Space Center Houston

2024 Eclipse Educator’s Guide

Safety First

Never look directly at the sun!

Totality will not occur in Houston, so at no point will it be safe to look directly at the sun during the April 8th eclipse.

Use safe viewing methods

Only wear approved eclipse glasses with a special-purpose safe solar filter or build a simple solar eclipse viewing box (See page 12)

Let's get excited!

On April 8, 2024 at 1:40pm, Houston will be treated to a very rare sight: a near-total or partial solar eclipse!

Space Center Houston is thrilled to provide this booklet to detail what is happening during the eclipse, explain STEM principles that can be applied to the event, and share ideas for fun and engaging activities for your students. Most of the activity materials are right in this box or can be easily found in the classroom!

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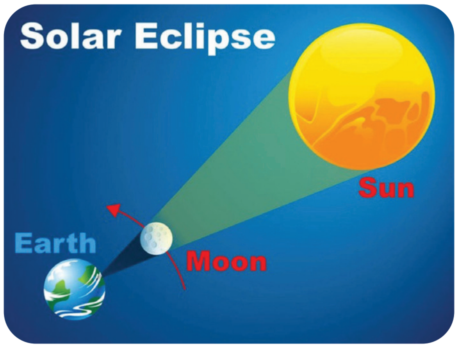
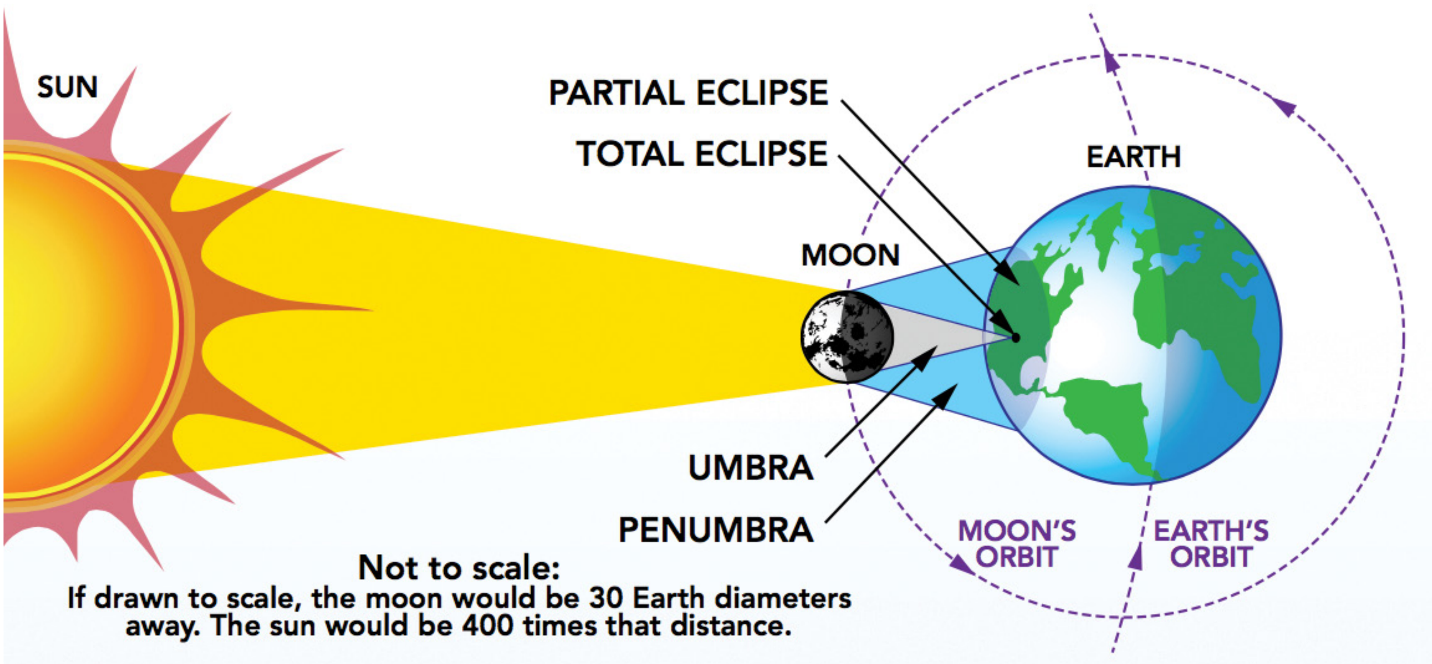
Digital Only Material

Scan for the full Educator's Guide

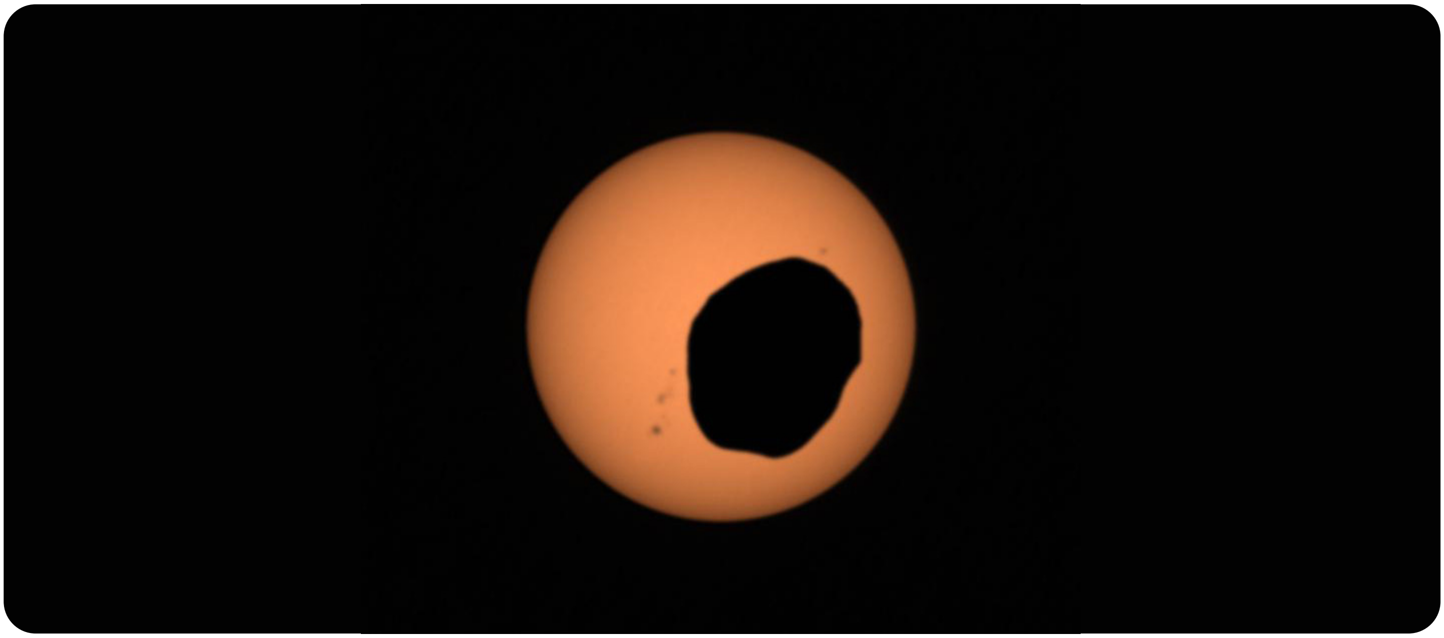
Section 1 What is happening during the 2024 eclipse?



We know that the Moon travels a path, or orbit, around the Earth, and that the Earth-Moon system travels a path around the Sun. A solar eclipse occurs when the Moon passes between the Earth and the Sun, blocking some of the Sun's light from reaching the Earth. In a total solar eclipse, this passage happens in a very special way, when the Moon lines up just right to completely block out the Sun for people viewing from certain areas on Earth.



Different locations on Earth will experience the eclipse to varying degrees, depending on where they are in the Moon's shadow. The darkest, inner portion of the shadow is called the umbra, while the lighter, outer portion of the shadow is called the penumbra. The umbra's circular shadow travels in a line over the Earth's surface called the path of totality, and for the 2024 eclipse, the shadow will be more than 100 miles wide! Those in the path of the penumbra, like all of us in Houston, will see a partial eclipse. Here in Houston we can expect a 94% blockage of the sun, or obscuration, which is pretty good when you consider other U.S. locations further from the umbra will only see a 50% blockage at best.



Our obscuration is especially remarkable when you consider how RARE a total solar eclipse is in the universe. Our Moon may be 400 times smaller than the Sun, but it's also 400 times closer to the Earth. At certain times, and from certain places on Earth, it's able to cover up the Sun entirely. The Moon also has to be the right shape, and all Moons are not created equal! Look at this eclipse by one of Mars' two moons taken by NASA's Perseverance Rover in 2022. This moon, Phobos, has an irregular shape and its size and distance isn't at the right ratio to create a total solar eclipse. But it still looks amazing!

Being so close to a total solar eclipse is very special, as they are **rare**! While the Earth has at least two solar eclipses per year, they are often only partial and many times occur over the ocean—oceans cover 70% of our planet, after all! In fact, the contiguous U.S. won't see another total solar eclipse for twenty years!

This special opportunity is why we at Space Center Houston have made this booklet and box, so you and your students of all ages can experience the excitement of the eclipse, learn about our universe, and make an educational memory that will last a lifetime.

Activation Ideas:

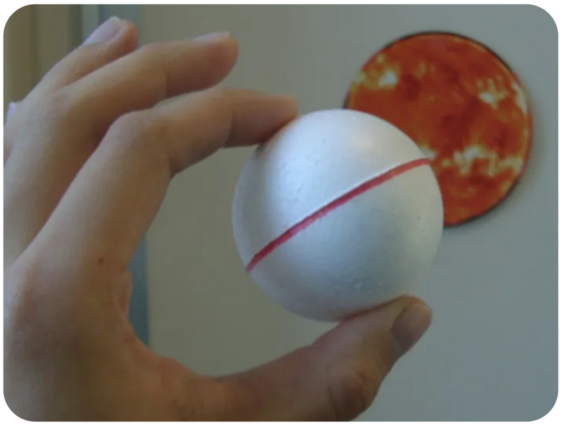
Section 1 Build a Sun-Earth-Moon Model

Major Concepts:

- A solar eclipse occurs when the Moon blocks light from the Sun from reaching Earth.
- An eclipse's coverage is relative to the size of the Earth, Moon, and Sun, and their distance from each other.
- Different-sized objects need different distances to create a total eclipse.

Activity Overview:

In this activity, students will experience hands-on exploration of how distance affects how we perceive an object's size. It is a simple introduction to eclipse mechanics and is accessible even for young children.



A participant eclipses an image of the Sun with a small Styrofoam ball. Here, the Sun image is 8.5" in diameter while the small ball is 2" in diameter.

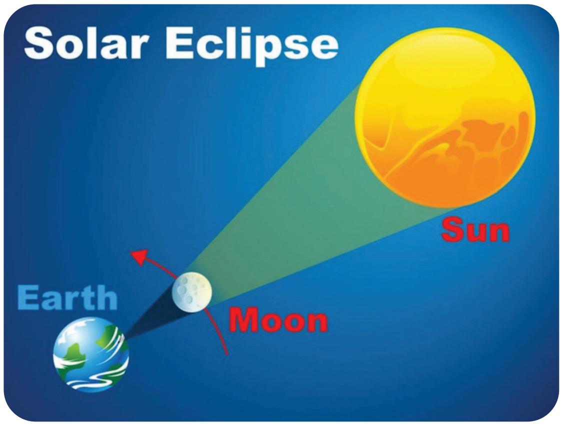


Diagram of a total solar eclipse.

Provided Materials:

- Ping-pong balls
- Surveyors tape
- Clay

Needed Materials:

Various-sized balls: tennis ball, baseball, basketball, soccer ball, etc.

HOW CAN OUR LITTLE MOON HIDE THE GIANT SUN?

Grades 3-5

Adapted from NASA. Find it online - search: little moon giant sun NASA

Teacher Instructions

1. Ask students about the Sun and the Moon: How big are they? Which one is bigger? Are they bigger or smaller than the Earth?
2. Ask students what they know about solar eclipses. Show an image of a total solar eclipse and explain that a solar eclipse happens when the Moon crosses between the Earth and the Sun, blocking the Sun's light.
3. Hold up a medium-sized ball and hand smaller balls to students. (They do not need to be to Sun/Moon scale.) Challenge students to 'eclipse' the medium ball with their smaller ones. (It may help students to cover one eye).
4. Ask participants what they noticed: Could they eclipse the ball? Why or why not?
5. Now hold up a larger ball and ask your students to eclipse this new 'Sun' with their smaller spheres. What did they have to change to eclipse the larger ball? They might have to step further away from the larger ball, or bring their ball closer to their eyes, making it appear big enough to eclipse the new 'Sun'. These principles of size and distance can be related to the mechanics of the eclipse.
6. Scale model option: Use one stick of blue clay to make a 1" Earth ball, and ¼ stick of gray clay to make a ¼" Moon ball (each block of clay has 8 sticks). Mark off 30 inches on your surveyor's tape. Compare the size of the Earth and Moon and ask students to guess how far apart they need to be to represent the Moon's distance to Earth. Have one student hold the Earth, one student hold the Moon and move closer together or farther apart based on the classroom's best guess. Show the surveyor's tape and bring the Earth and Moon to 30 inches apart to show the correct distance at this scale. Ask how far away the Sun would need to be at this scale (Answer: 975 feet, or about ¾ of a lap around a track). Discuss how far away that distance is from your classroom, playground, or other landmarks.

Another quick example to visualize sizes and distances in an eclipse: If the Sun is a standard 9" basketball, the Moon would be roughly a pinprick or a pencil dot (1/50 inch). At this scale, the Sun and Moon would be about 86 feet apart—just under the length of a basketball court. At this distance, the basketball Sun would be eclipsed by the dot of a Moon if put about 3" from your eye (your eye being the position and view from Earth).

Section 1 Build a Sun-Earth-Moon Orbit Model

Major Concepts:

- The tilted orbits of the Moon and Earth occasionally line up to produce an eclipse.
- When three celestial objects line up, it is called the very fun word: syzygy (sizz-ih-jee).
- When the Moon crosses the ecliptic plane, it creates a lunar node. A lunar node in alignment with the Sun creates an eclipse.
- There are two types of eclipses: A lunar eclipse is when the Earth is between the Sun and Moon, a solar eclipse is when the Moon is between the Earth and the Sun.

Activity Overview:

In this activity, students will make a model showing how the Moon's orbit around the Earth is tilted in relation to Earth's orbit around the Sun, resulting in the rarity of eclipses. Learners can track different orbital paths and understand the differences between solar and lunar eclipses. There are enough cups, pins, and clay for 15 groups of 2 students.

Provided Materials:

- 2.75 in ball (tennis ball or medium orange will also work)
- Three clear plastic cups
- Two different colors of clay—blue/green/brown for Earth, gray/white/beige for the Moon. Note: each block of clay comes in 8 strips. Half of one strip will make a ½" Earth. You can use a plastic knife to cut the clay.
- Pushpin

Needed Materials:

- Two different colors of permanent marker (we used red and blue)
- Flashlight or cell phone light

WHY ARE ECLIPSES SO RARE?

Grades 6-12

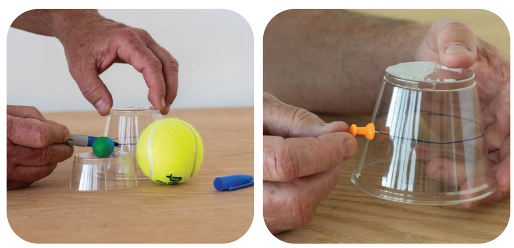
Adapted from the Exploratorium. Find it online - search: eclipse in a cup

Teacher Instructions

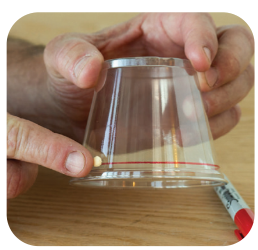
1. Make a model Earth by rolling out a small, ½-¾ inch ball of green or blue clay. Make a model moon in white or gray clay that is about one-fourth the size of the Earth. (Model is not to scale)

2. Cut one of the cups to make a stand so the model Earth will sit at the center of your "Sun." This is your Earth Cup (EC), as you will stick your Earth on top of it. (Try not to smash it down!)

3. Place a cup upside-down between your Earth and Sun. Use one color marker to draw a circle around this cup that is even with the centers of the earth and Sun. (Tip: hold your pen still and just spin the cup.) Once done, push in a tack anywhere on this circle. This is your Ecliptic-Plane Cup (EP).



4. Stack your cups in the following order: Earth cup (EC), Ecliptic-Plane cup (EP), Tilted-Lunar-Orbit cup (TLO). The brim of the TLO should rest on the pushpin, allowing the TLO cup to tilt.



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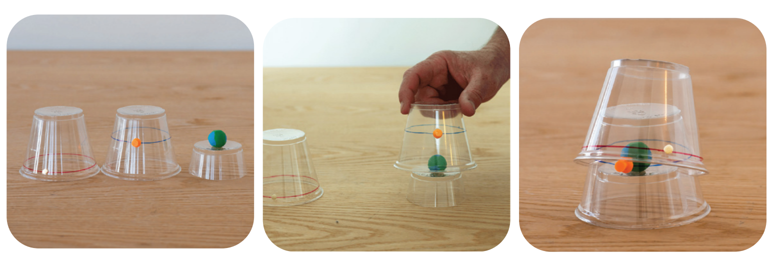
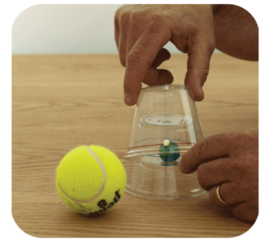


6. Place your Sun next to your new model and let's investigate!

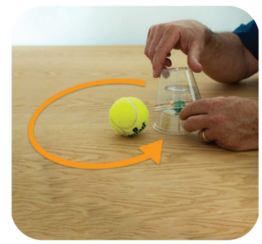
Investigation I: The moon orbits the Earth

Holding the pushpin with your fingers, spin the top (TLO) cup counterclockwise. Watch as your moon travels along its tilted orbit. (Note that the earth does not spin; in this model, one orbit of the moon defines one month. The earth would have rotated about 30 times during this period.)



Investigation II: The earth-moon system orbits the Sun

Hold the pushpin so that it always points in the same direction—at the same corner of the room or another fixed point. Use pin to move the stack of cups counterclockwise around the Sun. This represents the yearly orbit of the Earth-Moon system around the Sun.



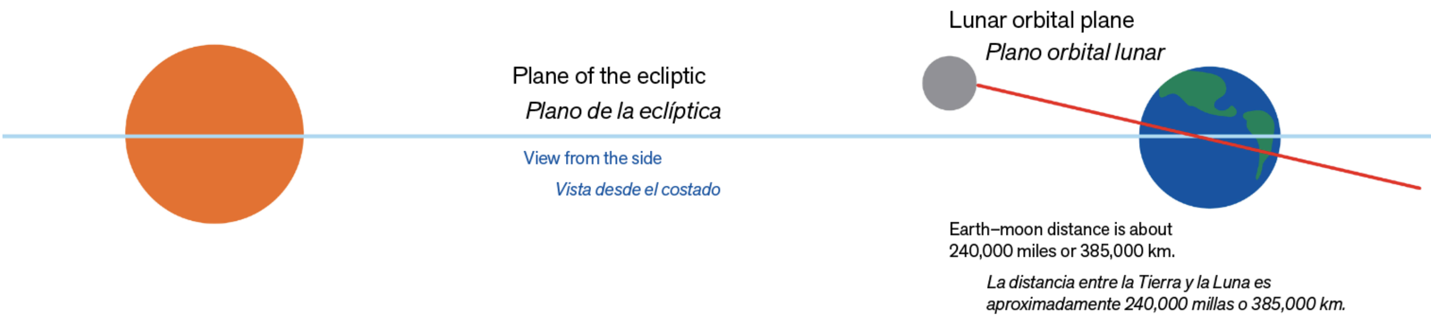
Move the stack once around the Sun while simultaneously turning the TLO cup counterclockwise 12 times. Try to space your 12 rotations evenly, for the twelve months of the year! Note that the Earth would have rotated about 365 times during this period.

Investigation III: Finding three-in-a-row alignments, or syzygys

As you move your stack of cups around the Sun, locate and count the number of times when the Earth, Moon, and Sun line up on the same plane (i.e. when the Moon intersects the orbit lines and the sun is in line, too). Either the moon can be in the middle (a solar eclipse) or the earth can be in the middle (a lunar eclipse). The moon will often be too low or high for a straight alignment, however, or not in the direct path of the sun.

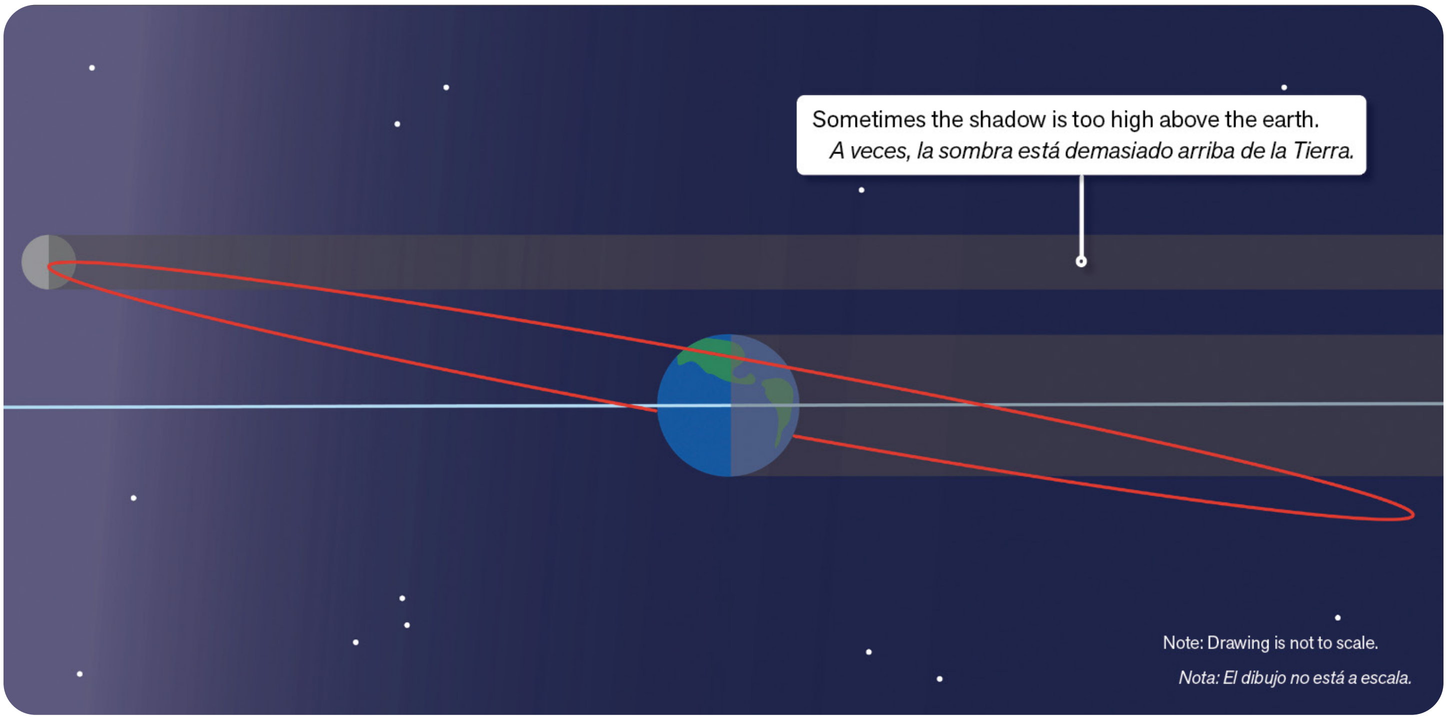
A lunar node occurs whenever the moon's tilted orbit crosses the ecliptic plane (i.e. the moon sits at the intersection of the colored circles). Note that for an eclipse to happen, the moon must be at a lunar node **and** in line with the Sun—quite rare!

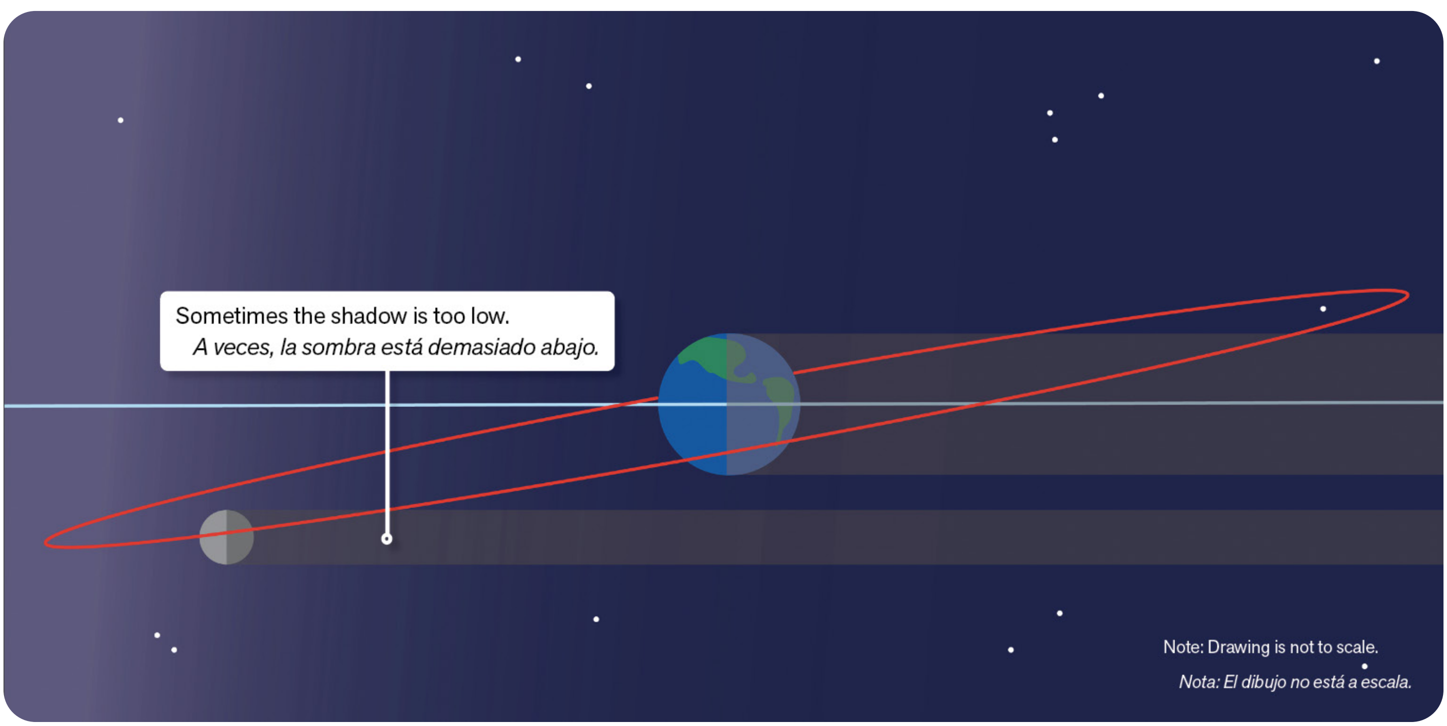
Once in a three-in-a-row alignment (or syzygy), use your flashlight to mimic the light emitted by the Sun. Note the shadow on the Earth in a solar eclipse, or the darkened moon in a lunar eclipse. Also notice how shadows are only seen when the Moon is at, or near, lunar nodes. The Moon's tilt (5.14 degrees off the ecliptic plane) causes the shadows to often miss each other. Only during syzygy do these shadows land on each other—an eclipse!



Note: Drawing is not to scale.

Nota: El dibujo no está a escala.





Section 1 Build an Eclipse Box Viewer

Major Concepts:

- It is **<u>never</u>** safe to look directly at the Sun, even when somewhat obscured during a partial eclipse.
- Scientists use dedicated tools to observe and measure this type of phenomena, as it is harmful to our eyes.
- Due to the way optics affect light, the image of the eclipse will appear upside-down in your viewing box. This doesn't alter the accuracy of the image, since the Sun is vertically symmetrical!

Activity Overview:

A pinhole viewer is one of the oldest and simplest optical devices that can be used to safely observe an eclipse. It is a basic version of the high-tech equipment that scientists use to study the sun. Students will work together to make an eclipse viewer to safely view the sun during all phases of the eclipse.

Provided Materials:

- Eclipse box—the box containing all the materials! (A shoe box or cereal box also works.)
- Piece of tinfoil
- Pushpin

Needed Materials:

- Tape
- Scissors or box cutter
- White piece of paper (optional)

Teacher Instructions

1. On one end of the box, near the right or left edge, cut a 1-inch hole. (Boxes from Space Center Houston have all cutting holes marked.)
2. Tape a piece of tinfoil over the hole, covering it completely.
3. Push a pin or needle through the tinfoil to make a small hole.
4. If using a different box, tape white paper inside the box, on the side opposite the hole.
5. Cut another 1-inch hole on the same side of the box as the tinfoil, at the opposite edge. This will be your viewing port.
6. Test your eclipse projector on a sunny day: With your back to the sun, face the side of the box with the tinfoil and viewing port. Hold the box so that sunlight passes through the tinfoil pinhole. Look through the viewing port without blocking the tinfoil, moving and tilting the box up and down until you see the sun projected onto the inside of the box. During the eclipse, the circle of sunshine will be obscured by the moon.

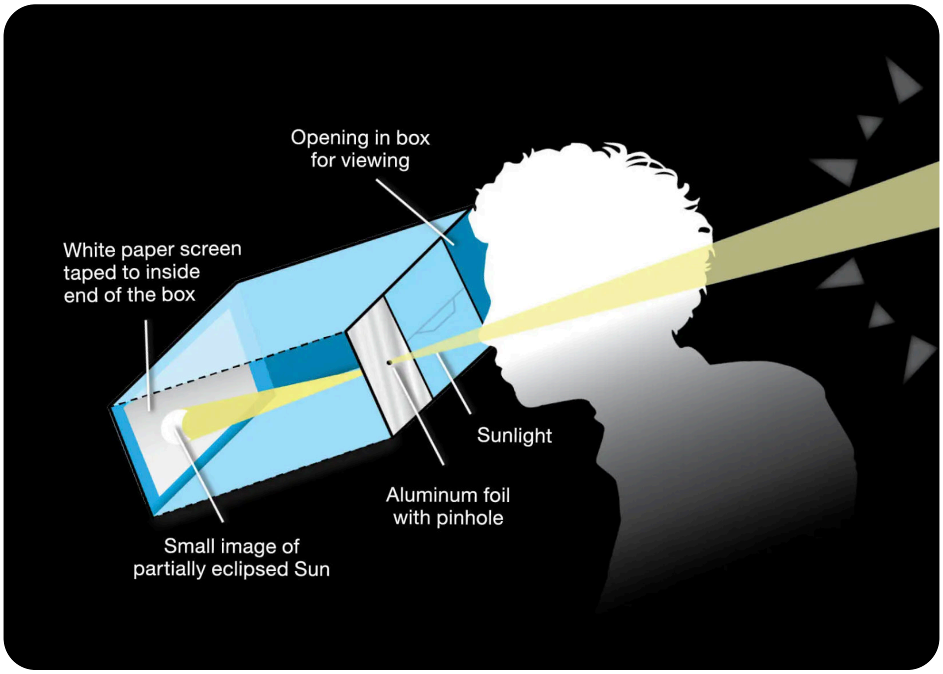
Lesson Extensions:

- Have students bring a cereal box or shoe box from home to make their own eclipse projectors individually or as a class.
- On the day of the eclipse, have students observe the eclipse every 10 minutes, drawing or documenting what they see (See page 23).

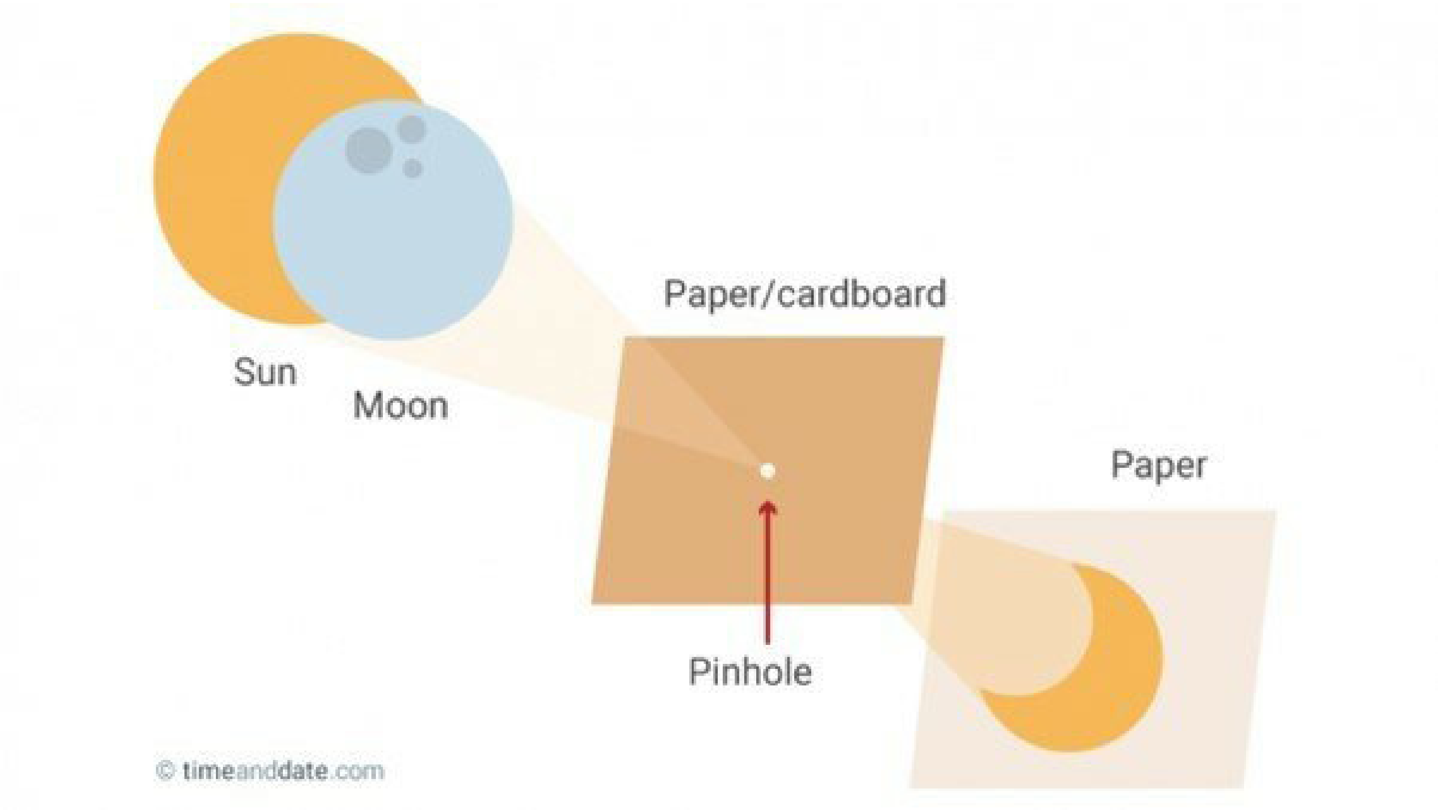
THE SAFEST WAY TO VIEW THE ECLIPSE

All Grades

Adapted from NASA. Find it online - search: eclipse safety 2024



Source: NASA. (Edited 2024, January 26). Total Solar Eclipse safety. Eye Safety During a Total Solar Eclipse. https://science.nasa.gov/eclipses/future-eclipses/eclipse-2024/safety/



Section 1 Pinhole Projector Activity + Math Extension

THE SIMPLEST WAY TO VIEW THE ECLIPSE

All Grades

Adapted from NASA. Find it online - search: 2024 eclipse pinhole projector NASA

Major Concepts:

- It is **never** safe to look directly at the Sun, even when somewhat obscured during a partial eclipse.
- You can use simple tools to allow safe and creative observation of the solar eclipse.
- You can use your observations and mathematical ratios to calculate the size of the Sun.

Activity Overview:

Students will learn that even with the simplest tools, the solar eclipse can be observed in a scientific manner.

Provided Materials:

- GLOBE Observer pinhole projector

Teacher Instructions:

1. Have the students make a prediction. What shape will the Sun be when it shines through each hole?
2. Direct the students to stand with their back toward the Sun, hold the card about 1 meter above the ground out in front of their body, allowing sunlight to shine through the holes onto the ground. Do **not** look at the Sun through the pinhole!
3. Have the students check their prediction. Does the shape of the hole affect the image of the Sun?

National Aeronautics and Space Administration

2024 Total Solar Eclipse Pinhole Projector Activity

Next Generation Science Standard 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.

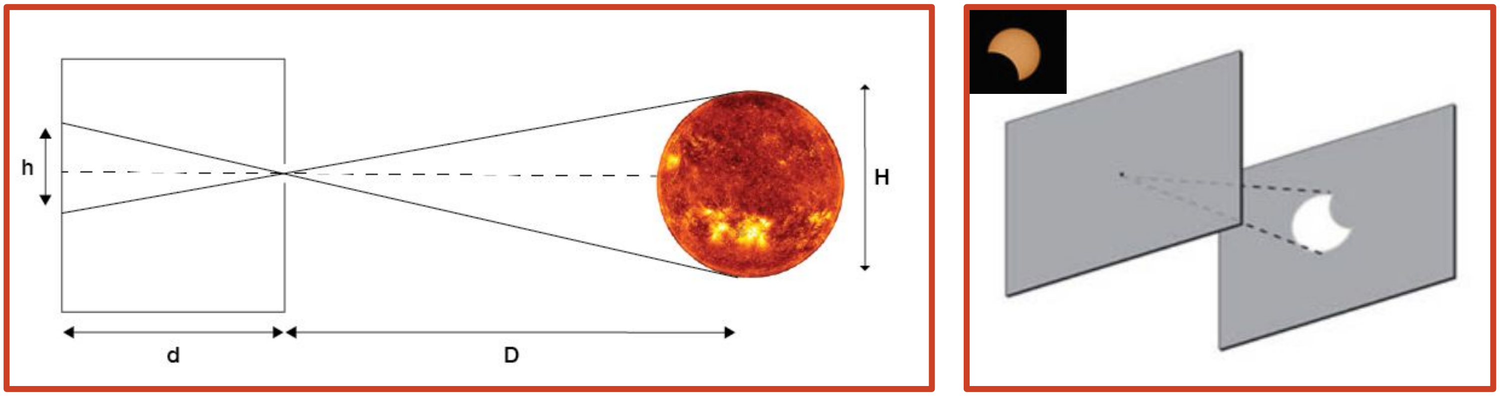


Figure 1. Left diagram shows the relationship between the height of the projected image (h), projection distance (d), distance to the object (D), and the height (diameter) of the Sun (H). See 'Educator Extensions' section for a math equation on how to calculate the Sun's diameter using a pinhole projector. The right diagram shows the shape of the Sun during the partial phase of a solar eclipse through a simple pinhole projector. Credit: NASA

Pinhole projectors allowed early scientists to view the shapes of illuminated objects, like the Sun, by shining the light from the object through a very small hole, projecting the image of the object onto the ground, wall, or other flat surface. Make this easy pinhole projector with your learners, see Figure 2, and have them experiment with the shape and size of the pinhole in this short (25- to 30-minute activity). See educator extensions for more ways to engage your learners.

Credit: NASA/Aubrey Gemignani

Your back should always be to the Sun when using a pinhole projector. Do NOT look at the Sun through the pinhole!

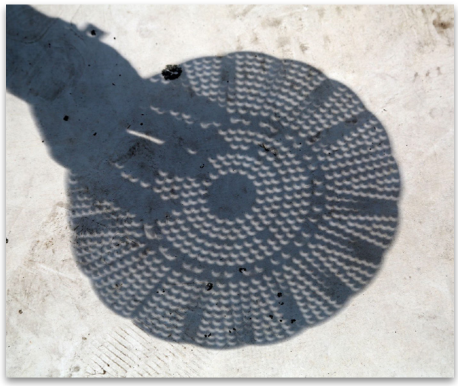
Remember to never look directly at the Sun without proper safety equipment.

Safety Messaging
Total Solar Eclipse 04.08.24

Two options for safely viewing a partial or total solar eclipse:

- Use a pinhole projector or other indirect safe viewing methods.
- Use a solar filter, like solar viewing glasses.

Indirect Viewing Method: Project images of the Sun using your hands. Credit: AAS



Indirect Viewing Method: Project images of the Sun using a colander. Credit: NASA/Joy Ng

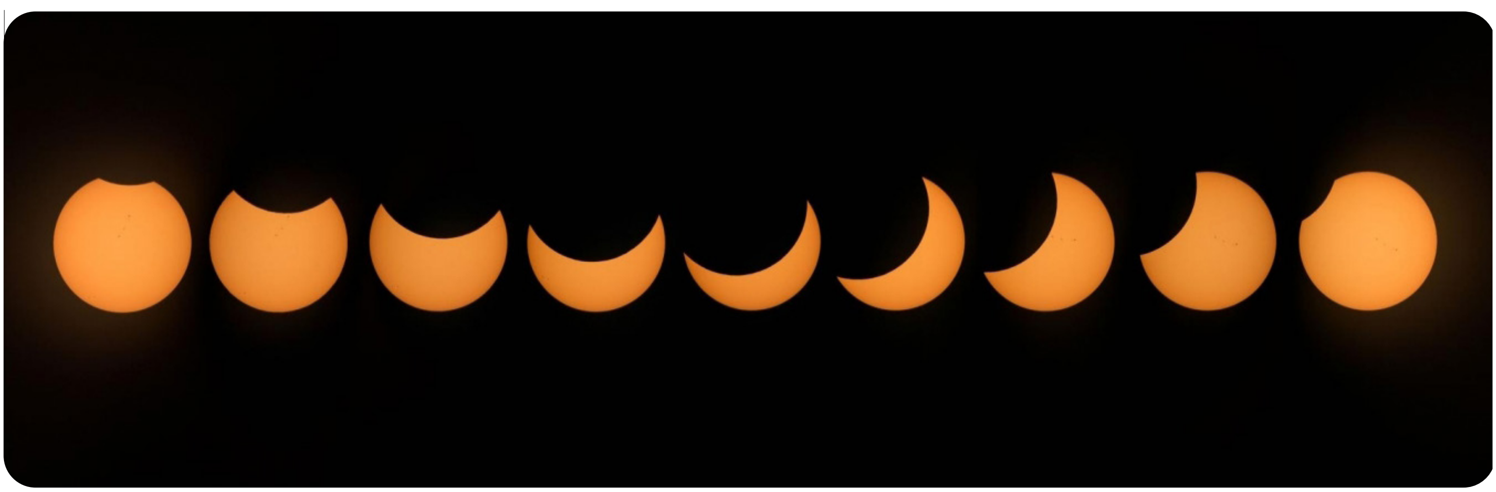
YES!

View the eclipse with special solar viewing glasses.

NO!

Regular sunglasses are not safe to view the eclipse.

Direct Viewing Method: Wear solar viewing glasses. Credit: NASA



If you choose to use solar eclipse glasses with your learners, remind them that they will need to wear the solar eclipse glasses any time they look at the sun. Houston will not experience totality, when the Moon completely blocks the Sun, so it is never safe to look at the Sun without solar eclipse glasses.

Make a Prediction!

Print and cut these predictions slips to encourage your learners to make predictions like NASA scientists do.

Make a prediction by using hole punchers on the - - lines to show the shape of the projection of the Sun through each hole:

The projection of the Sun through the ● will be in the shape of a - -

The projection of the Sun through the ■ will be in the shape of a - -

The projection of the Sun through the ▲ will be in the shape of a - -

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Show what you know!

Print and cut these assessment slips for a quick, easy way to see what your learners discovered.

Show what you know by using hole punchers on the - - lines to show the shape of the projection of the Sun through each hole:

The projection of the Sun through the ● was in the shape of a - -

The projection of the Sun through the ■ was in the shape of a - -

The projection of the Sun through the ▲ was in the shape of a - -

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Math Extension

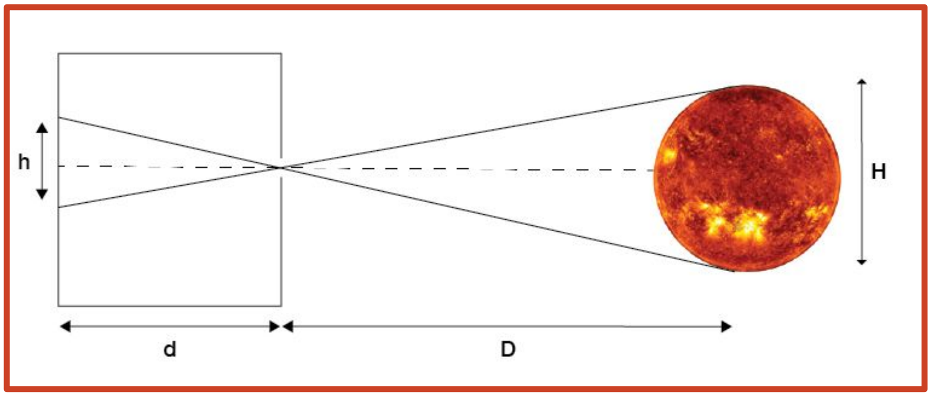
Calculate the diameter of the Sun using measurements taken with a pinhole projector.

Common Core Math Standard 6.RP.A.1 - Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

For a pinhole projector, the relationship between the Sun's height, the Sun's distance from Earth, the projection distance, and projection image height can be expressed as an equivalent ratio:

$$\frac{H}{D} = \frac{h}{d}$$

H = Height of the Sun
D = Distance to the Sun
h = Height of the projected image
d = Projection distance



Relationship between projection image height h, projection distance d, Sun distance D, and Sun height (diameter) H

To calculate height (Diameter) of the Sun (H):

1. **Define (d):** The pinhole projector is held about 1 meter (m) above the ground, which is the projection distance **(d)**.

   (d) = 1m

2. **Define (h):** The hole in your pinhole projector has a diameter of 5 millimeters (mm), creating a projection of the Sun on the ground of about 9mm in diameter, when you hold the pinhole projector 1 meter above the ground. We will use 9mm as the height **(h)** value.

   → To convert millimeters (mm) to meters (m), divide the **(h)** value by 1000.

   (h) = .009m

3. **Define (D):** The average distance from you (on Earth) to the Sun **(D)** is about 150 million kilometers (km), or 1.5×10^{11} meters (m).

   (D) = 1.5×10^{11} m

4. **Calculate (H):** Using the values for **D, h, and d,** calculate the diameter of the Sun **(H)** using the equation above. *Make sure to use scientific notation. For example, to enter 1.5×10^{11} into a computer/smartdevice calculator, type "1.5" [the "EE" button] "11". Or ask your instructor how to use the scientific notation feature on your specific calculator model.

5. **Try it!** Go outside and use your pinhole projector to measure **(d)** and **(h)**. Do you get the same result for **(H)**?

Remember to always keep your back to the Sun when using a pinhole projector. Do NOT look at the Sun through the pinhole!

This product is supported by the NASA Heliophysics Education Activation Team (NASA HEAT), part of NASA's Science Activation portfolio.

Section 2 The eclipse as a cultural and collective experience

Here at Space Center Houston, eclipses are as exciting as holidays and worthy of celebration—especially since they don't happen every year! We love to count down the days and share fun ways to celebrate, like our 2024 Eclipse Playlist on Spotify and the artwork of talented artists expressing how they see the eclipse and what it means to them and to cultures all across the Earth.

Many people will travel from across the country and world to view the eclipse at Space Center Houston and other sites here in Texas. There is always a collective joy that accompanies these celestial movements in the vast dance of our solar system. The eclipse is a truly special moment that we witness both in our local communities and as a global community. Even astronauts living aboard the International Space Station get excited for eclipses—it helps them feel connected to those back on Earth, knowing they are seeing the same awe-inspiring event.

Just as the Sun and Moon have always shaped life on Earth, humans have experienced total solar eclipses for our entire existence. But without understanding the movement of the Earth and Moon around the Sun, how would early humans have felt during an eclipse? Humans across many cultures may have experienced great fear at the unexpected change from daylight to darkness. Or perhaps they experienced a similar sense of wonder as we do today. We know that many early peoples created stories, myths and fables as a way to help them understand the natural world and celestial phenomena.

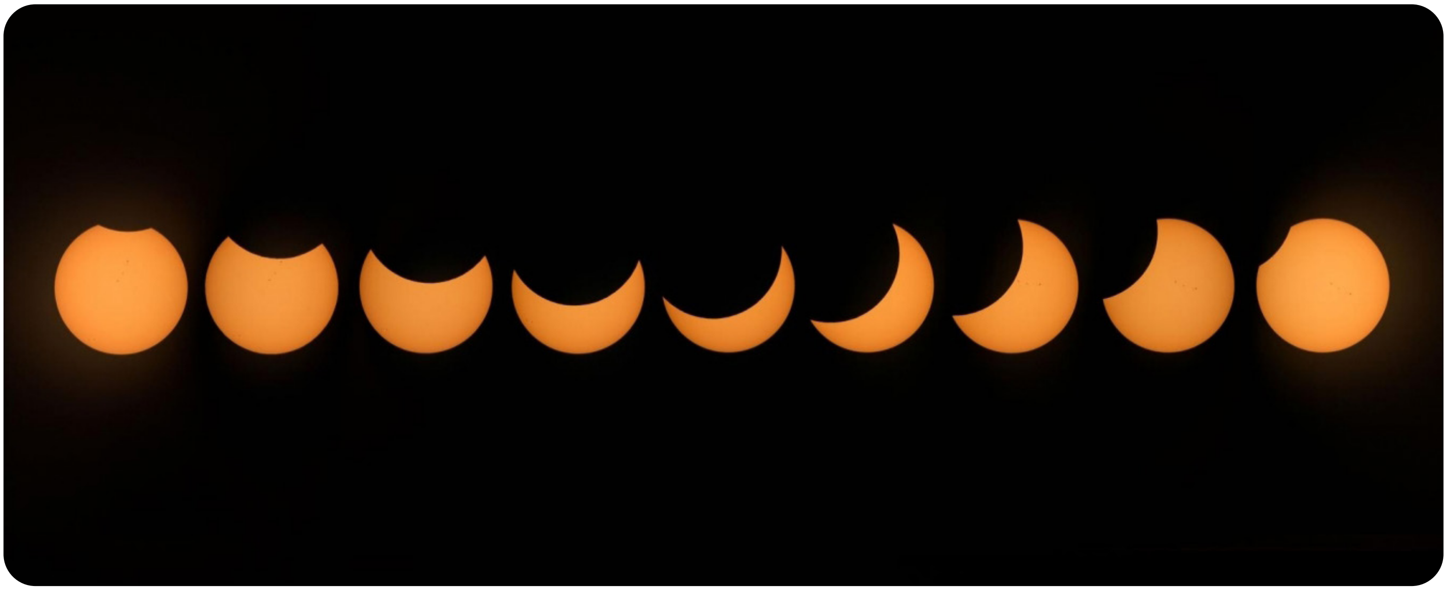
Our human curiosity has always led us to explore our surroundings and try to solve the mysteries of our universe. Some cultures recorded and even predicted eclipses with surprising accuracy thousands of years ago. We have since collected enough knowledge about the Sun-Earth-Moon system that scientists can now precisely predict eclipses years in advance. With our modern understanding of planetary movements and our solar system, we may not experience the same fear that early civilizations did, but our shared reverence for our universe can still help us connect with the mindset of our forebears.

Left: The 2017 total eclipse as seen from the International Space Station. Notice the Moon's umbra, or shadow, on the surface of the Earth.

Activation Ideas:

Section 2 Make an Eclipse Viewing Plan

All Grades



Brainstorm ideas for where to watch the eclipse at your school. Remember the eclipse will start at 12:20pm on Monday, April 8, 2024, and the maximum blockage of 94% will occur at 1:40pm. The eclipse will end at 3:01pm. Where is the sun most visible at those times?

We can't say this enough: Never look directly at the sun! Have a plan for safe viewing: Use special, safe solar viewing glasses, a pinhole projector postcard, or see Build an Eclipse Box viewer (page 16) to safely view the eclipse. Bring a colander from home, or create a pattern of punch holes on an index card to project the sunlight and witness the pattern created. Each one of the holes will act as a pinhole camera and you'll safely see many images of the crescent sun on the ground. This effect also occurs with sunlight filtering through the leaves of trees!

Solar Eclipse Journal

Name: **Date:** **Location:**

What does the Sun look like? These circles represent the Sun. Shade in how much of the Sun is covered by the moon at different times.

Max Cover: %

Start Time: **Max Time:** **End Time:**

What is going on around you? Describe or draw other things you notice at different times during the eclipse. What are birds or other animals doing? What is the weather like (clouds, temperature, wind)?

At Start	Around Max	At End

Share cloud and air temperature data with NASA during the eclipse with the GLOBE Observer app.
Learn More: observer.globe.gov

Safety First: *It is never safe to look directly at the Sun. The only safe way to look at the Sun is through special-purpose solar filters, such as "eclipse glasses" or hand-held solar viewers.*

Section 2 Creative Prompts

All Grades

Grades K-4

Read the book, A Few Beautiful Minutes: Experiencing a Solar Eclipse by Kate Allen Fox.

Have a Solar System Dance Party! Children can represent the Sun, Earth and Moon while rotating around one another. Or include all the planets! Here are some songs to try:

The Sun Song

The Moon Song

The Earth Song

The Solar System

Grades 4-6

Have you ever experienced an eclipse before? Write an essay about what you saw and how you felt then, or what you see and feel during the 2024 eclipse.

Interview a family member about their experience viewing an eclipse. Does your family hold any traditions or observations during the time of eclipse?

Animals set their daily schedule by the day-to-night cycle, just as humans do. How do you think animals would respond to a total eclipse? Write a comic strip imagining a "conversation" among animals whose normal day has been temporarily disrupted.

Grades 7-12

In Mark Twain's novel, A Connecticut Yankee in King Arthur's Court, a man travels back in time with prior knowledge of when a total solar eclipse will occur. He uses this knowledge to his advantage with the people of that time. Write a short story imagining how a community might react to an eclipse 1500 years ago, in Medieval times, or other periods of history.

In the short story "Nightfall," science fiction author Isaac Asimov introduces a planet with six suns where the inhabitants have never experienced night. A scientist discovers that the movement of the suns and a previously unseen moon will result in an eclipse. How do you think you would react if you'd grown up only in sunlight, and someone tried to convince you that total darkness was coming? What kind of evidence would convince you? How would you convince someone else?

Write a short story about an eclipse experience in the voice of the Sun, Moon or Earth.

Compose a song or poem inspired by a solar eclipse.

Any Age

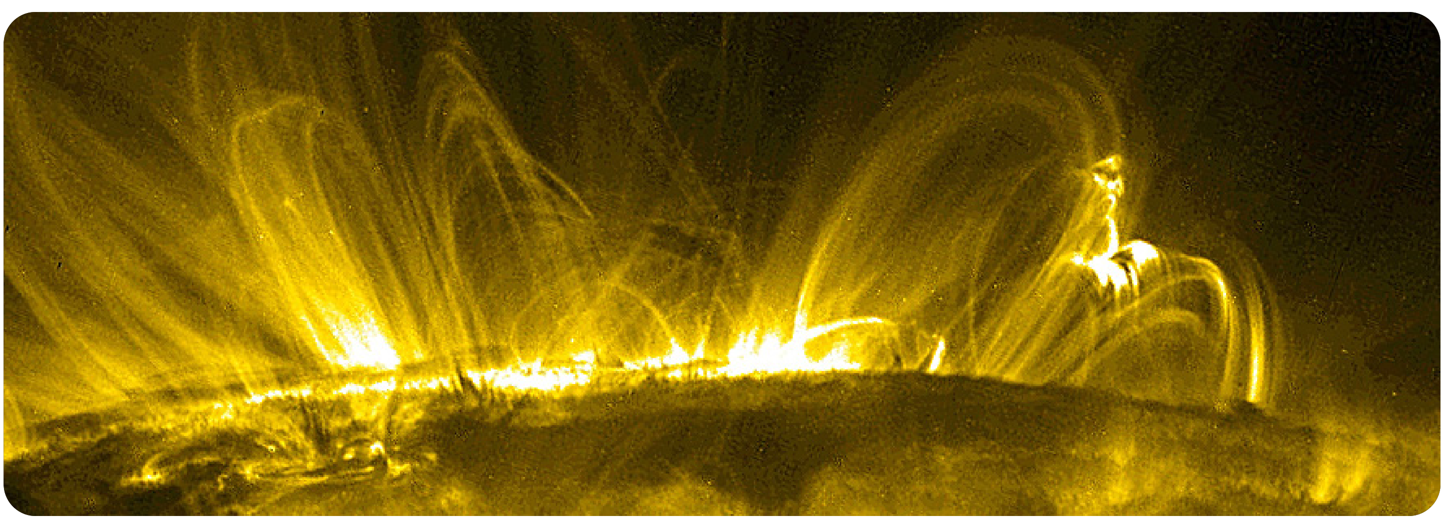
Create your own poster or patch design celebrating the eclipse.

Create an eclipse-themed menu of food and drink for an eclipse viewing party. Share your inspiration for each item on the menu!

Section 3 What can be learned by studying the eclipse?

The light and heat of our Sun is vital to most all life on Earth. But the Sun is always changing, and its changes can influence our planet and others in the Solar System—even space itself! Have you ever heard of solar wind and space weather? Read on and you will!

The time of totality during a solar eclipse is especially valuable for learning about the Sun. This may seem strange, as the Moon is actually blocking sunlight, but just like Earth, the Sun is surrounded by a layer of gases called an atmosphere. When the moon blocks most of the sun, we can better observe the sun's atmosphere, especially the corona—its outermost layer. The Sun's corona is much hotter than the surface of the sun, and scientists want to know why!



Studying the Sun's effects during an eclipse also helps us understand its everyday effects on our planet. For instance, with the moon in between, the Earth's atmosphere receives less of the Sun's energy, or solar radiation. This can change the Earth's upper atmosphere, the ionosphere, which is where radio waves "bend" allowing global travel of communications and navigation signals. Occasionally the Sun's activity can disrupt this technology, which is why scientists study atmospheric changes during an eclipse to better understand how our atmosphere works in general.

Some observations taken during the total solar eclipse will occur aboard very special aircraft based right here in Houston. NASA has two WB-57F high-altitude aircraft that will carry telescopes taking high-resolution and high-speed imagery along the path of totality. By moving with totality, they will get more time to observe the sun's corona, and by flying at 50,000 feet, the images will be less distorted by Earth's atmosphere. The images will be taken mostly in the visible light wavelengths—the light waves that we see with our eyes—and will provide different information about the Sun's corona than space-based telescopes which mostly take pictures in the ultraviolet light wavelengths—which are shorter and can only been seen with specific equipment.

The time during an eclipse is rare and special—not just for all we can experience in our own backyards, but for all we can learn about our solar system, and the clues it provides about other stars in the universe!

NASA's WB-57 at Ellington Field in Houston prepares to document the 2017 Total Solar Eclipse.

Activation Ideas:

Section 3 The Sun's Corona Part 1

1. Observing the Corona Through History

Major Concepts:

- Total solar eclipses have been recorded in different ways throughout human history.
- The Sun has seasons of low and high activity that occur in a regular, predictable cycle.
- The appearance of the Sun's corona for the April 8th eclipse can be predicted based on understanding where we are in the solar cycle.

Activity Overview:

The three parts of this activity can be done in succession or individually:

In Part 1, students examine different historic images of the Sun's corona (suitable for all grades).

In Part 2, students plot recent sunspot data to predict solar cycle conditions for the upcoming eclipse (suitable for all grades).

In Part 3, student combine images of the corona and knowledge of the solar cycle to predict and draw what the corona might look like during the April 8, 2024, total solar eclipse (an art activity adjustable for all grades).

Note: Houston is not in the path of totality, so the corona will not be visible in our location. It will **never** be safe to look directly at the eclipse without special solar eclipse glasses or a pinhole viewer (see page 18). This corona prediction activity doesn't require live viewing, however, and predictions can be compared with photos scientists take from the path of totality.

PREDICT THE SUN'S CORONA 1

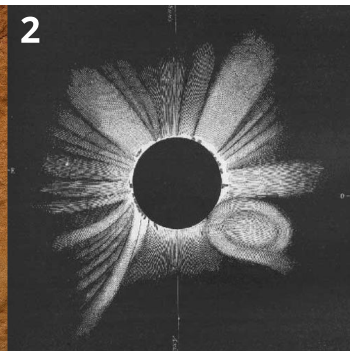
All Grades

Adapted from NASA. Find it online - search: predict sun's corona NASA

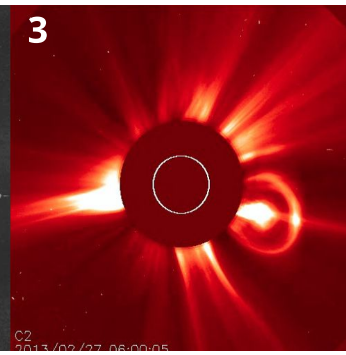
Activity Overview:

Early peoples recorded what they saw in the sky in words, carvings, drawings, and paintings. Examine these four images of the Sun's corona. What are their similarities and differences? Record your observations in the grid below.

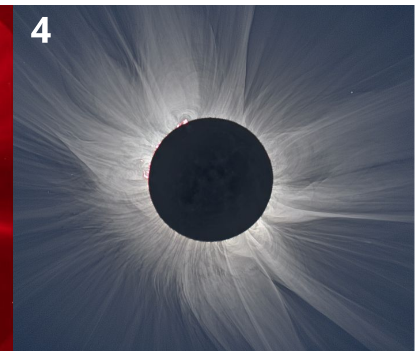
Ancient rock art in Chaco Canyon may depict a total solar eclipse in 1097.
Credit: National Park Service



A drawing depicts the 1860 total solar eclipse. Drawings created by observers in other locations also depict what appears to be a solar eruption, seen as a loop in this drawing.
Credit: G. Tempel



This coronagraph image was taken by the SOHO spacecraft. A coronagraph is a special camera that simulates a solar eclipse, blocking the Sun to reveal the corona.
Credit: NASA/ESA SOHO



This image of a total solar eclipse (2015) was taken with special equipment and includes multiple images on top of one another at different exposures.
Credit: S. Habbal, M. Druckmüller, and P. Aniol

	Image 1	Image 2	Image 3	Image 4
Observations of the Corona				
Similarities				
Differences				

This product is supported by the NASA Heliophysics Education Activation Team (NASA HEAT), part of NASA's Science Activation portfolio. NP-2023-2-012-GSFC (Rev. 1/2024)

Section 3 The Sun's Corona Part 2

Plotting Sunspots Through the Solar Cycle

Major Concepts:

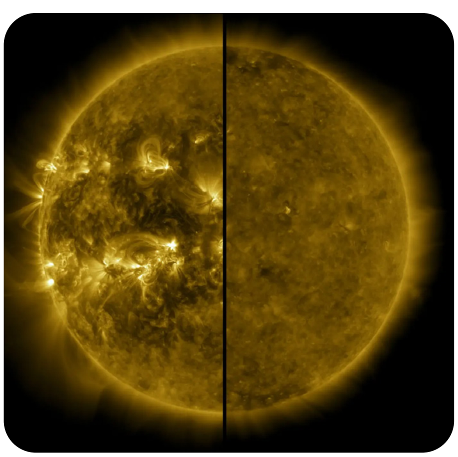
The Sun experiences seasons similar to Earth's own seasonal cycle. There are even times of "stormy weather" and "good weather" on the Sun. In this activity, students will predict where the Sun will be during its cycle of seasons (the solar cycle) by graphing the number of sunspots between 2011 and 2023.

Background:

Approximately every 11 years or so, the Sun's magnetic poles switch, causing magnetic field lines to become tangled, snap, and reconnect in huge releases of energy. This split-image shows the difference between an active, or stormy Sun, (known as a solar maximum) and a quiet Sun (a solar minimum). The Sun at solar maximum has more sunspots, solar flares, coronal loops, and prominences, resulting from a chaotic magnetic environment. The Sun at solar minimum has fewer sunspots and features, the result of a stable, symmetric magnetic environment.

Teacher Instructions

1. Plot the sunspot data from the table on the graph.
2. Identify the year in this data set that shows a solar minimum, which is when the cycle restarts.
3. Identify the year in this data set that shows a solar maximum, which is the middle of the cycle.
4. Solar Cycle 24 was exactly 11 years. Based on this data set, when did this cycle begin?
5. Solar Cycle 25 is predicted to be similar to 24. When do you predict the solar maximum will occur during cycle 25?



A split image showing the difference between solar maximum and solar minimum.
Credits: NASA/SDO

	Year	Number of Sunspots
Solar Cycle 24	2011	93
	2012	98
	2013	108
	2014	116
	2015	89
	2016	55
	2017	28
	2018	14
Solar Cycle 25	2019	5
	2020	15
	2021	56
	2022	101
	2023	120

Credit: NOAA

PREDICT THE SUN'S CORONA 2

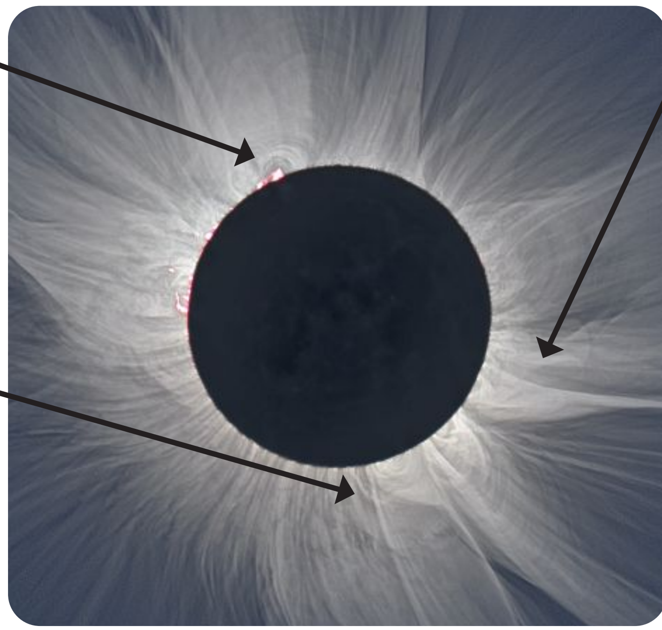
Grades 6-12

Adapted from NASA. Find it online - search: predict sun's corona NASA

Notice how the corona looks different depending on where the Sun is in the solar cycle. During solar maximum, the Sun is active because the magnetic field is unstable, which increases the velocity and density of the solar wind. This can be observed in the features of the corona during a total solar eclipse. Match the images on page 36 to the Solar Cycle Sunspot Progression graph below.

Prominences
Bright strands of cooler, denser solar material suspended above the Sun's surface by magnetic fields.

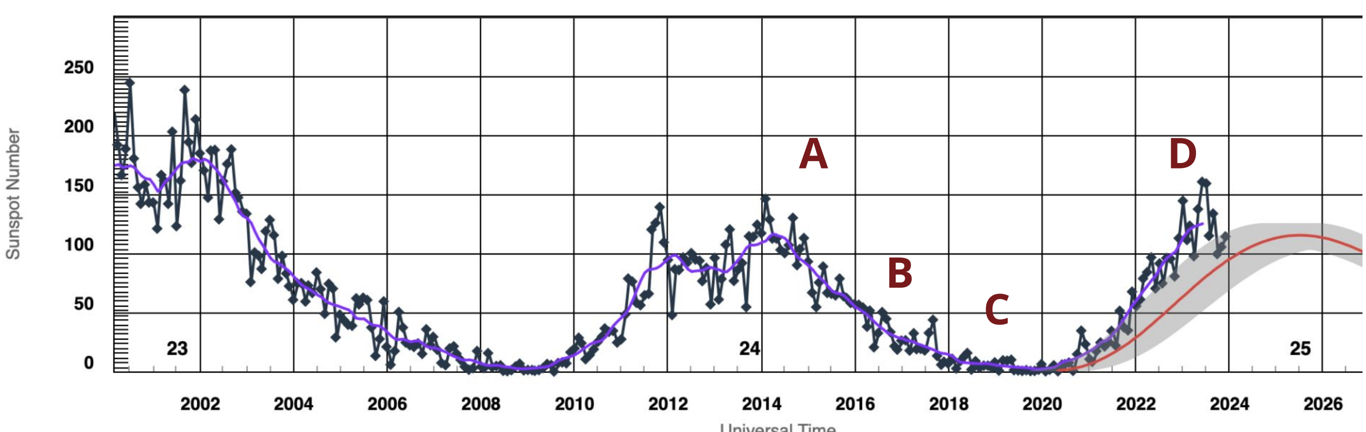
Coronal Loops
Found near sunspots, these loops of solar material connect magnetic regions on the solar surface.



Helmet Streamers
Large, cap-like structures with long, pointed peaks that usually occur over sunspots and active regions.

Total Solar Eclipse over Chile
March 20, 2015
Credit: S. Habbal, M. Druckmüller, and P. Anio

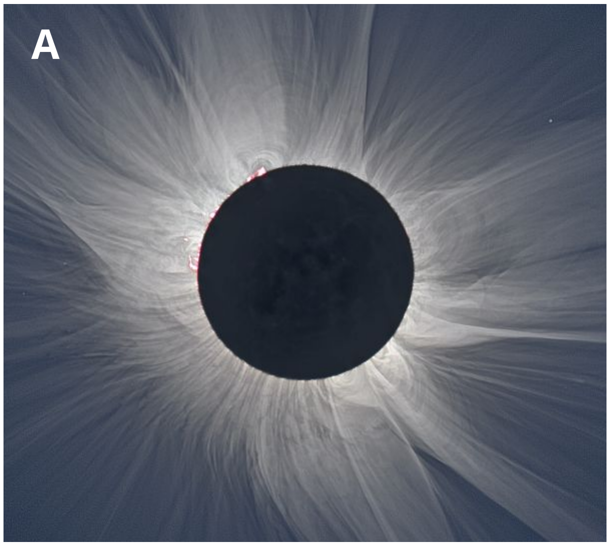
Solar Cycle Sunspot Progression



Credit: NOAA

The solar cycle is approximately 11 years, cycling through lower activity and higher activity as indicated by the number of sunspots. Using this graph, determine where the Sun is currently in the solar cycle (at solar maximum, at solar minimum, or approaching either). Label the coronal features you see in each image.

Section 3 The Sun’s Corona Part 2

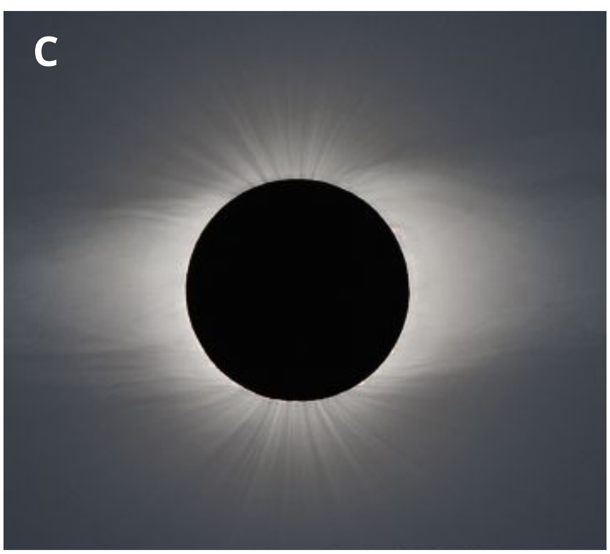


Total Solar Eclipse over Chile
March 20, 2015
Credit: S. Habbal, M. Druckmüller, and P. Aniol

A

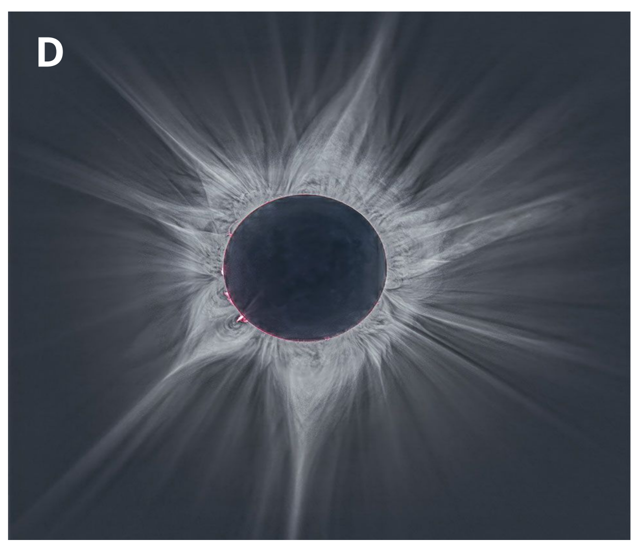
Total Solar Eclipse over USA
August 17, 2017
Credit: Nicholas Lefaudeux

B



Total Solar Eclipse over Argentina
July 2, 2019
Credit: Williams College Expedition Team

C



Total Solar Eclipse over Australia
April 20, 2023
Credit: Reinhold Wittich

D

Section 3 The Sun's Corona Part 3

3. Predict the Corona for April 8, 2024

Activity Overview:

Having examined different images of the Sun's corona and plotted sunspot data to predict the solar cycle, students will combine this knowledge to draw their own prediction of what the corona will look like during the April 8, 2024, total solar eclipse.

Provided Materials:

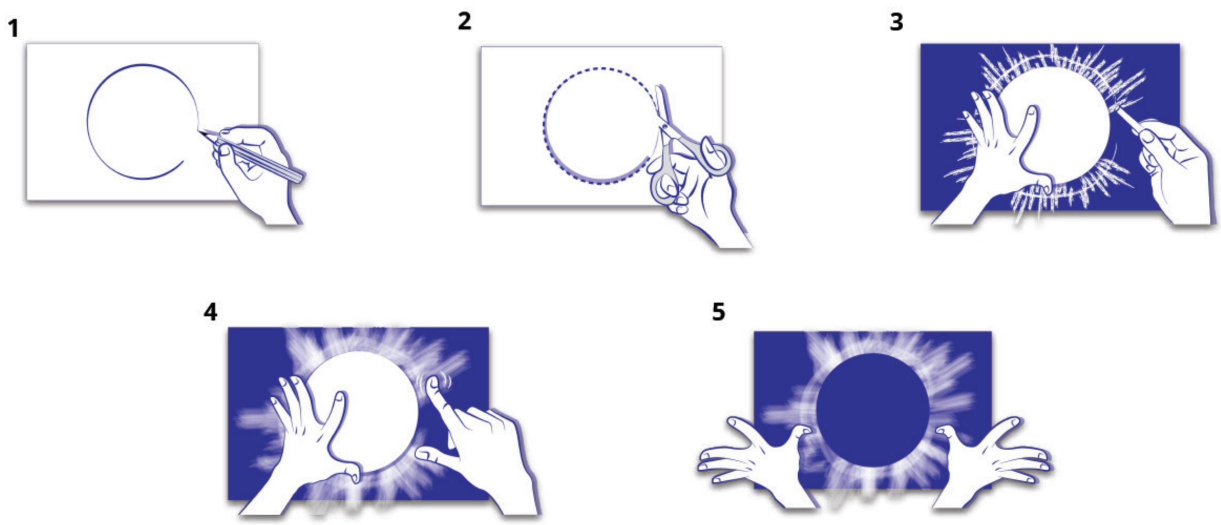
- White chalk
- Small plastic cups (also used for Sun-Earth-Moon Orbit Model activity)

Needed Materials:

- Cardstock paper
- Black or dark blue construction Paper
- Scissors
- Tape (optional)

Teacher Instructions

1. Using a bowl or a cup, trace a large circle approximately 3 inches in diameter on cardstock paper.
2. Carefully cut out the circle.
3. Place the circle template on construction paper and hold it down (or tape it). Outline the circle with thick lines of chalk – it doesn't need to be neat.
4. With the template still in place, smudge the chalk away from the circle, outward in all directions to represent the corona of the Sun and its features: loops, prominences and helmet streamers.
5. Once done with smudging, remove the circle. You've made total solar eclipse art just like observers of the past!



Section 3 Understanding The Sun and the Electromagnetic Spectrum

Major Concepts:

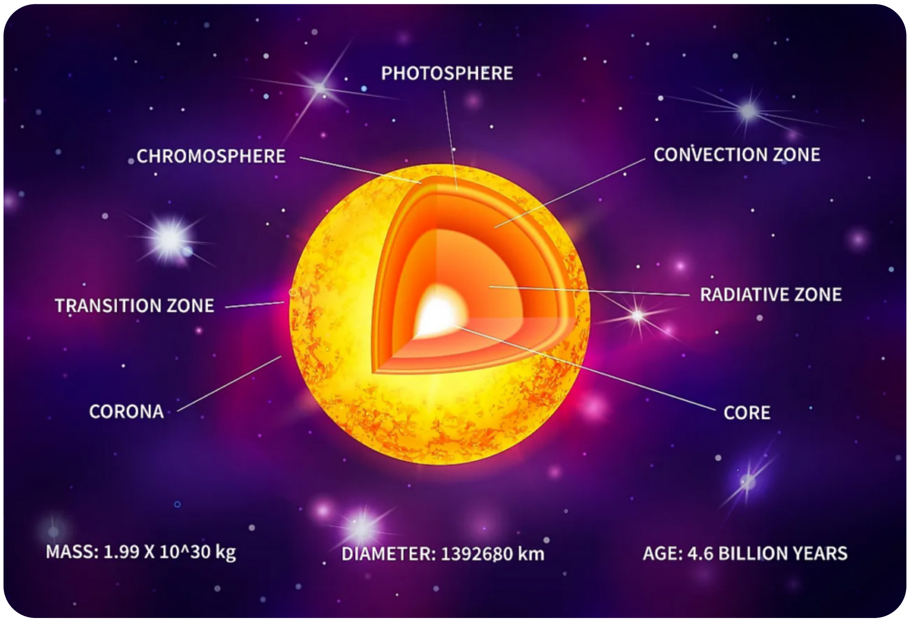
- The Sun produces light in all wavelengths, including invisible ultraviolet waves (UV).
- Scientists use specialized equipment to study the Sun to better understand its changing surface and atmosphere.
- Understanding the Sun and how it affects Earth is important to our health and well-being.
- The Earth's atmosphere provides significant, but not complete, protection from UV.
- UV can be dangerous—it can burn our skin, damage our eyes and destroy our cells.
- There are different ways to detect UV and also to protect ourselves from it.
- This is why you need special glasses or a pinhole projector when viewing the eclipse.

Activity Overview:

In Part 1, students will create a picture of the sun (or use NASA's collection of solar images) and examine it with colored filters to simulate specialized telescopes that scientists use to view different features of the sun. In Part 2, Students will use special beads as a tool for ultraviolet (UV) light detection. They will place the beads under different conditions to learn where UV radiation occurs, and what can steps can be taken to reduce UV exposure.

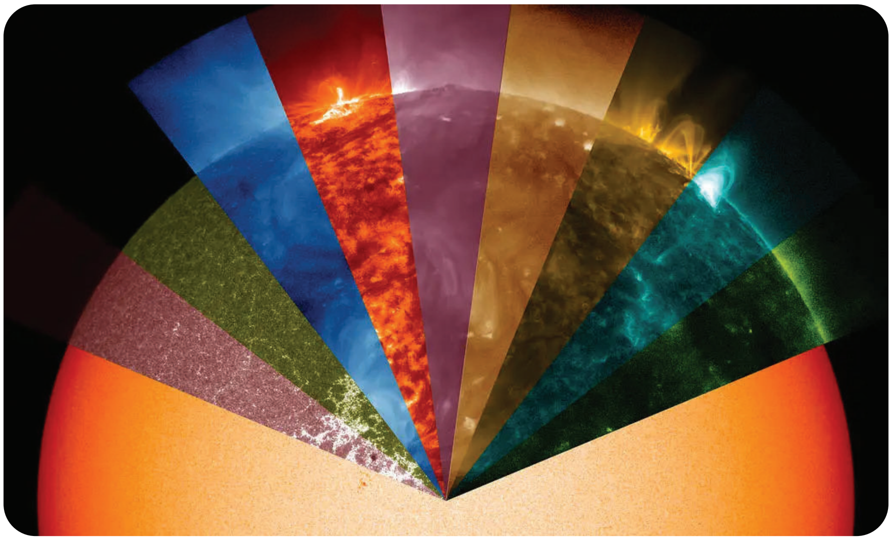
Background:

The Sun is a 4.6 billion-year-old star that is made up of different layers, each emitting a different color of light. The layer of the sun we can see is called the photosphere. Layers above the photosphere generate heat and light (also known as radiation) at a shorter wavelength than what the human eye can detect. This light is called ultraviolet light, or UV radiation. Scientists use special instruments to image the sun at these wavelengths that our eyes cannot see.



Why do we study the Sun? What can we learn?

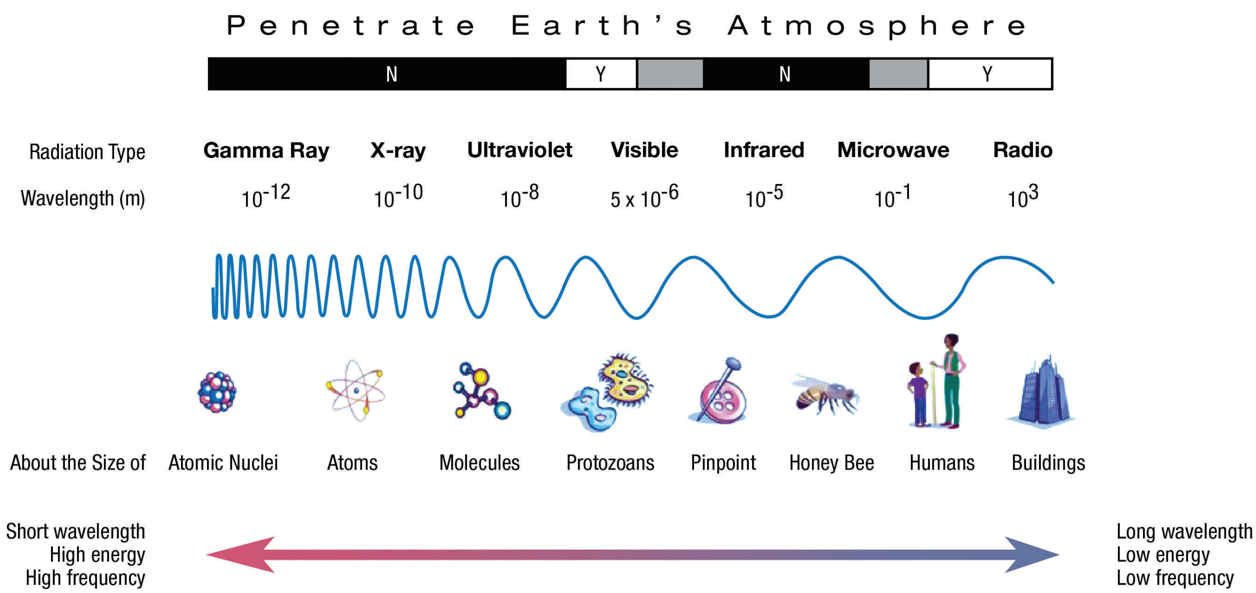
While sunlight fundamentally enables and sustains life on our planet, the Sun also produces radiation and magnetic energy that can disrupt the Earth's atmosphere, our satellites, and our way of life. NASA's Heliophysics Division studies the Sun to better understand its changes and how these changes affect space and the planets in our Solar System.



How do scientists observe and image the Sun?

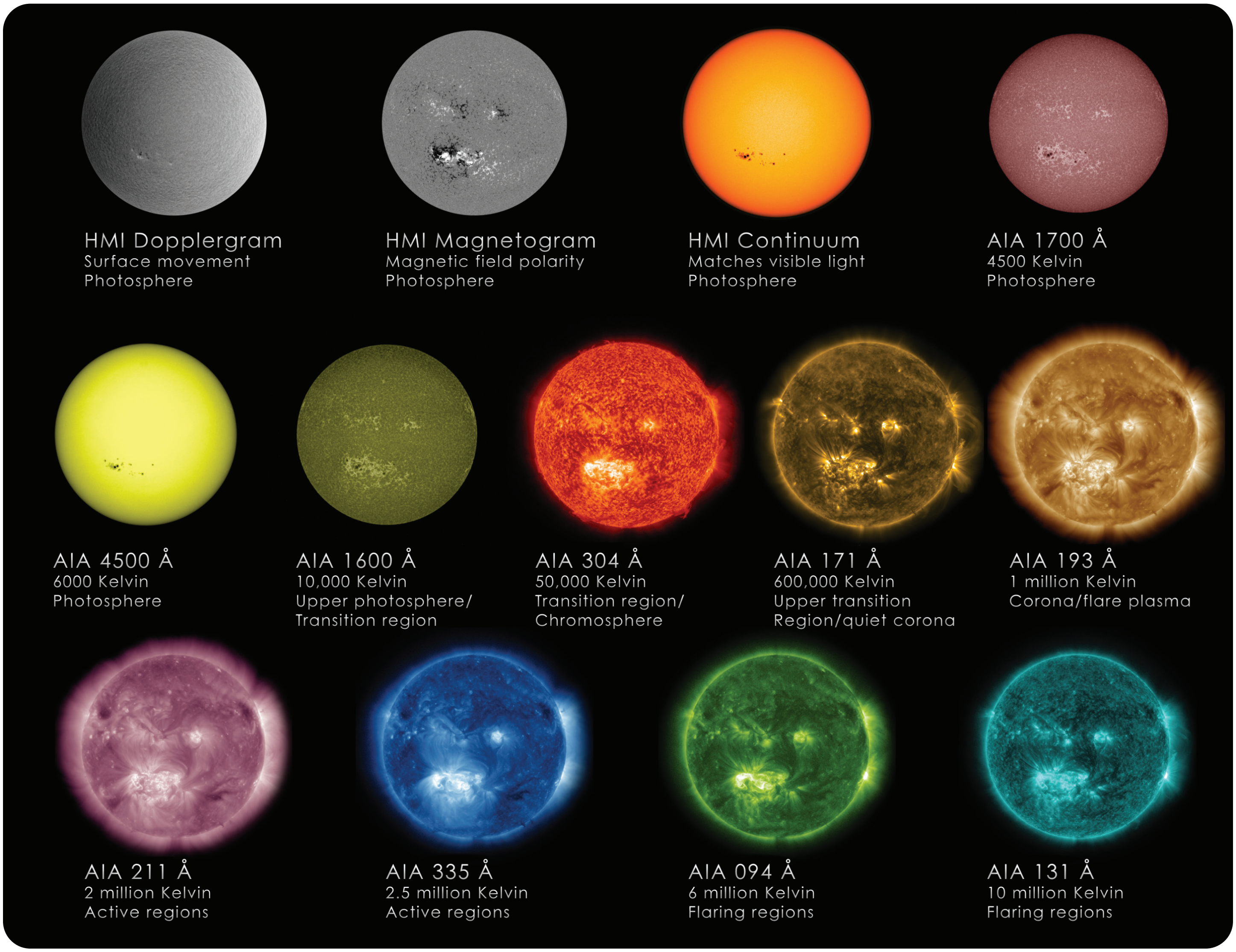
Special telescopes at NASA observe sunlight beyond the wavelengths of visible light that our eyes can detect. Different wavelengths reveal different parts of the sun and correspond to different temperatures. Visible light with a yellowish filter is effective for looking at the photosphere, or the surface of the sun, where temperatures are about 10,000 degrees Fahrenheit. The chromosphere can be seen in UV light, which is typically colorized as red. Very hot regions of the corona—up to 11 million degrees Fahrenheit—are visible in extreme UV light and are colorized to look green. This wavelength is also ideal for looking at solar flares.

THE ELECTROMAGNETIC SPECTRUM



Section 3

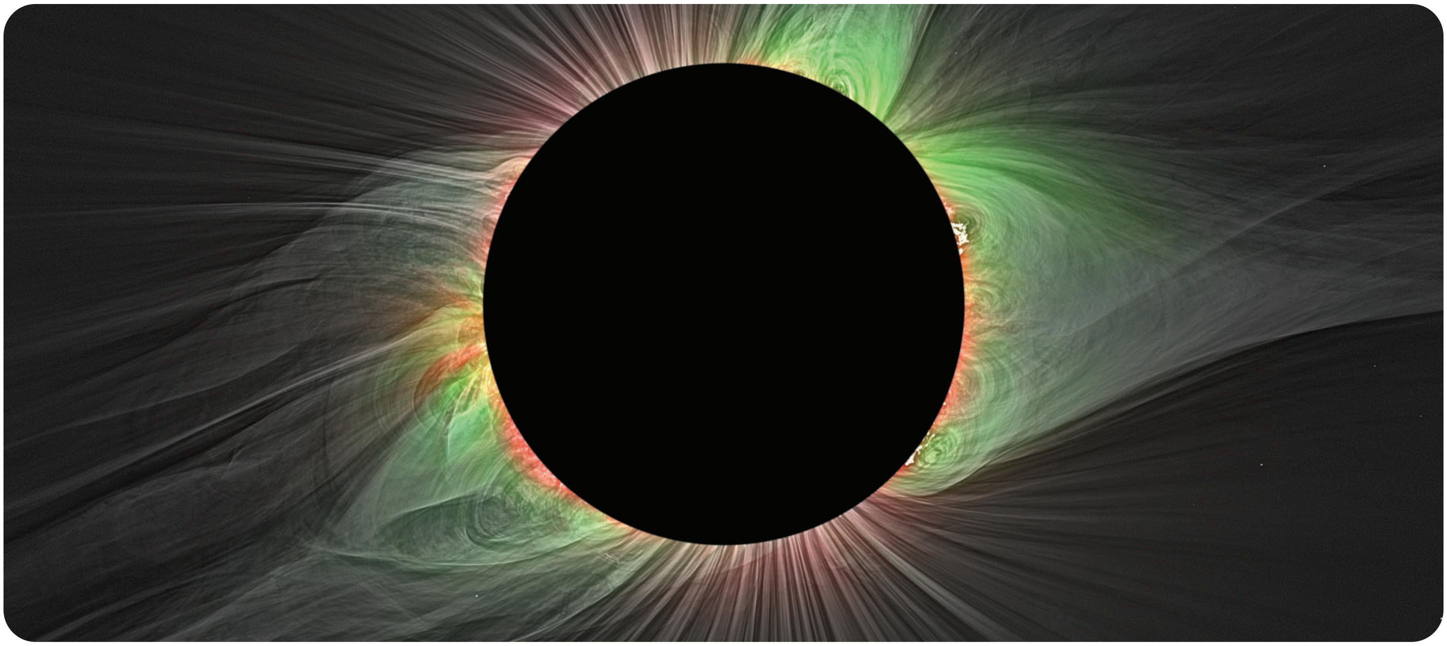
Understanding The Sun and the Electromagnetic Spectrum



NASA's Solar Dynamics Observatory observes the Sun at different wavelengths to study different features of the Sun's surface or atmosphere

Although ultraviolet (UV) radiation is invisible to the human eye, most people are aware of the effects of UV on the skin. In small doses, it can benefit human health: aiding the body's creation of Vitamin D and healing certain skin conditions. Too much exposure, however, results in suntans or sunburns, which can damage the skin and cause cancer. While the Earth's atmosphere—primarily the ozone layer—helps filter harmful UV rays to make life on Earth possible, some damaging rays still make it to Earth's surface, resulting in the need to detect and study ultraviolet light.

Why is it important to view and image the Sun during a total eclipse?
The Sun is completely hidden during a total solar eclipse, revealing the full glory of the solar corona, the Sun's outer atmosphere. During a total solar eclipse, the corona can be seen streaming into space from the Sun's surface. Normally, the corona's light is not visible because it is outshone by the bright photosphere. NASA uses Earth-based instruments and satellites in space to study eclipses as they occur. Astronomers can also create artificial solar eclipses with a special kind of telescope, called a coronagraph, which uses a disk to block the sun's bright surface, revealing the faint solar corona.



Expand your thinking:
Radiation from our Sun peaks in the visible light range, thus our human eyes have evolved to see visible light. But other species, like bees, can see ultraviolet light as well. Beings on planets with a Sun that peaks in different ranges would likely have different eyes than ours. How do you think a being's eyes would evolve on other planets with a different Sun? How would they see their world?

Teacher Resources:

Organize students into groups and view the video: NASA - Jewel Box Sun. Have students discuss with their groups what they noticed and share any interesting observations between the different colors and visible features of the Sun. Note how the same area of the Sun can look different depending on the light filter used.

Section 3 Understanding the Sun, Part 1

Major Concepts:

- The Sun is a 4.6 billion-year-old star that continually produces large amounts of radiation and releases magnetic energy into space, which affects the planets of our Solar System in different ways.
- Scientists use specialized equipment to study the Sun in order to better understand how its changing surface and atmosphere impact the Earth and our technologies.
- Telescopes capable of detecting wavelengths outside our visible spectrum help researchers understand the Sun and its lifecycle.
- A total solar eclipse is a unique time when scientists can observe the Sun's corona, the outermost layer of the Sun which is normally not visible due to the bright inner photosphere.

Activity Overview:

In this activity, students will create a picture of the sun (or use NASA's collection of solar images) and examine it with colored filters to simulate specialized instruments that scientists use to view different features of the sun.

Needed Materials:

- Cellophane sheets (4 colors)
- Rubber bands
- White paper (butcher paper or card stock)
- Colors (crayons, colored pencils or markers)
- Paper towel tubes
- Black pen or marker
- Images of the sun (images may be found online at: https://sdo.gsfc.nasa.gov/data/)

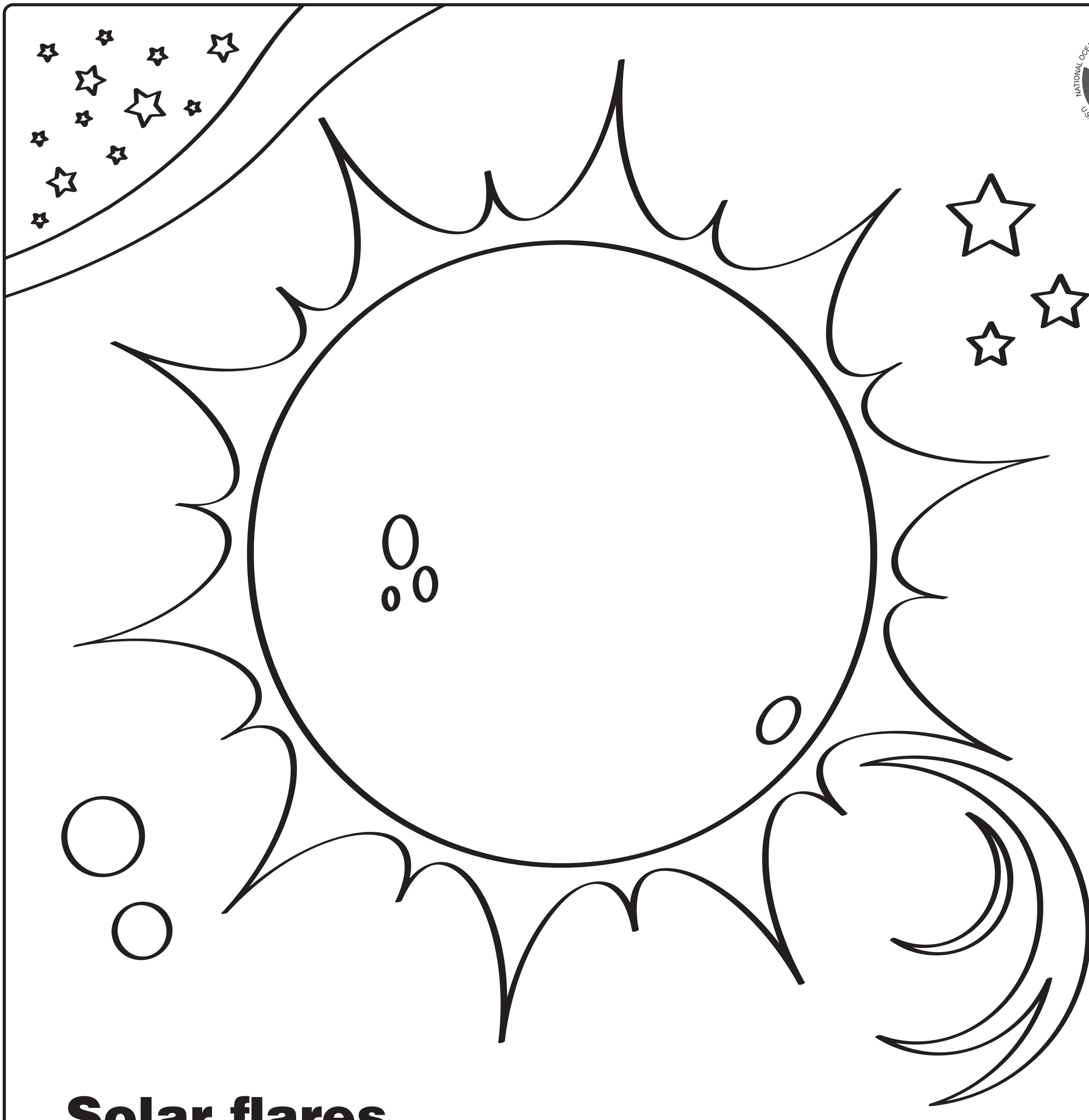
SOLAR IMAGES

All Grades

Adapted from NASA eClips. Find it online - search: Solar Images NASA eClips interactive

Teacher Instructions

1. Explain that special NASA telescopes like the Solar Dynamics Observatory (SDO) can detect the different wavelengths of light coming from the Sun that our eyes cannot see. SDO and other similar instruments change these wavelengths into a colorized picture that humans can interpret. Each color represents a specific wavelength, which represents a distinct temperature and tells scientists more information about the Sun.
2. Instruct students to create their own drawing of the Sun using three different colors (i.e. yellow, red, and orange). These can be crayons, markers, colored pencils or paints. Encourage them to mix shades and include features like solar flares, CMEs and sunspots. For definitions and descriptions of these terms, see the included glossary. Note: If desired, make copies of the provided NASA Sun coloring pages (page 40-41) for grades K-3.
3. Hand out the following materials to each group: (4) paper towel tubes, (4) pieces of cellophane including red, green, blue and purple, and (4) rubber bands. Note: if paper towel tubes are limited, have (1) tube per group with them exchanging the piece of cellophane between viewings. If no paper tubes are present, simply have students hold sheets up to images before observing.
4. Demonstrate to students how to carefully cover one end of each paper towel tube with a piece of colored cellophane, securing the sheet with a rubber band.
5. Guide students to look at their solar pictures through each of the 4 'telescopes'. Remind students that they should hold the tube so that the colored cellophane is away from their eye.
6. Ask students to record what they observe with and without the telescope filters. Did the images look the same or different? Did the visibility of images change between telescopes? Encourage them to write down notes and discuss what they saw.
7. Repeat this observation process (steps 4-5) using real images of the Sun posted by NASA's SDO telescope.
8. It is important to always remind students to **never** look directly at the Sun.



Solar flares

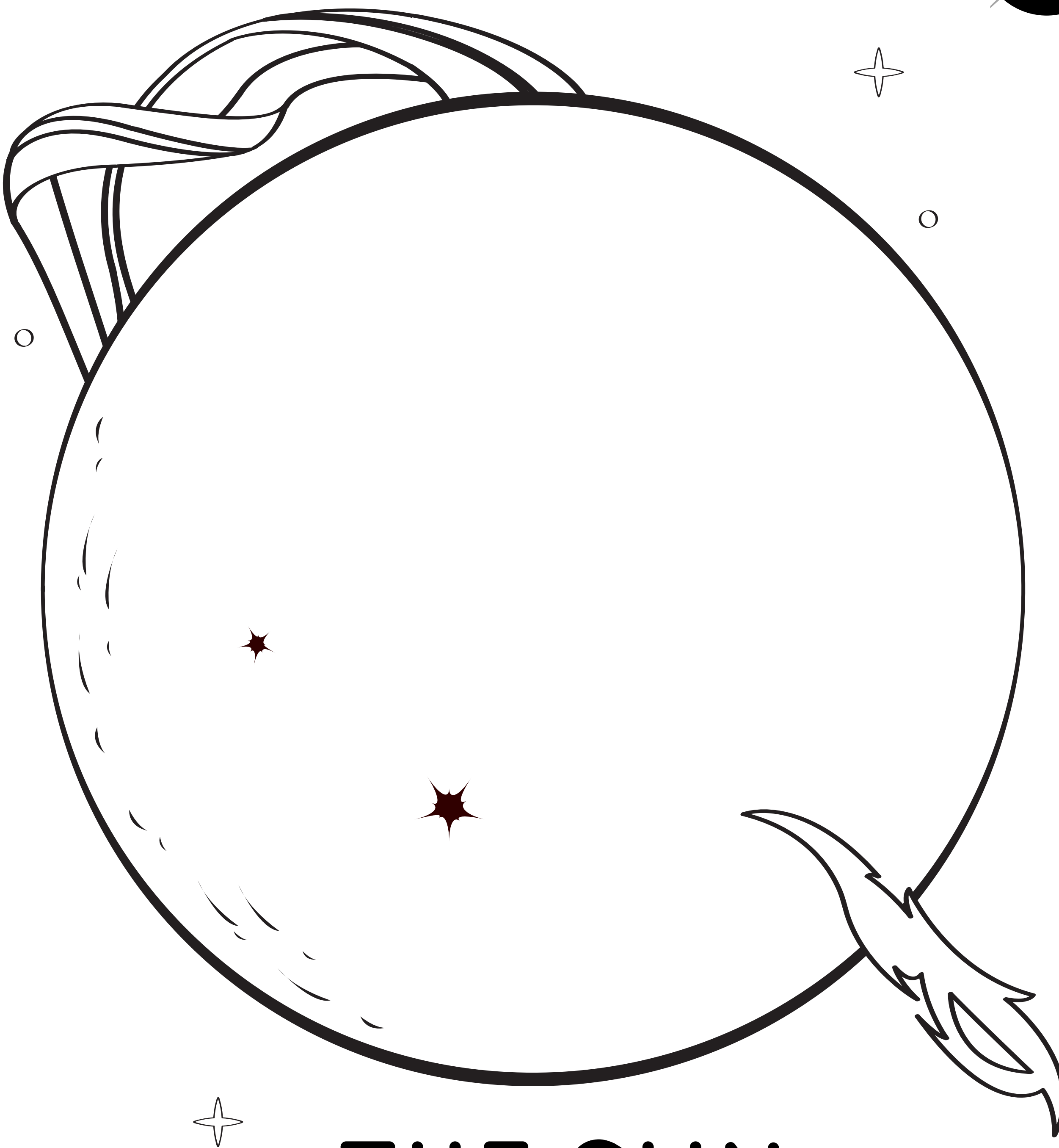
• The Sun is a burning ball of immensely hot gas. It's always releasing energy, but sometimes it lets off large bursts of energy and particles called solar flares. Occasionally, it has even bigger bursts of energy and particles called coronal mass ejections!

• These bursts of particles can damage satellites, power lines and radio communications here on Earth.

• Satellites, such as the GOES-R Series weather satellites, monitor solar flares from space. These satellites can help power companies and satellite operators have enough time to adapt to any troubling space weather headed our way.

Learn more about the GOES-R Series weather satellites here: https://scijinks.gov/goes-r

National Aeronautics and Space Administration



THE SUN

- It is a 4.5-billion-year-old star at the center of our solar system.
- It makes life on Earth possible.
- It is a hot glowing ball of hydrogen and helium.
- Color: The Sun is all of the colors of the rainbow at once, so it looks white.

For more information about the Sun visit: spaceplace.nasa.gov

Section 3 Understanding the Sun, Part 2

Provided Materials:

- Pipe cleaner (1 per student)
- UV beads (5 per student)
- Data Sheet (1 per student)

Needed Materials:

- Pen or pencil
- Items from home or classroom: bowl of water, sunglasses, colored bottles, sunscreen, etc.
- Optional: black light or flashlight

Teacher Instructions (Due to supply shortages, only 30 beads were included per box. Students may work in small groups or receive one bead each to make observations.)

1. Discuss how the Sun emits energy across a broad spectrum, some which we can see (visible light) and some we cannot (ultraviolet light - UV).
2. Discuss why it is helpful to have ways to detect ultraviolet light.
3. Explain that the beads contain a special chemical that changes color when exposed to UV light. Students will use them as their tool for UV light detection. The beads will stay white or clear when inside and not directly exposed to UV. (Typical indoor lights will not affect them.) They will turn bright colors when exposed to UV, usually from the Sun or a UV ("black") light. The darker the color of the beads, the more UV rays they are detecting. Once brought back indoors, they will slowly change to white again. This process can be repeated many times.
4. Have each student string five beads onto a pipe cleaner and twist the ends together, making a bracelet.
5. Working together, in pairs or individually, have students make predictions on their data sheets about what will happen to the UV beads in indoor and outdoor conditions.
6. Have students begin experimenting with their UV beads under indoor conditions. Ensure they record their observations before proceeding with the outdoor portion.
7. Set up a small table outdoors with the materials to "protect" the beads (bowl of water, sunglasses, etc).
8. Have students expose their beads to different outdoor conditions and record their observations on the data sheet.

DETECT UV RAYS WITH UV BEADS

All Grades

Adapted from Stanford Solar Center. Find it online - search: UV reactive bead investigation

	Your Prediction (white, faint or bright colored)	Actual Color (white, faint or bright colored)	Are the beads protected from UV rays?	Notes
Indoors				
Lights off				
Lights on				
Near window				
Outdoors/black light				
In sunlight				
In shadow				
Using sunscreen				
Cloudy sky (no direct sunlight)				
Behind paper				
Behind sun glasses				
Behind eye glasses				
Under cloth				
Inside plastic orange				
Medication bottle				
Behind window glass				
Behind car windshield				
Under brim of cap				
Behind plastic				
Sun at mid-day				
Sunset/sunrise				

Section 3 Modeling Magnetic Fields

Major Concepts:

- Both Earth and the Sun have magnetic fields.
- A magnetosphere is the region around a planet dominated by the planet's magnetic field.
- Earth's magnetosphere protects Earth from solar wind and other harmful effects of the Sun.
- The Sun's magnetic field is constantly interacting with Earth's magnetic field. Space weather describes the variations in the space environment between the Sun and Earth. In particular, it describes phenomena that impact systems and technologies in orbit (like satellites) and on Earth.
- When solar wind intensifies, geomagnetic storms can occur, which are disturbances in Earth's magnetic field.
- The energy and particles generated by solar storms can interact with gases in the Earth's atmosphere, creating auroras.

Activity Overview:

In this activity, students will explore the properties of magnetism by using a compass to draw the magnetic field lines of a bar magnet. Students will learn about the magnetic fields of Earth and the Sun, how the magnetic fields of the Sun produce space weather, and the impact space weather has on the Earth—including the creation of auroras. Students will observe the shape of Earth's magnetic field, which is the same shape as a bar magnet, and can view an animation of a coronal mass ejection (CME) from the Sun hitting Earth's magnetosphere.

Provided Materials:

- Bar magnet
- Compass
- Modeling Magnetic Fields Handout

Needed Materials:

- Blank paper and a pen or pencil
- Copies of handout

Background:

What is a magnetic field and how does a compass work?

Earth acts like a gigantic bar magnet, with its own magnetic North and South poles. Just like all magnets, it produces a magnetic field. Earth's magnetic field is generated from the slow movement of molten iron in its core and the resulting flow of electrical current. The magnetic field on our planet is strongest at the poles and weakest at the equator. Magnetic field lines are usually curved and always run from magnetic north to south. It is important to note though, that the Earth's magnetic North and North pole are not synonymous! This means that lines emerge from the Earth's South pole (magnetic North) and re-enter at the North pole (magnetic South).

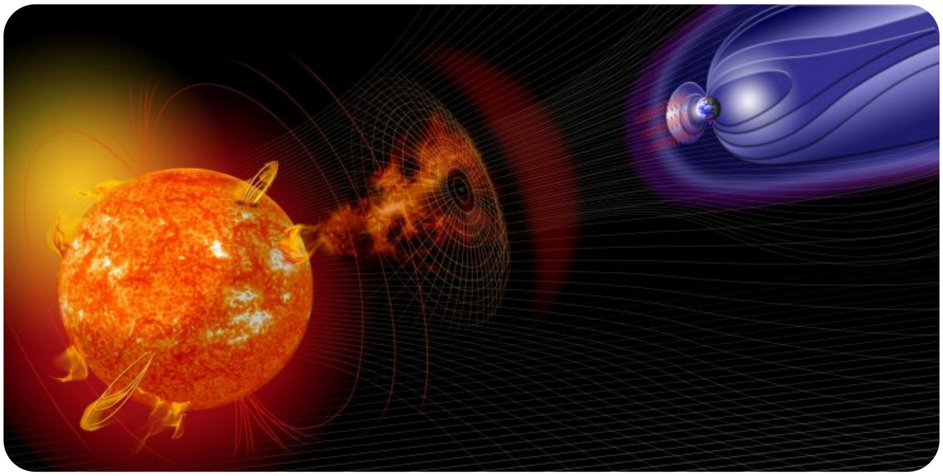
The small, metal needle in a compass aligns itself with the Earth's magnetic field to always point north. Magnetism is a noncontact force, meaning that magnets can affect materials without touching them. A magnet creates a magnetic field, or a region of influence in the space around the magnet. Bigger magnets have larger magnetic fields than smaller magnets.

MODELING MAGNETIC FIELDS

Grades 3-8

Adapted from NASA. Find it online - search: modeling magnetic fields NASA helio club

What happens when you put a compass near a magnet?
When you place a compass near a magnet, the small metal compass needle aligns with the magnetic field of that magnet. Even though Earth's magnetic field is gigantic, a nearby magnet has a stronger influence on a compass needle because the magnet is closer to the compass.



What is space weather?
The Sun is made of hot, electrically-charged plasma, which creates enormous, chaotic magnetic fields. These magnetic fields become twisted and tangled as the Sun rotates, creating enormous amounts of energy called solar wind. Solar wind causes space weather, or storms throughout the heliosphere, similar to wind storms that happen in Earth's atmosphere. While solar wind constantly flows from the Sun, sometimes it intensifies with increased activity on the Sun's surface. This activity includes solar flares, eruptions of light and particles triggered by the release of magnetic energy, and coronal mass ejections (CMEs), or large clouds of solar plasma released into space after a solar eruption. Unlike the Earth, the Sun's magnetic poles switch places frequently, about every 11 years, creating a new solar cycle.

What is an aurora?
Solar wind can travel into space and through our Solar System as high-energy particles. When these particles collide with the Earth's atmosphere, most are deflected back into space but some get trapped within Earth's magnetic field. The trapped particles follow the magnetic field currents and interact with different gases that make up our atmosphere. This process causes a transfer of energy, exciting the gases and causing them to emit different colors of light, which we call an aurora. Oxygen usually displays green and red light, while nitrogen looks blue and purple. Because of the shape of the Earth's magnetic field, auroras form at the North and South Poles, where the field is strongest. We call these the aurora borealis (northern lights) and aurora australis (southern lights). During a solar eclipse and in a peak solar cycle, auroras can sometimes be visible during totality, while the eclipse event itself has been shown to change the normal activity of the northern and southern lights. Auroras are not unique to Earth—they can happen on any planet that has an atmosphere and a magnetic field. Saturn, for example, has auroras that look red.

Section 3 Modeling Magnetic Fields

Teacher Instructions

1. Divide students into groups and distribute the materials. Each group should receive one bar magnet, one compass and handouts of the modeling magnetic fields (one per student).
2. Go over the lesson, introducing terms like magnetic fields, magnetic lines, solar winds and space weather.
3. Have students experiment with the compass and learn about how it functions. Encourage them to move it around, change its orientation, and share their observations.
4. Have students predict what will happen when they put their compass at various locations near the magnet. Have them record their answers and then test out their hypotheses. Allow time for them to share their observations with their group and class.
5. Continue with "Modeling Magnetic Fields" handout and have them examine what magnetic fields look like using their bar magnet and compass. If you have a gyrocompass, you must orient the magnet to magnetic North first. Remind students that their drawing is a 2-D representation of the magnetic field around a magnet, but that the field lines go all the way around the Earth in three-dimensional space.

Lesson Extension

1. You can find a demonstration video of this lesson here.
2. Have students watch this video before the lesson and again afterwards. Instruct learners to notice the shapes of the magnetic fields on the Sun during solar flares and CMEs.
3. Have students explore with other types and shapes of magnets around the classroom or from home. Do compasses work the same for all magnet sizes and types? What do their magnetic fields look like?
4. Have students discuss whether auroras can happen on other planets. Introduce the NASA YouTube video, Hubble Tracks Bright Auroras on Jupiter. Have students pick (or assign) a planet to investigate what kind of aurora is possible and create an artistic representation of that planet's aurora. Alternatively, present images of other planet's auroras and ask students to hypothesize what gases might make up their atmosphere or what colors they might expect based on known gases.

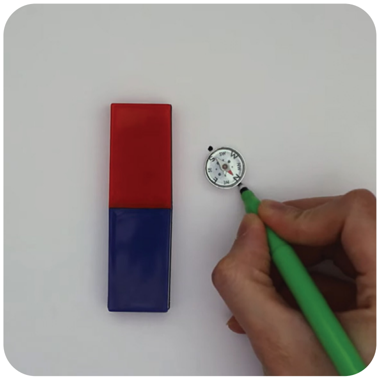
MODELING MAGNETIC FIELDS

Grades 3-8

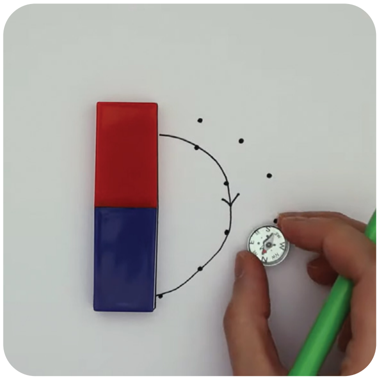
Adapted from NASA. Find it online - search: modeling magnetic fields NASA helio club

Modeling Magnetic Fields Handout

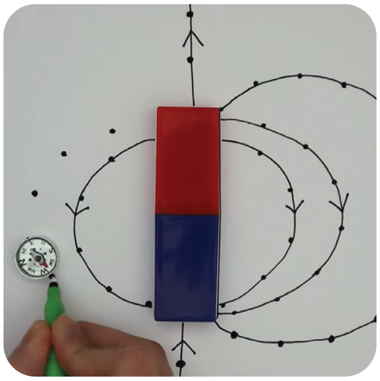
1. Trace one of the bar magnets on a piece of paper.
2. Start by placing the compass next to the magnet, near one of the magnet's poles.
3. On the paper, mark where the needle is pointing with a dot.
4. Move the compass so that the back of the needle lines up with the dot. Repeat step 3, every time marking where the needle points with a dot.



Step 4



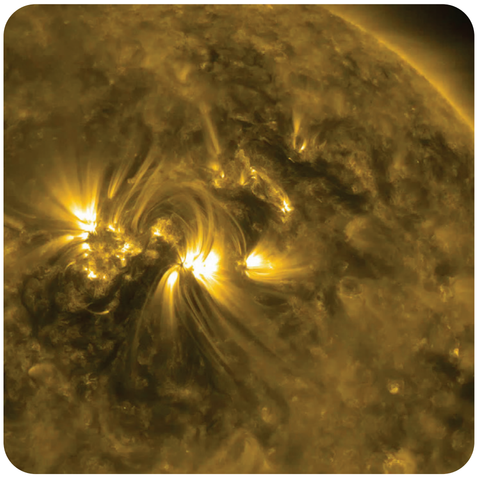
Step 6

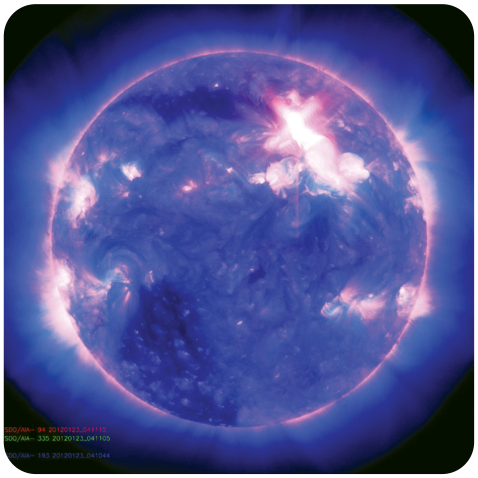


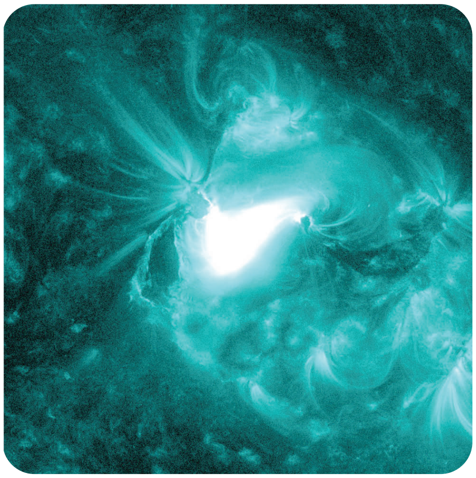
Step 7

Credit: VT Physics

5. Repeat step 4 until your compass is touching the magnet at the opposite pole. Connect the dots and make an arrow marking the direction the compass moved.
6. Repeat steps 2-5, starting at different points near the pole of the magnet, tracing the magnetic field lines.
7. Repeat steps 2-6 on the other side of the magnet.
8. Make your observations. What do you notice about the direction and shape of the magnetic field lines?







Section 3 Understanding The Sun

Activity Overview:

If you're ever near the North or South Pole, you may be in for a very special treat. Frequently there are beautiful light shows in the sky. These lights are called auroras. These displays are caused by energy that comes from the sun. In this activity, you can make your own colorful aurora with oil pastels

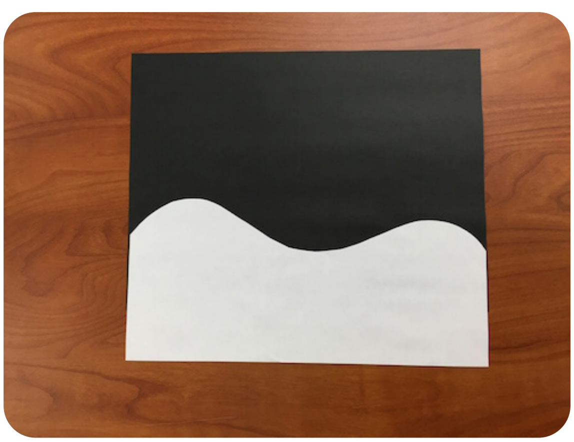
Needed Materials:

- Black construction paper
- Oil pastels
- Scissors
- Paper towels
- Blank sheet of paper

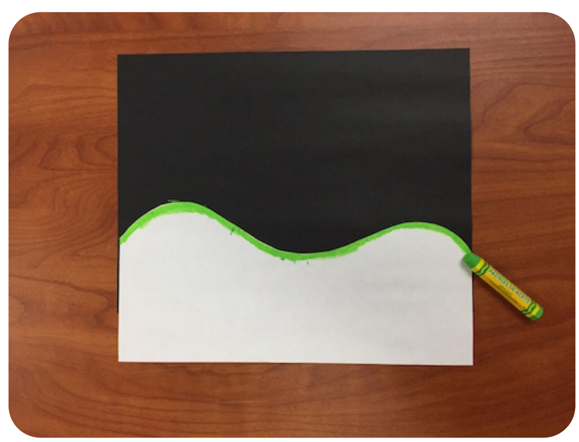
Colors

The colors of auroras are the result of atoms in the atmosphere interacting with energy from the sun. The atoms get excited and release bursts of light energy. It's similar to how neon lights work. Auroras are usually red, green, and blue. The red color is from oxygen atoms in the atmosphere. The greens and blues are the result of nitrogen. Sometimes these colors mix and yellow and pink colors will be seen in the sky too.

Instructions



1. Cut a smooth wavy line across a piece of paper. This is your aurora guide. Place it against a sheet of black construction paper.



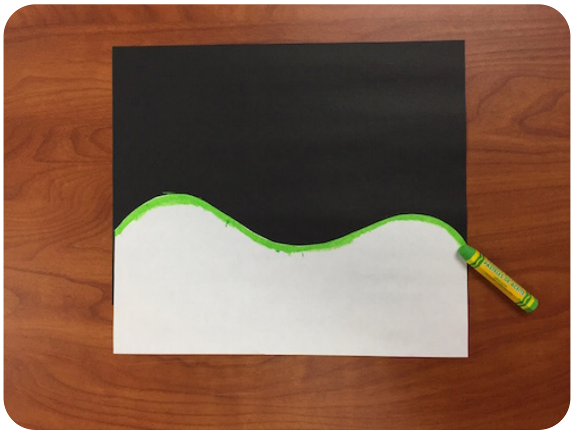
2. Trace the curve with your pastels. Go back and forth so lots of color gets on the guideline. It's okay to get a bit on the black construction paper too.

MAKING A PASTEL AURORA

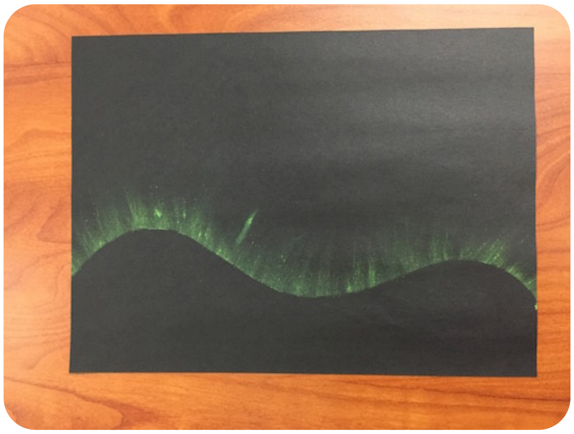
All Grades

Find it online - search: make a pastel aurora NASA

3. Hold your guideline down with one hand, and with the other, use your paper towel to push the pastel upward so it smudges onto the construction paper.



4. You can go over the area again with more pastels and smudge with the paper towel until you have as much color as you want.



5. Lift up the guideline to see the colorful band.

6. Place the guideline in a different spot and repeat steps 2 and 3 as many times as you like. Try flipping the guideline over or placing it at different angles to add to the overall effect of the painting.

7. Display your aurora masterpiece so everyone can see it. Be sure to tell them what the colors mean and why auroras happen!

Section 3 Eclipse Citizen Science: Become a GLOBE Observer

Major Concepts:

- Ground-based observations taken by citizen scientists can aid understanding of Earth's processes.
- Unique changes to our atmosphere can be observed and measured during a solar eclipse.

Activity Overview:

Students will learn to conduct standard environmental observation protocols that allow useful data to be collected by people around the globe, contributing to ongoing research about our planet. This is an outdoor activity, intended for the day of the eclipse. (Doing a test-run on another day is a great idea too!) Be sure to choose an outdoor location with the most unobstructed view of the sky, away from buildings and trees.

Provided Materials:

- Thermometer
- Compass
- Length of surveyors tape/ribbon
- GLOBE clouds sky window
- Data sheets

Needed Materials:

- Pen or pencil
- Yardstick or other 3 foot pole
- Copies of data sheets (also find them online - search: NASA globe cloud protocol data sheet and NASA globe air temp data sheet eclipse)
- Smartphone (optional)

Background:

Our Sun's energy drives processes in Earth's atmosphere like temperature, wind, and cloud formation. Clouds play a significant role in regional and global climate. Cloud type and distribution is changing in a changing climate. During an eclipse, some of the Sun's energy is blocked from reaching the Earth. Eclipses therefore produce a natural experiment in which solar energy is removed from the atmosphere for a brief period of time. How will this affect our atmosphere? What will the impact be on cloud cover in different climatic regions?

NASA's GLOBE observer program is a citizen science app for your smartphone, allowing volunteers in different countries to take observations and contribute to the Global Learning and Observations to Benefit the Environment (GLOBE) community. A special feature on the app allows for the collection of data during the time of eclipses from citizen scientists like you! You can make observations at any outdoor location in the path of the eclipse, and contribute your findings to help understand effects of the eclipse.

You can take air temperature measurements, make cloud observations, wind measurements, and provide simple information about your surroundings during the eclipse. Data collected during the 2017 total solar eclipse showed a strong correlation between total cloud cover and temperature changes within the path of totality, with areas that had the most cloud cover experiencing the smallest temperature change during the eclipse. Data from the 2024 eclipse will be used to continue this research.

BECOME A GLOBE OBSERVER

Grades 7-12

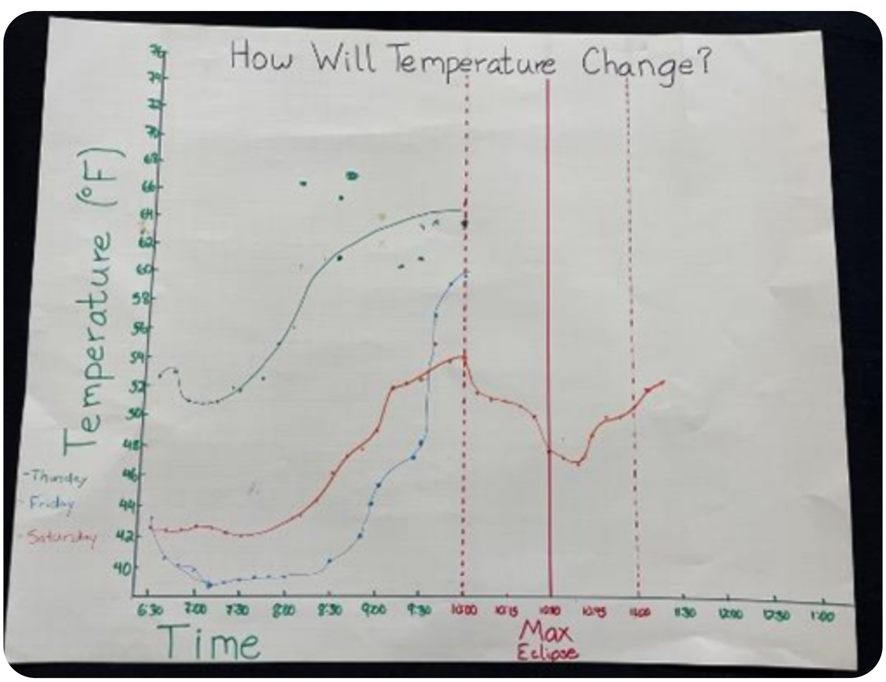
Adapted from NASA. Find it online - search: NASA GLOBE Observer eclipse

Teacher Instructions

1. Visit the GLOBE Observer website or download the GLOBE Observer app from any app store or online. You will have to create an account or look for your school's account to submit data through the app. However, you do not have to use the app to contribute students' observations. Each student, or small group of students, can record their observations on the included datasheets, and the data can be entered online after the event. You can then access the entire dataset, including input from citizen scientists across the country, to share with your students. For more ideas about how to use GLOBE data in your classroom, and more information about how to participate in data collection beyond the 2024 eclipse, visit www.globe.gov.
2. As a group, record information about the location where you'll be viewing the eclipse. What kind of ground cover (grass, concrete, etc.) do you have? The teacher can take images using the GLOBE app on their smartphone, if desired.
3. Divide the class into three teams to perform the observing tasks: Air Temperature Measurement, Cloud Observation, and Wind Speed Estimation. If desired, have each team rotate through the different tasks at 15-minute intervals.

For Air Temperature Measurement:

Hold the thermometer away from your body, in the shade (of your body if necessary) for 3 minutes, and note the temperature. Use the included form to record temperature in this way every 5 minutes. If you teach multiple classes on the day of the eclipse, consider creating a poster-sized graph that teams can plot their temperatures on throughout the day.



For Cloud Observation:

Look at the sky in every direction above 14 degrees. Four members of the group can choose to face a cardinal direction (North/South/East/West) and put their backs to one another. Place your arm in a V with your hand about head height. The observation area is above your hands.

Using the Sky Window and the Cloud Protocol Data Sheet, record observations of what you see, including sky color and visibility, cloud type and amount of cloud coverage.

For Wind Speed Estimation:

Attach the length of surveyor's tape to one end of a 3 foot stick.

Optional: Using a piece of cardstock, draw the cardinal directions (North, South, East, West) and push the card onto the stick at the opposite end of the surveyor's tape. Push the stick into the ground with the compass card just above the surface, or secure and stabilize the stick as needed in an open area. Use the hand held compass to be sure you've oriented your paper compass correctly.

Use the hand held compass and your paper copy to estimate which direction the wind is coming from. Winds are reported by the direction the wind originates, so a wind coming from the north will stream the ribbon toward the south. You would report this as a northerly wind. Use observations of your environment and the Beaufort Wind Scale to estimate wind speed. At regular intervals, note the time, wind direction, and wind speed estimates on your chart.

Air Temperature Data Sheet

National Aeronautics and Space Administration

Use this data sheet to record air temperature measurements during the total solar eclipse on April 8, 2024. All you need is a thermometer that measures air temperature. You do not need to be within the path of totality to collect data.

Eclipse Planner

You can look up the percent coverage, eclipse type, and times by scanning the QR code or going to **eclipsesoundscapes.org/eclipse-lookup-tool**.

Coverage:

Eclipse Type: ○ Total ○ Partial

Start: **Max:** **End:**

Site Description

You can find the coordinates of your site in decimal degrees by dropping a pin in a mapping application. Write a short description of your site, paying particular attention to features that might affect the temperature.

Latitude:

Longitude:

Time Zone:

Description:

Thermometer Set-Up

Place your thermometer in a shaded, but well-ventilated area. For example, you can place your thermometer under a chair or hold it in your own shadow. Be sure to hold the thermometer away from yourself or other sources of heat.

Thermometer Type:

- ○ Liquid Filled
- ○ Digital
- ○ Weather Station
- ○ Other:

Units:

- ○ Fahrenheit
- ○ Celsius

Safety First: Looking directly at the Sun without proper eye protection is unsafe EXCEPT when the Moon completely blocks the Sun. This happens ONLY within the narrow path of totality. Outside the path of totality, it is NEVER safe to look directly at the Sun without a solar filter.

To share your observations, scan or take legible photos of both pages and email them to **globeobserverhelp@lists.nasa.gov**.

Air Temperature Measurements

Your data is most useful to scientists if you record observations through all phases of the eclipse (about two hours before and after maximum eclipse); however, this is not a requirement. We recommend observing every 10 minutes for the first and last 1.5 hours and increasing the frequency to every 5 minutes in the 30 minutes before and after maximum eclipse. Take a break during maximum eclipse to enjoy this incredible experience!

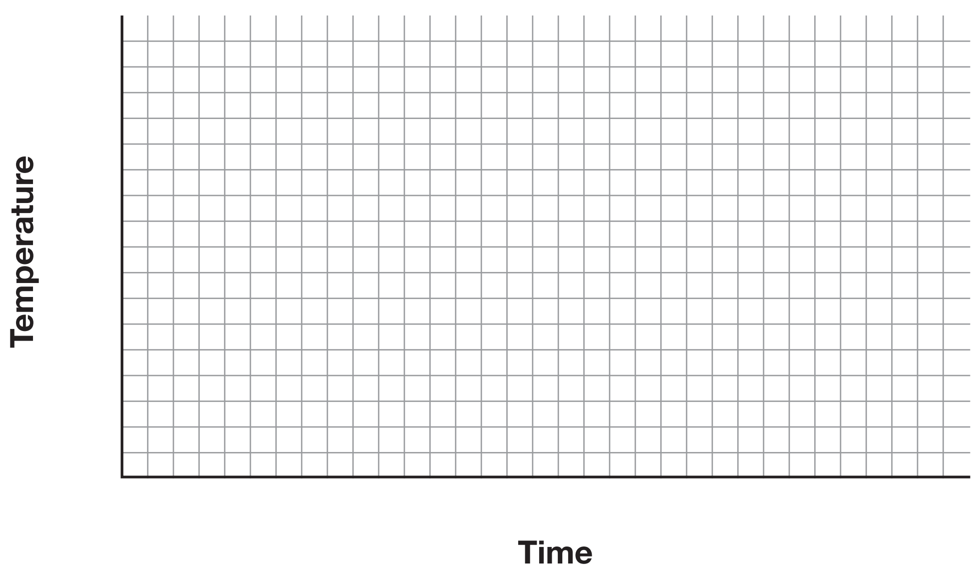
Time	Temp.	Time	Temp.	Time	Temp.	Time	Temp.

Graph Your Data

Use this space to create a line graph of your data after the eclipse.

Indicate when maximum eclipse occurred.

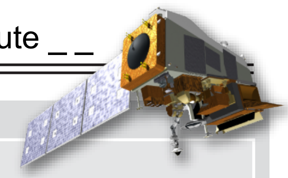
What do you notice about the temperature before and after maximum eclipse?



School/Observer Name:______________________________ Study Site:________________________

Date (ex. 2017 01 13): Year: _ _ _ _ Month: _ _ Day: _ _

Time (ex. 24 Hour Clock: 14 26): Local: Hour _ _ Minute _ _ Universal: Hour _ _ Minute _ _



1. What is in Your Sky?

Total Cloud/Contrail Cover:

- ○ Sky is Obscured →
  - ○ Fog
  - ○ Heavy Rain
  - ○ Heavy Snow
  - ○ Blowing Snow
  - ○ Sand
  - ○ Spray
  - ○ Smoke
  - ○ Dust
  - ○ Haze
  - ○ Volcanic Ash
  - Go to box 6
- ○ None (Go to box 2)
- ○ Few(<10%)
- ○ Isolated (10-25%)
- ○ Scattered (25-50%)
- ○ Broken (50-90%)
- ○ Overcast (90-100%)

*If you can observe sky color or visibility, complete box 2

2. Sky Color and Visibility

Color (Look Up): ○ Cannot Observe ○ Deep Blue ○ Blue ○ Light Blue ○ Pale Blue ○ Milky

Visibility (Look Across): ○ Cannot Observe ○ Unusually Clear ○ Clear ○ Somewhat Hazy ○ Very Hazy ○ Extremely Hazy

3. High Level Clouds

○ No High Level Clouds Observed (Go to box 4)

Cloud Type:

- ○ Contrails (number of): →
- ○ Cirrus
- ○ Cirrocumulus
- ○ Cirrostratus

short-lived #
persistent #
persistent spreading #

Cloud Cover:

- ○ Few (<10%)
- ○ Isolated (10%-25%)
- ○ Scattered (25%-50%)
- ○ Broken (50%-90%)
- ○ Overcast (>90%)

Visual Opacity:

- ○ Opaque
- ○ Translucent
- ○ Transparent

4. Mid Level Clouds

○ No Mid Level Clouds Observed (Go to box 5)

Cloud Type:

○ Altostratus ○ Altocumulus

Cloud Cover:

- ○ Few (<10%)
- ○ Isolated (10%-25%)
- ○ Scattered (25%-50%)
- ○ Broken (50%-90%)
- ○ Overcast (>90%)

Visual Opacity:

- ○ Opaque
- ○ Translucent
- ○ Transparent

5. Low Level Clouds

○ No Low Level Clouds Observed (Go to box 6)

Cloud Type:

- ○ Fog
- ○ Nimbostratus
- ○ Cumulonimbus
- ○ Stratus
- ○ Cumulus
- ○ Stratocumulus

Cloud Cover:

- ○ Few (<10%)
- ○ Isolated (10%-25%)
- ○ Scattered (25%-50%)
- ○ Broken (50%-90%)
- ○ Overcast (>90%)

Visual Opacity:

- ○ Opaque
- ○ Translucent
- ○ Transparent

6. Surface Conditions

Mandatory:

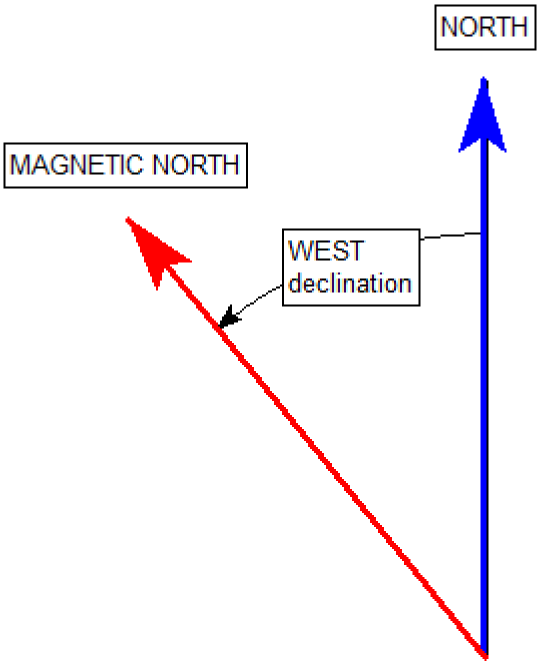
	Yes	No		Yes	No
Snow/Ice	○	○	Dry Ground	○	○
Standing Water	○	○	Leaves on Trees	○	○
Muddy	○	○	Raining/Snowing	○	○

Optional:
You may submit any or all

Temperature: ___°C
Barometric Pressure: ___mb
Relative Humidity: ___%

Comments:

Wind Observation Data Sheet

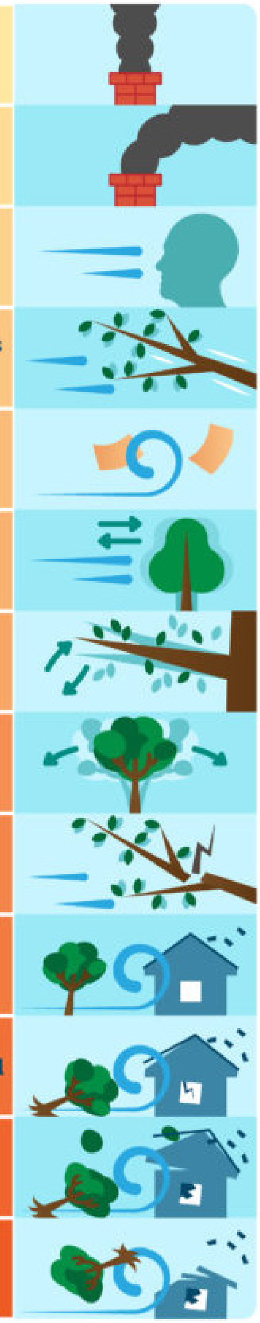


NOTE about True North and Magnetic North: True North points directly towards the Geographic North Pole. Your compass will indicate Magnetic North, which aligns with Earth's Magnetic Field. Magnetic North shifts over time in response to changes in the Earth's magnetic core. At any geographic point on Earth, the difference between True North and Magnetic North will be different. In Houston, the deviation from True North is -11.55 degrees which translates as Magnetic North being 11.55 degrees WEST of True North. You will ADD (-11.55 degrees) to each of your magnetic compass readings.

Time	Wind Direction	Corrected Direction (-11.55°)	Wind Speed Estimate (knots)	Notes

Beaufort Scale

Beaufort Number	Description	Wind speed	Wave height	Sea conditions	Land conditions
0	Calm	< 1 knot < 1 mph < 2 km/h	0 ft 0 m	Sea like a mirror	Smoke rises vertically
1	Light air	1–3 knots 1–3 mph 2–5 km/h	0–1 ft 0–0.3 m	Ripples	Direction shown by smoke drift
2	Light breeze	4–6 knots 4–7 mph 6–11 km/h	1–2 ft 0.3–0.6 m	Small wavelets	Wind felt on face
3	Gentle breeze	7–10 knots 8–12 mph 12–19 km/h	2–4 ft 0.6–1.2 m	Large wavelets	Leaves and small twigs in constant motion
4	Moderate breeze	11–16 knots 13–18 mph 20–28 km/h	3.5–6 ft 1–2 m	Small waves	Raises dust and loose paper
5	Fresh breeze	17–21 knots 19–24 mph 29–38 km/h	6–10 ft 2–3 m	Moderate waves	Small trees and leafs begin to sway
6	Strong breeze	22–27 knots 25–31 mph 39–49 km/h	9–13 ft 3–4 m	Large waves	Large branches in motion
7	High wind, moderate gale, near gale	28–33 knots 32–38 mph 50–61 km/h	13–19 ft 4–5.5 m	Sea heaps up	Whole trees in motion
8	Gale, fresh gale	34–40 knots 39–46 mph 62–74 km/h	18–25 ft 5.5–7.5 m	Moderately high waves	Twigs break off trees
9	Strong/severe gale	41–47 knots 47–54 mph 75–88 km/h	23–32 ft 7–10 m	High waves	Slight structural damage
10	Storm, whole gale	48–55 knots 55–63 mph 89–102 km/h	29–41 ft 9–12.5 m	Very high waves	Trees uprooted, considerable structural damage
11	Violent storm	56–63 knots 64–72 mph 103–117 km/h	37–52 ft 11.5–16 m	Exceptionally high waves	Widespread damage
12	Hurricane force	≥ 64 knots ≥ 73 mph ≥ 118 km/h	≥ 46 ft ≥ 14 m	Exceptionally high waves, sea is completely white	Devastation



Eclipse Glossary

Angstrom

A unit of measurement sometimes used by astronomers to measure wavelengths, equivalent to $1x10^{-10}$ meters or one ten-billionth of a meter.

Atmosphere

A layer of gases that envelop a planet or star.

Aurora

Brilliant ribbons of light weaving across Earth's northern or southern polar regions, caused by magnetic storms that have been triggered by solar activity.

Corona

The outermost layer of the atmosphere of a star.

Coronal Loops

Loops of solar material, found near sunspots, that connect magnetic regions on the solar surface.

Coronal Mass Ejection (CME)

Huge bubbles of the Sun's material threaded by intense magnetic field lines that are ejected from the Sun over the course of several hours. CMEs often look like huge, twisted rope, which scientists call "flux rope".

Coronagraph

A camera that simulates a solar eclipse, blocking the Sun to reveal the corona.

Ecliptic Plane

The imaginary plane containing the Earth's orbit around the sun.

Electromagnetism

One of the fundamental forces of nature, which exists between subatomic particles such as protons and elections. It helps to hold matter together.

Electromagnetic Spectrum

The full range of electromagnetic radiation, arranged by frequency or wavelength.

Geomagnetic Storms

A disturbance of Earth's upper atmosphere, caused by solar flares.

Heliosphere

The outer layer of a star's atmosphere and the edge of its magnetic influence in space. Our solar system is contained within the heliosphere of the Sun, which protects us from most rays of energy coming from outside our system.

Helmet Streamers

Large, cap-like structures with long, pointed peaks that usually occur over sunspots and active regions.

Ionosphere

Part of Earth's upper atmosphere, where the Sun's energy ionizes the atoms and molecules and creates a layer of electrons. The ionosphere reflects and changes radio waves used in communication.

Lunar Eclipse

When the Earth is between the Sun and Moon.

Lunar Node

Occurs when the moon's tilted orbit crosses the ecliptic plane.

Magnetic Field

The area around a magnet in which the effect of magnetism (a force that causes objects to attract or repel one another) is felt. Earth's magnetic field acts like an invisible shield around Earth that protects it from dangerous things, like radiation from the sun.

Magnetosphere

The region around a planet dominated by the planet's magnetic field.

Nanometer

A unit of measurement sometimes used by astronomers to measure wavelengths, equivalent to 1×10^{-9} meters or one billionth of a meter.

Noncontact Force

A force which acts on an object without coming physically in contact with it. Gravity and magnetism are examples of noncontact forces.

Obscuration

The concealment of one celestial body by another body passing between it and the observer.

Eclipse Glossary

Orbit
An orbit is a regular, repeating path that one object in space takes around another one.

Ozone Layer
A layer within Earth's stratosphere, which lies 10-50 km above the Earth. The ozone layer shields us and other living things from the sun's harmful ultraviolet radiation.

Path of Totality
The area where the darkest inner shadow of the moon, called the umbra, travels across the face of Earth during a total solar eclipse.

Penumbra
The lighter part of the shadow cast during an eclipse; occurs around the darkest central portion of the shadow called the umbra.

Photosphere
An outer layer of a star from which light is radiated.

Plasma
An electrically charged gas. The Sun is made of plasma.

Prominences
Bright strands of cooler, denser solar material suspended above the Sun's surface by magnetic fields.

Solar Cycle
The cycle that the Sun's magnetic field goes through approximately every 11 years, with periods of high and low solar activity.

Solar Flares
A brief eruption of intense high-energy radiation from the Sun's surface, associated with sunspots. Solar Flares can cause electromagnetic disturbances on the Earth, and may disrupt radio communications and electrical power distribution.

Solar Maximum
The regular period of highest solar activity during the 11-year solar cycle.

Solar Minimum
The regular period of lowest solar activity during the 11-year solar cycle.

Solar Radiation

The energy emitted by the Sun.

Solar Wind

Charged particles from the Sun's corona, where the gas is so hot the star's gravity cannot hold it. Solar wind carries plasma towards Earth that affects Earth's magnetosphere and can cause electrical problems, but also gives us the beautiful Northern and Southern Lights.

Space Weather

Space Weather refers to variations in the space environment between the Sun and Earth (and throughout the solar system) that can affect technologies in space and on Earth. Space weather is primarily driven by solar storm phenomena that include coronal mass ejections, solar flares, solar particle events, and solar wind.

Sunspots

Sunspots are areas that appear dark on the surface of the Sun. They appear dark because they are cooler than other parts of the Sun's surface.

Syzygy

(sizz-ih-jee) When three celestial objects line up.

Total Solar Eclipse

When the Moon completely blocks the Sun's light from reaching Earth.

Wavelength

The measured distance between two identical points on a wave of radiation, such as two adjacent crests or troughs. Wavelength determines color in the spectrum of visible light.

Ultraviolet

A type of electromagnetic radiation that has shorter wavelengths than visible light.

Umbra

The darkest part of the shadow cast during an eclipse; occurs inside the lighter portion of the shadow called the penumbra.