In one year, two solar eclipses cross the United States: an annular eclipse on October 14, 2023 and a total solar eclipse on April 8, 2024. Over 6.5 million people live under the annular eclipse path and over 31.5 million people in the continental U.S. will experience totality. About half of the US population lives within 250 miles of totality. Everyone will see at least one partial eclipse.

You can view a solar eclipse directly through solar filters, mounted on cards or in glasses. Safe filters must meet the ISO 12312-2 standard and block 100% of harmful ultraviolet and infrared radiation as well as over 99.99% of visible light.

The partial phases last over 2 hours so you will have plenty of time for students to share viewing filters to see the partial phases. I recommend that students also make safe pinhole viewers following the instructions provided.

Some eclipse times are included. For other locations, use links provided. Happy viewing!

Dr. Carolyn Sumners
Vice President for Astronomy, HMNS

Prof. Patricia Reiff
Dept. of Physics & Astronomy, Rice University

HOUSTON MUSEUM *of* NATURAL SCIENCE

RICE UNCONVENTIONAL WISDOM

TOTALITY! Planetarium Show

Totality! is a full-dome planetarium program about the upcoming eclipses. The show provides the history and geometry of eclipses followed by observing tips and a simulation of the upcoming totality. Everyone should see it, whether their eclipses will be total, annular, or deep partial. *Totality!* is featured in traveling Discovery Domes which visit schools, libraries, youth centers, and community events.

To see *Totality!* book a visit to the Burke Baker Planetarium (**www.hmns.org**) or schedule a dome at

www.hmns.org/discoverydome

Schools and planetariums can request a digital copy of our show at:

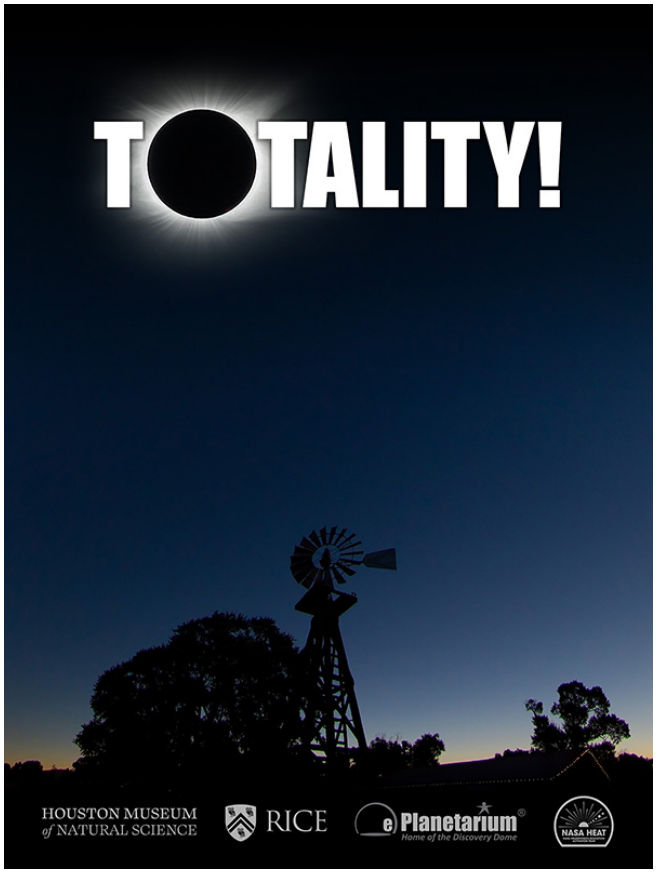
eplanetarium.com/totality

Learn more about eclipses at our website

space.rice.edu/eclipse

and join our eclipse newsletter

bit.ly/RiceEclipse



How to use the Solar Viewer

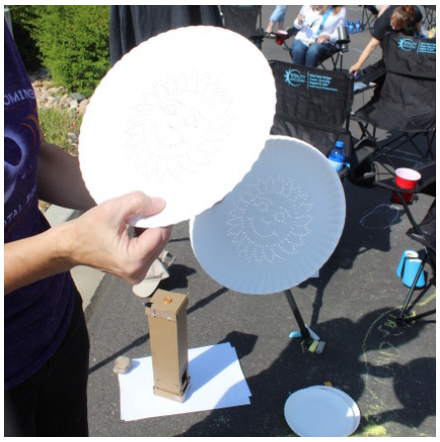
Hold the viewing glasses or card between your eyes and the Sun. The Sun will appear as a small yellow disk. During a solar eclipse, you will see the dark new Moon passing in front of the Sun. You can mount the viewing card or an eye filter from viewing glasses in the middle of a black card by cutting a hole in the card and taping the filter over the hole. Then more people can look through the viewer at the same time. You can also use your phone to photograph through the filter or you can draw how the eclipse looks. Record the time for each photo or drawing.

Sharing Eclipse Viewing Cards

The best way to use the viewing cards with a class of students is to make lanyards. Attach a lanyard (or a string made into a lanyard) after you have punched out a hole in the card. You may want to strengthen the hole in the card with a reinforcer. You can store the cards with the lanyard attached, being careful to protect the filters from being scratched by the lanyard.

Once the cards are on lanyards or strings, they can be passed from student to student during the hours of partial eclipse time. Students can wear the lanyards so the cards aren't dropped or scratched. They must hold up the viewing card and look at the Sun through it. Certified filters are required to look at the Sun, except during totality.

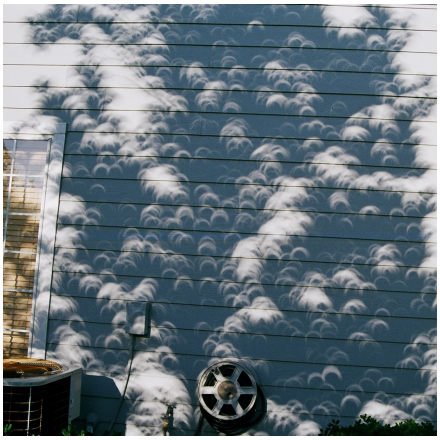
Pinhole Projector: A Safe Way to Observe the Sun



You MUST NOT stare directly at the Sun. Sunlight can cause permanent damage to the eye. To see the partial phases of an eclipse, you must look through a solar viewing card/glasses or look at a pinhole projection of the eclipsed Sun.

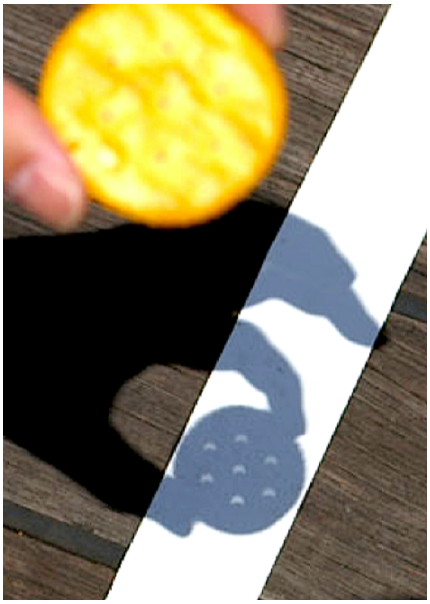
Make a Pinhole Projector

Use a pin or any other hole-punching device to create a small hole (or many holes) in a piece of cardstock. Stand with your back to the Sun and hold the perforated cardstock up so the Sun shines directly into the hole(s). Then, use another piece of cardstock as a "screen" in front of you. Little eclipses will be projected through the pinhole(s) onto the screen. The images are safe to observe and photograph. They show the partial phases of the eclipse. Your patterns of pinholes can be words, dates, or drawings. A smaller hole will make a sharper image. A larger hole will make a brighter, but softer, image. To make a smaller hole, cover a larger hole with aluminum foil. Then punch a hole in the aluminum foil.



Counting Crescents

Look for natural sources of pinholes like the holes created by leaves of a plant or tree. You can also collect leaves and make your own "natural pinholes".



Edible Pinholes

Experiment with pinholes made by food – either prepackaged, cooked, or combined. In this photo, a Ritz cracker with pinholes projects images of the Sun.

Pinhole Clothes

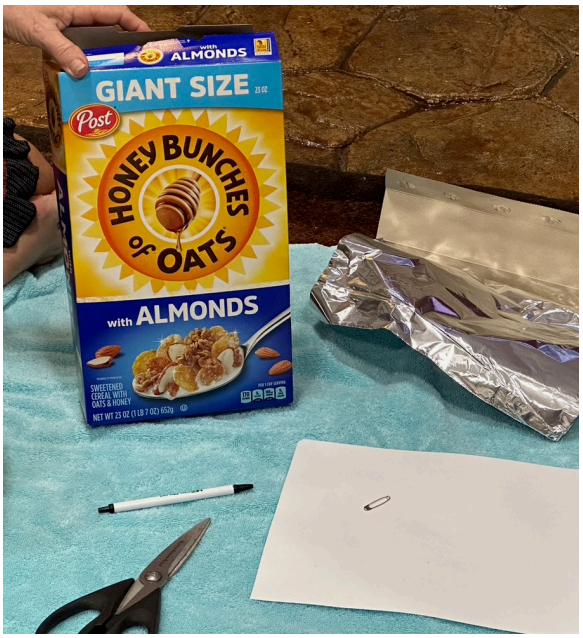
Make a pinhole projector you can wear. This includes hats, shawls, jewelry, backpacks, satchels, purses, buttons, etc. Notice the little Suns made by a straw hat.

Look how a button attached to a box creates pinhole projections in the bottom of the box. You must cut a window in the box to observe little Suns.

Making a Cereal Box Pinhole Viewer

A tall cereal box is the most easily found box to make a pinhole projector. Any similar box of the same general size will work. First remove the inner paper that held the cereal. Cut a white piece of paper to fit snuggly in the bottom of the box and insert it.

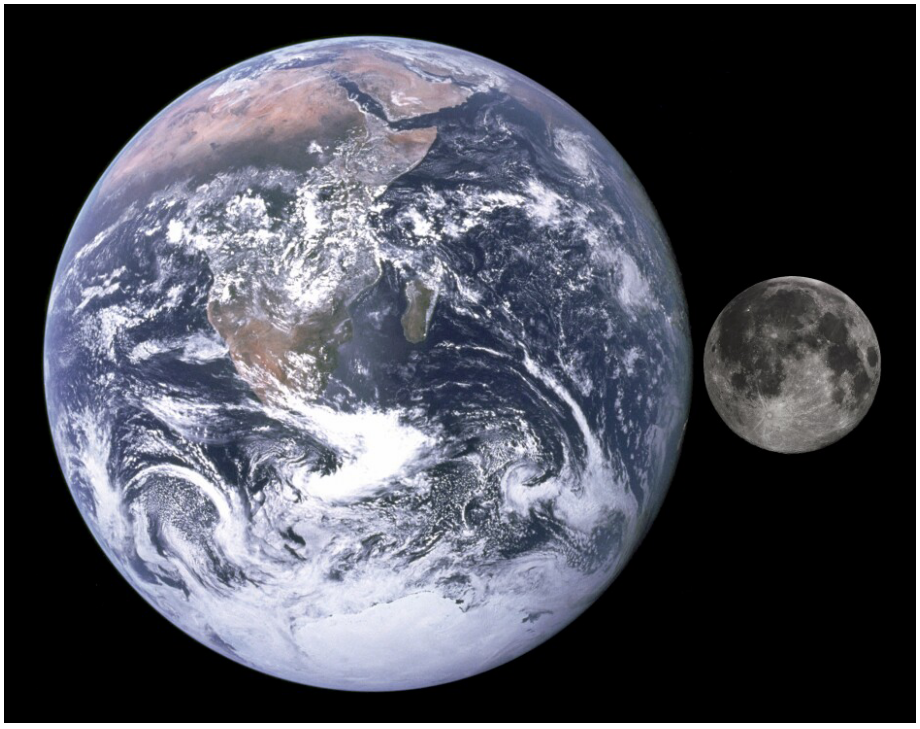
Remove both ends of the cereal box top. Leave the center intact. Put a piece of tape across the center of the top to securely hold it closed. Tape a piece of aluminum foil, covering one of the openings at the top of the cereal box. The other opening will remain open for viewing. Use a safety pin or small nail to push a hole in the foil. The finished box should be held with the pin-hole side facing the Sun. It may take a little practice pointing the box. With your back facing the Sun, look through the viewing opening. A small image of the Sun, about 1⁄2 cm in diameter, is projected on the white paper inside the box.



NEVER LOOK DIRECTLY AT THE SUN WITHOUT A SAFE FILTER!

Sun-Moon-Earth Scale Factors

Find a globe of any size. Wrap a string around the globe to get the length of the globe's circumference. The Moon would be a sphere 1/4th the diameter of the globe. It would be located at a distance of 9.5 circumferences.For instance, if the Earth globe is 12 inches in diameter, then its circumference is 3.14 feet. The Moon is 1/4th of the diameter of Earth or 3 inches wide. The Moon would be almost 30 feet away from the Earth.



The Moon and Sun are the same size in Earth's sky. For this reason, we have total solar eclipses. Actually, the Sun is 400 times larger than the Moon, which is 400 times closer to Earth. If you hold your hand out at arm's length, you can cover the Sun or Moon with just your pinky finger. Try it. It's surprising how small these objects appear in Earth's sky.

Using Viewing Glasses with Binoculars.

Viewing cards or glasses can also be used with binoculars. **The filter material must be in front of the front lenses of the binoculars, not at the eyepiece**. You will need to cut the viewing card very carefully, not damaging the filter material with your knife or scissors. Then make pieces of cardstock the size of your binocular front lenses and cut holes in them the size of the filters. Tape the filters to the cardstock circles. Be certain that the circles do not leak any light.

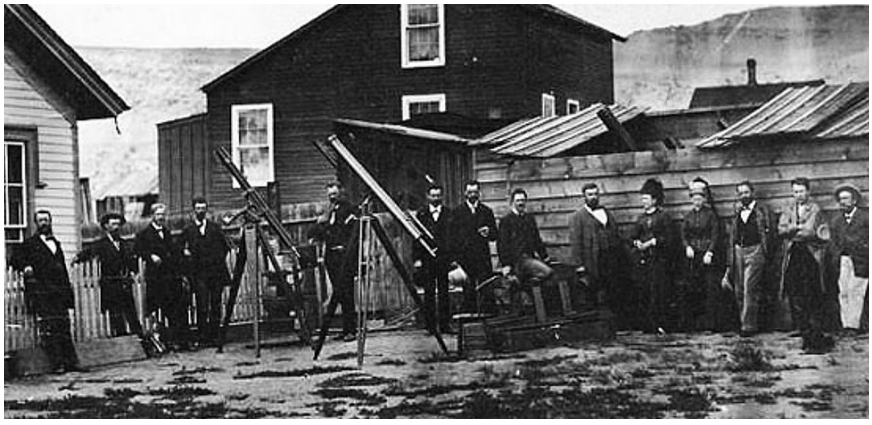
Then tape the two circles securely to the fronts of the binocular lenses. Now it is safe to look at the eclipsed Sun through your binoculars. Be careful not to stare at the Sun as you raise up your binoculars. You may want to put the binoculars on a tripod (adapter required) so students can look through them as well. Remember that the Sun appears to move as the Earth rotates under it. The binoculars will have to be adjusted to track the Sun.

See our eclipse equipment resource page:

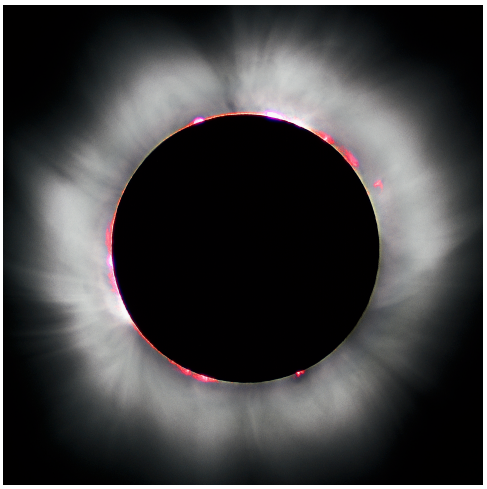
space.rice.edu/eclipse/eclipse_equipment.html

SOLAR ECLIPSE EVENTS

- On Nov. 30, 3,340 BCE, a solar eclipse darkened the Loughcrew region of Ireland. A drawing found in Cairn L may be the first recorded image of a solar eclipse.
- Astronomers, the public, and even Thomas Edison traveled to an eclipse path stretching from Idaho to the Gulf of Mexico on July 29, 1878. This was the last totality over Texas until 2024.
- Astronomers traveled to South America and Africa on May 29, 1919 to photograph stars near the Sun, visible only at totality. Their photos showed that the Sun's gravity shifted star positions, just as Einstein's Theory of General Relativity predicted.



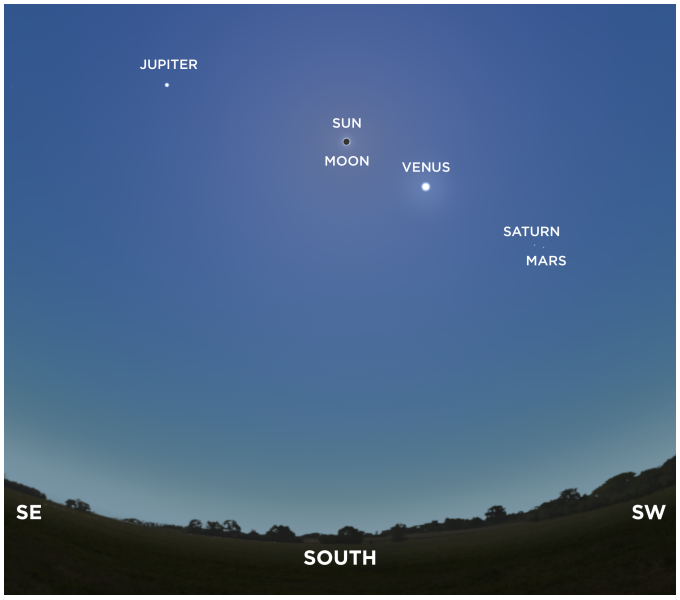
Solar Eclipse Science



During the partial phases, students can draw what they see through the filters and record the time of observation. They can measure any changes in temperature and light level (perhaps with a cell phone). When the Moon covers most of the Sun, shadows become sharper and look strange. Make photographs of specific objects when the partial phase is most complete and then photograph the area after the eclipse is over. Do your pics look different? Notice any changes in the behaviors of animals – especially birds.

For astronomers, a total solar eclipse is an opportunity to view the entire area of the solar atmosphere – the lower and middle corona. Astronomers study how the corona changes over the 11-year sunspot cycle, how the magnetic field around sunspots leads to the shapes of streamers we see in the corona, how the Sun's magnetic field heats the corona to over a million degrees, and which eruptions could reach the Earth. These images show Bailey's Beads, the last bit of photosphere peeking through mountains on the Moon. Notice the red prominences rising into the chromosphere and corona.

At totality on April 8, 2024, planets will become visible. Facing south, you will see Venus to the right and below the eclipsed Sun. Jupiter will be above and to the left of the Sun. Saturn and Mars are fainter and farther to the right of Venus. Planets are visible only at locations that experience totality.



There are many eclipse resources online. Begin with these:

- hmns.org/eclipse
- eclipse.gsfc.nasa.gov/solar.html
- space.rice.edu/eclipses
- eclipse.aas.org/resources
- solarsystem.nasa.gov/eclipses/home/
- my.nsta.org/collection/zIQlcKEtn2k_E
- greatamericaneclipse.com
- timeanddate.com/eclipse/
- mreclipse.com
- For solar filters: rainbowsymphonystore.com
- For Houston area telescope shopping: landseaskyco.com

Eclipse Words

Annular eclipse: a solar eclipse where the diameter of the Moon is too small to completely cover the Sun in Earth's sky. At mid-eclipse, the Sun appears as a blindingly bright ring surrounding the Moon.

Corona: the Sun's upper atmosphere, visible as a pearly glow around the eclipsed Sun during totality.

Eclipse magnitude: the fraction of the Sun's diameter covered by the Moon.

Eclipse obscuration is the fraction of the Sun's surface area covered by the Moon.

Eye safety: It is never safe to look at a partial or annular eclipse without the proper eye protection like a solar viewing card or glasses.

New Moon: the phase where the near side of the Moon is completely unlit; solar eclipses can occur only at New Moon.

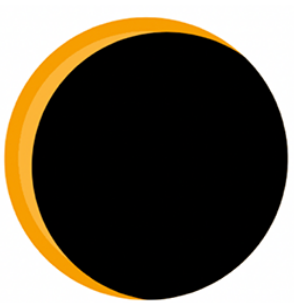
Partial eclipse: a solar eclipse where the Moon covers only a portion of the Sun.

Penumbra: the less dark outer region of the Moon's shadow; an observer in the penumbra sees a partial solar eclipse.

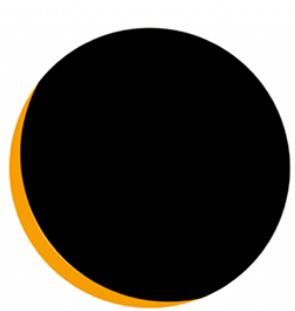
Photosphere: the visible Sun's surface where it emits light.

Pinhole projector: a device that projects an image of the Sun through a pinhole.

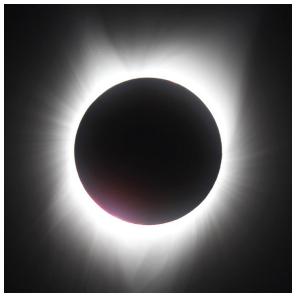
Total eclipse: a solar eclipse where the apparent diameter of the Moon is large enough to cover the Sun's photosphere completely and reveal the faint solar corona at totality.



Location: Houston, Texas
Event: Partial Solar Eclipse
Time: Saturday, Oct. 14, 2023
Eclipse time: 10:27am - 1:38 pm
Max coverage: 11:58 am
0.897 magnitude
84% obscuration
Avg cloud cover: 68% of the sky



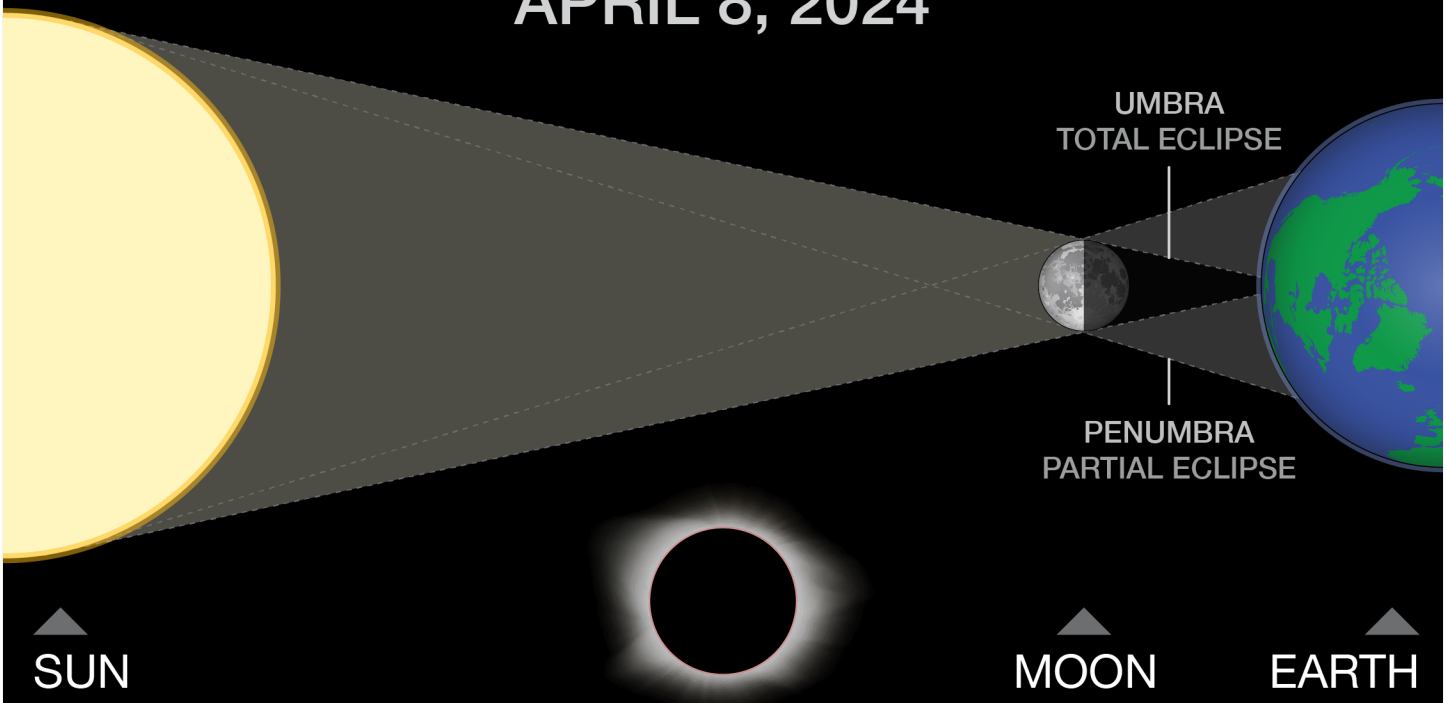
Location: Houston, Texas
Event: Partial Solar Eclipse
Time: Monday, April 8, 2024
Eclipse time: 12:20 pm - 3:01 pm
Max coverage: 1:40 pm
0.943 magnitude
94% obscuration
Avg cloud cover: 62% of the sky



Location: Bandera County, TX
Event: Total Solar Eclipse
Time: Monday, April 8, 2024
Eclipse time: 12:14 pm to 2:55 pm
Totality: 1:31 pm - 1:35:47 pm
1.0212 magnitude
100% obscuration
Avg cloud cover: 55% of the sky

TOTAL ECLIPSE

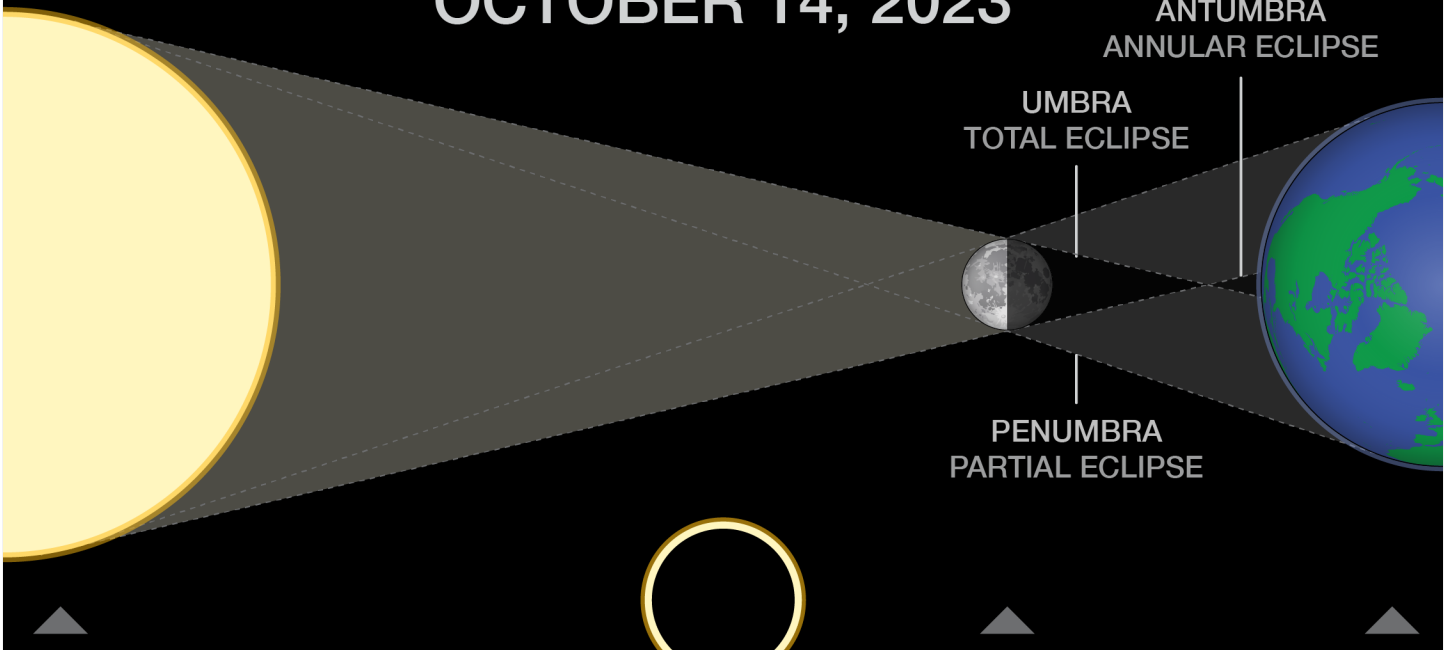
APRIL 8, 2024



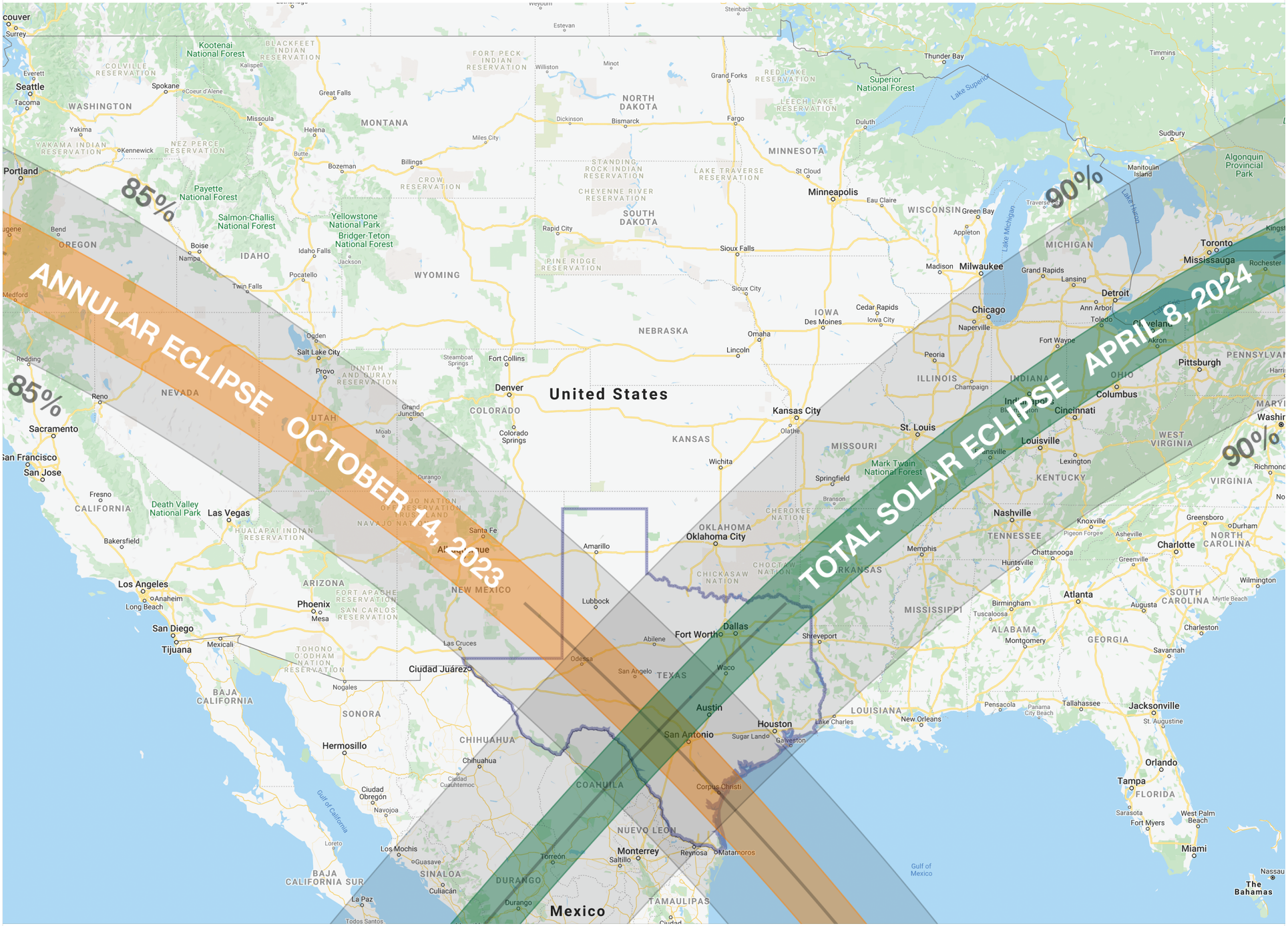
MOON COVERS SUN AT TOTALITY

ANNULAR ECLIPSE

OCTOBER 14, 2023



MOON TOO SMALL TO COVER SUN


ANNULAR ECLIPSE OCTOBER 14, 2023
TOTAL SOLAR ECLIPSE APRIL 8, 2024
85%
85%
90%
90%
United States
Mexico
Gulf of Mexico
Gulf of California