Perot Museum

SOLAR ECLIPSE EDUCATOR GUIDE

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Carnegie Science

SUGGESTED GRADE LEVELS: PreK-5

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Credit: Gregory Castillo, photo taken during the annular eclipse in October 2023

HOW TO USE THIS GUIDE

This guide will help you turn the opportunity of viewing a total solar eclipse into a complete learning experience for your students. It is composed of three main sections:

The **introduction** section gives an overview of a solar eclipse and how to view one safely.

The **activities** section includes four activities recommended for specific age ranges that can be done in the classroom or at home.

The **additional resources** section includes a glossary, reading list, and links to continue learning.

LEARNING OBJECTIVES

Students will be able to:

- Describe the interactions between the Sun, Earth, and Moon during a solar eclipse.
- Identify safe practices for viewing objects in the daytime sky, including an eclipse.
- Create a model highlighting either the interactions involved in a solar eclipse or the tools used to view one safely.

STANDARDS ALIGNMENT

Science TEKS Alignment:

The student knows that there are recognizable patterns in the natural world and among the Sun, Earth, and Moon system. Student expectations include:

PK4.IX.C.1 Child practices good habits of personal safety.

PK4.VI.C.2 Child identifies, observes, describes, and discusses objects in the sky.

K.9B Observe, describe, and illustrate the Sun, Moon, stars, and other objects in the sky such as clouds.

3.9A Construct models and explain the orbits of the Sun, Earth, and Moon in relation to each other.

5.9 The student recognizes patterns among the Sun, Earth, and Moon system and their effects. The student is expected to demonstrate that Earth rotates on its axis once approximately every 24 hours and explain how that causes the day/night cycle and the appearance of the Sun moving across the sky, resulting in changes in shadow positions and shapes.

SEPs and RTCs:

K.1A Ask questions and define problems based on observations or information from text, phenomena, models, or investigations.

K.1C Identify, describe, and demonstrate safe practices during classroom and field investigations as outlined in Texas Education Agency-approved safety standards.

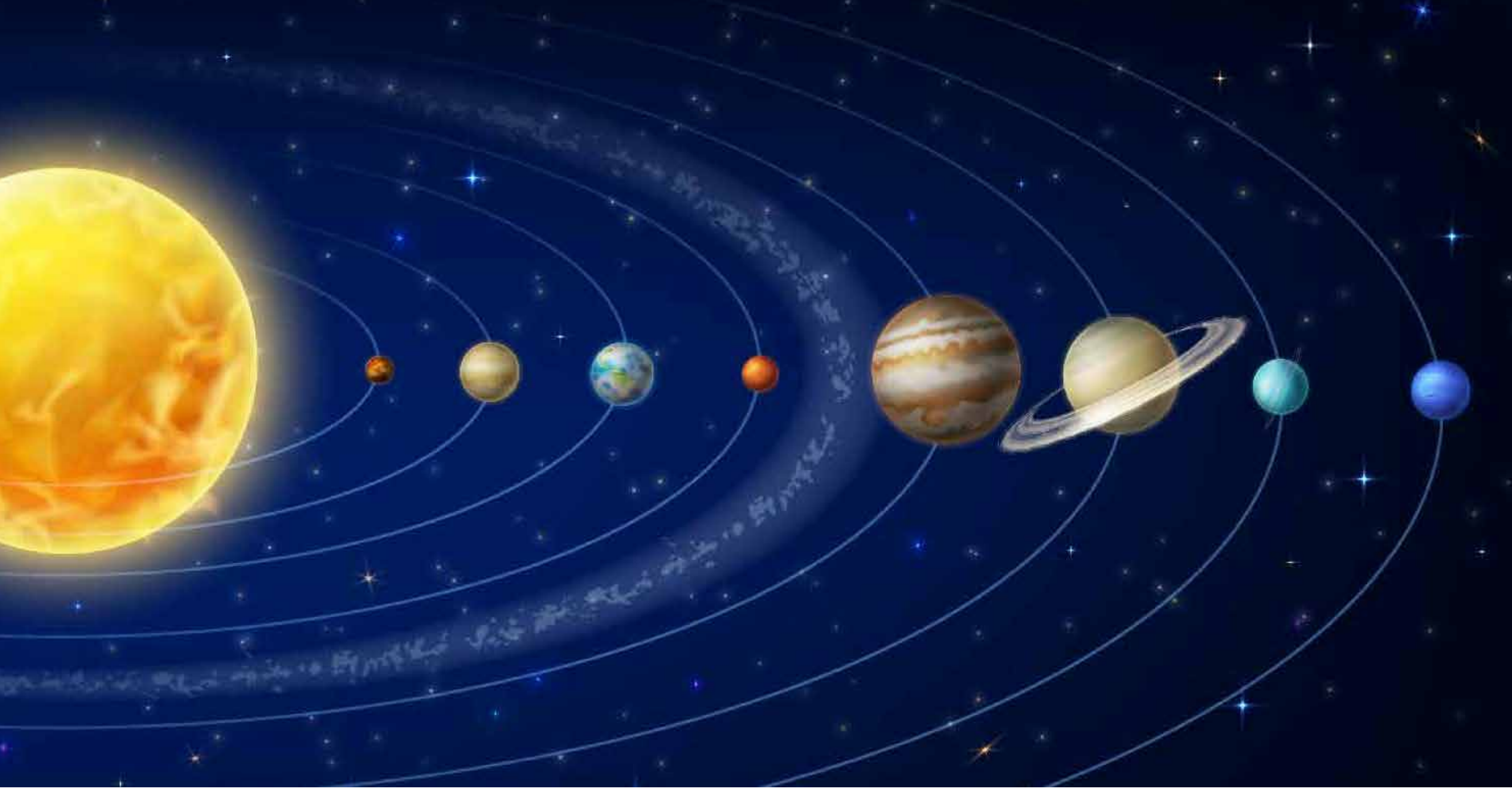
1-2.5A Identify and use patterns to describe phenomena or design solutions.

NGSS Alignment:

Students who demonstrate understanding can:

1-ESS1-1. Use observations of the Sun, Moon, and stars to describe patterns that can be predicted.

MS-ESS1-1. Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.



BACKGROUND INFORMATION

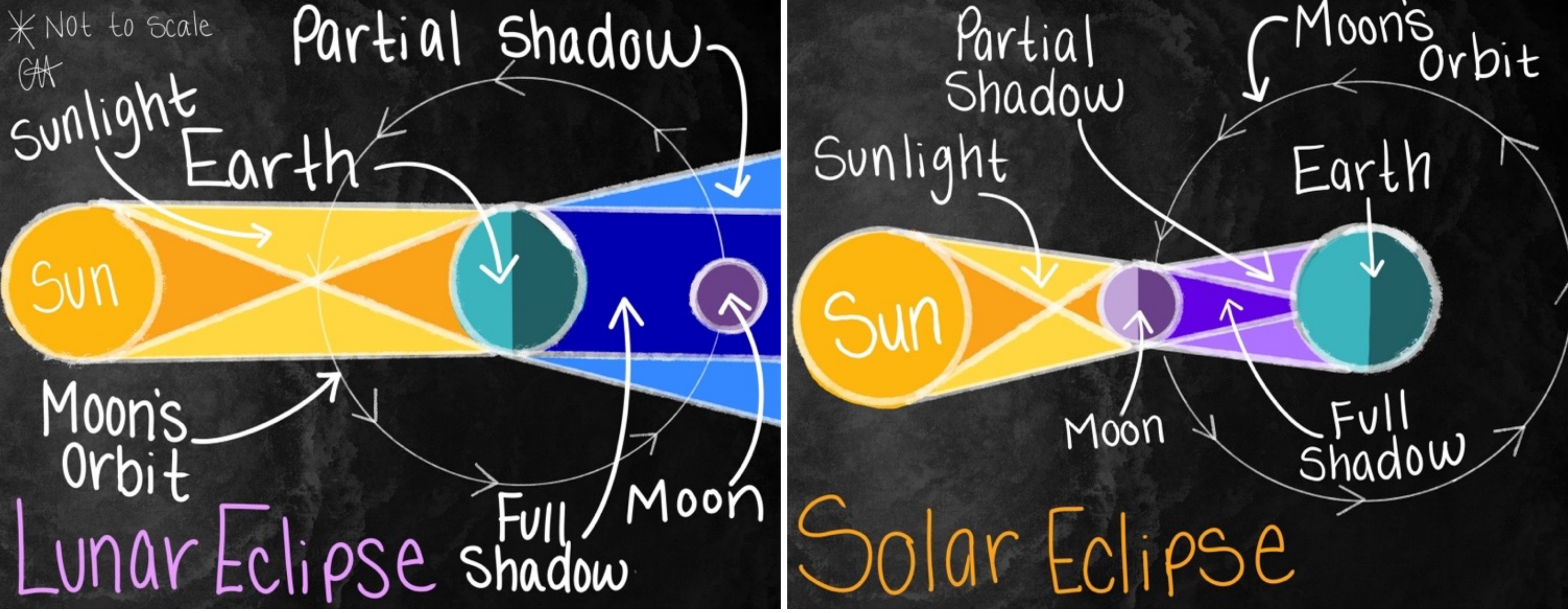
Objects in Space: Our Solar System

Gravity is one of the most easily observable forces in daily life. Whenever you jump up, you feel the force of the Earth's gravity pulling you back down. **Gravity** is a force of attraction that pulls matter together. **Matter** refers to any substance that has mass and takes up space. Earth's gravity comes from its mass. **Mass** is the amount of matter in an object, and anything with mass has its own gravitational pull.

The closest star to Earth, the **Sun**, is literally the most massive thing around for billions of miles. It contains 99.8% of the mass in the surrounding space. Thus, its gravity is strong enough to hold all planets, dwarf planets, moons, asteroids, comets, and meteoroids in the surrounding space in orbit around it, forming our **solar system**.

A **planet** is a celestial object that orbits a star and is big enough for its gravity to compact it into a roughly spherical shape and clear its orbit of other objects. There are eight diverse planets in orbit around our Sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

An **orbit** is the curved path an object takes as it revolves around another object. A **revolution** is the time it takes to complete one full orbit around an object. Earth takes about 365 days, or a year, to make one revolution around the Sun, and 24 hours, or a day, to make one complete **rotation** on its axis. The Moon is Earth's only natural **satellite** – or an object which orbits another object. Each of the other planets, except for Mercury and Venus, has moons as well. Saturn and Jupiter have the most moons, with dozens apiece.



Credit: Cassidy Hamilton

What is an Eclipse?

An **eclipse** occurs when one object in space passes through the shadow of another object in space. Here on Earth, we can experience lunar and solar eclipses.

A **lunar eclipse** occurs when the Earth's shadow blocks the light from the Sun hitting the Moon (which causes the Moon to shine at night). Earth's shadow causes the Moon to look reddish-orange.

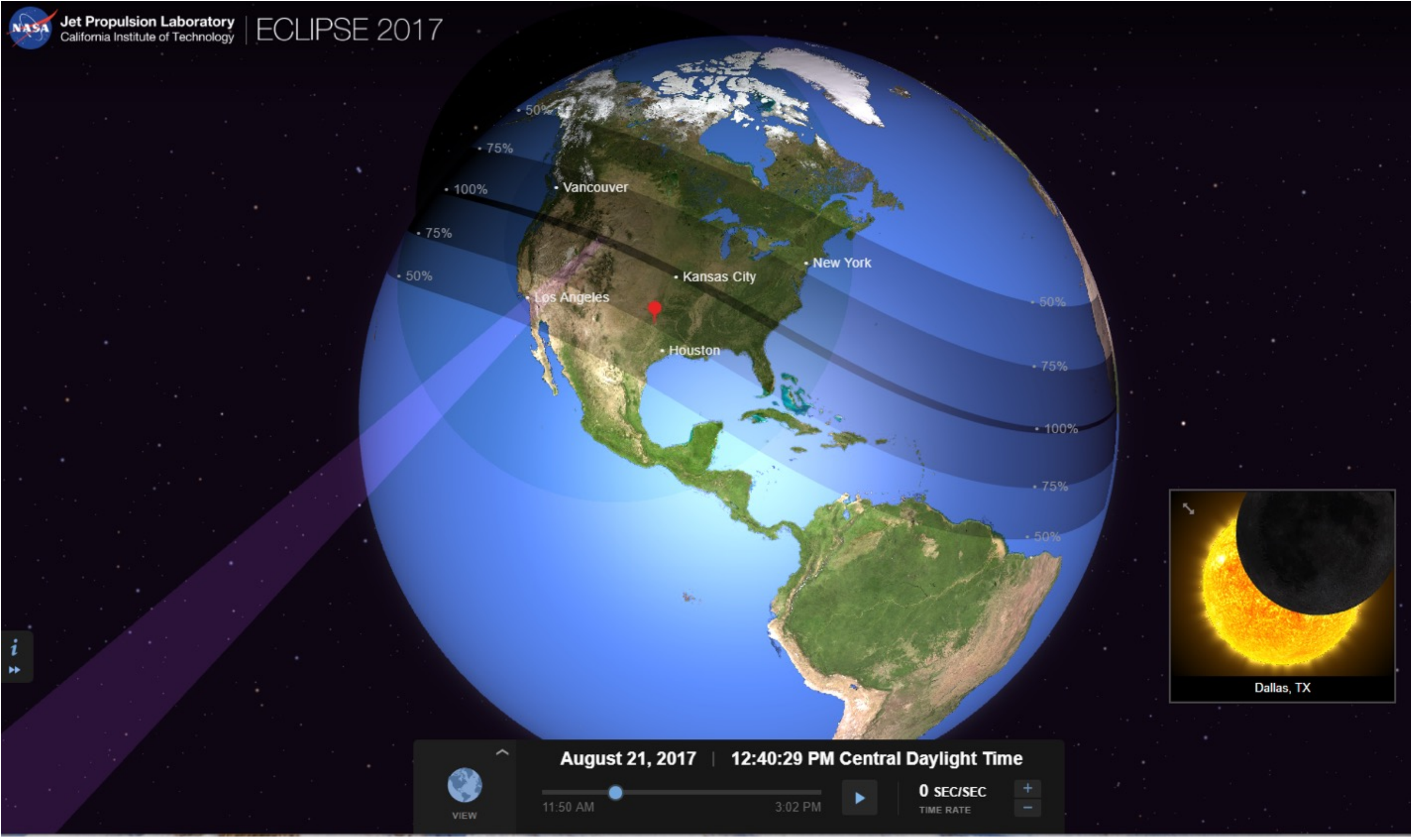
A **solar eclipse** occurs when the Moon passes between the Sun and the Earth (during the new moon phase), blocking all or part of the Sun for the viewer. This complete obstruction from view is key to defining an eclipse. But how is this possible when the Sun is WAY larger than our Moon?

When objects are farther away, they appear smaller than they actually are. Luckily, the Sun just so happens to be the proper distance farther away from our Moon for the two objects to ***appear*** the same size from our view here on Earth. (So, while the Sun is about 400 times wider than our Moon, it also is 400 times farther away from Earth.) The size-to-distance ratio is not the same for Mercury or Venus, so these planets do not eclipse the Sun from our view on Earth. (When a celestial body passes in front of another without eclipsing it, we call that a **transit**.)

Location, Location, Location

Even on the daytime side of the planet, a solar eclipse is not viewable by everyone at the same time. This is because the Moon's shadow on the Earth's surface is relatively small, only about 300 miles wide. The shadow consists of two parts: the smaller **umbra** (UM-bruh), where the Sun is completely blocked, and the larger **penumbra** (pe-NUM-bruh), where the Sun is only partially obscured. One has to be in the path of the umbra to experience a total solar eclipse. (Conversely, the Earth's shadow is much larger, so lunar eclipses can be viewed anywhere on Earth currently experiencing nighttime.)

But don't forget about the weather! Even in the path of the umbra, if the sky is cloudy, viewers will not be able to see the eclipse.



In 2017, Dallas was not within the path of the umbra (called the path of totality) but was within the penumbra, so we saw a partial eclipse. Credit: JPL | Eclipse 2017

There are four types of solar eclipses: total, partial, annular, and hybrid.

A **total solar eclipse** occurs when the Moon completely obscures the Sun's surface. The sky will darken as if dusk has come early. (It will not quite be as dark as night.) Viewers must be at a location within the center of the Moon's shadow when it touches the Earth to experience a total eclipse. If weather conditions are right, viewers might even be able to see the Sun's corona, the outer atmosphere of the Sun, at totality (as seen in image). Totality usually lasts only a few minutes, and then the Sun will slowly be uncovered.

Credit: Carnegie Institution for Science (2017)

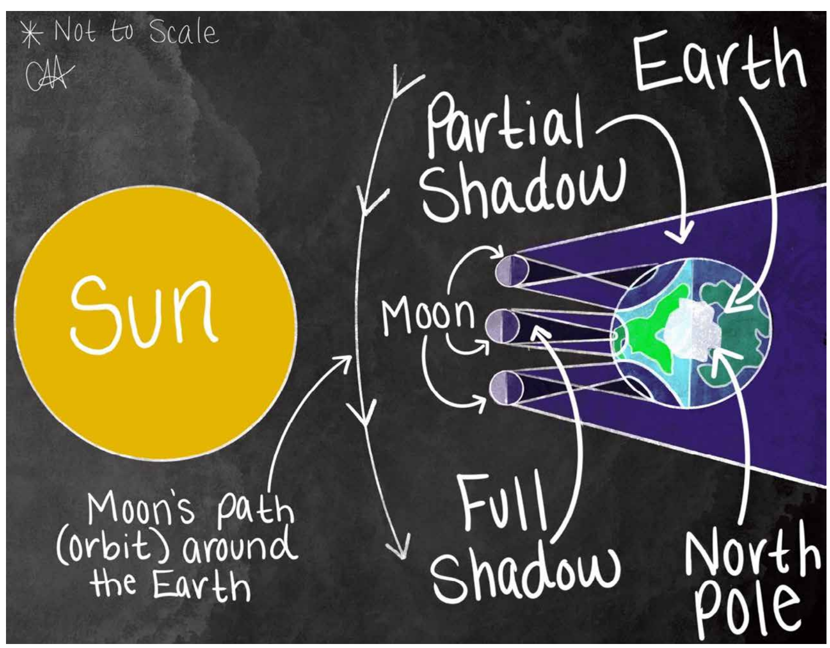
In an **annular solar eclipse**, the Moon passes directly in front of the Sun but appears too small to cover the surface of the Sun entirely. This happens when the Moon is at the furthest point away from the Earth in its orbit. Because it is farther away, the size-to-distance ratio changes, and the Moon appears smaller than the Sun. The Sun appears as a ring around the Moon.

Credit: NASA/Bill Dunford (2012)

In a **partial solar eclipse**, the Moon only partially covers the Sun's surface. Most often, this is seen by viewers in the larger regions covered by the Moon's lesser shadow (penumbra) just outside the path of totality. A partial eclipse could also occur if the Moon's penumbra falls on Earth, but the umbra does not. The partially eclipsed Sun appears as a crescent shape.

Credit: Carnegie Institution for Science (2017)

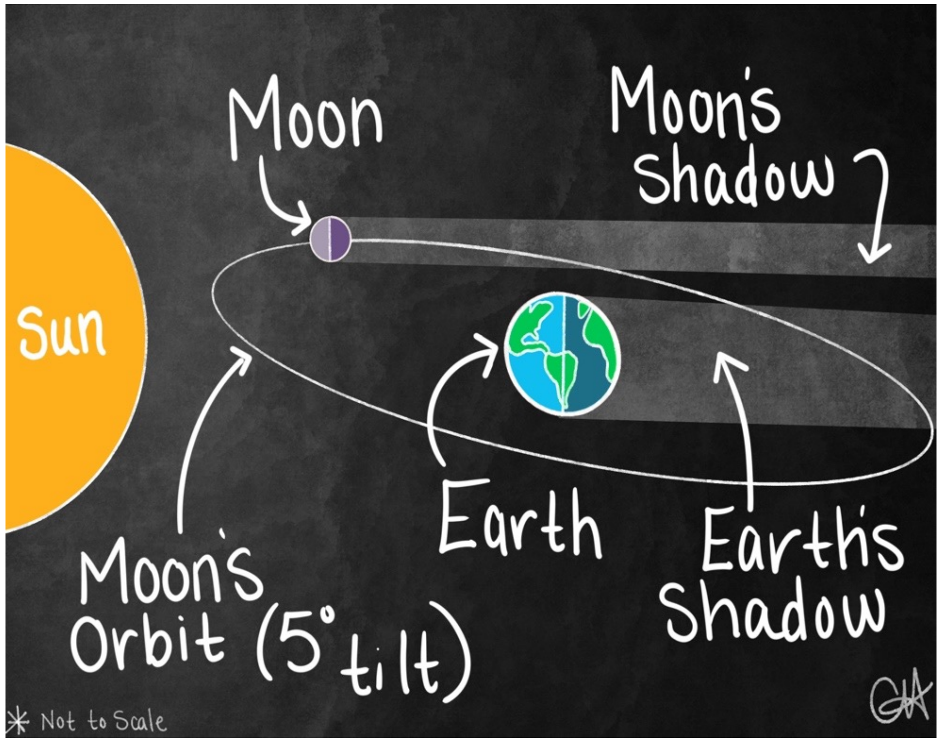
During a **hybrid solar eclipse**, depending on the viewer's location, they may see either a total eclipse or an annular eclipse. Because of the Earth's curvature, as the Moon's shadow moves across the globe, an eclipse can shift between being a total eclipse and an annular eclipse.



Credit: Cassidy Hamilton

A total solar eclipse happens somewhere on the Earth about once every 18 months. Eclipses do not occur every month because not only is the Moon's orbit around Earth elliptical — meaning the distance between the two changes — but it is also tilted five degrees relative to the Earth's orbit around the Sun.

Therefore, most months, the Moon doesn't line up in the same plane as the Sun and the Earth, and the Moon's shadow misses us.



Credit: Cassidy Hamilton

Science in the Shadow

NASA scientists still study eclipses to make new discoveries about the Sun's structure. Total solar eclipses allow scientists to see the outermost part of the Sun's atmosphere — the corona — which is usually too faint to observe except when the Sun's bright light is blocked. Scientists also study how the heat and energy transferred from the Sun as solar wind affects our upper atmosphere on Earth, which is important for predicting how solar wind might impact our satellites and communication signals.

The study of solar eclipses over the past century has led to many discoveries, not only about the Sun's structure, but also in supporting evidence for Einstein's theory of relativity and even the discovery of the element helium. And there is still so much to learn!

Solar Superstar Safety

Practicing Sun safety is of the utmost importance when observing a solar eclipse! The Sun emits ultraviolet rays, which can cause serious harm to our skin and eyes.

Protect Your Eyes

- Never look directly at the Sun without proper eye protection, such as safe eclipse viewing glasses.

- Regular sunglasses, camera lenses, binoculars, or telescopes are NOT safe for viewing the Sun. Safe eclipse viewing glasses are MUCH darker and comply with international safety standards. Always ensure that your eclipse viewing glasses are free of scratches or damage before use.

- No other optical devices should be used in addition to safe eclipse glasses. Additional lenses can concentrate the solar rays and burn through the protective filter of the eclipse glasses.
  - If you want to use cameras, binoculars, or telescopes, have them outfitted by an expert with proper solar filters for safe viewing. These optical devices require different types of solar filters than eclipse glasses. The solar filters on the optical devices will do the same job as the eclipse glasses to protect your eyes.

- If you do not have eclipse glasses, you can use an indirect viewing method that projects an image of the Sun onto a nearby surface. (See the "Eyes on the Eclipse" activity.)

Protect Your Skin

- Don't forget to protect your skin, too! Just like any time we go outside for some fun in the Sun, the Sun's ultraviolet rays can burn our skin. The duration of a solar eclipse from start to finish can take hours. Remember to apply sunscreen, and wear a hat and protective clothing.

GLASSES GALORE

Suggested Grades:

- PreK-K

Driving Questions:

- Why are there different kinds of glasses?
- How can we keep our eyes safe when viewing objects in the daytime sky?

Objectives:

- Students will be able to identify the correct eyewear for viewing the daytime sky during different weather conditions.
- Students will be able to describe the connection between eyewear and eye safety.

Materials (per student):

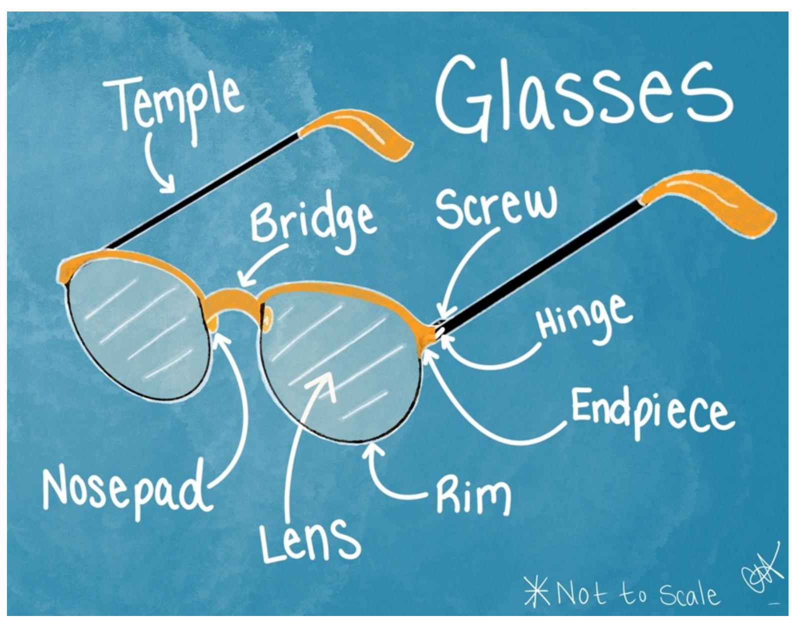
- Eyewear frames template (printed on cardstock)
- Craft stick
- Plastic strip or plastic snack bag
- Glue stick
- Art supplies (construction paper, crayons, markers, etc.)
- Optional: Magnifying glasses

Introduction:

Do you know someone who wears glasses? Glasses are a kind of **eyewear** worn in front of a person's eyes. Have you noticed how different glasses can look? Glasses come in all shapes, colors, and sizes. This is because glasses can serve various purposes, like making faraway objects look closer or shielding our eyes from harmful light rays.

Someone who works with eyeglasses is called an **optician**. Opticians work hard to design eyewear and ensure the correct fit for each person. When they design glasses, they must think about the parts, how they fit together, and what they will be used to do. Glasses consist of two parts: the lenses and the frame. The frame includes the temples, hinges, rim, and bridge. The frame also holds the lenses in place!

Today, let's explore different kinds of lenses and their purposes.



Credit: Cassidy Hamilton

Lenses can be made of different materials such as plastic or glass. An optician will choose the material depending on the wearer. Weight and safety are two important factors to consider when selecting the material. For example, lenses for young children are usually made of plastic because they weigh less and are safer.

The plastic and glass used for lenses are tailored to a person's vision. Some lenses are used to see objects far away, while others make nearby objects appear clearer to the wearer. Lenses change how light passes through them and reaches the wearer's eyes.

Lenses can come in many colors. Chemicals are applied to the plastic or glass to **tint** them. The tint on sunglasses can protect our eyes from harmful rays of light. However, even though sunglasses can provide our eyes with some protection, you **should not** look directly at the Sun while wearing sunglasses!

One of the main benefits of tinted lenses is that they can reduce the **glare**, or shine, we see. Some lens colors are more effective, or work better, at protecting our eyes in different weather conditions. For example, blue lenses are great in snowy weather. Yellow lenses can be worn when it is cloudy or overcast. Look at the table below. When would you wear red lenses?

Weather	Gray Black	Brown	Green	Yellow	Blue	Red
Sunny	●	●	●			●
Cloudy	●	●	●	●		●
Snowy					●	●

Now it is your turn to take on the role of an optician and create your own model of protective eyewear!

Daytime Eyewear Procedure:

1. Choose your frame. Color it in and add your own design!
2. Add glue to the top of your craft stick.
3. Turn your frame around so that the back side faces up.
4. Place the sticky part of the craft stick to the edge of the frame. Press and hold the craft stick to the frame for 15 seconds.
5. Add glue along the edges of the frame.

6. Place the plastic strip or plastic bag on the sticky side. Press and hold the plastic to the frame for 15 seconds.

7. Pick a marker and color in your lenses. What color did you choose? Look at the lens table. During what weather conditions can your model glasses be used? Your lenses will protect your eyes from the Sun's rays!
   Important Safety Note: You have just created a model of safety eyewear!
   This model should NOT be used in place of real safety eyewear.

8. Optional: Hold up one or two magnifying glasses, along with the student glasses, to demonstrate how prescription glasses function.

Discussion Questions:

- Why might you or someone you know wear glasses or goggles?
  > Glasses or goggles can be used to ____.
  Potential answers might include: Sunglasses can be used to protect our eyes from the Sun's rays. Safety goggles can be used to protect our eyes from chemicals. Goggles can also be used to keep water from getting into our eyes.

- Why do lenses have different colors?
  > Lenses have different colors because ____.
  Potential answers might include: Lenses have different colors for different purposes. Some lenses, like blue or red lenses, can be used during snowy weather. Other lenses, like gray and brown lenses, can help reduce glare when it is bright outside.

- What other tools or equipment can we use to better observe small or faraway objects?
  > Scientists use ____ to ____.
  Potential answers might include: Scientists use microscopes to see organisms too small to see with the naked eye. Scientists use binoculars to see distant objects more clearly. Scientists use telescopes to view celestial objects millions of miles away in the nighttime sky.

Excellent Eclipse Eyewear

We discussed how eyewear can look different depending on its purpose. From reading glasses to sunglasses, we use eyewear for many reasons. However, one kind of eyewear that is less common is one that we use to view a solar eclipse. What is a solar eclipse?

A **solar eclipse** happens when the Sun, the Moon, and the Earth line up in such a way that the Moon blocks some of the light of the Sun from reaching the Earth. However, it is never safe to look directly at the Sun, even when part of the Sun is blocked. Doing so can damage your eyes. When viewing an eclipse, you must either wear special eclipse glasses or use a tool to view the eclipse indirectly. Just like regular eyewear, eclipse glasses have a frame and lenses. However, they are also tinted with a special material that blocks more than 99.99% of the Sun's harmful rays from reaching our eyes. This dark lens makes it safe to view an eclipse.

Discussion Questions:

- What makes eclipse glasses special?
  > I think eclipse glasses are special because ____.
  Answers will vary based on students' observations. Key points to make are that eclipse glasses are specially made to protect your eyes while looking directly up at the Sun for short periods. The tint used in eclipse glasses is made of a different material that provides more protection from the Sun's rays than regular sunglasses.

- How are eclipse glasses and other forms of eyewear similar? Different?
  > I think eclipse glasses and sunglasses are similar/different because ____.
  Potential answers might include: I think eclipse glasses and sunglasses are similar because both have tinted lenses. I think eclipse glasses and sunglasses are different because eclipse glasses allow you to look directly at the Sun. But sunglasses do not allow you to look directly at the Sun.

Extensions:

- Experiment with shadows! Periodically throughout the day, go outside to trace the students' shadows. Have students stand in the same spot each time. What happens to their shadow as the Sun moves across the sky?
- ELAR — Have students write a short story spreading eye safety awareness. Read *George the Sun Safe Superstar* with your students as an example.
- Family Learning — As a family, count down the days, hours, minutes, and seconds until the eclipse. Additional family activities can be found on the resource tab of the **NASA website**.

TEKS Alignment:

PK4.IX.C.1 Child practices good habits of personal safety.

PK4.VI.C.2 Child identifies, observes, describes, and discusses objects in the sky.

SEPs:

K.1A Ask questions and define problems based on observations or information from text, phenomena, models, or investigations.

K.1C Identify, describe, and demonstrate safe practices during classroom and field investigations as outlined in Texas Education Agency-approved safety standards.

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CREATE YOUR OWN SAFETY EYEWEAR

Name: ______________________________ Date: ______________________________

Procedure:

1. Choose your frame. Color it in and add your own design!
2. Add glue to the top of your craft stick.
3. Turn your frame around so that the back side faces up.
4. Place the sticky part of the craft stick to the edge of the frame. Press and hold the craft stick to the frame for 15 seconds.
5. Add glue along the edges of the frame.
6. Place the plastic strip or plastic bag on the sticky side. Press and hold the plastic to the frame for 15 seconds.
7. Pick a marker and color in your lenses.

What color did you choose?

I chose the color ________________________________ .

Look at the lens table. During what weather conditions can your model glasses be used?

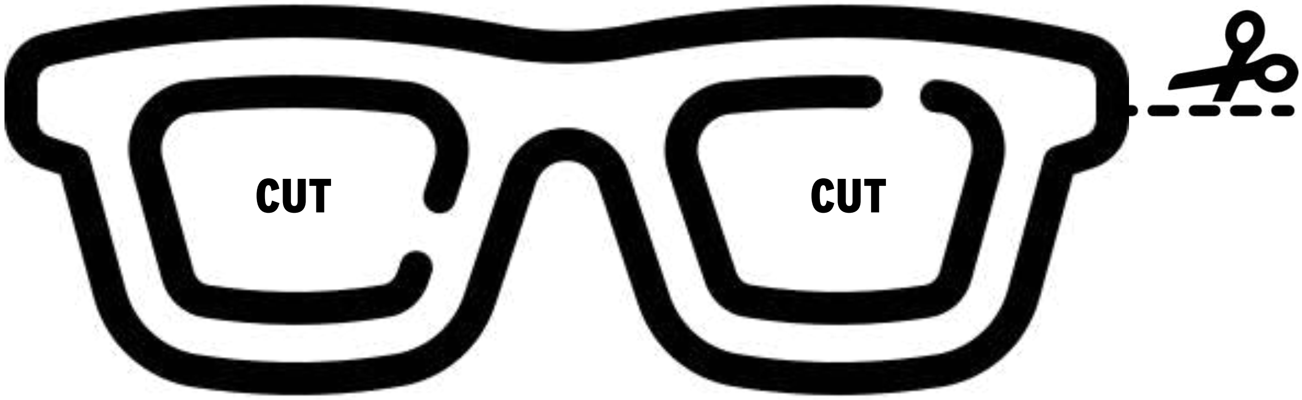
Weather	Gray Black	Brown	Green	Yellow	Blue	Red
Sunny	●	●	●			●
Cloudy	●	●	●	●		●
Snowy					●	●

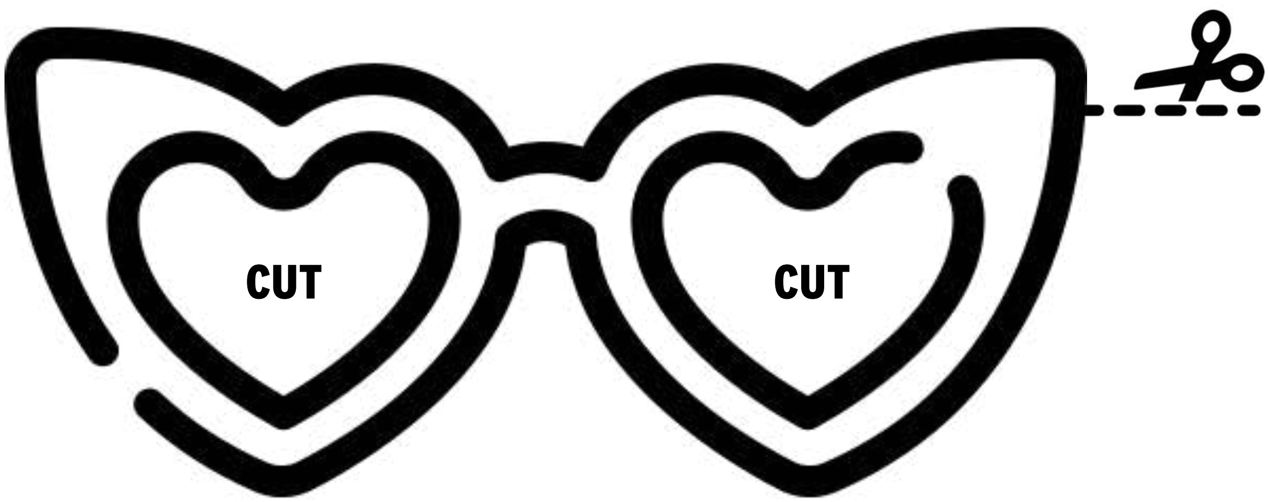
I can use my model glasses during ____________________ weather.

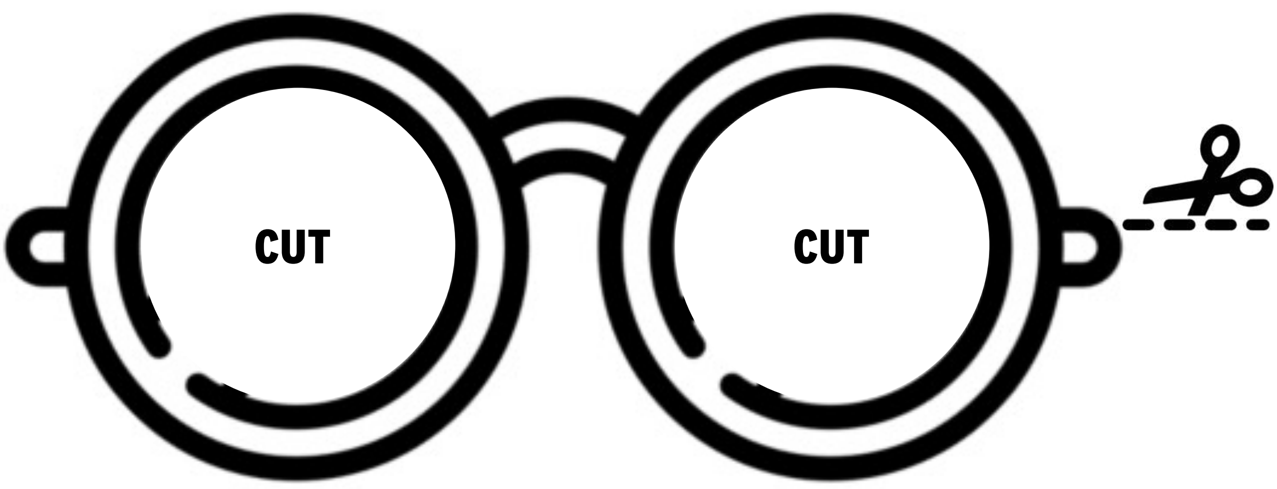
Your lenses will provide some protection for your eyes from the Sun's rays!

IMPORTANT SAFETY NOTE: You have just created a model of safety eyewear! This model should NOT be used in place of real safety eyewear.

EYEWEAR FRAME TEMPLATE







PATTERNS IN THE SKY

Suggested Grades:

- 1-2

Driving Questions:

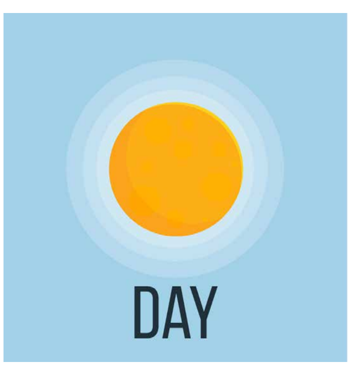
- What can we observe happening in the daytime sky? What can we observe happening in the nighttime sky?
- What patterns can we observe in the sky?
- Why do we not see an eclipse every month?

Objective:

Students will be able to describe patterns in the sky, such as cycles of day and night, phases of the Moon, and/or occurrences of eclipses.

Materials (per student):

- Sun, Earth, and Moon template
- Scissors
- Glue stick
- Two (2) brass fasteners
- Optional: Art supplies (crayons, markers, etc.)



Introduction:

A **pattern** is a regular and repeating way in which something happens. Patterns allow us to predict or guess what is coming next. Objects in the sky can occur in patterns, too. What is something you can observe in the daytime sky?

The **Sun** is a star at the center of our solar system, providing the Earth with light and heat. The **Earth** is the planet on which we live. The Earth **revolves**, or goes around, the Sun. The Moon revolves around Earth and is our nearest neighbor in space. What other things can you observe in the sky?

The movement of the Sun across the sky makes the pattern we know as day and night. The Sun rises in the east every morning (sunrise), moves across the sky, and then sets in the west every evening (sunset). The day starts when the Sun rises and ends when the Sun sets.

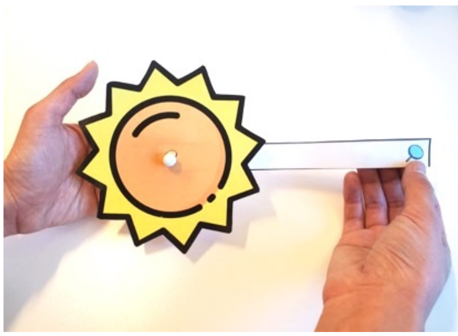
The night starts when the Sun sets and ends when the Sun rises. At night, we can often see the Moon and stars. Like the Sun, the Moon rises in the east, moves across the sky, and then sets in the west. But unlike the Sun, we can sometimes see the Moon during both the day and night sky, depending on its location.

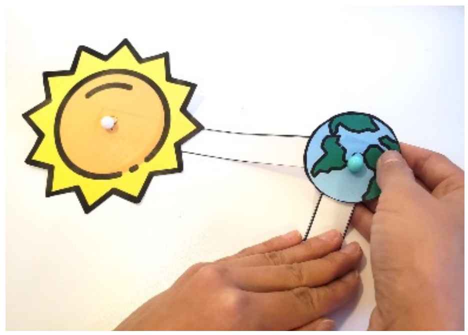
Sometimes, the Moon, the Sun, and the Earth line up in such a way that the Moon blocks the light of the Sun from reaching the Earth. This is called a **solar eclipse**. Solar eclipses occur two to four times per year.

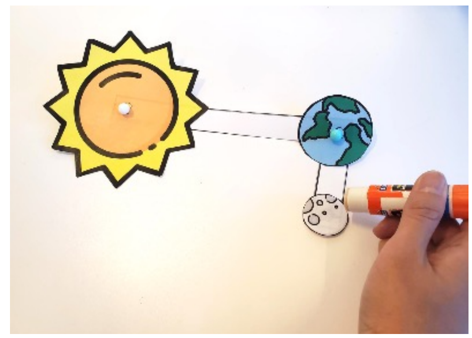
Now it is your turn! Make a model to best understand why we see these patterns in the sky.

Procedure:

1. Optional: Color the Sun, the Moon, and the Earth.
2. Cut out the Sun, the Moon, the Earth, and connecting strips. Notice that the connecting strips are color-coded for your convenience. The Sun, the Moon, and the Earth fastener icons are also color-coded.
3. Stack the yellow fastener icon on the Sun to the matching yellow icon on the connecting strip. Then push the first brass fastener through both pieces.
4. Stack the blue fastener icon on the Earth to the matching blue fasteners on the two connecting strips. Then push the second brass fastener through all three pieces.
5. Glue the Moon onto the connecting strip labeled "GLUE."







6. Discuss how the model works with students.
   a. When demonstrating how the model works, keep your finger on the Earth so it does not move, and practice revolving the Moon around the Earth.
   b. Now, practice moving the Earth around the Sun. You may turn the Earth to show that it both rotates and revolves around the Sun.
   c. Finally, place the Moon in between the Sun and Earth. This is when we could see an eclipse.

Discussion Questions:

- What are some things you have observed in the sky?
  > I have observed ___ in the sky.
- Day and night are a pattern. Use your model to show why we have this pattern.
  > Day and night are a pattern because ___.
- Use your model to describe how the Sun, the Earth, and/or the Moon can move.
  > The Earth ___ around the Sun.
  > The Moon ___ around the Earth.
- Why do you think keeping track of patterns in the sky is important?
  > I think keeping track of patterns is important because ___.
- Use your model to show the Moon blocking the Sun. This is a solar eclipse!
  > Ask students to describe an eclipse and/or show a video.

THUMBS UP ACTIVITY

1. Use your thumb to block out various-sized items that are near and far to demonstrate how, with the right angle and distance, a smaller object can block out a larger object.
2. Have students try blocking objects larger than their thumbs around the room.
3. Have students share their observations.
   - I can block out an object larger than my thumb when I move my thumb ____ (closer to me/further away from me).
4. Optional: Have students share when they cannot block objects larger than their thumbs.
   - I cannot block out an object larger than my thumb when I move my thumb ____ (closer to me/further away from me).
5. Pose the discussion question: We know the Moon is smaller than the Sun. How can the Moon block out all of the sunlight?
   - The Moon can block out all the Sun's sunlight because ____.

Extensions:

- Experiment with shadows! Periodically throughout the day, go outside to trace students' shadows. Have students stand in the same spot each time. What happens to their shadow as the Sun moves across the sky?
- ELAR — Have students write a short story about how early civilizations might have tracked day and night or eclipses.
- Family Learning — Have students work with their families to write a short story that incorporates today's learning.
- Family Learning — Does an eclipse have cultural meaning to the students' families? If so, ask students to share a story, dance, gesture, drawing, or verbal presentation.

TEKS Alignment:

K.9B Observe, describe, and illustrate the Sun, Moon, stars, and objects in the sky such as clouds.

RTCs:

1-2.5A Identify and use patterns to describe phenomena or design solutions.

NGSS Alignment:

1-ESS1-11. Use observations of the Sun, the Moon, and stars to describe patterns that can be predicted.

PATTERNS IN THE SKY

Name: ______________________________ Date: ______________________________

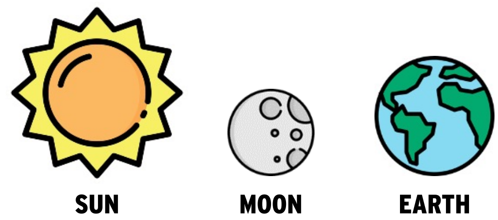
A **pattern** is a regular and repeating way in which something happens. Patterns allow us to predict or guess what is coming next. Can you predict what comes next?

Draw one to three patterns of your own.

Now, draw one pattern in the sky, as discussed in your class.

WHAT MAKES THE PATTERNS IN THE SKY?

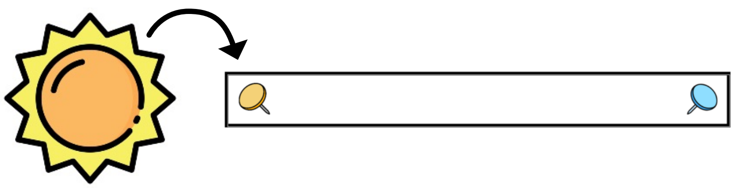
Procedure:



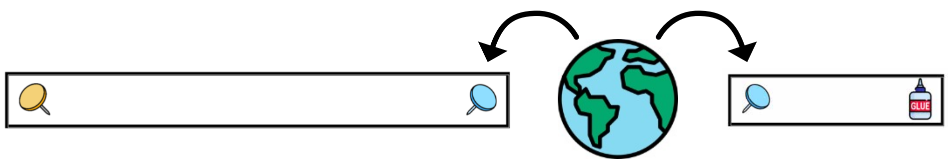
1. Optional: Color the Sun, the Moon, and the Earth.

2. Cut out the Sun, the Moon, the Earth, and connecting strips.

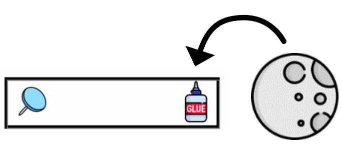
3. Stack the Sun onto the matching yellow icon on the connecting strip. Then, push the first brass fastener through both pieces.



4. Stack the blue fastener icon on the Earth on the matching blue fasteners on the two connecting strips, then push the second brass fastener through all three pieces.



5. Glue the Moon onto the connecting strip labeled "GLUE."



Reflection Questions:

1. What patterns can we observe in the sky?

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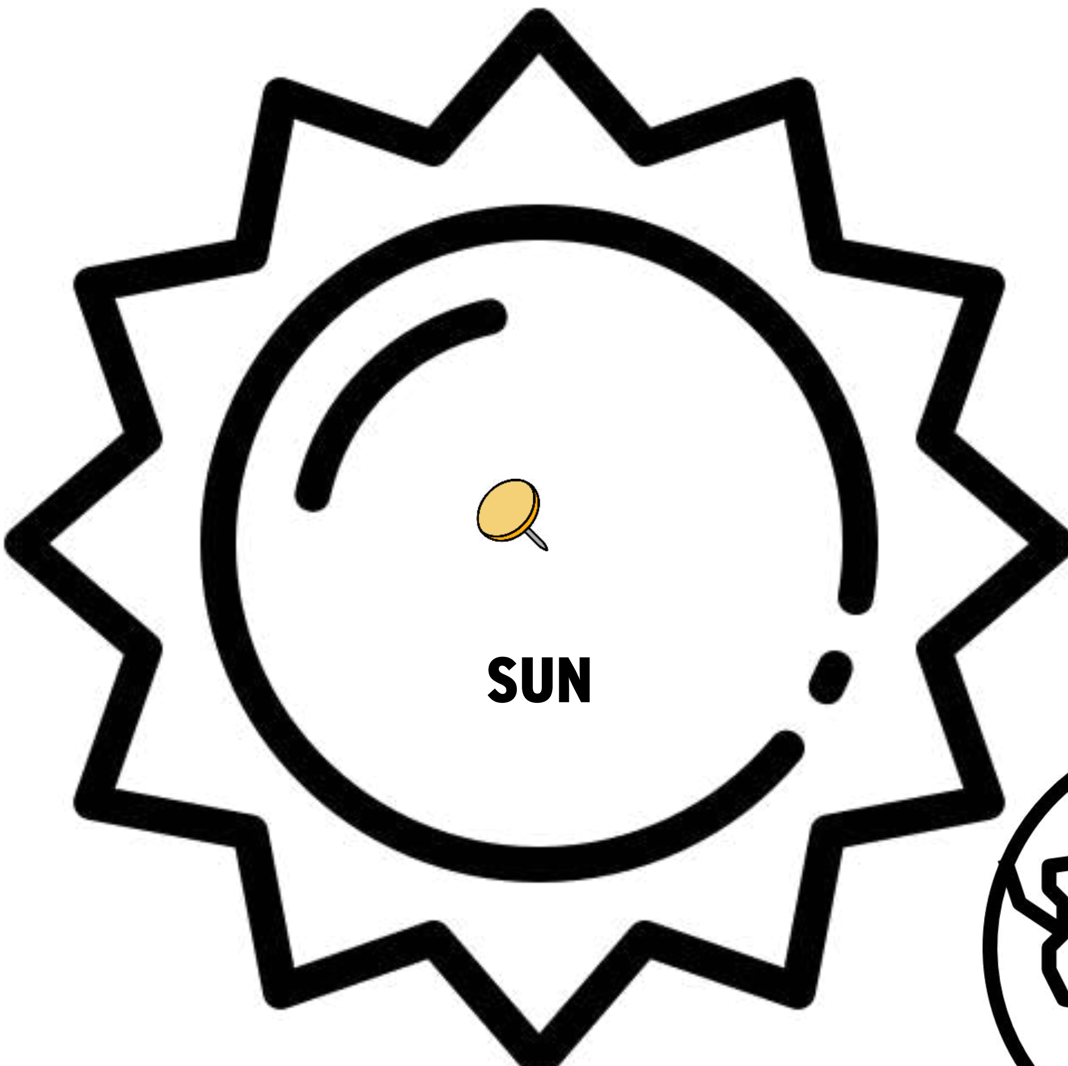
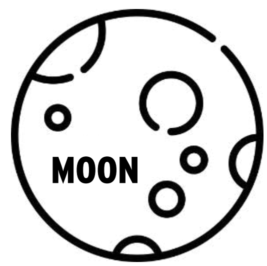
2. What makes a pattern in the sky?


GLUE


SUN


MOON


EARTH

ANSWER KEY – PATTERNS IN THE SKY

A **pattern** is a regular and repeating way in which something happens. Patterns allow us to predict or guess what is coming next. Can you predict what comes next?

Draw one to three patterns of your own.

Answers will vary.

Now, draw one pattern in the sky, as discussed in your class.

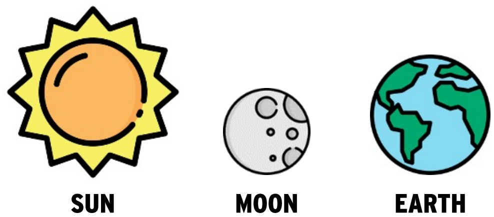
Answers will vary, but can include:

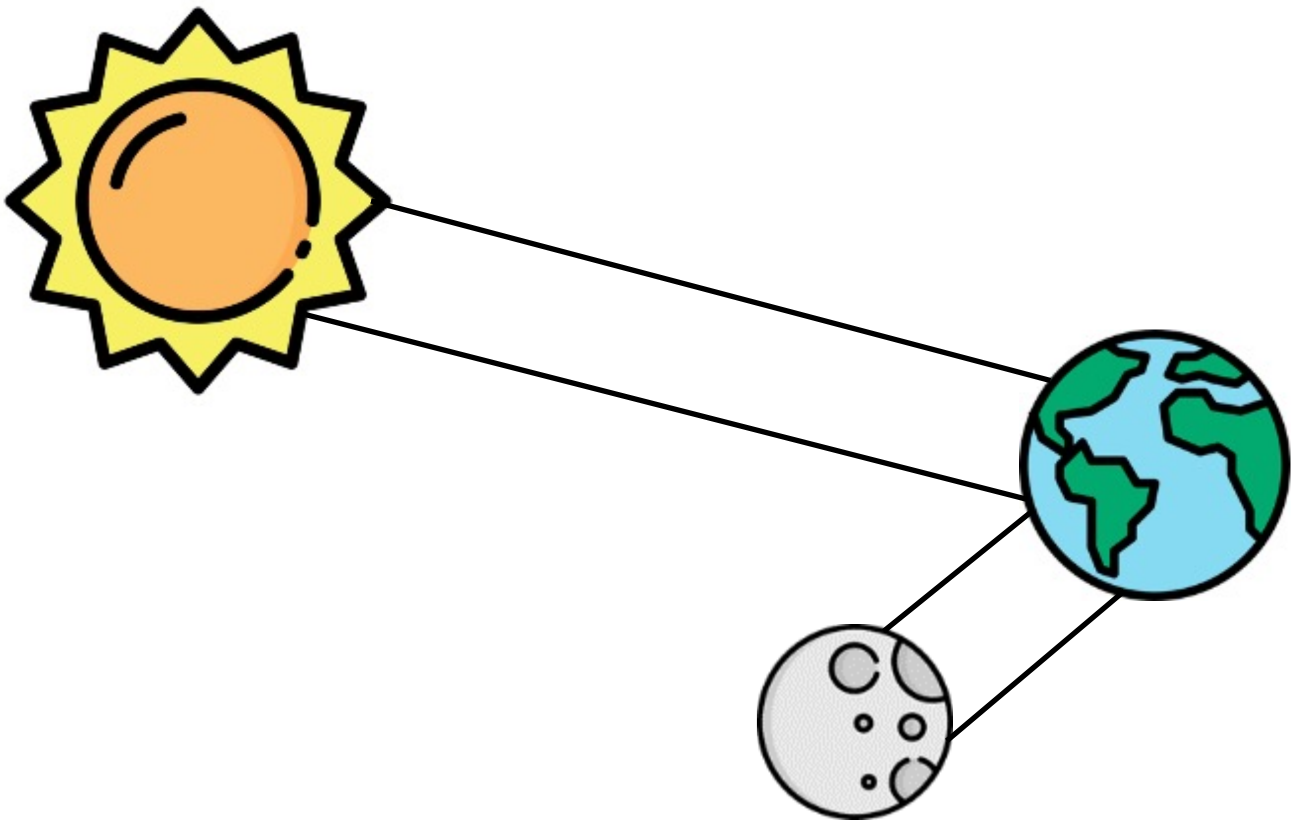
- **Day and night**
- **Phases of the Moon**
- **Planes' flight paths**
- **Sunrise and sunset**
- **Seasonal cloud changes**

ANSWER KEY – WHAT MAKES THE PATTERNS IN THE SKY?

Procedure:

1. Optional: Color the Sun, the Moon, and the Earth.





Reflection Questions:

1. What patterns can we observe in the sky?

   Answers will vary based on selected discussion questions.

---

2. What makes a pattern in the sky?

   Answers will vary based on the pattern selected.

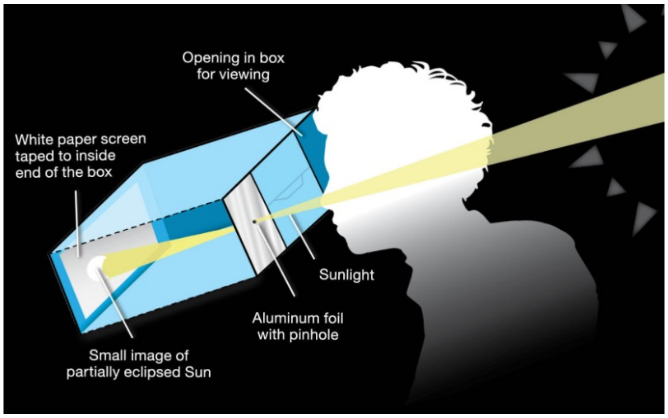
EYES ON THE ECLIPSE

Suggested Grades:

• 3-5

Driving Question:

How can we safely view a solar eclipse?



Credit: NASA, Eclipse Safety

Objective:

Students will apply safety protocols for viewing an eclipse and use everyday materials to build an eclipse viewer.

Materials (per student):

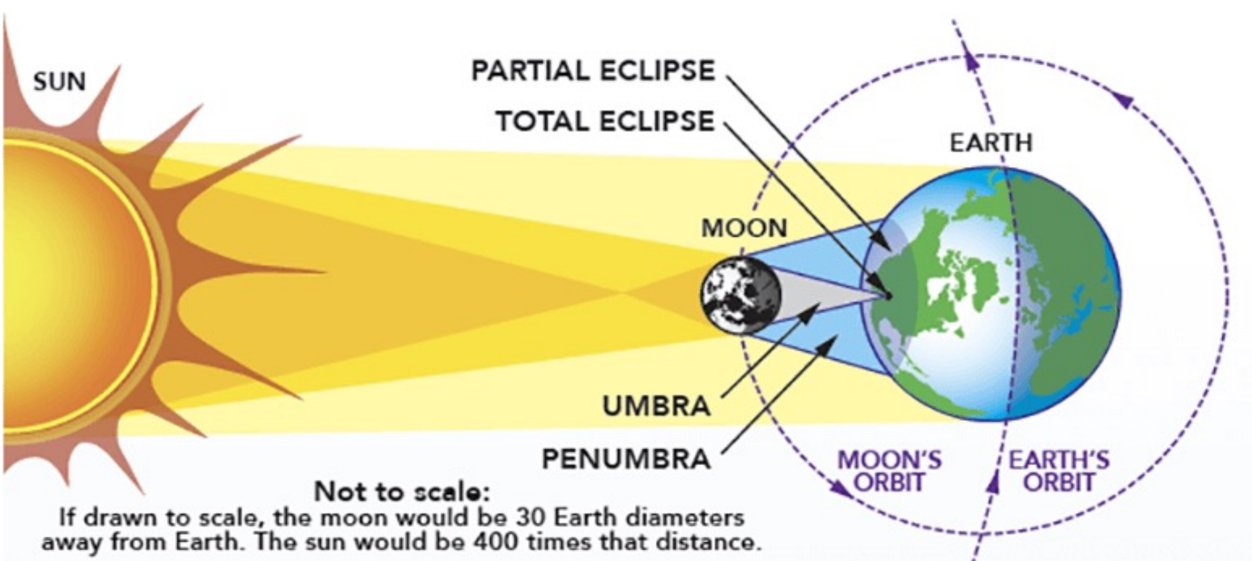
• Cereal or shoe boxes
• White paper
• Aluminum foil
• Tape
• Scissors
• Pin or nail to poke a hole
• Student activity sheet

Introduction:

What is happening during a solar eclipse?

Watch an introductory video with your class: **Solar Eclipse 101 | National Geographic**

The Earth and the Moon are aligned in their orbit around the Sun. The Moon passes between the Earth and the Sun in a solar eclipse. The Moon blocks some or all of the Sun's light, creating a short period of darkness in certain locations on Earth.



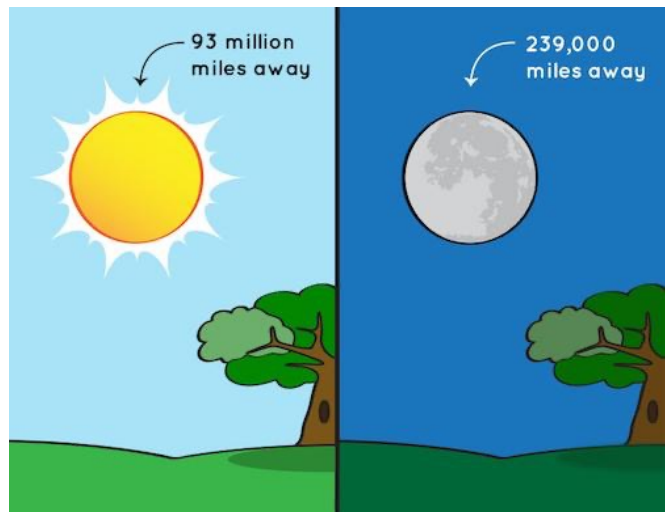
Credit: NASA, Total Solar Eclipse (2017)

Not all locations on Earth will see an eclipse, and most locations where the solar eclipse is visible will only see a partial eclipse. Places in the **path of totality** will see a total solar eclipse where the new Moon completely covers the Sun at the maximum phase. Totality can last from a fraction of a second to a record-setting seven minutes and eight seconds.

During a solar eclipse, two shadows are cast. The first is called the **umbra** (UM-bruh). This is the dark center of the eclipse shadow, and the parts of Earth in this shadow will see a total eclipse. The second shadow is called the **penumbra** (pe-NUM-bruh), and the parts of the Earth in this shadow will see a partial eclipse.

Why do the Sun and the Moon appear to be the same size?

The Sun is about 400 times wider than the Moon. Even though the Sun is much larger, they appear the same size in the sky because the Sun is 400 times farther away from Earth. When objects are farther away, they appear smaller than they actually are.



Credit: NASA, Space Place: How Is the Sun Completely Blocked in an Eclipse?

Discussion Question:

Why do we need to wear protective eyewear when viewing an eclipse?

It is never safe to look directly at the Sun, even when part of the Sun is blocked. Doing so can damage your eyes. When viewing an eclipse, you must either wear special glasses or create a viewer. Eclipse glasses are shaded darker than regular sunglasses and block more than 99.99% of the Sun's harmful rays. Another option is to use an eclipse viewer, which can be made using everyday materials.

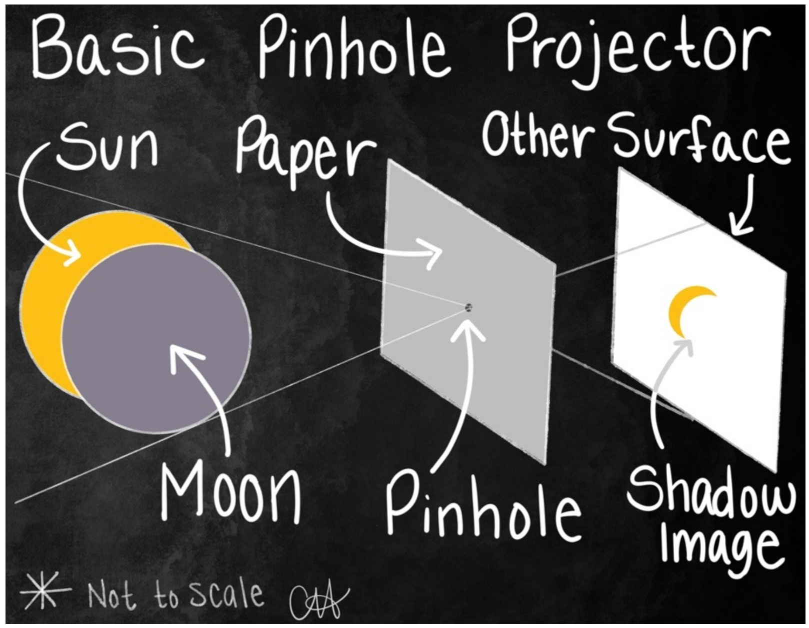
Pinhole Viewer Activity:

Students will use a box, foil, tape, white paper, a push pin or nail, and scissors to build their viewers. They will use their viewers with their backs to the Sun and view the shadow that is cast inside their viewer boxes.

Example instructional video here: **How to make a pinhole projector to watch the eclipse**
Credit: The Denver Post (2017)

Modifications:

Students can make a simple viewer using two sheets of paper. Poke a hole in one piece of paper and hold that piece with your back to the Sun. Line up the papers so that the second piece catches the light coming through the pinhole, then watch the shape of the Sun change during the eclipse.



Credit: Cassidy Hamilton

Students can choose to poke multiple holes into their viewer and create a design. As the light passes through the design, the projected sunlight will create a pattern of tiny eclipses!

Credit: Mariah Slovacek, photo taken during the annular eclipse in October 2023

Extensions:

- Students can create a video as a news reporter covering the solar eclipse. In their video, they should explain the causes of the eclipse and the importance of eye safety.
- Students can write a short story about characters experiencing an eclipse. What would they see? How might other people, animals, and insects in the story react to the eclipse?

Closure:

After creating the pinhole viewers, students can complete the reflection questions at the end of the student activity sheet. Discuss their responses and clear up any misconceptions.

Student Reflection:

1. What is happening during a solar eclipse? Draw a model of the Sun, the Earth, and the Moon, and label what is happening.

   The Earth and the Moon are aligned in their orbit around the Sun. The Moon passes between the Earth and the Sun. The Moon blocks some or all of the Sun's light, creating a short period of darkness in certain locations on Earth.

2. Describe the sizes of the Sun and the Moon. How do their sizes affect a solar eclipse?

   The Sun is about 400 times wider than the Moon. Even though the Sun is much larger, they appear the same size in the sky because the Sun is 400 times farther away from Earth. When objects are farther away, they appear smaller than they actually are.

3. Why isn't it safe to view a solar eclipse directly? What options are there for safely viewing a solar eclipse?

   It is never safe to look directly at the Sun, even when part of the Sun is blocked. When viewing an eclipse, you must either wear special glasses or create a viewer.

4. How does a pinhole viewer allow us to view an eclipse safely?

   The pinhole allows only a tiny amount of light to enter the box, which our eyes can view safely.

SEPs:

3.-5.1C Demonstrate safe practices and the use of safety equipment during classroom and field investigations as outlined in Texas Education Agency approved safety standards.

3.-5.1G Develop and use models to represent phenomena, objects, and processes or design a prototype for a solution to a problem.

EYES ON THE ECLIPSE

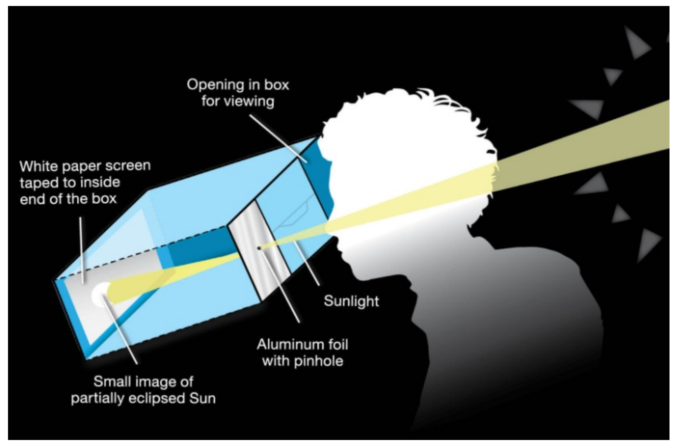
Name: ______________________ Date: ______________________

Guiding Question:

How can we safely view a solar eclipse?

Materials:

- Cereal or shoe boxes
- White paper
- Aluminum foil
- Tape
- Scissors
- Pin or nail to poke a hole



Credit: NASA, Eclipse Safety

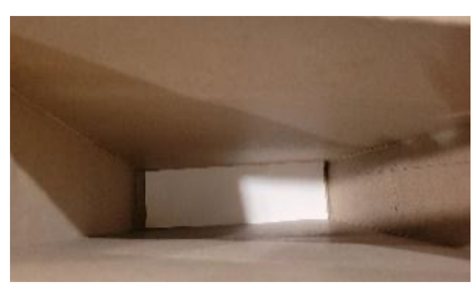
Introduction:

Looking directly at the Sun can damage our eyes, so we cannot observe a **solar eclipse** without using special glasses or other viewing tools. A pinhole viewer helps us to see what is happening during a solar eclipse safely. The pinhole allows only a tiny amount of light to enter the viewer, and our eyes can look at the reflected image of the eclipse without any danger.

Procedure:

1. Secure the bottom of your viewer by taping it closed.

2. Cut a piece of white paper to be slightly smaller than the bottom of your box. Tape the paper to the bottom of the inside of your box. This will be the projection screen.



3. Now cut the viewing holes in the top of the box. Cut a rectangular hole on the lid of your box on the left and right side, leaving the middle of the lid intact.

4. Cut a small piece of foil and tape it over one of the holes. Use a pin or nail to poke a small hole into the foil.

5. Now, test your pinhole viewer. Stand with your back to the Sun and hold your viewer so that the Sun can shine directly onto the foil. Place your eye near the viewing window and look for the projected light inside the box.

Reflections:

1. What is happening during a solar eclipse? Draw a model of the Sun, the Earth, and the Moon, and label what is happening.

2. Describe the sizes of the Sun and the Moon. How do their sizes affect a solar eclipse?

3. Why isn't it safe to view a solar eclipse directly? What options are there for safely viewing a solar eclipse?

4. How does a pinhole viewer allow us to view an eclipse safely?

ENGINEER AN ECLIPSE MODEL

Suggested Grades:

• 3-5

Driving Question:

What does the Sun, Earth, and Moon system look like during an eclipse?

Objective:

Using a 3D model, the students will describe and demonstrate the interactions between the Sun, the Earth, and the Moon during an eclipse.

Materials (per student):

- Cardboard or chipboard
- Corrugated cardboard
- 2 straws
- 1 toilet paper roll
- Foil, paper, or balls for the Earth and the Moon
- 2 large paper clips
- Tape or glue
- Scissors
- Flashlight
- Student activity sheet

Introduction:

What is the relationship between the Sun, the Earth, and the Moon in space?

The Sun is the center of our solar system, and the Earth and other planets **revolve** (orbit) around the Sun. The Earth has one Moon that revolves around it. The Earth also **rotates** (spins) while it revolves around the Sun.

Key Facts:

- The Earth takes 365 days to revolve one time around the Sun.
- The Earth makes a full rotation every 24 hours.
- The Moon takes 28 days to revolve around the Earth.
- We always see the same side of the Moon, but it technically makes one rotation as it revolves around the Earth.

Interactive digital resource suggestion: **PhET Simulation | Gravity and Orbits**

It is challenging to create a model to match the actual scale of the system, but we can demonstrate the movement of the Sun, the Earth, and the Moon using models.

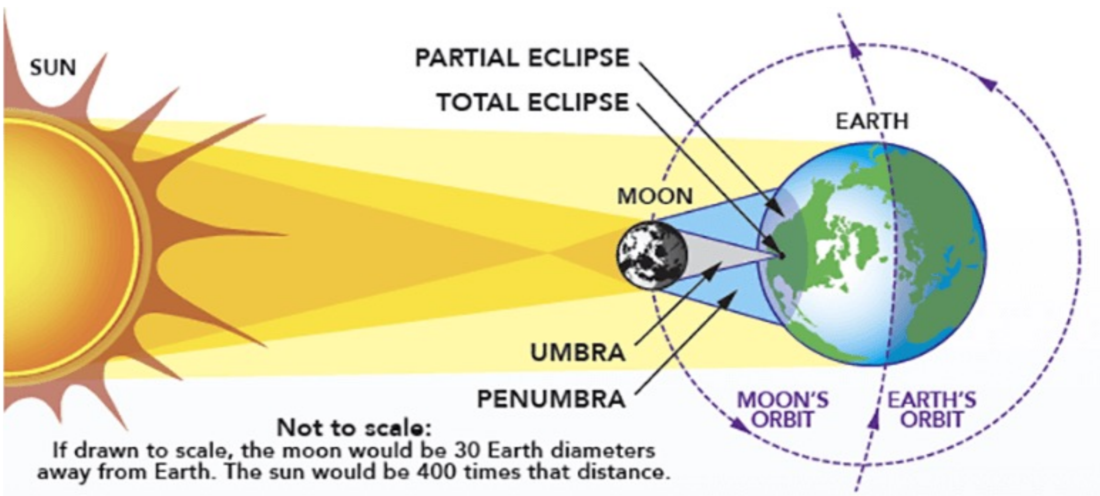
What is happening during a solar eclipse?

Watch an introductory video with your class: **Solar Eclipse 101 | National Geographic**

The Earth and the Moon are aligned in their **orbit** around the Sun. The Moon passes between the Earth and the Sun in a **solar eclipse**. The Moon blocks some or all of the Sun's light, creating a short period of darkness in certain locations on Earth.

Not all locations on Earth will see an eclipse, and most locations where the solar eclipse is visible will only see a partial eclipse. Places in the **path of totality** will see a total solar eclipse where the new Moon completely covers the Sun at the maximum phase. Totality can last from a fraction of a second to a record-setting seven minutes and eight seconds.

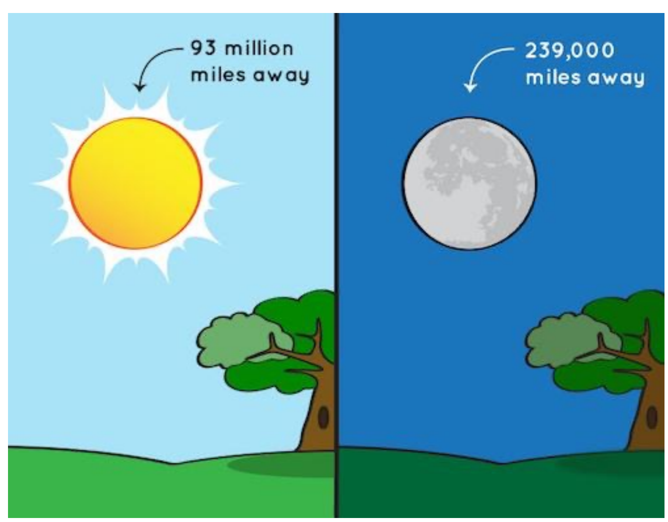
During a solar eclipse, two shadows are cast. The first is called the **umbra** (UM-bruh). This is the dark center of the eclipse shadow, and the parts of Earth in this shadow will see a total eclipse. The second shadow is called the **penumbra** (pe-NUM-bruh), and the parts of Earth in this shadow will see a partial eclipse.



Credit: NASA, Total Solar Eclipse (2017)

Why do the Sun and the Moon appear to be the same size?

The Sun is about 400 times wider than the Moon. Even though the Sun is much larger, it appears to be the same size in the sky because the Sun is 400 times farther away from Earth. When objects are farther away, they appear smaller than they actually are.



Credit: NASA, Space Place: How Is the Sun Completely Blocked in an Eclipse?

Create a Working Model of the Sun, Earth, and Moon System Activity

Students will use craft materials to build a gear-driven model of the Earth and the Moon in orbit. A flashlight can be used to represent the Sun in this model. Detailed instructions are included in the student activity sheet. A gear model template is provided to assist with constructing the model.

View a demonstration video: **Gear Eclipse Model**

Modifications:

Students can create Earth and Moon models without gears. The Earth and the Moon can each be attached to a stick or straw and held by hand, or the students can design their own models.

Extension:

Students can record a video of themselves using the model and explaining the movement of the Earth and the Moon around the Sun.

Closure:

After creating models, students can complete the reflection question at the end of the student activity sheet. Discuss their responses and address any misconceptions regarding the science of an eclipse.

TEKS Alignment:

3.9A Construct models and explain the orbits of the Sun, Earth, and Moon in relation to each other.

5.9 The student recognizes patterns among the Sun, Earth, and Moon system and their effects. The student is expected to demonstrate that Earth rotates on its axis once approximately every 24 hours and explain how that causes the day/night cycle and the appearance of the Sun moving across the sky, resulting in changes in shadow positions and shapes.

NGSS Alignment:

MS-ESS1-1. Develop and use a model of the Sun, Earth, Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and the Moon, and seasons.

Student Reflections:

1. Describe the movement of the Sun, the Earth, and the Moon in space. Draw a model to help explain your thinking.

   The Sun is the center of our solar system, and the Earth and other planets revolve (orbit) around the Sun. The Earth has one Moon that revolves around it. The Earth also rotates (spins) while it revolves around the Sun.

2. What does the Sun, Earth, and Moon system look like during a solar eclipse? Where are the Earth and Moon located in relation to the Sun? Draw a model to help explain your thinking.

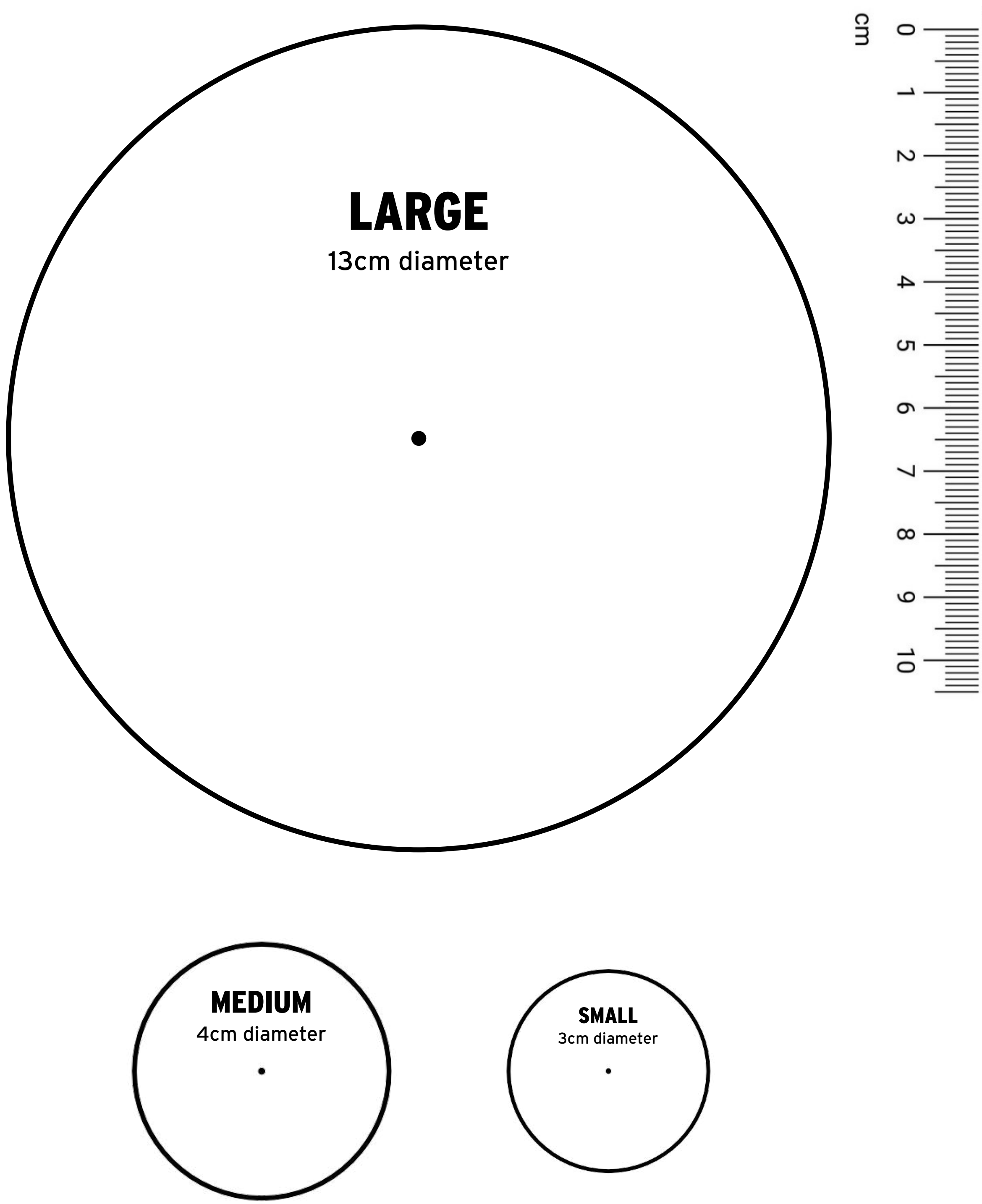
   The Moon passes between the Earth and the Sun in a solar eclipse. The Moon blocks some or all of the Sun's light, creating a short period of darkness in certain locations on Earth.

3. It is difficult to perfectly model the Sun, Earth, and Moon system. What are some limitations of the model you created? What could be improved to create a better model?

   There are several limitations, and student responses will vary.

   - *The sizes of the Earth and the Moon are not to scale.*
   - *The distance between the Earth and the Moon is not to scale.*
   - *The Moon only rotates once per revolution, but in our model, it rotates many times.*
   - *The Moon's orbit is elliptical, while our model's orbit is circular.*

ENGINEER AN ECLIPSE – GEAR MODEL TEMPLATE



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Museum of Nature and Science

ENGINEER AN ECLIPSE MODEL

Name: ______________________________ Date: ______________________________

Guiding Question:

How can we demonstrate an eclipse using a working model?

Materials:

- Cardboard or chipboard
- Corrugated cardboard
- 2 straws
- 1 toilet paper roll
- Foil, paper, or balls for the Earth and the Moon
- 2 large paper clips
- Tape or glue
- Scissors
- Flashlight

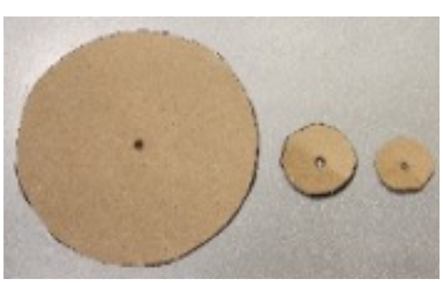
Introduction:

Use the materials provided to build a working model of the Sun, Earth, and Moon system. Then, use your model to demonstrate a solar eclipse.

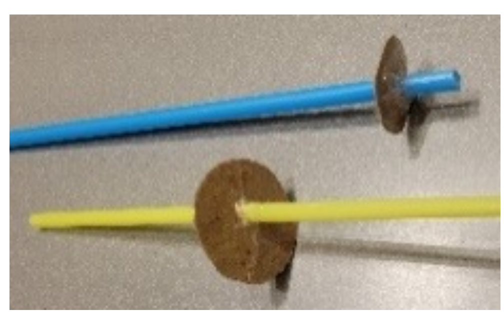
Procedure:

1. Use the templates to trace and cut out three circles from cardboard or chipboard. You will have a large, medium, and small circles with diameters of 13 cm, 4 cm, and 3 cm.

2. Poke a hole in the center of each circle that is big enough for a straw to fit in snugly.



3. Push one straw about halfway through the medium circle. Glue or tape the straw to the cardboard to secure it. The straw should not be able to spin inside the circle.

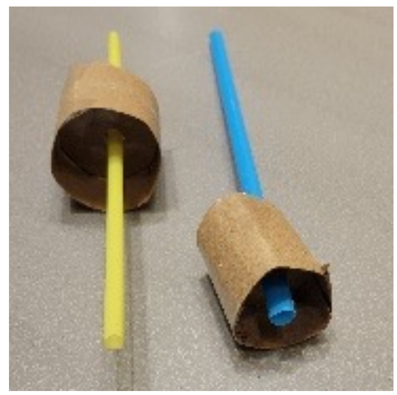


4. Push the other straw approximately 2 cm through the small circle and use glue or tape to secure it.

5. Make a cut all the way down the toilet paper roll.

6. Lay the toilet paper roll flat and use a ruler or template to mark a line 4 cm from the top of the roll. Cut off this section from the roll, then repeat by marking another line 4 cm from the top and cutting off a second section from the roll.

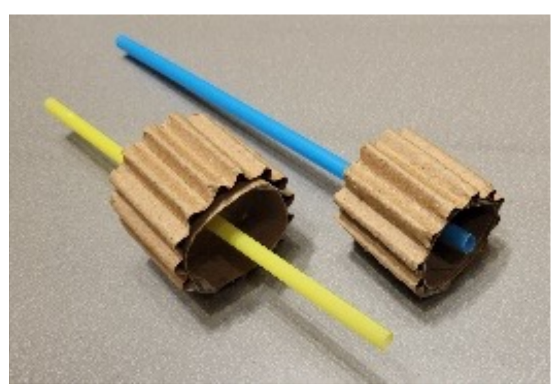
7. Secure the toilet paper sections to the circles using glue or tape on both sides. You may need to trim off excess length of cardboard from the roll.



8. Cut two strips of corrugated cardboard 4 cm tall and long enough to fit around the outside of the medium and small circles.

9. With the corrugated side facing out, glue or tape the cardboard to the toilet paper roll section around each circle. Cut off any excess cardboard.

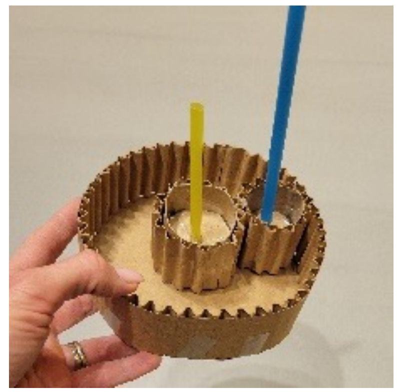
   **Note: Be sure you don't tape over the corrugation because this will need to be a working gear. It might help to push the tape into each peak and valley of the grooves, if needed.*



10. Cut a strip of corrugated cardboard 2 cm tall and long enough to fit around the outside of the large circle.

11. With the corrugated side facing in, wrap the cardboard around the large circle and glue or tape it securely. Cut off any excess cardboard.

12. Push the bottom of the straw from the medium circle through the hole in the center of the large circle. This will be the gear for the Earth.



13. Place the small circle gear next to the medium circle with the straw sticking straight up. This will be the gear for the Moon.

14. Grab two large paperclips. Put one over each straw, then tape the paperclips together so that the straws remain aligned and support a smooth movement of the gears.

15. Create your Earth and Moon using paper, foil, Styrofoam balls, or other materials.

16. Secure your Earth atop the medium gear and your Moon atop the small gear.

17. Test your model by twisting the straw that extends underneath your model. Modify the places where the gears touch to improve movement.

18. Shine the flashlight onto Earth to complete your working model.

19. Finally, set up your model to demonstrate the placement of the Sun, the Earth, and the Moon during a solar eclipse.

Reflections:

1. Describe the movement of the Sun, the Earth, and the Moon in space. Draw a model to help explain your thinking.

2. What does the Sun, Earth, and Moon system look like during a solar eclipse? Where are the Earth and the Moon located in relation to the Sun? Draw a model to help explain your thinking.

3. It is difficult to perfectly model the Sun, Earth, and Moon system. What are some limitations of the model you created? What could be improved to create a better model?

GLOSSARY

Appearance — the way something looks

Corona — the outer atmosphere of the Sun; usually obscured from view by the bright light from the visible surface of the Sun

Eclipse — occurs when one object in space passes through the shadow of another object in space

Full moon — the lunar phase when the side of the Moon facing the Earth can be seen completely, a whole bright circle in the sky; lunar eclipses occur during a full moon

Gravity — a force of attraction that pulls matter together

Lunar eclipse — occurs when the Earth is between the Moon and the Sun, and Earth's shadow (umbra) dims the view of the Moon, causing the Moon to look reddish-orange

Mass — the amount of matter something is made of

Matter — any substance that has mass and takes up space

Moon — a natural object that travels around a bigger natural object; planets, dwarf planets, and even some asteroids have moons; our planet, Earth, has one Moon, and because our Moon was the only one we knew about for a long time, we call it "the Moon"

New moon — the lunar phase when the side of the Moon facing the Earth is dark; the Moon cannot be seen from Earth during this phase; a solar eclipse can only occur during a new moon

Orbit — the curved path that a planet, satellite, or spacecraft takes around another object

Path of totality — the path traced across the Earth's surface by the Moon's shadow (umbra) during a total solar eclipse

Pattern — a regular and repeating way something happens; patterns help predict what may happen next

Penumbra — the shadow cast by an eclipse has two parts; during a solar eclipse, the penumbra is the portion of the shadow cast by the Moon in which only part of the Sun is covered; an observer standing in the penumbra only sees a partial solar eclipse

Planet — a large object in outer space that:
- orbits a star
- is big enough (has enough mass) to have enough gravity to force it into a spherical shape
- has cleared away any other objects of a similar size near its orbit around the star

Revolution — the time it takes to complete one full orbit around an object; the Earth takes about 365 days, or a year, to make one revolution around the Sun

GLOSSARY (continued)

Rotation — the time it takes for an object to spin completely around once on its own axis; the Earth takes 24 hours, or a day, to make one complete rotation on its axis relative to the Sun

Satellite — an object that orbits another object; a moon is a natural satellite; we also use satellite to refer to spacecraft built by people that orbit Earth or other objects out in space

Shadow — a dark place made where an object blocks the light; as the Sun moves across the sky, shadows can change; they might get longer, change shape, or change position

Solar eclipse — occurs when the Moon passes between the Sun and the Earth (during the new moon phase), blocking all or part of the Sun for the viewer

Solar system — a star and all of the objects that orbit it, including planets, moons, asteroids, and comets

Star — a ball of shining gas and plasma, composed mostly of hydrogen and helium and held together by its own gravity

Sun — the star in the center of our solar system; our Sun is a medium-sized yellow dwarf star

Transit — when an object in space passes in front of another WITHOUT eclipsing it as seen from the viewer; for example, in a planetary transit, Mercury (or Venus) appears as a small dark spot that seems to pass across the surface of the Sun

Totality — the relatively brief phase of a solar eclipse when the Moon completely blocks the Sun and only the corona is visible

Umbra — the shadow cast by an eclipse has two parts; during a total solar eclipse, the umbra is the smaller, darkest part of the Moon's shadow, where the entire Sun is blocked by the Moon; an observer standing within the umbra will see a total solar eclipse

READING LIST

Grade Levels K-5

Boothroyd, Jennifer. *Playing with Light and Shadows*. LernerClassroom, 2014.

Branley, Franklyn. *The Moon Seems to Change*. HarperCollins, 2015.

Coffelt, Nancy. *The Big Eclipse*. Orbit Oregon, 2016.

DeCristofano, Carolyn. *The Sun and the Moon*. HarperCollins, 2016.

Gardner, Jane. *Eclipses* (Pogo Books: Amazing Sights in the Sky). Jump!, Inc., 2020.

Gibbons, Gail. *The Moon Book* (Updated Edition). Holiday House, 2019.

Gower, Meg. *Breakfast Moon*. Astronomical Society of the Pacific, 2018.

Pattison, Darcy. *Eclipse: How the 1919 Solar Eclipse Proved Einstein's Theory of General Relativity*. Mims House, 2019.

Seluk, Nick. *The Sun is Kind of a Big Deal*. Orchard Books, 2018.

Whitethorne, Baje. *Sunpainters: Eclipse of the Navajo Sun*. Salina Bookshelf, Inc., 2002.

Grade Levels 6-8

Bennett, Jeffrey. *Totality!: An Eclipse Guide in Rhyme and Science*. Big Kid Science, 2022.

Fraknoi, Andrew and Dennis Schatz. *When the Sun Goes Dark*. NSTA Kids, 2017.

Loomis, Ilima. *Eclipse Chaser: Science in the Moon's Shadow*. Clarion Books, 2019.

Nordgren, Tyler. *Sun Moon Earth: The History of Solar Eclipses from Omens of Doom to Einstein and Exoplanets*. Basic Books, 2016.

Fiction and Myth

Cuevas, Adrianna. *Total Eclipse of Nestor Lopez*. Square Fish, 2021.

Hoult, Janet. *Where did the Sun Go? Myths and Legends of Solar Eclipses Around the World Told with Poetry and Puppetry*. Outskirts Press, 2013.

Mass, Wendy. *Every Soul a Star*. Little, Brown and Company Books for Young Readers, 2009.

RESOURCES

Online Articles:

Frontiers for Young Minds – an open-access scientific journal written by scientists and reviewed by a board of kids and teens

- "The Solar Eclipse That Validated Einstein's Theory of Relativity" by Hanoch Gutfreund (2022)

Smithsonian Magazine – an open-access magazine chronicling topics researched by the Smithsonian Institution

- "American Indian Beliefs About the Eclipse" by Dennis Zotigh (2017)

Online Resources:

Perot Museum | GREAT NORTH AMERICAN ECLIPSE
Carnegie Science | Virtual Open House 2020
NASA Eclipse Home

- 2023 Solar Eclipse
- 2024 Solar Eclipse
- NASA Space Place | Eclipse
- NASA | Maps: 2023 and 2024 Solar Eclipses in the US
- NASA | Earth's Moon
- NASA | Solar System Exploration – Sun
- NASA | Space Math, Problem 516: X-Ray Satellite Observes a Solar Eclipse from Space (3-5)
- NASA | What determines when we have an eclipse?

Eclipses:

- American Astronomical Society | Solar Eclipse Across America
- Eclipse 2024 Simulator
- JPL | Eclipse 2017 Animation
- National Science Teaching Association | Eclipse Guides, Resources, and More
- National Geographic | Lunar Eclipse 101
- National Geographic | Solar Eclipse 101
- PBS LearningMedia | Lunar and Solar Eclipses
- Princeton Museum of Art | Transient Effects: Eclipses in Art

Light and Shadow:

- National Air and Space Museum | The Science of Light and Shadows (PreK)

Sun and Moon:

- Astronomical Society of the Pacific | Breakfast Moon
- Center for Astrophysics, Harvard & Smithsonian | Current Night Sky
- Genius by Stephen Hawking on PBS | "Where Are We?"
- McDonald Observatory | Classroom Activities & Resources for K-12
- NASA Space Place | What Are the Moon's Phases?
- PhET Interactive Simulations | Gravity and Orbits

STEM Careers:

- Carnegie Science Careers
- Exploring Careers at NASA – Students
- IF/THEN Collection
  - Erika Hamden, Astrophysics Professor
  - Dana Bolles, NASA Spaceflight Engineer
  - Kelly Korreck, Astrophysicist
  - Miriam Fuchs, Telescope System Specialist for the James Clerk Maxwell Telescope
- Smithsonian Science Education Center | Space STEM Career Resource Guide
- Skype a Scientist