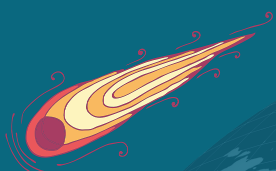
Earth Science

Mysteries of Space

Where would you search for life in space?



Module 1

WHAT DOES OUR SOLAR SYSTEM LOOK LIKE?

Module 2

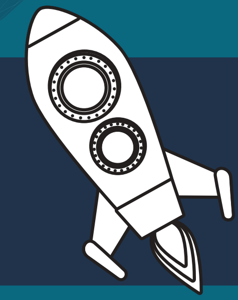
WHY DOES OUR SOLAR SYSTEM LOOK THE WAY IT DOES?

Module 3

WHAT WOULD IT TAKE TO SURVIVE IN SPACE?

FINAL PRODUCT:

Teams use what they know about the scale and nature of our solar system and galaxy to design a mystery organism that can endure the forces and elements found on another moon or planet.



educurious

learning that connects

Dear Educator,

We are very excited to bring you this lesson from a three week, Educurious project-based learning unit, *Mysteries of Space*. If you are planning to use this lesson independently of the unit or in a remote learning setting, we have included suggested adaptions throughout the lesson in bold, colored font in the Teacher Guide section.

Unit Driving Question

Where would you search for life in space?

Module Driving Question

What does our solar system look like?

Module 1 — Our Solar System
What does our solar system look like?

Module 2 — Shaping our Solar System
Why does our solar system look the way it does?

Module 3 — Life in Space
What would it take to survive in space?

Module Overview

In this first lesson, students use and analyze data to classify the planets and moons in our solar system by their defining characteristics in order to understand the diversity and nature of our solar system. Students are then introduced to the scale of the solar system, and the units scientists use to measure objects and distance in space. Finally, students construct a scale model of the solar system on their school grounds.

Lesson 1.1: Unit Launch: Mysteries of Space (75 minutes)	
Learning Targets: I can: • Learn about the diversity of life and life-supporting environments on Earth, and possibly beyond. • Use data about planets, moons, and dwarf planets to understand the similarities and differences of objects in our solar system. • Analyze planetary data to understand the relative size and scale of solar system objects.	This lesson sets the foundation for students' capstone project, the Life in Space Discovery Challenge. Students begin this lesson by learning about extremophiles, a diverse set of organisms on Earth that can thrive in extreme environments; environments that would be inhospitable for most life, as we know it. Students are then introduced to the unit project, receive their project groups, and are assigned a planet or moon in our solar system for their project work. Finally, students work in project teams as they complete a solar system sorting activity. During this activity, students use and analyze data to classify the planets and moons in our solar system by their defining characteristics.

Lesson 1.2: What Is the Scale of Our Solar System? (90 min)	
Learning Targets: I can: ● Compare the size and scale of planets in our solar system. ● Calculate and walk the distance of our solar system at scale. ● Describe the nature of planets in our solar system based on their distance from the Sun.	In this lesson, students are introduced to units of measurement scientists use to measure objects within and outside of our solar system. Using these units of measurements, students then calculate the dimensions of a solar system built to scale. Finally, students use the school and nearby grounds to construct their solar system model at scale. This lesson also provides options for constructing a model in smaller space, and in the classroom using a printed map of the school grounds and surrounding area.

Assessments

None

Vocabulary

astronomical unit (AU): a unit of measurement equal to 149.6 million kilometers, the mean distance from the center of the Earth to the center of the Sun.

dwarf planet: a small body in space that resembles a planet, but lacks some of the criteria to be labeled as a planet.

galaxy: A system of millions or billions of stars, along with gas and dust that is held together by gravity and often surrounds a black hole. Our galaxy is approximately 13.5 billion years old.

habitable zone: the range of distances from a star where liquid water might pool on the surface of an orbiting planet, allowing for life to survive.

light-year: a unit used in astronomy equivalent of the distance that light travels in one year.

moon: a rocky satellite that orbits a planet.

planet: a large body in space that orbits a star.

scientific notation: a way of writing very large numbers to show decimal place (ex: $5.47 \times 10^4 = 54{,}700$).

solar system: A collection of planets, their moons, and other space objects, such as asteroids, meteors, etc. around a sun. Our solar system is believed to be 4.6 billion years old.

star: A luminous ball of gas, mostly hydrogen and helium, held together by its own gravity. Nuclear fusion occurs in stars when hydrogen atoms bond to form helium. This produces light and heat.

Sun: the medium-sized star at the center of our solar system.

Teacher Guide

Lesson 1.2: What is the Scale of Our Solar System?
Mysteries of Space

Dear Educator,

We are very excited to bring you this lesson from a three week, Educurious project-based learning unit, *Mysteries of Space*. If you are planning to use this lesson independently of the unit or in a remote learning setting, we have included suggested adaptions throughout the lesson in bold, colored font.

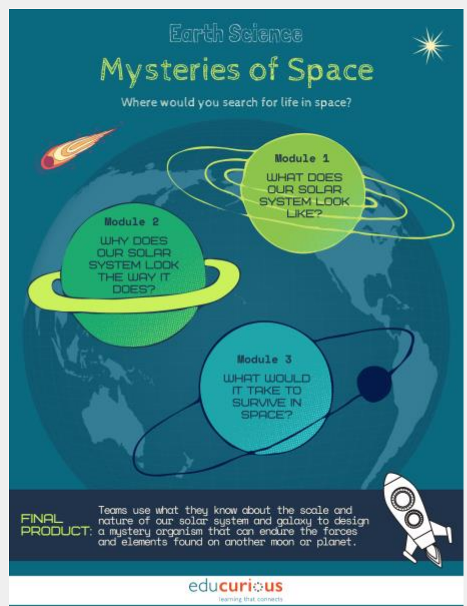
Lesson 1.2: What Is the Scale of Our Solar System?

Unit Driving Question:
Where would you search for life in space?

Module Driving Question:
What does our solar system look like?

Learning Targets
I can:

- Compare the size and scale of planets in our solar system.
- Calculate and walk the distance of our solar system at scale.
- Describe the nature of planets in our solar system based on their distance from the Sun.



Purpose
In this lesson, you will construct a scale model of our solar system to visualize the relative size of solar system objects and their distances from each other in space. You will learn about the units scientists use to measure and describe space for use in your final project poster. As you build this model, you will consider where your planet or moon is located compared to the Sun and other nearby planets. This will help you understand the forces that act on your planet or moon, including any potential life that may be found there.

Lesson Steps

1. Introduce Scale
2. Determine the Scale of Your Planet & Its Orbit
3. Build a Scale Model of Our Solar System
4. Add to the Summary Table

Resources

- Cosmic Eye video
- Solar System Model Guide

Teacher Preparation Notes

Pacing	
Lesson 1.2 Timing:	90 minutes

Standards	
✓ **PE**	**MS-ESS1-3**: Analyze and interpret data to determine scale properties of objects in the solar system.
✓ **DCI**	**ESS1.B: Earth and the Solar System**: The solar system consist of the Sun and a collection of objects, including planets, their moons, and asteroids that are held…
✓ **SEP**	**Developing and Using Models**: Develop and use a model to describe phenomena. **Using Mathematical and Computational Thinking**: Apply mathematical concepts and/or processes (such as ration, rate, percent, basic operations, and simple algebra)…
✓ **CCC**	**Scale, Proportion, and Quantity**: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too… **Systems and System Models**: Models can be used to represent system and their interactions.
✓ **CCSS**	**CCSS.ELA-Literacy.SL.6.1**: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Complete Lesson Resources

Student Resources	Teacher Resources	Lab Materials
• Cosmic Eye video • Solar System Model Guide	• Lesson 1.2 Slide Deck • Solar System Model Teacher Key • To Scale: The Solar System video (optional) • How do measure extreme distances video (optional)	• A ball 8 inches in diameter (kickball, bowling ball, etc.) • One ounce each of modeling clay in the following colors: gray, yellow (used twice), blue, red, orange, purple, light blue • Index cards • Markers • Tape • Calculators

Lesson Overview

In this lesson, students are introduced to units of measurement scientists use to measure objects within and outside of our solar system. Using these units of measurements, students then calculate the dimensions of a solar system built to scale. Finally, students use the school or nearby grounds to construct their solar system model at scale. This lesson also provides options for constructing a model in smaller space, and in the classroom using a printed map of the school grounds and surrounding area.

Teacher Preparation

Test the Cosmic Eye video to make sure it runs in your classroom.

Find an area where students can walk 1,000 yards in a straight line. The line can also fold back on itself in smaller spaces. If you are unable to take students outside, they can do the same activity using a printed map of the school and its surrounding kilometer (1/2 mile).

Lesson Steps in Detail

Step 1: Introduce Scale (20 min)

Purpose: Students learn about the units scientists use to measure vast distances in space in order to understand and visualize the scale of objects in our solar system. If you are doing the entire project, students will use these units as they move into their final projects. They will help students communicate and compare information about our solar system's planets and moons between groups, and make sense of the impact of scale on their organism's structures for survival.

> **You might say:** *In our last activity, we used metric units, such as kilometers, to determine the size of our planets and their distances from the Sun. These numbers were so large that it might have been challenging to visualize the vastness and scale of space. Today, we are going to learn which units scientists use to measure and communicate distances in space. These units will help us compare our planets and moons to each other, and to think about the way scale might impact an organism's structures for survival.*

[Slide 2] Elicit students' ideas about the size of the solar system from their prior learning and the Launch Lesson. Ask students to talk with a partner and use their notes and **Planet Sort Cards Classification Directions** document to answer the questions below:

- *How does planet spacing change as we move farther away from the Sun (i.e., are all planets spaced evenly throughout the solar system, or do they get farther apart or closer together)?*
    - The spacing gets farther apart as we move to the outer planets. So, Neptune is about 30x farther from the Sun than Mercury, even though it is the 8^{th} planet in terms of distance. Therefore, life farther from the Sun gets considerably less solar radiation, which would have implications for the organisms on those planets.
- *How do planets differ based on how far they are from the Sun?*
    - Students should notice the trends in inner rocky planets and gas giants, which is related to the temperatures of these planets.
- *What are the challenges of visualizing our solar system using kilometers and days as units of measurement?*
    - Data for the first three questions are below. Students may share that it is difficult to visualize scientific notations, such as 778 x 10_6 for distance from the Sun, or an orbital period of 59,800 days.

Planets Only	Distance from Sun (10^6 km)	Orbital Period (days)
1. Mercury	57.9	88
2. Venus	108.2	224.7
3. Earth	149.6	365.2
4. Mars	227.9	687.0
5. Jupiter	778.6	4331
6. Saturn	1433.5	10,747
7. Uranus	2872.5	30,589
8. Neptune	4495.1	59,800

[Slide 3] Introduce the units used to measure objects in space. Tell students that most objects in space are so far away that everyday units of measurement, such as kilometers and days, are not practical.

- Share that in astronomy, the most common measurements are the astronomical unit and the light year.
    - **Astronomical Unit (AU)**: Distance between the Earth and the Sun (150 million kilometers). Used for objects inside of our solar system (i.e., Neptune is 30 times farther from the Sun than Earth.).
    - **Light-Year (ly)**: The distance that light can travel in one year in a vacuum (empty space). Used to measure objects outside our solar system.
    - Interpret the data in the table showing each planet's distance from the son in Astronomical Units (AU).
    - **Optional:** Play the video, How to measure extreme distances to provide more background information about how scientists use light-years to understand and communicate the vast scale of space.

Planet	Distance from Sun (AU)
Mercury	.4
Venus	.7
Earth	1.0
Mars	1.5
Jupiter	5.2
Saturn	9.6
Uranus	19.2
Neptune	30.0

- As you review the table, help students visualize the solar system using Astronomical Units. For example, if Neptune is 30 AU, it is 30 times farther from the Sun than Earth.
- Ask students if it is easier to visualize distance this way, compared to kilometers in scientific notation.

[Slide 4] Define the habitable zone as the range of distances from a star where liquid water might pool on the surface of a planet, allowing life as we know it to survive.

- The location of the habitable zone changes depending on the size of the star, and is farther for hotter stars and closer for cooler stars.
- As students engage in project work for this unit, they may consider what their organism requires to live outside of the habitable zone. For example, on Earth, bacteria live and thrive in some extreme environments once thought uninhabitable.

[Slide 5] Play the Cosmic Eye video to support student understanding of the micro and macro views of our universe. Ask students to consider the following questions as they watch the video:

- *How are the filmmakers using measurement to show scale?*
- *How much does the view increase or decrease with each frame?*

After the video, have students share their responses to these questions with a partner.

Step 2: Determine the Scale of Your Planet and Its Orbit (20 min)

Purpose: Students construct the parts of our solar system at scale to see the differences in scale between planets and calculate the spacing between each planet and the Sun in Astronomical Units.

[Slide 6] Introduce the Solar System Model at Scale activity.

- Divide students into nine groups, one for each planet and one for the Sun. **If students are working in an asynchronous learning environment, students can read all of the Model Guides or enjoy this lesson with family members.**
- Distribute one **Solar System Model Guide** to each group.
- Have students read the first paragraph on the **Solar System Model Guide** about how few solar system models online and in-person are built to scale. Inform students that they will construct their own scale model of the solar system.

Provide clay materials for Step 1 of the Solar System Model Guide. Assign each group a planet, and have them build their planet to scale out of clay. **If students are working in an asynchronous learning environment, students can build all nine planets.**

- Have each group tape their planet to an index card labeled with the planet's name. When students place their planet on the ground in Step 3 of the guide, it will be hard to find without the index card as a marker.
- The scale of this model is 1 inch: 100,000 miles.

Planet	Object & Color	Size of clay (diameter in inches)
Sun	Any ball with an 8" diameter	8" (size of a bowling ball)
Mercury	Gray clay ball	.03" (size of a pinhead)
Venus	Yellow clay ball	.08" (size of a peppercorn)
Earth	Blue and white clay ball	.08" (size of a peppercorn)
Mars	Red clay ball	.03" (size of a pinhead)
Jupiter	Orange and yellow clay ball	.90" (size of a chestnut)
Saturn	Yellow and white clay ball	.70" (size of an acorn)
Uranus	Light blue clay ball	.30" (size of a coffee bean)
Neptune	Blue and purple clay ball	.30" (size of a coffee bean)

[Slide 7] Prompt students to complete Step 2 of the Solar System Model Guide, in which they calculate the distance from the Sun for each planet in Astronomical Units.

- Have each group calculate the AU for all eight planets.
- In this model, **1 Astronomical Unit (AU) = 26 yards**
- Have students calculate and record—in the third column on the table—the number of yards they need to walk for each planet to build their scale model of the solar system.

Planet	Distance from Sun (AU)	Scaled Distance in Yards (1 AU x 26 yards)
Mercury	.4	0
Venus	.7	10.4 yards from the Sun
Earth	1.0	18.2…
Mars	1.5	26…
Jupiter	5.2	39…

Saturn	9.6	135.2…
Uranus	19.2	249.6…
Neptune	30.0	499.2…

Step 3: Build a Scale Model of Our Solar System (40 min)

Purpose: To fully visualize the scale of our solar systems, students take their planets and measurements outdoors.

[Slide 8] Construct the model outside. Have each group bring their sun or planet secured to a labeled index card, and the **Solar System Model Guide** outside to construct their physical scale model of our solar system.

- Tell students that there are walking guidelines under Step 3 of their **Solar System Model Guide** that will help them use steps to gauge Astronomical Units (yards) outside.

During this activity, walk together as a whole class or if at home, students do this alone or with family members.

- First, the sun group will place their scale model of the Sun at the starting point for your model.
- Next, walk ten steps, and have the Mercury group place their index card with their planet on the ground.
- Follow the same steps for the other planets, using the step counts below and on the **Solar System Model Guide**.
    - Place Sun at the start of the model.
    - Walk ten steps for Mercury.
    - Walk another nine steps for Venus.
    - Walk another seven steps for Earth.
    - Walk another 14 steps for Mars.
    - Walk another 95 steps for Jupiter.
    - Walk another 112 steps for Saturn.
    - Walk another 249 steps for Uranus.
    - Walk another 281 steps for Neptune.
- As you walk back inside, have students pick up their scale models of the planets and the Sun.
- Optional: Play the To Scale: The Solar System to show students how scientists constructed a scale model of space in the desert.

[Slide 9] When students are back inside, have each group answer the reflection questions on the Solar System Model Guide before sharing their reflections with the class. If students are working from home they can answer the reflection questions and then join the rest of their classmates via video conferences to share their experiences.

1. *How did planet size and distances change as you moved farther from the Sun?*
2. *How might distance from the Sun impact your organism's structures for survival on these planets?*
3. *What might they need closer to or farther from the Sun to thrive?*

Step 4: Add to Summary Table (10 min)

Purpose: Students reflect collectively on the new ideas they have gained from building a scale model of the solar system.

- **[Slide 10] Add to the class Summary Table:** Work with the class to add their ideas about building the scale model of the solar system to the Summary Table. Sample student responses below are provided as examples to guide your instructional planning. The **Sample Summary Table** provides a full sample Summary Table for the unit.

- **If you are not doing the full project, adapt the question in the final column to: "How does it help you know where to search for life in space?"**

What did we do?	What did we learn?	How does it help us understand how Earth is unique?	How does it relate to the Life in Space Design Challenge?
Lesson 1.2: Solar System Scale Model Activity	• Most models of the solar system are not to scale. • The solar system is vast and outer planets are spaced much more widely apart than inner planets. Outer planets are also much larger. • The Sun is massive compared to all other solar system objects.	• Earth is in the habitable zone, which is very small. • Being in the habitable zone means that Earth has many features necessary for supporting life as we know it.	• We will need to consider what organisms would need to live outside of the habitable zone. • In particular, we should consider the proximity of a planet to the Sun—outer planets have very different characteristics than inner planets.