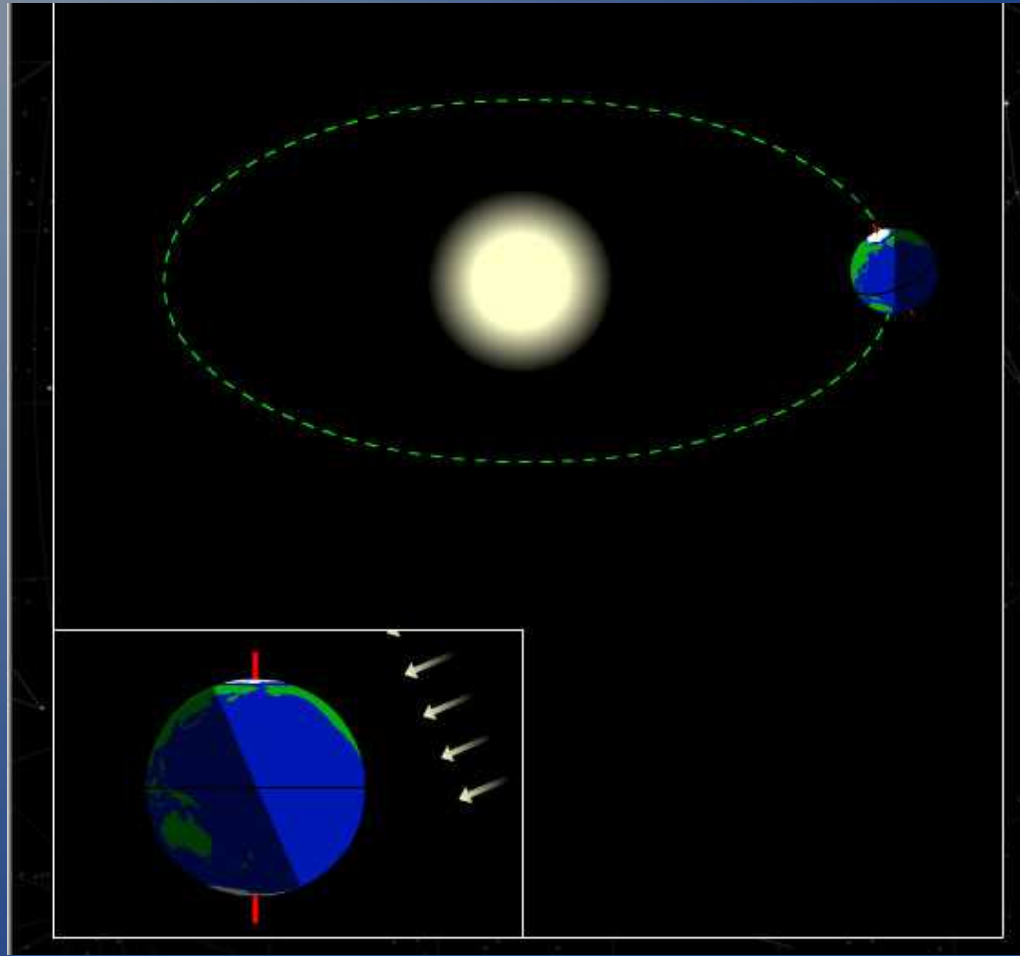


The Cause of the Seasons



- **Seasons** are caused by the Earth's axis tilt, *not* the distance from the Earth to the Sun!

Axis tilt changes directness of sunlight during the year.

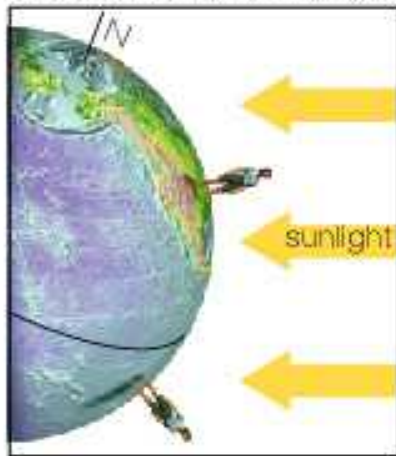


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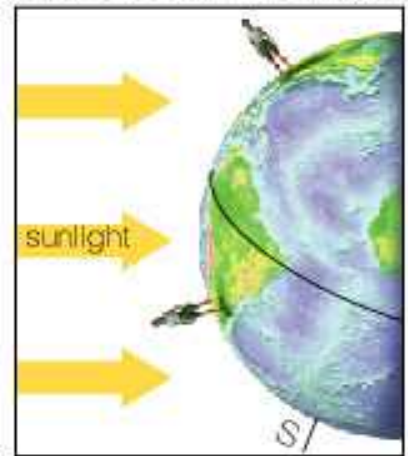
Why Does Flux Sunlight Vary

The Cause of the Seasons

Sunlight striking the Northern Hemisphere is concentrated in a smaller area (note the smaller shadow) than the same amount of sunlight striking the Southern Hemisphere.

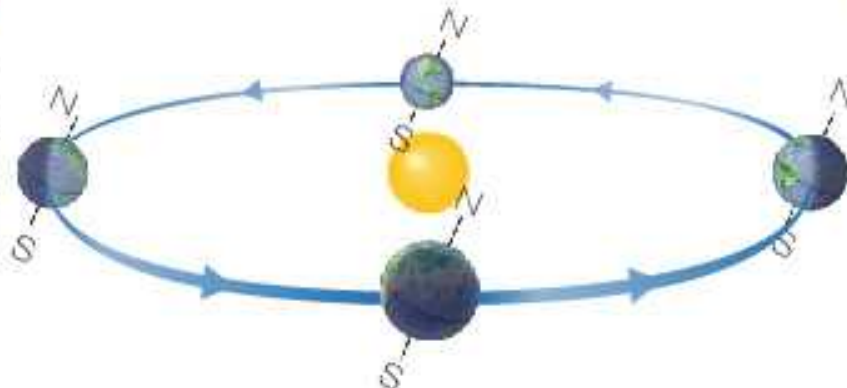


The situation is reversed from the summer solstice, with sunlight striking a smaller area in the Southern Hemisphere (note the smaller shadow) than in the Northern Hemisphere.



1. Spring Equinox

Spring begins in the Northern Hemisphere, fall in the Southern Hemisphere.



2. Summer Solstice

Summer begins in the Northern Hemisphere, winter in the Southern Hemisphere.

4. Winter Solstice

Winter begins in the Northern Hemisphere, summer in the Southern Hemisphere.

3. Fall Equinox

Fall begins in the Northern Hemisphere, spring in the Southern Hemisphere.

Seasonal Change in Sun's Altitude

- The “Figure 8” shows Sun at same time each day over a year.

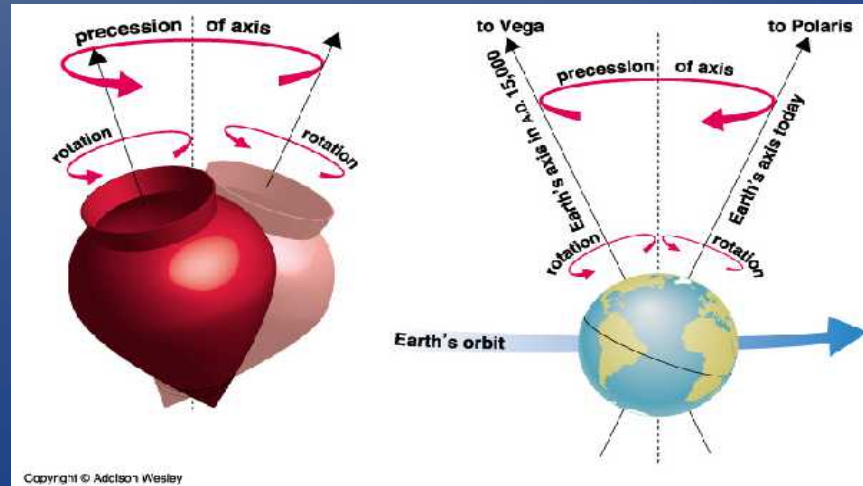


When is summer?

- The solstice which occurs around June 21 is considered the first day of summer.
- It takes time for the more direct sunlight to heat up the land and water.
- Therefore, July & August are typically hotter than June.

Precession of the Equinoxes

- The Earth's axis precesses (wobbles) like a top, once about every 26,000 years.
- Precession changes the positions in the sky of the celestial poles and the equinoxes.
 - ⇒ *Polaris* won't always be the north star.
 - ⇒ The spring equinox, seen by ancient Greeks in *Aries*, moves westward and is now in *Pisces*!



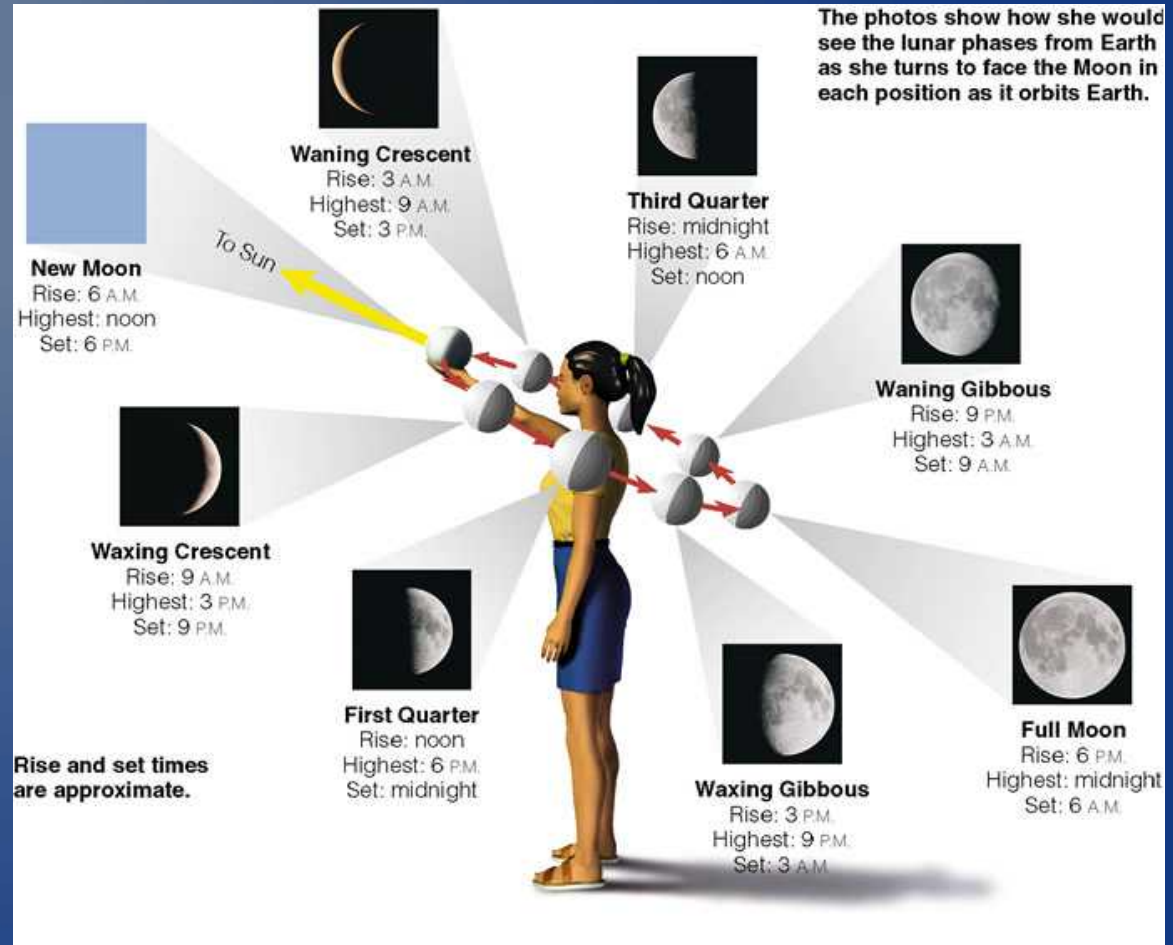
Why doesn't orbital distance from the Sun matter?

- Small variation for Earth — about 3% (but orbit distance *does* matter for some other planets, notably Mars and Pluto).
- Surprisingly, seasons are more extreme in N. hemisphere, even though Earth is closer to Sun in S. hemisphere summer (and farther in S. hemisphere winter) – Why?



Phases of Moon

- Half of the Moon is illuminated by the Sun and half is dark.
- We see a changing combination of the bright and dark faces as the Moon orbits Earth.

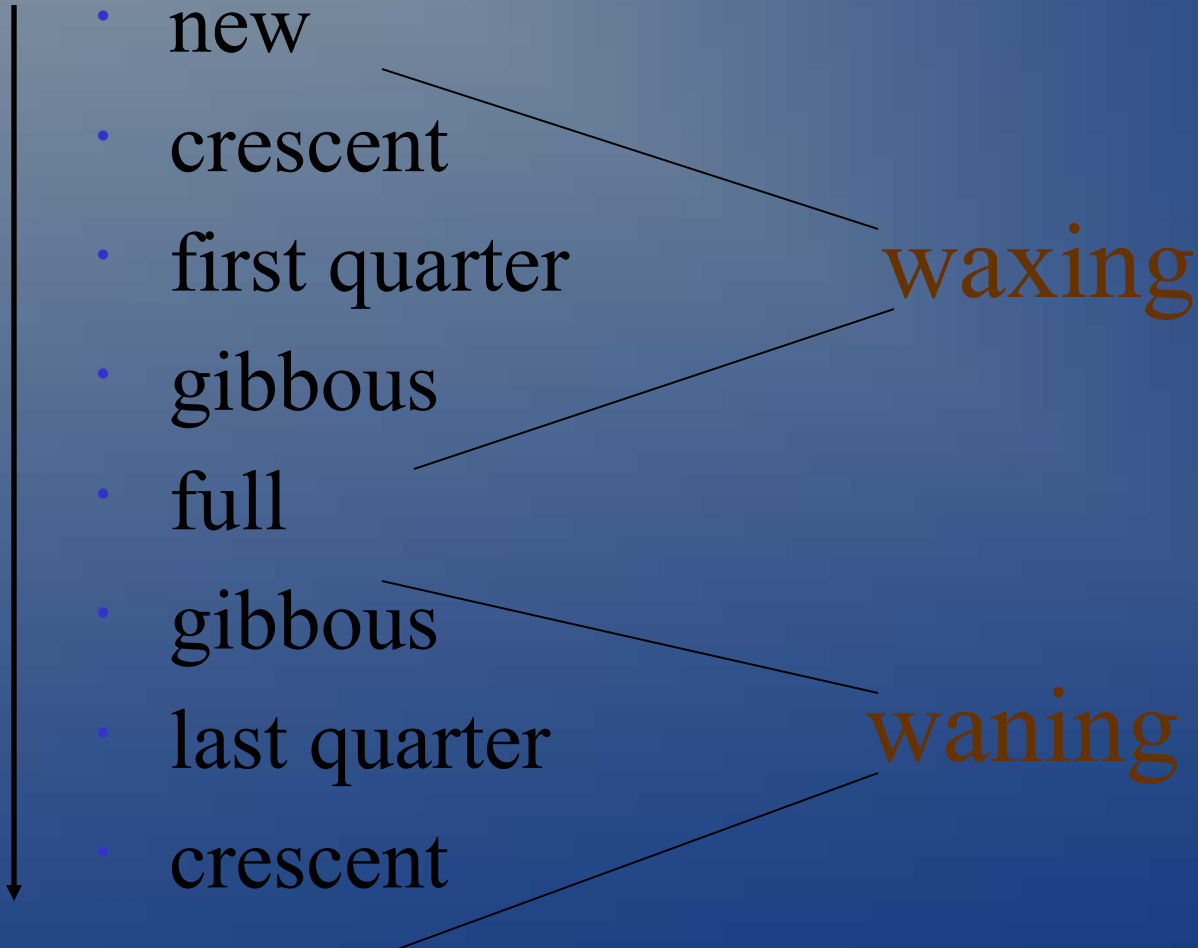


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How to Simulate Lunar Phases

Lunar Motion

Phases of the Moon's 29.5 day cycle



We see only one side of the Moon



Synchronous rotation:
The Moon rotates exactly
once with each orbit.

This is why only one side
is visible from Earth.

Thought Question

It's 9 A.M. You look up in the sky and see a moon with half its face bright and half dark.

What phase is it?

- A. First quarter
- B. Waxing gibbous
- C. Third quarter
- D. Half moon

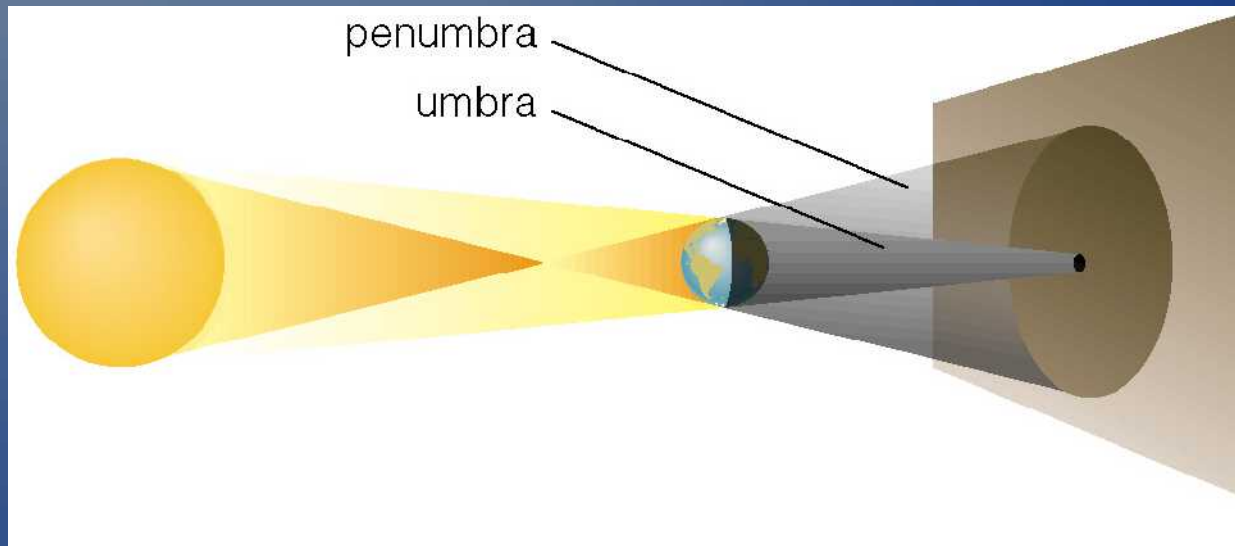
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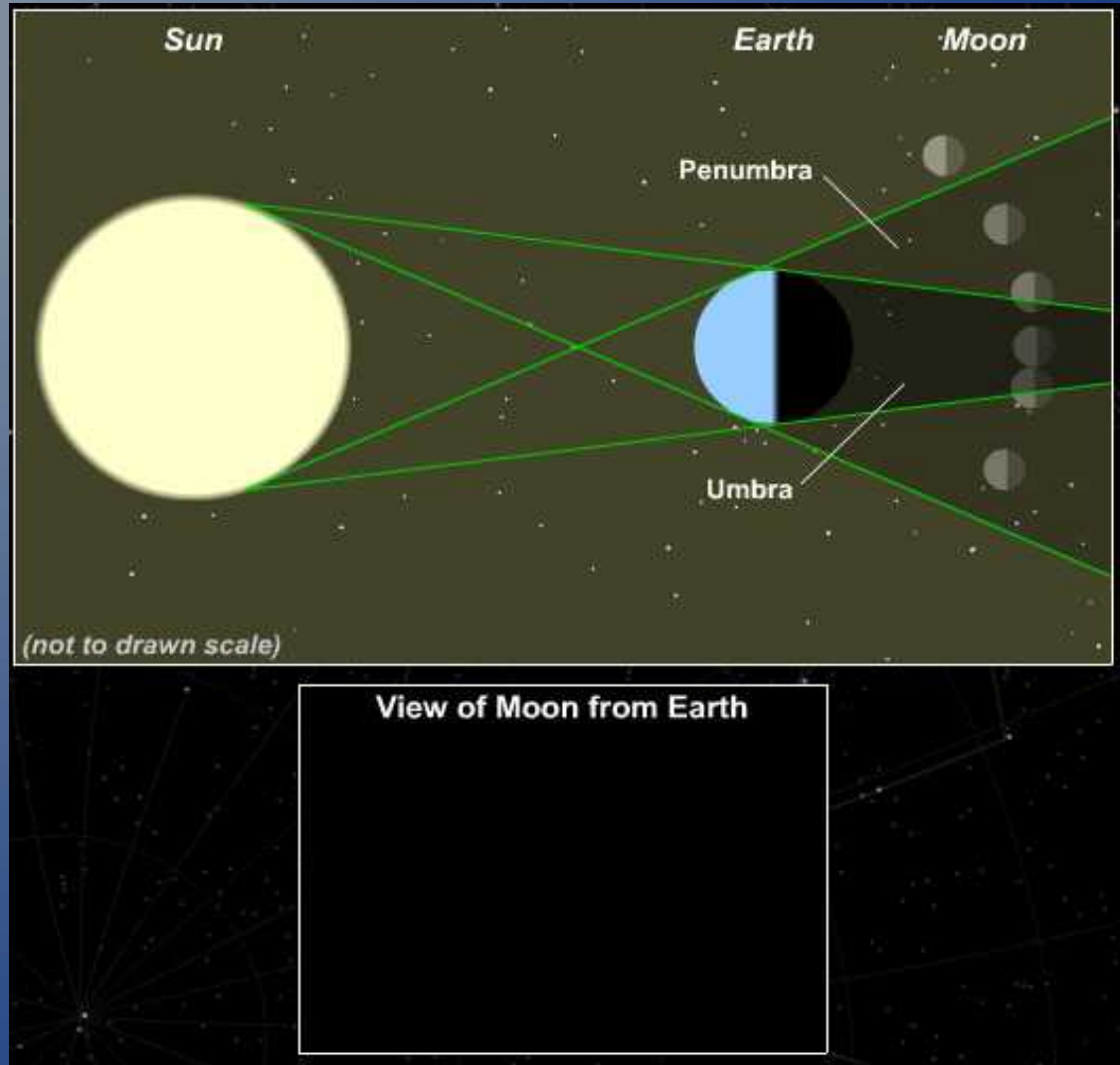
- A. First quarter
- B. Waxing gibbous
- C. **Third quarter**
- D. Half moon

What causes eclipses?

- The Earth and Moon cast shadows.
- When either passes through the other's shadow, we have an **eclipse**.



Lunar Eclipse

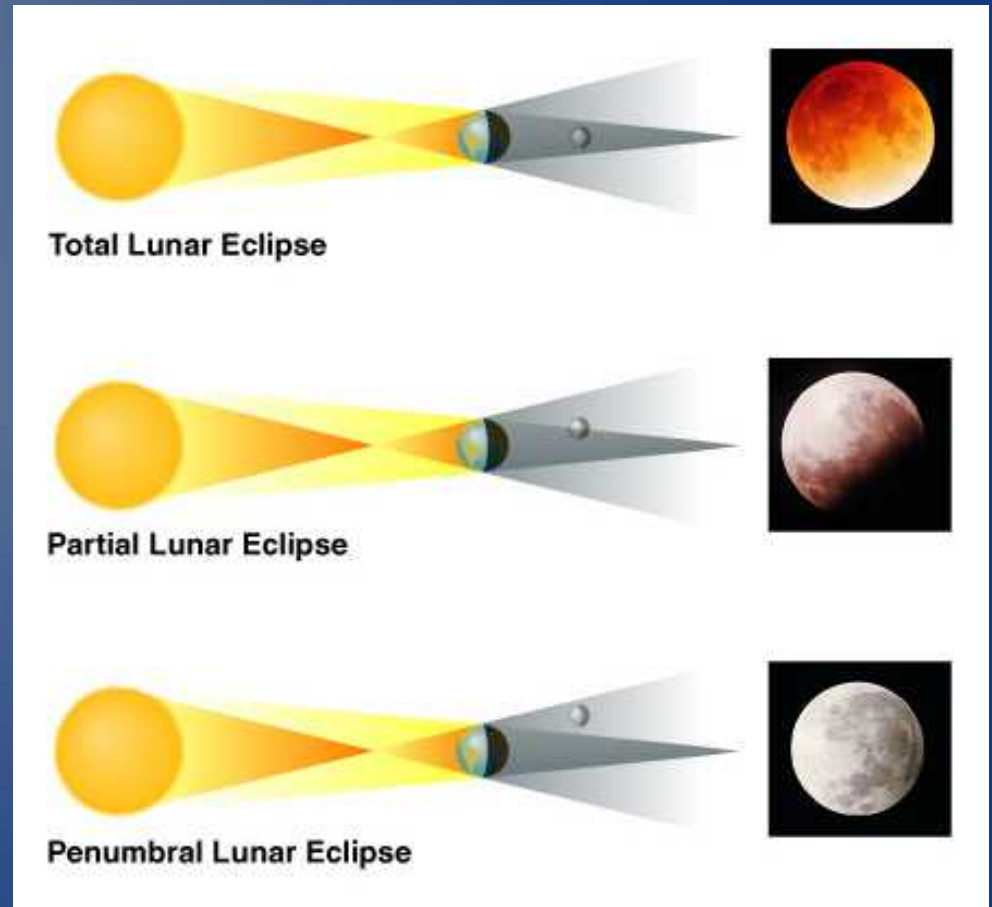


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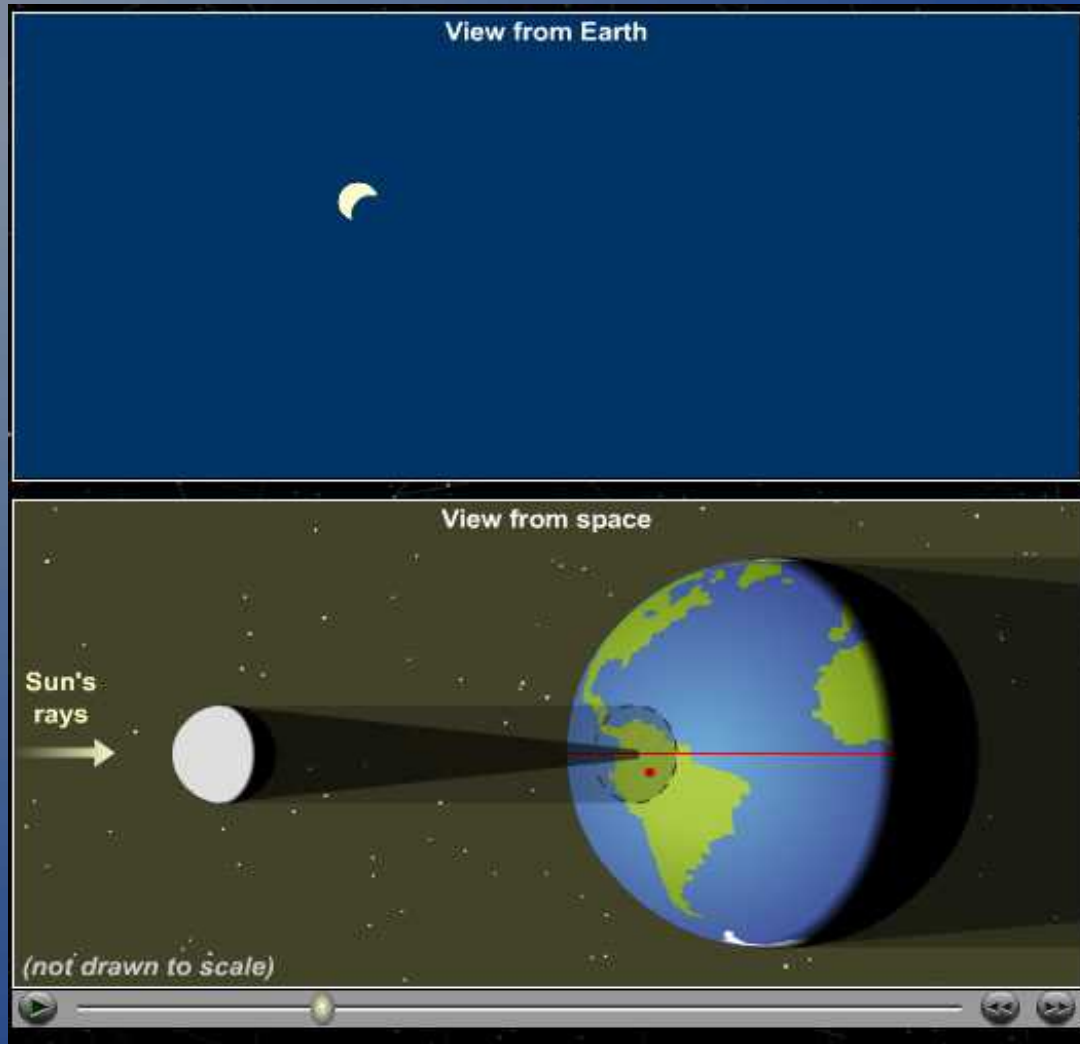
Lunar Eclipse

When can eclipses occur?

- **Lunar eclipses** can occur only at *full moon*.
- Lunar eclipses can be **penumbral**, **partial**, or **total**.



Solar Eclipse

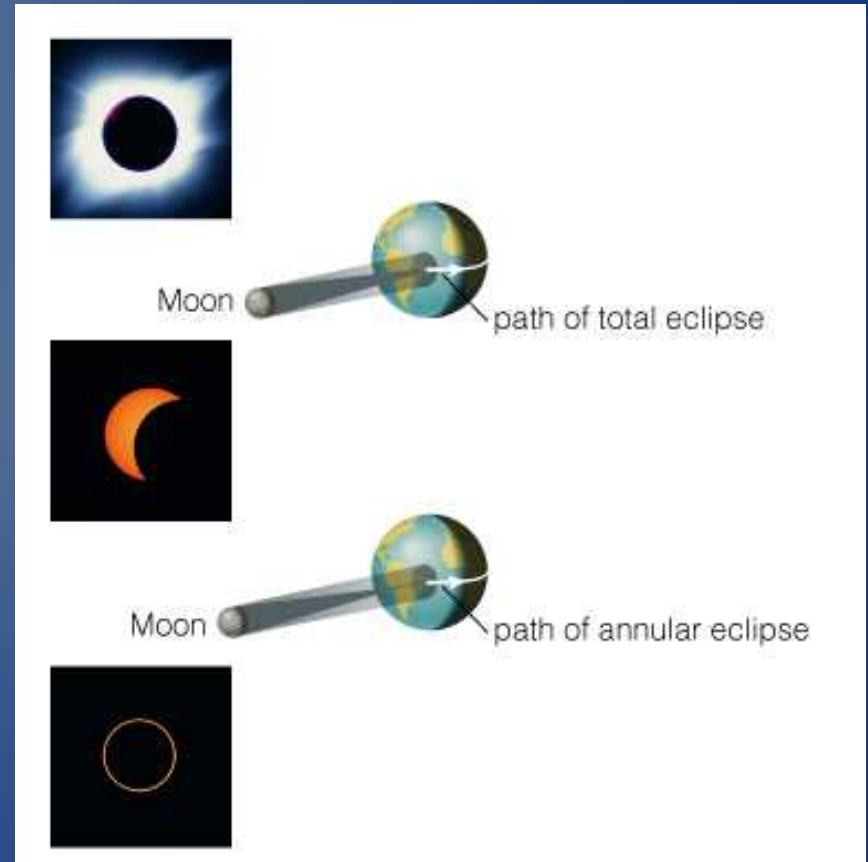


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Evolution of a Total Solar Eclipse

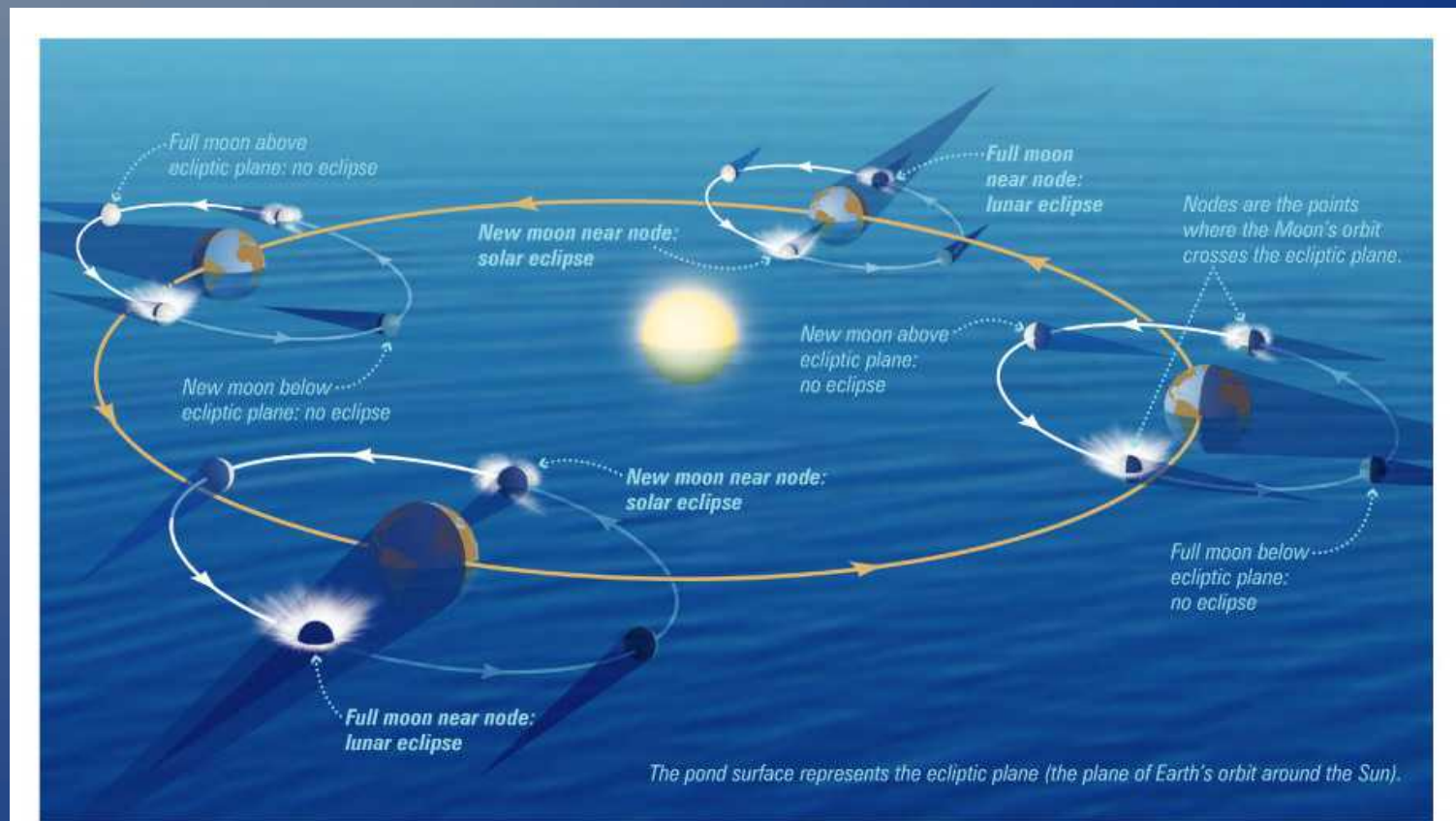
When can eclipses occur?

- **Solar eclipses** can occur only at *new moon*.
- Solar eclipses can be **partial**, **total**, or **annular**.



Why don't we have an eclipse at every new and full moon?

- The Moon's orbit is tilted 5° to ecliptic plane.
- So we have about two **eclipse seasons** each year, with a lunar eclipse at new moon and solar eclipse at full moon.



Summary: Two conditions must be met to have an eclipse:

1. It must be a full moon (for a lunar eclipse) or a new moon (for a solar eclipse).

AND

2. The Moon must be at or near one of the two points in its orbit where it crosses the ecliptic plane (its nodes).

Eclipse Predictions

- Eclipses recur in the approx. 18 yr, 11 1/3 day **saros cycle**
- But even then, eclipse location and type (e.g., partial, total) may vary

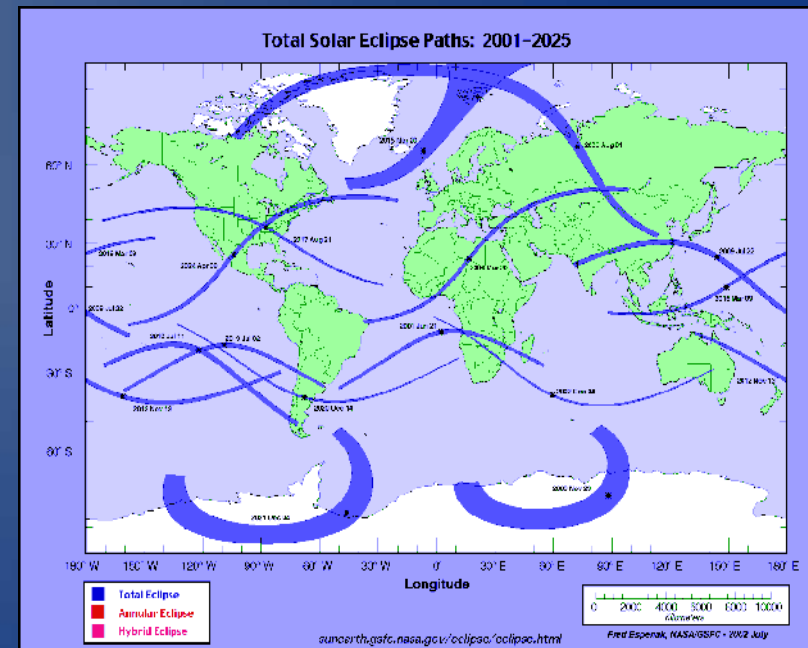
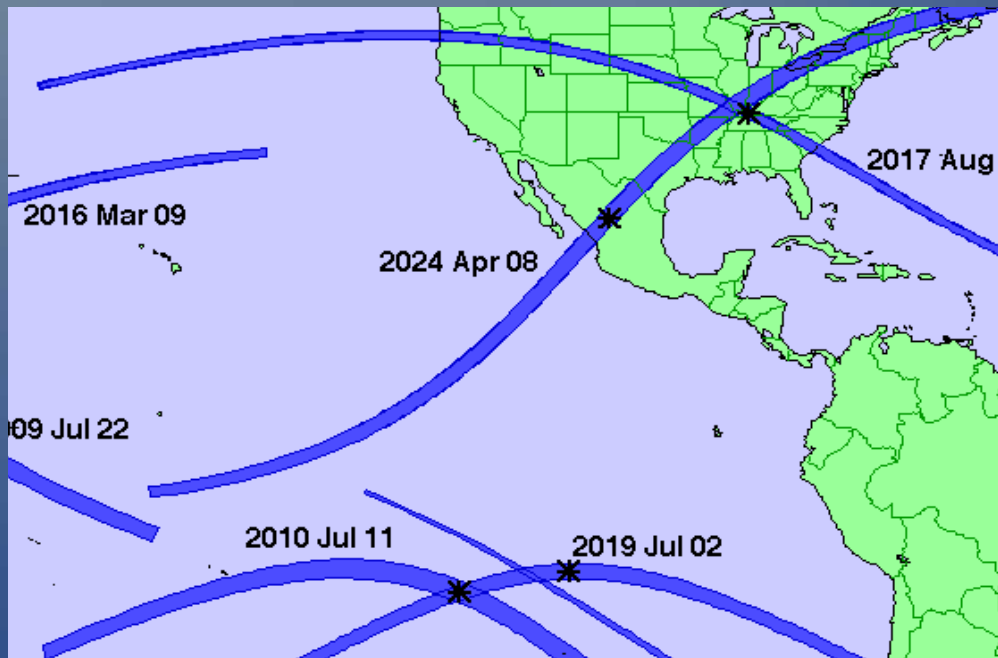




Photo by Olaf Menkens (1999 Mauna Loa)

What have we learned?

- What is a **constellation**?
 - A constellation is a region of the sky. The sky is divided into 88 official constellations.
- What is the **celestial sphere**?
 - An imaginary sphere surrounding the Earth upon which the stars, Sun, Moon, and planets appear to reside.
- Why do we see a band of light called the *Milky Way* in our sky?
 - It traces the Galactic plane as it appears from our location in the *Milky Way Galaxy*.

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What have we learned?

- Why do we see phases of the Moon?
 - At any time, half the Moon is illuminated by the Sun and half is in darkness. The face of the Moon that we see is some combination of these two portions, determined by the relative locations of the Sun, Earth, and Moon during the Moon's 29.5 day cycle.
- What conditions are necessary for an eclipse?
 - An eclipse can occur only when the nodes of the Moon's orbit are nearly aligned with the Earth and the Sun. When this condition is met, we can get a solar eclipse at new moon and a lunar eclipse at full moon.