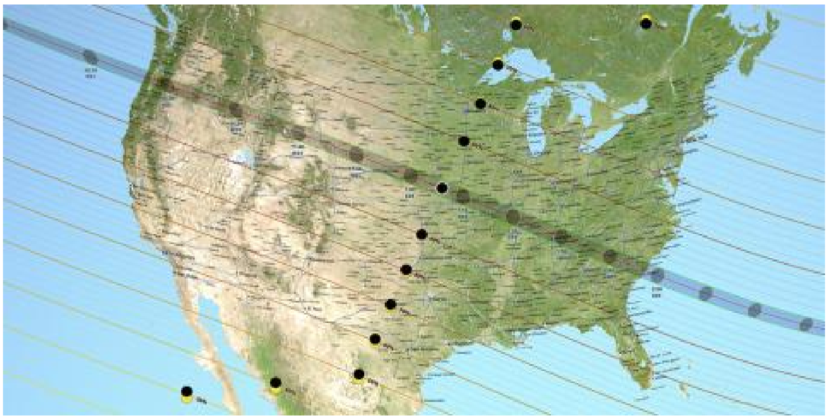


This image, online via NASA, shows the "path of totality" for the Great American Eclipse of 2017. The "path of totality," about 70 miles wide, is where the solar eclipse of August 21, 2017 will be total. Click on the image for a full-page view.

What happens when day becomes night—for a few minutes—during a total eclipse? It has everything to do with the Sun, the Moon and the Earth all lining-up together.

This happens more than we think, but we have to be in the right place at the right time to see it. The last time people in the U.S. could see a total eclipse—weather permitting, of course—was in 1979.

Let's explore how this phenomenon occurs.

A solar eclipse happens when the Moon's shadow falls somewhere on the Earth's surface. (A lunar eclipse, parenthetically, is just the opposite—occurring when the Earth's shadow falls somewhere on the Moon.)

The placement of the two sections of the Moon's shadow—the smaller and darker Umbra and the partially shaded Penumbra—determines what kind of eclipse we can see on Earth. The most spectacular, of the various types of eclipse, is the total eclipse of the Sun.

A total solar eclipse begins as a partial eclipse when the Moon's shadow begins falling on the Earth. What will *we* see as this partial eclipse begins? Trees will start to project the crescent sun while shadows start to look sharper than normal.

Then the landscape starts to darken, to a bluish-gray, and the temperature—even on a hot summer day—will start to drop. From the West, the Moon's shadow starts rushing toward us—almost like a silent storm in-the-making. Birds will stop chirping because they sense night is upon us.

If we look up, on an unclouded day, we'll see something extraordinary. The Sun will seem like it's just a sliver and, at its top, will look like a sparkling diamond ring. Then that diamond ring will look like it's breaking-up into a string of beads (known as Baily's Beads).

Why does the light, at the top of the eclipsing sun, look like a string of beads? Because the Moon doesn't have a smooth surface. Its rough terrain, at this stage of the eclipse, makes the remaining light appear like a series of beads.

Next ... and this is what makes a total eclipse so spectacular ... we can see the pearly glow of the Sun's corona (with its pink and red light coming from the chromosphere's hydrogen gas). Together, the corona and the chromosphere make up the Sun's outer atmosphere—and—a total eclipse is the only time we can see that outer atmosphere.

Wow!

That "wow!" period is known as "totality." It's an amazing thing to see!

Let's dive a little further into the details of a total solar eclipse, starting with some facts about the Moon's path around Earth.

Every 29.5 days, the Moon makes that trip. We don't get a solar eclipse every month, though, because the Moon's orbit isn't in line with Earth's orbit. It's tilted about 5.1 degrees.

That degree of tilt might not seem like much, but this NASA animation shows us what happens when we apply the accurate distance between the Earth and Moon. Most of the time, the Moon's shadow doesn't fall over the Earth.

What's happening when we do get an eclipse? There are two points when the Moon's orbit crosses the Sun's plane. These points are called "Nodes." As the Earth makes its annual orbit around the Sun, those Nodes line-up with the Sun about twice a year:

- When the Moon passes between the Sun and Earth, at that time, we get a solar eclipse.
- When it's behind Earth, at that time, we get a lunar eclipse.

So—whether the eclipse is lunar or solar depends on the Moon's location when it reaches the Nodes.

We usually get some sort of lunar and solar eclipses every year. That is not to say, however, that those yearly eclipses are total eclipses. And we're far more likely to *see* a total lunar eclipse than a total solar eclipse.

A total lunar eclipse can last around an hour. A total solar eclipse is over in a few minutes. The "Great American Eclipse of 2017," for example, will last 2 minutes and 43 seconds at its point of longest duration. Its path of totality, measuring about 70 miles wide, will stretch across the US from Oregon to South Carolina.

The path of totality shows the eclipse track moving across America from West to East. Why is that? NASA provides a succinct answer (in its list of FAQs):

> *Because the Moon moves to the east in its orbit at about 3,400 km/hour. Earth rotates to the east at 1,670 km/hr at the equator, so the lunar shadow moves to the east at 3,400 – 1,670 = 1,730 km/hr near the equator. You cannot keep up with the shadow of the eclipse unless you traveled at Mach 1.5.*

On average, there's a total solar eclipse every eighteen months—but—each one of those solar eclipses is only viewable by less than half-a-percent of Earth's surface. That's because the Earth has so much water—71% of the Earth's surface—in its five oceans.

In a total solar eclipse, the Moon precisely covers the Sun from the vantage point of someplace on Earth. This is possible because the Sun and the Moon appear to be about the same size in our sky. They are far from the same size, however.

The Sun is about 400 times bigger than the Moon, but it's also about 400 times farther away. That helps to explain why the Sun and the Moon appear to be about the same size. But this alignment isn't constant. The Moon has an elliptical orbit and the size of that orbit varies about 12% throughout the month.

When the Moon's orbit is closer to Earth, we can get total solar eclipses. But less than 30% of solar eclipses—26.7% to be more precise—are total eclipses. More frequently, we get:

- Partial solar eclipses (35.3%) when the alignment—between the Earth and the Moon—is a bit off; or
- Annular solar eclipses (33.2%) when the Moon is too far away to fully block the Sun (leaving just a ring of fire around the Sun).

Far into the future, Earth will only get partial and annular eclipses because the Moon is moving away from the Earth at about 3.2 cm every year. That may not seem like much, but over time it adds up.

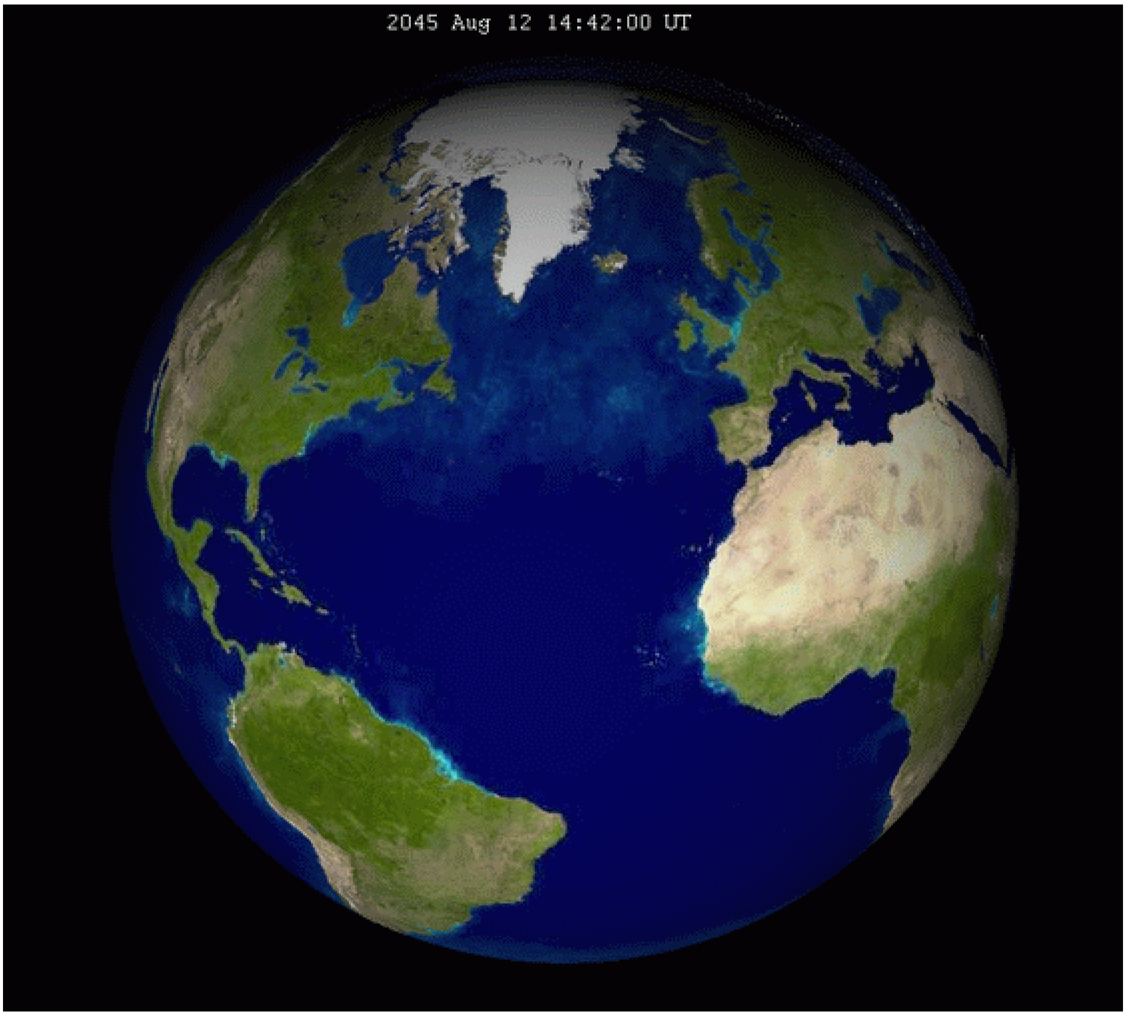
How do we know that the Moon is moving further away from our Earth? Because Apollo astronauts, like Neil Armstrong and Buzz Aldrin, left mirrors on the Moon. Astronomers bounce lasers off those mirrors, to measure the Moon's distance from Earth, and that's how they've realized that the Moon is moving away from us.

At some time in the future, therefore, the Earth will have its last total solar eclipse. But on August 21, 2017, people in America saw quite a spectacle as the Moon's shadow moved from the Pacific to the Atlantic coast. NOAA's satellites captured the whole event (which we can see in this time-compressed video).

Today, seeing a total solar eclipse is an exciting experience, but people who lived in ancient times viewed those events quite differently. They weren't sure what was happening and viewed them as omens or events causing dreadful consequences. A total solar eclipse, for example, was considered as an attack on the Sun by the "forces of darkness."

The next visible total solar eclipse is predicted for July 2, 2019 where it will be viewable to people in the South Pacific and in the southern part of South America.

The next visible total solar eclipse, viewable in North America, will occur on April 8, 2024. That eclipse, however, will not traverse the contiguous United States from west to east. For that event, we have to wait until August 12, 2045.



One of the most-famous, and most-significant, solar eclipses occurred in 1919. That's when a total solar eclipse proved that Albert Einstein's thought experiment, which he called his "Theory of General Relativity," was ... right!

Credits:

Images, used in this story, are online via NASA (unless otherwise noted):

Moon's shadow falls on Earth during a solar annular eclipse in May of 2012. The photo was captured when the Lunar Reconnaissance Orbiter turned its camera away from the Moon toward Earth. Image Credit: Centre National d'Etudes Spatiales (CNES).

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