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.

Module Overview

Module 1: 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 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.

Dear Educator,

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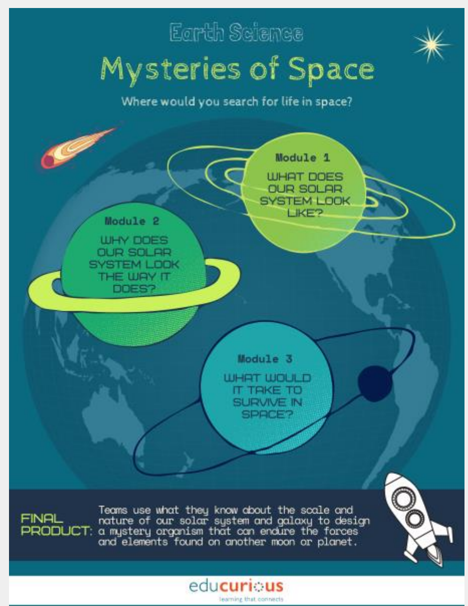
Lesson 1.1: Unit Launch: Mysteries of Space

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:

- 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.



Purpose
Did you know that Earth holds clues to how life could exist in space? On Earth, scientists study small organisms called extremophiles that live in extreme environments without water, sunlight, or oxygen. In this lesson, you will be introduced to extremophiles and begin researching the environments on different planets to consider what types of extreme life could live beyond Earth.

Lesson Steps
1. Introduce Extremophiles: Organisms That Defy the Limits of Life
2. Introduce Unit Project
3. Create a *Know & Need to Know* Chart
4. Explore Our Solar System with the Planet Cards
5. Create a Class Summary Table

Resources
- Video: Meet the Tardigrade, the toughest animal on Earth
- Planet Cards
- Planet Card Sort: Classification Directions

Teacher Preparation Notes

Pacing	
Lesson 1.1 Timing:	75 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 consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held…
✓ **SEP**	**Analyzing and Interpreting Data**: Analyze and interpret data to determine similarities and differences in findings. **Obtaining, Evaluating and Communicating Information**: Critically read scientific texts adapted for classroom use to determine the central ideas and/ or obtain…
✓ **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…
✓ **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
• Planet Cards • Planet Card Sort: Classification Directions	• Lesson 1.1 Slide Deck • Video: Meet the Tardigrade, the toughest animal on Earth • Planet Classification Teacher Key	• None

Lesson Overview

This lesson is the first lesson in a project-based learning unit, *Mysteries of Space* and is the foundation for students' unit 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. The lesson ends with students working 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.

Teacher Preparation

- **Test the video,** Meet the Tardigrade, the toughest animal on Earth, **to make sure it plays in your classroom.**
- **Print a set of planet cards for each group of 2 – 3 students**. Black & white printouts work fine for this activity. **If working remotely, make sure students have a set to print at home or send them to students.**
- **To provide an asynchronous learning option, consider recording your narration of the slide deck for students to view on their own.**
- **Decide on project groups and assign a planet/moon.** There are 14 planet cards available for capstone project groups, so students should work in project teams of 2 – 3. Do not assign Earth, as it is always

included in lessons leading up to the project work. The lesson plans will indicate when students will work in their project teams or in other groups, based on the nature of the activity.

- **If you do plan to do the full unit, begin thinking about how you will structure the final project exhibition; options include a Gallery Walk or student presentations to the whole class.** Here is an example of a final design for Mars. Show the example to student groups after you introduce the project in this lesson. In Lesson 3.1, students will look more closely at this example to see how their own projects will require more evidence and information about extremophiles and their planet's environment. Share with students that this example is for upper-elementary students, and as middle schoolers, they will move beyond this level of information. Note that this example links to an external site, and is not included in the slide desks for this lesson or Lesson 3.1.

Lesson Steps in Detail

Step 1: Introduce Extremophiles: Organisms That Defy the Limits of Life (15 min)

Purpose: The unit launch uses examples of extremophiles, organisms that live in extreme environments on Earth, to anchor the capstone project, The Life in Space Discovery Challenge. Through the lens of extremophiles, students consider what it would take for an organism to thrive on another planet or moon in our solar system. This framing invites students to learn about the forces that shape our solar system, and the nature of planets and moons shaped by these forces, which are the focal content areas for this unit.

> **You might say:** *As we study the planets in our solar system and the forces that shaped our universe, we will continually revisit the question:* Where would you search for life in space? *Sixty years ago, the thought of finding life in space was considered science fiction, but today there is an entire field of astrobiology devoted to searching for life beyond Earth. However, the clues for where to look might be right on our own planet.*

[Slide 2] Draw on students' prior knowledge of what most organisms on Earth need to survive. This will compare our assumptions about what life requires with extremophiles that thrive in harsh environments on Earth. Ask students the following questions:

- *What do all living things need to survive?*
  - Students should recognize that living organisms generally require light, oxygen, water, and moderate temperatures to survive. Some students may already know that there is life in some extreme environments. If this is the case, you can tell students that they will be learning even more about those organisms today.
- *How can this guide scientists' search for life beyond Earth?*
  - Student answers will vary. If students are not sure, ask probing questions:
    - *Can we find these foundations for life on other moons or planets?*
    - *Would it be possible for life to exist without these conditions?*

[Slide 3] Introduce the concept of extremophiles by playing the video, Meet the Tardigrade, the toughest animal on Earth. As students watch the video, ask them to consider the questions from the prior slide but with the new information about the tardigrade.

- *What do all living things need to survive?*
  - The tardigrade can live without water, oxygen, etc.
- *How can this guide scientists' search for life beyond Earth?*
  - Scientists may choose to look in places once thought inhospitable for life, so they may broaden their search.

[Slide 4] Define the term *extremophile* for students. Tell students that the tardigrade is just one example of an extremophile and that many more have been discovered in recent decades. The diversity of extremophiles lays the foundation for students' project work, in which they explore the possibility of life on diverse planets.

- An *extremophile* is an organism that lives in an extreme environment on Earth, including places without water, sunlight, or oxygen.
- Extremophiles were first discovered in the 1960s; these organisms changed how we view life. Many more have been discovered since the 1980s.
- Most extremophiles are microorganisms, but some are multicellular, and even complex, organisms.

[Slides 5 - 7] Introduce some of Earth's extremophiles to show the range of environments in which they are found.

- Invite students to engage in these slides by having volunteers read the text for the class. Ask students to share their quick thoughts about where these organisms are found. Note that longer conversations around these slides will extend the instructional time for this lesson.

[Slide 8] Tell students that there are many more types of extremophiles than the examples they previewed and that there will be opportunities to research these organisms in a future lesson.

You might say: *These slides are only a short preview of some extremophiles. Extremophiles have been found living in high gravity environments that mimic the gravity of the Sun. They can exist without water for decades, as well as in a full range of temperatures from well below freezing to boiling, and at pH levels more acidic than battery acid. Extremophiles defy what we know about life, and open the potential to discover life in places we never imagined.*

- Until the 1970s, scientists thought that all life needed air, water, and sunlight to grow.
- The discovery of extremophiles changed what we know about life, what life needs, and where life is possible.
- Scientists called astrobiologists—who study the origin and evolution of life in the universe—are interested in extremophiles because they suggest life may be possible beyond Earth!

Step 2: Introduce the Unit Project (10 min)

Purpose: Introduce the Life in Space Discovery Challenge to students. This allows them to ground their later learning about our solar system and the forces that shaped space in the unit project. **If you are not doing the full project you can skip this step.**

You might say: *You may have already guessed that extremophiles are connected to our project for this unit. Our project is called The Life in Space Discovery Challenge. Over the next few lessons, you are going to learn about the scale of our solar system. You will explore the nature of our planets and moons and the forces that shaped them to design an organism that scientists might find on your assigned planet or moon.*

[Slide 9] Introduce the unit project, The Life in Space Discovery Challenge, by showing the [example project poster] to provide an example of what the final project will look like.

- Tell students that this poster is an example from an elementary classroom. Make it clear that their work will require more information about their assigned planet or moon, with more scientific evidence from their research in Lesson 3.2 to support the design decisions for their organism.

Divide students into groups of 2 – 3, depending on the number of groups you would have for 14 moon and planet options.

- Remind students that they should keep their planet/moon assignment a secret so their classmates can guess during the final showcase.
- Assign each group the planet or moon they will investigate for the final project by putting the name of the assigned moon or planet in an envelope. They will use this envelope for the remaining lessons.

Step 3: Create a *Know & Need to Know* Chart (10 min)

Purpose: Help students articulate what they already know about space, our solar system, and the project challenge. Supporting students' inquiry questions builds a sense of ownership and helps you assess students' early understanding of the core content related to the project.

[Slide 10] Create a *Know & Need to Know* chart: Now that students have been introduced to the project challenge, record their ideas and questions in a *Know & Need to Know* chart that students can revisit throughout the unit.

- Ask students to discuss these two questions with a partner.
- Then share out ideas and questions in a whole-class discussion.
- Record the class' ideas in a *Know & Need to Know* chart.

What do we already *know* about our solar system?	What do we *need to know* to design an organism capable of surviving elsewhere in our solar system?

Keep the chart visible in the classroom, or **easily accessible online**, to record and measure students' expertise and questions.

Teacher Tip: Tracking and Resolving Questions with a *Know & Need to Know* Chart

A *Know & Need to Know* chart is another way for students to track how their thinking changes over time, at a whole class level rather than individual or small group explanatory models. For Project-Based Learning units, the chart also helps students make connections between the content they are learning and their project work. To learn more about *Know & Need to* Know charts in PBL, read about different tactics and pedagogical considerations at the Opening Paths Consulting website and how to use students' questions for planning and assessment at the Buck Institute for Education website.

Step 4: Explore Our Solar System with the Planet Cards (30 min)

Purpose: Now students will begin investigating the extreme environments found on the planets and moons in our solar system. Students will learn about all of the planets and moons.

> **You might say:** *Our solar system is filled with planets, moons, and other space objects that have many similarities to Earth, including ice and oxygen in the atmosphere. However, we know that their environments also differ from Earth in ways that many consider inhospitable for life. Next, we will do a*

Planet Card Sort Activity to learn more about the nature and diversity of planets and moons in our solar system, paying special attention to our team's assigned moon or planet.

[Slide 11] Introduce the Planet Card Sort Activity. Arrange students in groups, and review the example Planet Card image on this slide. Review the categories on the example, allowing students to ask clarifying questions about any information on the slide, such as defining terms or making sense of the data.

- Give each group a set of **Planet Cards** and a copy of the **Planet Card Sort: Classification Directions**.
- **To provide an asynchronous learning option, students could do the sorting activity on their own or enjoy it with their family. Remember to adapt the directions on Slide 11.**
- Review the directions with students as outlined on Slide 6 and in the handout:
  - Use the **Planet Cards** to sort our solar system's planets, moons, and other space objects into a variety of different categories.
  - Use the **Planet Card Sort: Classification Directions** to sort the planets into three categories.
  - Next, each group will create three more categories on their own.
  - Partner with another group to share your categories.
  - Answer the questions related to the sorting activity to make sense of the nature of planets, moons, and other space objects in our solar system.

[Slide 12] Reflect on the sorting activity by asking students to share their final claims about the diversity and traits of planets and moons within our solar system, based on their analysis of the data for this activity.

- Remind students to use 2 – 3 pieces of evidence and/or data from the planet cards to support their claims.
- **To provide an asynchronous learning option, you can bring students together through a video call to share their final claims.**

Step 5: Create a Class Summary Table (10 min)

Purpose: Students make connections between the new information gained through the class activities, the phenomenon they are investigating (the scale and diversity of the solar system), and the unit design challenge.

[Slide 13] Create a class Summary Table: Work with the class to add their ideas to the Summary Table.

- The Summary Table should relate the main findings from students' activities to both the focal content for this unit (the scale and nature of the solar system and galaxy) and the project (designing an organism that could survive on another planet, moon, or dwarf planet).
- The primary goal is to document and follow your students' ideas about these relationships. The column headers and sample student responses below are intended only as examples to guide your instructional planning.
- **If you are not doing the full project, adapt the question in final column to, "How does it help you know *where to search for life in space?"***

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The **Sample Summary Table** provides a full sample Summary Table for the unit.

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 Discovery Challenge?
Lesson 1.1: Planet Cards Classification Activity	• There are different types of objects in our solar system. • Planets share many traits depending on their proximity to the Sun. • Many moons share features of rocky planets. • Oxygen and ice (from water) are found throughout our solar system.	• Earth shares many traits with these planets and moons, but only Earth has temperatures that allow for liquid water. • Planets outside of our solar system, called exoplanets, may share many of Earth's features.	• We were able to learn more about our group's assigned planet/moon. This information will help us find an extremophile that might live in similar conditions, which will help with the design of our project organism.

Teacher Tip: Supporting Student Sensemaking with Summary Tables

Summary Tables help students make sense of the content they learned in specific activities and relate new ideas to their developing understanding of the unit's anchoring phenomenon. For PBL units, Summary Tables also provide an opportunity to contextualize the content in relation to the unit project. To learn more about Summary Tables, read about how to structure and use them on the Ambitious Science Teaching website.