LESSON 4: What other patterns related to the Moon can our model explain?

PREVIOUS LESSON

We looked at the current shape of the Moon and then looked for patterns in photographs of the Moon over a month. We looked at historic images of the Moon from cultures around the world. We used a 3-D model to help make sense of the positions of the objects in the Earth-Sun-Moon system and how the apparent shape of the Moon we saw changed. We used an interactive to help us explain how changes in the position of the Moon affected the shape of the Moon we see.

THIS LESSON

INVESTIGATION, PUTTING PIECES TOGETHER

3 days

We watch videos of two kinds of eclipses. We try to reproduce and explain what we saw in the videos using a computer interactive and then with a physical model of the system. We compile the ideas we want to include in a conceptual model. We model and then explain (in our own videos) how the position of the Moon changes what you see on Earth in eclipses and lunar phases. We provide feedback to our peers before taking an individual assessment.

NEXT LESSON

We will consider why the Moon orbits Earth and use a simulation of the Earth-Moon system to investigate how factors like mass and speed of the Moon and its distance from Earth affect the size of the gravity force and whether the Moon stays in orbit, falls to Earth, or flies away.

BUILDING TOWARD NGSS

MS-ESS1-1, MS-ESS1-2, MS-ESS1-3, MS-PS2-4, MS-PS4-2

WHAT STUDENTS WILL DO

4. A Construct an explanation and critique peer explanations for lunar phases, lunar eclipses, and solar eclipses using a revised model of the Earth-Sun-Moon system.

4. B Communicate information gathered from multiple appropriate sources about how the interactions in the Earth-Moon-Sun system change the appearance of the Moon from the perspective on Earth.

WHAT STUDENTS WILL FIGURE OUT

- Sometimes the Moon looks like it covers the Sun and we get a solar eclipse. Sometimes the Moon falls into Earth's shadow and we get a lunar eclipse.
- The Moon's orbit is not perfectly flat relative to Earth's orbit around the Sun; it is tilted just a little. This is why we don't see eclipses every month.

Lesson 4 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Revisit our questions about eclipses (on the Driving Question Board).	A	DQB
2	15 min	**OBSERVE TWO KINDS OF ECLIPSES** Watch videos of lunar and solar eclipses.	B-D	https://www.youtube.com/watch?v=buXTecdfqxo, https://www.youtube.com/watch?v=G10m2ZZRH4U
3	7 min	**MAKE CLAIMS ABOUT WHAT IS CAUSING ECLIPSES** Table groups discuss the cause of eclipses before creating whole-class claims.	E	whiteboards or loose-leaf paper, chart paper, markers
4	12 min	**COLLECT EVIDENCE FROM ECLIPSES USING AN INTERACTIVE AND PHYSICAL** Observe an interactive and create physical models to figure out what interactions are occuring during eclipses.	F	*Observing the Eclipses with Stellarium Teacher Reference*, Claims about What Is Causing Solar and Lunar Eclipses poster, markers, www.stellarium.org, physical modeling supplies from Lesson 3
5	5 min	**ADD TO OUR PROGRESS TRACKER** Students record what they figured out in the Progress Tracker.	G	
				End of day 1
6	5 min	**NAVIGATION** Students reflect on their entries in the Progress Tracker and consider how the information they figured out last time helps prepare them to come to consensus on key model ideas so far.	H	
7	20 min	**CONSENSUS DISCUSSION TO DEVELOP KEY MODEL IDEAS** Gather students in a Scientists Circle to build consensus around key model ideas we will need to explain patterns in the appearance of the Moon on paper.	I	chart paper, markers, 1 4-inch Styrofoam sphere, 1 ⅜ inch dowel, 1 block with hole drilled, 1 skewer, 1 rubber band, 1 thumbtack, 1 twist tie, 1 1-inch Styrofoam sphere, 1 bulb socket, 1 bright light bulb, 1 phone camera, 1 extension cord with power strip, plastic clamp
8	10 min	**PROBLEMATIZE WHY THERE AREN'T ECLIPSES EACH MONTH** Facilitate a problematizing discussion to poke holes in the model and see if any key model ideas are missing. Use physical modeling supplies to try to figure out why eclipses are not seen with every new Moon.	J	1 4-inch Styrofoam sphere, 1 ⅜ inch dowel, 1 block with hole drilled, 1 skewer, 1 rubber band, 1 thumbtack, 1 twist tie, 1 1-inch Styrofoam sphere, 1 paper clip, 1 bulb socket, 1 phone camera, 1 extension cord with power strip
9	10 min	**ADD NEW KEY MODEL IDEAS** Watch a video to see what ideas we already have in our model and if any new ideas need to be added.	K	https://www.youtube.com/watch?v=sbgjdTQHZXY&feature=youtu.be, Key Model Ideas poster
				End of day 2
10	13 min	**EXPLAIN LUNAR PHENOMENA IN SMALL GROUPS** Create a video (or oral presentation) to communicate and explain key model ideas from the Earth-Moon-Sun system about why the appearance of the Moon is what it is at certain times.	L	1 4-inch Styrofoam sphere, 1 ⅜ inch dowel, 1 block with hole drilled, 1 skewer, 1 rubber band, 1 thumbtack, 1 twist tie, 1 1-inch Styrofoam sphere, 1 paper clip, 1 bulb socket, 1 camera, 1 extension cord with power strip

Part	Duration	Summary	Slide	Materials
11	15 min	**PEER FEEDBACK ASSESSMENT** Provide and receive feedback about *Peer-Feedback Rubric for Explanation Using a Physical Model* with another group.	M	*Peer-Feedback Rubric for Explanation Using a Physical Model*, video recording application
12	17 min	**INDIVIDUAL ASSESSMENT**	N	*Modeling the Sun-Moon-Earth System Assessment*

End of day 3

Lesson 4 • Materials List

	per student	per group	per class
Lesson materials	• science notebook • *Peer-Feedback Rubric for Explanation Using a Physical Model* • *Modeling the Sun-Moon-Earth System Assessment*	• whiteboards or loose-leaf paper • 1 4-inch Styrofoam sphere • 1 ⅜ inch dowel • 1 block with hole drilled • 1 skewer • 1 rubber band • 1 thumbtack • 1 twist tie • 1 1-inch Styrofoam sphere • 1 paper clip • 1 bulb socket • 1 camera • 1 extension cord with power strip • video recording application	• DQB • https://www.youtube.com/watch?v=buXTecdfqxo • https://www.youtube.com/watch?v=G10m2ZZRH4U • chart paper • markers • *Observing the Eclipses with Stellarium Teacher Reference* • Claims about What Is Causing Solar and Lunar Eclipses poster • www.stellarium.org • physical modeling supplies from Lesson 3 • 1 4-inch Styrofoam sphere • 1 ⅜ inch dowel • 1 block with hole drilled • 1 skewer • 1 rubber band • 1 thumbtack • 1 twist tie • 1 1-inch Styrofoam sphere • 1 bulb socket • 1 bright light bulb • 1 phone camera • 1 extension cord with power strip • plastic clamp • 1 paper clip • https://www.youtube.com/watch?v=sbgjdTQHZXY&feature=youtu.be • Key Model Ideas poster

Materials preparation (15 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Test https://www.youtube.com/watch?v=buXTecdfqxo , https://www.youtube.com/watch?v=G10m2ZZRH4U , and https://www.youtube.com/watch?v=sbgjdTQHZXY&feature=youtu.be . Make sure you can hear the audio.

If you need a refresher from Lesson 2, use www.teachersopensciedfieldtest.org/space to orient yourself to the Stellarium software, including getting ready to move the perspective, zoom in and out, set the date and location, and speed up and slow down time.

Use www.teachersopensciedfieldtest.org/space and *Observing the Eclipses with Stellarium Teacher Reference* to walk you through the process of using Stellarium to show a lunar and solar eclipse.

Each group (2-3 students) will be making a video explanation, so make sure to have several devices (e.g., phones, tablets, computers) to record their videos.

Prepare chart paper for posters. The posters you will make in this lesson are as follows:

- Claims about What Is Causing Solar and Lunar Eclipses

- Key Model Ideas

Be sure you have materials ready to add the following word to the Word Wall and/or a personal glossary: *eclipse*. Do not post this on the Word Wall until after your class has developed a shared understanding of its meaning.

Keep the physical modeling materials from Lessons 2 and 3 available for students to use when making their videos.

Lesson 4 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students create video explanations and develop a model for explaining how the apparent motion of the Earth-Moon-Sun system changes what we see. This explains phenomena such as lunar phases and eclipses while building an understanding of part of ESS1.A: The Universe and Its Stars and ESS1.B: Earth and the Solar System. By the end of this lesson, students should understand that celestial bodies are in motion and that motion changes what we see, dependent on perspective.

Where We Are NOT Going

This lesson does not require students to memorize the names of the lunar phases or solar and lunar eclipse. Instead, the lesson helps students connect how the movement of the Moon in relation to the Sun and Earth changes what we see.

We do not explicitly develop a model to explain the role of gravity in causing the motion of objects (such as the Moon and Earth) in the solar system part of ESS1.B. This is the problematizing move at the beginning of Lesson 5 and explained in Lesson Set 2.

We do not expect students to be held accountable for the word *occultation* or to add it to the Word Wall in this lesson. Although, the occultations of stars by the Moon connects back to the podcasts in Lesson 1.

LEARNING PLAN for LESSON 4

1 · NAVIGATION

5 min

MATERIALS: DQB

Navigate to where we left off last time. Display **slide A**. Begin class with everyone standing around the DQB. Say, *Last time, we modeled the pattern of the Moon's changing shape over a month which explained some of the answers to our questions. But we wondered if our model could also explain eclipses.* If you have a cluster of questions on the DQB about eclipses, point to the questions and read some of those.

Turn and Talk about student experiences with eclipse. Ask, *How many of you have observed an eclipse or heard about what happens when one occurs?* Have several groups share out an experience they heard their partner explain. Then say, *Eclipses are kind of rare, so let's all get ready to make some observations of what happens during an eclipse by analyzing some videos that people took of them occurring.*

ALTERNATE ACTIVITY

While many people view eclipses as a cause for celebration, in some indigenous communities eclipses are seen as a bad omen, and it may be taboo to look at videos or images of them. According to Rudy Begay, a Navajo cultural resource specialist consulting with various federal programs, "when there is an eclipse either lunar or solar, this is a sacred time where the sun, the moon and the earth is kind of like in an intimate position when they line up, so it's such a sacred thing that's happening, you don't look at those things that are happening out in the sky" (Braine, T. (2017, August 18). *Avert Your Eyes: Eclipse Viewing Taboo in Navajo and Other Cultures*. Retrieved from https://indiancountrytoday.com/archive/avert-your-eyes-eclipse-viewing-taboo-in-navajo-and-other-cultures-aSQi5i4mPEqVo-K7IVuhbw).

Be thoughtful about the students in your classroom, and if you believe viewing eclipses may be an issue for anyone, provide accessible alternatives to the activities that follow. These might include going directly to occultations of other celestial objects by the Moon (such as other stars or planets) in either images, videos, or interactives like www.stellarium.org . Another option is to have students look at images of the shadows created by eclipses and cast onto places on Earth. See *Alternative to viewing eclipses* for examples.

2 · OBSERVE TWO KINDS OF ECLIPSES

15 min

MATERIALS: science notebook, https://www.youtube.com/watch?v=buXTecdfqxo, https://www.youtube.com/watch?v=G10m2ZZRH4U

Watch videos of solar and lunar eclipses. Present **slide B**. Say, *I have videos here of two different kinds of eclipses. One is called a lunar eclipse, and the other is called a solar eclipse.*

Have students make two Notice and Wonder charts in their notebooks (on opposing pages so they can easily compare them) to record their observations and questions. See example on slide B.

Play the lunar eclipse video and allow students to just watch. Then ask them to record noticings and wonderings in their science notebooks before playing the video a second time. As they are watching the video again, students can write any additional noticings and wonderings in their charts. Repeat this process for the solar eclipse video after students complete their charts for the lunar eclipse video. You do not need to watch the whole video a second time, just 0:40 to 1:25, 1:58 to 2:45, and 4:16 to 4:34.

https://www.youtube.com/watch?v=buXTecdfqxo
https://www.youtube.com/watch?v=G10m2ZZRH4U

Share noticings and wonderings about solar and lunar eclipses. Present **slide C**. Ask students to share out :

- What did they notice and wonder about the lunar eclipse in https://www.youtube.com/watch?v=buXTecdfqxo ?
- What did they notice and wonder about the solar eclipse in https://www.youtube.com/watch?v=G10m2ZZRH4U ?

Compare solar and lunar eclipses. Present **slide D**. Ask students to turn and talk about these questions:

- What similarities and differences did they notice between these two types of eclipses?
- What do the differences tell us about what might be causing these two kinds of eclipses?

3 · MAKE CLAIMS ABOUT WHAT IS CAUSING ECLIPSES

7 min

MATERIALS: whiteboards or loose-leaf paper, chart paper, markers

Make claims about what might be causing eclipses. Present **slide E**. Ask students to talk in their existing table groups (or with a partner) about what they think is causing each of these eclipses. If you have whiteboards (or loose-leaf paper), groups can record ideas and images of what they want to share with the whole class. Have each group put a star next to the idea they most want to share with the class.

Share claims as a class. Have a representative from each group share one claim that their group brainstormed. Record these claims at the front of the room on chart paper to investigate with our models next time. Label the chart paper "Claims about What Is Causing Solar and Lunar Eclipses." If groups share similar claims, put a check mark next to the original claim on the chart paper.

Some anticipated claims include the following:

- The lunar eclipse is caused by the shadow of Earth on the Moon.
- The lunar eclipse is caused by Earth blocking sunlight from reaching the Moon
- The lunar eclipse is caused by Earth moving into the path of light between the Moon and the Sun.
- The lunar eclipse is caused by the Moon moving into a part of space where light from the Sun can't reach because Earth has blocked it.
- The solar eclipse is caused by the Moon going in front of the Sun.
- The solar eclipse is caused by the shadow of the Moon on Earth.
- The solar eclipse is caused by the Moon blocking sunlight from reaching Earth.

- The solar eclipse is caused by the Moon moving into the path of light between Earth and the Sun.
- The lunar eclipse is caused by Earth moving into a part of space where light from the Sun can't reach because the Moon has blocked it.
- The lunar eclipse is caused by the Moon going in front of the Sun.

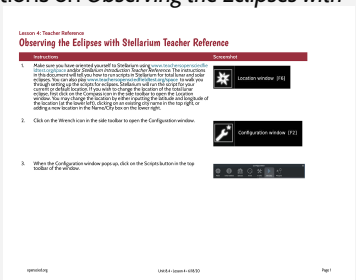
Then say, *Let's see if we can get some additional evidence for these claims using our Stellarium software.*

4 · COLLECT EVIDENCE FROM ECLIPSES USING AN INTERACTIVE AND PHYSICAL

12 min

MATERIALS: *Observing the Eclipses with Stellarium Teacher Reference*, Claims about What Is Causing Solar and Lunar Eclipses poster, markers, www.stellarium.org, physical modeling supplies from Lesson 3

Use www.stellarium.org to simulate a solar eclipse and a lunar eclipse. Display **slide F**. Follow the instructions on *Observing the Eclipses with Stellarium Teacher Reference* for setting up the eclipse interactive on www.stellarium.org .


Lesson 4: Teacher Reference

Observing the Eclipses with Stellarium Teacher Reference

Materials | Screenshot

Location window (F6)

Configuration window (F2)

Ask students to report out what they notice. Students will notice that when we zoom in on a solar eclipse we can see that the Moon is actually covering up the Sun. When we zoom in on a lunar eclipse we can see a shadow passing over the Moon--the shadow of Earth.

Model eclipses as a class. Say, *OK, now that we have some additional evidence let's see if we can use our physical model of the Sun-Earth-Moon system and an observer on Earth to explain why they would be seeing this happening in the sky.*

Ask students to come up to the front of the room and use the physical modeling supplies to demonstrate what is going on with eclipses. Place something (e.g., a tack) on the globe to represent where we would be located in relation to everything else in the system if we saw these phenomena occurring firsthand.

Suggested prompts	Sample student responses	Follow-up questions
What is happening when we see a solar eclipse?	*We would see a solar eclipse when the Moon passes in front of the Sun. We saw in the interactive that the sky got lighter. The Sun rose in the sky. There was a little circle rising in front of the Sun at the same time. The little circle appeared to get right in front of the Sun and blocked the Sun until the sky turned dark. Then the little circle blocked the Sun less and less (as the Sun moved) and the sky got brighter.*	*Can someone add onto what _____ said? Does anyone else agree or disagree with _____?*
Can someone demonstrate what is happening in the sky during a solar eclipse using our physical modeling items?	*(Look for students to put the Moon in between Earth and the Sun and the person on Earth should be on the daytime side of Earth.)*	*So, what you are showing is that when the Moon is between the Sun and Earth, it blocks the Sun?* *When this happens, its shadow passes over Earth. People in that shadow will see an eclipse.*

✱ ATTENDING TO EQUITY

Supporting emergent multilinguals
If you teach in a linguistically diverse classroom, this is an opportunity to build on the language expertise of your students by soliciting student ideas about cognates. Cognates are words that are similar in both spelling and meaning. The word *solar* comes from the Latin word for the Sun: *Sol*. Sol has cognates across many languages, including Spanish and Portuguese (sun = sol), French (sun = soleil), Icelandic (sun = sól), Italian (sun = sole), and Russian (sun = солнце, read as solntse). Using cognates, teachers can support emerging multilingual students in making connections between new science vocabulary and their native language(s). This can reduce the vocabulary overload that they may experience in science. If you use a Word Wall or personal glossary to support your students' vocabulary learning, place cognates alongside the new vocabulary terms or include cognates in text using parentheses.

Suggested prompts	Sample student responses	Follow-up questions
Where would these objects in the system need to be if we were to see a lunar eclipse, which is when the Moon gets dark?	*We would see a lunar eclipse when a shadow covers part or all of the Moon.* *We saw in the interactive that a shadow appears from the left side of the Moon. It gradually moves to the right and covers the whole j Moon, making it dark. Then the shadow moves to the right and gradually covers less and less of the Moon and more and more of the Moon is bright again.*	*Who can revoice what _____ said and put it into their own words?*
Can someone demonstrate what is happening in the sky during a lunar eclipse using our physical modeling items?	*(Look for students to put the Moon on the side of Earth that is opposite the Sun, in the shadow of the light, and the person on Earth that represents us should be on the nighttime side of Earth.)*	*So, is what you are showing that a lunar eclipse happens when the Moon is behind Earth and no sunlight can get to it (and/or Earth's shadow passes over it)?*

On the Claims about What Is Causing Solar and Lunar Eclipses poster, underline the claims that students made that are supported by what we saw in Stellarium and modeled with the physical model. Say, *It looks like these ideas were spot on.*

5 · ADD TO OUR PROGRESS TRACKER

5 min

MATERIALS: science notebook

Add to the Progress Tracker. Display **slide G**. Have the students work individually to add a row to their Progress Tracker to note what they have discovered and how this will help them figure out what causes eclipses to behave the way they do. Encourage them to add what they have learned about the Sun-Earth-Moon system. Do not score the Progress Tracker, but rather, use it as a way to formatively assess what your students have figured out to this point. Sample ideas that students may list as to what they figured out are shown here:

Question / Lesson #	What I figured out
What other patterns related to the Moon can our model explain? (Lesson 4)	Sometimes the Moon looks like it covers the Sun and we get a solar eclipse. Sometimes the Moon falls into Earth's shadow and we get a lunar eclipse.

End of day 1

6 · NAVIGATION

5 min

MATERIALS: science notebook

Turn and talk to share ideas from the Progress Tracker. Display **slide H**. Say, *Work with your partner to see what ideas you had that were similar and what ideas were different in the Progress Tracker you individually recorded last time. Circle any ideas you had that were similar. Then you can share your ideas during the Consensus Discussion and if we agree they can become our key model ideas.*✱

✱ ATTENDING TO EQUITY

Supporting Emergent Multilinguals
Students who are learning English benefit from redundancy of content and vocabulary. One way to give students the opportunity to hear ideas again is to revoice them. For example, after students have shared what we figured out last time, check to clarify what students agree upon by asking, "So I'm hearing _____ and _____. Do I have that right?" For all science students, but particularly those who are learning English, the opportunity to hear scientific language in varied contexts is fundamental to the development of disciplinary literacy.

7 · CONSENSUS DISCUSSION TO DEVELOP KEY MODEL IDEAS

20 min

MATERIALS: science notebook, chart paper, markers, 1 4-inch Styrofoam sphere, 1 ⅜ inch dowel, 1 block with hole drilled, 1 skewer, 1 rubber band, 1 thumbtack, 1 twist tie, 1 1-inch Styrofoam sphere, 1 bulb socket, 1 bright light bulb, 1 phone camera, 1 extension cord with power strip, plastic clamp

Develop key model ideas in a Consensus Discussion. Present **slide I**. Gather in the Scientists Circle with science notebooks. Come to consensus as a class about how to represent in two dimensions what we have learned about the Moon. During the discussion, ask students how to represent their ideas visually and remind students of previously agreed-upon modeling conventions for how to represent the parts and interactions in their models of the Earth-Sun-Moon system.

Record agreed-upon key model ideas on chart paper.✱ Say, *I am going to record our agreed-upon key model ideas. We used some physical modeling supplies to talk about this earlier, but now we want to be able to make a model on paper. I will type these up and hand them out to you next time for you to use as you make a video explanation of our model.* Title the chart paper "Key Model Ideas".

✱ STRATEGIES FOR THIS CONSENSUS DISCUSSION

- It is important that, as you record suggested ideas, you ask everyone to weigh in on each proposed idea —e.g., they should consider if they had a similar idea.
- It is also important for students to work on restating and rephrasing the ideas that you write down and to make sure each idea captures what everyone thinks are the essential pieces of the design feature. Revise the ideas as students make suggestions that others in class agree with to help clarify the proposed design feature.
- Do not have students write these features down at this time. Have them work on listening and linking to the ideas that other people share.

Suggested prompts	Sample student responses	Follow-up questions
Before we get started with the parts and interactions we want to include in our model, how can we help orient someone new looking at our models?	*We need to make sure to include the pattern they would be seeing! In order to show the pattern, we would need to include the perspective of the observer in the model.*	*What are some ways you could show the perspective in a model?*
It seems like we have a lot of parts and interactions to add to our model to help us explain why the Moon's shape can appear different in the sky. Can someone nominate a place for us to start?	*We need to add the Moon to our model!*	*Thanks for sharing! Can someone remind me of the other parts of the system we want to remember to include in our model?*
Great! I hear you saying we need Earth, the Moon, and the Sun in our model. Can someone explain some of the interactions we would want to show among those objects?	*We need to include the Sun shining on something and only half of it being lit up.* *The Moon is only lit up by the Sun, it doesn't make its own light.* *What we see of the moon here on Earth is different than if our perspective was looking down on the system from space. We only see the part of the Moon that is lit up by the Sun, depending on what part of the month it is.* *Sometimes the Moon's position causes an eclipse*	*Can you say more about that?* *What do you mean by _____?* *Why do you think that?* *What is our evidence?*
What do you notice about the Moon's position during an eclipse? What is the phase of the Moon is it during an eclipse?	*Sometimes a new Moon moves in front of the Sun, blocking the Sun's light.* *Sometimes the Moon is in the shadow of Earth, so it appears dark to us because the light from the Sun is blocked by Earth.*	*So, I hear you saying that the phase of the Moon is important for an eclipse? Why does the phase of the Moon matter?*

Add *eclipse* to the Word Wall. Say, *It feels like we have earned the word "eclipse". Let's add it to the Word Wall. Can someone suggest a definition we can use as a class moving forward?*

Listen for students to suggest a definition similar to this: when the position of an object in space blocks how we see another object. Students may wish to add further details to the Word Wall highlighting the differences between solar and lunar eclipses.

Say, *Do we think anything is missing in our model ideas? Are there patterns we can't yet explain? Do we have all of the pieces?*

ASSESSMENT OPPORTUNITY

Building towards: 4. A Construct an explanation and critique peer explanations for lunar phases, lunar eclipses, and solar eclipses using a revised model of the Earth-Sun-Moon system.

What to look/listen for:

- Moon is going around Earth.
- When the Sun shines on something spherical, half of the thing is lit up. This creates a "daytime side" and a "nighttime side" (like on Earth).
- What we see when we look up at the Moon is only the sunlit part; the Moon doesn't create its own light that we can see.
- From Earth, we can see only part of the Moon:the sunlit part (the daytime side for someone standing on the Moon). When we see the whole sunlit side of the Moon, we can only do that from the non-sunlit side of Earth (the nighttime side for someone standing on Earth). When the Moon is between the Sun and Earth, the Sun is shining on the part of the Moon that we can't see: the non-sunlit side of the Moon (the nighttime side for someone standing on the Moon).
- Sometimes the Moon looks like it covers the Sun and we get a solar eclipse. Sometimes the Moon falls into Earth's shadow and we get a lunar eclipse.

What to do: The purpose of this discussion is to agree, based on evidence, on how the movement of Earth, the Moon, and the Sun affects what we see and experience on Earth, which is a prime opportunity to formatively assess where your students are as a class before moving into small-group work and then individual assessment tasks. If students are struggling to identify the positions of Earth, the Moon, and the Sun and explain why each celestial object has to be in a certain configuration for the apparent pattern to be seen, ask students to show you with their hands or the physical modeling supplies (from Lesson 3) where each object would need to be to reproduce each pattern. As students share, press them for evidence from the photographs, videos, and simulation of eclipses.

8 · PROBLEMATIZE WHY THERE AREN'T ECLIPSES EACH MONTH

10 min

MATERIALS: science notebook, 1 4-inch Styrofoam sphere, 1 ⅜ inch dowel, 1 block with hole drilled, 1 skewer, 1 rubber band, 1 thumbtack, 1 twist tie, 1 1-inch Styrofoam sphere, 1 paper clip, 1 bulb socket, 1 phone camera, 1 extension cord with power strip

Problematize why do not see eclipses every month. Display **slide J**. Say, *OK, let's check and see if our model ideas explain everything we were wondering about lunar phases and eclipses.*

Suggested prompts	Sample student responses	Follow-up questions
Can someone explain the patterns we see in the appearance of the Moon each month?	*The Moon is moving around Earth, and the Sun shines light on it.* *Where the Moon is in its movement around Earth each month determines the amount of the sunlit part of the Moon that we see, which determines the shape we see.*	*Do we have evidence to support these ideas?*

Suggested prompts	Sample student responses	Follow-up questions
Can someone remind me what needs to be happening in order for there to be a solar eclipse or a lunar eclipse?	*For a total lunar eclipse, the Moon needs to be where Earth completely blocks the light from the Sun so that the Moon is in Earth's shadow.* *For a total solar eclipse, a new Moon needs to pass in front of the Sun and block the light from the Sun.*	*What phase of the Moon is that where that happens?*
I hear you saying that if there is a new Moon we can see a solar eclipse and if there is a full Moon we can see a lunar eclipse. Do you agree?	*Yes!*	
But then why don't we see eclipses every time there is a new or full Moon?	*[Accept all answers.]*	*This is interesting. Let's play a little with our physical models and see if we can figure it out.*

Manipulate the physical models of the Earth-Sun-Moon system. Ask students to gather around the physical modeling supplies at the front of the room. Invite three students to come up and demonstrate for the class. Ask the rest of the class,

- *What should we do to model a new Moon where the observer would not see a solar eclipse? Where should they put the Moon?*
- *What should we do to model a full Moon where the observer would not see a lunar eclipse? Where should they put the Moon?*

Look for students to move the Moon slightly higher or lower in order to prevent the light from the bulb from being blocked from the view of the webcam.

Suggested prompt	Sample student response
What did we do in order to change the view from a lunar eclipse to a full Moon?	*We had to move the Moon just a little bit up or down.*
What did we do in order to change the view from a solar eclipse to a new Moon?	*We had to move the Moon just a little bit up or down.*
What does this mean in the real Earth-Sun-Moon system?	*(Accept all ideas.)*

9 · ADD NEW KEY MODEL IDEAS

10 min

MATERIALS: https://www.youtube.com/watch?v=sbgjdTQHZXY&feature=youtu.be, Key Model Ideas poster

Say, *We noticed that we had to move the Moon a little bit in order to get an eclipse to not occur because we don't have eclipses every month. But we are not quite sure yet how this change in our physical model maps to the real world. I have another video of eclipses we can watch that might be able to help us figure this out so we can add about why eclipses do not occur each month to our model ideas.*

Watch video https://www.youtube.com/watch?v=sbgjdTQHZXY&feature=youtu.be **.**

Suggested prompt	Sample student response
What ideas from the video do we already have in our model that they are using in their model too?	*We already have the Earth-Moon-Sun system!* *The Moon is going around Earth!* *We see the Moon's shadow on Earth making it dark.*
What new ideas do we need to add?	*The first part of the video was from 1979 and said a total solar eclipse wouldn't be seen in North America again until 2017.* *The Sun is bigger than the Moon but further away.* *The Moon goes around Earth on a tilt! And it is only when the three parts of the Earth-Moon-Sun system all line up in a straight line that we see an eclipse.*

Record new model ideas on the Key Model Ideas chart paper from earlier. Say, *Let's add these to our Key Model Ideas poster. Next time we can try to incorporate all these ideas into the video explanations of our model.*

ADDITIONAL GUIDANCE

If your circumstances permit, you can handout *Peer-Feedback Rubric for Explanation Using a Physical Model* at the end of Day 1 and have groups do some brainstorming or practice for their videos (from Day 2) as home learning.

End of day 2

10 · EXPLAIN LUNAR PHENOMENA IN SMALL GROUPS

13 min

MATERIALS: science notebook, 1 4-inch Styrofoam sphere, 1 ⅜ inch dowel, 1 block with hole drilled, 1 skewer, 1 rubber band, 1 thumbtack, 1 twist tie, 1 1-inch Styrofoam sphere, 1 paper clip, 1 bulb socket, 1 camera, 1 extension cord with power strip

Say, *Today, we are going to take some time to work in small groups before taking an individual assessment. There are some interesting, complex, three-dimensional interactions going on here, which is going to be hard to get into two dimensions on paper. So, let's do it in groups using our physical models first.*

Explain lunar phenomena using short videos or presentations. Present **slide L**. Ask students to work in groups of 2-3 to plan for using Flipgrid or a similar application to record videos (no longer than 90 seconds) of them explaining lunar phases and eclipses. Students can use their physical modeling materials, diagrams, and words in their videos. Remind students that this is fast! They will have to be very precise with their explanations, and it will take practice.

Say, *I typed up your key model ideas from last time for you to use as you make your presentations.*
Hand out *Peer-Feedback Rubric for Explanation Using a Physical Model* to help guide each group as they plan their videos. If students are unable to make videos, they can explain orally to a peer group. Walk around as groups are working and look for groups to be incorporating the ideas from each row on *Peer-Feedback Rubric for Explanation Using a Physical Model* into their videos.

ALTERNATE ACTIVITY

You could assign making the video learning at the end of day 2 if it is feasible for your students to work in groups after class. Alternatively if the logistics of using video are not possible, students can explain their models on paper or as presentations to the class. Reserve an extra class period for presentations if you make this choice.

11 · PEER FEEDBACK ASSESSMENT

15 min

MATERIALS: *Peer-Feedback Rubric for Explanation Using a Physical Model*, video recording application

Collaborate on the *Peer-Feedback Rubric for Explanation Using a Physical Model*. Present **slide M**. Pair groups for this activity. As each group explains their model, their peer group should fill out *Peer-Feedback Rubric for Explanation Using a Physical Model* to assess how well they thought they explained lunar phases and eclipses.

Give groups five minutes to incorporate the feedback they received into their explanation before recording their video. Groups should turn *Peer-Feedback Rubric for Explanation Using a Physical Model* in to you, along with their videos, explanations, or presentations.

ASSESSMENT OPPORTUNITY

Building towards: 4. B Communicate information gathered from various forms of scientific text and investigation about how the interactions in the Earth-Moon-Sun system change the appearance of the Moon from the perspective on Earth.

What to look for/listen for: Students communicating the relationship of where an observer is on Earth, the movement of the Moon around Earth, and position relative to the Sun and the light it produces that change the shape of the Moon seen by the observer.

What to do: This is a fantastic opportunity for just-in-time conversations with individual students or groups. Use *Peer-Feedback Rubric for Explanation Using a Physical Model* to help point groups to the peer feedback they received. If students struggle to incorporate or elaborate on ideas in their explanation, ask them to look through their science notebooks for evidence that supports the ideas from peer feedback.

12 · INDIVIDUAL ASSESSMENT

17 min

MATERIALS: *Modeling the Sun-Moon-Earth System Assessment*

Conduct an individual assessment. Display **slide N**. Say, *Now that you have had a chance to work through your ideas about lunar phenomena as a group, you will have the opportunity to demonstrate your ideas individually.* Hand out *Modeling the Sun-Moon-Earth System Assessment* to each student.

ASSESSMENT OPPORTUNITY

Building towards: Construct an explanation and critique peer explanations for lunar phases, lunar eclipses, and solar eclipses using a revised model of the Earth-Sun-Moon system.

What to look for/listen for: Scoring guidance for this assessment is provided in *Key for Modeling the Sun-Moon-Earth System Assessment*.

What to do: This is a summative assessment coming at the end of the learning set. If your students are not able to demonstrate competence on the Lesson Level Performance Expectation above, consider spending more time with the physical models before moving onto the next lesson set.

ALTERNATE ACTIVITY

If you are short on time, *Modeling the Sun-Moon-Earth System Assessment* can also be done as a take-home assessment.

The last two questions on *Modeling the Sun-Moon-Earth System Assessment* are meant to be ungraded as they are previews to the navigation in future lessons. Students can tear off the last page of *Modeling the Sun-Moon-Earth System Assessment* and hand it in separately or take with them to answer at home. If you can, read these questions and use them to help navigate into Lesson 5.

After students finish *Modeling the Sun-Moon-Earth System Assessment*, hand out *Making stars disappear and reappear* as home learning. Explain to students that *Making stars disappear and reappear* has information about some of their other questions that we have yet to figure out .

✱ ATTENDING TO EQUITY

Some students may benefit from using other modalities, such as a drawing, to show their thinking for any or all of the questions on this assessment. You may consider allowing some students to present their answers verbally with you and then scribe their thinking on paper. This might allow students to also use gestures to help articulate and explain their understanding about how the positions of objects in the Earth-Sun-Moon system change the patterns we see in the sky. Encouraging students to use other modalities to show their thinking creates an equitable pathway for all students to demonstrate proficiency.