SUCCESS
ACADEMY
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INSTITUTE

Earth and Space Science: Unit 5

Earth in Space: Lessons

Lesson 1: Is Anyone Out There?

Lesson Objective: Scientists study the universe to grow our body of knowledge and benefit human interests. Scholars can explain why scientists study space and articulate some of the challenges they face. Materials Needed

- For the teacher: the ISS video loaded on a viewable screen
- For each scholar: computer, copies of printed articles (optional)

Prep

- Materials Prep:
  - Email or print written materials.

What are scholars doing in this lesson?

- Scholars investigate different articles and videos to determine why scientists are interested in studying space while getting excited about the topic for the unit.

Do Now

- Follow the **Do Now plan**.

Launch

- Ask scholars what comes to mind when they think of outer space. Have each scholar make a list independently for 1–2 minutes.
    - Ask a few scholars to share. Ask the class what makes them most excited about outer space and what they have questions about. Compile a list of questions to revisit and reference throughout the unit.
- Explain to scholars that in this unit, we will pretend that an alien named Peeko has just landed in New York, and he needs our help! Through the use and creation of models, we will help Peeko answer the many questions he has about outer space.
    - Introduce the Essential Question: An alien from a faraway planet just landed in New York. How can we help him explain the puzzling phenomena he has observed in his home **solar system**?
- As we begin our quest to help Peeko, we will engage with another important question: Why do we bother to study space at all? It looks like everything is just sitting out there, so why do we care what Jupiter is made of or what lies beyond our own galaxy?

Activity

- Scholars review the articles and videos provided and take notes while focused on the driving question: Why study space?
- Provide the following to scholars:
    - **What's Next for NASA?**
    - **Life beyond Earth: Are we alone? Scientists search for an extraterrestrial answer**
    - **The Coming Age of Space Colonization**
    - **Can We Survive the Sun's Death? video** (3 minutes and 36 seconds)
    - **5 Ways The World Could End video** (2 minutes and 51 seconds)
    - **Why We Do And Must Go Into Space**
- Come together as a class to watch some or all of the **HOW IT WORKS: The International Space Station video** (28 minutes and 57 seconds).
    - Provide a short explanation of what the International Space Station (ISS) is for scholars who are unfamiliar.
    - During the video, scholars take notes on the purpose of the ISS and record any new questions they have about the study of space.

[**Engagement Tip:** If you would like to show the entire video but cannot finish it during the allotted time, you can hold a follow-up screening and discussion on another day. It does *not* need to be shown as a prerequisite for Lesson 2.]

- As scholars are working, circulate and ask them to describe something new that they learned from the videos or articles. Ask them what they are most excited to learn about during this unit.

Discourse Debrief activity:

- Why do we study space?
- What makes studying space difficult?
- Why do scientific discoveries change over time?

Make connections to the Essential Question:

- Consider our Essential Question. How might scientists find answers to their questions about space? How can we find answers to help our new alien friend?

Make broader connections:

- What might happen if scientists did not study space?

Accountability (Lab Notebook)

1. Why do scientists study outer space? Include evidence and reasoning to support your response. [3]

Scientists study outer space to grow our body of scientific knowledge and to benefit human interests. We want to understand the universe beyond our planet for many reasons. For example, we are very interested in finding out whether there is life on another planet that we could study or contact. Also, we are very interested in exploring the idea of humans' living on Mars someday. Scientific research gives us the information we need to pursue these projects and many others.

Scoring

1. Score based on the quality of the idea and the evidence for it. Use data from the Exit Ticket to gauge scholar effort and assess prior knowledge.

- How will you press scholars to improve their ideas and evidence?
- How will you help struggling scholars to express their ideas?

Lesson 2: The Beginning

Lesson Objective: Evidence suggests that the universe is expanding, and by considering the available evidence, we can determine that it used to be very small. Hypotheses or theories are only as strong as our best evidence for them. Materials Needed

- For each scholar: copy of Labeled Galaxy Field 1 and 2 (copied on transparency film), transparency marker, ruler

Prep

- Materials Prep:
    - Print the Labeled Galaxy Field 1 and 2 from the **Modeling the Expanding Universe Teacher Guide** (pages 44 and 45). Ensure worksheets are printed on transparency film.
- Intellectual Prep:
    - Review **The Origin of the Universe** article.
    - Review the **Modeling the Expanding Universe Teacher Guide** (pages 39–46).

What are scholars doing in this lesson?

- Scholars analyze different data sets to create a hypothesis on how the universe began. They are introduced to the current leading theory of the origin of the universe, the big bang theory.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain that Peeko has a lot of questions about his home planet and that you're confident that with some research and experimentation, we can find most of the answers. But one question is really puzzling him, because he's not sure how we could ever possibly answer it (unless we are time travelers): How was the **universe** created?
- What stories have you heard about the creation of the universe?

[**Tip:** This can be a sensitive subject because of scholars' own faith-based beliefs. Explain that in this unit, we will study this from a scientist's perspective. Our focus as scientists will be looking at the available evidence and seeing what we can infer.]

- How can scientists study the past?
    - Connect this discussion back to earlier units from this year, such as Earth's Materials. How did scientists learn about the dinosaurs and their extinction?
    - What "evidence" might remain from the creation of the universe?

Activity Adapted from "Modeling the Expanding Universe," pages 39–46 in **Cosmic Questions, Our Place and Space in Time: Harvard-Smithsonian Center for Astrophysics**.

- Scholars complete the following "Evidence of the Big Bang" activity:
    - Each scholar chooses a different galaxy and locates it in the galaxy field on the worksheet Labeled Galaxy Field 1.
        - Reminder: This is just an idealized map. Real galaxies are neither sized this regularly nor spread this regularly throughout the universe.

    - Scholars lay Labeled Galaxy Field 2 over Labeled Galaxy Field 1 and align the two so that their chosen galaxy is in the same place on both sheets. This simulates one second of universal galaxy motion.
        - Scholars take note of what they observe about how the other galaxies appear to have moved.
    - Scholars use a transparency marker to draw an arrow from each galaxy's position at time 00:00:00 to where it has moved 1 second later.
    - Scholars record their observations and answer questions in their Lab Notebooks.
- Collect all the copies of the Labeled Galaxy Field 2 transparencies. Pile a few transparencies on top of each other on the document camera and have scholars share their observations.
    - Scholars will notice that their classmates have drawn arrows in different directions for the same galaxies.
    - Is it possible for something to move at different speeds and directions at the same time? Is one set of data right and another wrong?
        - Ask scholars to explain this apparent contradiction. Confirm that everyone began with identical worksheets. What might be happening here?
    - Guide scholars to the understanding that the entire universe appears to be expanding. Explain that from any vantage point, it appears that everyone else is moving but you aren't. We can't feel ourselves or our own galaxy moving, so it appears to us that we're in the same place and that all the others have moved away from us.

[**Tip:** Provide scholars with a structured outline for note-taking. This is a difficult skill for scholars.]

- Scholars discuss:
    - What is happening to the universe?
    - Based on this evidence, what can you infer that the universe might have looked like a million years ago? A billion years ago? Ten billion?
- Scholars construct a hypothesis about the origin of the universe and explain how the available evidence supports their idea.
- As scholars are working, circulate and coach those who struggle to understand how to connect their findings to the past, present, and future states of our universe.

Discourse Debrief activity:

- Considering the evidence you were presented with, how do you think the universe looked many years ago?
- Based on the available evidence, how do you think the universe formed?
    - Is it difficult to agree on one idea? Why?

Make broader connections:

- What are the limitations of the modeling activity we used in class?
- Explain that because no one was here to witness it, scientists have had to piece together a picture of the early universe from the available evidence. We sometimes don't think about it, but this is what scientists do every day: They gather the available evidence and draw the most logical conclusions from it.
- Present the current leading theory: the big bang theory.
    - Review the NASA Space Place **website** together on a viewable screen.

Make connections to the Essential Question:

- After presenting the big bang theory, consider our Essential Question.
    - Are scientists positive that this is what really happened?
    - Why do scientists accept this theory if they're not positive it's correct?
    - What should we tell Peeko? Why?

[**Tip:** If your school has a BrainPOP account, showing the **Big Bang Theory** video (4 minutes and 16 seconds) is also a great option during this Discourse.]

Accountability (Exit Ticket) Directions: Read **"The Dark Side of the Universe"** and answer the questions that follow.

1. Describe one way in which the text supports our understanding of the formation of the universe. [2]

Scientists have found evidence that the universe seems to have been expanding outward in every direction since its creation. This article discusses how dark energy acts as the opposite of gravity and sends things flying apart, which might be the reason why our universe is expanding.

2. In relation to us, most galaxies are ___________. [1]
    1. moving toward us
    2. not moving
    3. moving away from us
    4. exploding

Scoring

1. Award points as follows:
    - One point for an accurate/reasonable claim (must demonstrate understanding that the universe has been expanding since its formation)
    - One point for a logical connection from their claim to the text (most likely will address how dark energy may be related to the expansion of the universe)

2. Award one point for selecting answer C.

Lesson 3: Our Universe, to Scale

Lesson Objective: Scholars have a more robust appreciation for the truly astonishing scale of the universe. They are familiar with the common units used to describe distances in space. Applying their understanding of the scale of the universe, they are able to articulate the usefulness of these units. Scholars will recognize the interactives they used in class as scale models, which will support their understanding as they design their own scale models in the next lesson. Materials Needed

- For the teacher: the **Pale Blue Dot** video loaded on a viewable screen
- For each scholar: computer/device, ruler

Prep

- Materials Prep:
    - Email sources in advance for scholars' independent viewing or partner work.

What are scholars doing in this lesson?

- Scholars explore the vastness of the universe using two online interactives to create a relative scale of the universe.

Do Now

- Follow the **Do Now plan**.

Launch

- Show the **"Pale Blue Dot"** video (3 minutes and 30 seconds).
    - Why is Earth referred to as "the pale blue dot"?
    - How big do you think the rest of the universe is compared to the Earth?
    - Introduce and define the concept of **scales** and **scale models**.
- Peeko is curious about the size of our universe and wonders if he can take a tour to the edge of the universe and back after his visit on Earth. Today we will investigate the size of outer space to help him answer his question.

Activity

- Scholars explore the following interactives on their computers or devices:
    - **Universcale**
    - **Interstellar Trip Planner**
- Scholars record their observations and create their own diagrams showing the relative scale of major components of our universe (planets, stars, solar systems, galaxies, etc.).

- As scholars are working, circulate and ask them to share what surprises them about the scale of the universe. Press them to then evaluate the usefulness of a scale model over something such as an annotated diagram of all the objects in the universe.

Discourse Debrief activity:

- What did you learn about the scale of the universe?
- How do you think scientists determined the sizes of the bodies in space and the distances between them?

Make connections to the Essential Question:

- Return to the question in the Launch.
    - How can we answer Peeko's question?

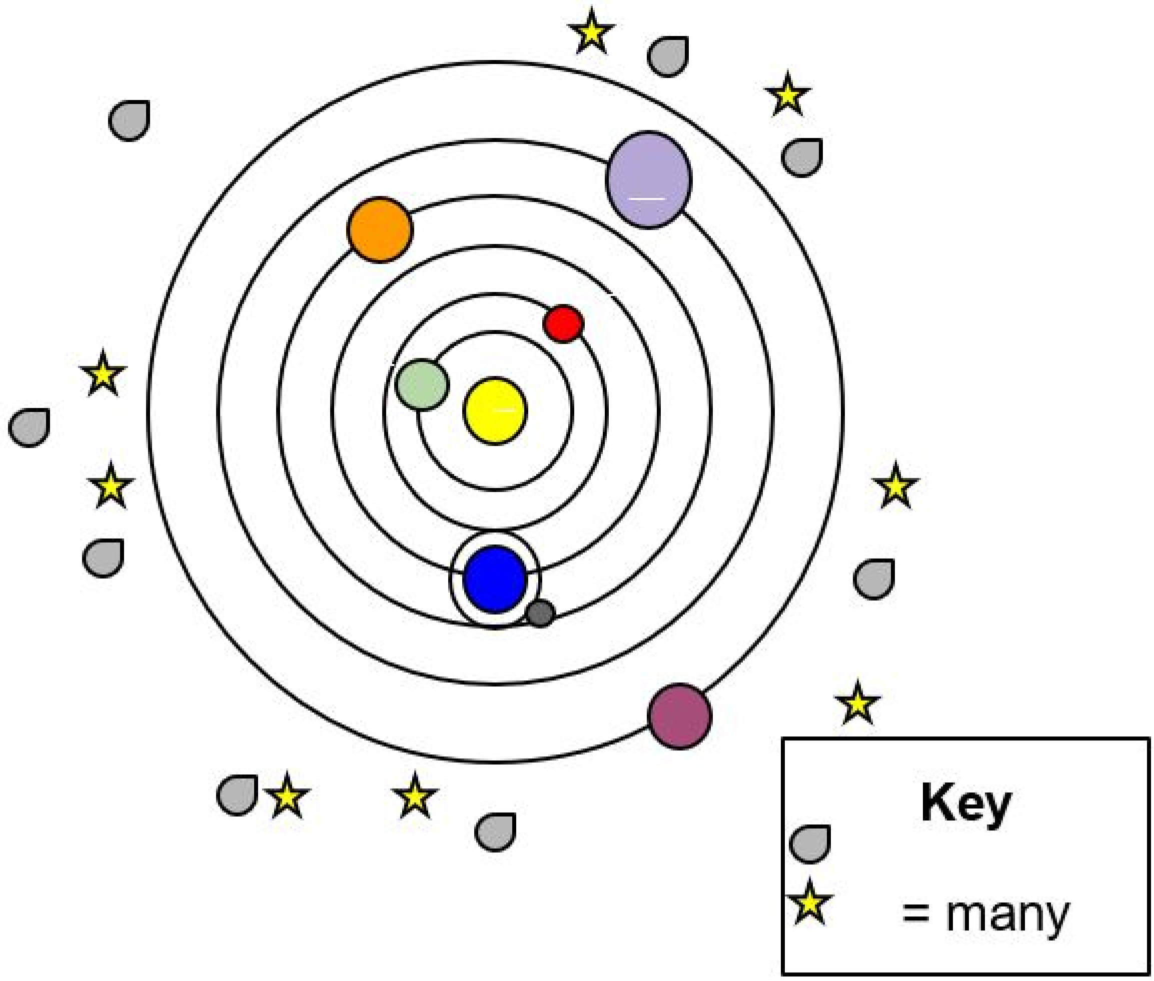
Make broader connections:

- Why do we have separate units of measure for space? What are they?

[**Tip:** Ensure **astronomical units** and **light-years** are introduced during this Discourse, as scholars will need familiarity with them for the next lesson.]

- We learned in the last lesson that scientists have found evidence that the universe is expanding in size. How will this affect the scale models we saw today in the future?

Accountability (Exit Ticket) Directions: Lucy created a model of part of the universe as part of a homework assignment for science class. Her model is shown below.



1. Is Lucy's model a scale model? Include evidence and reasoning to support your response. [3]

Lucy's model is not a scale model. Scale models use consistent proportions for relative mass or relative distance of different objects, and Lucy's does not. For example, her model shows that Jupiter is larger than the Sun.

2. If Lucy wants to represent a model of the universe 5,000 years ago, what would change in her model, above? [1]
    1. The many galaxies and solar systems would be farther away from the Sun, but the planets would remain in the same position.
    2. The many galaxies and solar systems would be closer to the Sun, and the planets would be farther from the Sun.
    3. All objects in her model would be closer together.
    4. All objects in her model would be farther from the Sun.

Scoring

1. Award points as follows:

    - One point for identifying that the model is not a scale model
    - One point for evidence from the model that supports which aspects do not represent consistent proportions
    - One point for a justification/reasoning that further explains how scale models accurately represent relative mass or distance of objects

2. Award one point for selecting answer C.

Lesson 4: Our Solar System, to Scale

Lesson Objective: Scale models serve a specific purpose for scientists, allowing them to conduct research on objects or bodies that are too large or too small to experiment on directly. Scale models differ from other models and will understand that models inherently have limitations.
Materials Needed

- For each scholar: piece of register tape (approximately 1 meter long), 1 can of playdough, calculator, ruler

Prep

- Materials Prep:
    - Cut a strip of paper measuring a little more than 1 meter long for each scholar. (The measurement need not be exactâ€" it's okay to estimate using your arm span.)

What are scholars doing in this lesson?

- Scholars are challenged to create their own scale model, this time of our solar system! They choose to focus on either the scale of the planets or the scaled distance between the planets.

Do Now

- Follow the **Do Now plan**.

Launch

- During the last lesson, we saw several scale models of the universe. What is a scale model used for?
- Peeko now knows that a trip to the edge of the universe is out of the question, but he's hoping to take a tour of our solar system instead. To plan his trip, he needs to get a better idea of the scale of our solar system.

Activity

- Scholars use the data in their Lab Notebooks to create a scale model of the solar system. Groups may plan together, but each pair should make their own model.
    - Provide scholars with calculators during this activity.
    - If scholars are struggling after the first 15 minutes, have two or three scholars who've developed mathematically sound procedures share their thinking.
- As scholars are working, circulate and coach struggling scholars. Help them develop a procedure for scaling quantities down and have them record and follow that procedure repeatedly until all measurements are complete. Do not simply give a formula to scholarsâ€" they must understand scale models conceptually.

[**Parent Investment Tip:** Once scholars are finished with their models, allow them to take them home to show their families.]

Discourse Debrief activity:

- How did you create your scale model?
- What are we able to see using the scale model that we could not see with an annotated diagram?

Make connections to the Essential Question:

- Return to the question in the Launch.
  - Will your scale model be useful for Peeko as he plans his trip? Why or why not?
    - What are the limitations of your model?
    - What additional information might Peeko need to research to plan his trip?

Make broader connections:

- What would we need to do to make a combined scale model (distance + size)?
  - One major limitation of these models is that they cannot combine both the relative sizes of the planets and their distances from each other. If time allows, you can use a flex day to create a true scale model as a class. (Note that this requires approximately 45 minutes and includes walking several blocks from the school building.)

Accountability (Exit Ticket)

- Note that scholars will need a ruler to complete this Exit Ticket.

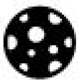
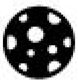
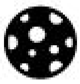
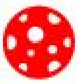
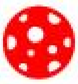
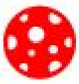
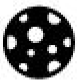
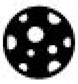
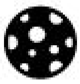
A team of researchers are studying a planet called Lallan. They collect the following data about Lallan's moons:

Table 1: Moons Orbiting Lallan			
Moon	Sphera	Ellisi	Bonba
Distance from Lallan	50 million km	125 million km	150 million km
Mass	2 billion kg (2,000,000,000 kg)	4 billion kg	3 billion kg
Other Details	The planet Lallan has two thin rings around it.		

1. In the space below, construct a scale model to show the distances between Lallan and its moons. Label the planet and each moon. [5]

Identify the scale of your model here: _____2____ ___cm______= ____50 million_____ km
(number) (unit) (number)

2. Which of the models below would <u>not</u> be considered an accurate scale model of the moons orbiting Lallan according to their masses? [1]

    1. Sphera  Ellisi  Bonba 
    2. Sphera  Ellisi  Bonba 
    3. Sphera  Ellisi  Bonba 

Scoring

1. Award points as follows:

    - One point for all components being present and labeled (Lallan and all three moons)
    - One point for all components being in the correct order (Starting from Lallan, the order should be Lallan, Sphera, Ellisi, and Bonba. These may be in different locations in orbit or in a line in accordance with the design of the scholars' model.)
    - One point for a reasonable scale identified below their model
    - Two points for each of the moons and the planet drawn in the correct locations in accordance to the defined scale (allow a range of +/− 3 mm)

        - <u>Note: Partial credit may be awarded if two to three of the four bodies are drawn in the correct locations according to the scale.</u>

2. Award one point for selecting answer B.

Lesson 5: Pieces of the Universe

Lesson Objective: There are many types of celestial bodies in outer space and patterns in the organization of our solar system. Our solar system consists of a central star and a collection of other bodies held in orbit by gravity. Scholars understand that because we have not yet traveled outside our solar system, scientists have gathered evidence about the rest of the universe by studying available dataâ€" some of which comes in the form of images from strong telescopes such as the Hubble. However, this dependence on satellite imagery means we can only see as far as our tools allow us to. Materials Needed

- For each scholar: computer

Prep

- Materials Prep:
    - Distribute the NASA **website** via email in advance.

[**Tip:** Consider giving extra reading material on different celestial bodies such as asteroids, comets, dwarf planets, and other small bodies for scholars to read for homework!]

What are scholars doing in this lesson?

- Scholars use a Hubble Deep Field telescope interactive to determine the different celestial bodies that make up the universe.

Do Now

- Peeko has noticed that in addition to his home planet and its star there are many other objects in his solar system. He is wondering what they are and how he can identify them.
- Besides the Earth, the Sun, and the Moon, what other objects are in our solar system?
- Have scholars complete independent/partner research to collect information about the different components of our solar system and record their information in data tables in their Lab Notebook.
    - The research organizer in their Lab Notebook outlines the information they need to obtain for each planet and space object in our solar system.
    - All information can be found on the **NASA Solar System Exploration website**, but other sources can be used at the teacher's discretion.
- When all information has been collected, scholars come together as a class to share information.
    - As their classmates share, scholars record key information about each object in their graphic organizers.

*Note: During the Do Now, scholars are introduced to several new vocabulary terms: **star**, **planet**, **moon**, **asteroid**, **comet**, **dwarf planet**, **meteor/meteorite**.*

Launch

- During the Do Now, you learned more about the different **celestial bodies** that can be found within our solar system. But what lies outside our solar system? What fills the rest of the universe? Today you will complete the Hubble Deep Field Academy simulation to find out.
- Provide scholars with a brief introduction to the Hubble **telescope** by exploring the **What Is the Hubble Space Telescope? website** on a viewable screen as a class.

Activity

- Scholars examine Hubble Deep Field imagery in order to analyze what our sky is actually showing us and what we can learn from satellite imagery.

- Scholars complete The **Hubble Deep Field Academy** simulation.
    - They start with the orientation and continue through the “Cosmic Classifier” level.
    - Scholars with time may proceed farther in the simulation or explore the **Hubble Telescope website**.
    - All scholars maintain a log of their work within their Lab Notebook.
- As scholars are working, circulate and ask them to identify the patterns they notice among various stars, galaxies, and solar systems.
    - What do all galaxies seem to have in common?
    - What do all solar systems have in common? Continue to promote discussion that will reinforce scholars’ understanding of these systems in our universe.

*Note: During the lesson, scholars are introduced to several new vocabulary terms: **galaxy**, **elliptical galaxy**, **spiral galaxy**, **irregular galaxy**.*

Discourse Debrief activity:

- Review information from the Do Now.
    - How do the inner planets and outer planets differ?
    - In what ways is Earth unique?
    - What patterns exist within our data?
    - How do the other space objects compare to planets?
- What are the levels of organization in our universe?

Make connections to the Essential Question:

- How can we answer Peeko’s question?

Make broader connections:

- How does the Hubble telescope help scientists to learn more about parts of the universe they can’t visit?
- Describe the limitations of using the Hubble telescope to study bodies outside our solar system.

Accountability (Exit Ticket)

1. What do all the planets in our solar system have in common? Explain why. [2]

All planets orbit the Sun. The Sun is a massive star, and it holds the planets in orbit by its gravitational pull.

2. Choose five terms from the list below and place them in order from smallest to largest. [2]

List of terms: galaxy, comet, planet, Moon, the Sun, our solar system, the universe, dwarf planet

planet → the Sun → solar system → galaxy → universe

3. Which statements below are <u>false</u>? [1]

1. The universe has three different types of galaxies classified by their color.

---

2. Our solar system is older and smaller than the universe.

---

3. In our solar system, planets orbit a moon and that planet orbits the Sun.

1. I only
2. II only
3. III only
4. I and II
5. All statements

Scoring

1. Award points as follows:
   - One point for an accurate claim: e.g., all orbit the Sun
   - One point for a reasonable explanation for the identified property. (Scholars may receive full credit for an inaccurate idea that is logical given their current level of understanding, but teachers should circle back to scholars to let them know if their ideas are actually misconceptions.)
2. Award points as follows:
   - Two points for five terms from the list ordered correctly from smallest to largest in relative size
     - Award partial credit for three or four correct answers.
     - Award zero credit for two or fewer correct answers.
3. Award one point for selecting answer E.

Lesson 6: Is the Sun the Largest Star?

Lesson Objective: An observer's proximity to a star can affect the star's apparent size and brightness, with those farther away often appearing smaller and dimmer. However, stars themselves also vary in their size and brightness, which can create differences in their appearance. Our Sun is not the largest or brightest starâ€" in fact, it's not even close! Materials Needed

- For each group: 1 large flashlight, 2 small flashlights

Prep

- Materials Prep:
    - If possible, reserve a large room (such as an auditorium or gym) for this activity.
    - Ensure all flashlights have working batteries.

What are scholars doing in this lesson?

- Scholars use flashlights as a model to understand why stars are observed in varying sizes and levels of brightness.

Do Now

- Follow the **Do Now plan**.

Launch

- What is the biggest star you see each day?
- Do you think the Sun is the largest star in the universe? Why or why not?
- Peeko is wondering why some stars in the night sky look bigger and brighter than others. Today your challenge will be to find an answer.

Activity Adapted from **NASA's Sun as a Star Science Learning Activities for Afterschool Educator Resource Guide**

- Using two small flashlights and one large flashlight, scholars develop models to help them discover the potential cause(s) of the apparently varying sizes and brightness of stars. While working, they consider the following guiding questions:
    - Which light has the largest beam? Can you make all the beams appear to be the same size? How?
    - Which light shines most brightly on the wall or floor? Can you make all the beams look equally bright? How?
    - Can you make the two identical flashlights appear to be of different sizes and brightness? How?
    - What do your findings make you think about the apparent size and brightness of the stars in the night sky? What does this tell you about their distance from Earth?
- Scholars write an explanation of how their model demonstrates these concepts. They also evaluate the limitations of their models.
- As scholars are working, circulate and discuss with them the strengths and limitations of their models.

Discourse Debrief activity:

- Allow scholars to demonstrate and show off parts of their model during Discourse.
- What are the limitations of your model?

- Review the types of stars commonly seen in our universe on the **Different Types of Stars in the Universe website** as a class. Highlight the differences in their color, mass, and volumâ€" scholars will quickly notice that even though our Sun appears to be the largest star in the sky, it actually isn't.

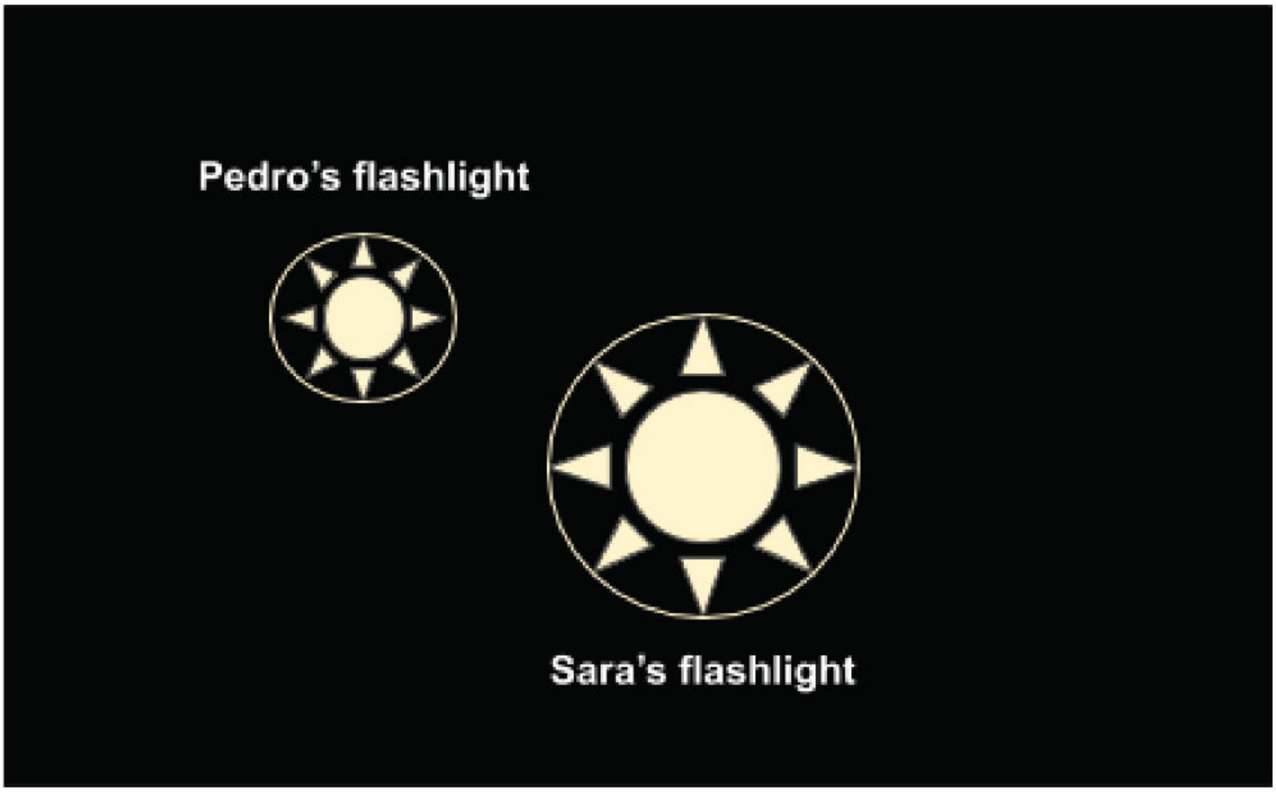
Make connections to the Essential Question:

- Generally, what might Peeko assume to be true about a star that looks bigger? What about a star that looks brighter in the sky? How did your model help you to develop these ideas?

Make broader connections:

- Why are models important to scientists?

Accountability (Exit Ticket) Directions: Ijahni is playing flashlight tag with two friends in his backyard at night. He sees the beams of his friends' flashlights, as shown in the diagram below.



1. Based on what Ijahni sees, which friend is likely closer to him? Include evidence and reasoning to support your response. [3]

Sara is closer to Ijahni. In the picture of the backyard, Sara's flashlight beam looks larger than Pedro's. Similar to the celestial bodies in our universe, when a light source is closer, it looks larger, and when it is farther away, it looks smaller.

2. Which of the following could be evidence that both Pedro and Sara are standing at the same distance from Ijahni? [1]
    1. Sara has a smaller flashlight than Pedro.
    2. Pedro has a smaller flashlight than Sara.
    3. Pedro has a more powerful flashlight with new batteries.
    4. Sara has a less powerful flashlight with old batteries.

Scoring

1. Award points as follows:

   - One point for an accurate claim that identifies Sara as being closer
   - One point for evidence that supports the claim (must reference the relative size and/or brightness of the beams)
   - One point for a justification that ties the evidence to the claim using accurate information from class

Note: Scholars may argue that it is impossible to say, as the perspective of the observer makes it difficult to say for sure which star is closest. In this scenario, Sara's flashlight may in fact be farther away than Pedro's, but Pedro has a smaller/less powerful flashlight. Responses of this nature may receive credit as long as they reflect a clear understanding of how the apparent size/brightness of a light can change.

2. Award one point for selecting answer B.

Lesson 7: The Celestial Dance

Lesson Objective: Like the Sun, other stars in space only *appear* to move relative to the Earthâ€" in fact, Earth's own movement creates that illusion. Scholars know the significant role that the night sky played for early navigators and will have had a refresher on their elementary school knowledge of Earth's rotation and revolution.

Materials Needed

- For the teacher: the **"How Did Early Sailors Navigate the Oceans?" video** loaded up on a viewable screen
- For each scholar: copies of the Star Wheel cutouts (**disk** and **sleeve**), scissors, tape, or stapler

Prep

- Materials Prep:
  - Print a copy of the Star Wheel materials for each scholar.
  - Create a few extra Star Wheels in advance in case scholars need them during the Investigation (instructions in Investigation below).
- Intellectual Prep:
  - Read about **Why the Night Sky Changes with the Seasons** throughout the year.

What are scholars doing in this lesson?

- Scholars use constellations in a new model to determine the organization of the stars in the night sky throughout the course of a year.

Do Now

- Follow the **Do Now plan**.

Launch

- Ask scholars to share the information they recall about the Earth–Sun–Moon system. Focus on the following:
    - Does the Earth move relative to the Sun? In what ways? How fast does it move?
    - Does the Moon move relative to the Earth?
    - What effects of Earth's movement can we see in our daily lives?
    - What effects of the Moon's movement can we see in our daily lives?
- Chart scholar responses. Have the class discuss and clear up any misconceptions.
- Explain that scholars will need to apply their understanding from elementary school as they study a new phenomenon: the changing appearance of the night sky throughout the year.
    - Peeko has noticed that all the stars in the sky above his home planet seem to swirl around slowly, moving to different locations throughout the year. He wonders if they're dancing.
    - Scholars will create and study the organization of stars in the night sky at different times of year to determine whether or not the stars are moving relative to our planet.
    - Explain that the Star Wheel shows groups of stars called constellations.

Activity

- Scholars create a **Star Wheel** using the following procedure:
    - Take one circular sky map and one outer sleeve.
    - Trim away the gray corners of the sky map so you are left with a circle 8 inches across.
    - Take the outer sleeve and trim away the white border around the edge. **Do NOT cut the white rectangle off the bottom**. Simply trim along the black line when you get to that area. When you're done, cut out the white oval in the middle.
    - To make the Star Wheel, fold back the white rectangle at the bottom of the outer sleeve so it's underneath the front. Then staple or tape the rectangle to the front at the locations marked by short white lines to either side of the oval. Now slip in the circular sky map so it shows through the oval.
- By rotating the wheel, scholars can study the orientation of the night sky throughout the year.
- Scholars record their observations and use the model to determine whether they think the stars are moving relative to the planets. They record a conclusion and explain their evidence from using the model.
- As scholars are working, circulate and ask them to explain their conclusion with evidence.

Discourse Debrief activity:

- Have two or three scholars share their conclusions.
  - Ask the class to evaluate the strength of the evidence in each statement.
- Explain that relative to the Earth, the stars in the night sky are not moving. Like our own star, the Sun, they only appear to move because the Earth is moving.
  - Elicit prior knowledge. How does Earth move?

Make broader connections:

- Ask scholars to think about when they are riding in a car or on a bus. It looks like the trees, street signs, and everything else are moving quickly past youâ€” but of course it is you that's moving, not your surroundings.
  - You can show the **"View Out of Car Window, Switzerland" video** (2 minutes and 2 seconds) if helpful.
- Explain that because of the Earth's **orbit** (revolution), the night sky looks similar at the same time of year each year. This allowed people throughout history to use the stars for navigation at night?
  - Show the **"How Did Early Sailors Navigate the Oceans?" video** (first 2 minutes and 20 seconds).

[**Engagement Tip:** If time allows, read the Zodiac section from the **American Federation of Astrologers** website, which provides a simple explanation of the origin of the "zodiac signs" they see in horoscopes!]

Make connections to the Essential Question:

- Revisit the question from the Launch.
  - How can we answer Peeko's latest question?

Accountability (Lab Notebook) Have scholars revise their conclusions from the Activity after Discourse.

1. Are the stars moving relative to the Earth? Use evidence from the model to support and justify your response. [3]

The stars are not moving relative to the Earth. Earth's movementâ€” its rotation on its axis and its revolution around the Sunâ€— changes our position in space. This in turn changes the angle from which we view the stars, making it look as if the stars are in different places throughout the year.

Scoring

1. Award points as follows:
   - One point for an accurate claim identifying that the stars are not moving

- One point for evidence that supports the claim
- One point for a justification that ties the claim to the evidence (must demonstrate conceptual understanding of why it looks like the stars move)

Lesson 8: Total Eclipse of the Science Lab

Lesson Objective: Eclipses happen when the Moon, Earth, and Sun are in complete alignment. Because of the Earth's tilt on its axis and the Moon's tilted orbit, all three celestial bodies only come into complete alignment about once every 18 months. Materials Needed

- For the teacher: the **Solar Eclipse video** loaded on a viewable screen
- For each pair of scholars: meter stick, 1" styrofoam ball, ¼" round plastic necklace bead, 2 pointed toothpicks, 2 medium-sized binder clips, flashlight, bottle of all-purpose/school glue, 4Êº × 6Êº index card

Prep

- Materials Prep:
    - Ensure all flashlights have working batteries.
- Intellectual Prep:
    - Read the information on NASA's **What Is an Eclipse? website**.

What are scholars doing in this lesson?

- Scholars create a scale model of the Earth and the Moon to determine how lunar eclipses occur.

Do Now

- Follow the **Do Now plan**.

Launch

- Show scholars examples of **partial** and **total** lunar eclipses as they appear from Earth.
    - Scholars record their observations independently and then share as a group.
- Explain that there are eclipses on Peeko's home planet but that Peeko does not know the cause of these phenomena.
    - Ask scholars to share what they think they already know about eclipses and their causes. Do not confirm the accuracy of any ideas yet.
- Ask scholars to independently draw the configuration of the Earth, Sun, and Moon that they think would cause a lunar eclipse to occur.

- Explain to scholars that they will be provided with materials to create their own models, with the Earth and Moon to scale, to determine the cause of a partial or total lunar eclipse.
- Frontload the following information and allow scholars to record it in their Lab Notebook:
    - The diameter of the Moon is about one-quarter of the Earth's diameter.
    - The distance between the Earth and the Moon is approximately as far as 30 Earth diameters.

Activity Adapted from **"Exploring Lunar and Solar Eclipses via 3D Modeling Design Task"** by Rommel J. Miranda, Brian R. Kruse, and Ronald S. Hermann published in *Science Scope* (October 2016)

- Scholars use the provided materials to make a scaled model of the Earth and the Moon.
    - Scholars clearly draw and label their 3D model of the Earth–Sun–Moon system in their Lab Notebook.
    - They describe the specific procedures they used to construct their 3D model in their Lab Notebook.
    - Scholars use their models to discover the causes of both partial and full lunar eclipses.
- As scholars are working, circulate and ask them to explain the parts of their model and what they represent. Then, ask them to show you how they think an eclipse happens and to explain, with evidence, how the model shows them that.

[**Tip:** Close all classroom blinds and turn off the lights during part of the activity so scholars can experiment with their models.]

Discourse Debrief activity:

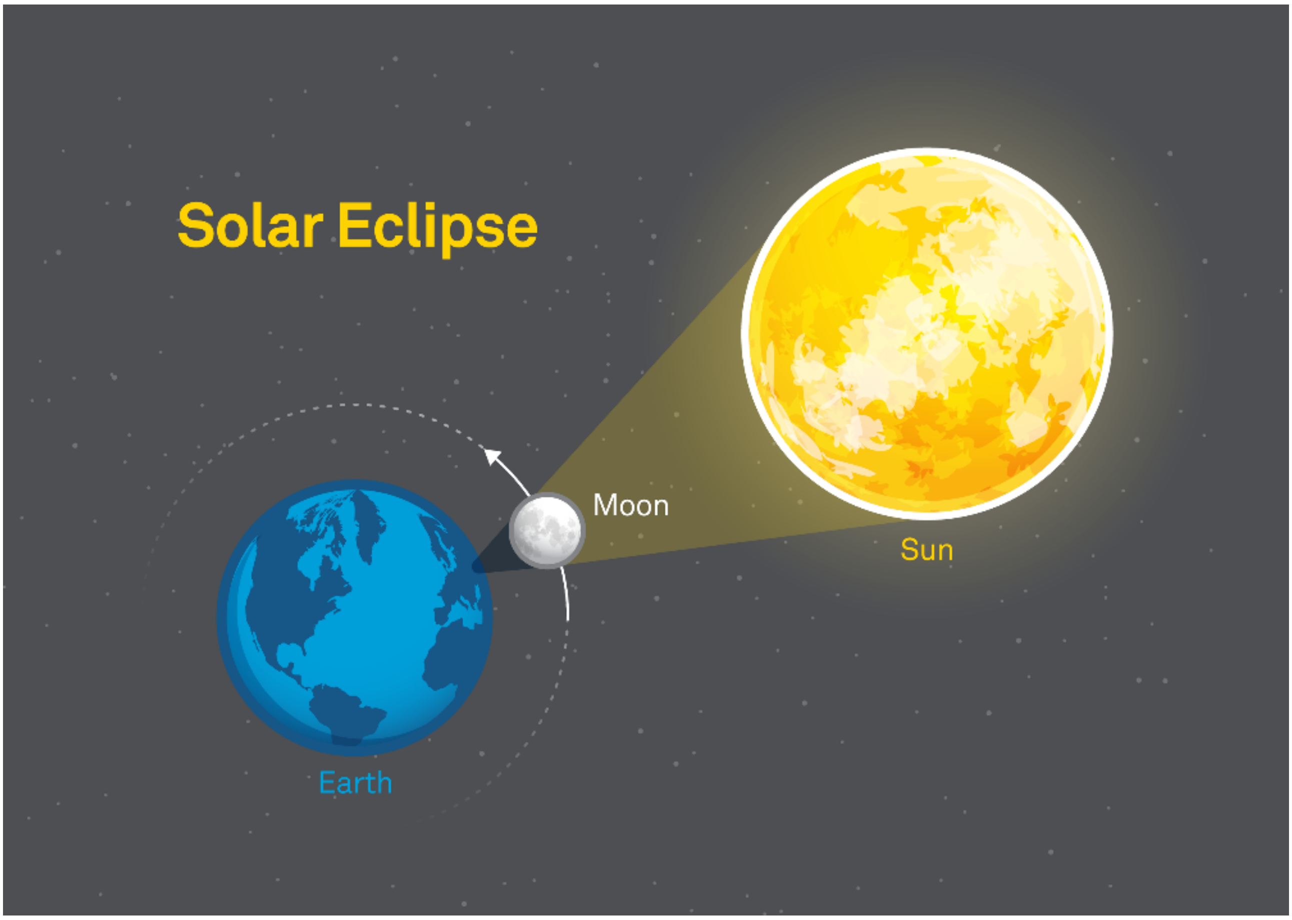
- How was your group able to discover the causes of **partial** and **total lunar eclipses** through modeling?
    - What were the strengths of your models? What were their limitations?

Make connections to the Essential Question:

- What happened to create the **eclipses** Peeko observed?

Make broader connections:

- Given your new understanding of lunar eclipses, look at these photos and this **video** (1 minute and 1 second) of the progression of a total solar eclipse. What do you think causes a solar eclipse?
    - Explain that a solar eclipse occurs when the Moon passes between the Sun and the Earth, temporarily blocking out part (or, rarely, all) of the Sun, as shown in the diagram below:



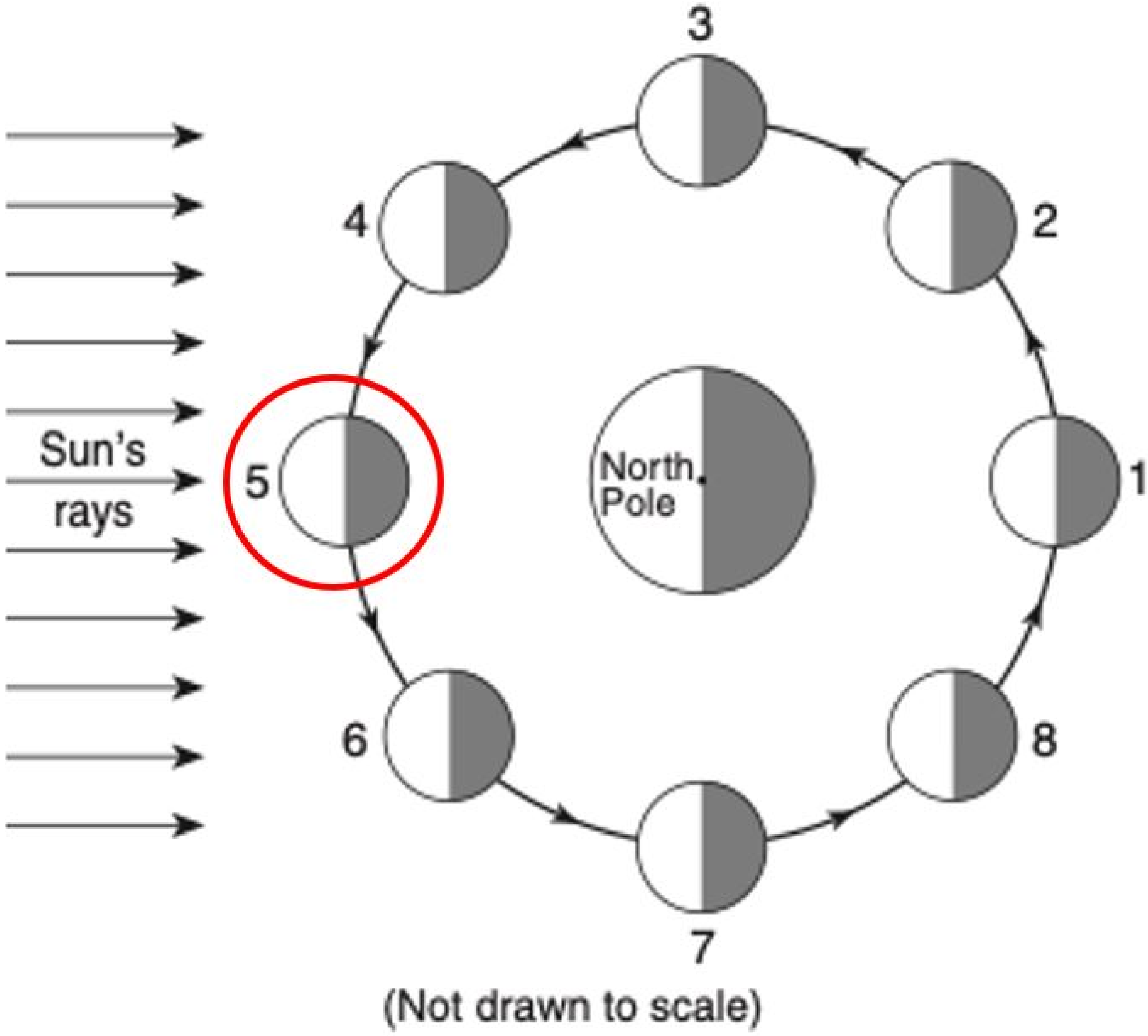
- Tie in yesterday's conversation about how the Earth revolves around the Sun and extend it to how the Moon revolves around the Earth
- Show the **Solar and Lunar Eclipses Worldwide - Next 10 Years website** on viewable screen. Explain that this resource can tell you when eclipses will occur anywhere on Earth.
    - How are scientists able to predict eclipses before they happen?
    - If the Moon goes around the Earth every 28 days, why don't we see eclipses each time?

[**Engagement Tip:** Find the date of the next eclipse that will be visible in your location and post it in your classroom. After it occurs, allow scholars to share their observations during the next science class!]

Accountability (Exit Ticket)

1. In the box below, draw the positioning of the Earth, Sun, and Moon during a total lunar eclipse. Label each body. Your drawing does not need to be to scale. [2]

2. Which of the following affects the timing of a lunar eclipse? [1]
    1. The composition of Earth's atmosphere
    2. The tilt of the Earth on its axis and the tilt of the Moon's orbit
    3. The position of the Moon in its orbit around Earth
    4. The gravitational pull of the Sun
    5. Both B and C
3. The diagram below represents Earth as viewed from above the North Pole. The nighttime side of Earth and the Moon have been shaded. The Moon is represented in eight positions in its orbit around Earth. Identify the Moon's position where a solar eclipse might be observed from Earth by circling the number on the diagram. [1]



Adapted from the New York State Education Department. Science Regents Examinations: Physical Setting/Earth Science, June 2017. Available from **https://www.nysedregents.org/earthscience**.

Scoring

1. Award points as follows:

   - One point for the Earth, Sun, and Moon being present and labeled
   - One point for the bodies that are correctly oriented, as shown in the exemplar diagram above

2. Award one point for selecting answer E.
3. Award one point for circling position 5 on the diagram.

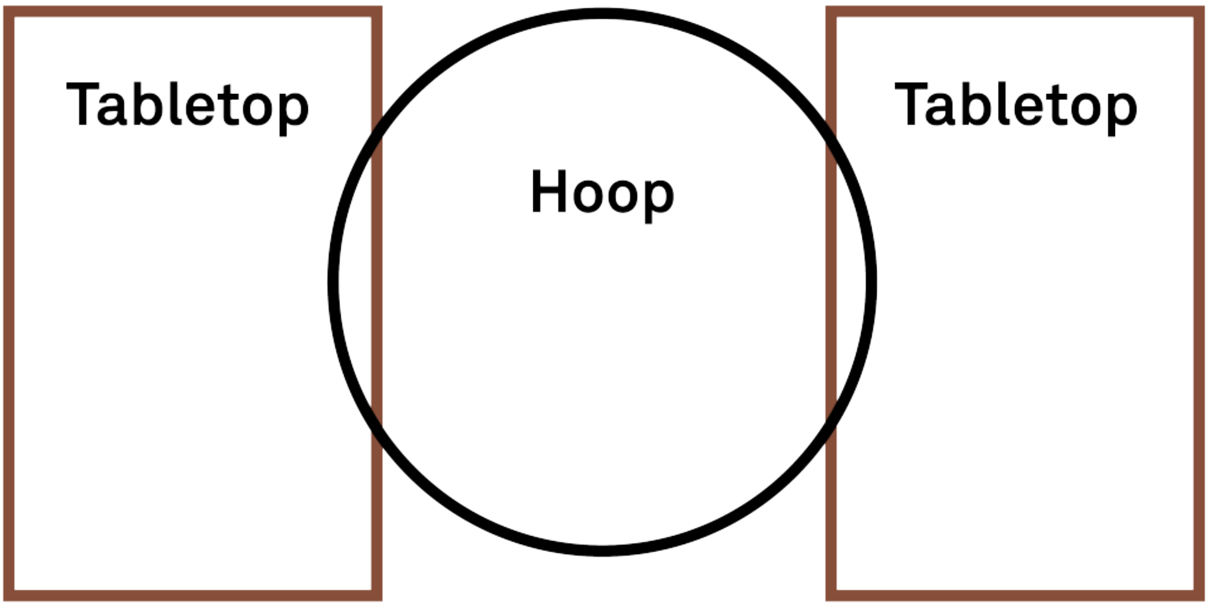
Lesson 9: Invisible Forces

Lesson Objective: Gravitational forces are responsible for the organization of celestial bodies and other objects in space. There is a direct relationship between mass and gravitational pull and an inverse relationship between distance and gravitational pull. Materials Needed

- For the teacher: spandex fabric (approximately 8 yards), large binder clips (about 100 clips), 8 Hula-Hoops
- For each group: triple beam balance scale, 1 Hula-Hoop model (made using teacher materials above), 3 or 4 foam bricks or books (optional to prop up Hula-Hoops), 8 marbles (at least 2 different sizes), 1 , 2 golf balls, 2 Ping-Pong balls, 2 billiard balls
- For each scholar: computer/device

Prep

- Materials Prep:
    - Create the Hula-Hoop “space-time” models using the following guidelines:
        - Stretch approximately 1 yard of spandex fabric tightly over a Hula-Hoop.
        - Attach the fabric to the Hula-Hoop using large binder clips. The fabric should be taut and springy.
    - Arrange the tables in the classroom so you can suspend the Hula-Hoops between pairs of tables. The edges of each Hula-Hoop should rest gently on the edges of the tables so as much of the Hula-Hoop as possible lies over the opening between the tables, as shown below.



[**Materials Tip:** Billiards balls, golf balls, and marbles must be handled with care. Model how to send objects “into orbit” and carefully supervise all objects placed “into orbit.”]

- Intellectual Prep:
    - Before this lesson, use flex time to teach scholars how to use a triple-beam balance scale. Allow them to practice measuring the mass of small objects around the classroom.
    - Complete the **Gravity and Orbits PhET Simulation** to intellectually prepare for the lesson. Identify areas where scholars may struggle, and create a plan to coach them in advance.
    - Preview a larger version of the lab setup by watching the **“Gravity Visualized” video** (9 minutes and 57 seconds).

What are scholars doing in this lesson?

- Scholars explore two models to determine how gravity impacts the organization of celestial bodies in the universe.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain that Peeko has yet another question! He has noticed that his home planet seems to float around its star, and he wonders why the entire planet doesn’t just fly away into space.
    - Scholars will likely respond that this is related to gravity. Ask scholars to define gravity independently.
        - Call on scholars to share their definitions. Record common themes on a viewable screen.
- Explain that scholars likely have an incomplete picture of gravity, and that today they will learn more about it as they discover how it affects the organization and movement of objects in space.
- Frontload the following information:
    - **Gravity** is an attractive force between objects with mass.
        - Explain that every object with massâ€” yes, even our bodiesâ€” has a gravitational field. Scholars may wonder, then, why objects aren’t zooming across the room into their hands at that very moment. You can allow them to share their ideas, but do not reveal the answer to this, as scholars will discover the relationship between mass, distance, and gravitational pull during the lab.
    - Gravity is responsible for keeping objects in orbit.

- Explain to scholars that through the use of two models (one physical model and one computer simulation), their challenge will be to determine the factors that can increase or decrease the strength of the gravitational force between objects.
- Give a quick demonstration of how to use the Hula-Hoop models with two balls. Ask scholars to imagine that the balls are celestial bodies, and show them how to (safely) make one body orbit another.

Activity Adapted from NASA's **Create Your Own Gravity Well Activity** and "Gravity and Orbits" from **PhET Interactive Simulations**, University of Colorado Boulder

- Scholars use the materials to model the interactions between bodies in space and discover the factors that affect gravitational force.
- Leave one triple-beam balance out for each group to calculate the mass of the balls as needed to collect data.
    - As scholars are working, circulate and press them with the following guiding questions:
        - What happens if you put a more massive ball in the middle and a less massive ball into orbit?
            - Is that true for every possible combination of larger and smaller balls?
            - What happens when you put a less massive ball in the middle and a more massive ball into orbit? Why?
            - Do you think mass affects gravitational force?
        - What happens if you put a larger ball in the middle and a smaller ball into orbit?
            - Is that true for every possible combination of larger and smaller balls? Do you think size affects gravitational force?
        - Is there a difference in the way an object orbits when it is closer to the center object versus farther away? Why do you think that is?
- Introduce scholars who finish early to the following challenge:
    - Model the Earth–Moon–Sun system:
        - Can they use their materials to create two simultaneous orbits (the Moon around the Earth and the Earth around the Sun) in the same model?
- Allow scholars to explore with the materials to discover other phenomena they can modelâ€" dual stars, multiple orbits, etc.

- Approximately halfway through the Investigation, scholars switch to explore the **Gravity and Orbits PhET Simulation**.

    - Provide a quick model on a viewable screen and then allow scholars to explore the simulation:

        - Scholars should primarily be using the Earth/Sun option.
        - Ensure the blue gravity arrow is onâ€" and explain that the length corresponds to the force of gravity.
        - Ensure the Path button is on.
        - Without manipulating settings, scholars watch the simulation and record initial observations (e.g., circular path, 365 days to complete revolution).
        - Scholars then manipulate the following settings, one at a time:

            - Mass of star
            - Mass of planet
            - Distance of planet to Sun (Manipulate distance between objects by clicking and dragging the object to desired location.)
            - Gravity turned off (Manipulate distance between objects by clicking and dragging the object to desired location.)

        - Scholars record what changed about the simulated motion when various factors were altered. They connect this back to the broader investigative question: What factors affect the gravitational force between objects?

- As scholars are working, circulate and ask them to compare and contrast the two models. What did they learn from each model? Would one model be more useful than the other for learning about a particular topic? What's their evidence?

Discourse Debrief activity:

- Based on the lab activity, what factors do you think affect gravitational force? What's your evidence?
- Based on the computer simulation, what factors do you think affect gravitational force? What's your evidence?

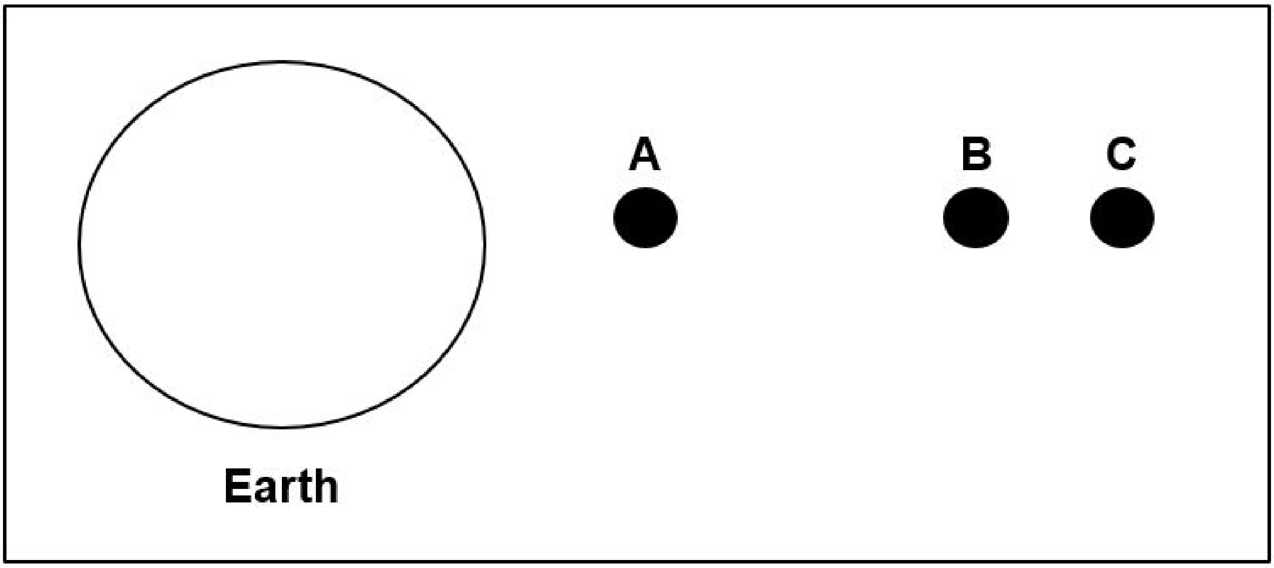
    - As scholars conceptually explain them, introduce and define **direct** and **inverse relationships**.
    - Which model better helped you to discover the answer to our investigative question? Why?
    - What were the strengths and limitations of each model?
    - Revisit the question from the Launch of this lesson: If we have gravity, why aren't objects zooming across the room toward us?

[**Tip:** When scholars are answering the first two questions, it's a good idea to have a set of materials under the document camera and a copy of the simulation on a viewable screen to allow demonstration and dispel any lingering misconceptions.]

Make connections to the Essential Question:

- Revisit Peeko's question. How should we answer it?

Accountability (Exit Ticket) In the diagram below, the letters A, B, and C represent three identical satellites and their relative distances from Earth as seen from space. Use this diagram to answer the questions that follow.



1. Which satellite would experience the strongest pull from Earth's gravity? Include evidence and reasoning to support your response. [3]

Satellite A would experience the greatest pull from Earth's gravity. Even though all three satellites have the same mass, Satellite A is the closest to Earth. As distance between two objects decreases, the force of gravity increases.

2. If a fourth satellite, Satellite D, was found at the same distance from the Earth as Satellite A but had twice the amount of mass, which of the following would be true? [1]
    1. Satellite A would feel the pull from Earth's gravity more strongly than Satellite D.
    2. Satellite D would feel the pull from Earth's gravity more strongly than Satellite A.
    3. Satellites A and D would experience an equally strong pull from Earth's gravity.

Scoring

1. Award points as follows:

    - One point for identifying Satellite A as experiencing the strongest pull from Earth
    - One point for including evidence from the diagram that Satellite A is the closest to Earth compared to the other satellites and that the mass does not impact the pull because all three have the same mass
    - One point for justification/reasoning that ties the evidence to the claim (should further reason that as distance decreases, force of gravity increasesâ€" an inverse relationship)

2. Award one point for selecting answer B.

Lesson 10: Crash Landing

Lesson Objective: Certain conditions must be present for a planet to be habitable for life as we know it, including the ability to meet the basic needs of living things (nutrients, water, air, gravity, and a range of temperatures that is not too extreme for our survival). Materials Needed

- For each scholar: computer, the **Habitable World Analysis Sheet**

Prep

- Materials Prep:
    - Make a copy and email out in advance the **Solar System X** document for activity.
    - Preload the "transmission" into the **Robot Voice Generator website** (see the Activity below for reference).
- Intellectual Prep:
    - Read about the **Goldilocks Zone**.

What are scholars doing in this lesson?

- Scholars simulate a crash landing to determine the factors of habitability necessary for supporting life on a new planet.

Do Now

- Follow the **Do Now plan**.

Launch

- Peeko was wondering why the other planets around Earth don't seem to be home to any living things. Explain to scholars that they will investigate this further today through an exciting simulation.
- Pretend it is the year 2335, and you all have your spaceship driver's licenses. Congratulations!
- You are on a space voyage through hyperspace, but something goes terribly wrong just as you're flying through **Solar System X**.
    - Use the **Robot Voice Generator** to "transmit" the following message to scholars:
        - Attention! An emergency situation is occurring on this spacecraft. A critical leak in Sector 135-76-998 has resulted in imminent engine failure. This spacecraft must make an emergency landing to ensure passenger safety. This craft will self-destruct in 35 minutes.

    - In order to survive, you must determine the **habitability** of the planets and moons within the solar system based on the provided information and make a decision about where to land.
        - Define **habitable zone** and **atmosphere**.
    - You must assume that you will be unable to leave again once you land and will need a place where you can survive for several days until a rescue ship can reach you.

[**Engagement Tip:** Set a countdown timer as scholars are working and quietly play space-themed or suspenseful music (such as **this**) in the background.]

Activity

- Scholars complete the Habitable World Analysis in their Lab Notebook for each option presented.
    - Scholars evaluate their options, determine where they choose to land, and explain their decision in writing in their Lab Notebook.
- As scholars are working, circulate and look to see how they are evaluating the available options.
    - Are scholars selecting the best evidence when choosing whether to keep or eliminate potential destinations? If not, ask them to explain their decisions to diagnose the root cause and coach them accordingly.

Discourse Debrief activity:

- Where did your group choose to land? Why?
    - Why did you eliminate the other choices? Give specific examples.
        - Were any of the options perfect? If not, how did you weigh the available evidence to make your decision?
        - Are there any planets that may be able to support life but not human life? Why?
    - How might a planet's gravitational pull affect its ability to support life?

Make connections to the Essential Question:

- Return to the question in the Launch.
    - Explain Peeko's observation of our solar system.

Make broader connections:

- Many scientists are currently studying the visible universe, hoping to find signs of life on another planet. Because they cannot possibly explore every planet in detail, how do you think they decide which ones to look at more closely?
    - Explain how scientists target planets that appear to reside in the "Goldilocks Zone."

Accountability (Exit Ticket) A scientist looking for life in outer space is researching four planets from another solar system. He has gathered data about each planet and organized it in the table below. Of the four planets, he only has the time and money to research one, and he wants to choose the planet with the greatest chance of supporting life.

Planet	Atmosphere Present?	Mountain Ranges Visible?	Liquid Water Present?	Volcanoes Present?
A	Yes (helium, oxygen, carbon dioxide, and nitrogen)	Yes	No	No
B	No	No	No	No
C	Yes (nitrogen only)	No	Yes	Yes
D	Yes (helium, oxygen, carbon dioxide, and nitrogen)	Yes	Yes	Yes

1. Given the data available, which planet would be most likely habitable for life? Include evidence and reasoning to support your response. [3]

Planet D would be most likely to support life. Planet D has both liquid water present and an atmosphere with oxygen and carbon dioxide. Living things on Earth need water and air to survive, so I think Planet D provides the right environment for sustaining organisms.

2. What additional data would be helpful in determining the habitability of a planet? [1]
    1. Gravitational pull
    2. Temperature
    3. Presence of moons
    4. Both A and B

Scoring

1. Award points as follows:
    - One point for an accurate claim identifying Planet D as the most likely to support life
    - One point for evidence from the data table that supports the claim
    - One point for justification/reasoning that ties the evidence to the claim (must reference the needs of living things)
2. Award one point for selecting answer E.

Note: Scholars may receive partial credit if they have an incorrect claim but accurate evidence and/or justification.

Lesson 11: A Cosmic Finale

Lesson Objective: Scholars have a much better understanding of the composition of our universe and the laws that govern the behavior of the celestial bodies that surround us. Scholars also have improved their ability to evaluate materials and create and use models. Materials Needed

- For each scholar: ruler, paper, colored pencils

What are scholars doing in this lesson?

- Scholars synthesize information learned throughout the entire unit by creating a poster that shows Peeko's observations and answers all of his questions.

Do Now

- Follow the **Do Now plan**.

Launch

- Throughout this unit, you have learned new things about our own solar system as well as the universe beyond. You have also worked to refine two important scientific skills: the ability to develop models and the ability to evaluate arguments, models, and experimental designs to determine their strengths and limitations.
- Today you will face a final challenge that requires you to show off your knowledge and skills. Your challenge is to create a poster with your group that will teach Peeko about the phenomena he observed in his home solar system.

Activity

- Scholars create a poster for Peeko to take back to his home solar system that summarizes their discoveries from the unit.
    - Posters must address the following questions:
        - Why do a planet's star and moons sometimes seem to be partially or fully "covered up"?
        - Why do the stars in the sky appear to move around in the sky throughout the year?
        - Why don't planets, moons, or other celestial bodies fly away into space?
        - Why do some stars look much bigger than others?
        - How do models help us learn more about outer space?
- As scholars are working, circulate and record information on their mastery of major concepts throughout the unit. Use your notes to plan strategic review activities to prepare scholars for their next assessment.

Discourse Debrief activity:

- Have scholars present their posters to the class.
- What knowledge and skills from throughout the unit did you need to apply to complete this challenge?
- How can you feel confident about what you told the alien if you've never visited his solar system?

Make connections to the Essential Question:

- Compose a final answer to the unit's Essential Question: An alien from a faraway planet just landed in New York. How can we help him explain the puzzling phenomena he has observed in his home solar system?

Accountability (Classwork) In place of a formal Exit Ticket, score scholars' posters from class to assess mastery of the Unit Goals. Minimize coaching as scholars complete their posters during this lesson, as those will allow you to evaluate scholars' mastery of major unit concepts. Take informal notes on lingering misconceptions or areas of confusion, and provide scholars with extra practice with relevant material before their Trimester 3 Final.

Scoring

1. Award up to two points for each question accurately addressed on the scholar's poster from the list below, for a total of 10 points:

   - Why do a planet's star and moons sometimes seem to be partially or fully "covered up"?
   - Why do the stars in the sky appear to move around in the sky throughout the year?
   - Why don't planets, moons, or other celestial bodies fly away into space?
   - Why do some stars look much bigger than others?
   - How do models help us learn more about outer space?

[**Tip:** Allow scholars who do not finish in class to complete their work on another day or for homework before scoring. This particular assignment is primarily meant to assess the depth of their understanding, not their ability to adhere to the pacing necessary to succeed on an assessment.]

Unit Vocabulary

Vocabulary List

- **universe**
- **scale model**
- **light-year**
- **astronomical unit (AU)**
- **solar system**
- **celestial body**

- **orbit**
- **asteroid**
- **comet**
- **dwarf planet**
- **planet**
- **moon**
- **star**
- **galaxy**
- **elliptical galaxy**
- **spiral galaxy**
- **irregular galaxy**
- **telescope**
- **eclipse**
- **partial lunar eclipse**
- **total lunar eclipse**
- **direct relationship**
- **inverse relationship**
- **atmosphere**
- **habitable zone**
- **gravity**