Unit 4

Earth in Space:

How are we connected to the patterns we see in the sky and space?

Student Work Pages

GRADE 8 Core Knowledge Science®

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Earth in Space

How are we connected to the patterns we see in the sky and space?

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Science Literacy Exercise Pages

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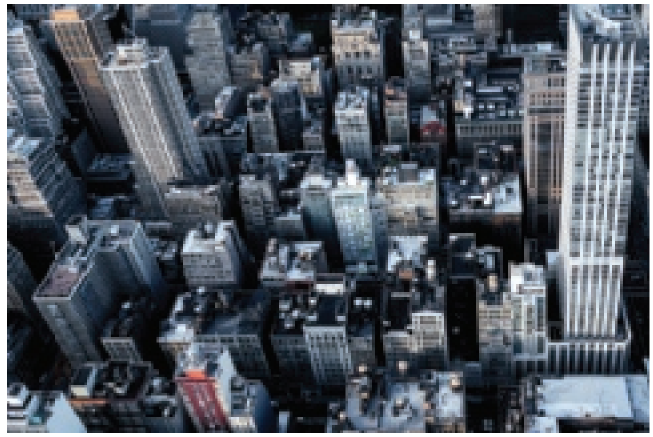
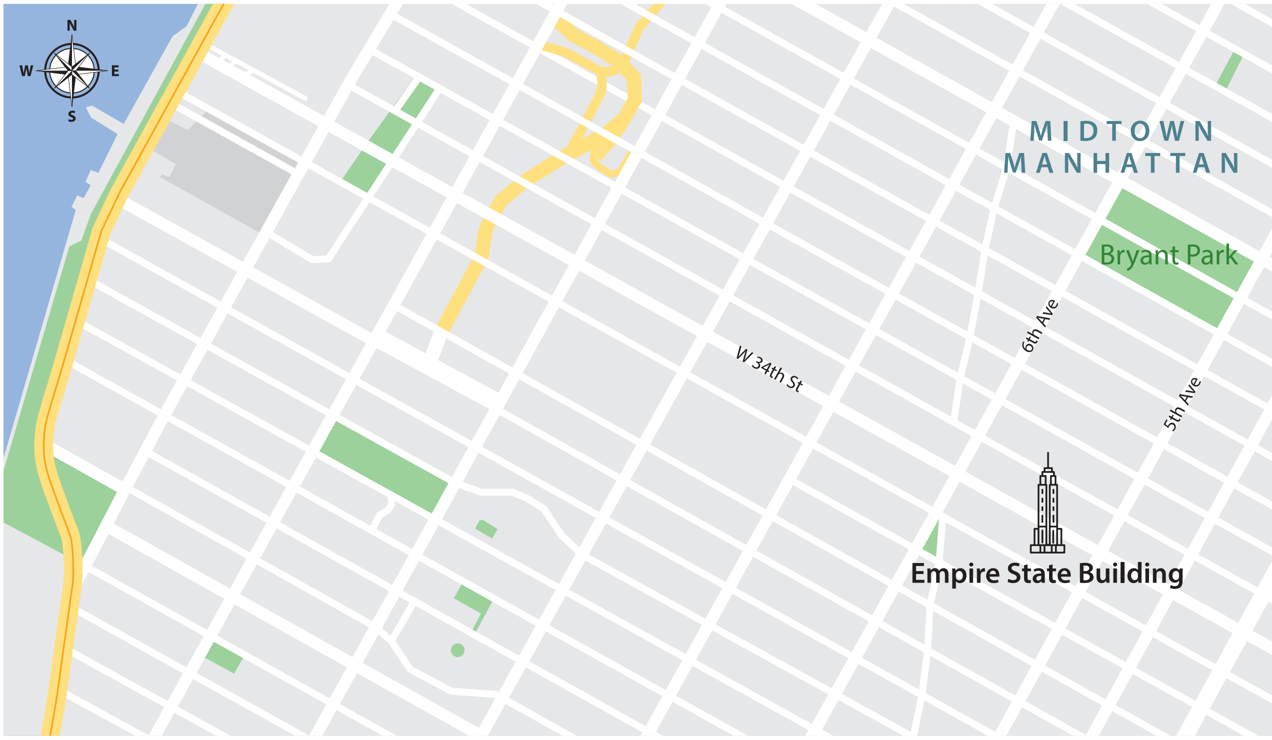
Initial Manhattanhenge Model

Standing at the corner of 34th Street and 5th Avenue and facing northwest, where people say you can get some of the best views of the Manhattanhenge phenomenon.

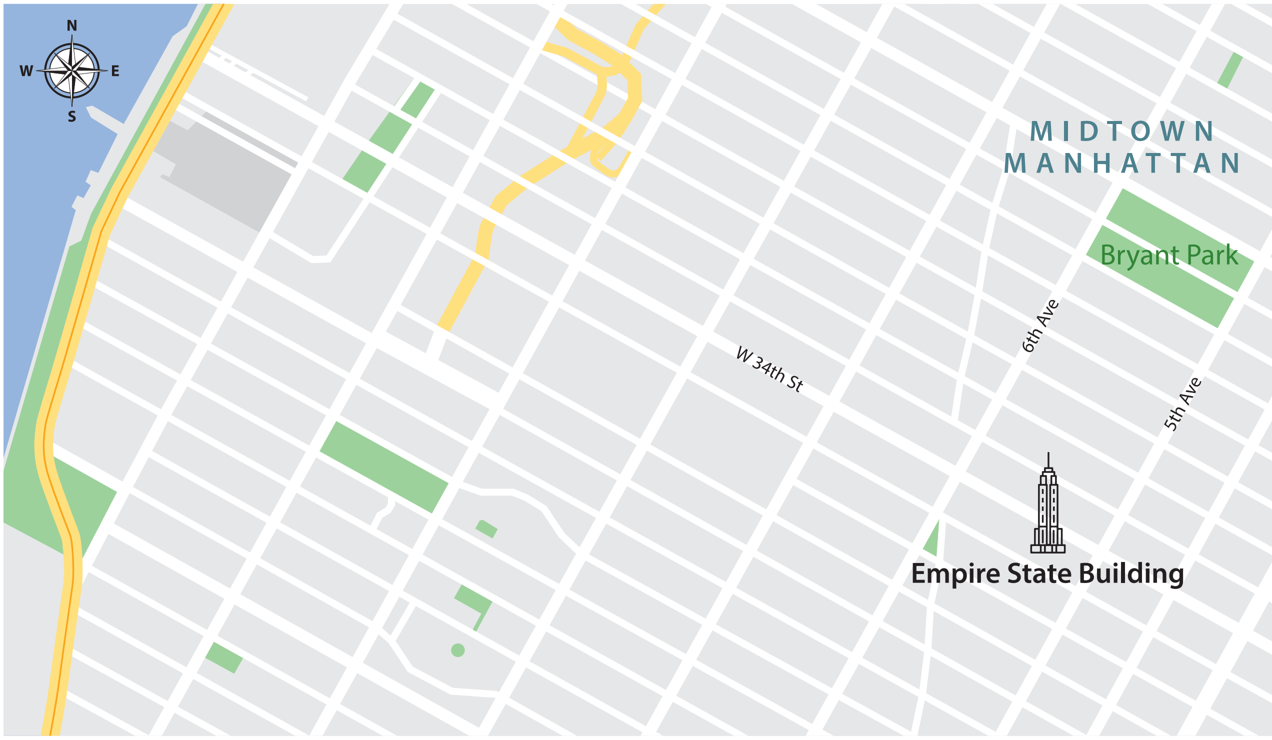
On the next page, develop two models on the different maps to help explain different aspects of this phenomenon.



Use the map below to show why you can see Manhattanhenge on a cloudless day when standing at the corner of 34th Street and 5th Avenue and facing northwest.



Annotate the map below to show why you wouldn't be able to see this phenomenon on a cloudless day when standing from this same location facing the same direction a day or a month later.



What changes or interactions in the system can help explain why we only see Manhattanhenge on certain days of the year?

Name: ______________________ Date: ______________________

Community Connections to the Sky

Go home and connect with your friends, family, and trusted community members.

First, share with them what we have been talking about and share an example of a pattern or event we discussed in class. Let them know that this is not about weather but about patterns we think are connected to space. Then ask them these questions:

1. What patterns or phenomena have they seen in the sky?

2. What stories have they heard from their family and community about patterns others have observed in the sky or about things on Earth that are connected to patterns and objects in the sky?

Name: ______________________________ Date: ______________________

Making Sense of the Podcast Jigsaw

BEFORE

1. What is the title of the podcast you will listen to?

    - Look at the title of your podcast and discuss with your group: What does the title tell you about what will be in the podcast?

2. What is a question you have that you hope the podcast will help answer?

DURING

- Listen carefully. As you listen, use the provided transcript to follow along.
- Highlight or underline words, phrases, and ideas that you have never heard before or that you want to know more about.
- Each person in your group will be allowed one pause request. When you hear something that you want to discuss or have clarified, raise your hand to use your pause request.

AFTER

Discuss with your group:

1. Look at the title of your podcast again. Now that you have heard the podcast, why do you think the podcast producers chose this title?

2. How did the people you learned about
   - observe the sky and keep track of what they saw?
   - use their observations of the sky?

Respond to the questions below and be ready to share with the class:

3. What phenomena and patterns in the sky did you hear about in the podcast? Why did the people you learned about observe those patterns?

4. How can observing the sky help us better understand our own planet and our own lives?

5. How do the patterns that we see in the sky help set the rhythm of our lives?

Name: ______________________ Date: ______________________

Reference: Listening Group Roles

- **Progress monitor.** This person periodically asks others to take the measure of the group's progress. This includes watching the time to keep the group on track. Some questions the progress monitor might ask are the following:
  - "What can we say we've accomplished so far?"
  - "What do we still need to know or do to accomplish this task?"
  - "We have _________ minutes left. What can we do in that time to accomplish our task?"
- **Big ideas person.** The role of this student is to relate the podcast to the question we are trying to answer.
  - "How does what you said relate to _________?"
  - "How does this change the way we're thinking about _________?"
- **Clarifier.** This person monitors everyone's comprehension about 1 or 2 key science terms. The clarifier might ask questions such as these:
  - "Do we know what the word _________ refers to?"
  - "Can we put what we just heard/read into our own words?"
- **Questioner.** This person asks probing questions during the activity. The questioner listens for questions posed by other group members and then revoices the questions to make sure that the whole group takes a moment to hear and entertain questions from everyone.:
  - "What does it mean that _________?"
  - "How do we know that _________?"
  - "So, what I think you are saying is _________. Is that right?"
- **Conductor.** This person monitors the airtime of people in the group. The conductor is allowed to control who has "the floor" with the goal of ensuring that everyone gets a chance to talk and that everyone takes time to listen. The conductor should invite comments or questions from group members who haven't been heard from yet. The conductor will also be in charge of playing/pausing the podcast when requested.
  - "_________, we haven't heard from you yet. What do you think?"
  - "Wait _________, we need to hear from someone else before you share again."

Name: ______________________ Date: ________________

My Initial Model to Explain: ______________________

1a. This is what a person on Earth would see:

1b. This is the time period for this pattern, or this is the time when the phenomenon occurred.

Change in perspective

Perspective is a place where you would have to be in the system in order to see a particular view.

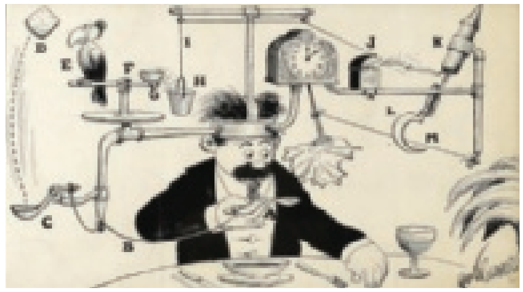
2a. This is a model that can help explain what causes the pattern/phenomena I see from Earth.

2b. This is the perspective I took in the model above:

3. This is what is happening with the parts and interactions in this system that causes us to see the pattern/phenomenon in 1a:

Name: ______________________________ Date: ______________________

Systems Modeling Scaffold



Rube Goldberg. Originally published in *Collier's*, September 26, 1931.

1. What is the **function** (or intended effect) of the system?
2. What are the important **parts** (or components) of the system?
3. How do these parts **move** and **interact**?
4. What do you see that are **not** important parts to how the system functions?
5. From what **perspective** has Rube Goldberg modeled the system?

Name: ______________________ Date: ________________

Initial Models Gallery Walk

For each model that you visit, fill out one of the rows of the table.

What pattern or phenomena is the model trying to explain?	What parts, movements, and interactions are represented in the system model that are similar to ones you included in your model?	What parts, movements, and interactions are different?

Name: ______________________ Date: ______________

Lesson 1 Community Guide for Looking at the Sky

Throughout this unit, we will be looking at the sky. There is a lot to see up there and there will be times that you cannot find what you are looking for, but there is no right or wrong in looking at the stars! The goal is not to see it all. The goal is for you to find your own connections to the sky, no matter what your sky looks like and where you are located. Everyone has their own celestial story—let's find yours.

There is not a right way to complete this activity— all students will do this differently with their different people and record their ideas in different ways. The important thing is that you take time to connect with someone else about the things you are figuring out about the sky.

Purpose of this Guide
Why would I use this community guide? How can this guide help me observe the sky?
Think about the support and resources that other people provide you as a learner. • Do other people connect you to your family's knowledge, practices, and values? • Do other people give you opportunities to investigate beyond what you are doing in school? • Do other people allow you a chance to share and explain what you have figured out? • How does their support help you make progress in your learning?

Lesson 1: Watching for Patterns in the Sky

For Lesson 1, take note of which of the objects from our Patterns and Phenomena in the Sky poster you plan to look for in the sky.

Bring these papers home and share it with at least one other person (could be a friend, sibling, other family member, other trusted person). Use the questions following to guide you as you explore patterns in the sky together. Please remember to never look directly at the Sun as it could be permanently damaging to your eyes.

Before	
Where will you go to look at the sky? • Will you look from inside or outside where you live? • From somewhere at school? On your way to or from somewhere? • Maybe even at a park, parking lot, or other open space?	
What will your view be? • Are there trees or buildings around? • Are there bright lights? • Which direction(s) can you see best (north, south, etc.)?	
How will you stay safe when you are looking at the sky? • Do you need to consider traffic? • Are you going with an adult, or does an adult know where you're going and when you will be back?	
How will you record your observations? What tools will you need to bring with you? • Will you need a paper and pencil? A timer or watch? A flashlight? • Will you get these tools from a community center? from school? From where you live?	
Anything else that you want to share about the place(s) where you can go to observe the sky?	
My observing plan: • How often will you look? • If you're watching for patterns, should you set reminders for certain times of day or night to go look?	

My observations	
When did I make this observation?	
Describe what you saw:	
Draw what you saw:	

During/After your observations
What did you notice? What did you wonder?   Talk with your person about why what you are seeing is important: How does this experience help you connect to the sky?

Name: ______________________ Date: ______________________

A Model to Explain the Movements of Objects in the Sky

a. This is a model that can help explain what causes the patterns of motion of objects in the day and night sky that we observed in the sky video from the computer simulation.

b. This is the perspective I took in the model above:

c. This is what is happening with the parts and interactions in this system that causes us to see the pattern/ phenomenon in 1a:

____

____

____

____

____

Name: ______________________ Date: ________________

Observations of the Sun: Location ______________

	Amount of sunlight	Angle of the Sun in the sky at midday: -very high above the horizon? -very low near the horizon? -somewhere in between?
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		

Name: ______________________ Date: ______________

Sun Patterns Over Many Hundreds of Years

Record data about changes in the Sun.

- Use https://gml.noaa.gov/grad/solcalc/to record sunrise and sunset. Determine the length of daylight by subtracting the time of sunset from sunrise.
- Use https://gml.noaa.gov/grad/solcalc/azel.html to record the solar elevation. You will need to enter in the latitude and longitude for the location used by your class to match the location used to measure sunrise and sunset.

Year	Date	Sunrise	Sunset	Length of daylight	Solar elevation at noon
My year:	March 20				
	June 20				
	September 22				
	December 21				

Record the other group's measurements in the data tables below.

Year	Date	Sunrise	Sunset	Length of daylight	Solar elevation at noon
For this year:	March 20				
	June 20				
	September 22				
	December 21				
For this year:	March 20				
	June 20				
	September 22				
	December 21				
For this year:	March 20				
	June 20				
	September 22				
	December 21				

Work with your partner to complete the data analysis questions below.

	Over 500 years	Over 1,000 years	Over 1,500 years
How has the amount of daylight changed?			
How has the elevation of the Sun at noon changed?			

What relationship do you notice between the solar elevation at noon and amount of daylight over time? How does this compare to the measurements you recorded from the video of the sky created with a computer simulation?

____

____

____

How does this data help explain why or how different communities created rituals to help mark and predict changes in the patterns of daylight during a year?

____

____

____

____

____

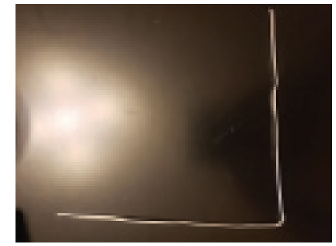
Mapping the Model to the Earth–Sun System

Feature of the representation...	***is like this feature of the real world...***	***because...***	***and is not like it because...***
Light bulb	Sun		
Large foam ball on a stick	Earth and its axis		
Round pushpin (with twist-tie around it)	Person on Earth		
Rubber band	Path the person follows over 24 hours (latitude line)		

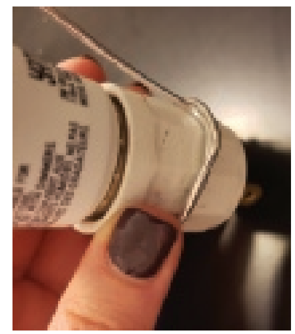
Name: ____________________ Date: ____________

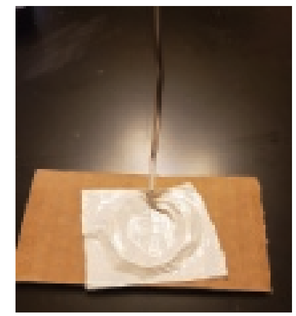
Modeling the Earth–Sun System

1. Each group will need a 4-inch sphere, 2 pushpins, 1 round pushpin, a bare-bulb lamp, a fabric tape measure, 12 inches of aluminum wire, a plastic coffee stirrer, a twist-tie, a rubber band, duct tape, a piece of cardboard cut in a rectangle of 2.5 x 4.75 inches, a Sharpie marker, a ruler, safety goggles, and 1 pair of pliers.
2. Straighten the aluminum wire as much as possible. Bend the wire in an L-shape in half.

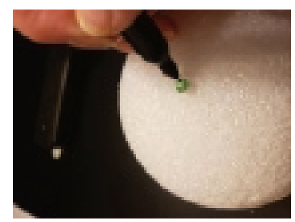


3. Using the end of the bare-bulb lamp, carefully wrap one end of the wire around the end of the bare-bulb lamp to make a stand. Place the wire in the middle of the piece of cardboard and tape in place using a piece of duct tape.



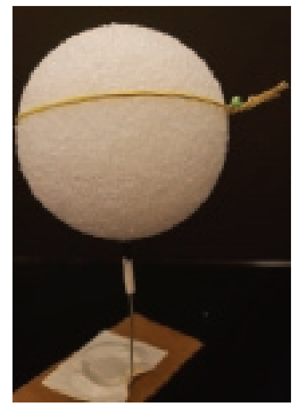


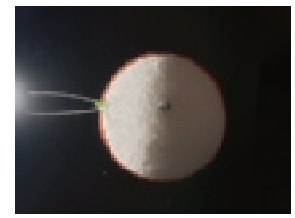
4. Draw eyeballs on your round pushpin with a Sharpie marker. Insert a coffee stirrer through the center of your foam sphere.



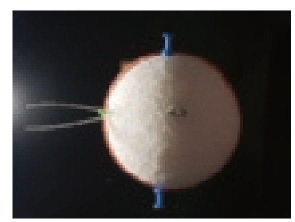
5. Slide the wire stand through the center of the coffee stirrer. Secure the end of the coffee stirrer with another piece of duct tape.

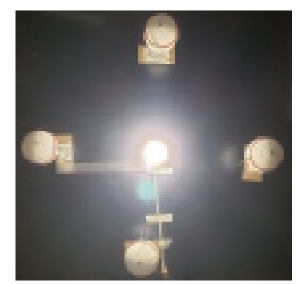
6. Put the round pushpin on your approximate location on the foam Earth. Wrap the twist-tie around the round pushpin to represent an arm that you can point toward the lamp Sun. Then slip a rubber band over the sphere to indicate the path of the observer pushpin over the surface of the Earth as the Earth spins. Make sure that when you look down at the top of your sphere, the North Pole is at the center of the circle created by the rubber band.



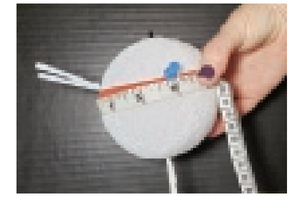


7. Keep the observer looking at the Sun. Make sure the wire is the same distance from the edge of the light bulb as you move it from position 1 to 2 to 3 to 4, so that it follows a circular path through these positions. Pause at each of the positions and have another group member use two pushpins to indicate sunrise and sunset.

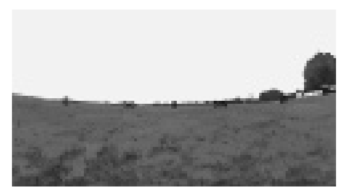
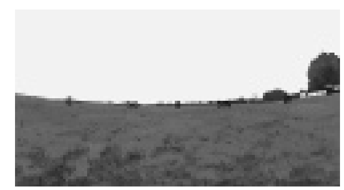




8. For each position, record in the data table the length of the path for the observer. Measure between the two pushpins in inches, rounding to the nearest half-inch. Remember that this represents the length of a day for this observer. The shorter the measurement, the less time the observer spends in the light and the more time the observer spends in the dark.



9. Do the following task for each of the four positions of the foam Earth. Imagine standing on the rubber band in the middle of the day, looking at the lightbulb. Orient the round pushpin to that location. Point the twist-tie arm at the lamp Sun to indicate a pointing arm. Would you have to look up high above you to see the lightbulb? Or would it appear closer to the ground? Approximate how high the Sun appears in the sky for this observer using the twist-tie to help you picture how high in the sky you would have to point. Then draw what you predict the shape of the Sun's apparent path would be on the corresponding background in the table.

	Position 1 or March 20	Position 2 or June 20	Position 3 or September 22	Position 4 or December 21
Length of observer's path through daylight (inches)				
Approximate path of the Sun in the sky from the observer's perspective	 Stellarium	 Stellarium	 Stellarium	 Stellarium

Reflect on changes to the physical model.

1. Record what adjustments to the physical model your group made to better match the data we recorded from the NOAA websites.

2. How did this/these adjustment(s) affect Earth's orientation in space?

3. What did this/these adjustment(s) do to help make the model better match the data?

Name: ______________________ Date: ______________________

Seasonal Temperature Data

The data table describes the average distance between Earth and the Sun for two cities in each month of the year. We chose the cities because they are comparable. Both cities are a little under 2,500 miles from the equator (Raleigh is 2,474 miles [3,982 km] and San Diego is 2,260 miles [3,679 km]). And both cities are fewer than 500 feet from sea level (Raleigh is 315 feet [96 meters] above sea level, and San Diego is 62 feet [19 meters] above sea level).

Month	Average distance between Earth and Sun	Average high temp. in Raleigh, NC, USA	Average high temp, in San Diego, CA, USA
January	91.398.199 miles (147,091,144 km)	50°F (10°C)	66°F (18.9°C)
February	91.795.766 miles (147,730,965 km)	54°F (12.2°C)	66°F (18.9°C)
March	92.697.585 miles (149,182,303 km)	62°F (16.7°C)	67°F (19.4°C)
April	93.337.768 miles (150,212,577 km)	72°F (22.2°C)	69°F (20.5°C)
May	94.025.957 miles (151,320,110 km)	79°F (26.1°C)	69°F (20.5°C)
June	94.445.928 miles (151,995,988 km)	86°F (30°C)	72°F (22.2°C)
July	94.511.923 miles (152,102,196 km)	89°F (31.7°C)	76°F (24.4°C)
August	94.093.022 miles (151,428,040 km)	88°F (31.1°C)	77°F (25°C)
September	93.404.767 miles (150,320,402 km)	82°F (27.8°C)	77°F (25°C)
October	92.613.451 miles (149,046,902 km)	72°F (22.2°C)	74°F (23.3°C)
November	91.847.268 miles (147,813,849 km)	62°F (16.7°C)	70°F (21.1°C)
December	91.466.911 miles (147,201,725 km)	54°F (12.2°C)	66°F (18.9°C)

1. How does the pattern of average high temperatures of both cities compare?

2. Circle the hottest temperature for both cities in the data table on the previous page.
3. Record the two hottest temperatures for both cities, the month they occur, and the average distance of Earth from the Sun for those months in the following table.

	Hottest temperature	**Month**	**Average distance of Earth from the Sun during this month**
Raleigh, NC, USA			
San Diego, CA, USA			

4. Circle the two coldest temperatures for both cities in the data table on the previous page.
5. Record the two coldest temperatures for both cities, the month they occur, and the average distance of Earth from the Sun for those months in the following table.

	Coldest temperature	**Month**	**Average distance of Earth from the Sun during this month**
Raleigh, NC, USA			
San Diego, CA, USA			

6. Compare the two tables. What pattern is there between temperature and average distance of Earth from the Sun?

7. What new questions does this raise for you?

Name: ______________________ Date: ______________________

Defining Seasons

Meteorological versus astronomical seasons

You may have noticed that meteorologists and climatologists define seasons differently from “regular” or astronomical spring, summer, fall, and winter. So, why do meteorological and astronomical seasons begin and end on different dates? In short, it is because the astronomical seasons are based on the position of Earth in relation to the Sun, whereas the meteorological seasons are based on the annual temperature cycle.

The astronomical seasons

People have used observable periodic natural phenomena to mark time for thousands of years. The natural rotation of Earth around the Sun forms the basis for the astronomical calendar, in which we define seasons with two solstices and two equinoxes. Earth’s tilt and the Sun’s alignment over the equator determine both the solstices and equinoxes.

The equinoxes mark the times when the Sun passes directly above the equator. In the Northern Hemisphere, the summer solstice falls on or around June 21, the winter solstice on or around December 22, the vernal or spring equinox on or around March 21, and the autumnal equinox on or around September 22. These seasons are reversed but begin on the same dates in the Southern Hemisphere.

Because Earth actually travels around the Sun in 365.24 days, an extra day is needed every fourth year, creating what we know as a leap year. This also causes the exact date of the solstices and equinoxes to vary. Additionally, the elliptical shape of Earth’s orbit around the Sun causes the lengths of the astronomical seasons to vary between 89 and 93 days. These variations in season length and season start would make it very difficult to consistently compare climatological statistics for a particular season from one year to the next. Thus, the meteorological seasons were born.

The meteorological seasons

Meteorologists and climatologists break the seasons down into groupings of three months based on the annual temperature cycle and our calendar. We generally think of winter as the coldest time of the year and summer as the warmest time of the year, with spring and fall being the transition seasons, and that is what the meteorological seasons are based on. Meteorological spring in the Northern Hemisphere includes March, April, and May; meteorological summer includes June, July, and August; meteorological fall includes September, October, and November; and meteorological winter includes December, January, and February.

Meteorological observing and forecasting led to the creation of these seasons, and they are more closely tied to our monthly civil calendar than the astronomical seasons are. The length of the meteorological seasons is also more consistent, ranging from 90 days for winter of a non-leap year to 92 days for spring and summer. By following the civil calendar and having less variation in season length and season start, it becomes much easier to calculate seasonal statistics from the monthly statistics, both of which are very useful for agriculture, commerce, and a variety of other purposes.

Reprinted from:

National Center for Environmental Information (2021). *Meteorological versus astronomical seasons*. Retrieved from: https://www.ncei.noaa.gov/news/meteorological-versus-astronomical-seasons

Name: ______________________________ Date: ______________________

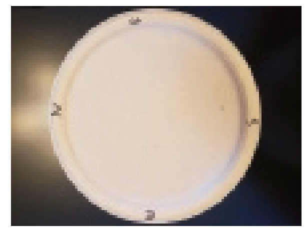
Modeling Sunlight Angles

Materials per team of 2–3 students

- science notebook
- 1 ruler
- 1 protractor
- 1 pencil
- 1 marker
- scissors
- safety goggles
- tape
- 1 flashlight
- 3 10-inch paper plates
- 3 pieces of graph paper
- 5 12-inch pipe cleaners in 3 colors (2 sets of 2 in 2 different colors and 1 in a third color)
- 1 7.5x11-inch piece of cardboard

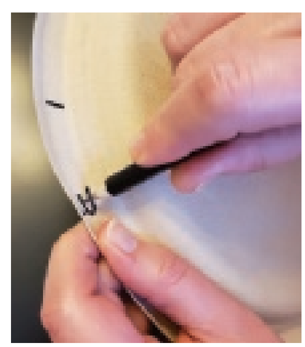
Follow the directions on the next few pages.

1. Turn one of the paper plates upside down and use the marker to mark North (N), South (S), East (E), and West (W) on the edges of the plate.

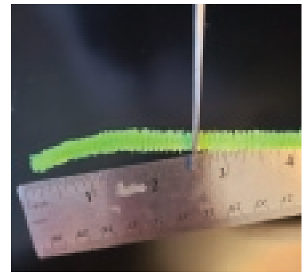


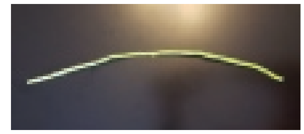
2. Use a protractor to measure 30° above and below your marking on E and W.

3. With a sharp pencil, poke holes at E, W, and the markings you made 30° above and below E and W.



4. Set the plate aside and grab two of the same colored pipe cleaners. Use a ruler to measure 2 and a half inches from the end of each pipe cleaner. Cut off both of the ends. Then, twist the ends of the pipe cleaners together to make one long pipe cleaner. The finished pipe cleaner should be about 18 inches long.

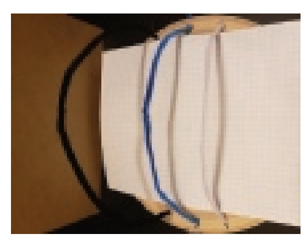




5. Grab the other two pipe cleaners of the same color. Use a ruler to measure 4 and a half inches from the end of each pipe cleaner. Cut off both ends. Then, twist the ends of the pipe cleaners together to make one long pipe cleaner. The finished pipe cleaner should be about 15 inches long.
6. Take the three pipe cleaners, 18 inches long, 15 inches long, and 12 inches long, and insert them into the holes on the E and W sides of the paper plate, and bend the ends so they stay in place. The 18-inch long pipe cleaner should be closest to N, the 15-inch pipe cleaner in the middle, and the 12-inch pipe cleaner should be closest to S. Once you have inserted the three pipe cleaners, tilt them so they lean towards S.

7. Tape the ends of the pipe cleaners to the underside of the paper plate.

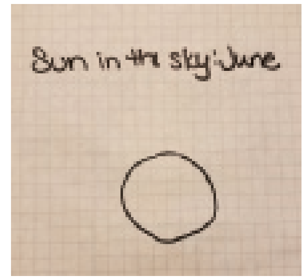
8. Put the second paper plate underneath and tape it to the top paper plate to provide more stability to the pipe cleaners.
9. Trim each piece of graph paper so it will fit underneath the pipe cleaners.



10. As you move to the next step of the investigation, discuss the questions on the following page with your group:
    a. Describe how the image of the light changes when the flashlight changes from one position to another.
    b. Do you observe any difference in the brightness of the light? Describe your observations.
    c. When you hold the flashlight in different positions, do you think there is any difference in the amount of energy from the flashlight that reaches any particular square on the graph paper?

11. Place the third paper plate next to the paper plates with pipe cleaners. Next, carefully place the piece of cardboard so it is lined up with the end of the 18-inch long pipe cleaner and place a piece of graph paper on top. Starting with the 18-inch long pipe cleaner, one student should hold the ruler so that the end of it is lined up with the end of the paper plate with pipe cleaners. Next, tilt the ruler so it is aligned with the tilt of the pipe cleaner. Turn the flashlight on and pull on the end so that the light is focused. Then lay the flashlight so that it is lined up with the 5-inch mark on the ruler.

12. The student holding the flashlight should observe the shape and size of the light image and describe it to your partner(s).
13. Trace around the pattern of light. The third group member can do this, or the person holding the tray can trace the pattern without moving the position of the tray. Take your time! Remove the paper from the flat surface and label it "Sun in the sky: June."



14. Add a new sheet of graph paper, placing it so that the edge is under the 15-inch long pipe cleaner. Repeat step 11 with the 15-inch long pipe cleaner.
15. Repeat steps 12 and 13, this time labeling the sheet of graph paper "Sun in the sky: March & September."
16. Add the final piece of graph paper, placing it so that the edge is under the 12-inch pipe cleaner. Repeat step 11 with the 12 inch long pipe cleaner.

17. Repeat steps 10 and 11, this time labeling the sheet of graph paper "Sun in the sky: December."

Making Sense

1. Fill in the data table by following these steps:
   a. Count the number of squares on each image. In the table, write the number of squares that the light covers for each condition. (Decide how you want to count partial squares, and be consistent. You could drop them all out, count them all, or estimate them to the nearest fraction.)
   b. Look for the wattage on the flashlight you are using. This number describes the rate of energy output of the flashlight. Write this number in the "Energy from the flashlight" column of the data table, in both rows. If you cannot find the wattage of the flashlight, assume that the rate of energy output of the light is about 5 watts.
   c. Calculate how much energy from light is concentrated on each square of graph paper by dividing the value in column 1 by the value in column 2 and recording the result in column 3:

Energy from light (column 1) ÷ Area (column 2) = Energy per square (column 3)

Time of year	Energy from the flashlight (measured in watts)	Area (total number of squares the light shines on)	Energy per square of graph paper (watts/square)
Sun in the sky: June			
Sun in the sky: March & September			
Sun in the sky: December			

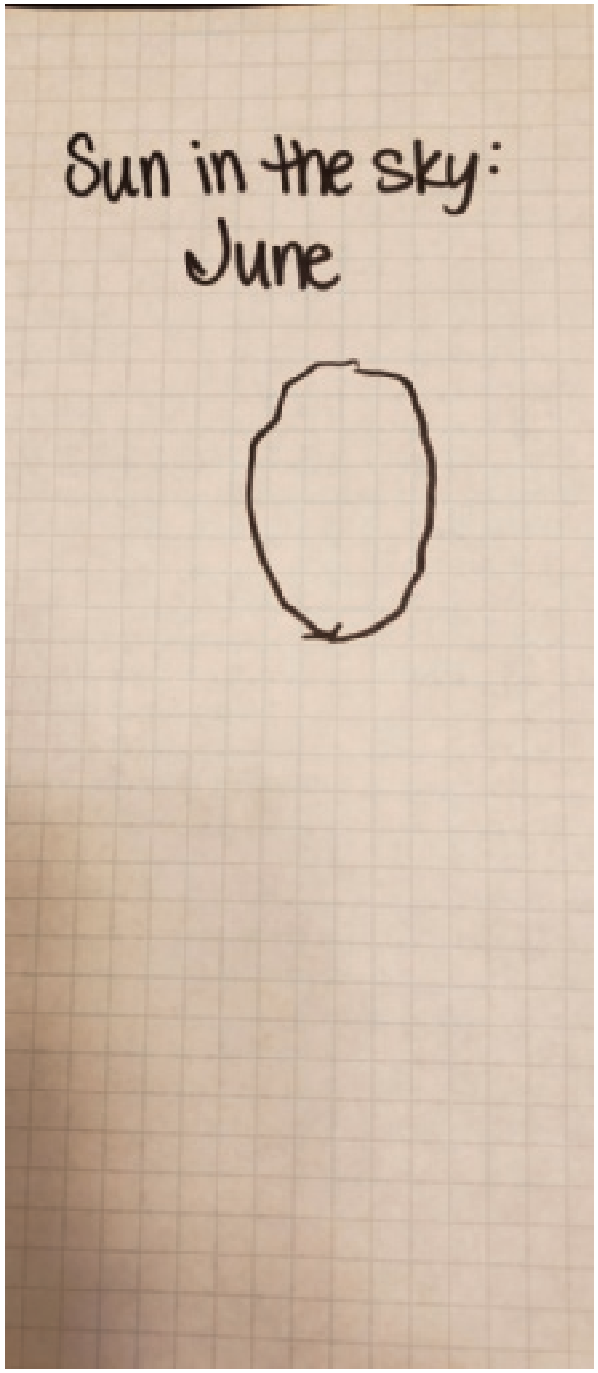
2. How do the angles of the pipe cleaners relate to the solar elevation measurements we made?

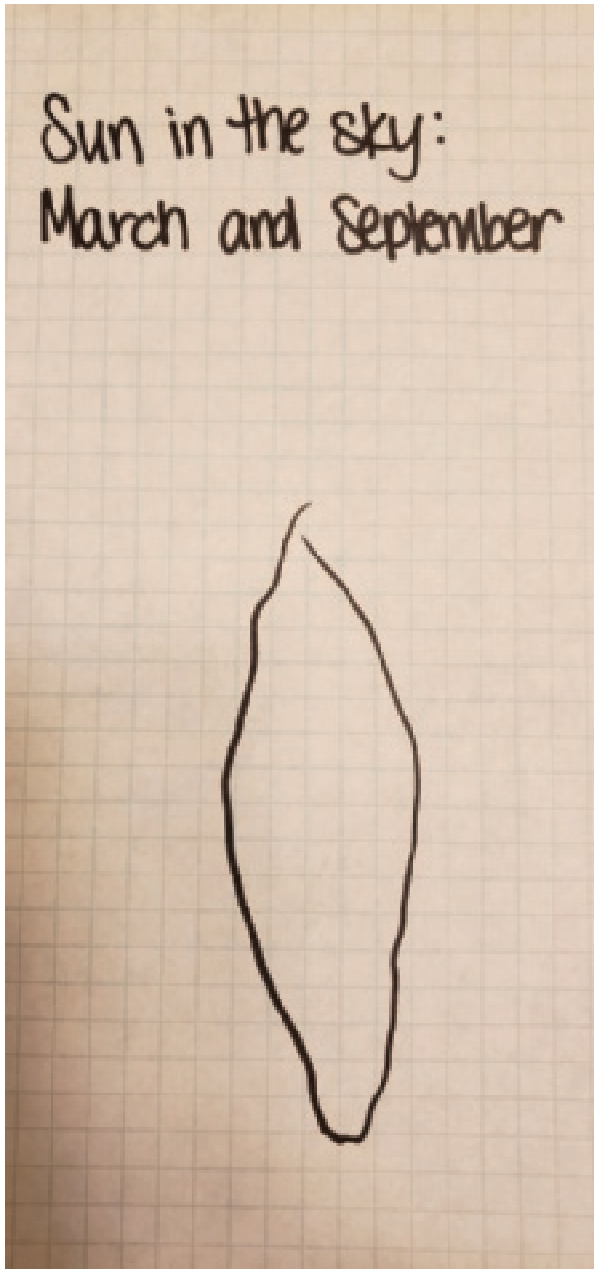
3. What pattern do you see in the energy from light per square of graph paper data?

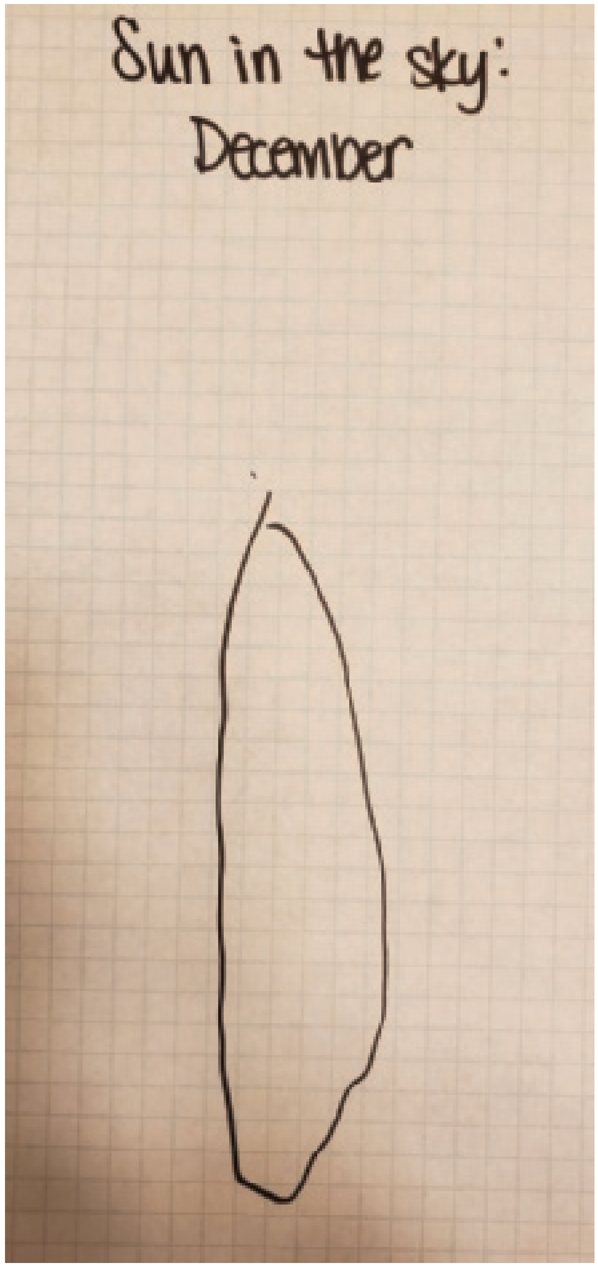
4. What relationship is there between the angle of the Sun in the sky, the watts per square, and temperatures on Earth? Why?

Name: ______________________ Date: ______________________

Graph Paper Images: Modeling Sunlight Angles




Sun in the sky:
March and September


Sun in the sky:
December

Lesson 4 Gotta-Have-It Checklist

Instructions: Use your Progress Tracker and your science notebook to make a checklist of the most important ideas we would need to model and explain: Why are there different seasons on Earth? Why do those seasons not happen at the same time for each place on Earth? Use words, labels, pictures, symbols, or zoom-ins to help express your ideas.

Why are there different seasons on Earth? Why do those seasons not happen at the same time for each place on Earth?	**Check off ideas as you use them.**	
	Used	*Not used*

Name: ______________________ Date: ______________________

Connecting Patterns in the Sun to Manhattanhenge

Play the https://youtu.be/3k7wYibhSq4 to gather data about the path and position of the Sun in the sky to help explain the Manhattanhenge phenomenon.

Jeffrey S. Putman

1. What patterns do you notice with the Sun that could be responsible for the Manhattanhenge alignment?

2. How do the patterns we see here compare to patterns we saw working with our orbital model of the Earth's tilt and path around the Sun?

3. Could our orbital model of the Earth's tilt and path around the sound explain why the position of the Sun at sunset changes the way it does in a cyclical pattern?

After creating the classroom consensus model:

4. *Use the class consensus model to explain why Manhattanhenge occurs just twice a year and why each of these days are about the same length of time away (~22 days) from the summer solstice (which is on June 21st, the longest day of the year).*

Name: ____________________ Date: ____________

Self-Assessment for Classroom Discussions

1. Read each statement and mark YES or NO for whole-class discussions and/or small-group discussions.

Today, I…	In whole-class discussions		In small-group or partner discussions	
	YES	NO	YES	NO
… shared my thinking by sharing new ideas, asking new questions, or asking for clarification from others.				
… listened actively to others by rephrasing, repeating and/or reusing the ideas of others, and/or by asking others to repeat their statements or to clarify ideas when they are difficult to hear or understand.				
… respectfully gave critiques to others about their explanations, models, investigation plans, or questions by using observations, data, or evidence and asking questions.				
… invited others to share their thinking.				

2. Choose one statement for which you checked NO—or a statement that you think you can improve on—and write down 2 ideas for what you can do to improve in the next discussion.

Name: ______________________ Date: ______________

Lesson 5 Community Guide for Looking at the Sky

There is not a right way to complete this activity—all students will do this differently with their different people and record their ideas in different ways. The important thing is that you take time to connect with someone else about the things you are figuring out about the sky.

Purpose of this Guide
Why would I use this community guide? How can this guide help me observe the sky?
Think about the supports and resources that other people provide you as a learner. • Do other people connect you to your family's knowledge, practices, and values? • Do other people give you opportunities to investigate beyond what you are doing in school? • Do other people allow you a chance to share and explain what you have figured out? • How do those supports help you make progress in your learning?

Lesson 5: Observing the Shape of the Moon

For Lesson 5, record the shape of the Moon in the sky before we meet next class. This could be a sketch, a picture, or a paragraph describing the shape of the Moon.

Bring this page home and share it with at least one other person (could be a friend, sibling, other family member, other trusted person). Use the following questions to guide you as you explore patterns in the sky together.

Before	
Where will you go to look at the sky? • Will you look from inside or outside where you live? • From somewhere at school? On your way to or from somewhere? • Maybe even at a park, parking lot, or other open space?	
What will your view be? • Are there trees or buildings around? • Are there bright lights? • Which direction(s) can you see best (north, south, etc.)?	
How will you stay safe when you are looking at the sky? • Do you need to consider traffic? • Are you going with an adult, or does an adult know where you're going and when you will be back?	

How will you record your observations? What tools will you need to bring with you? • Will you need a paper and pencil? A timer or watch? A flashlight? • Will you get these tools from a community center? From school? From where you live?	
Anything else that you want to share about the place(s) where you can go to observe the sky?	
My observing plan: • How often will you look? • If you're watching for patterns, should you set reminders for certain times of day or night to go look?	

Find the Moon in the sky (it isn't always visible!) and record your Moon observations below:

My Moon Observations	
When did I make this observation (include the date and time)?	
Draw and describe what you saw:	

My Moon Observations	
When did I make this observation (include the date and time)?	
Draw and describe what you saw:	

During/After Your Moon Observations
Now that you have made some Moon observations, what did you notice?
What did you wonder?
Talk with your person about why what you are seeing is important: How does this experience help you connect to the sky?

Name: ______________________ Date: ______________

Lesson 6: My Initial Model to Explain: ______________

1a. This is what a person on Earth would see:

1b. This is the time period for this pattern, or this is the time when the phenomenon occurred.

Change in perspective

Perspective is a place where you would have to be in the system in order to see a particular view.

2a. This is a model that can help explain what causes the pattern/phenomena I see from Earth.

2b. This is the perspective I took in the model above:

3. This is what is happening with the parts and interactions in this system that causes us to see the pattern/phenomenon in 1a:

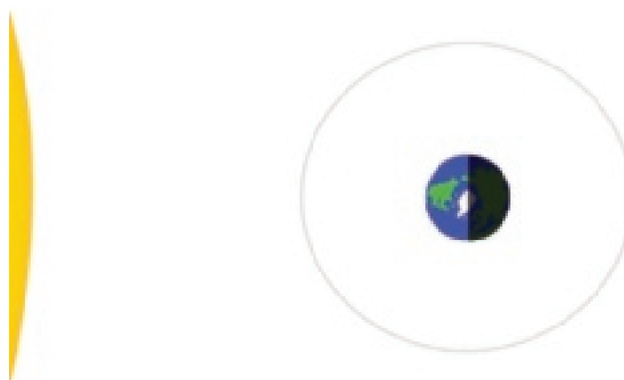
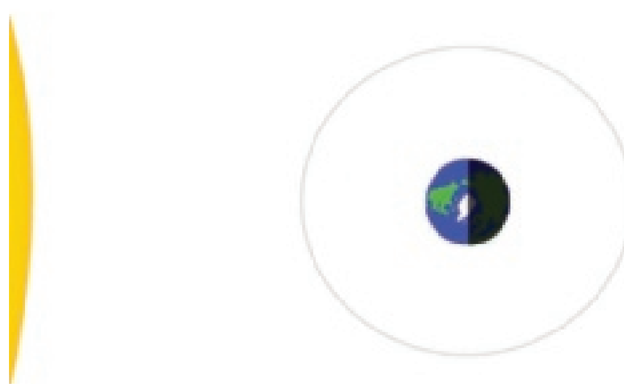
____

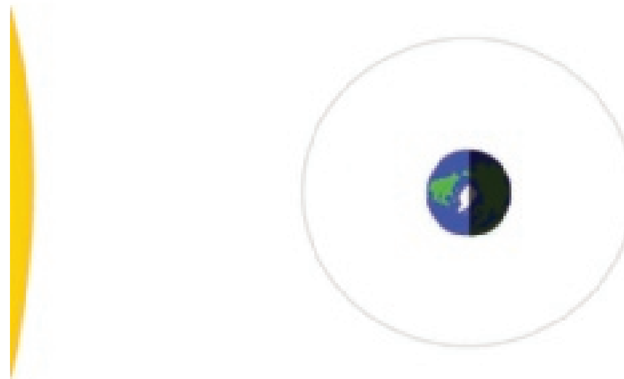
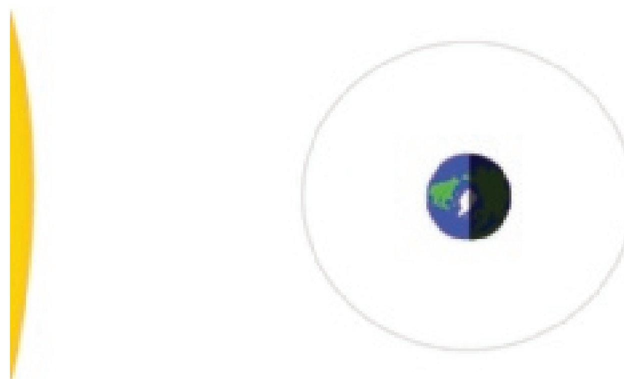
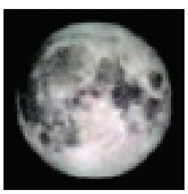
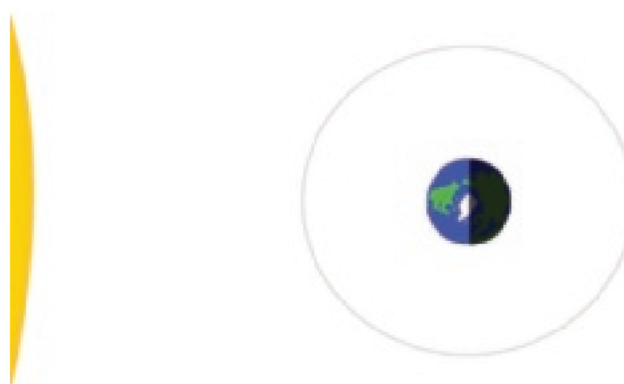
____

____

Name: ______________________ Date: ______________

Shape Patterns of Earth-Sun-Moon System

Shape Patterns of Earth-Sun-Moon System		
Image of the Moon (in the sky)	Description of the shape of Moon we see	Complete the model of the Earth-Sun-Moon system to explain why the Moon looks that way. • Add the location of the Moon on the circle that represents the orbit of the Moon. • Show the lit and unlit halves of the Moon. • Add an observer on the Earth.
 NASA's Scientific Visualization Studio		
 NASA's Scientific Visualization Studio		

 NASA's Scientific Visualization Studio		
 NASA's Scientific Visualization Studio		
 NASA's Scientific Visualization Studio		

Name: ______________________ Date: ________________

Lesson 7: My Initial Model to Explain: ______________

1a. This is what a person on Earth would see:

1b. This is the time period for this pattern, or this is the time when the phenomenon occurred.

Change in perspective

Perspective is a place where you would have to be in the system in order to see a particular view.

2a. This is a model that can help explain what causes the pattern/phenomena I see from Earth.

2b. This is the perspective I took in the model above:

3. This is what is happening with the parts and interactions in this system that causes us to see the pattern/phenomenon in 1a:

____

____

____

Name: ______________________ Date: ______________

Lesson 7: Self-Assessment for Collaborative Group Work

1. Read each statement and mark YES or NO for small group collaboration.

In my small group, I...	YES	NO
shared my thinking by sharing new ideas, asking new questions, or asking for clarification from others.		
listened actively to others by rephrasing, repeating and/or reusing the ideas of others and/or by asking others to repeat their statements or to clarify ideas when they are difficult to hear or understand.		
respectfully gave critiques to others about their explanations, models, investigation plans, or questions by using observations, data, or evidence and asking questions.		
invited others to share their thinking.		

2. Choose one statement (from above) for which you checked NO or that you think you can improve on.

3. Write down 2 ideas for what you can do to contribute more productively in small group collaboration. (Refer to our classroom norms to help you choose.)

Name: ______________________ Date: ______________

Analyzing Lunar Eclipse Images

Lunar eclipses usually last a couple of hours.

A. Predict: What do you think the Moon would look like on a clear night of a lunar eclipse?

before the eclipse starts	after it starts, but when the Moon is not totally eclipsed yet	in the middle, when the Moon is totally eclipsed

B. Observe: What do you notice in the lunar eclipse photos? What patterns do you see?	**C. Wonder:** What new questions do you have about this phenomenon?

D. Reflect: Our model correctly predicted …	**E. Reflect:** Our model did not predict …

F. Predict: What are some possible causes for the parts of a lunar eclipse that our model did not predict or you are not able to explain yet? What do you think is happening?

Name: ______________________ Date: ______________________

Home Learning: Choice Brightness / Color Data Collection

Measuring light is one of the simplest forms of data we can collect about the Sun, Moon and Stars. We have seen in class that sometimes light does not do what we expect. Scientists today measure light for many reasons. Perhaps collecting some light data from our own community might help us think about and better understand the patterns and effects of light as we experience it. If you have access to a smartphone, tablet, or other digital device that includes a camera, you can collect and measure light yourself.

As a class community, we can collect some data to help answer some of the questions we have about brightness and color. The tricky part is that there are so many different variables to consider! We need to decide who will measure, when to measure, how to measure, and what to measure.

Bring these papers home and share it with at least one other person (could be a friend, sibling, other family member, other trusted person). Use the questions following to guide you as you explore patterns in the sky together.

Instructions:

1. Download a light meter app that measures light in lux. Figure out if your app uses your front-facing or rear-facing camera to measure with. (Hint: when you cover the camera with your finger, the lux value should change to close to 0.)
2. Decide what question you would like to investigate related to brightness and/or color that your light meter might be able to help you answer. Plan what data you will record and how often, and fill in the table below with these plans.
3. At each planned time, take a picture. Remember: Do not look directly at the Sun with your own eyes. Also take a light reading while pointing the camera at the same object. Record the light reading with a screen shot to help you remember the date and time.
4. Add the images to your copy of this handout (or however your class has decided to collect your data), and be ready to share in class.

1. Use the camera on a phone or other device to take pictures of ___________				
Times:				
(drop photo here)				

2. Whenever you take a photo, also take a screenshot of your light meter app's reading to go with it.				
Light meter reading:	Light meter reading:	Light meter reading:	Light meter reading:	Light meter reading:
(drop screen shot here)				

3. Share your data with the class. What did you notice as you collected data?

4. What other investigations can you try using your light meter app? What ideas do you have that might be interesting to try?

During/After your observations

Talk with your person about why what you are seeing is important: How does this experience help you connect to the sky?

Name: ______________________ Date: ______________________

Home Learning: Sunset Brightness and Color Data Collection

Measuring light is one of the simplest forms of data we can collect about the Sun, Moon and stars. We have seen in class that sometimes light does not do what we expect. Scientists today measure light for many reasons. Perhaps collecting some light data from our own community might help us think about and better understand the patterns and effects of light as we experience it. If you have access to a smartphone, tablet, or other digital device that includes a camera, you can collect and measure light yourself.

As a class community, we can collect some data to help answer some of the questions we have about light and color. The tricky part is there are so many different variables to consider! We need to decide who will measure, when to measure, how to measure, and what to measure. To get our class started, let's try some sunset measurements and photos. We can always decide to collect other data later.

Bring these papers home and share it with at least one other person (could be a friend, sibling, other family member, other trusted person). Use the questions following to guide you as you explore patterns in the sky together.

Instructions:

1. Download a light meter app that measures light in lux. Figure out if your app uses your front-facing or rear-facing camera to measure with. (Hint: when you cover the camera with your finger, the lux value should change to close to 0.)
2. Check a weather forecast to see when the Sun will set. Choose a safe location to watch the sunset from (even if you cannot see the horizon from your location, you'll know when the Sun sets based on the time). This will be more fun if you are with a friend or family member.
3. Plan to spend 2 hours watching the sunset: an hour before and an hour after. Starting 60 minutes before sunset, take a picture and a light reading while pointing the camera at the Sun. Remember: Do not look directly at the Sun with your own eyes. Record the light reading with a screen shot to help you remember the date and time. (If you are short on time, plan to begin 30 minutes before sunset and continue to 30 minutes after, for a total of only 1 hour.)
4. Take another photo and light reading every 30 minutes until 60 minutes after sunset. You will have 5 photos and light measurements when you are done. (If you're only spending 1 hour, take photos and readings every 15 minutes.)
5. Add the images to your copy of this handout (or however your class has decided to collect your data), and be ready to share in class.

1. Use the camera on a phone or other device to take pictures of the Sun. Insert your images below.				
60 min before sunset	30 min before sunset	at sunset	30 min after sunset	60 min after sunset

2. Whenever you take a Sun photo, take a screenshot of your light meter app's reading to go with it. Insert your screenshots below.				
60 min before sunset	30 min before sunset	at sunset	30 min after sunset	60 min after sunset

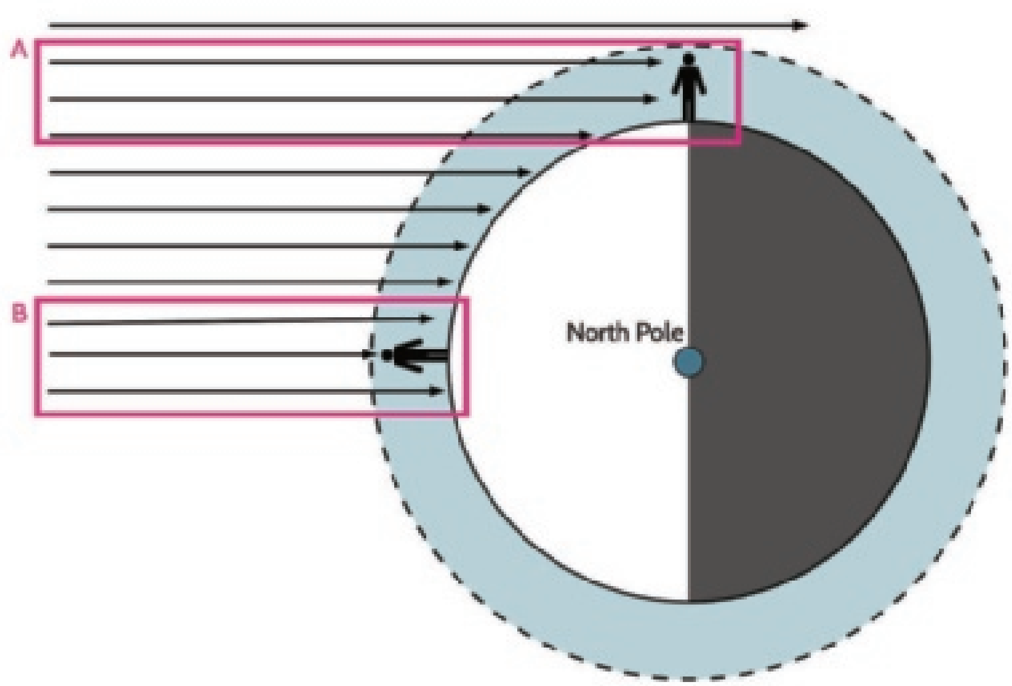
3. Share your data with the class. What did you notice as you collected data?

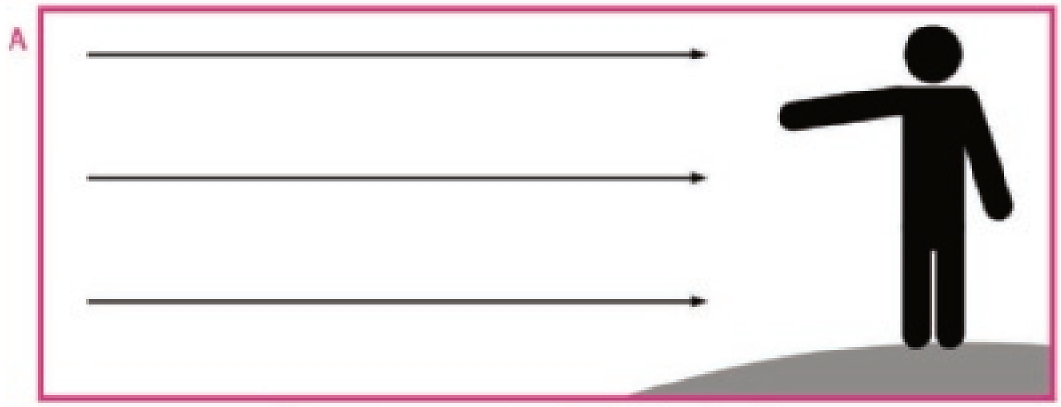
4. What other investigations can you try using your light meter app? What ideas do you have that might be interesting to try?

During/After your observations
Talk with your person about why what you are seeing is important: How does this experience help you connect to the sky?

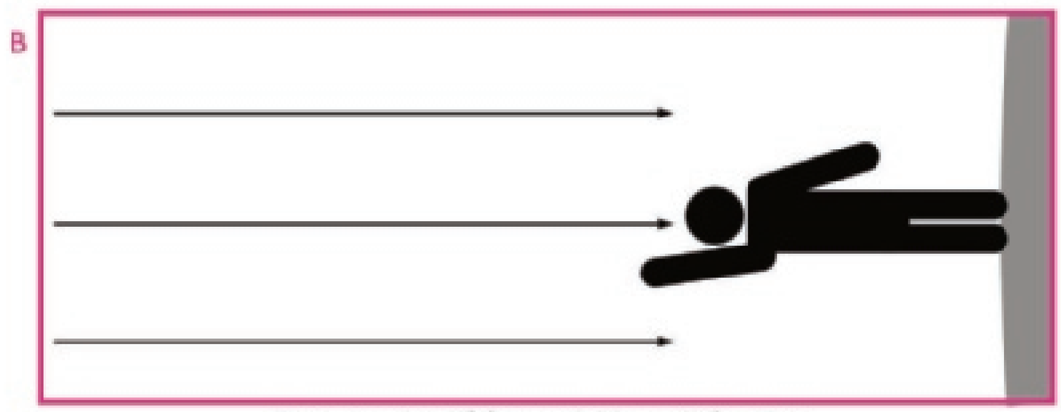
Name: ____________________ Date: ____________________

Comparing Sunlight at Sunrise vs. Midday





Person at sunset pointing at the Sun



Person at midday pointing at the Sun

Name: ____________________ Date: ____________

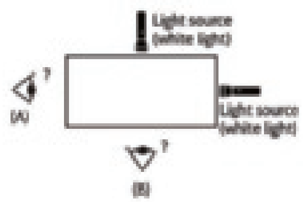
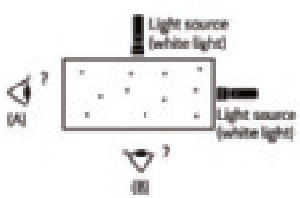
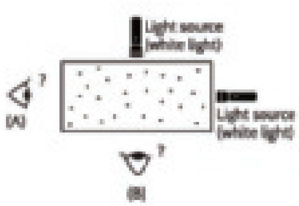
Investigation Elements Map, Predictions, and Results

Directions: Fill in the table as you map each part of the investigation set-up to the real-world phenomenon we are wondering about.

This part in our investigation...	is like this part in the real world...	because...
flashlight	the sun	
water	the gasses of our atmosphere	
milk powder	the particles in the atmosphere that are larger than molecules	
adding additional milk powder to the water	areas (or times) in the atmosphere where (or when) the particles are more dense	
the color of light from the flashlight (before it reaches the liquid)	the color of light from the Sun before it reaches Earth's atmosphere	
length of the container of liquid	the longer path of light through the atmosphere at sunrise or sunset	
width of the container of liquid	the shorter path of light through the atmosphere at noon	

Directions:

1. Record your predictions in the following table describing what you expect to see in terms of brightness ***and*** color.
2. Record your results as you find them in the following table describing what you do see in terms of brightness ***and*** color.

What color and brightness do we see through the simulated atmosphere at different positions/times of day?			
Investigation condition	**Scenario**	**Prediction**	**Results**
1) plain water 	(A) at eye level		
	(A) from above		
	(B) at eye level		
	(B) from above		
2) ¼ tsp milk powder + water 	(A) at eye level		
	(A) from above		
	(B) at eye level		
	(B) from above		
3) additional ¼ tsp milk powder + water 	(A) at eye level		
	(A) from above		
	(B) at eye level		
	(B) from above		

Making sense of the data:

1. How does the amount of the simulated atmosphere (the distance the light must pass through and/or the density of the particles in it) affect the ***brightnesses*** the light from the simulated sun after the light travels through it?

2. How does the amount of the simulated atmosphere (the distance the light must pass through and/or the density of the particles in it) affect the ***color*** of light from the simulated sun after the light travels through it?

3. Based on what you could see from the "imaginary cutaway" view of the atmosphere, what do you think is causing the changes we see when viewing light through the atmosphere?

Instructions for the Light and Milky Water Lab

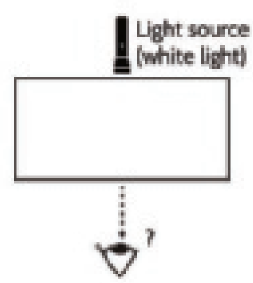
Follow the steps below to investigate how light shines through a simulated atmosphere. Your group will need the following materials:

- clear rectangular container
- water to fill the container ¾ full
- small cup of milk powder
- flashlight
- ¼ teaspoon measuring spoon
- small block or thin book to center flashlight on the water
- white paper to place under the container (if needed)
- science notebook with *Investigation Elements Map, Predictions, and Results*
- safety goggles

1. Fill your bin to about ¾ full of water and set it on a flat surface with space around all sides.
   - If the flat surface you are using is a dark color, slide a sheet or two of white paper under the bin to help you see any color changes more clearly.

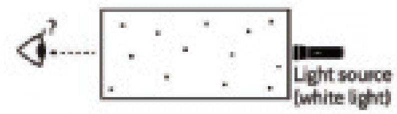
2. Shine a flashlight lengthwise (the long way) through the container and water. Set the flashlight on a small block or thin book to raise it so it shines into the center of the container.
   - Observe the light from eye level from the opposite side of the container.
   - Observe the container from above.
   - Record your observations on your handout in the rows for scenario 1A.

3. Shine a flashlight across (the short way) through the container and water.
   - Observe the light from eye level from the opposite side of the container.
   - Observe the container from above.
   - Record your observations on your handout in the rows for scenario 1B.

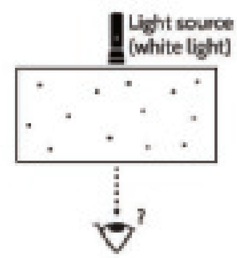


4. Add ¼ teaspoon of milk powder to the water and stir to dissolve.

5. Shine a flashlight lengthwise (the long way) through the container and milky water.
   a. Observe the light from eye level from the opposite side of the container.
   b. Observe the container from above.
   c. Record your observations on your handout in the rows for scenario 2A.



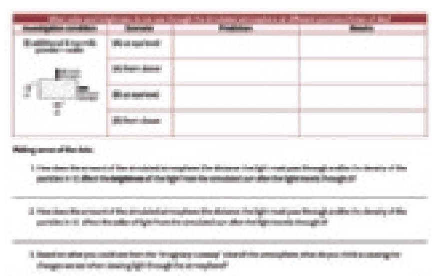
6. Shine a flashlight across (the short way) through the container and milky water.
   a. Observe the light from eye level from the opposite side of the container.
   b. Observe the container from above.
   c. Record your observations on your handout in the rows for scenario 2B.



7. Complete the predictions column for the third scenario on your handout (adding an additional ¼ tsp milk powder).

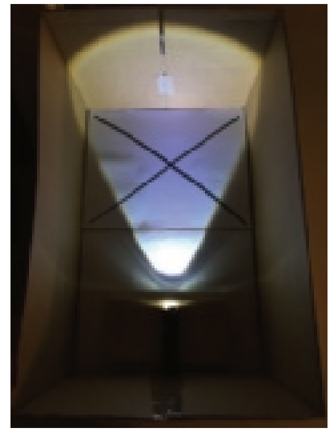
8. Add another ¼ teaspoon of milk powder to the water and stir to dissolve.

- Repeat steps 5 and 6 now that you have added more milk powder.
- Record your observations on your handout in the rows for scenarios 3A and 3B.



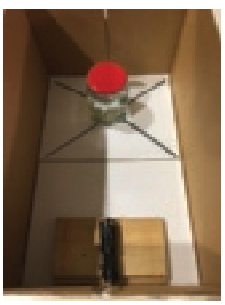
Name: ____________________ Date: ____________________

Rainbow Lab Instructions and Data Collection

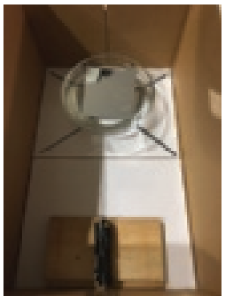


1. When you arrive at a lab station, notice how the flashlight is positioned. (You will need to reset it before you leave this station.) Turn on the light with the beam as wide as possible. Use a small piece of tape or a sticky note to mark the center of where the light shines on the inside of the box.
2. Carefully move the object at the station onto the X in the box. Turn on the flashlight and record observations on your data sheet of what you see. Pay special attention to the following:
   a. The locations of light at various places in the box. Label these.
   b. The location of any rainbows or colored light that appears. Make notes about where you find them. Be specific about color.
   c. Note any changes in light intensity—if the light became brighter or darker anywhere in the box as a result of interacting with the object.
3. Take some time to move and manipulate either the flashlight or the object to see if you can produce any different effects. If you create something interesting, record it in the third column of your observation sheet for the lab station you are working on. Hint: Think in 3 dimensions.
4. When time is up, remove the station object from the box and replace the flashlight on the block in the correct location. Move to the next station. Repeat these steps until you have visited all 4 investigation stations. Your station should look like the picture.

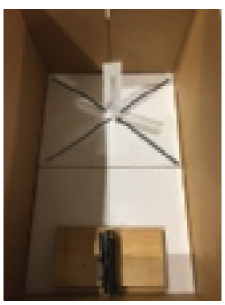
Station 1: round glass of water		
Image of Station	Observations (Record path of light and positions of light features such as rainbows, color patterns, etc.)	Improvements? Could you make a bigger, brighter or different rainbow in some way?
		

Station 2: hexagonal jar of water		
Image of Station	Observations (Record path of light and positions of light features such as rainbows, color patterns, etc.)	Improvements? Could you make a bigger, brighter or different rainbow in some way?
		

Station 3: bowl of water with mirror in it

Image of Station (use the lid of the box on an angle to see the reflections above)	Observations (Record path of light and positions of light features such as rainbows, color patterns, etc.)	Improvements? Could you make a bigger, brighter or different rainbow in some way?
		

Station 4: solid triangular prism

Image of Station	Observations (Record path of light and positions of light features such as rainbows, color patterns, etc.)	Improvements? Could you make a bigger, brighter or different rainbow in some way?
		

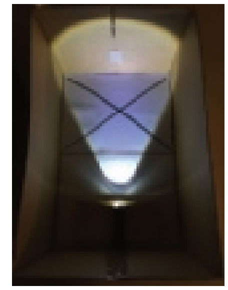
Reflection questions: As you think about the three questions, try to think about patterns (observations that were true for all stations) and unique moments (something that happened at only one station). Write about each idea, pattern, and unique moment as you answer each question.

- What happened to the *path* of light as it passed through the different shapes and mediums?

- What happened to the *color* of the white light as it passed through different mediums and shapes?

- What happened to the *brightness* of the light as it passed through different mediums and shapes?

Rainbow Lab Station Card



1. When you arrive at a lab station, note the position and orientation of the flashlight. In the observation space for that station, mark where the light would go if nothing got in the way (path of light) with a small piece of tape.
2. Using the X on the bottom of the box as a guide, place the object at the station on the X. Turn on the flashlight, and record observations of what you see. Pay special attention to the following:
   a. The locations of light at various places in the light. Label these.
   b. The location of any rainbows or colored light that appears. Make notes about where you find them. Be specific about color.
   c. Note any changes in light intensity—if the light became brighter or darker anywhere in the box as a result of interacting with the object.
3. Take some time to move and manipulate either the flashlight or the object to see if you can produce any different effects. If you create something interesting, record it in the third column of your observation sheet for the lab station you are working on. HINT: Think in 3 dimensions.
4. When time is up, remove the station object from the box and replace the flashlight on the block in the correct location. Move to the next station. Repeat these steps until you have visited all 4 investigation stations. Your station should look like the picture.

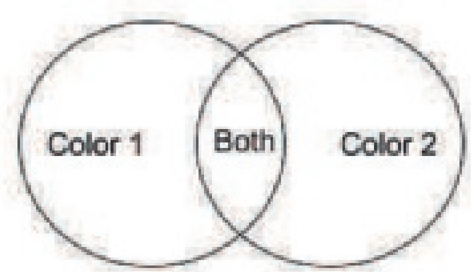
Reference: Combining Light Investigation

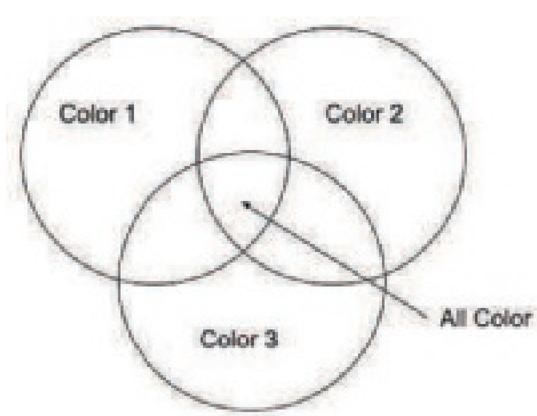
Part 1: Control Data (with your class)

1. Measure 1 meter from a wall and mark the spot with a piece of tape.
2. Tape one or more pieces of white paper to the wall (unless the wall is already white) to use as a target for the light.
3. Mark the center of the paper with an X. Label the X “Light Sensor”.
4. Hold the light sensor on the X and turn it on.
5. Standing on the 1m tape mark, point the flashlight at the light sensor and turn it on. Set the beam to the widest setting. Allow a few minutes to get a steady reading. Record this value (lux) in your lab handout *Rainbow Lab Instructions and Data Collection.*
6. Repeat step 5 for the remaining colors until you have a value for each individual color.

Part 2: Combining Colors (with your partner)

1. Gather 2 flashlights or team up with another lab group for this part.
2. Using the 1m mark you created in part 1, turn on both flashlights with a wide beam and overlap the colors about halfway on the white piece of paper as shown below.
   - Red and Green
   - Red and Blue
   - Green and Blue
3. After observing and recording the colors, place the light meter into the circles where both colors are. Record lux data for the combined colors.
4. Repeat steps 2 and 3 for all color combinations.
5. Gather one more flashlight or combine with a third lab group.
6. Shine all three colors (red, green, and blue) onto the white paper from the 1m mark. Observe and record the colors.
7. Place the light meter into the center of all three. Record the lux data for the combination of the three colors.





Name: ____________________ Date: ____________________

Combining Colors of Light Data

Part A: Control Data. Record the brightness of each color in the spaces below following the lab procedures.

Blue	Green	Red	White

Additional Observations or Questions:

Part B: Recombining light. We know that white light can be split into many colors. What will we see happen if we recombine those colors? Record your predictions and then your observations about both the color and brightness of these combinations of light.

Combination	**Color(s)**		**Brightness (More, Less, Same)**	
	Prediction	Observed	Prediction	Observed
Red Light and Green Light				
Green Light and Blue Light				
Red Light and Blue Light				
Red Light, Green Light, and Blue Light				

Name: ____________________ Date: ____________

Evaluating Past Models

Model	Parts, interactions, or ideas to keep
Lesson 7: Our class consensus model predicted that the Moon would go completely dark during a lunar eclipse. It included • the sun, the Earth, and the Moon traveling in an orbit around the Earth, and • light rays traveling in straight lines and a person viewing the event.	
Lesson 9: Our model showed that • the changes in color and brightness that occur in sunlight as it passes through the atmosphere, and • how the angle of that light and the amount of atmosphere it travels through differs at sunset/sunrise compared to midday.	
Lesson 10: Our model showed that when we shine a white light from a flashlight through a simulated "atmosphere" the following: • The color of the light that passes through the "atmosphere" becomes oranger or redder, and the brightness of the light decreases the more "atmosphere" it travels through. • Light reflecting/bouncing off of particles in the "atmosphere" in all other directions appears bluish.	
Lesson 11: Our model showed the following: • When a beam of light enters and/or exits different types of material/media, the angle of that light can diffract some (change direction) and the colors that make up that light can be separated into the colors of the rainbow; each color will diffract at a different angle. • When different colors of light overlap, the resulting combination of light is a new color that is brighter than any of the beams of light before they overlapped.	

Now, record any new parts, interactions, or ideas we should include in our revised models to explain the color and brightness changes we observe in lunar eclipses. Be sure to provide reasoning for why we need these.

New parts, interactions, or ideas to include	Why do we need to include these?

Name: ______________________ Date: ______________

Peer Feedback Self-Assessment

Giving Feedback: How well did you give feedback today?

Today, I ...	YES	NO
gave feedback that was **specific** and about **science ideas.**		
shared a suggestion to help improve my peer's work.		
used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

One thing I can do better the next time I give feedback is:

Receiving Feedback: How well did you receive feedback today?

Today, I ...	YES	NO
carefully **considered the feedback** I received.		
asked follow-up questions to better understand the feedback I received.		
said why I agreed or disagreed with the feedback.		
revised my work based on the feedback.		

What is one piece of feedback you received?

What did you add or change to address this feedback?

Name: ______________________________ Date: ______________________

Giving Feedback to Peers

This tool was inspired by the Sticky Note Feedback resource originally developed by Ambitious Science Teaching at: https://ambitiousscienceteaching.org/sticky-note-student-feedback/.

Feedback needs to be specific and actionable.

That means it needs to be related to science ideas and provide your own suggestions for improvement. Nonproductive examples of feedback that do not help other students improve are as follows:

- "I like your drawing."
- "Your poster is really pretty."
- "I agree with everything you said."

How to Give Feedback

Your feedback should give ideas for specific changes or additions the person or group can make. Use the sentence starters below if you need help writing feedback.

- The poster said ______________________. We disagree because ______________________. We think you should change ______________________.
- I like how you ______________________. It would be more complete if you added ______________________.
- We agree that ______________________. We think you should add more evidence from the ______________________ investigation.
- We agree/disagree with your claim that ______________________. However, we do not think the ______________________ (evidence) you used matches your claim.

Receiving Feedback from Peers

The purpose of feedback is to get ideas from your peers about things you might improve or change to make your work more clear, more accurate, or better supported by evidence you have collected. It can also help you communicate your ideas more effectively to others.

When you receive feedback, you should take these steps:

- Read it carefully. Ask someone else to help you understand it if necessary.
- Decide if you agree or disagree with the feedback and say why you agree or disagree.
- Revise your work to address the feedback.

Name: ____________________ Date: ____________________

Experiences and Connections with the Planets

Have you ever observed a planet in the night sky? If so, when? What thoughts and questions came to mind?	
Do you have a favorite planet that you have heard about or are interested in?	
What are some other ways that people in your community or beyond have made connections with planets?	

Name: ____________________ Date: ____________________

Explaining Venus-Related Patterns

Use manipulatives to show where Venus and Earth would need to be located in the system that would help explain each Venus-related pattern below. After doing this, draw and label where Earth, Venus, and the Sun would need to be located in the system to explain what a person on Earth observes related to each phenomena. Use a perspective similar to the one on *Competing Models of the Venus, Earth, and Sun System,* which is drawn looking down on Earth from a location far above the Earth's North Pole.

When a transit of Venus can be seen from Earth	When we see only half of Venus lit up (like a half moon)
When the size of Venus appears to be growing bigger from one day to the next when it is being viewed from Earth	When the size of Venus appears to be growing smaller from one day to the next when it is being viewed from Earth

Name: ______________________ Date: ______________________

L13: Community Guide for Looking at the Sky

There is not a right way to complete this activity—all students will do this differently with their different people and record their ideas in different ways. The important thing is that you take time to connect with someone else about the things you are figuring out about the sky.

Purpose of This Guide
Why would I use this community guide? How can this guide help me observe the sky?
Think about the support and resources that other people provide you as a learner. • Do other people connect you to your family's knowledge, practices, and values? • Do other people give you opportunities to investigate beyond what you are doing in school? • Do other people allow you a chance to share and explain what you have figured out? • How does their support help you make progress in your learning?

Lesson 13: Planets and Other Patterns in the Sky

For Lesson 13, take note of any other objects (such as planets) from our Patterns and Phenomena in the Sky poster you plan to look for in the sky, especially if we have not yet investigated their patterns.

Bring these pages home, and share it with at least one other person (could be a friend, sibling, other family member, or other trusted person). Use the following questions to guide you as you explore patterns in the sky together. Please remember to never look directly at the Sun as it could be permanently damaging to your eyes.

My Observing Spot	
Where will you go to look at the sky? • Will you look from inside or outside where you live? • From somewhere at school? On your way to or from somewhere? • Maybe even at a park, parking lot, or other open space?	
What will your view be? • Are there trees or buildings around? • Are there bright lights? • Which direction(s) can you see best (north, south, etc.)?	
How will you stay safe when you are looking at the sky? • Do you need to consider traffic? • Are you going with an adult, or does an adult know where you are going and when you will be back?	
How will you record your observations? What tools will you need to bring with you? • Will you need a paper and pencil? A timer or watch? A flashlight? • Will you get these tools from a community center? From school? From where you live?	
Anything else that you want to share about the place(s) where you can go to observe the sky?	

Before	
My observing plan: • How often will you look? • If you are watching for patterns, should you set reminders for certain times of day or night to go look?	

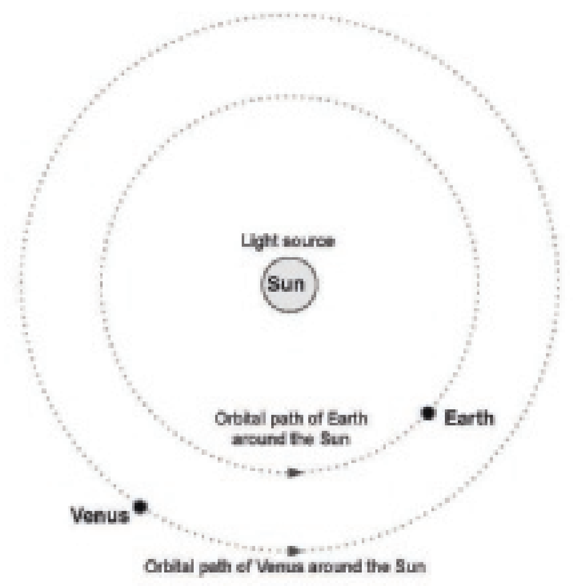
My Observations	
When did I make this observation?	
Describe what you saw:	
Draw what you saw:	

During/After Your Observations
1. What did you notice? What did you wonder?
2. Talk with your person about why what you are seeing is important: How does this experience help you connect to the sky?

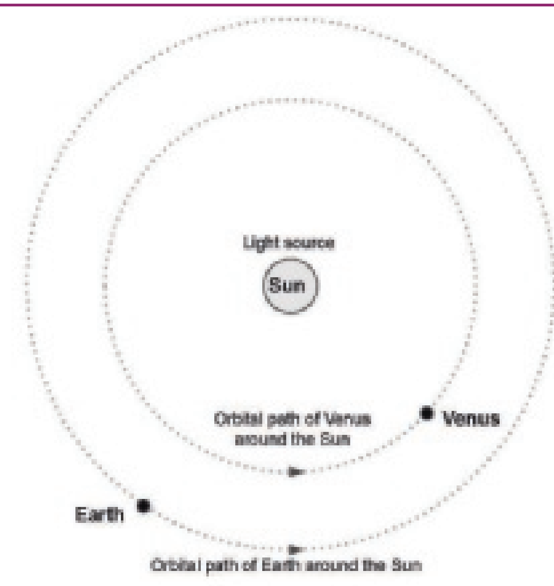
Name: ______________________ Date: ________________

Competing Models of the Venus, Earth, and Sun System

Below are two different models that two groups of students developed to try to explain some of the patterns in the observations people have made of Venus. Note: the perspective is drawn looking down on Earth from a location far above the Earth's North Pole.



Model A



Model B

Which model, A or B, better supports an explanation of all the patterns of Venus that people have observed over time? Use evidence from your investigations on *Explaining Venus-Related Patterns* to support your answer.

Name: ______________________ Date: ______________________

Looking for Patterns in the Solar System Infographics

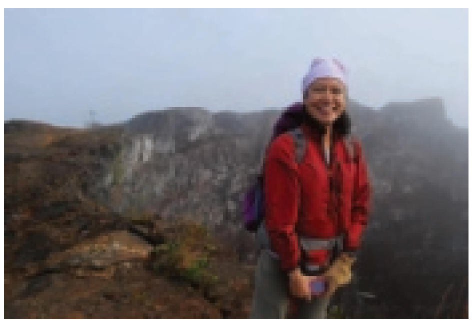
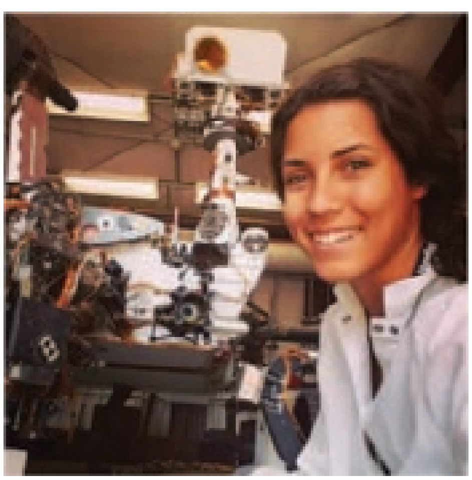
Trim the top and bottom borders of each infographic. Align the bottom of the first page of each infographic to the top of the next page, and use tape to attach them.

Analyzing and Interpreting Data from Infographics Close Reading Protocol

<table>
<tr><th colspan="2">Analyzing and Interpreting Data from Infographics</th></tr>
<tr><td>Before</td><td>With Your Partner
• What object or objects are the focus of each infographic?
• What do you know already about this object (or objects)?
• What do you want to know more about this object (or objects)?
Discuss these questions with your partner.</td></tr>
<tr><td>During</td><td>• Read the infographic once individually for understanding to see what it is about.
• Select methods for marking up the text. For example...
    • keep track of questions or wonderings in your science notebook;
    • circle key words;
    • put question marks by words you want to learn more about; and
    • underline main ideas.
• Examine any images, graphs, or tables. Write about any patterns you notice in each infographic or across infographics.
• Consider reading parts of the infographics a second time out loud with your partner to identify the key ideas.</td></tr>
<tr><td>After</td><td>Discuss this question with your partner, and then answer them in your Progress Tracker:
• What new patterns do we see when we look more closely at other objects in the sky?
Be ready to share this information with the class.</td></tr>
</table>

Name: ______________________ Date: ______________

Gravity Assist Podcast Transcripts

Link	Podcast Title and Narrator	Timestamps for Watching Video
1. https://youtu.be/1-_1YTs2zjl	NASA Gravity Assist Podcast: Breaking barriers, with Dana Bolles 	0:00-3:26; 18:18-21:20
2. https://youtu.be/WtVmAnzs7d8	NASA Gravity Assist Podcast: Before you launch, practice, with Darlene Lim  NASA, non-commercial	0:00-1:22; 17:54-20:59
3. https://youtu.be/I5bNJIwt0yk	NASA Gravity Assist Podcast: Driving on Mars with rover driver, with Sophia Mitchell  NASA/JPL-Caltech, non-commercial	0:00-1:23; 16:21-21:29

4. https://youtu.be/CCreOzT8J_o	NASA Gravity Assist Podcast: Puffy planets, powerful telescopes, with Knicole Colon  NASA/Knicole Colon	0:00-1:09; 20:03-23:20
5. https://youtu.be/5X_Nf0AhsA0	NASA Gravity Assist Podcast: talking to ingenuity and other space robots, with Nacer Chahat  NASA/JPL-Caltech, non-commercial	0:00-1:04; 15:36-18:05

Questions to think about as you listen

1. What does the individual interviewed do at NASA?
2. What was their "gravity assist" in getting interested in their field?
3. What questions do you have for the person interviewed?
4. Have you thought about a career involving space exploration?

1: Dana Bolles Transcript

Dana Bolles has worked in many exciting areas of NASA, including assuring the safety of experiments and spacecraft going to space, managing environmental programs, and thinking about the possibility of life beyond Earth. In her journey as a space professional, a key challenge has been encountering other people's assumptions about what she can and cannot do. Dana gets around in a wheelchair and uses hooks for hands. In this episode, she talks about her experiences around NASA and how everyone can be a better ally for people with diverse abilities: "By getting to know us first, without preconceived notions, the benefit is seeing the community for the beauty we bring to living life every day."

Jim Green: Behind the scenes of NASA, so many things have to work right for us to be able to make a mission successful. Let's talk to somebody who has worked in many different areas of NASA.

Dana Bolles: With my disability, people tend to make assumptions about what I can and can't do. I would say that's been the biggest challenge.

Jim Green: Hi, I'm Jim Green, and this is a new season of *Gravity Assist*. We're going to explore the inside workings of NASA in making these fabulous missions happen. I'm here with Dana Bolles. And she works for the Science Engagement and Partnership Division at NASA Headquarters. Dana was first hired as a payload safety engineer at the Kennedy Space Center in 1995. And since then, she has worked at 4 NASA centers and mission support roles, and at least 10 more years in the human exploration and science divisions. Welcome, Dana, to *Gravity Assist*.

Dana Bolles: Thank you, Jim, for inviting me. I appreciate it.

Jim Green: My pleasure. Well, I really want to know what really got you excited and wanted to work for NASA.

Dana Bolles: So, you know, most kids would say, "Oh, I want to work for NASA". Right? That's a common, common thing. But more specifically, when I was younger, when I was thinking of all the different jobs to have, I thought, an astronaut, being an astronaut would be perfect, because it would, I would be in an environment where I wouldn't need the wheelchair, and the fact that I don't have legs would be okay. And in fact, it can even be an advantage, right? Because, back then, you're having to launch in these, these little spaces, these small spaces where you're all crammed in like sardines. And I thought, well I'd be, I'd be at an advantage. I wouldn't need leg space. And thirdly, I use artificial arms. So, I was born without arms, and I have used my artificial legs since I was two years old, so I'm pretty proficient in them. So I thought, that's a third reason why it might be an advantage to hire me as an astronaut because I could use my hooks, you know, like the astronauts use the robotic arms. And, so, there you go, three reasons to hire me. (laughs)

Jim Green: Well, what was your biggest challenge, you know, that you faced when you prepared for your career at NASA?

Dana Bolles: One of the biggest challenges was, you know, I was getting my engineering degree in the early 90s. And still, at that time, there was a handful of us girls and women in the class, but we were largely outnumbered. And so that was a weird feeling, right? Being one of the few women and going through the major. Also, the biggest thing for me is, with my disability, people tend to make assumptions about what I can and can't do. So I would say, the biggest challenge in, in my success in my career and working at NASA or wherever, is just having to always put up against those assumptions and limiting me. So I would say that's the biggest challenge. And it gets kind of tiring, always having to prove myself, you know?

Jim Green: Well, what's the one thing that people could do to really be a better ally for the disability community?

Dana Bolles: Jim, thanks for asking that question. The one thing that people could do to be a better ally to the community is to not see us for what we can't do. But be curious about what we can do. So while people's initial reaction to disability is often negative and feeling sorry for us, they don't see that living this experience makes us better problem solvers. So by getting to know us first, without preconceived notions, the benefit is seeing the community for the beauty we bring to living life every day.

Jim Green: Well, NASA really looks for a diversity of people because each and every one of our experiences, and that includes people with disabilities, brings a certain level of sensitivity and a certain ability to solve some of the most complex problems that, you know, we really face if we're going to learn to live and work on a planetary surface. Dana, I always like to ask my guest to tell me what was the event, the person, place, or thing that got them so excited about being the engineer they are today in NASA. And I call that event a gravity assist. So, Dana, what was your gravity assist?

Dana Bolles: This was a really difficult question for me to answer. You know, at first, I thought it was, of course, it's my mom, she's the one who gave me my backbone. She helped build my confidence. And then, and then I thought, well, then it could be the principal and the teachers who mainstreamed me at such a young age. It could be my father who, not knowing him for the first 39 years of my life, when I do find him, I find that he builds spacecraft models for a living. So when I look at all of this, you know, I would say, if I had to narrow it down, I would say it would be people. You know, it's my family, my friends, my mentors. All of that kind of helped to give me the gravity assist to come to NASA and to be successful.

Jim Green: Dana, thanks so much for joining me and discussing this fascinating topic of all the activities that you've been doing in NASA.

Dana Bolles: Thank you. It was a great honor.

Jim Green: Well, join me next time as we continue our journey to see what happens underneath the hood in NASA. I'm Jim Green, and this is your *Gravity Assist.*

Credits:

Lead producer: Elizabeth Landau

Audio engineer: Manny Cooper

2: Darlene Lim Transcript

The Moon doesn't have Wi-Fi; neither does Mars. When future astronauts explore the surfaces of the Moon, Mars, or beyond, they'll have big challenges communicating with Mission Control back on Earth. Darlene Lim at NASA Ames Research Center has been organizing expeditions on Earth that simulate science operations on other planetary bodies. Her team demonstrates how astronauts, scientists, and mission operations specialists can collaborate on expeditions, despite communication delays and location differences. She also discusses her role on VIPER, a rover that will explore ice deposits on the Moon and drill in shadowed craters colder than Pluto.

Jim Green: How does an astronaut know what to do when they are walking on the surface of the Moon or Mars? Let's talk to an expert who helps the astronauts do their job. Hi, I'm Jim Green, and this is a new season of *Gravity Assist.* We're going to explore the inside workings of NASA in making these fabulous missions happen. I'm here with Dr. Darlene Lim. Darlene is a NASA geobiologist and exobiologist at NASA's Ames Research Center, out in Mountain View, California. Darlene works on preparing astronauts for scientific exploration of the Moon and Mars. Her expertise involves Mars human analog missions. And analogs are places that we go to here on Earth that are extremes and have the physical attributes for the harsh environments that we're going to send humans to in space. Welcome, Darlene, to *Gravity Assist.*

Darlene Lim: Thank you so much for having me here. It's such a joy. It's such a privilege. Thank you, Jim.

Jim Green: Well, Darlene, I always like to ask my guest to tell me what was that event or person, place, or thing that got them so excited about being the scientists they are today. I call that event a gravity assist. So, Darlene, what was your gravity assist?

Darlene Lim: Well, I am so grateful for you to ask this question because I tell you, it's taken a village to get me to where I am. And I will answer your question with two answers. First, it's people, many people. There are the colleagues that have believed in me. There are my parents who have showed me what hard work is, gave me an appreciation for the natural world. They were immigrants to Canada, and they really wanted to embrace their new country, and we spent a lot of time camping and fishing and so forth. That gave me such a love of the natural world and, you know, imbued me to this day with that love. And my mom, you know, my mom, she came to help care for my kids when they were young—I have two children—so that I could go into the field, so that there was that possibility, and I couldn't have done anything without her. She was a huge gravity assist in my life. There's my husband, who is a true partner in every sense of the word. And then there are my kids who inspire me to be better, to work smarter, to be more focused every single day. There is not a spare moment because I want to be present for them too. So as a collective, I see all of these people as being so intrinsically part of the gravity assist. And then the second thing I want to mention is that event-wise, every single failure that I have been through in my life, every single anxiety, moment of difficulty, I wouldn't be here in this, you know, place speaking to you if it wasn't for all of those failures that we don't see captured in our CVs, that we don't see captured in even these types of conversations, but they're there. And they've helped me understand how to be better at my job, how to be more thoughtful, how to be more inclusive, how to, you know, get through difficult things and know that it'll be okay on the other end. And that's such a big part of learning to work with other people.

Jim Green: Well, Darlene, thank you so much for joining me in discussing these fantastic things that you do to help make this agency successful.

Darlene Lim: Thank you so much for having me on this wonderful program, Jim. I really appreciate it.

Jim Green: My pleasure. Join me next time as we continue our journey to look under the hood at NASA and see how we do what we do. I'm Jim Green, and this is your gravity assist.

Credits:

Lead producer: Elizabeth Landau

Audio engineer: Manny Cooper

3: Sophia Mitchell Transcript

What does it take to drive a rover that's more than 100 million miles away? Sophia Mitchell at NASA's Jet Propulsion Laboratory has been driving the Mars Curiosity rover since 2018. In addition to her science and engineering background, Mitchell is also an avid hiker and pilot and explains how she combines all of these interests and skills in her job. Curiosity landed on Mars on August 6, 2012, and sends back images and other science data from Mount Sharp in Gale Crater. On February 18, 2021, NASA's Perseverance rover will land on Mars at Jezero Crater. Mitchell also explains how these craters are different and why she's excited to have a second rover exploring the Red Planet.

Jim Green: What does it take to drive a rover on Mars? How easy or how hard is it? What do we need to know to do it right? Hi, I'm Jim Green, and this is a new season of *Gravity Assist*. We're going to explore the inside workings of NASA in making these fabulous missions happen. I'm here with Sophia Mitchell, a NASA engineer at the Jet Propulsion Laboratory. Sophia currently works on the flight operations team for the Mars Curiosity rover. And she's been involved in the Perseverance rover, soon to land on Mars. So, Sophia, welcome to *Gravity Assist*.

Sophia Mitchell: Hi, thank you so much for having me.

Jim Green: Before we named the rover Curiosity, the whole program was called the Mars Science Laboratory, or MSL. Well, how long have you been driving Curiosity?

Sophia Mitchell: So, my first drive on Mars with Curiosity was in 2018. It was actually right around New Year's. And it was extremely exciting. But it was also very satisfying because learning to drive the rover is a very long process. And while driving it wasn't the end of that learning process, I began learning how to drive the rover in 2017.

Jim Green: Well, you know, I think Mars rover driving is a real dream job. What would you suggest for, you know, the younger crowd that's thinking about a future and a way to get into the NASA workforce? How would they go about doing that?

Sophia Mitchell: So, there's not one specific path to becoming a rover driver. But it is important to, as always, focus on math and science skills. Make sure that you're studying and things like that but also make sure that you have a good work–life balance, that you do the things that you enjoy doing. I mentioned how I bring some skills from backpacking into being a rover driver. I've also brought in skills from being a private pilot into being a rover driver. There's a lot of talking over radios and having to remember different information that's being told to me very quickly and listening to two or three radios at the same time sometimes. And so, there's all these different aspects of my life that I pull into being a rover driver, [and] make me a better one. So if I only focused on, you know, just engineering period with my life, then that actually wouldn't be great. And then also just being persistent. The way that I got into doing research at University of Louisville was I literally walked into the astrophysics department with my mom. And my mom, to her credit, said, "This girl needs to be with people who understand what she's talking about. I don't know what she's talking about." My mom's an artist, and I love her. So, just don't be afraid to ask questions. Don't be afraid to email people, knock on doors. Go say hi. More often than not, they'll be happy that you did.

Jim Green: So, Sophia, I always like to ask my guest to tell me, what was that event? Or was it a person, place or thing that got them so excited to become the engineers they are today? And I call that event a gravity assist. So, Sophia, what was your gravity assist?

Sophia Mitchell: So, my gravity assist, I think, was my sixth grade science fair. I've been interested in space since, probably since I was born. And when I was in middle school, we had to do science fair. It was mandatory. And I didn't really take it seriously. My first science fair project was on the tenacity of hair. So, I had cut some of my hair, put it in creek water from our creek in our yard in Kentucky, put some in some pool water, put some in some tap water, and tried to see when hair broke. And I thought I did a good job. And we get to science fair. And my teacher told me, "This needs to have a better purpose." And looking back, I realized that she just meant I should rewrite my purpose. But at the time, I took that to mean, this project doesn't have a purpose, like, what are we going to do with the tenacity of hair? That's not really helping people. Why are we looking at this? And so, I started to think about, how could I take this research process, the scientific process that I was learning about, and apply it to something that I really, really enjoy? I was just so, like, determined, because I had this teacher say, "Your project has no purpose." And I was just so upset by that. I wanted to prove her wrong. And so the next year, my project was finding a correlation between sunspot count and global mean temperature. And there really wasn't a huge correlation there. But it started getting me to think about the bigger questions that we can answer with science and trying to figure out how to make that more accessible, and so yeah, I ended up moving on to looking at solar flare size compared to sunspots and proton density in the solar wind compared to solar flare size. I had started getting data from Ace observatory, went to International Science Fair, which for anybody listening, it's completely worth it. Go crazy with science fair because International Science Fair is extremely fun. I went twice. That's how I ended up then working at the University of Louisville in the Astrophysics Department. So it really just exploded from angry at the sixth grade science fair into getting published in the monthly notices for the Royal Astronomical Society. Yeah, I was really determined. I went and knocked on a lot of doors, and that's how I got where I am now.

Jim Green: Well, Sophia, thanks so much for joining me in discussing this fascinating topic, how we work on Mars.

Sophia Mitchell: Yes, and thank you again for having me. I've really enjoyed talking with you today.

Jim Green: Well, join me next time as we continue our journey to lift up the hood and look inside of the activities that NASA does to make fantastic missions happen. I'm Jim Green, and this is your *Gravity Assist*.

Credits:

Lead producer: Elizabeth Landau

Audio engineer: Manny Cooper

4: Knicole Colon Transcript

With more than 4,000 planets known that orbit other stars, scientists have discovered that many of these exoplanets are quite unlike our own. NASA has a whole fleet of spacecraft that look at different aspects of these planets. Currently TESS, the Transiting Exoplanet Survey Satellite, is checking out nearby stars for possible planets. It is helping to identify candidates that future telescopes will explore further. The upcoming James Webb Space Telescope will examine the atmospheres of exoplanets and look for clues about whether they are habitable. NASA astrophysicist Knicole Colon describes her work on the Kepler, Hubble, TESS, and Webb missions and takes us on a tour of some of her favorite planets.

Jim Green: After James Webb gets launched, it's going to find all kinds of fantastic things and enhance our understanding of habitability. But what are the real measurements that it needs to make to tell us that these planets may be habitable?

Knicole Colon: Any information we can get is really going to help us move forward in our understanding of the universe, really.

Jim Green: Hi, I'm Jim Green, chief scientist at NASA, and this *Gravity Assist.* On this season of *Gravity Assist,* we're looking for life beyond Earth. I'm here with Dr. Knicole Colon, and she's a research scientist, an astrophysicist at NASA's Goddard Space Flight Center, where she leads projects on the search for planets outside the solar system using the TESS spacecraft and also planning for the upcoming James Webb Space Telescope. Welcome, Knicole, to *Gravity Assist.*

Knicole Colon: Thanks for having me.

Jim Green: Well, Knicole, I always like to ask my guest to tell me what was that event or person, place, or thing that happened to them that got them so excited that they became the scientist they are today. I call that event a gravity assist. So, Knicole, what was your gravity assist?

Knicole Colon: Is it OK if I give two answers?

Jim Green: Of course. Yeah, sometimes we all need a little extra.

Knicole Colon: Yeah. Well, for me, it was kind of two simultaneous events. And, really, it boils down to being a young teenager, and I fell in love with science fiction at the same time that my dad started encouraging me to have an interest in astronomy, and his interest came from the fact that he was just interested in everything, so he saw I started liking science fiction, and certain movies really inspired me, and he encouraged me to pursue astronomy. And those things really had me excited about the idea of being a scientist, and now to this day, I still am excited about being a scientist, so I guess it all worked out.

Jim Green: Well, I can see now, as you say the science fiction part of it, why you were so excited to find Tatooine, a planet orbiting two stars. But I had heard that you were really excited about the book that Carl Sagan wrote, *Contact,* and then the subsequent movie about finding life beyond Earth.

Knicole Colon: Yes. 100%. That is one of the first books and movies that just really floored me. I mean, I was wondering what would it really be like if we found life? How would humanity react? How would we communicate with them? Could I actually do something like this myself when I grow up? And here I am, however many years later.

Jim Green: That's right.

Knicole Colon: Working on that goal with TESS and Webb.

Jim Green: That's right. Indeed. Actually, you're right. We need to also start thinking ahead a little bit of what has to happen, or what will happen when we announce for sure that there is life beyond Earth, and how we're going to explain it, how we're going to interact with the public, what we think their interactions will be, their reactions, and try to anticipate those.

Knicole Colon: Yeah. It's going to be really interesting. That's why I hope I'm around when that happens, too. In my lifetime.

Jim Green: Well, just make it happen. I want you to do that. I want you to find it.

Knicole Colon: I'll work on that.

Jim Green: All right. Well, good. Great. Well, Knicole, thanks so much. I really enjoyed talking to you today about all your vast experience and the progress that we're making in looking for life beyond Earth with exoplanets.

Knicole Colon: Thank you so much for having me. I really enjoyed talking with you.

Jim Green: Well, join me next time as we continue our journey to look for life beyond Earth. I'm Jim Green, and this is your *Gravity Assist*.

Credits:

Lead producer: Elizabeth Landau

Audio engineer: Manny Cooper

5: Nacer Chahat Transcript

The Ingenuity helicopter made history on April 19, 2021, with the first powered, controlled flight of an aircraft on another planet. How do engineers talk to a helicopter all the way out on Mars? how about other spacecraft? We'll hear about it from Nacer Chahat of NASA's Jet Propulsion Laboratory, who works on antenna and telecommunication systems for a variety of NASA missions. He chats with NASA's Chief Scientist Jim Green in this episode of the Gravity Assist *podcast.*

Jim Green: NASA flies spacecraft all over the solar system and orbits the Earth. How do we communicate with them when they're so far away? Let's find out from an expert. Hi, I'm Jim Green, and this is a new season of *Gravity Assist.* We're going to explore the inside workings of NASA in making these fabulous missions happen. I'm here with Nacer Chahat, and he is the senior antenna and microwave engineer with NASA's Jet Propulsion Laboratory out in Pasadena, California. He has worked on one of the most important challenges for NASA and that is, in designing a spacecraft, how do you make it communicate back and forth with Earth? So welcome to *Gravity Assist.*

Nacer Chahat: Thank you for having me here.

Jim Green: Nacer, I always like to ask my guest to tell me what was that event, that person, place, or thing that got them so excited about being the engineer they are today. And I call that event a gravity assist. So, Nacer, what was your gravity assist?

Nacer Chahat: The scientist that I respected the most is Marie Curie, who was also from the same country that I am from, from France. But really, what I like about Marie Curie is her dedication for work. And I think nobody was as dedicated as her because she actually gave her life for her work. And the work ethic that she has demonstrated is what I share the most with Marie Curie. So, but I would say, as well, that it's not necessarily an engineer or a scientist that really inspired me, in my case. My parents are from a very poor country, in Algeria, north of Africa, and they didn't have access to education. So, after they moved in France, I was born and raised in France, they really shared this notion of understanding that the education is a gift. They didn't have the chance, and they wanted to make sure that I realized the chance I had and could take advantage of the education I was given as much as possible. So, that's why I always worked really, really hard to do as much as I could and learn as much as I could. And so I would say that my gravity assist are not engineers or scientists but are actually my parents.

Jim Green: Now, that's a wonderful story. Thank you so much for sharing it with me.

Jim Green: Nacer, thank you so much for joining me in discussing this fantastic topic.

Nacer Chahat: It was my pleasure. It's always great to share the experience that we have developing new technology at JPL. So, thank you for having me.

Jim Green: Join me next time as we continue our journey to look under the hood at NASA and see how we do what we do. I'm Jim Green, and this is your *Gravity Assist.*

Credits:

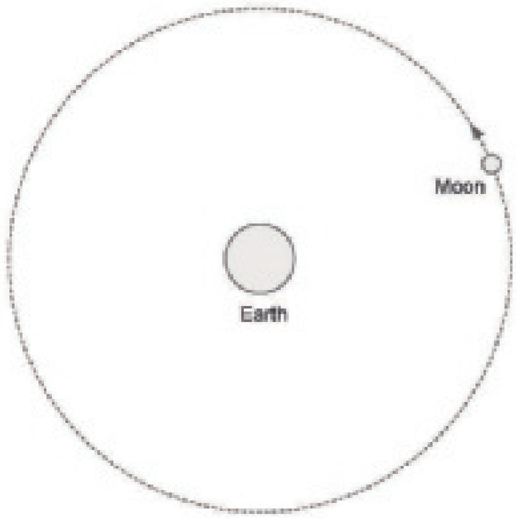
Lead producer: Elizabeth Landau

Audio engineer: Manny Cooper

Name: ______________________ Date: ______________

What causes one solar system object to move around another one?

This model represents some of what we know about the Moon's motion around Earth through one full orbit (29–30 days).



Use this model to develop an initial explanation for what **causes** the Moon to move around Earth in the pattern of motion that it does?

____

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____

Part B: Choose one of these 4 questions that you want to answer. Put a checkmark next to the question you chose:

_______ How would increasing the mass of the Moon affect its motion?

_______ How would decreasing the mass of the Moon affect its motion?

_______ How would increasing the distance between Earth and the Moon affect the Moon's motion?

_______ How would increasing the distance between Earth to the Moon affect the Moon's motion?

Record your prediction for the question you chose in the space below. Explain the how and why behind your prediction.

____

____

____

____

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Part C: Pick two other objects in the solar system, where one object orbits around another one.

Which objects did you pick?

Do you think if a similar change was made in the system of these two objects, it would cause the same effect as what you predicted in **part B**?

Name: ____________________ Date: ____________________

Simulating a Two-Object System

Part 1: Consider

- Which two objects are in the system you are investigating? __________ and __________
- What do you already know about how the size/mass of those objects or the distance between them compare?

____

____

Part 2: Record the question you wanted to investigate from part B of your previous handout.

____

____

Part 3: Procedure

1. Go to https://www.openscied.org/general/orbits-fixed/ in your web browser to load the simulation.
2. Remember, you must click "Setup" to launch the simulation and for any changes you make in the "Initial System Conditions" section to go into effect. Then press "Go/Pause" to run the simulation.
3. Explore the simulation for 3–5 minutes.
4. Then, take 5 more minutes to complete the data table on the next page.
5. If time permits, go to https://www.openscied.org/general/orbits-adjustable/ in your web browser to load this new simulation and continue your investigations. This simulation lets you zoom out further in your perspective.
6. After completing the table, discuss the making-sense questions below the table with your group.

Data Table

What I changed in the system	What the effect was of that change on my objects or the system

Making-sense questions for small-group discussion

1. Explain how object B was able to stay in a stable orbit with object A in your system.

2. Describe the evidence from the simulation that supports this conclusion.

3. How does what you figured out in the simulation help answer any other wonderings you had in your notebook from Lesson 13? Explain.

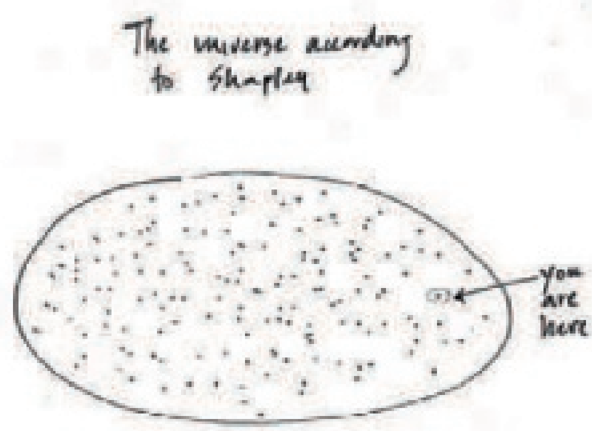
Name: ______________________ Date: ________________

Comic Book Storyboard Showing the Formation of the Solar System

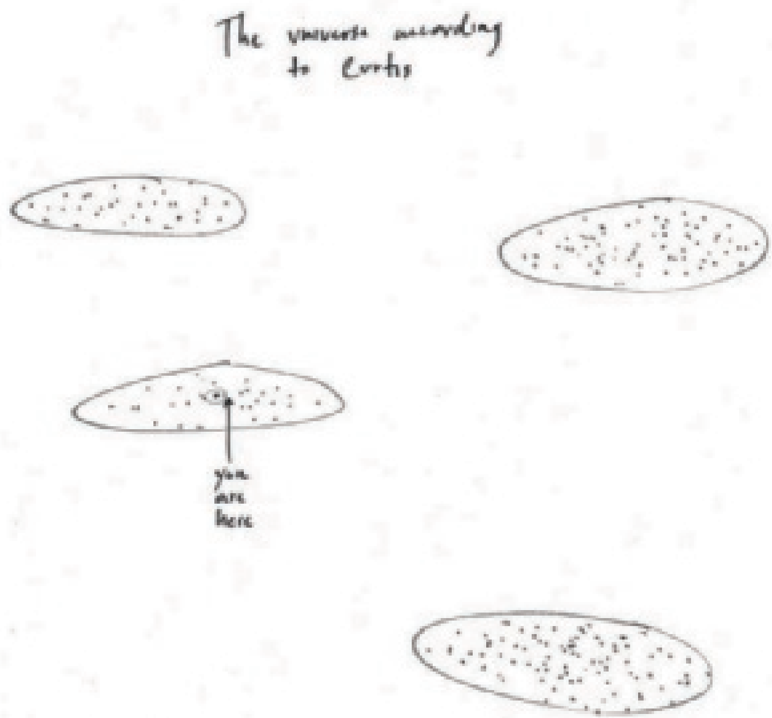
Reading: The Great Debate

One of the most important events in astronomy was the Great Debate in 1920. The Great Debate was between astronomers Harlow Shapley and Heber Curtis. Both astronomers had seen fuzzy blobs in space through a telescope, but they disagreed on how this evidence should be interpreted.

Shapley said that the stars in the sky made up our universe and there was nothing beyond it. He said that we live on a planet going around one star (our Sun) at the edge of a great universe of stars held together by gravity, surrounded by vast emptiness. He said that the blobs in the sky that we see with telescopes were just regular clouds of dust and gas, called nebulae, scattered among the stars.



Opposing him was Heber Curtis, who believed that the stars in our sky were just a tiny fraction of our universe. He said that we live on a planet going around one star (our Sun) at the center of a great island of stars held together by gravity and surrounded by many more islands of stars, also held together by gravity.



Discuss with your class your ideas about these questions:

1. How did Shapley's model for the universe explain the evidence they had at the time? How did Curtis's model for the universe explain that same evidence?
2. What would you do to resolve this debate? What kind of data would you collect, and how?

Tour of the Universe

Video Description from California Academy of Sciences: Take a journey through the observable universe and back in time. Use this resource to stimulate thinking about the immense scale of the universe and Earth's place in it and to visualize how the light from distant objects represents objects and events from the past, allowing us to peer into the ancient universe.

Light travel time away from Earth	What do you notice? What do you wonder? Think about the objects you see and the scale at which you see them.
1 second	
1 minute	
1 hour	
10 hours	
1 month	
1 year	
10 years	
100 years	
1,000 years	
10,000 years	
100,000 years	
1 million years	
10 million years	
100 million years	
1 billion years	
10 billion years	

Name: ______________________ Date: ______________________

Reviewing Our Driving Question Board

Instructions: Below is a list of questions from our Driving Question Board (DQB). Indicate whether you think the class has answered each question by putting a symbol next to it:

- We did not answer this question or any parts of it yet: **O**
- Our class answered some parts of this question, or the ideas we developed helped me see how I could now answer some parts of this question: ✓
- Our class answered this question, or the ideas we developed helped me see how I could now answer this question: ✓+

(Teacher: Insert questions from the class Driving Question Board in left column of table)

Question from Driving Question Board	Mark

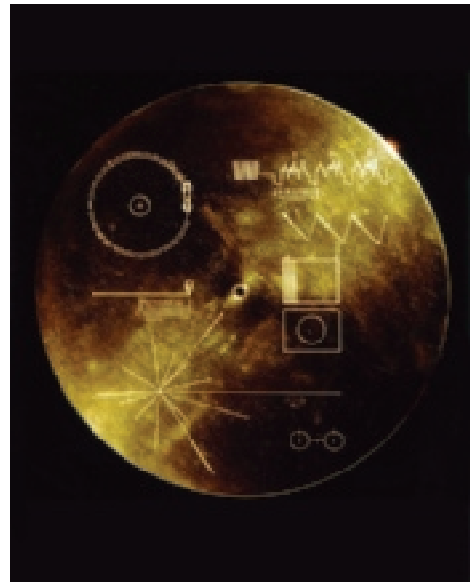
Name: ______________________________ Date: ______________________

The Pale Blue Dot

The Voyager 1 spacecraft was launched in 1977 with the mission to photograph Jupiter and Saturn. By February 1990, Voyager 1 had completed its original mission and was more than 6 billion kilometers (4 billion miles) from Earth, on its way out of our solar system. Before leaving the planets of our solar system and the Sun behind, scientists sent instructions to Voyager to turn around for one last photo opportunity, a "family portrait" of our solar system. This image is the photo Voyager 1 took of Earth. In the image, Earth looks like a tiny point of light, like a distant star.

The pale blue dot. NASA/JPL-Caltech

In 2012, Voyager 1 became the first spacecraft from Earth to leave our solar system. Knowing that Voyager 1 would be moving fast enough to escape the Sun's gravity forces, scientists decided to include a message should the spacecraft ever be found by intelligent life-forms from other planetary systems exploring the Milky Way. The spacecraft carries a golden record with photos of Earth and its life-forms, a range of scientific information, spoken greetings from people around the world, and the sounds of whales, a baby crying, waves breaking on a shore, and a collection of music.



NASA/JPL

1. What would you include in a message to other intelligent life-forms about life on Earth and our connection to the sky?

The astronomer Carl Sagan was so inspired by the Pale Blue Dot photo and the mission of Voyager 1 that he wrote a book called *Pale Blue Dot: A Vision of the Human Future in Space*. This is an excerpt from that book.

> Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives.
>
> —Carl Sagan, *Pale Blue Dot,* 1994

2. Carl Sagan wrote that the Pale Blue Dot photo "underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known." What do you think he means by this? Do you agree or disagree with this sentiment?

3. Think back to Lesson 1 when we learned about the connection between patterns in the sky and rhythms of life on Earth across time, space, and culture. How have your ideas about this connection changed over this unit, and why?

Name: ______________________ Date: ______________

Roadmap for Reading

This week's reading collection focuses on how ancient and modern humans have attempted to explain what they see in the daytime and nighttime skies. The selections include examples from many cultures around the world.

"Collection 1: Sky Watching Since Days of Old" consists of four selections.

1 Celestial Stories

2 Archimedes's Mirror

3 Make Your Own Sundial

4 Around the World, Across Time

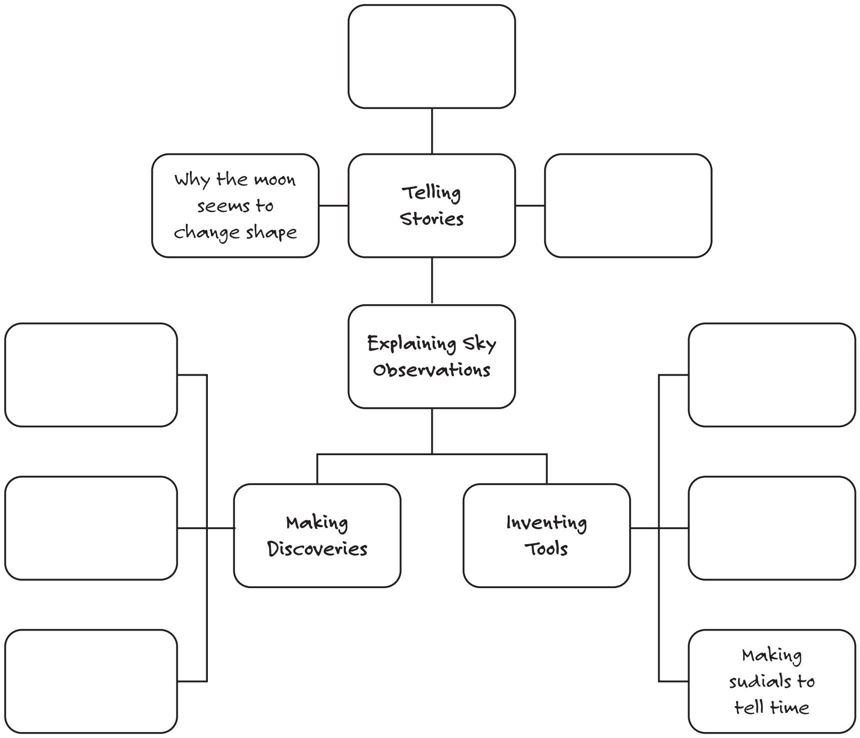
As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, an attempt to persuade, or to entertain?
- Consider if the stories and myths in two of the selections may be similar to modern works of fiction, including television shows and movies.
- Consider how each part of the reading relates to knowledge you gained from your discussion and investigations in Lessons 1–4.

Written Response

Your writing exercise is to complete a concept map showing examples of some of the stories, discoveries, and tools that people who lived in the past used to build understanding of objects in the sky.

- Using the partially completed organizer shown as a model, sketch your graphic organizer to fill the entire side of a separate sheet of paper. Attach this sheet to the front of it when you turn it in.
- Review the reading selections to find interesting examples of each of the three ways humans have tried to explain what they see in the sky. Write the examples on your map.
- Add color to improve your design. Check the connecting lines and text to make sure they are attractive and readable.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.



Evaluation Guidelines

Element	1	2	3	Feedback
Content	Map includes ideas from only one or two selections with some stated inaccurately.	Map includes mostly accurately stated ideas from all four selections.	Map includes accurately stated ideas from all four selections.	
Relationships of details	Organization of the details on the map is unclear or not accurate.	Linking lines and text for details are mostly clear and correct.	Linking lines and labels for all details show relationships to the three categories correctly.	
Design	Major improvements are needed in the design of the shapes, lines, text, and arrangement to fill the page.	All but one of the following are well executed: shapes, text, color, and filling the page.	Shapes are attractively arranged, and the text is easy to read. Color is used effectively to show organization of concepts. The map fills the whole page well.	
Grammar and mechanics	There are five or more errors in capitalization and spelling.	Work contains a few errors in capitalization and spelling.	There are no errors in capitalization and spelling.	

Additional Feedback Notes:

Name: ______________________ Date: ______________________

Science Literacy Exercise Page 2 Use with Reading Collection 2

Roadmap for Reading

This week's reading collection focuses on discoveries in the arts and engineering that culminated in the first human exploration of the moon in 1969. The selections include an online discussion with people who think that the Apollo 11 mission might have been faked.

"Collection 2: Reaching for the Moon" consists of four selections.

1 *Le Voyage dans la Lune*

2 The Space Race

3 Consider the Evidence

4 Script versus Transcript

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Use your prior science learning, contextual clues, and other methods to determine the meaning of science terms.
- Consider how first paragraphs set the stage for understanding the main idea of each selection.

Written Response

Your writing exercise is to complete a clever social media post to share one interesting thing you read and why it intrigued you.

- Compose your post on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Limit your post to 70–100 characters.
- Specify at least one image you would like to include in your post.
- Create a hashtag (the # symbol, followed by keywords or a phrase, without spaces or punctuation) to identify your topic and to allow others can use it to continue the conversation.
- Identify one thing you'd like to learn more about that someone else on social media may be able to answer or react to.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	Post identifies an idea from the readings but it is not stated accurately; does not explain why it is interesting or pose a related question.	Post adequately identifies one interesting idea from the readings that is stated mostly accurately; explains why it is interesting or poses a related question.	Post clearly identifies one interesting idea from the readings that is stated accurately; explains why it is interesting; poses a reasonable and related question.	
Social media elements	Post includes far less than 70 characters and is missing both an image and a hashtag.	Post includes less than 70 or more than 100 characters and is missing either a related image or an appropriate hashtag.	Post includes between 70 and 100 characters, a related image from one of the selections, and an appropriate hashtag.	
Audience	Post is not likely to interest other students; has two or more elements that will offend or break a school rule.	Post is clearly worded but may not interest others; has at least one questionable element that may offend or break a school rule.	Post is worded to interest other 8th grade students but also not to offend their teacher or break school policies; includes a question that followers can react to.	
Grammar and mechanics	There are six or more errors in punctuation, capitalization, and spelling.	There are three to five errors in punctuation, capitalization, and spelling.	There are fewer than three errors in punctuation, capitalization, and spelling.	

Additional Feedback Notes:

Name: ____________________ Date: ____________

Science Literacy Exercise Page 3 Use with Reading Collection 3

Roadmap for Reading

This week's reading collection focuses on how people imagine and visualize moons, planets, and the stars. The selections include profiles of women scientists and mathematicians whose work changed our understanding of objects in space.

"Collection 3: Imaging and Imagining Space" consists of five selections.

1 Sparking the Imagination
2 Taking a Long Look
3 Our Pale Blue Dot
4 Beyond Photography
5 Out of the Shadows

As you read:

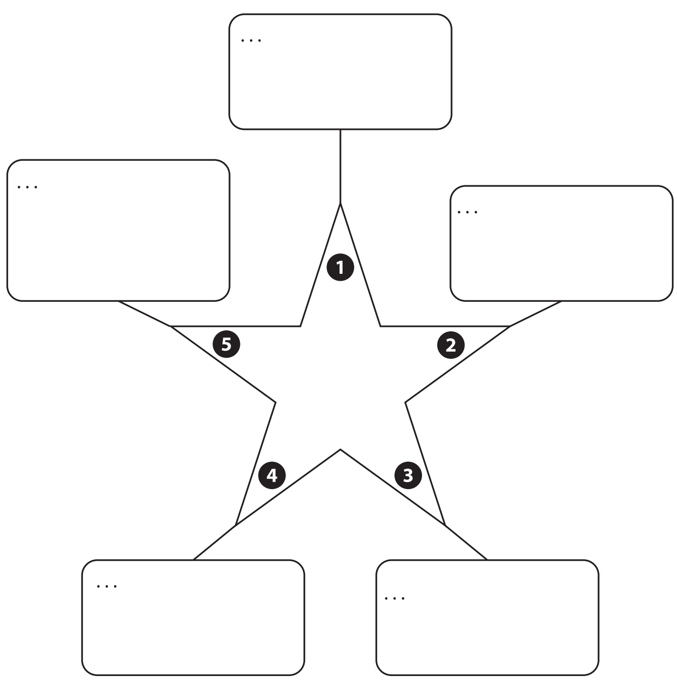
- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how the images and text support one another.
- Use contextual clues along with your prior knowledge to determine the meaning of science terms used in the text.

Written Response

Your writing exercise is to complete a star diagram to communicate something new you learned from each of the five readings in Collection 3.

- Using the partially completed graphic organizer shown as a model, sketch your star diagram to fill the entire side of a separate sheet of paper. Attach this sheet to the front of it when you turn it in.
- For each point on the star, complete the sentence that begins "I didn't know that . . . ."
- Add color to improve your design. Check your text to make sure it is readable and uses correct spelling and grammar.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

I didn't know that . . .



Evaluation Guidelines

Element	1	2	3	Feedback
Content	Diagram includes ideas from only one or two selections with some stated inaccurately.	Diagram includes mostly accurately stated ideas from all five selections.	Diagram includes an accurately stated idea from each of the five selections.	
Organization of statements	The statements and linking lines do not seem related to the five readings in the collection correctly.	Most, but not all, statements and linking lines show relationships to the five readings in the collection correctly.	All statements and linking lines to points on the star show relationships to the five readings in the collection correctly.	
Design	Major improvements are needed in the design of the shape, lines, text, and arrangement to fill the page.	All but one of the following are well executed: shapes, text, color, and filling the page.	Shapes are attractively arranged, and the text is easy to read; color is used effectively; the diagram fills the whole page well.	
Grammar and mechanics	There are five or more errors in capitalization and spelling.	There are few errors in capitalization and spelling.	There are no errors in capitalization and spelling.	

Additional Feedback Notes:

Name: ____________________ Date: ____________________

Science Literacy Exercise Page 4 Use with Reading Collection 4

Roadmap for Reading

This week's reading collection focuses on the connection between entertainment and science. The selections include a close look at two popular movies and reveal how moviemakers try to get the science right.

"Collection 4: Space On-Screen" consists of four selections.

1 Director Spotlight

2 Facts in the Fiction

3 Science from Fantasy

4 Is There Anybody Out There?

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how each part of the reading relates to knowledge you gained from the previous part.
- Consider how what you have learned about our solar system and beyond prepares you to interpret what you are reading.

Written Response

Your writing exercise is to complete a thoughtful paragraph that refers to the connections between entertainment and science.

- Compose your paragraph on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Choose one of the following claims as your topic sentence.
  - *Movies and streaming entertainment can inspire young people to learn science.*
  - *Science fiction directors should always get scientists involved in developing the story.*
  - *Scientists who want to reach the public should be more like entertainers.*
  - *Part of science literacy is knowing how to think about science fiction movies and shows.*
- Build on the topic sentence to complete a well-constructed paragraph. Use details from the reading selections as evidence in your paragraph's supporting sentences.
- You may also include evidence from your own life.
- Explain how your evidence supports your claim.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	Paragraph contains inadequate evidence and reasoning to support the chosen claim.	Paragraph contains adequate support of the claim in the topic sentence, citing specific, relevant details from the reading selections as evidence for reasoning.	Paragraph contains thorough support of the claim in the topic sentence, citing specific, relevant details from the reading selections as evidence for reasoning.	
Supporting sentences (details)	Paragraph contains incomplete sentences, or evidence and reasoning irrelevant to the paragraph topic.	Paragraph contains complete sentences, but too few, lacking in support from the reading, or using unclear reasoning.	Paragraph contains at least six complete sentences, encompassing three major points that support the topic sentence.	
Organization and transitions	Paragraph contains statements with little clear relationship to the topic sentence or each other.	Paragraph contains ideas supporting details present, but absent or choppy transitions.	Paragraph contains in an order that helps the topic make increasingly more sense.	
Grammar and mechanics	There are six or more errors in punctuation, capitalization, and spelling.	There are three to five errors in punctuation, capitalization, and spelling.	There are fewer than three errors in punctuation, capitalization, and spelling.	

Additional Feedback Notes:

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