On October 17, 2001, a one to ten billion scale model of the Solar System was permanently installed on the National Mall in Washington, DC. The *Voyage* exhibition stretches nearly half a mile from the National Air and Space Museum to the Smithsonian’s Castle Building. *Voyage* is a celebration of what we know of Earth’s place in space and our ability to explore beyond the confines of this tiny world. It is a celebration worthy of the National Mall. Take the *Voyage* at www.voyageonline.org, and consider a *Voyage* exhibition for permanent installation in your own community.

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.

*Voyage* and *Journey through the Universe* are programs of the National Center for Earth and Space Science Education, Universities Space Research Association (www.usra.edu). The *Voyage* 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
From research on the planets, students design a Solar System model, which includes planetary characteristics, such as patterns and cycles like the length of day and year. This model may be set up on a playground, so that students could take a voyage through 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 stories can be used to represent objects, events, and processes in the real world, although such representations can never be exact in every detail.
Related Education Standards

**AAAS Benchmarks for Science Literacy**

Benchmark 9C3:
- Graphical display of numbers may make it possible to spot patterns that are not otherwise obvious, such as comparative size and trends.

Benchmark 11D2:
- Finding out what the biggest and smallest possible value of something is often as revealing 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 nine planets.
  - 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
Nine 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 is the smallest planet in the Solar System. Unlike the terrestrial planets, it 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, the farthest planet, 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 Work-sheets also have graphical representations of the Sun and planets at the scale of Voyage.

Table 1 includes some basic characteristics of the nine planets in our Solar System. 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.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Revolves Around the Sun</th>
<th>Rotation</th>
<th>Moons</th>
<th>Rings</th>
<th>Atmosphere</th>
<th>Kind of Planet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>88 days</td>
<td>59 days</td>
<td>0</td>
<td>0</td>
<td>Practically none</td>
<td>Rocky</td>
</tr>
<tr>
<td>Venus</td>
<td>224.7 days</td>
<td>243 days</td>
<td>0</td>
<td>0</td>
<td>Mostly carbon dioxide</td>
<td>Rocky</td>
</tr>
<tr>
<td>Earth</td>
<td>365.3 days</td>
<td>24 hours</td>
<td>1</td>
<td>0</td>
<td>Air: mostly nitrogen &amp; oxygen</td>
<td>Rocky</td>
</tr>
<tr>
<td>Mars</td>
<td>687 days</td>
<td>24.6 hours</td>
<td>2</td>
<td>0</td>
<td>Mostly carbon dioxide</td>
<td>Rocky</td>
</tr>
<tr>
<td>Jupiter</td>
<td>11.86 years</td>
<td>10 hours</td>
<td>At least 63</td>
<td>4</td>
<td>Mostly hydrogen &amp; helium</td>
<td>Gas giant</td>
</tr>
<tr>
<td>Saturn</td>
<td>29.46 years</td>
<td>10.75 hours</td>
<td>At least 47</td>
<td>Many</td>
<td>Mostly hydrogen &amp; helium</td>
<td>Gas giant</td>
</tr>
<tr>
<td>Uranus</td>
<td>84 years</td>
<td>17 hours</td>
<td>At least 27</td>
<td>11</td>
<td>Mostly hydrogen &amp; helium</td>
<td>Gas giant</td>
</tr>
<tr>
<td>Neptune</td>
<td>165 years</td>
<td>16 hours</td>
<td>At least 13</td>
<td>4</td>
<td>Mostly hydrogen &amp; helium</td>
<td>Gas giant</td>
</tr>
<tr>
<td>Pluto</td>
<td>248 years</td>
<td>6 days</td>
<td>1</td>
<td>0</td>
<td>Practically none</td>
<td>Rock &amp; ice</td>
</tr>
</tbody>
</table>
**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.
**Activity: Build a Scale Model of the Planets**

In this activity, students physically build a scale model of the 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 either need to 1) use their research information from previous lessons; 2) consult class wall charts with planetary facts; or 3) find out some interesting facts about the planets as homework. (These facts will be added to the posters.)

2. Have them 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 regarding the *Voyage* model included 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 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).
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 an 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
  kids.msfc.nasa.gov/SolarSystem/
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/bolinintro.htm
Exploring Planets in the Classroom
  www.spacegrant.hawaii.edu/classActs/
National Science Education Standards
  www.nap.edu/html/nses/
The Nine Planets
  www.nineplanets.org/
Voyage Online
  www.voyageonline.org/
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*
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.
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.
Chart of paces to set up the *Voyage* Model of the Solar System

### Chart of Paces Between Model Planets

<table>
<thead>
<tr>
<th></th>
<th>Sun to Mercury</th>
<th>Mercury to Venus</th>
<th>Venus to Earth</th>
<th>Earth to Mars</th>
<th>Mars to Jupiter</th>
<th>Jupiter to Saturn</th>
<th>Saturn to Uranus</th>
<th>Uranus to Neptune</th>
<th>Neptune to Pluto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paces</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>55</td>
<td>65</td>
<td>144</td>
<td>163</td>
<td>142</td>
</tr>
</tbody>
</table>

### Chart of Total Distances (Meters) from Model Sun to Each Model Planet

<table>
<thead>
<tr>
<th></th>
<th>Mercury</th>
<th>Venus</th>
<th>Earth</th>
<th>Mars</th>
<th>Jupiter</th>
<th>Saturn</th>
<th>Uranus</th>
<th>Neptune</th>
<th>Pluto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meters</td>
<td>6</td>
<td>11</td>
<td>15</td>
<td>23</td>
<td>78</td>
<td>143</td>
<td>287</td>
<td>450</td>
<td>592</td>
</tr>
</tbody>
</table>