JOURNEY through the UNIVERSE

Voyage: A Journey through our Solar System

Grades 3-4

Lesson 2: Designing a Scale Model of the Solar System

On a visit to the National Mall in Washington, DC, one can see monuments of a nation—Memorials to Lincoln, Jefferson, and WWII, the Vietnam Veterans Memorial Wall, and Washington Monument. Standing among them is *Voyage*—a one to 10-billion scale model of our Solar System—spanning 2,000 feet from the National Air and Space Museum to the Smithsonian Castle. *Voyage* provides visitors a powerful understanding of what we know about Earth's place in space and celebrates our ability to know it. It reveals the true nature of humanity's existence—six billion souls occupying a tiny, fragile, beautiful world in a vast space.

Voyage is an exhibition that speaks to all humanity. Replicas of *Voyage* are therefore available for permanent installation in communities worldwide (http://voyagesolarsystem.org.)

This lesson is one of many grade K-12 lessons developed to bring the *Voyage* experience to classrooms across the nation through the *Journey through the Universe* program. *Journey through the Universe* takes entire communities to the space frontier (http://journeythroughtheuniverse.org.)

Voyage and *Journey through the Universe* are programs of the National Center for Earth and Space Science Education (http://ncesse.org). The exhibition on the National Mall was developed by Challenger Center for Space Science Education, the Smithsonian Institution, and NASA.

Lesson 2: Designing a Scale Model of the Solar System

Lesson at a Glance

Lesson Overview

Students conduct research on the planets, with emphasis on patterns and cycles, and gain an appreciation for the variation in length of year, length of day, and seasonal variation across the Solar System. To explore whether the patterns and cycles on the planets are related to planetary position in the Solar System, students create posters that can be used to mark the locations of the planets within a *Voyage* model of the Solar System.

Lesson Duration

One 45-minute class

Core Education Standards

National Science Education Standards

Standard D2: Objects in the sky

- The Sun, Moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.

AAAS Benchmarks for Science Literacy

Benchmark 4A4:

- The earth is one of several planets that orbit the sun, and the moon orbits around the earth.

Benchmark 9C6:

- Scale drawings show shapes and compare locations of things very different in size.

Benchmark 11B2:

- Geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and oral and written descriptions can be used to represent objects, events, and processes in the real world.

Related Education Standards

AAAS Benchmarks for Science Literacy
Benchmark 9C3:
- Graphical display of quantities may make it possible to spot patterns that are not otherwise obvious, such as cycles and trends.

Benchmark 11D2:
- Finding out what the largest and the smallest values of something are is often as informative as knowing what the usual value is.

Essential Question
- What can we learn from designing a scale model of the Solar System?

Concepts
Students will learn the following concepts:
- Earth is one of several planets that orbit the Sun.
- The Earth is the third planet from the Sun.
- Each planet has a unique set of characteristics.

Objectives
Students will be able to do the following:
- Using the *Voyage* scale model and planetary data from other resources, make a poster of the Sun and planets, identifying their scale distances from the Sun.
- Identify unique characteristics of Earth, especially regarding its location in relation to the Sun.

Science Overview

The Planets

Eight major planets orbit the Sun. They fall into two main categories:

- The inner planets, which are also called "terrestrial" ("like Earth") or rocky planets, are small and have a dense, solid core and surface, which we could stand on. These planets are Mercury, Venus, Earth, and Mars.
- The outer planets, which are also called the "Jovian" ("like Jupiter") planets or gas giants, are large and have extensive atmospheres. Trying to stand on their visible surfaces would be like trying to stand on a cloud. This applies to Jupiter, Saturn, Uranus, and Neptune.

Pluto is a special case. It used to be called the ninth planet, but after the discovery of several objects similar to Pluto further out in the Solar System—the largest of which is larger than Pluto—the International Astronomical Union decided in 2006 that Pluto belongs to a new class of objects called dwarf planets, and is not an actual planet. Pluto is included in the discussion of planets here as an example of this new class of objects. It is small, like the terrestrial planets, but unlike them, is made of a mixture of ice and rock.

The Voyage Model

Voyage is a 1 to 10-billion scale model of the Solar System that was permanently installed in Washington, DC, in October 2001. The real Solar System is exactly 10 billion times larger than the *Voyage* model. On this scale the Sun is about the size of a large grapefruit. The Earth is 15 meters (50 feet) away and smaller than the head of a pin. The entire orbit of the Moon fits comfortably in the palm of your hand. Pluto is approximately 600 meters (2,000 feet or 6.5 football fields) away from the Sun. The nearest star to the Sun would be the size of a cherry located in coastal California.

We are going to use the *Voyage* model in this lesson. The Student Worksheets also have graphical representations of the Sun and planets at the scale of *Voyage*.

Table 1 includes some basic characteristics of the eight planets in the Solar System, as well as Pluto (as en example of dwarf planets.) The table includes rotation and revolution periods, which give rise to the length of a day and a year on that planet.

Life on Earth

Earth is located in a unique place in the Solar System. It receives just enough energy in the form of light and heat from the Sun to support many forms of life.

Even though the temperatures feel different in winter and summer, there is relatively little variation in the Earth's temperatures. This allows life to thrive on Earth. Living things could not survive the temperature extremes of hot and cold on the other planets. On Venus, lead would melt. On Pluto, the air in your lungs would freeze solid. If the Earth were much closer to the Sun, it would be too hot for living beings to survive when the Earth faced the Sun. If Earth were much farther away, the Sun would not be able to warm the planet enough for life to survive.

Earth also has water, which, in addition to energy, is a requirement for life. For now, there is no direct proof that liquid water currently exists on any other planet.

The Earth also has an atmosphere that provides natural protection from some of the Sun's harmful radiation. Some of this is in the form of ultraviolet light. The Earth remains the only known place in the Solar System, and in fact the Universe, that has—or ever has had—life.

Table 1.

Planet	Revolves Around the Sun	Rotation	Moons	Rings	Atmosphere	Kind of Planet
Mercury	88 days	59 days	0	0	Practically none	Rocky
Venus	225 days	244 days	0	0	Mostly carbon dioxide	Rocky
Earth	365.3 days	24 hours	1	0	Air: mostly nitrogen & oxygen	Rocky
Mars	687 days	24.6 hours	2	0	Mostly carbon dioxide	Rocky
Jupiter	11.86 years	9.9 hours	At least 63	4	Mostly hydrogen & helium	Gas giant
Saturn	29.46 years	10.7 hours	At least 61	Many	Mostly hydrogen & helium	Gas giant
Uranus	84 years	17 hours	At least 27	11	Mostly hydrogen & helium	Gas giant
Neptune	165 years	16 hours	At least 13	4	Mostly hydrogen & helium	Gas giant
Pluto (dwarf planet)	248 years	6 days	3	0	Practically none	Rock & ice

Conducting the Lesson

Warm-Up & Pre-Assessment

Preparation & Procedures

Let the class know they are going to design a model of the Solar System. Discuss what that means and why they are doing it. When they design the model Solar System, they will learn a lot about the characteristics of each planet, and what it would be like if they lived there.

NOTES:

Designing a Scale Model of the Solar System

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Warm-Up & Pre-Assessment

Activity: Build a Scale Model of the Planets

Lesson Wrap-Up

Resources

Activity: Build a Scale Model of the Planets

Students create a poster for each planet that contains planetary characteristics relevant to patterns and cycles, together with a graphic representing the planet at the *Voyage* scale, and the number of paces to the next planet. At the end of this activity students are ready to lay out the *Voyage* scale model Solar System.

Student Materials

- 1 posterboard per student, 24” x 36”
- 1 set of *Voyage* worksheets per student
- Glue
- Scissors
- Colored crayons or markers

Preparation & Procedures

1. Ask the students how they can make their own model of the Earth, Sun, Moon, and neighboring planets. They will need to 1) use their research information from previous lessons; 2) consult class wall charts with planetary facts; or 3) find out interesting facts about the planets as homework. (These facts will be added to the posters.)

2. Have the students look for information reflecting cycles associated with the planets, including length of day, length of year, and daily and annual variations in temperature.

3. Hand out the posterboard and Student Worksheets with the scale models and pacing charts.

4. Have students cut out the planets and Sun and position them on the posterboard. Students must place the planets in order from the Sun. Make sure students leave enough space between the model planets to write information about how far to walk to place each planet.

5. Have students glue the planets and Sun onto the posterboard.

Teaching Tip

There is information about the *Voyage* model on the Student Worksheet. This is for students to incorporate onto their posters. They should not just copy the information on to their poster, but use the information to write directions for where to place each planet relative to the model Sun. The directions should allow a student to “pace” out the Solar System. The charts assume one “pace” is one meter long. For younger students, a pace would likely be two steps.

6. Tell the students to write out the pace instructions for constructing the scale model. (Suggested wording: "To reach the next planet (e.g., Venus), walk 4 paces."

7. Tell the students to add information from their research.

Reflection & Discussion

1. Now that the students can see the relative size of all the planets on a 1:10-billion scale model, ask them to consider the following questions.
   - Which planet is closest to the Sun? Which is farthest from the Sun?
   - Can you name the planets (including the dwarf planet Pluto) in order from the Sun? (Help the students remember the sequence of the planets using the mnemonic "My very excited mother just served us nine pizzas." The first letter of each word is the first letter of the planets' names in order from the Sun.
   - What is the largest planet? The smallest?
   - Which planets are called the inner planets? The outer planets?

2. Discuss the following questions:
   - What was the most surprising thing you learned about the planets?
   - What was the most interesting?
   - What would you like to learn more about?

Transfer of Knowledge

1. Discuss with students how big the Earth is, how many hours or days it takes to drive across the country, or how long it takes to fly places even in airplanes. Emphasize that most of the time, people never even go to the other side of the Earth from where they live.

2. Have students compare their understanding of the Earth's size to the 1:10-billion scale model on their posterboards. See if they can imagine how tiny a country, a building, or a person would be on this scale.

3. Have the students compare Earth to the largest planet, Jupiter. Ask the students what they think is between Earth and Jupiter in space. Have them hypothesize as to how "full" or "empty" space is.

4. Discuss their remarks and questions about what must exist in between the planets, in all that space (mostly nothing).

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Assessment Criteria for Activity 1

Grades 3-4 students may be evaluated as follows. They need not demonstrate all the characteristics of a category to fall within it, though strong evidence of their classification by the teacher should be provided.

4 Points
- Clearly and consistently demonstrates a sophisticated understanding of the concepts nearly 100% of the time by applying them accurately in activities, questions, comments, work, and projects both in the classroom and elsewhere.

3 Points
- Shows a nearly complete grasp of the concepts by using them appropriately at least 75% of the time in class, asking pertinent questions, and by making viable attempts at applying the concepts to other aspects of learning.

2 Points
- Responds correctly to direct questions regarding the meaning of the concepts, but cannot yet express them or demonstrate them consistently and accurately; still makes errors about 50% of the time.

1 Point
- Indicates little more than random guessing at understanding the concepts; cannot focus on essential elements or regularly respond correctly to leading questions; less than 50% accurate.

0 Points
- No work completed.

Placing the Activity Within the Lesson

Discuss with students how, by building a scale model Solar System, they can gain an appreciation of Earth as a unique planet, one of nine in the Solar System.

Lesson Wrap-Up

Lesson Closure

Have a class discussion about how they would take the model Solar System they just designed and set it up in a playground.

Have a class discussion about why Earth's characteristics are important for life:

- Not too close or too far from the Sun. Temperature is right for liquid water and, therefore, life.
- It has a atmosphere which protects life from harmful types of sunlight, like ultraviolet light.

Notes:

Resources

Internet Resources & References

Student-Friendly Web Sites:

Astronomy for Kids
www.frontiernet.net/~kidpower/astronomy.html

Kids Astronomy
www.kidsastronomy.com/solar_system.htm

NASA Kids' Club
www.nasa.gov/audience/forkids/kidsclub/flash/

NASA's Planetary Photojournal
photojournal.jpl.nasa.gov

Teacher-Oriented Web Sites:

American Association for the Advancement of Science, Project 2061 Benchmarks
www.project2061.org/tools/benchol/bolintro.htm

Exploring Planets in the Classroom
www.spacegrant.hawaii.edu/class_acts/

National Science Education Standards
www.nap.edu/html/nses/

The Nine Planets
www.nineplanets.org

Voyage: A Journey through Our Solar System
www.voyagesolarsystem.org

Journey through the Universe
www.journeythroughtheuniverse.org

Discussion about Pluto's reclassification as a dwarf planet
www.voyagesolarsystem.org/pluto/pluto_default.html

Other Resources

Bull, Angela. *Flying Ace… Amelia Earhart*
Lambert, David. *The Kingfisher Young People's Book of the Universe*
Little, Karen E. and Thomas, A. *Things that Fly*
Nicolson, Cynthia. *Comets, Asteroids, and Meteorites*
Rabe, Tish. *There's No Place Like Space! A Dr. Seuss book.*
Reynolds, Quentin. *The Wright Brothers*
Stein, R. Conrad. *Chuck Yeager Breaks the Sound Barrier*

NOTES:

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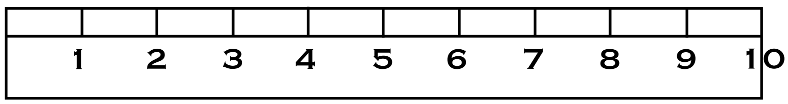
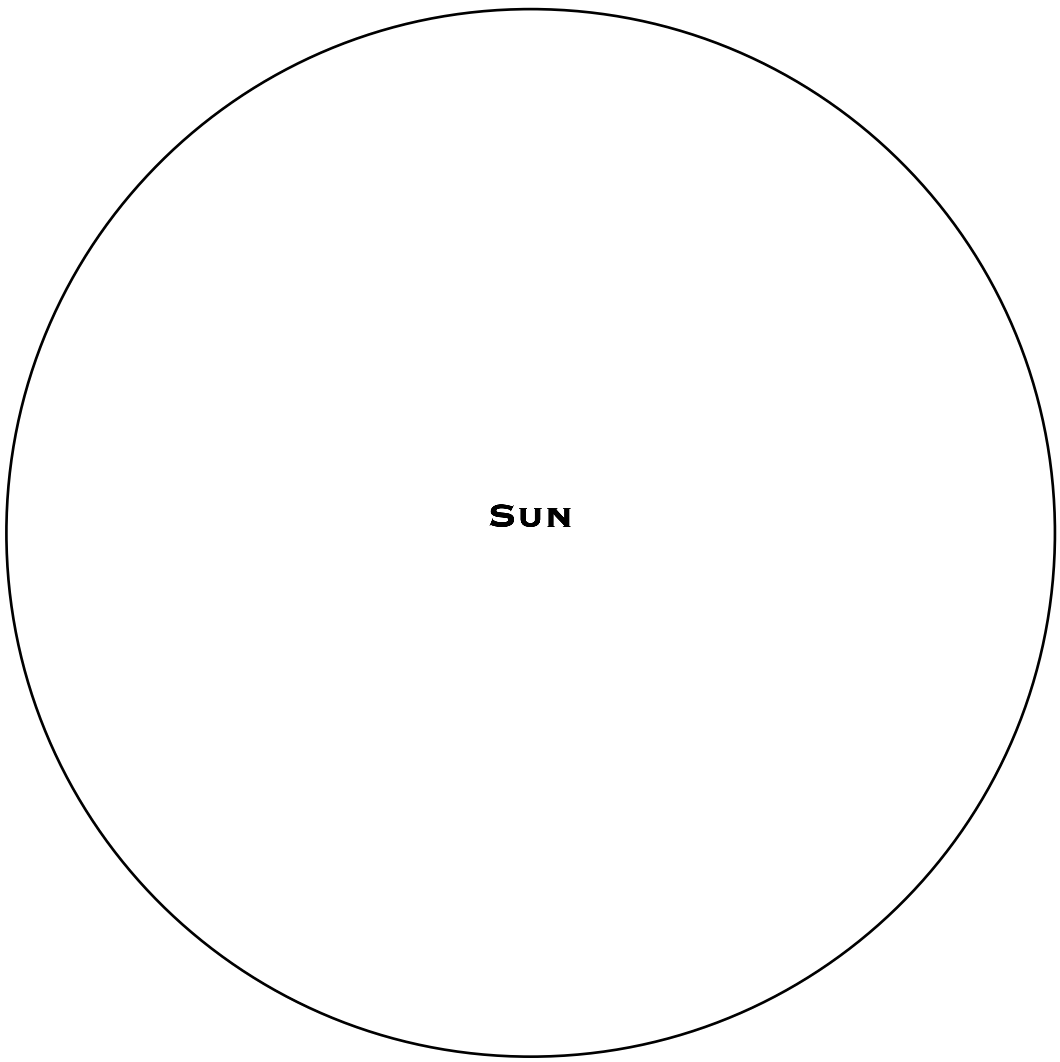
Student Worksheet: Designing a Scale Model of the Solar System

Name ____ Date ___________

IMPORTANT NOTE: Your printer may not have produced the planets on these worksheets at their correct size. To check and correct, adjust the enlargement/reduction on your printer to ensure that this ruler measures exactly 10 cm long.





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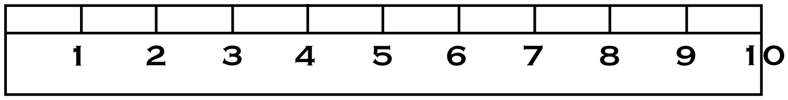


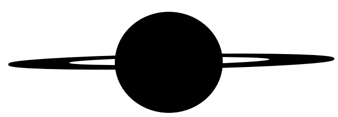
Mercury

Venus

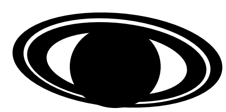
Earth

Mars

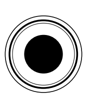
Jupiter



Saturn



Uranus



Neptune

Pluto

Chart of paces to set up the *Voyage* Model of the Solar System

Chart of Paces Between Model Planets								
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
6 paces	5 paces	4 paces	8 paces	55 paces	65 paces	144 paces	163 paces	142 paces

Chart of Total Distances (Meters) from Model Sun to Each Model Planet								
Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto (dwarf planet)
6 meters	11 meters	15 meters	23 meters	78 meters	143 meters	287 meters	450 meters	592 meters