the effect of solar activity on Earth
- Eclipses
- Possibility of life in the solar system
- Moons of the planets
- Debate: whether or not Pluto is a planet
- Comets
- Craters on the Moon
- Craters on Earth, history of meteor impacts on Earth
- What meteorites tell us about the solar system
- Volcanic activity and plate tectonics on planets and moons
- Search for and discovery of planets around other stars (called exoplanets)
- Humans in space
- History of knowledge of the solar system

Additional Resources

http://www.omsi.edu
OMSI's homepage is a gateway to science resources and information about the museum and local science activities.

Some examples of useful OMSI web pages are below:

http://www.omsi.edu/explore/resources.cfm
This OMSI website has a plethora of useful science links for teachers and students.

http://www.omsi.edu/teachers/resources
This is OMSI's website especially for teachers to link them with more OMSI science resources.

http://www.omsi.edu/visit/planetarium
This is the homepage for the Kendall Planetarium at OMSI.

http://www.nasa.gov
NASA's homepage. On NASA's web pages, one can find a vast amount of information. Some example sites are below:
http://www.nasa.gov/worldbook/sun_worldbook.html, and
http://solarscience.msfc.nasa.gov are some NASA pages focused on the Sun.
http://solarsystem.jpl.nasa.gov/planets is about the planets and **http://mars.jpl.nasa.gov/** is about the exploration of Mars.
http://imagine.gsfc.nasa.gov/index.html is NASA's Imagine the Universe page, intended for students ages 14 and up.

http://sohowww.nascom.nasa.gov
This is the website for the Solar and Heliospheric Observatory project being carried out by NASA and ESA.

http://www.spaceweather.com
This site tracks sunspots and offers up-to-date information about the Sun's activity and its affect on the Earth. It also has many photographs of the Sun and links to more information about the Sun, asteroids, and comets.

http://antwrp.gsfc.nasa.gov/apod/astropix.html
Astronomy Picture of the Day. This site displays one astronomy-related picture per day. Searching the site's archives provides a plethora of pictures of the Sun and the planets.

http://www.astronomyonline.org
This site is connected with the San Mateo Astronomical Society and the Astronomical Society of the Pacific and has astronomy information on a variety of subjects.

http://www.windows.ucar.edu
"Windows to the Universe" is an astronomy resource for students and teachers created by the University Corporation for Atmospheric Research (UCAR) covering many topics.

http://www.sciencedaily.com
Science Daily is an online science news page.

Additional Resources

Oregon Science Standards covered in space show or activities

Each planet it our solar system is different. There are terrestrial and gaseous planets. Some planets have active plate tectonics and volcanoes, while others are no longer active. The atmospheres and compositions of the planets also vary.

The Sun is the star of our solar system and greatly affects the conditions on each planet. For example, the Sun affects the weather and seasons on Earth, plays a vital part in our water cycle, and allows life to survive on our planet. Understanding the features of our Earth can help in making comparisons with other planets.

Also, the Sun's gravity affects the motions of all the planets. The extent of the Sun's effect depends on the distance to the planet. We can see several of the planets from Earth and can detect these varying motions.

Related Oregon Science Standards:

Earth and Space Science:

CCG: The Dynamic Earth: Understand changes occurring within the lithosphere, hydrosphere, and atmosphere of the Earth.

Third Grade:
- Identify daily and seasonal weather changes.

Fifth Grade:
- Describe patterns of seasonal weather.
- Identify causes of Earth surface changes.

Eighth Grade:
- Explain the water cycle and its relationship to weather and climatic patterns.
- Describe Earth's structure and how it changes over time.

CIM:
- Analyze the relationship between global energy transfer and climate.
- Analyze evidence of ongoing evolution of the Earth system.

CCG: The Earth in Space: Understand the Earth's place in the solar system and the universe.

Third Grade:
- Identify and trace the movement of objects in the sky.

Fifth Grade:
- Describe the Earth's place in the solar system and the patterns of movement of objects within the solar system using pictorial models.

Eighth Grade:
- Explain the relationship of the Earth's motion to the day, season, year, phases of the moon, and eclipses.

CIM:
- Explain how mass and distance affects the interaction between Earth and other objects in space.

Each planet has a different composition and matter exists naturally on the planets in three forms: solid, liquid, and gas. Through processes that cause temperature or pressure changes on or inside the planets, the matter can change states.

Related Oregon Science Standards:

Physical Science:

Additional Resources

<u>CCG: Matter:</u> Understand structure and properties of matter.
- *Third Grade:*
  - Describe objects according to their physical properties.
- *Fifth Grade:*
  - Identify substances as they exist in different states of matter.

<u>CCG: Matter:</u> Understand chemical and physical changes.
- *Third Grade:*
  - Describe changes that occur in matter.
- *Fifth Grade:*
  - Describe the ability of matter to change states by heating and cooling.
- *CIM:*
  - Analyze the effects of various factors on physical changes and chemical reactions.

Gravity rules in much of the universe, keeping stars and other celestial bodies together and causing these bodies to orbit each other.
Related Oregon Science Standards:

<u>CCG: Force</u>: Understand fundamental forces, their forms, and their affects on motion.
- *Fifth Grade:*
  - Identify examples of magnetism and gravity exerting force on an object.
- *Eighth Grade:*
  - Explain interactions between force and matter and relationships among force, mass, and motion.
  - Recognize that every object exerts gravitational force on every other object.
- *CIM:*
  - Recognize that gravity is a universal force.

Two activities, "The Seasons: The angle of the Sun's rays" and "Craters: Size and speed of meteoroids," can be structured, and elaborated as needed, to include the scientific method as the format for the investigations.
Related Oregon Science Standards:

Scientific Inquiry

<u>CCG: Forming the Question/Hypothesis:</u> Formulate and express scientific questions or hypotheses to be investigated.
- *Third Grade, Fifth Grade:*
  - Make observations. Based on these observations, ask questions or form hypotheses, which can be explored through simple investigations.
- *Eighth Grade, CIM:*
  - Based on observations and scientific concepts, ask questions or form hypotheses which can be explored through simple investigations.

<u>CCG: Designing the Investigation:</u> Design safe and ethical scientific investigations to address questions or hypotheses.
- *Third Grade:*
  - Plan a simple investigation.
- *Fifth Grade:*
  - Design a simple scientific investigation to answer questions or test hypothesis.
- *Eighth Grade:*
  - Design a scientific investigation to answer questions or test hypothesis.

Additional Resources

CIM:
- Design a scientific investigation that provides sufficient data to answer a question or test a hypothesis.

CCG: Collecting and Presenting Data: Conduct procedures to collect, organize, and display scientific data.

Third Grade:
- Collect data from an investigation.

Fifth Grade:
- Collect, organize, and summarize data from investigations.

Eighth Grade:
- Collect, organize, and display sufficient data to support analysis

CIM:
- Collect, organize, and display sufficient data to facilitate scientific analysis and interpretation.

CCG: Analyzing Data and Interpreting Results: Analyze scientific information to develop and present conclusions.

Third Grade:
- Use the data collected from an investigation to explain the results.

Fifth Grade:
- Summarize, analyze, and interpret data from investigations.

Eighth Grade:
- Summarize and analyze data including possible sources of error. Explain results and offer reasonable and accurate interpretations and implications.

CIM:
- Summarize and analyze data, evaluating sources of error or bias. Propose explanations that are supported by data and knowledge of scientific terminology.

References

Science for Kids: 39 Easy Astronomy Experiments. Robert W. Wood. TAB Books. 1991.

Rainy Day Astronomy. Diane Tesmer. Ancient Eyes Productions. 1992.

Additional Resources

For Further Information on the
ASTRONOMICAL SOCIETY OF THE PACIFIC

OMSI would like to extend a sincere thank you to the ASP for their contributions to this Teacher's Guide. Their extensive work in preparing the Project ASTRO publication list below titled, *The Universe at Your Fingertips,* is a wonderful accomplishment for astronomy education in America.

The Universe at Your Fingertips: An Astronomy Activity and Resource Notebook is published by the Astronomical Society of the Pacific and was supported by a grant from the National Science Foundation. This comprehensive and ready-to-use collection of classroom activities, teaching ideas, and annotated resource lists is a result of Project ASTRO, an innovative program to form partnerships between teachers and astronomers. It features more than 90 classroom-tested, hands-on activities for teaching many aspects of astronomy, and dozens of resource sheets listing readings, software, organizations, and national projects for astronomy education.

The ASP can be reached at 415-337-1100. The Society's mail order catalog number is 1-800-335-2624. Their address is:
Astronomical Society of the Pacific
390 Ashton Avenue
San Francisco, CA 94112

Website: www.astrosociety.org

The Universe in the Classroom is a free classroom resource for grades 3-12. It is an online newsletter on teaching astronomy in primary and secondary schools and is being offered by the four leading professional astronomy societies in North America. Designed to help teachers, curriculum specialists, and librarians include more astronomy in their classroom work, the newsletter is produced by the non-profit Astronomical Society of the Pacific and is co-sponsored by the American Astronomical Society, the Canadian Astronomical Society, and the International Planetarium Society.

To sign up to receive email notification of new issues as they are posted, teachers or school librarians should go to the following website:

http://www.astrosociety.org/education/publications/tnl/tnl.html

KENDALL PLANETARIUM
Oregon Museum of Science and Industry

Since opening in 1968, OMSI's planetarium, alternately called the Kendall Planetarium and Murdock Sky Theater, has served hundreds of thousands of visitors. Over the years, it has evolved from a facility for teaching only basic astronomy to a modern, multipurpose theater. Shows presented in the planetarium are dynamic and motivational, while providing our visitors with the current knowledge about the universe in which we live.

OMSI's Harry C. Kendall Planetarium is the largest and most technologically advanced planetarium in the Pacific Northwest. The 52-foot domed theater seats 200 and features educational astronomy shows with state-of-the-art visuals and special effects using the latest multimedia technology, Digistar 3.

Digistar 3 is an all-digital system that combines star projection, full-motion color video, digital surround sound, and the ability to interact with the audience. Anything that can be placed on a computer monitor can be shown in the planetarium, so viewers are able to zoom into any area of the sky, orbit the Sun, visit planets, or fly through asteroids. Digistar 3 provides the most authentic view available of the night sky from Earth, along with a complete view of our solar neighborhood and real data representing the state of the universe, as we know it today. The system includes a library of real-time 3D astronomy models (planets, moons, comets, asteroids, and deep space objects), as well as a library of full-dome video astronomy sequences, to create a more realistic and exciting planetarium experience.

The Kendall Planetarium is the only major public planetarium in Oregon and Washington and is the regional site for astronomy activities and education. It is the largest planetarium theater between Vancouver, B.C. and San Francisco, and as far East as Boise. School groups from all around Oregon and SW Washington come to OMSI's planetarium for one-of-a-kind educational experiences.

The Harry C. Kendall Planetarium offers a variety of educational and entertaining multimedia presentations on astronomy, space science, and laser programs. The planetarium is not only a place to learn about the sky, but also a place to experience a unique environment that blends art, science, fantasy and fun.

OMSI Kendall Planetarium Information Line: (503) 797-4610

OMSI Laser Light Hotline: (503) 797-4646

www.omsi.edu

NASA Regional Teacher Resource Center
Oregon Museum of Science and Industry

Supplement your curriculum with the latest in aerospace information and educational materials from OMSI's NASA Regional Teacher Resource Center! NASA's educational materials provide a springboard for classroom discussions in life science, physical science, astronomy, energy, Earth resources, the environment, mathematics, and career education.

Developed in cooperation with NASA Central Operation of Resource for Educator (CORE), Teacher Resource Centers are located at each of the NASA Field Centers and Selected museums and universities throughout the U.S. Through CORE's distribution network, the public has access to more than 180 videocassettes, slides, filmstrips, and computer programs.

Materials are produced by NASA and other private and government agencies. Educators can preview audiovisual materials at the center prior to placing orders through CORE. Resources **include lesson plans, NASA publications, videotapes, 35mm slide sets, cassettes, computer software, books, and CDs.**

NASA Homepage:
www.nasa.gov

NASA CORE
Lorain County JVS-CORE
15181 Route 58 South
Oberlin, OH 44074

Tel: (440) 775-1400
Fax: (440) 775-1460
E-mail: nasa_order@leeca.org
Website:
http://education.nasa.gov/edprograms/core

NASA Ames Research Center
http://education.arc.nasa.gov/

HOURS OF OPERATION

Thursdays 3:00 – 5:00 (except holidays)
To make an appointment at another time, please email teachers@omsi.edu.

To Visit

Admission is FREE to the NRTRC. Check in at OMSI's Membership Window. The Center is located in OMSI's Science Education Resource Center (SERC).

For more information
or to be on our professional email list and stay updated on teacher education, email teachers@omsi.edu.

Additional Resources

THE ROSE CITY ASTRONOMERS

Some people will promise you the universe…

…we deliver

Welcome to the Rose City Astronomers (RCA)! We are a Portland-area astronomy club devoted to promoting the enjoyment and understanding of astronomy. Club members participate in a number of formal and informal club functions, activities, star parties, and special interest groups.

In addition, the RCA coordinates with The Oregon Museum of Science and Industry (OMSI) in supporting educational activities such as public star parties, telescope making workshops, Astronomy Day, and other celestial events and gatherings.

The RCA is a member of the National Astronomical League, and with over 400 members throughout Oregon and Southwestern Washington, we are the largest amateur club in the Pacific Northwest. Everyone is welcome to our club meetings and star parties.

Our monthly meetings are held at OMSI on the third Monday of every month. An informal social gathering time starts around 7:00 PM. The actual business meeting and announcements start at 7:30, followed by an astronomy or science-related presentation. The formal part of the meeting concludes about 9:00 PM.

You can visit our web page at: http://www.rca-omsi.org
Our information line is: 503-255-2016.