

# Announcements

- **Quiz 1 due tonight**
- Office hours 1-2 pm today
- Reminder: Supplemental Instruction (SI) review sessions in the Library E170
  - Mondays 3-4 pm
  - Tuesdays 11 am-12 pm
  - Wednesdays 3-4 pm
  - Fridays 10-11 am and 2-3 pm

# Planetarium this week

- Last names A-K Wednesday
- Last names L-Z Friday
- Across hall from Physics 137
- **Door locks so be on time!**
- Assignment: Short 100-150 word summary of show, due in lecture after show you attend – must contain at least one fact!

# ASTRONOMY CLUB



- Astronomy activities
- Discuss current topics
- Paid research opportunities
  - Pulsar searching
  - Operate radio telescopes
  - \$10/hour

**Starts Monday February 3, 4 pm in Physics 142**  
**Meetings every Monday**

**Questions? [erbd@uwm.edu](mailto:erbd@uwm.edu) |   UWMAstroclub**

# Review

- Earth rotates about its axis in **1 day**
- Earth revolves around the sun in **1 year**
- Seasons are caused by 23.5 degree tilt of Earth's axis
  - Sunlight is more direct in summer
  - Days are longer in summer
- Orientation of Earth's axis changes on **26,000 year** cycle: precession
- Next: **1 month** cycle of Moon phases

# Astronomy 103

## The Phases of the Moon and Eclipses

Reading assignment: Sections 0.3-0.5

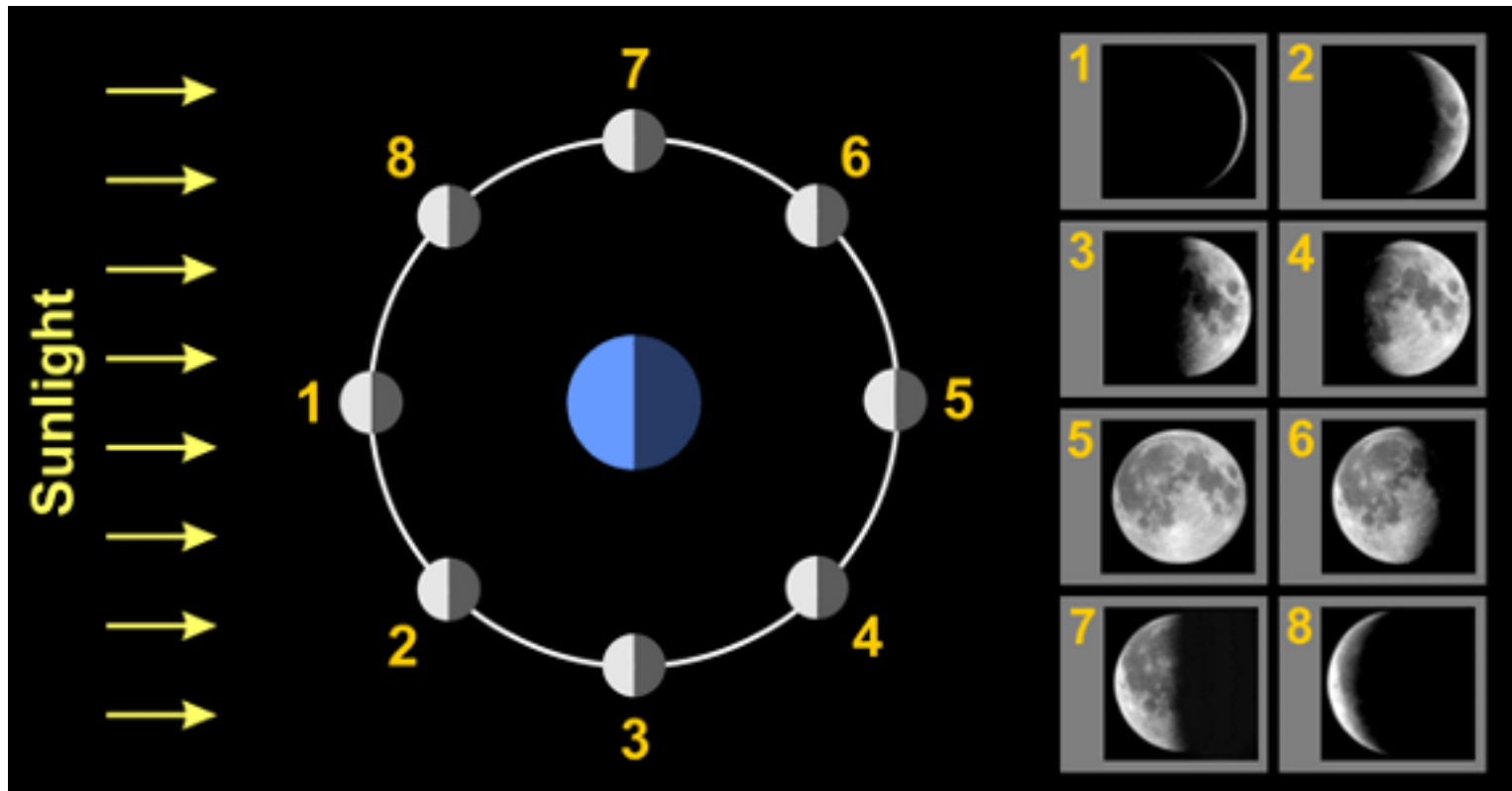
# Phases of the Moon

- Over the course of a month, the Moon changes in appearance
- Why?



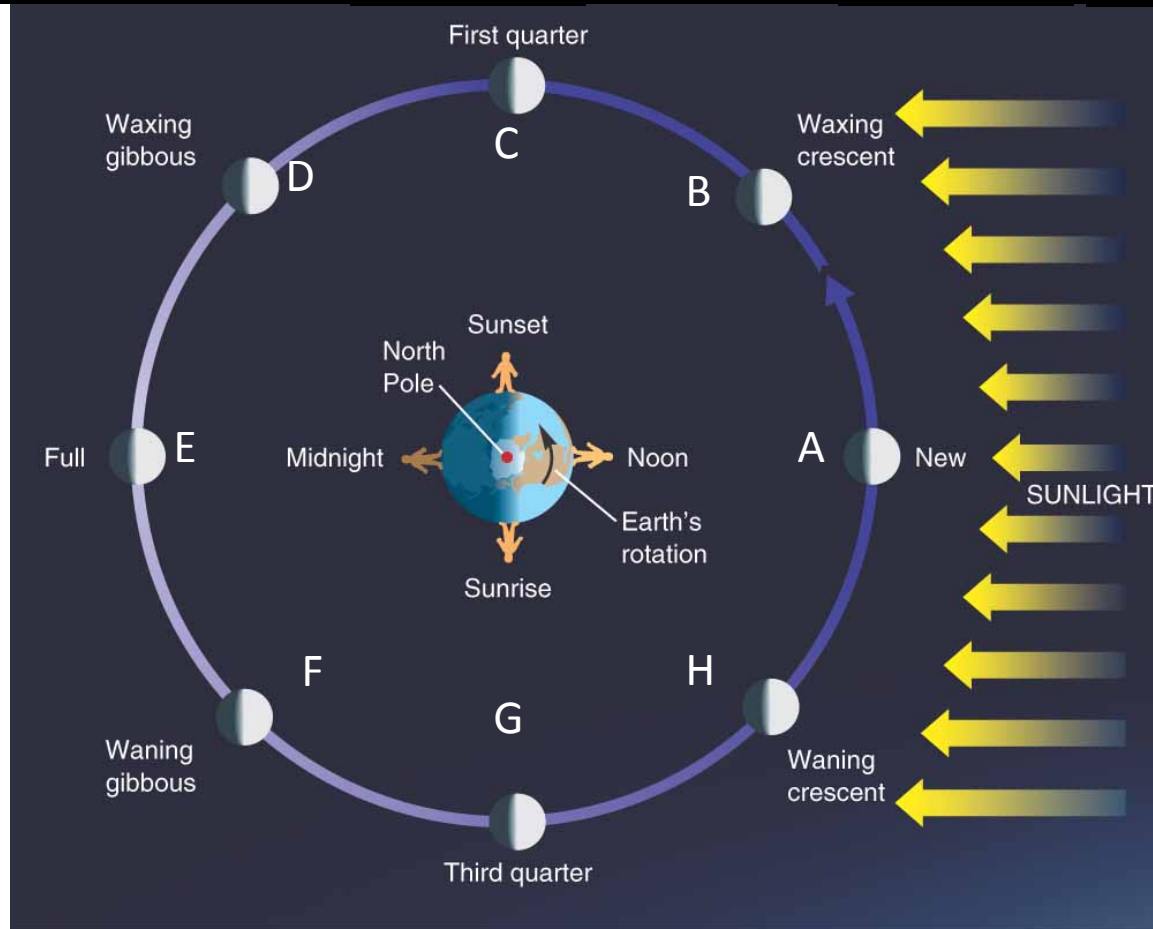
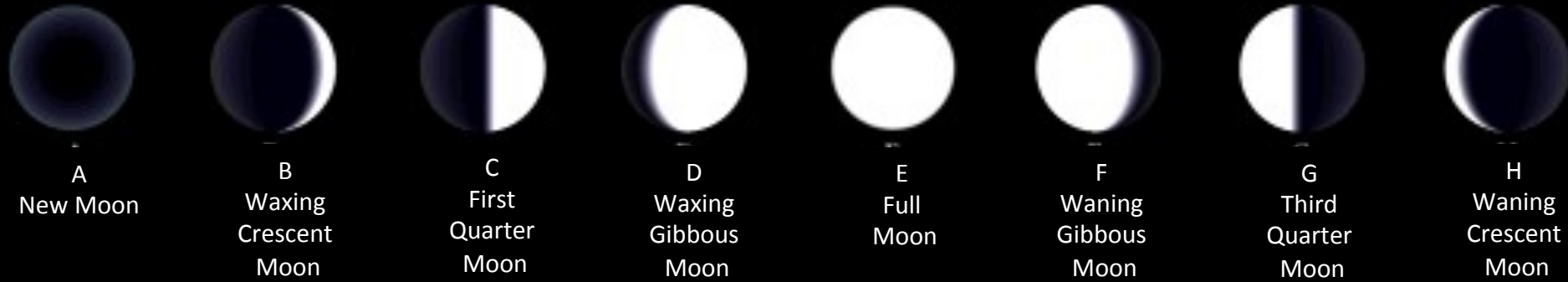
# Phases of the Moon

- Why does the Moon shine?
- **Reflected sunlight**
  - The side of the Moon facing the Sun is lighted
  - The side of the Moon facing away from the Sun is dark
- Moon orbits Earth in 1 month (29 days)



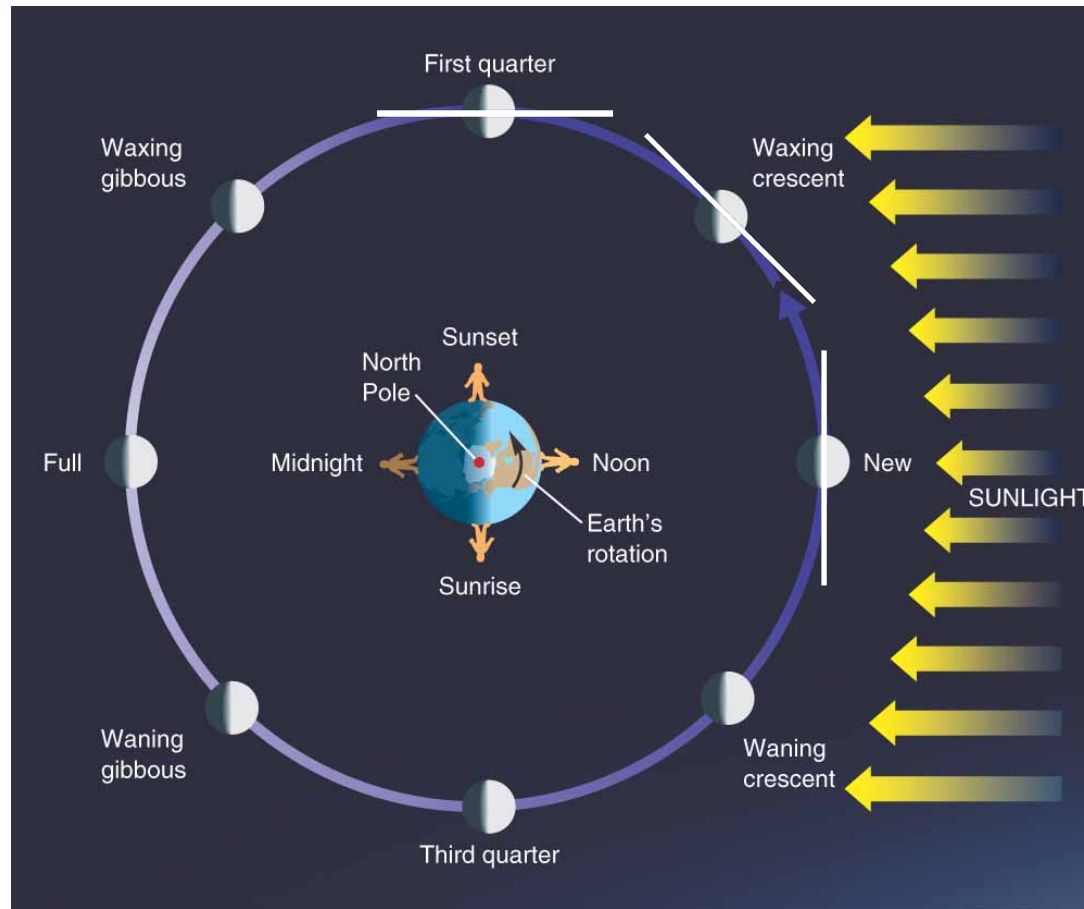
# The phase of the Moon is the result of its position in its orbit about the Earth:

## View of the moon as seen from earth





Here's the picture again, with lines drawn to show which part of the Moon faces the Earth.

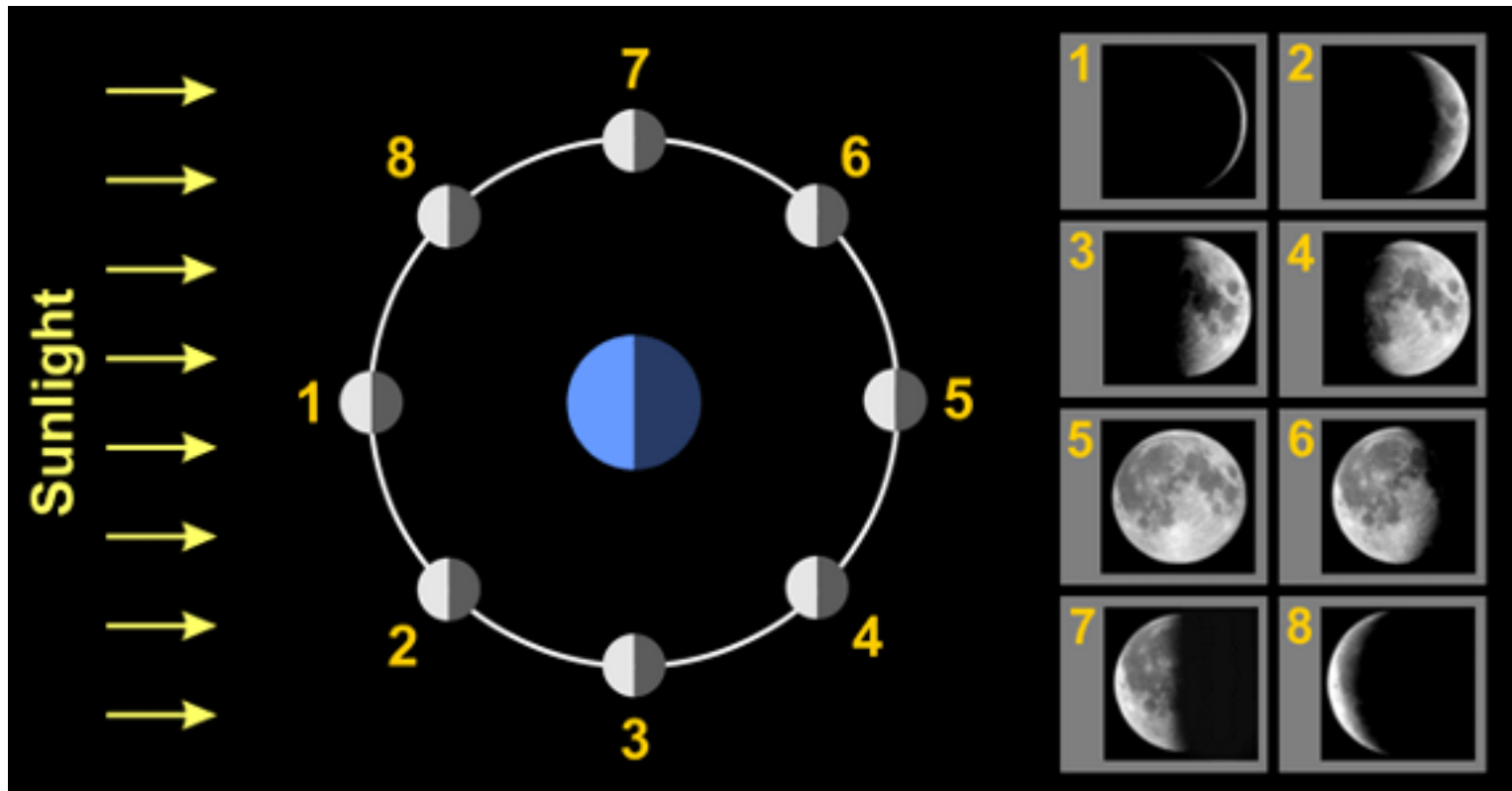


© 2004 Thomson/Brooks Cole

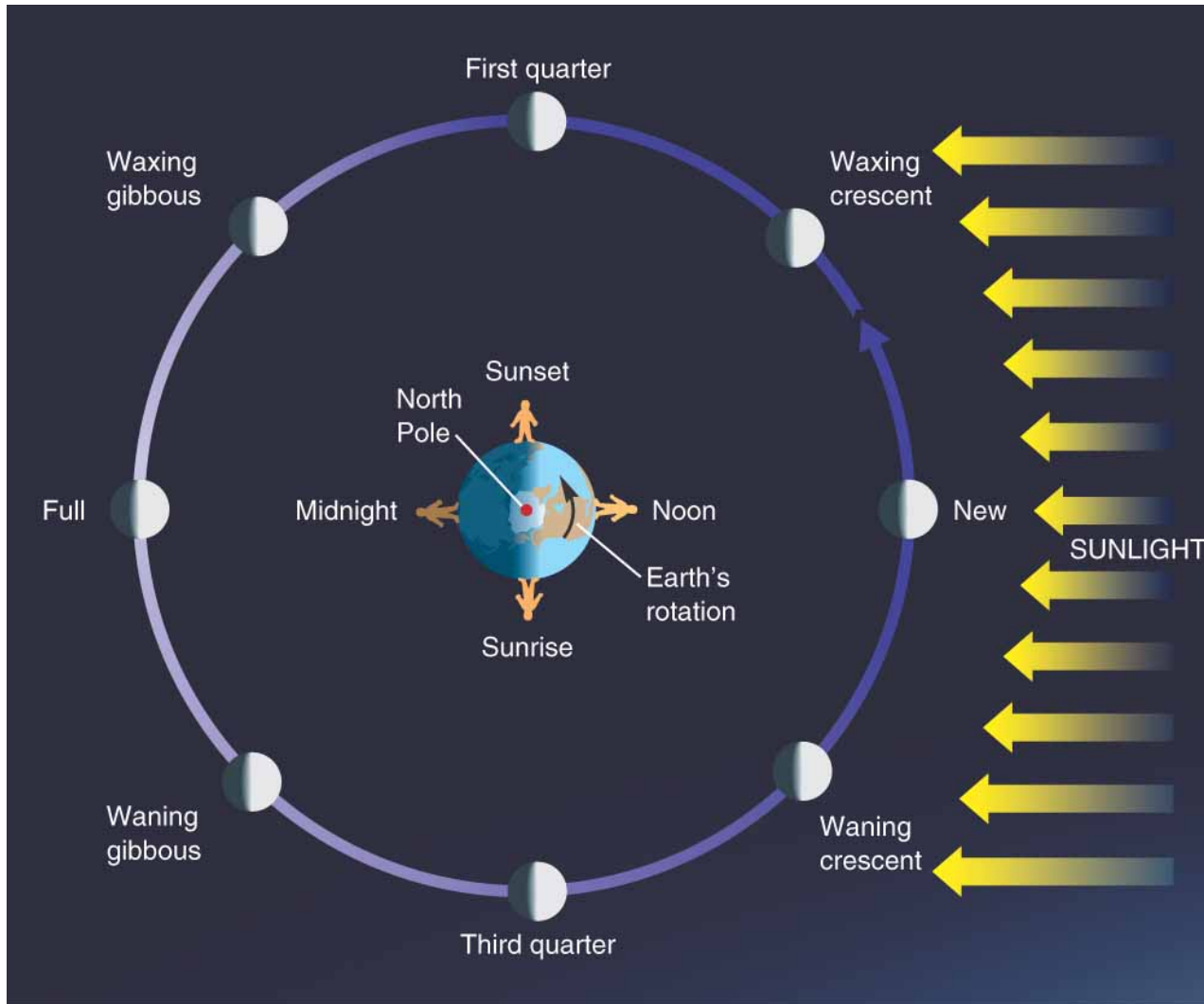
- Moon between Earth and Sun: dark side faces us — **new Moon**, we see no Moon at all
- A couple of days earlier or later, we see a sliver of the side of the Moon in sunlight—a **crescent**
- As the Moon moves in its orbit about the Earth, crescent grows larger. Seven days after new Moon (1/4 of the way around its orbit), half the side of the Moon facing us is lighted: We see a **half Moon**
- Because the size of the sunlit part of the Moon that we can see is increasing, we call it a **waxing half Moon**. When over half the Moon's disk is visible, we call it a **gibbous Moon**.

# Phases of the Moon

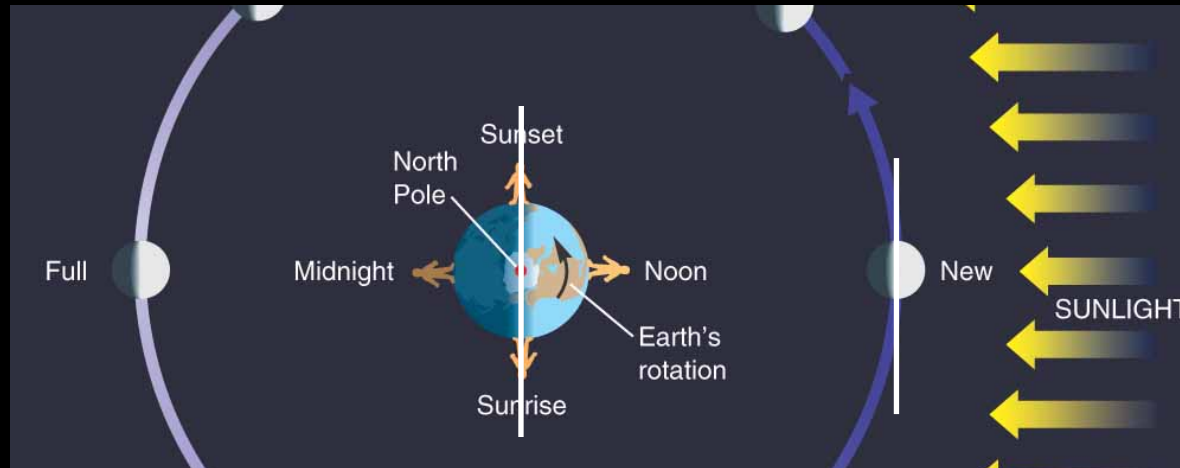
- Consider
  - Appearance of Moon from Earth
  - Time of day
- What is the relation between phase of Moon and time it rises and sets?



- Time on the Earth: Sun rises when we rotate out of shadow and into sunlight (when we are in the location labeled *Sunrise*)



# The relation between the phase of the Moon and the times it rises and sets

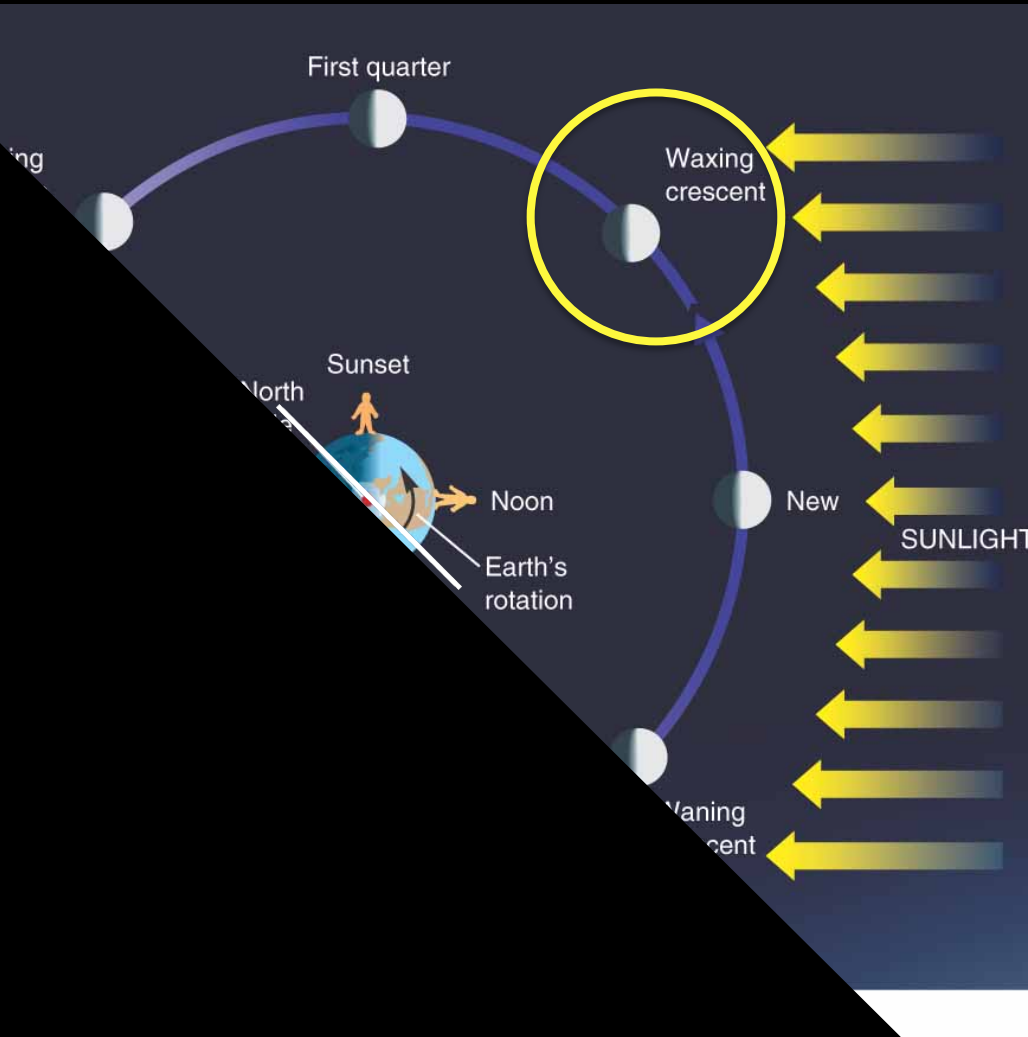


In these pictures, lines are drawn to show the part of the Earth from which the Moon is visible.

Here a new Moon is visible from the part of the Earth in sunlight. The new Moon rises at about 6 am and sets at about 6 pm:

None of the Moon's disk is visible, and it is up for none of the night.

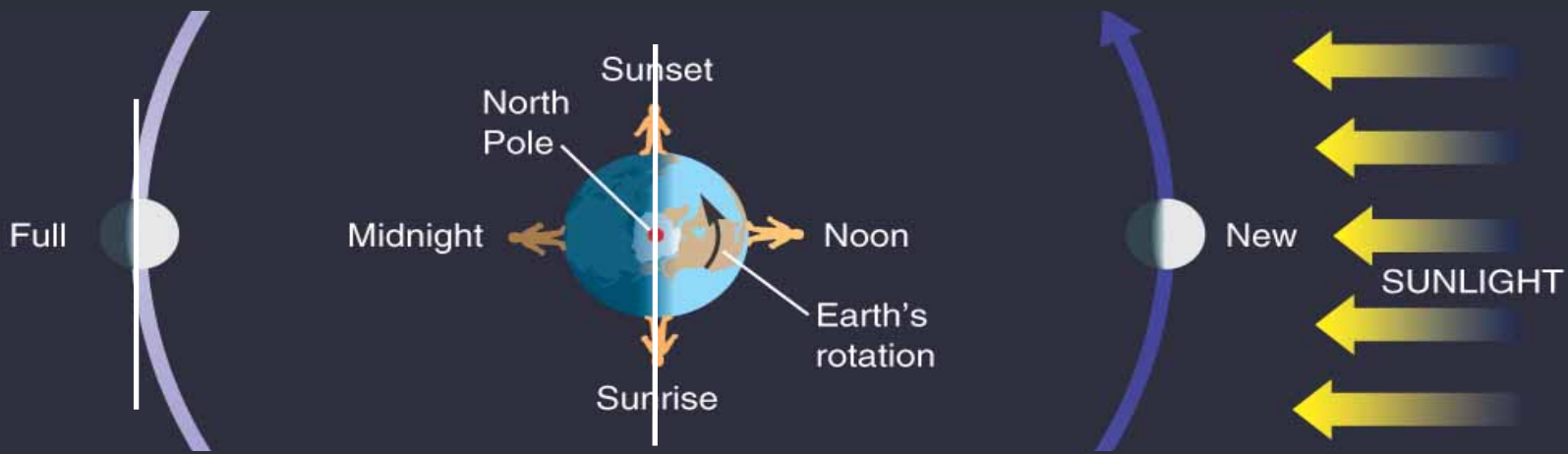
# The relation between the phase of the Moon and the times it rises and sets



Here for this waxing crescent moon, about  $\frac{1}{4}$  of the part of the Moon facing the Earth is in sunlight. And  $\frac{1}{4}$  of the part of the Earth that faces the Moon is in shadow:

When you look at the Moon, you see about  $\frac{1}{4}$  of a disk, and it is up for  $\frac{1}{4}$  of the night, setting at 9 pm (and rising at 9 am).

# Full Moon



Rises at Sunset  
Overhead at Midnight  
Sets at Sunrise

Summary:

**The fraction of the Moon's disk that is visible  
= the fraction of the night that the moon is up**

When the Moon is in the first part of its cycle (waxing) it is up for the first part of the night. When in the last part of its cycle (waning) it is up for the last part of the night.

What time is it when the new moon is highest in the sky?

A

Sunrise

B

Noon

C

Sunset

D

Midnight



# What time is it when the new moon is highest in the sky?

A

Sunrise

B

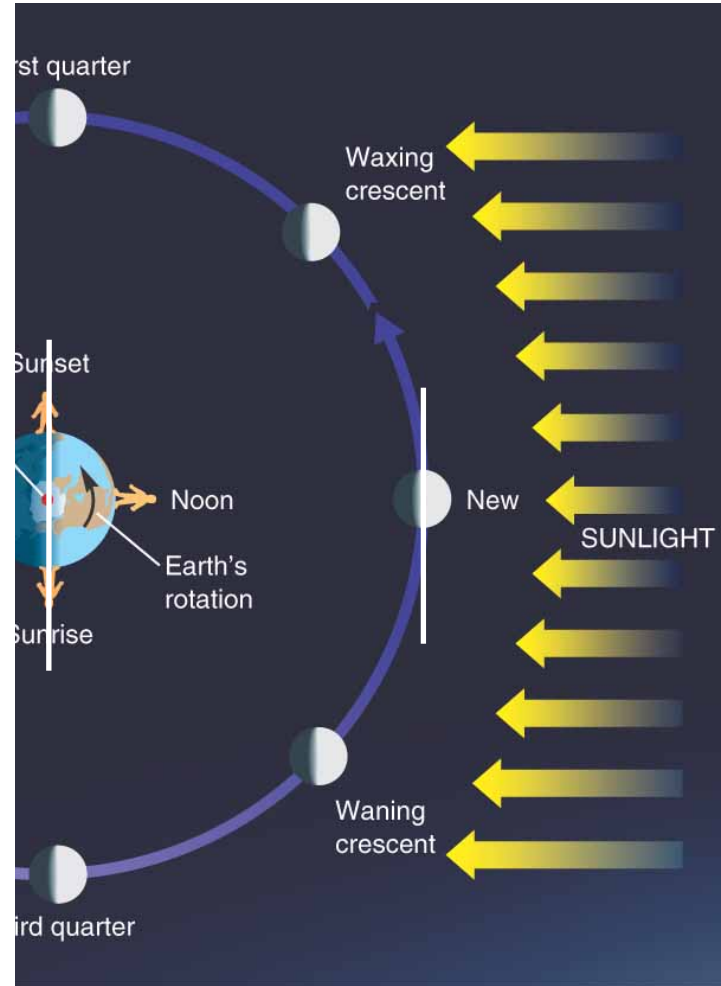
Noon

C

Sunset

D

Midnight



During the new moon phase, how much of the Moon's total surface is being illuminated by sunlight?

A

None

B

Less than half

C

Half

D

More than half

During the new moon phase, how much of the Moon's total surface is being illuminated by sunlight?

A

None

B

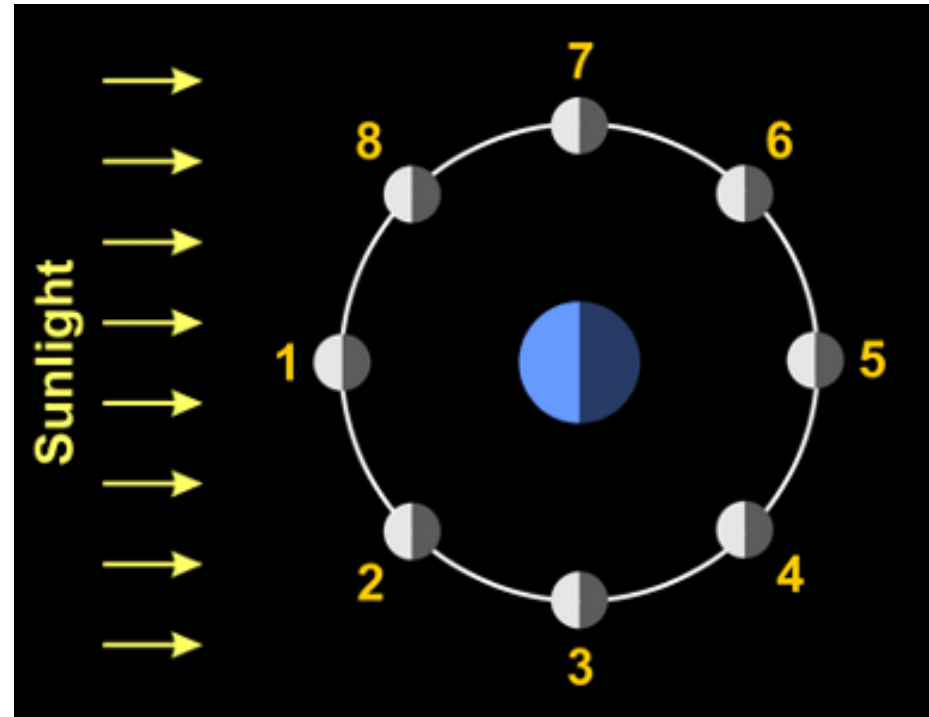
Less than half

C

Half

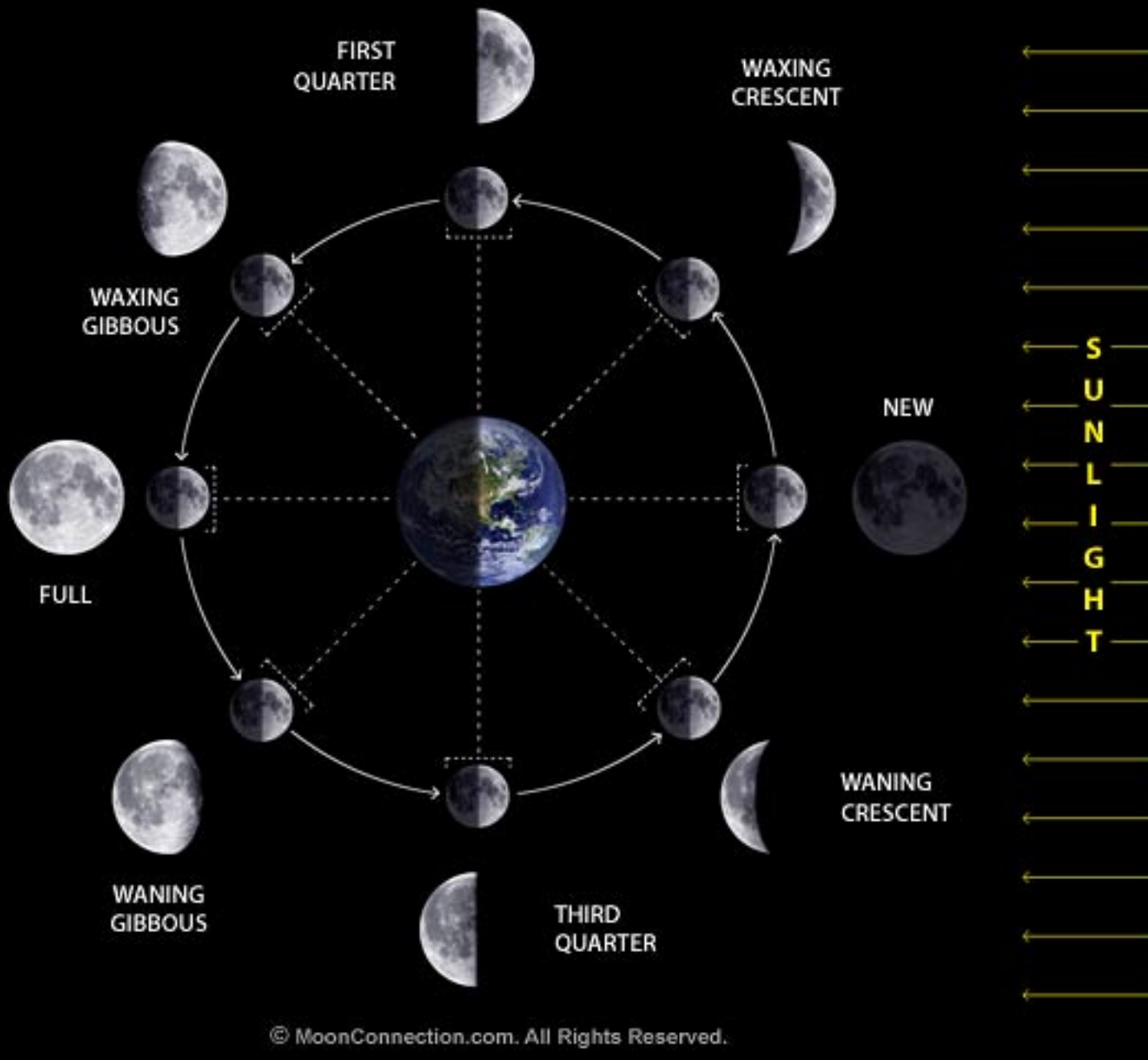
D

More than half



# Recap: Phases of the Moon

- Due to relative positions of Moon and Sun
- We see illuminated portion of Moon only
- Fraction of disk visible = fraction of night Moon is up

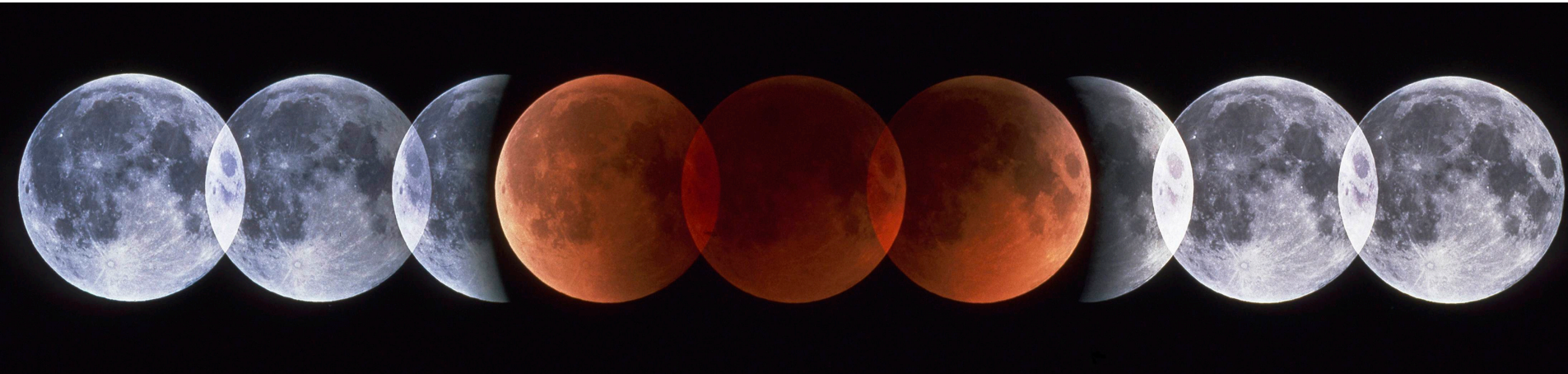


# Eclipses



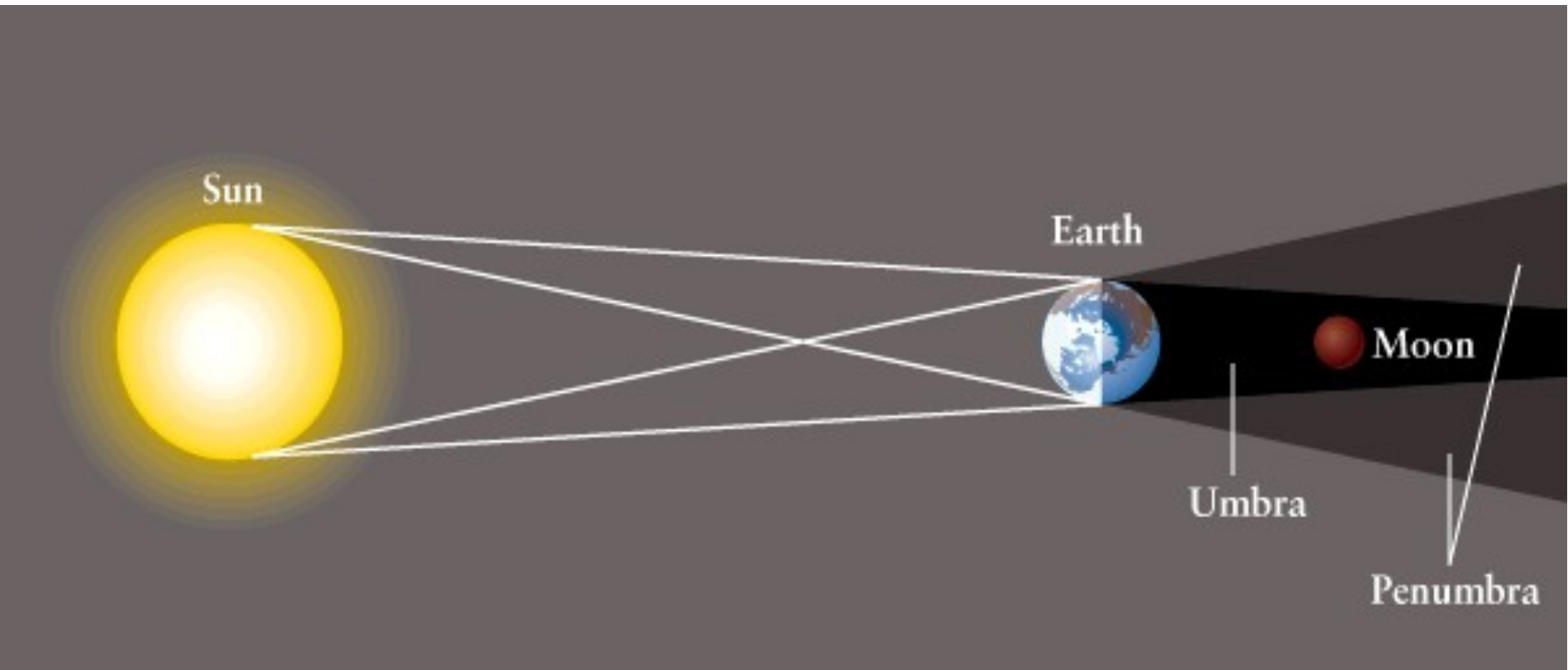
- **Solar eclipse:** Moon between Earth and Sun
- **Lunar eclipse:** Earth between Sun and Moon

# Lunar eclipse: Eclipse of the Moon



- Happens when Earth's shadow falls on Moon
- Can only happen when Moon and Sun are on opposite sides of the Earth
  - **Moon has to be full**

# Total eclipse of the Moon: Shadow of the Earth covers the Moon



Visible simultaneously from everywhere on night side of Earth

**Relative size of Moon and Earth:** Size of Earth's shadow is nearly the size of the Earth, because the Sun's rays are nearly parallel.

You see a sequence of images of the Moon during a period of about five hours. It moves about  $\frac{1}{2}^\circ$  each hour, taking about 3 hours to cross the Earth's shadow. You can see from the figure that the Earth's shadow has a diameter about 3 times the diameter of the Moon.

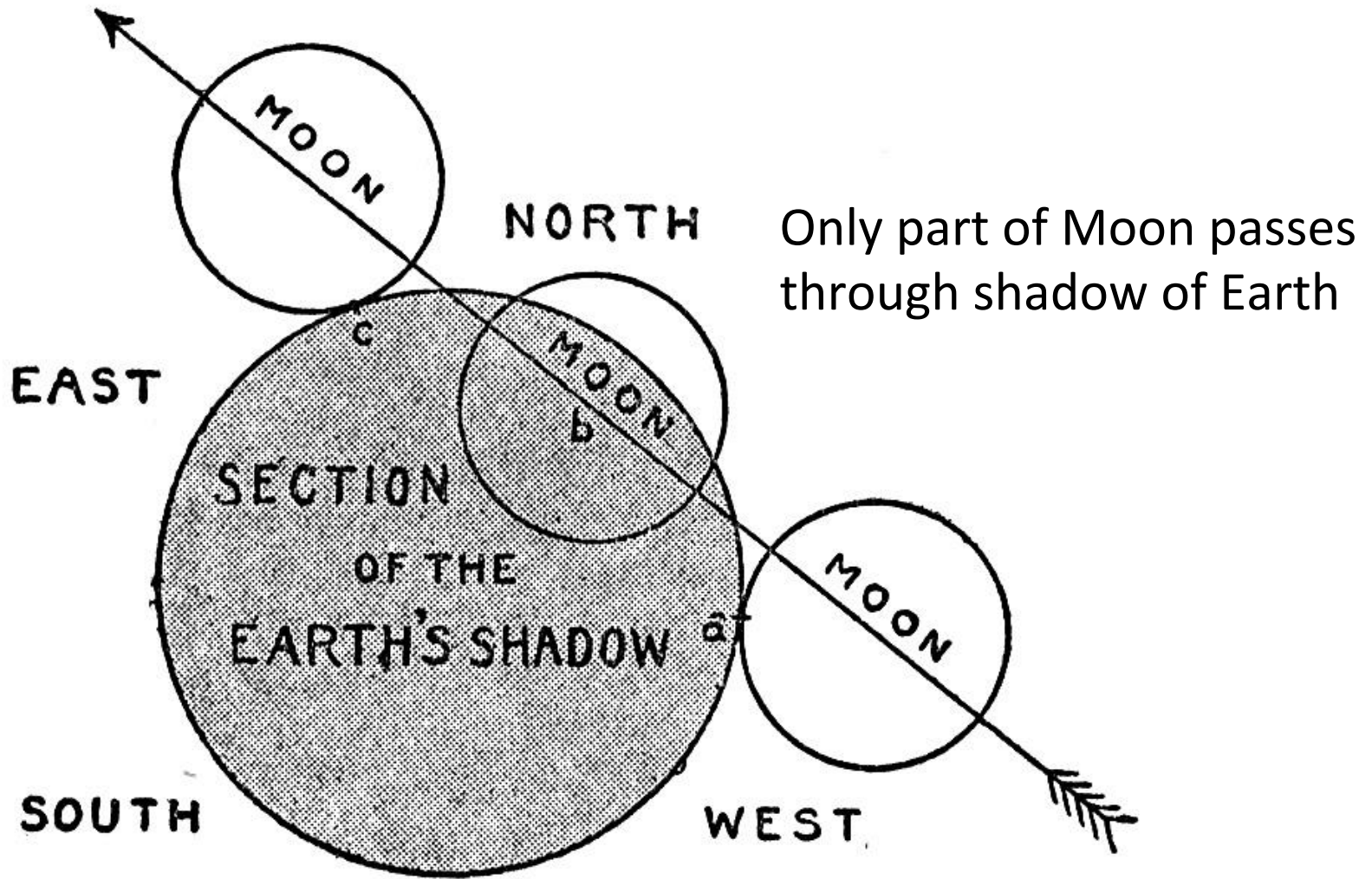


The Moon is reddish during the eclipse because it is lit by sunlight that nearly hits the Earth and is reddened as in a sunset as it goes through the Earth's atmosphere.

Amazingly, Aristarchus (310-230 BC) used the size of the Earth's shadow on the Moon to estimate that the moon's diameter was about  $\frac{1}{3}$  that of the Earth – about right.



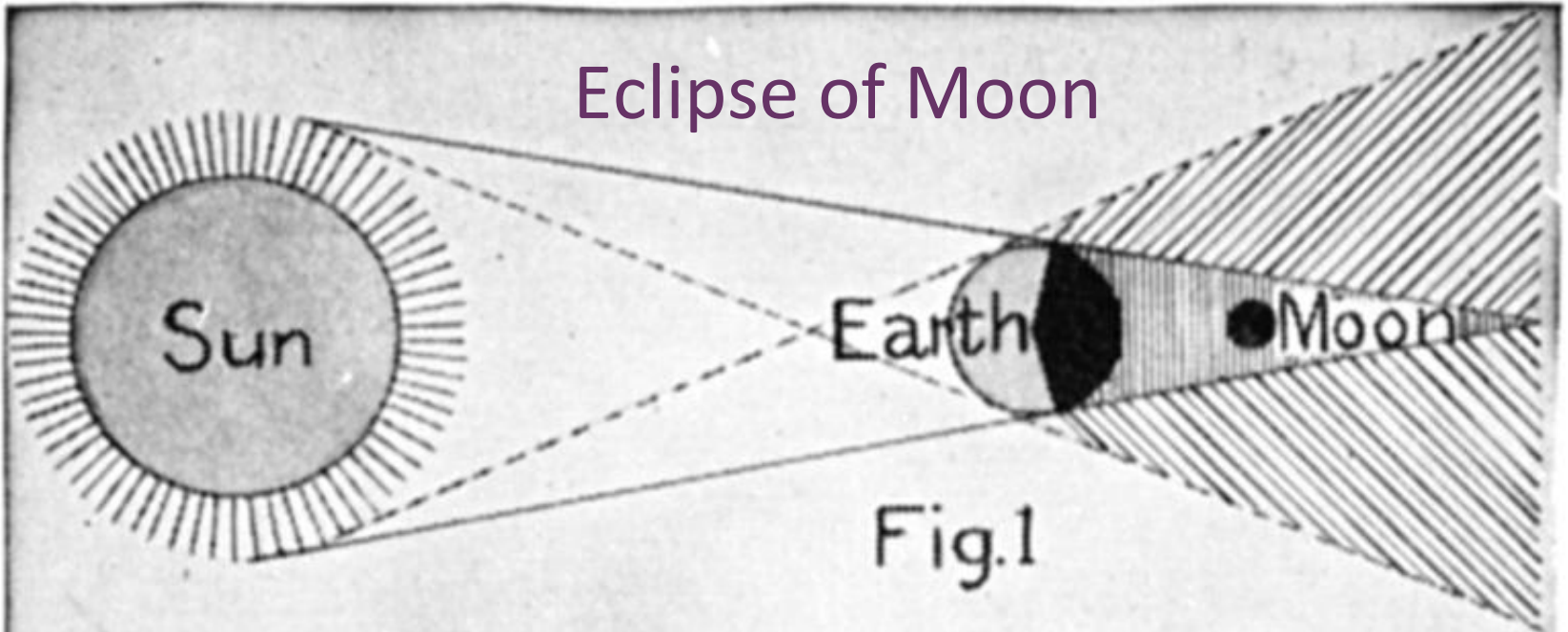
# A partial eclipse of the Moon



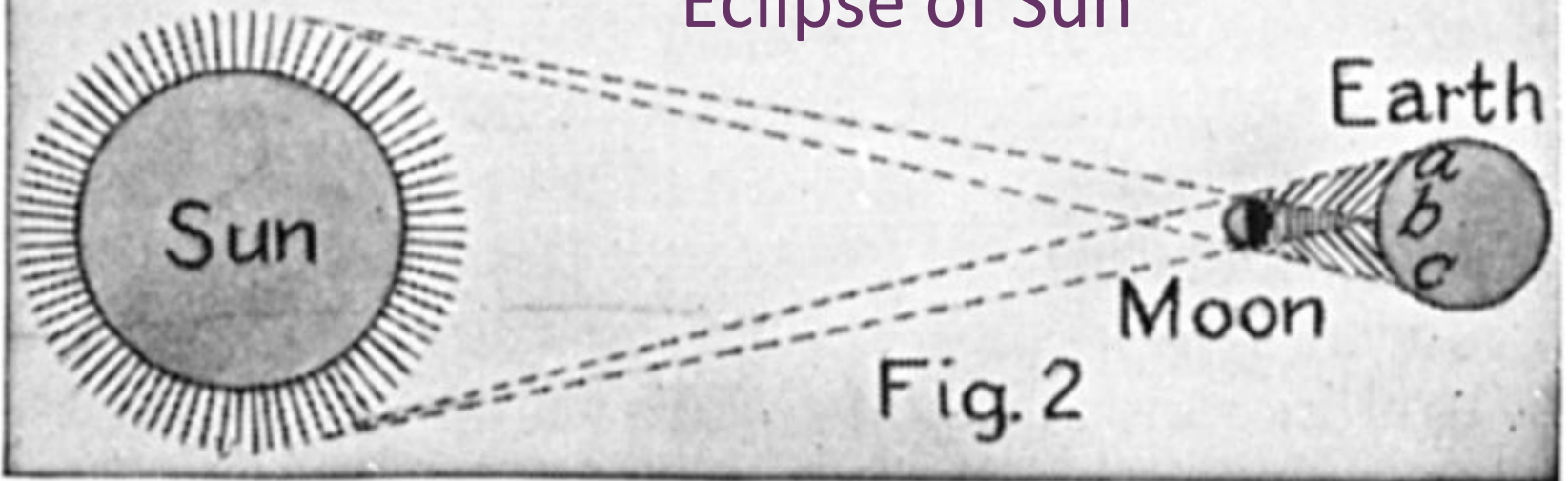
# Photo of partial eclipse of Moon



# Eclipse of Moon



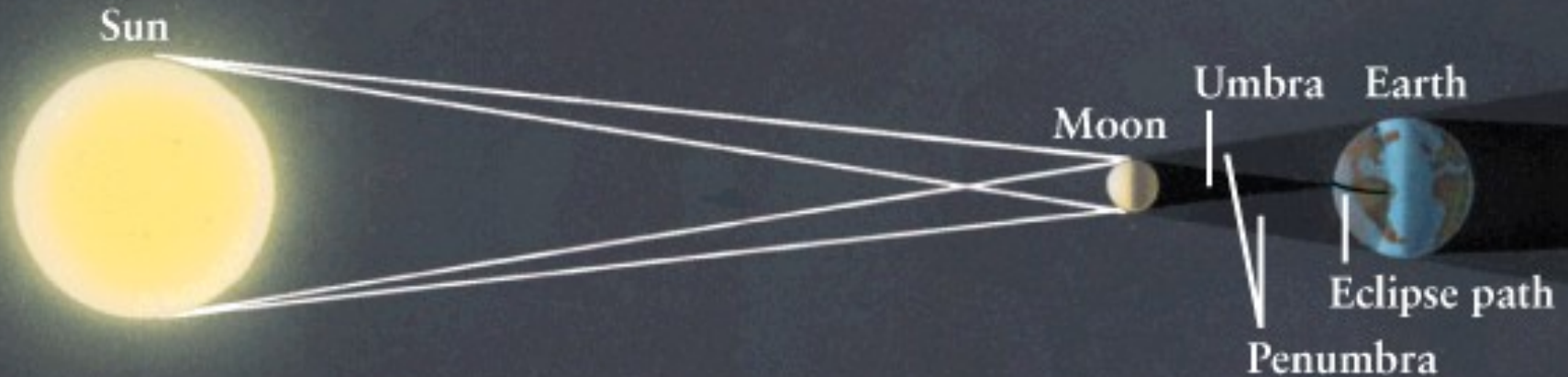
# Eclipse of Sun



# Eclipse of the Sun

Total: umbra of Sun's shadow falls on the Earth **(Moon blocks all of Sun)**

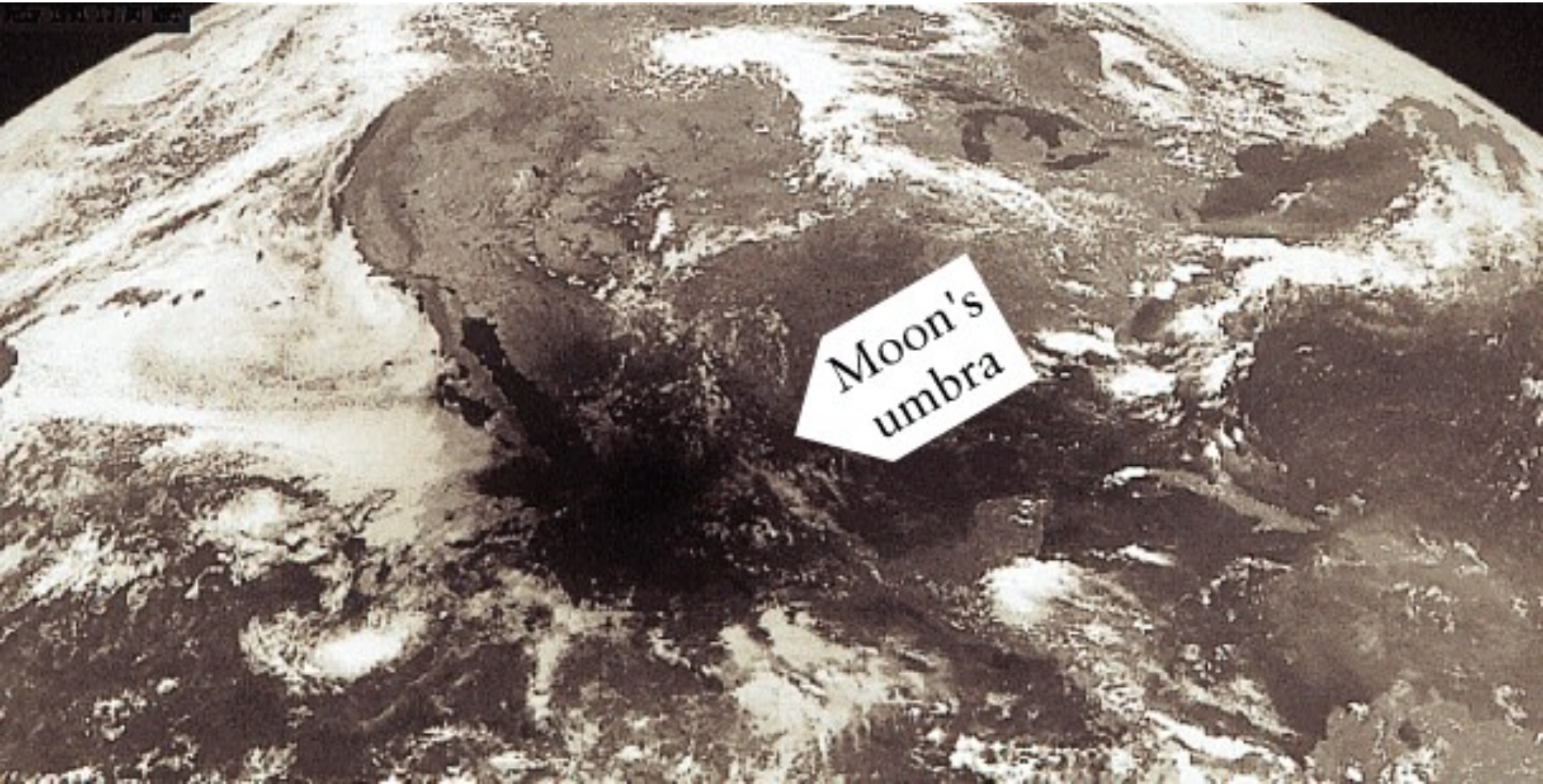
Partial: penumbra of Sun's shadow falls on Earth **(Moon blocks part of Sun)**



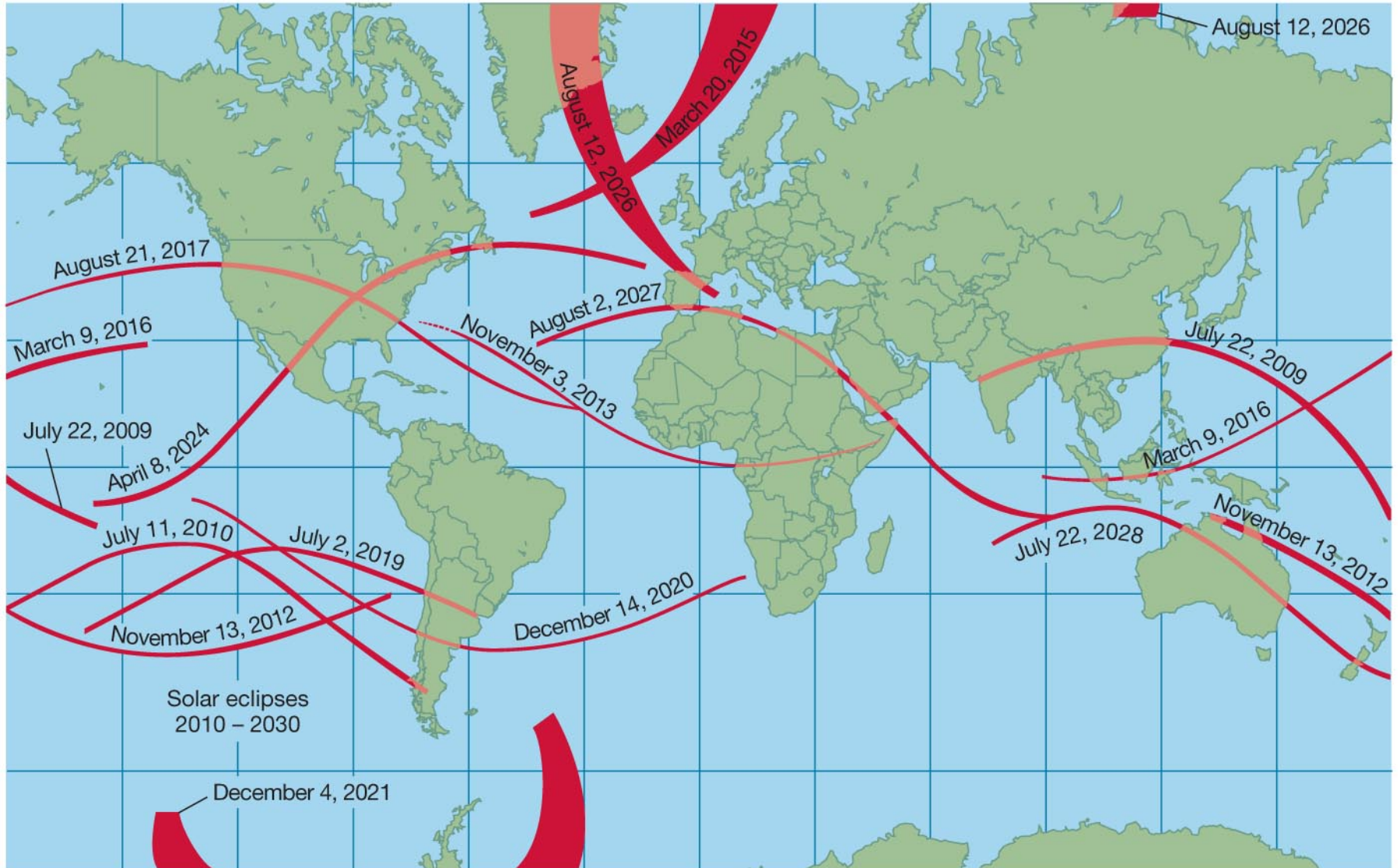
# Total eclipse of the Sun



You can see an eclipse of the Sun only if you are on the path of the Moon's shadow.



# Recent and future paths of total eclipses of the Sun



When the Moon is farther than usual from the Earth, its angular size in the sky is slightly smaller than the Sun's, allowing an *annular eclipse* of the Sun





# Partial Solar Eclipse



Moon passes in front of part of the Sun  
Photo: Milwaukee, March 20, 2012

**How often do eclipses occur?**

**Why isn't there an eclipse every month?**

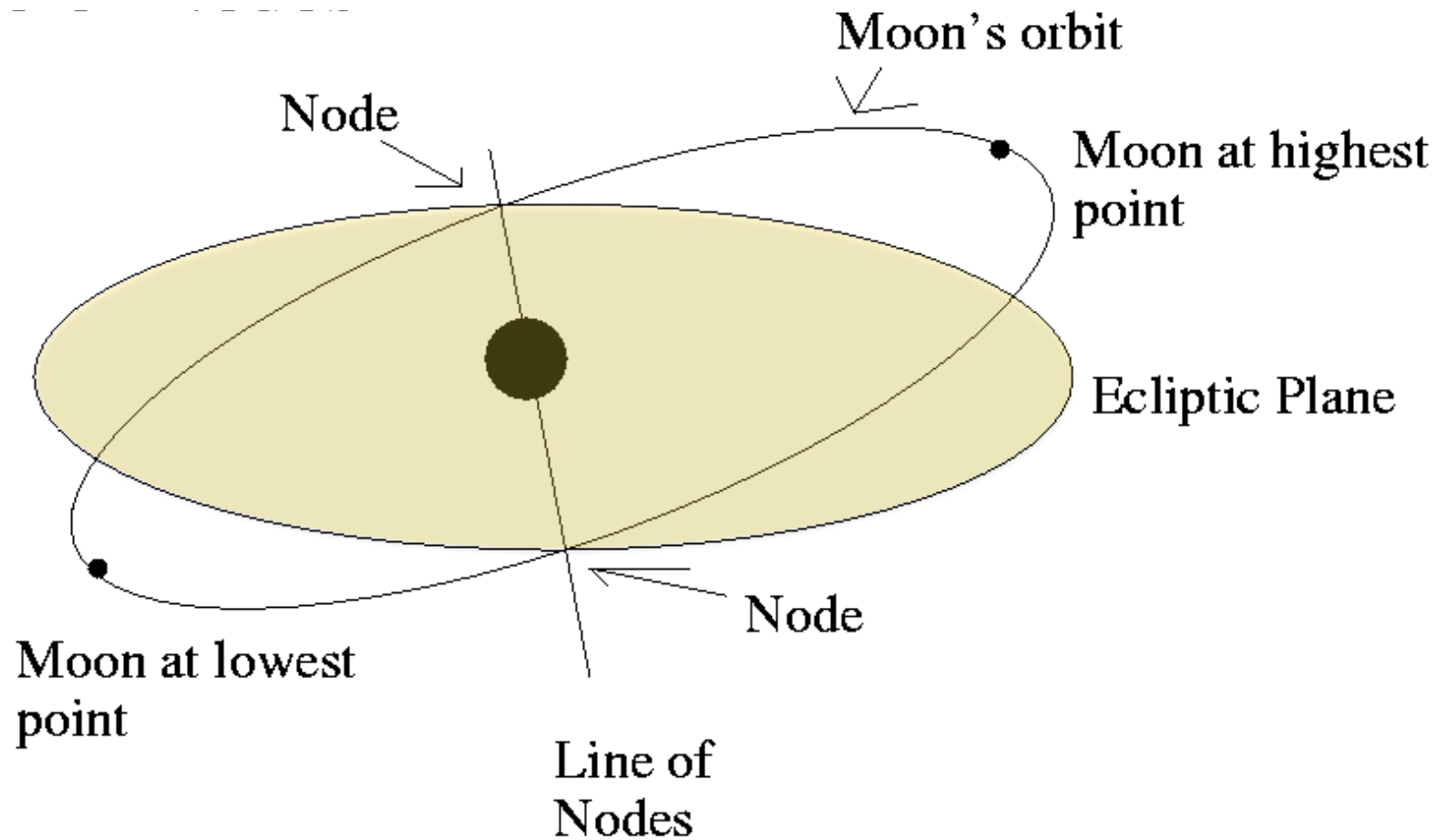
If the Moon's orbit were exactly in the plane of the Earth's orbit about the Sun (the plane of the ecliptic), there would be a lunar and solar eclipse each month:

Solar eclipse at each new moon

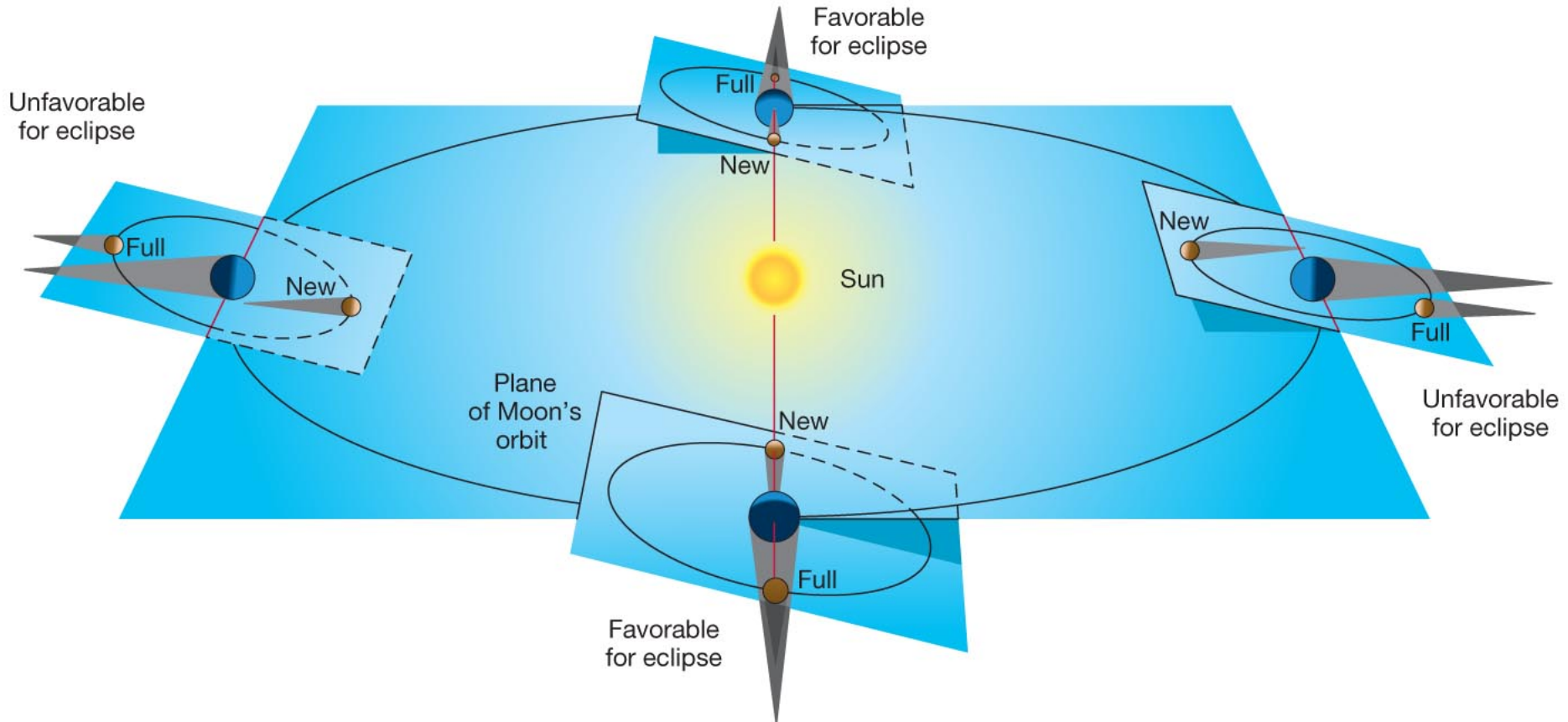
Lunar eclipse at each full moon

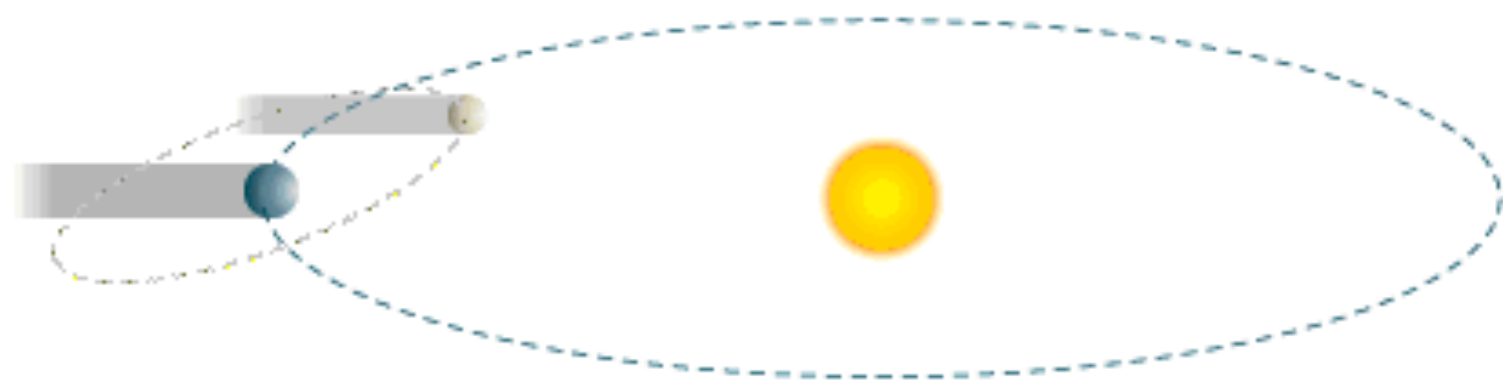
But... the Moon's orbit is tilted by about 5 degrees out of the plane of the ecliptic, the Moon is usually either slightly above or slightly below the Earth's shadow at full Moon, and the Earth is usually either slightly above or slightly below the Moon's shadow at New Moon. But twice a year, the orbit of the Moon is lined up with the Sun, and the line from Sun to Earth intersects the Moon's orbit. The two points where the Moon's orbit hits the plane of the ecliptic are called nodes.

# The plane of the Moon's orbit does not exactly coincide with the plane of the Earth's orbit about the Sun



About once every 6 months, the line from Sun to Earth lies in the plane of the Moon's orbit.  
Eclipses of Moon and Sun occur at these  
*eclipse seasons*



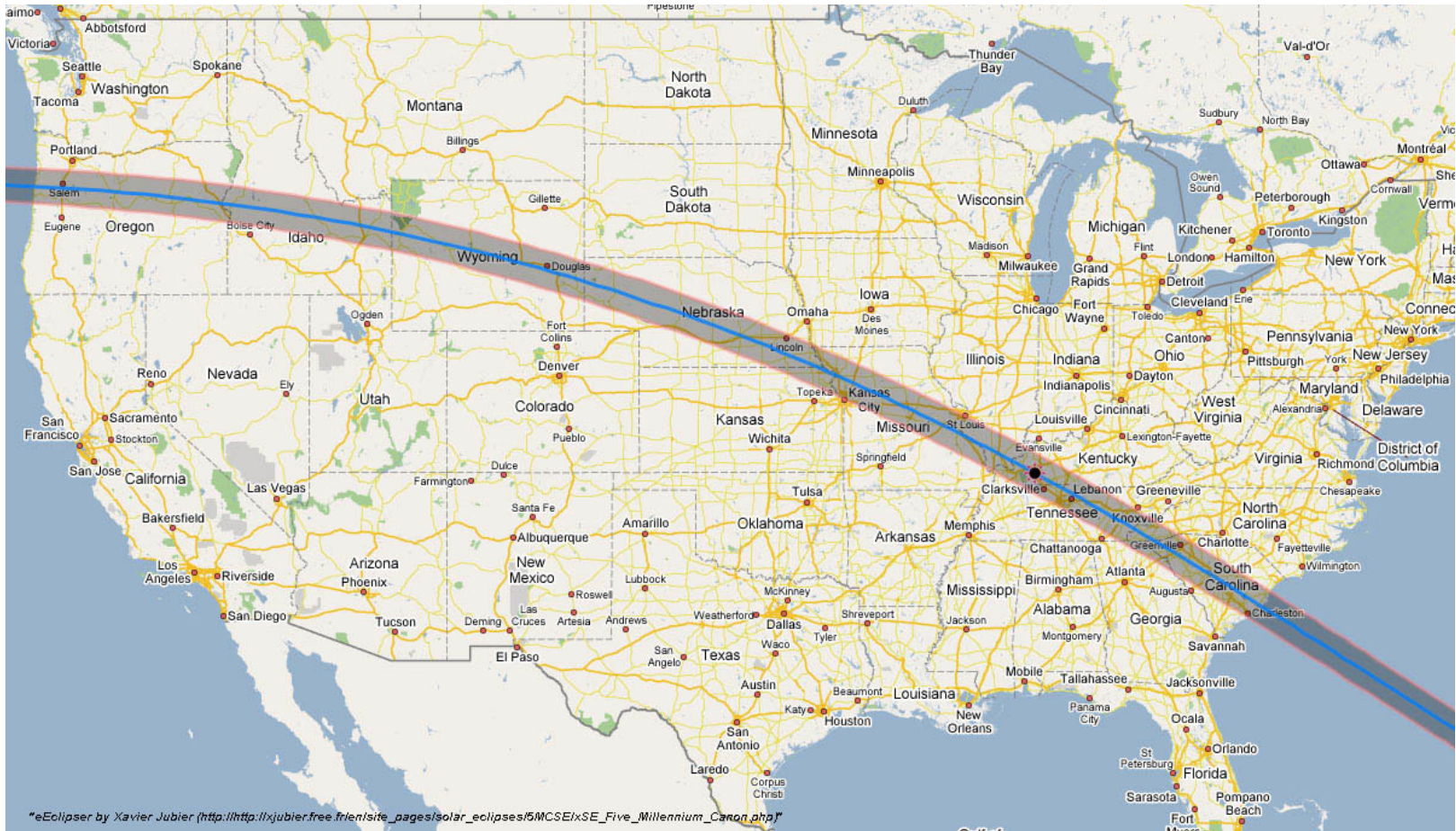


No eclipses possible

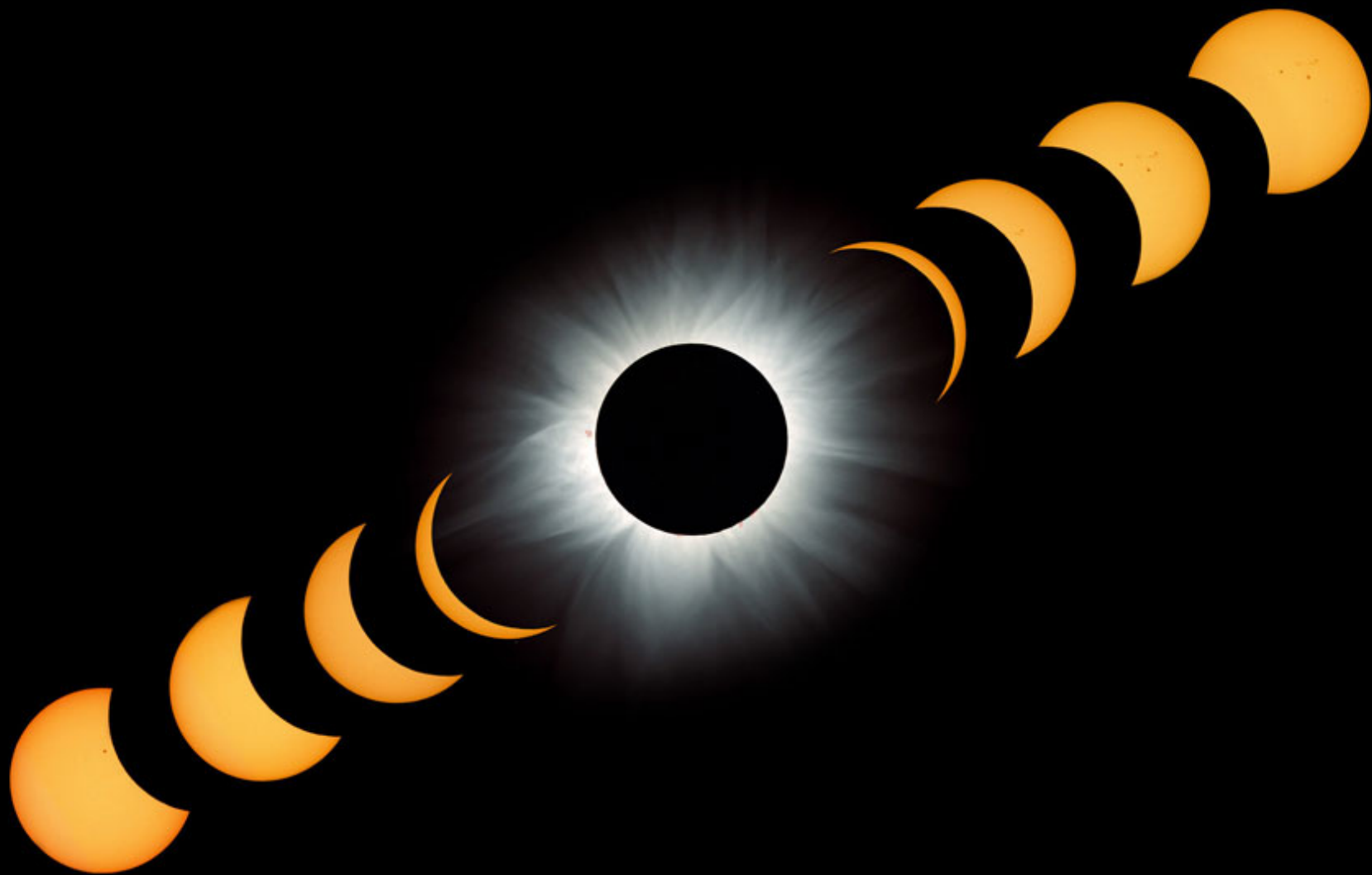
**A**

Although solar eclipses occur slightly more often than lunar eclipses, they are only visible if you happen to be standing in the eclipse path. An eclipse of the Moon, on the other hand, can be seen from the half of the Earth for which the Moon is up. So from any one place you see many more lunar than solar eclipses.

# August 21, 2017



- First total solar eclipse visible from mainland US since 1979
- Mark your calendars!







Total solar eclipse, Queensland, Australia  
November 2012  
Photo: Geoff Sims

# From “Total Eclipse” by Annie Dillard (*Teaching a Stone to Talk*, 1988)

You may read that the moon has something to do with eclipses. I have never seen the moon yet. You do not see the moon. So near the sun, it is as completely invisible as the stars are by day. What you see before your eyes is the sun going through phases. It gets narrower and narrower, as the waning moon does, and, like the ordinary moon, it travels alone in the simple sky. The sky is of course background. It does not appear to eat the sun; it is far behind the sun. The sun simply shaves away; gradually, you see less sun and more sky.

....

I turned back to the sun. It was going. The sun was going, and the world was wrong. The grasses were wrong; they were platinum. Their every detail of stem, head, and blade shone lightless and artificially distinct as an art photographer's platinum print. This color has never been seen on earth. The hues were metallic; their finish was matte. The hillside was a nineteenth-century tinted photograph from which the tints had faded. All the people you see in the photograph, distinct and detailed as their faces look, are now dead. The sky was navy blue. My hands were silver. All the distant hills' grasses were finespun metal which the wind laid down. I was watching a faded color print of a movie filmed in the Middle Ages; I was standing in it, by some mistake. I was standing in a movie of hillside grasses filmed in the Middle Ages. I missed my own century, the people I knew, and the real light of day.

....

From all the hills came screams. A piece of sky beside the crescent sun was detaching. It was a loosened circle of evening sky, suddenly lighted from the back. It was an abrupt black body out of nowhere; it was a flat disk; it was almost over the sun. That is when there were screams. At once this disk of sky slid over the sun like a lid. The sky snapped over the sun like a lens cover. The hatch in the brain slammed. Abruptly it was dark night, on the land and in the sky. In the night sky was a tiny ring of light. The hole where the sun belongs is very small. A thin ring of light marked its place. There was no sound. The eyes dried, the arteries drained, the lungs hushed. There was no world. We were the world's dead people rotating and orbiting around and around, embedded in the planet's crust, while the earth rolled down. Our minds were light-years distant, forgetful of almost everything. Only an extraordinary act of will could recall to us our former, living selves and our contexts in matter and time. We had, it seems, loved the planet and loved our lives, but could no longer remember the way of them. We got the light wrong. In the sky was something that should not be there. In the black sky was a ring of light. It was a thin ring, an old, thin silver wedding band, an old, worn ring. It was an old wedding band in the sky, or a morsel of bone. There were stars. It was all over.



August 21, 2017  
Start planning!