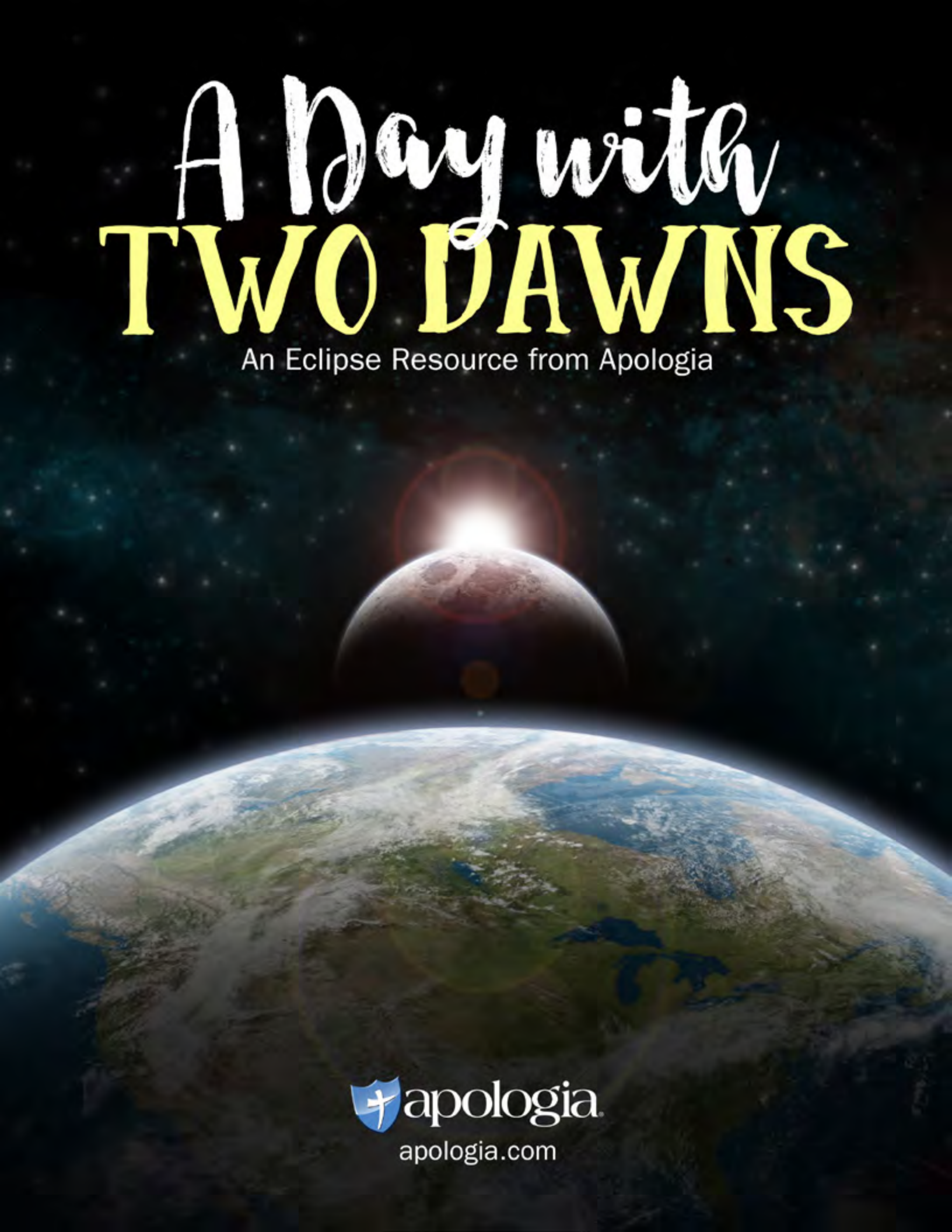
A Day with TWO DAWNS

An Eclipse Resource from Apologia



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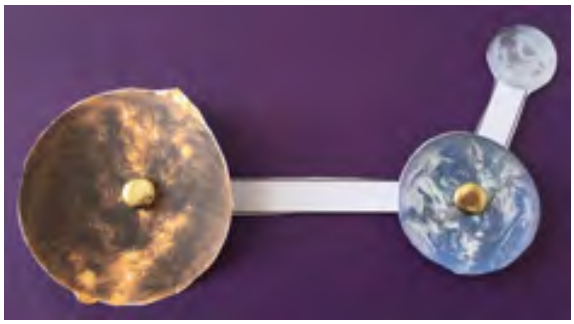
What is an Eclipse?

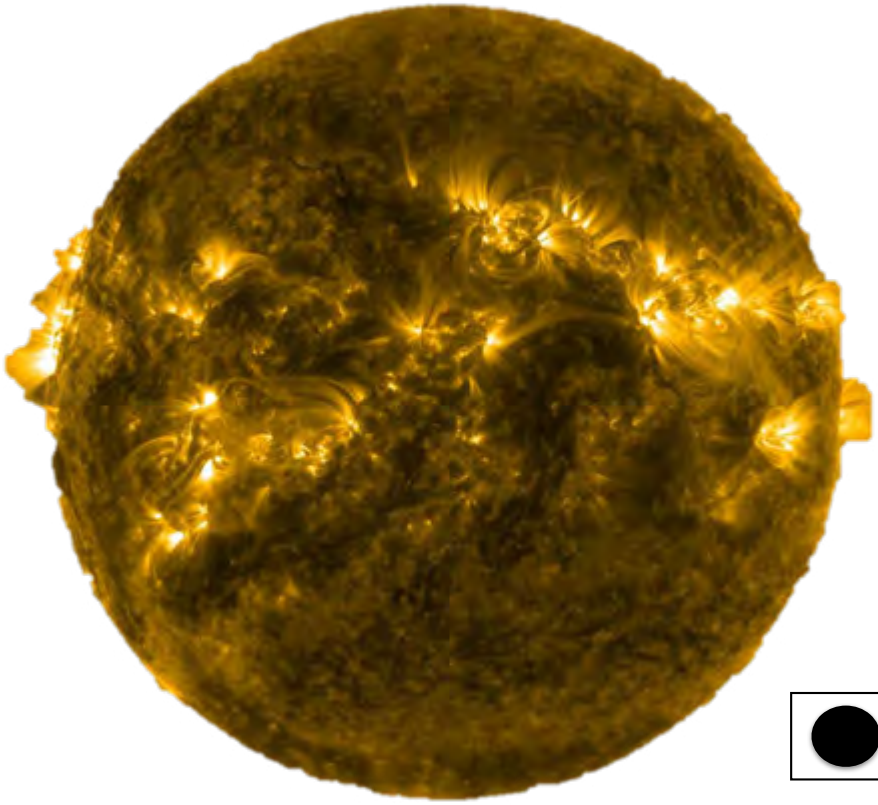
An eclipse happens when light is blocked from one celestial body because another celestial body has moved between it and its light source. Eclipses can happen anywhere in our universe, and it is one method we use to find exoplanets, which are planets that orbit stars outside of our solar system. Here on Earth, we experience two different types of eclipses. These occur because of the orbits of our Earth and our moon around our sun. Let's do an activity to understand orbits and eclipses better.

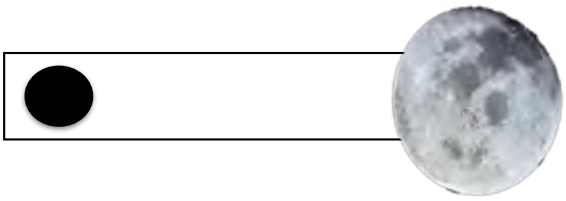
Supplies:
- Provided images
- Scissors
- Tape
- Two brass fasteners

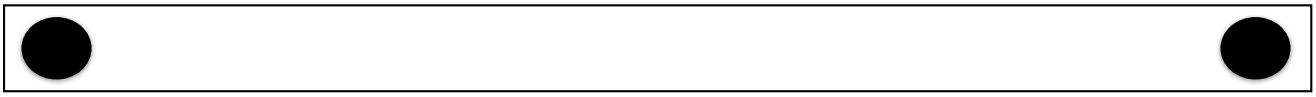


Note: This model is not to scale.

Directions:
1. Print and cut out the images provided.
2. Put a piece of tape around the black dots to reinforce attachment sites.
3. Attach the images using the brass fasteners as shown in the illustration.







Two Types of Eclipses

Look at the model that you just made. What do you notice? You should see that our moon orbits the Earth. That means that our moon travels around the Earth. We also use the term revolve. Revolve and orbit mean the same thing.

You should also see that as our moon orbits the Earth, the Earth and moon are orbiting around the sun. If you rotate your model's images, you will see that there are two places where one "celestial body" would block the sun's light from the other "celestial body."

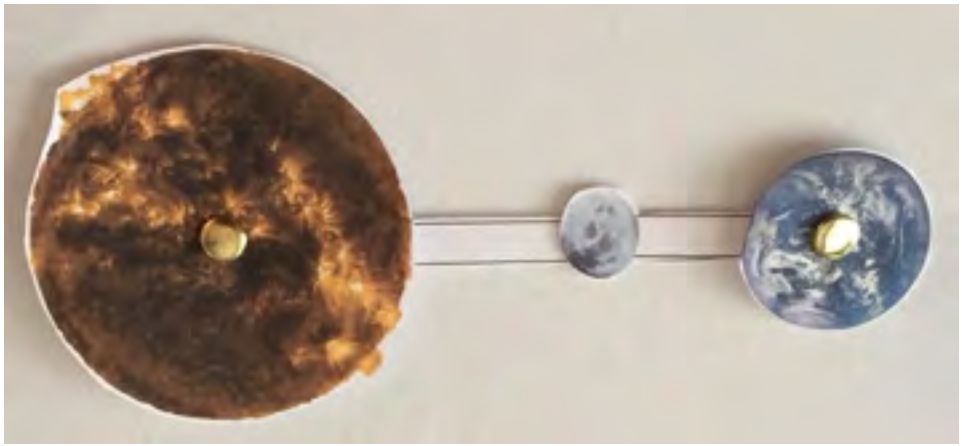
A Lunar Eclipse

The Earth blocks the light from the sun.
Our moon is in the Earth's shadow.

You can learn more about Lunar Eclipses at this link.

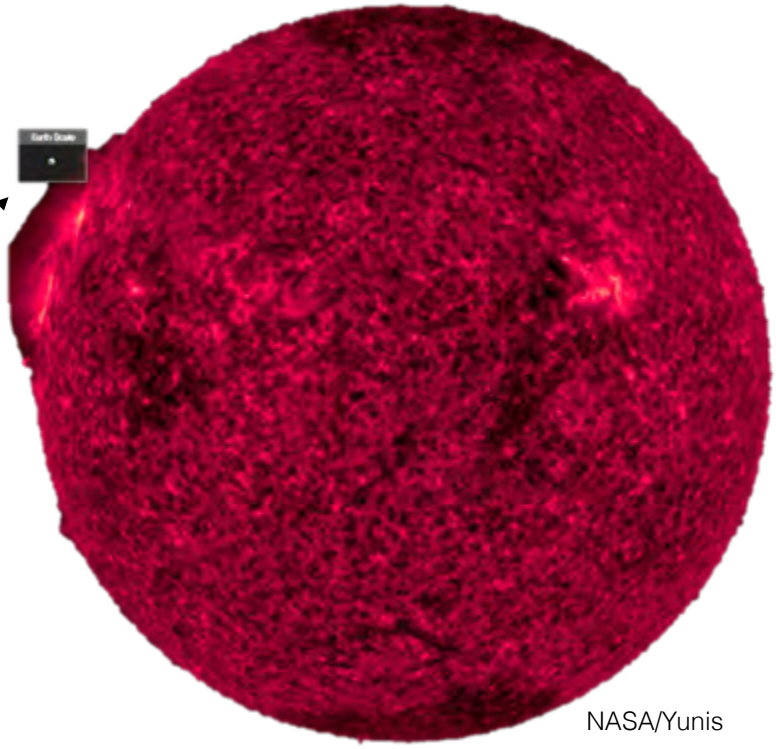
A Solar Eclipse

The moon blocks the light from the sun.
Parts of the Earth are in our moon's shadow.



You can learn more about Solar Eclipses at this link.

Size and Distance

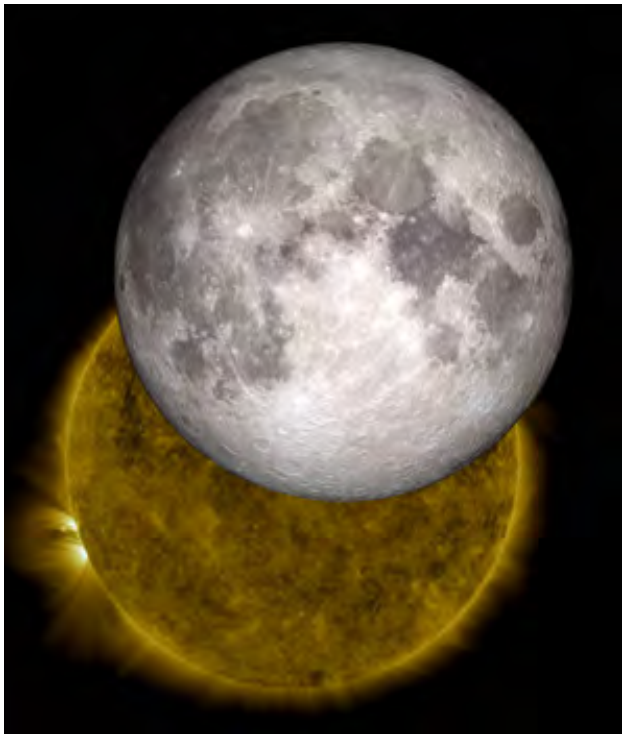


The size of the Earth in comparison to the sun. The Earth is the dot *inside* the box.

NASA/Yunis

Ask Yourself This

If our Earth is so tiny compared to our sun, and if our moon is even smaller than our Earth, how can our moon ever totally block out the sun's light?



NASA

Well, our moon's diameter is about 400X smaller than our sun, but the sun is about 400X farther away from the Earth than the moon is. So, when you are standing on the Earth, our moon appears to be the same size as our sun.

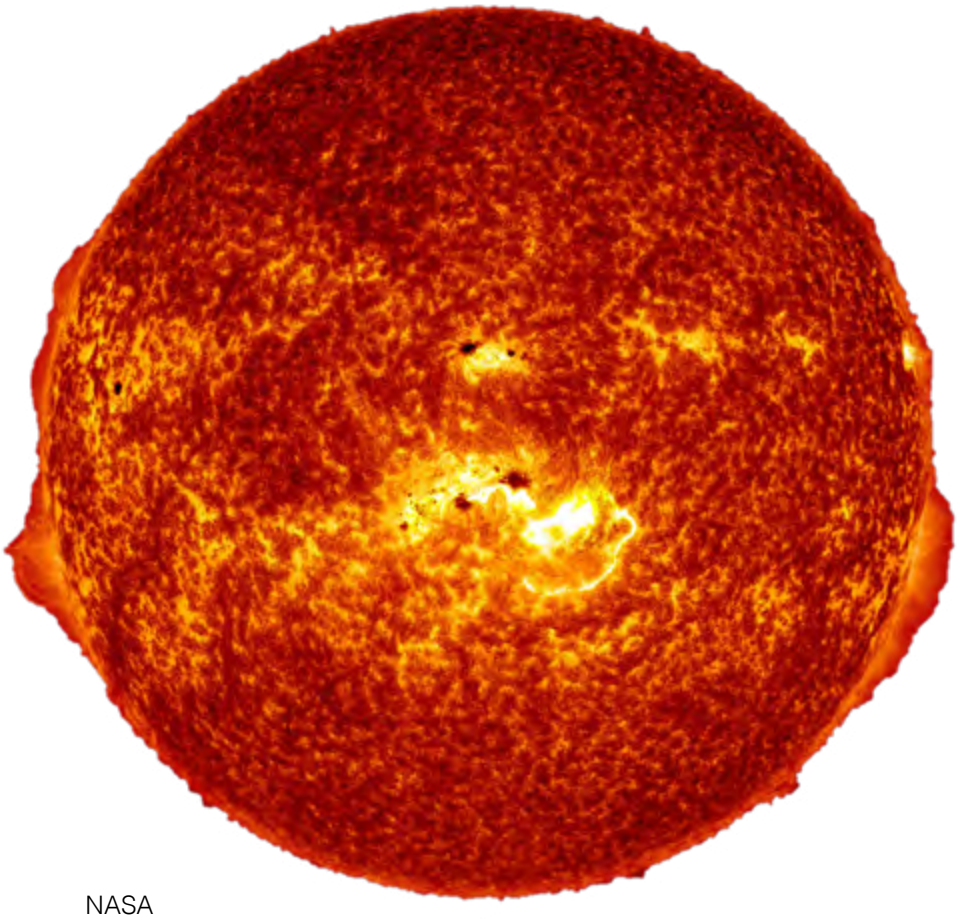
If our moon was smaller or farther away from the Earth, we would only see annular (ring) eclipses.

If our moon was larger or closer to the Earth, the sun would be totally blocked during an eclipse, and we wouldn't even see the sun's corona shining outward around the moon.

Activity on Size and Distance

Supplies:
- Provided images of sun and moon
- Scissors
- Friend

Directions:
1. Print and cut out the images provided.
2. Set your sun and moon next to each other; note their size difference.
3. Have your friend take the sun and walk away from you. How far does he have to walk to make the sun seem smaller?
4. Close one eye and hold up your moon. Does it seem to be closer to the size of your sun? When there is enough distance between your moon and your sun, they will appear to be the same size. You can eventually block out the image of your sun with the image of your moon.



NASA

Demonstrate a Solar Eclipse

Apologia

Supplies:
- Flashlight
- Globe
- Small sphere attached to string

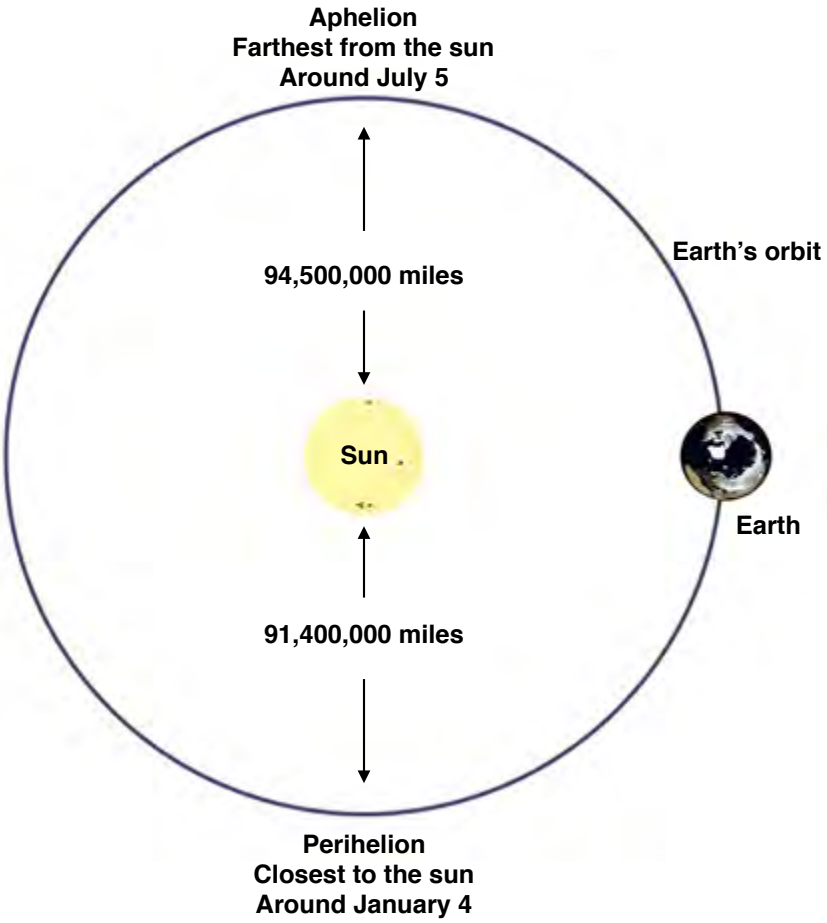
Directions:
1. Place your globe on a solid surface.
2. Place your flashlight up on a few books and illuminate your globe. The section of the globe that is lit is experiencing daytime. The section of the globe that does not have light shining on it is experiencing nighttime. Day and night happen because the Earth rotates on its axis once every 24 hours. The sun rises as the Earth rotates into the sunlight. The sun sets as the Earth rotates out of the sunlight.
3. Bring the sphere attached to the string into the light. This sphere represents our moon. You will see a shadow cast on the Earth. That area on the Earth that is in the moon's shadow is experiencing a solar eclipse.

Ask Yourself This

If our moon orbits around our Earth once every month, why don't we experience lunar and solar eclipses every month? Let's find out.

Earth's Orbit

Our Earth orbits our sun once every year. It follows an elliptical pathway. This means that at times it is closer to the sun, known as perihelion. It is farther from the sun at other times, known as aphelion. You should know that distance from the sun isn't what causes our seasons; the tilt of the Earth as it orbits our sun causes them. You can learn more about the tilt of the Earth and its seasons at this NASA link.

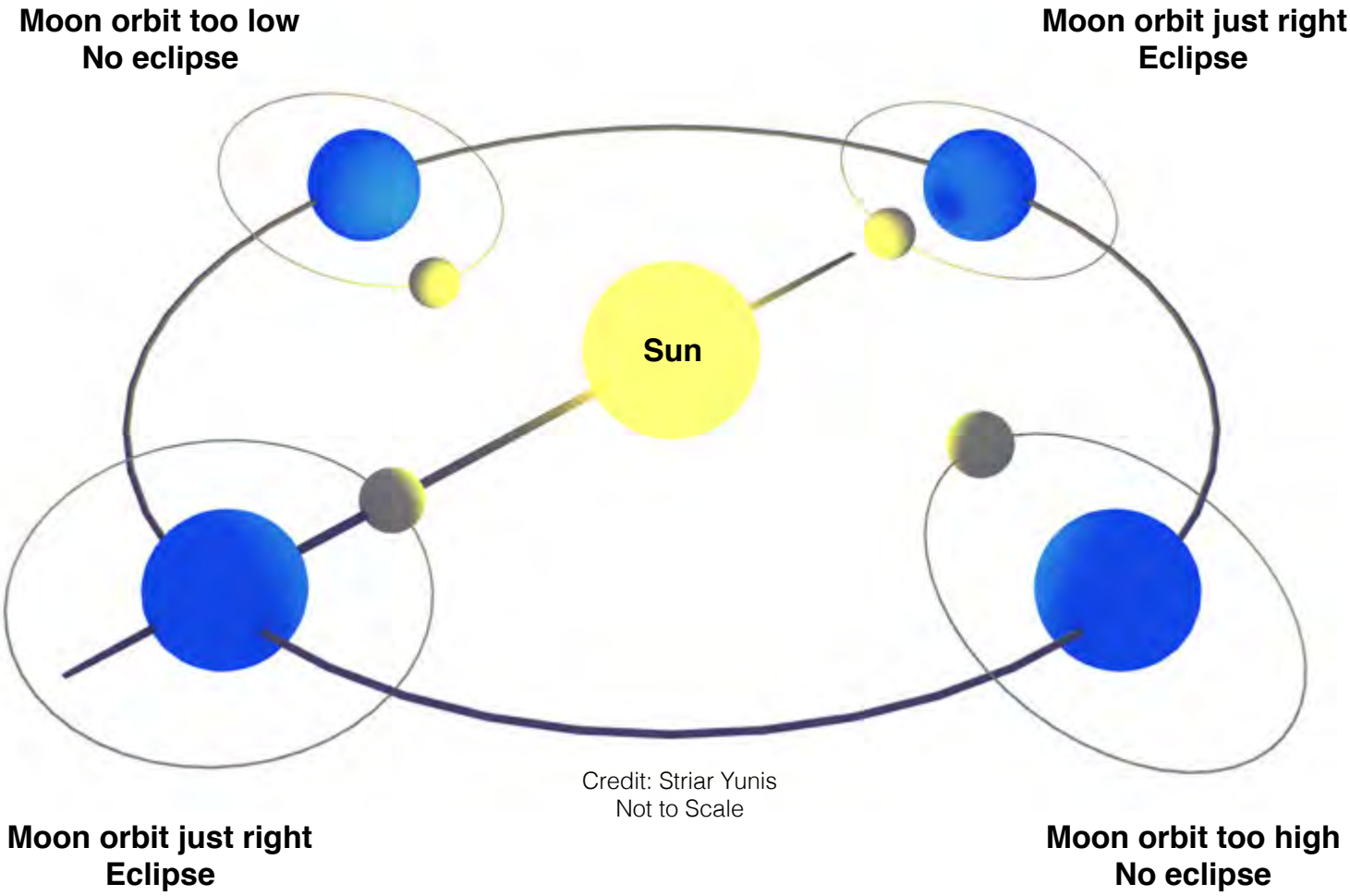


Moon's Orbit

Our moon orbits the Earth once every month. It also follows an elliptical pathway. Notice in the illustration below that the orbit of the moon is tilted by 5°. This is very important when it comes to understanding eclipses.

Images: NASA
Illustrations: Striar Yunis

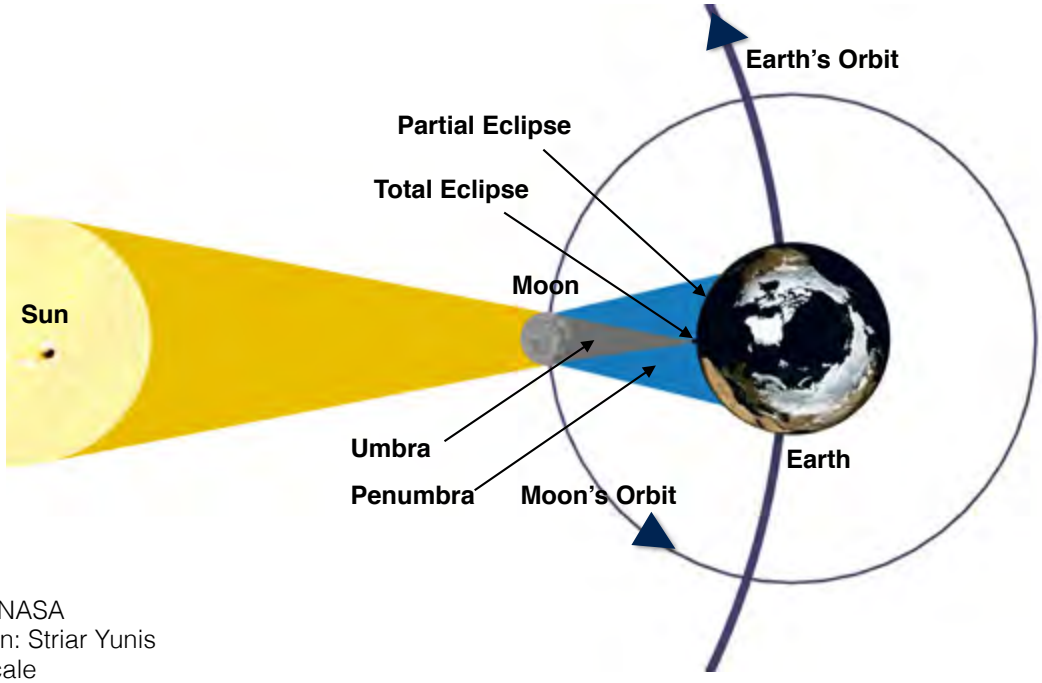
Earth's and Moon's Orbits Together



Credit: Striar Yunis
Not to Scale

The 5° tilt of our moon's orbit is just enough to cause it to be out of sync with the Earth's orbit most of the time. Twice a year, however, both the Earth's and moon's orbits line up so that somewhere on the Earth there is a solar eclipse. You can see the moon's shadow on the Earth in the upper right.
Anyone in that shadow would be experiencing a solar eclipse.

What Could You See During an Eclipse?



Images: NASA
Illustration: Striar Yunis
Not to Scale

What you see during an eclipse is the culmination of several factors. Do you remember that our moon's orbit is elliptical? That means that sometimes it is farther from the Earth, and sometimes it is closer to the Earth. That is one factor. In 2017, it will be closer to the Earth. Another factor has to do with the shadows cast by our moon during a solar eclipse. There are two shadows cast during a solar eclipse. They are called the **umbra** and the **penumbra**.

NASA

When our moon is closer to the Earth and you are in the path of the umbra shadow, you will experience a **total eclipse** of the sun. Only in a total eclipse can you see the sun's atmosphere. This is what people in the path of totality will see in 2017.

Diane Fisher

When you are in the path of the penumbra shadow, you will experience a **partial eclipse** of the sun. The sun will never be totally covered. This is similar to what people outside the path of totality will see in 2017.

Hinode/XRT

If our moon was farther from the Earth (not in 2017) and you were in the path of the umbra shadow, you would experience an annular eclipse of the sun. Our moon would not appear to be big enough to cover the entire sun.

Safely Viewing a Solar Eclipse

Many people mistakenly think that a solar eclipse is a dangerous time, that they should not be outside during the eclipse, and that they should not attempt to view the eclipse. None of these are true. Here is what you need to know:

- You should NEVER look directly at the bright sun. This isn't just a warning for solar eclipses. This is a warning for every day of your life. Your eyes do not contain pain receptors. Looking directly at the sun at any time during your life puts you at risk for serious eye damage and even blindness!

- You can safely view the sun IF you have the proper equipment. As tempting as it might be to look through a pair of dark sunglasses, old film, or any other idea you might have - don't do it. You can purchase special viewing glasses that are certified as safe. Unless you have certified viewing materials, do not view the sun directly.

This site contains important guidance on what you need to know.

- There is only one time that it is safe to look directly up at the sun. IF you are in the path of totality, you can view the totality (total coverage of the sun) safely because the sun is completely behind our moon.

- You can make a completely safe viewer in seconds. All it takes is a pinhole. Because this method of viewing a solar eclipse does not involve looking at the sun directly, it is a safe way for everyone to watch an eclipse.

Make a Pinhole Viewer

Any piece of paper will work, but a thicker piece of paper works best. We are going to use a paper plate.

Supplies:
- Paper plate
- Markers (optional)
- Pin
- White sheet of paper

Directions:
1. If you wish, color your paper plate to look like a sun.
2. Make a pinhole in the middle of your paper plate.
3. On a sunny day, take your plate outside. With the sun at your back, hold your plate up to capture the sun's light. It will project a small image of the sun through the pinhole.
4. Place the white piece of paper on the ground for the best viewing of the projected sun's image. You may want to use something to keep it in position, such as a handful of pebbles around its edge.
5. Use your safe pinhole viewer to watch the eclipse.

The Day of the Eclipse

Plan to set aside the day so that you can fully enjoy the eclipse.

Allot plenty of time to get to your spot if you are traveling to see totality. Many people from around the world will be doing the same thing. Check the weather. Adjust your plans as necessary.

It will take about 40 minutes for our moon to grow from a dark notch into a crescent. Remember - don't look at the sun directly! Use certified safe-viewing materials, or make a pinhole viewer.

It will take about an hour for the eclipse to reach totality. Here are some images you might experience if you are in the path of totality:

NASA/Arne Danielson

Bailey's Beads are the last rays of the sun streaming through the valleys of our moon. Our moon is not a smooth sphere. It has mountains and valleys. Bailey's Beads are a great way to see these.

NASA/The Exploratorium

The Diamond Ring effect just before totality.

NASA/Hartwig Luethen

The solar corona seen during totality. You will only see this if you are viewing the eclipse in the area of totality. This is the ONLY time it is safe to look at the sun.

When you see the first bead of light appear again, you should stop looking at the sun. Use either approved viewing equipment or a safe method, such as a pinhole viewer.
Be sure to watch this video on eye safety.

Map Your Position and Plan Your Viewing

1. Mark your position on the map.
2. Use this link to determine the time that the eclipse will be in your viewing area.
3. Fill in the information below, and mark the date on your calendar.

We will be viewing the eclipse from _____.

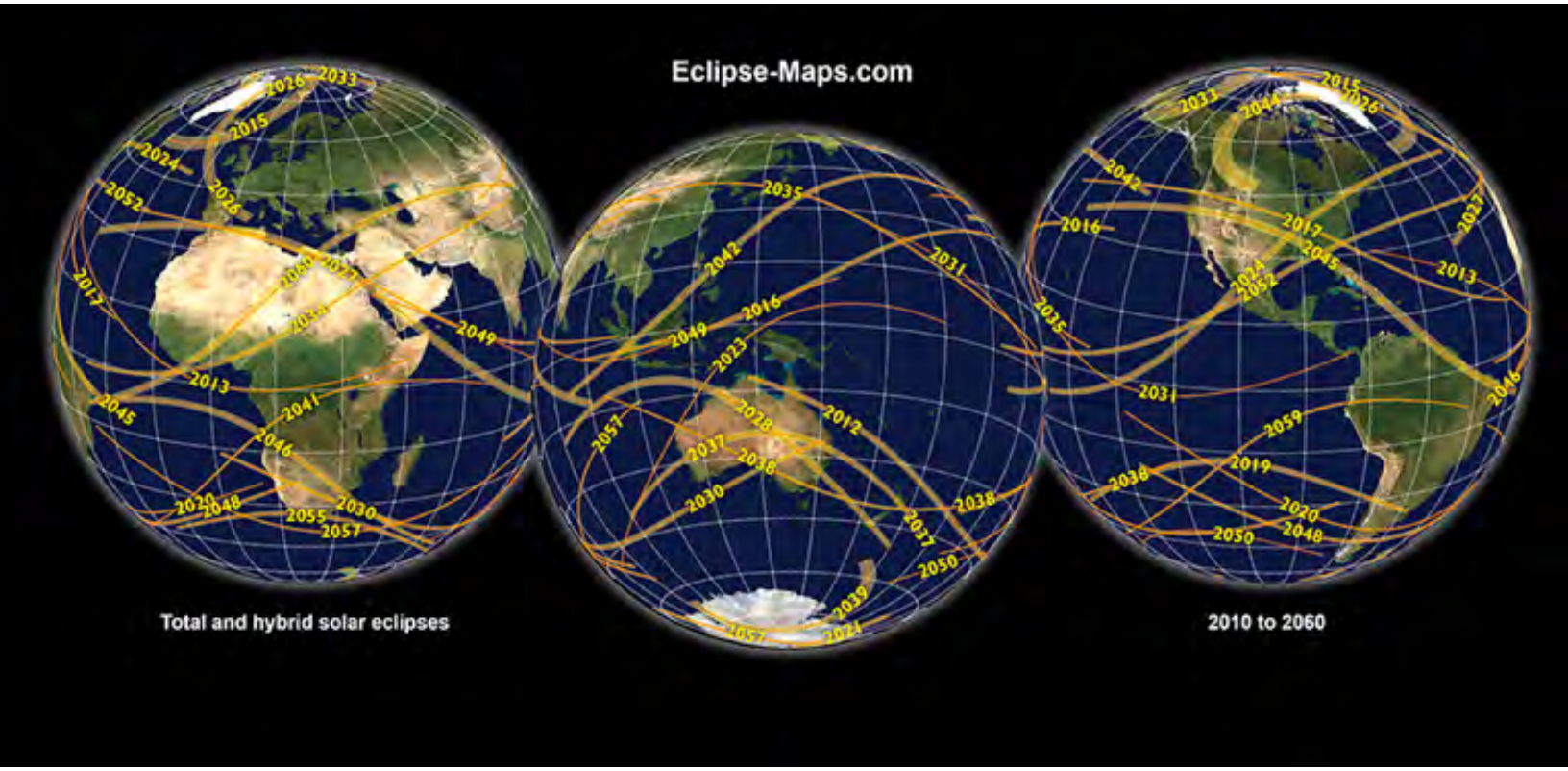
The time of the eclipse in our viewing area is at _____.

From our position, we will see ____% of the eclipse.

We will see a Total/Partial eclipse.
(Circle one.)

What's Next?

If you miss this eclipse, you can make plans to travel to see the next one.



eclipse-maps.com

Meet the Author

Rachael Yunis is the Science and Math Director at Apologia. She has advanced degrees in molecular genetics and developmental biology and biomedical ethics, over 10 years' experience in molecular genetic research, and publications in multiple peer-reviewed scientific journals. Rachael is author of *Exploring Creation with Earth Science* and co-author of the Apologia textbook, *Exploring Creation with Advanced Biology*, 2nd edition.

She has worked as an ethicist and science writer for the American Medical Association, the Alzheimer's Association, and other national publications such as Association News. Rachael also speaks on science, ethics, and homeschooling topics. She has been a volunteer member of local hospital ethics committees, is an on-call foster parent to infants waiting to be adopted into their forever families, and works globally to support orphaned children. Rachael and her husband, Sam, a NASA engineer with a Ph.D. in mechanical and aerospace engineering, have always homeschooled their children and been active in their Virginia homeschool community.

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