

# Announcements

- Quiz 1 due tonight
- Planetarium (across hall) on Sept. 22nd usual time, 9.00 - 9.50 am
- Change in Office Hours:  
Monday, 1-2 pm (was 10-11 am)  
Wednesday 10-11 in PHY 122

# Astronomy Club

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



Starts Monday September 22nd,  
4 pm in Physics 144 - 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?

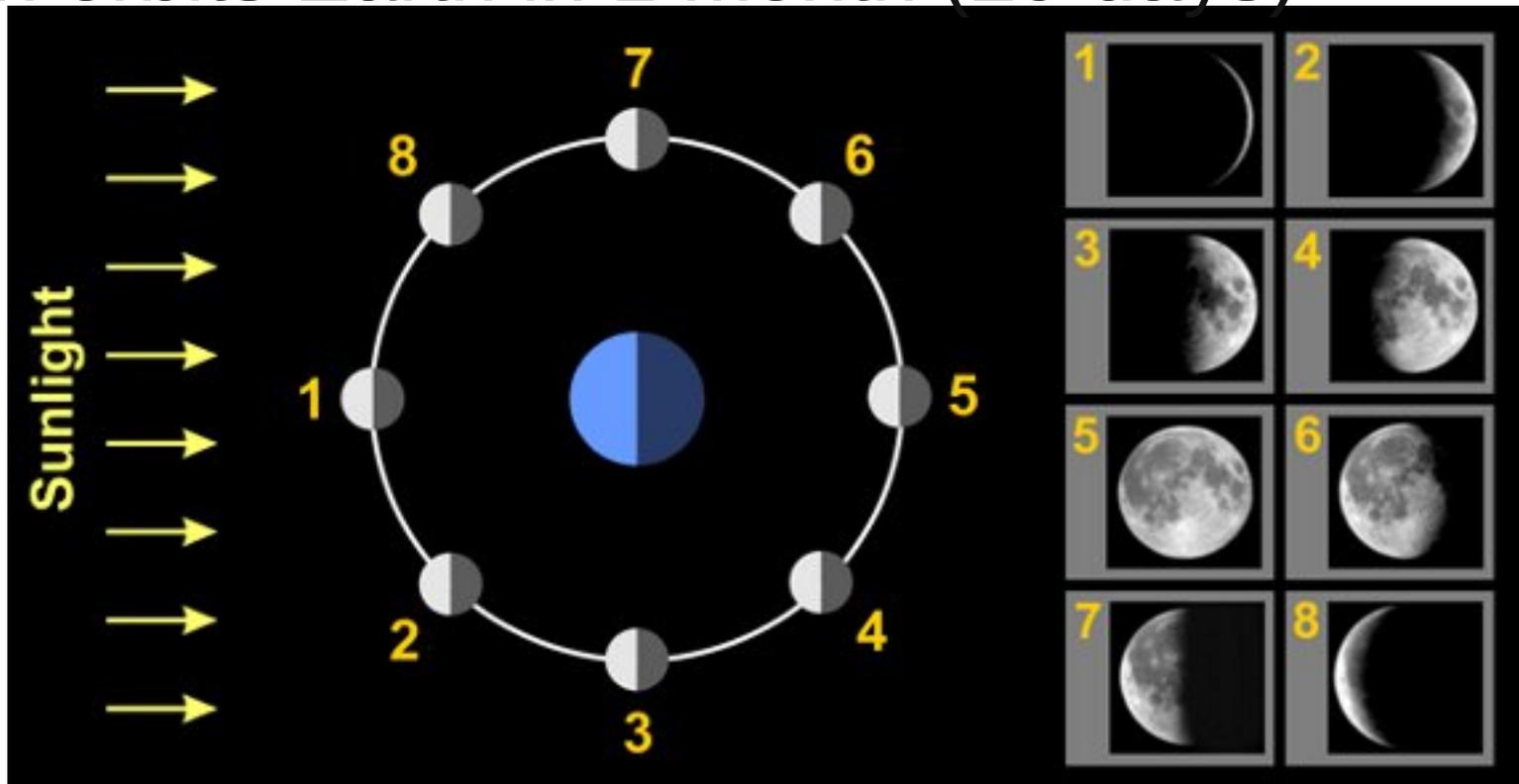


# Phases of the Moon

Why does the Moon shine? Reflected sunlight:

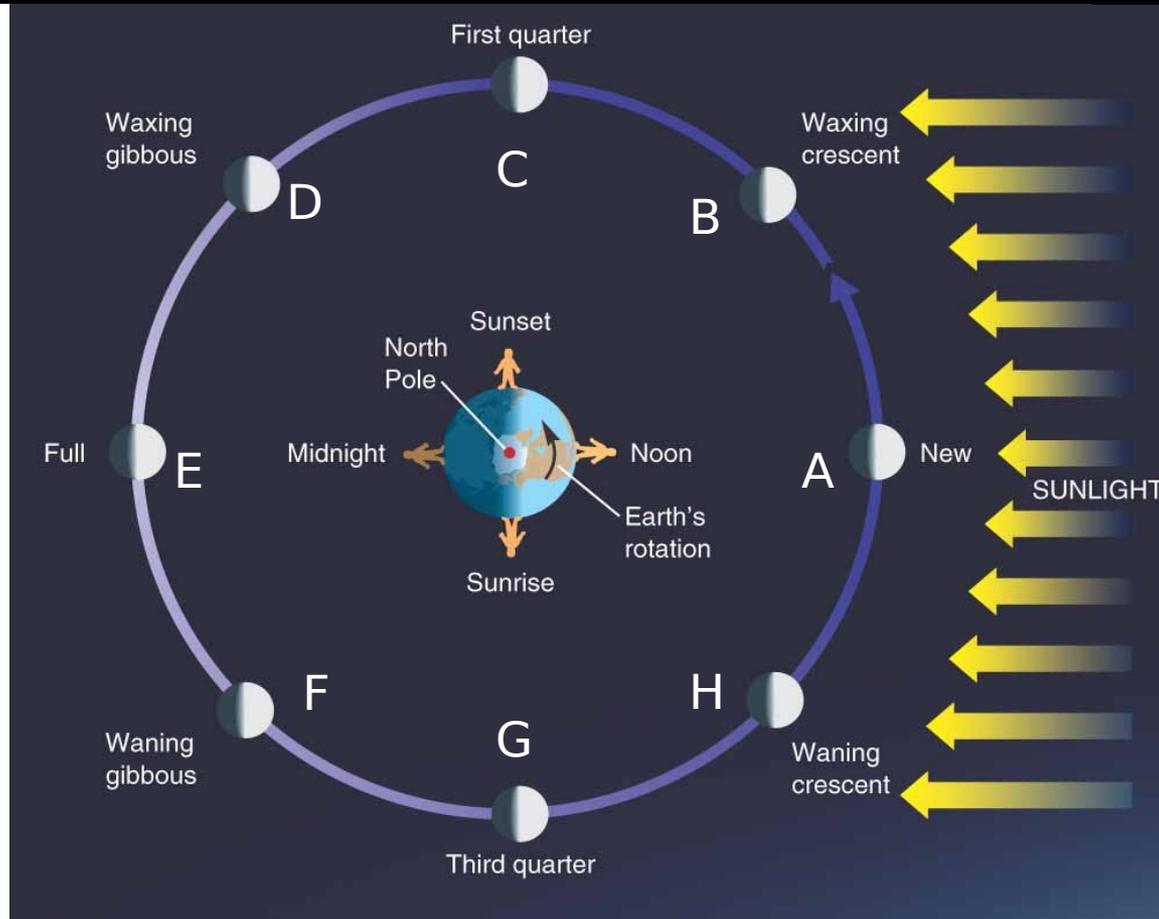
- The side of the Moon facing the Sun is lighted
- The side of the Moon facing away from the Sun is dark

Moon orbits Earth in 1 month (29 days)

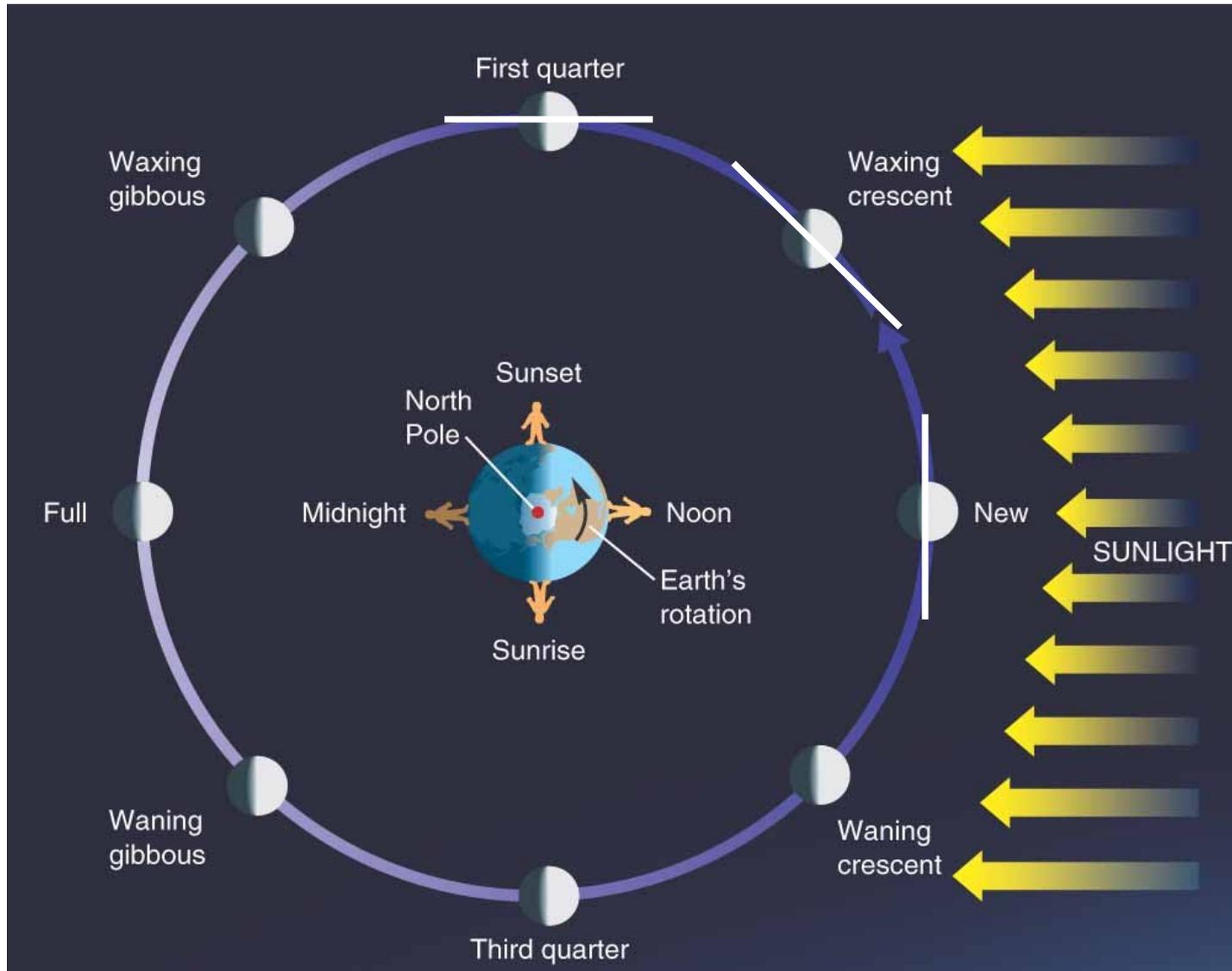


# The phase of the Moon is the result of its position in its orbit about the Earth:

## View of the moon as seen from earth



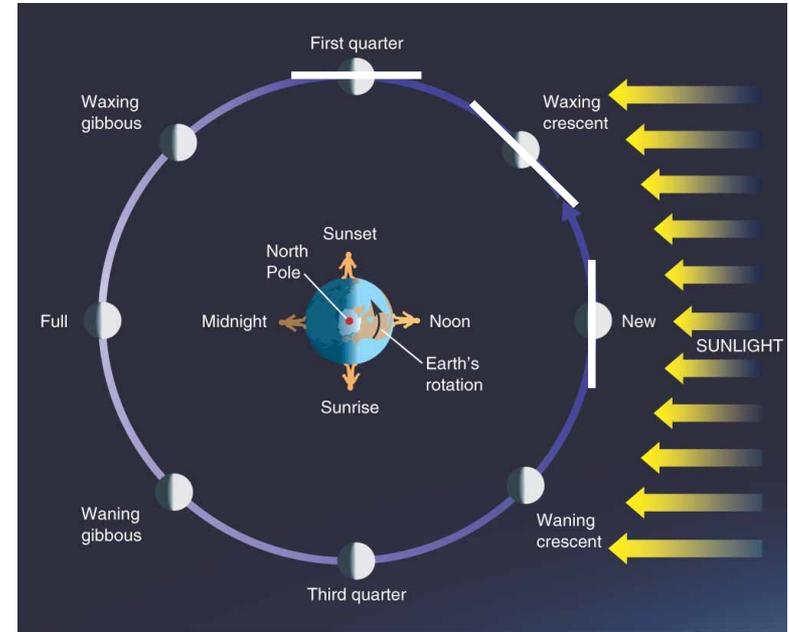
# Phases of the Moon – as seen from Earth



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

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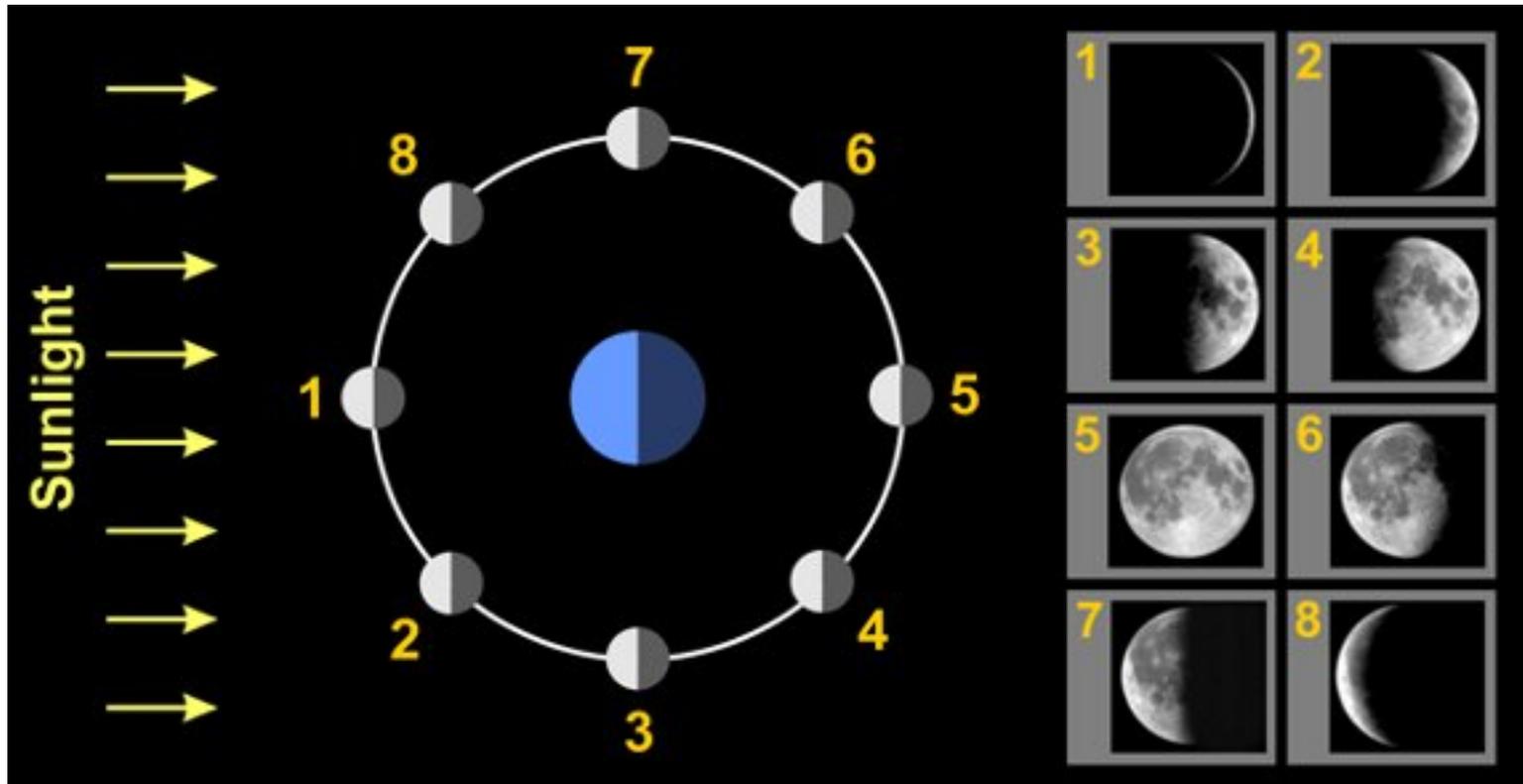
- Moon between Earth and Sun: dark side faces us → new Moon, we see no Moon at all
- A couple of days earlier or later, we see a sliver of the side of the Moon in sunlight → a crescent



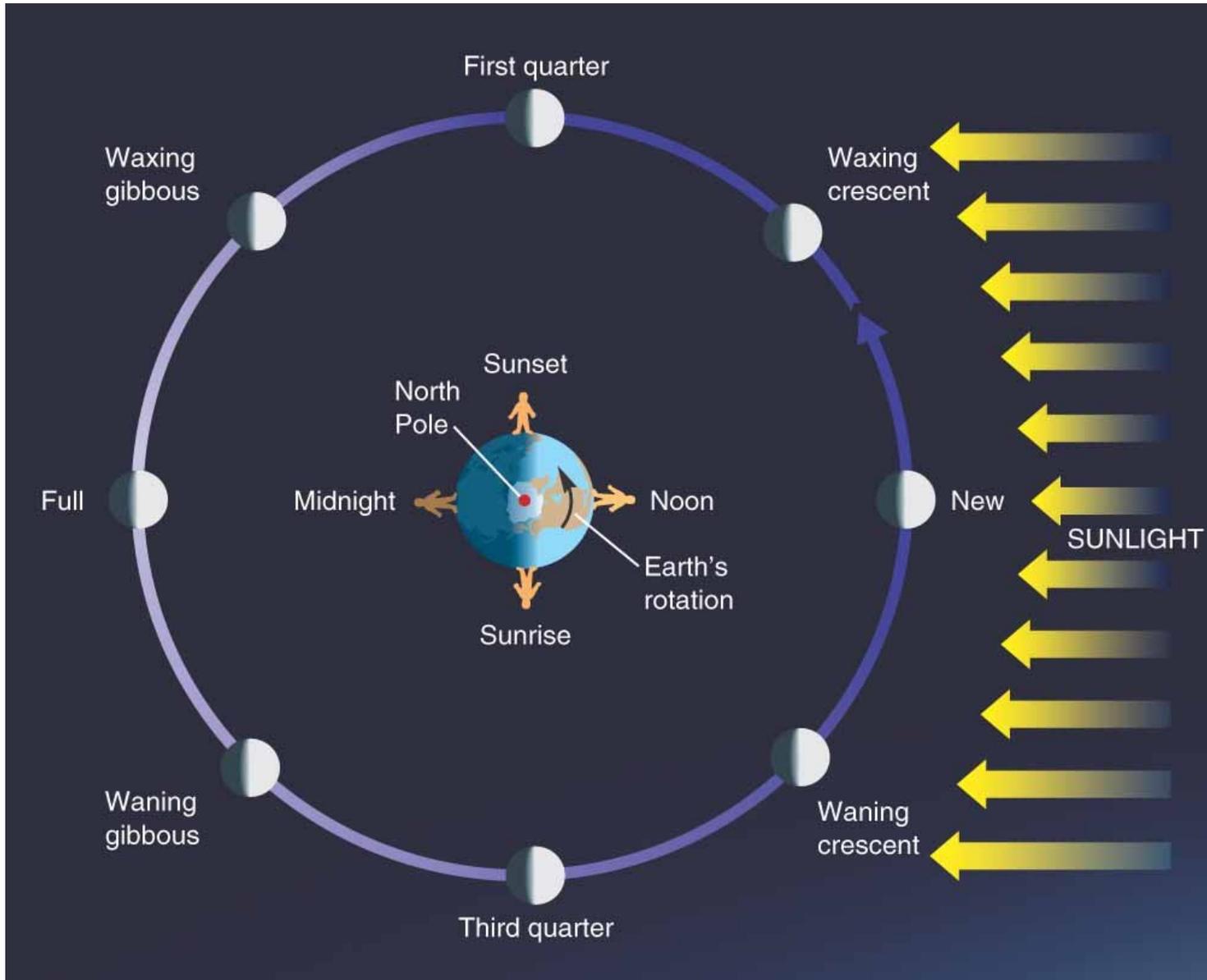
- As the Moon moves in its orbit about the Earth, the crescent grows larger. Seven days after new Moon (1/4 of the way around its orbit), half the side of the Moon facing us is lighted: We see a half Moon
- Because the size of the sunlit part of the Moon that we can see is increasing, we call it a waxing 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?



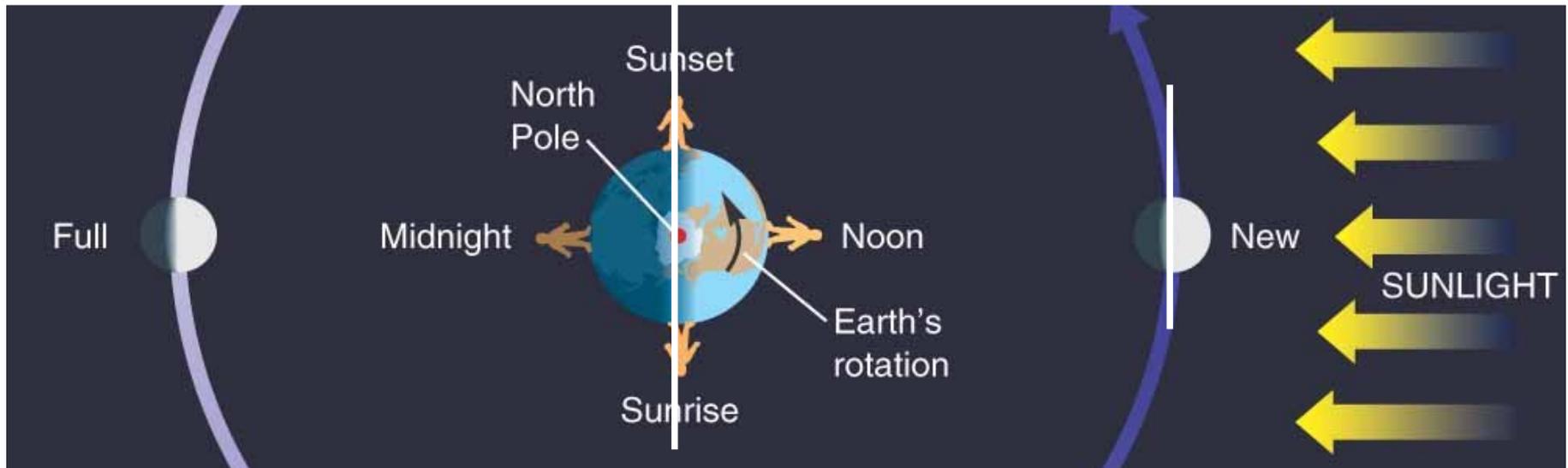
Time on the Earth: Sun rises when we rotate out of shadow and into sunlight (when we are in the location labeled Sunrise)



# Moon Phases and rise/set times: New Moon

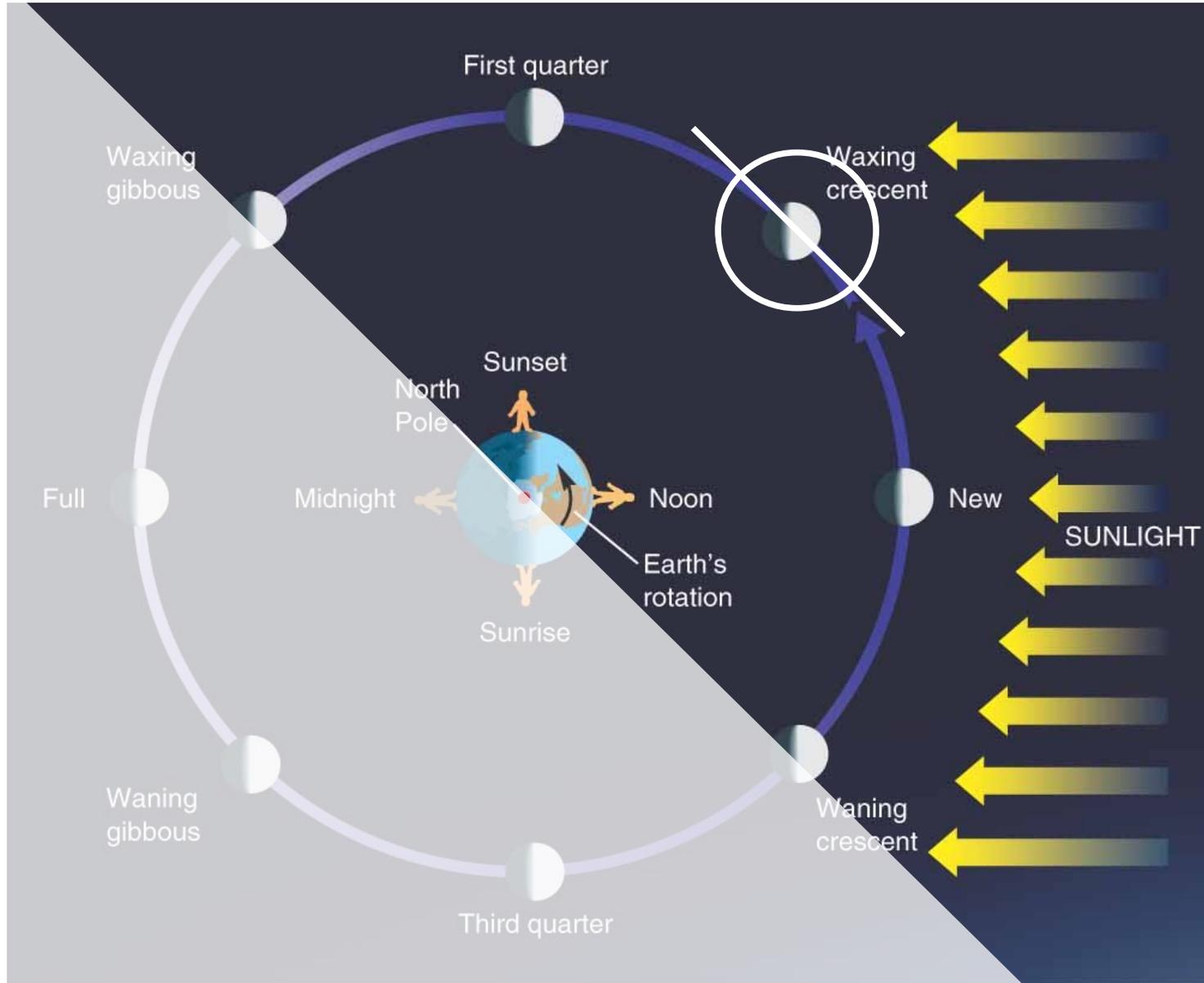
In these pictures, lines are drawn to show the part of the Earth from which the Moon is visible.

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:



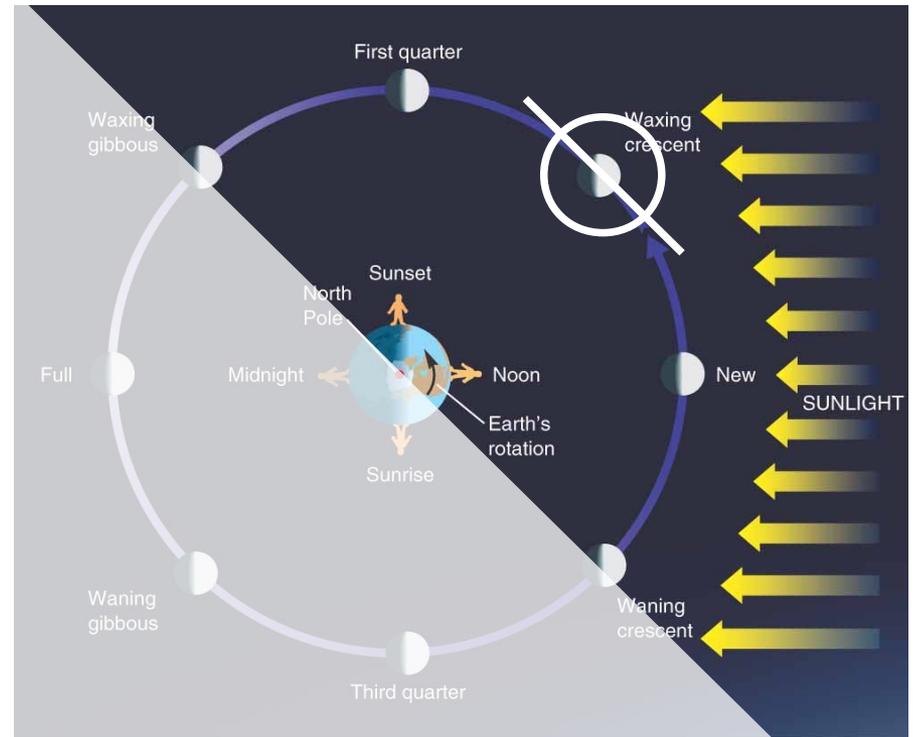
None of the Moon's disk is visible, and it is up for none of the night.

# Moon Phases and rise/set times: Waxing Crescent



# Moon Phases and rise/set times: Waxing Crescent

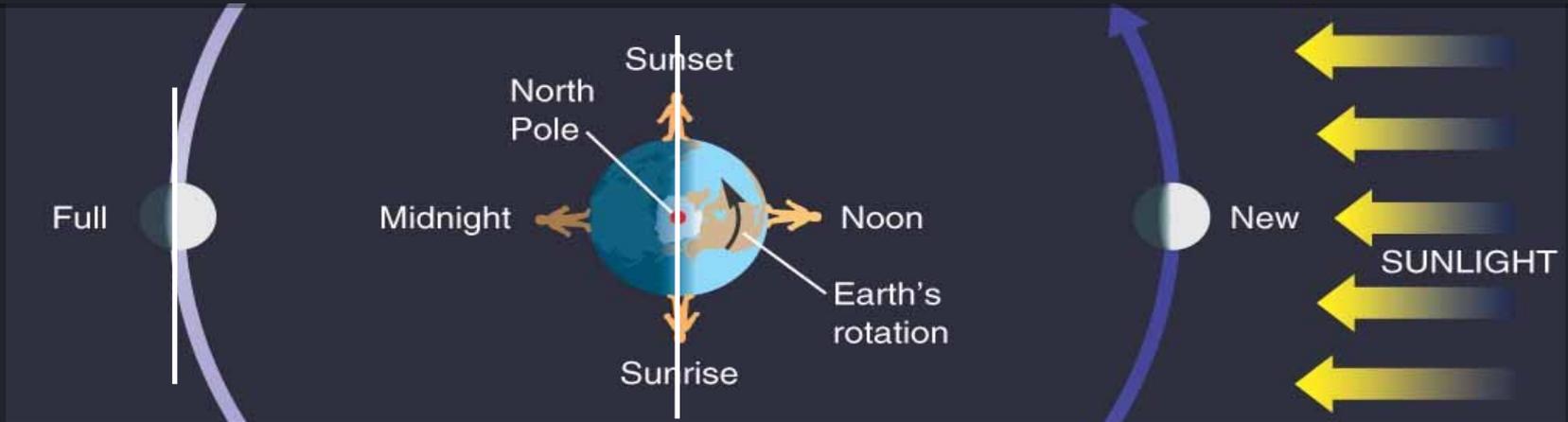
Here for this waxing crescent moon, about  $\frac{1}{4}$  of the part of the Moon facing the Earth is in sunlight. And  $\frac{1}{4}$  of the part of the Earth that faces the Moon is in shadow:



© 2004 Thomson/Brooks Cole

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

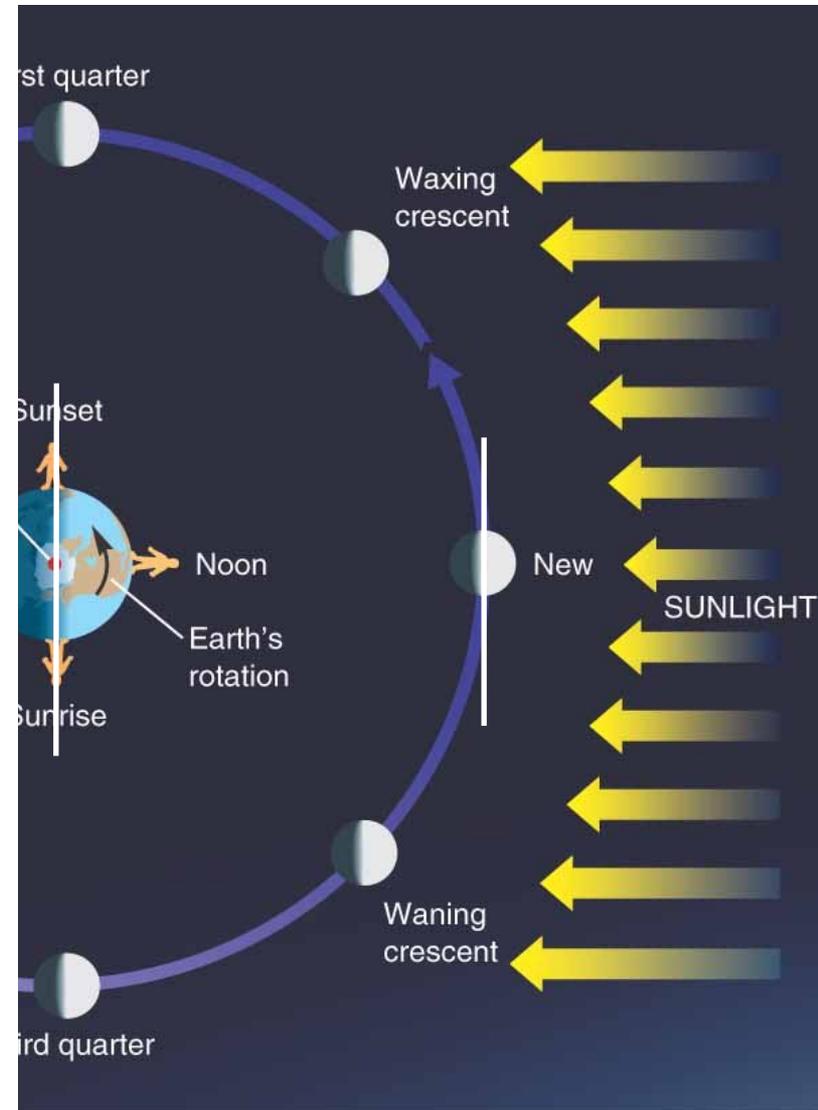
Noon

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

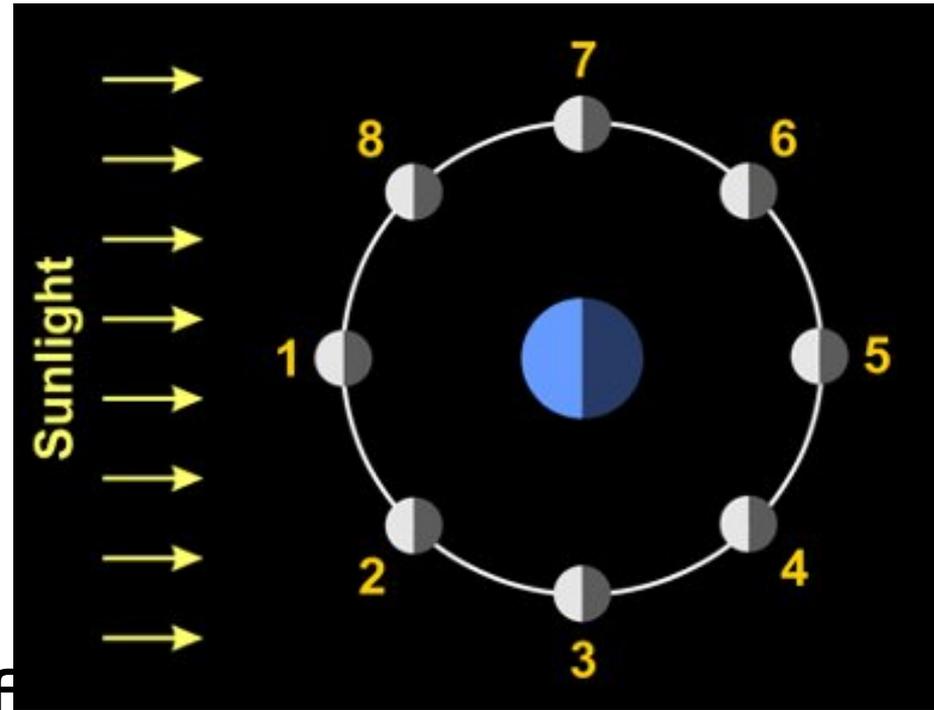
Less than half

C

Half

D

More than half

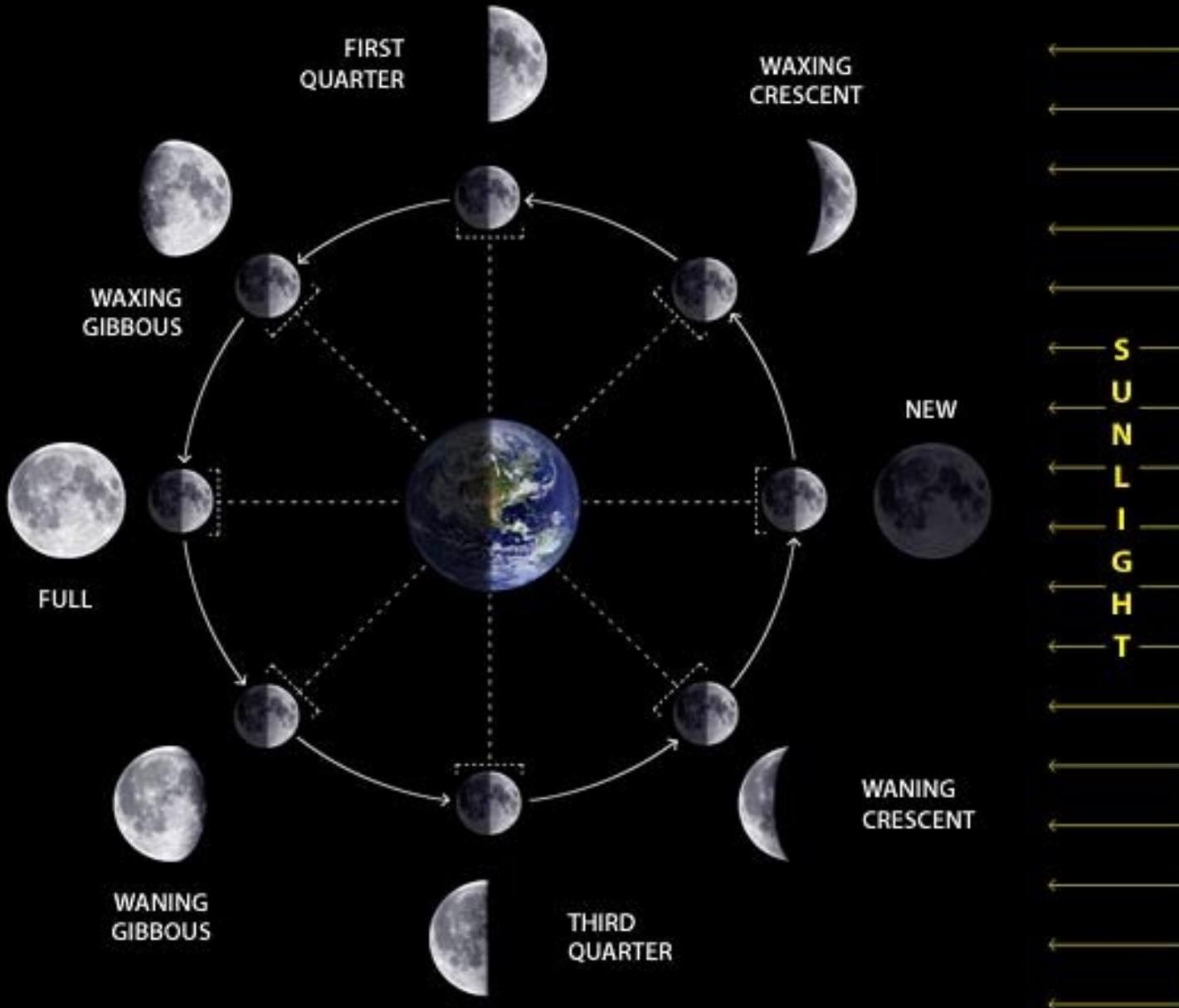


# Recap: Phases of the Moon

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



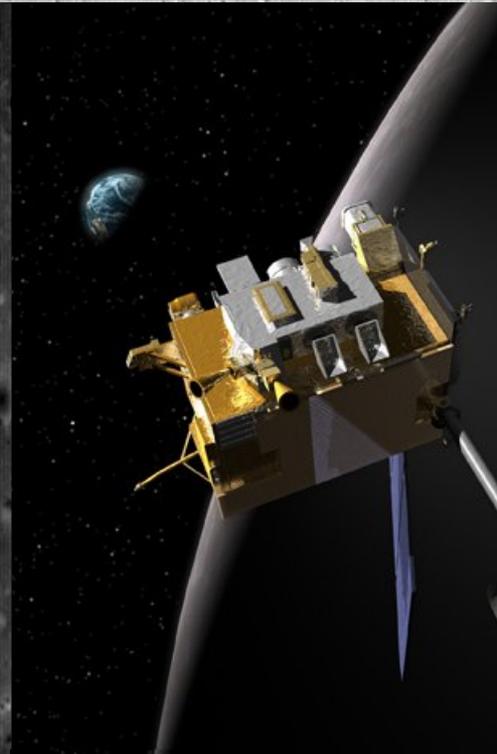
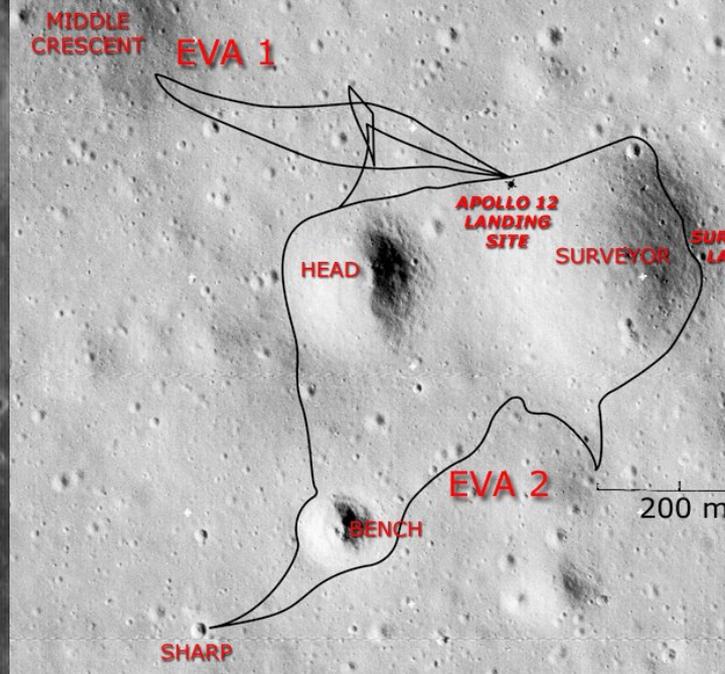
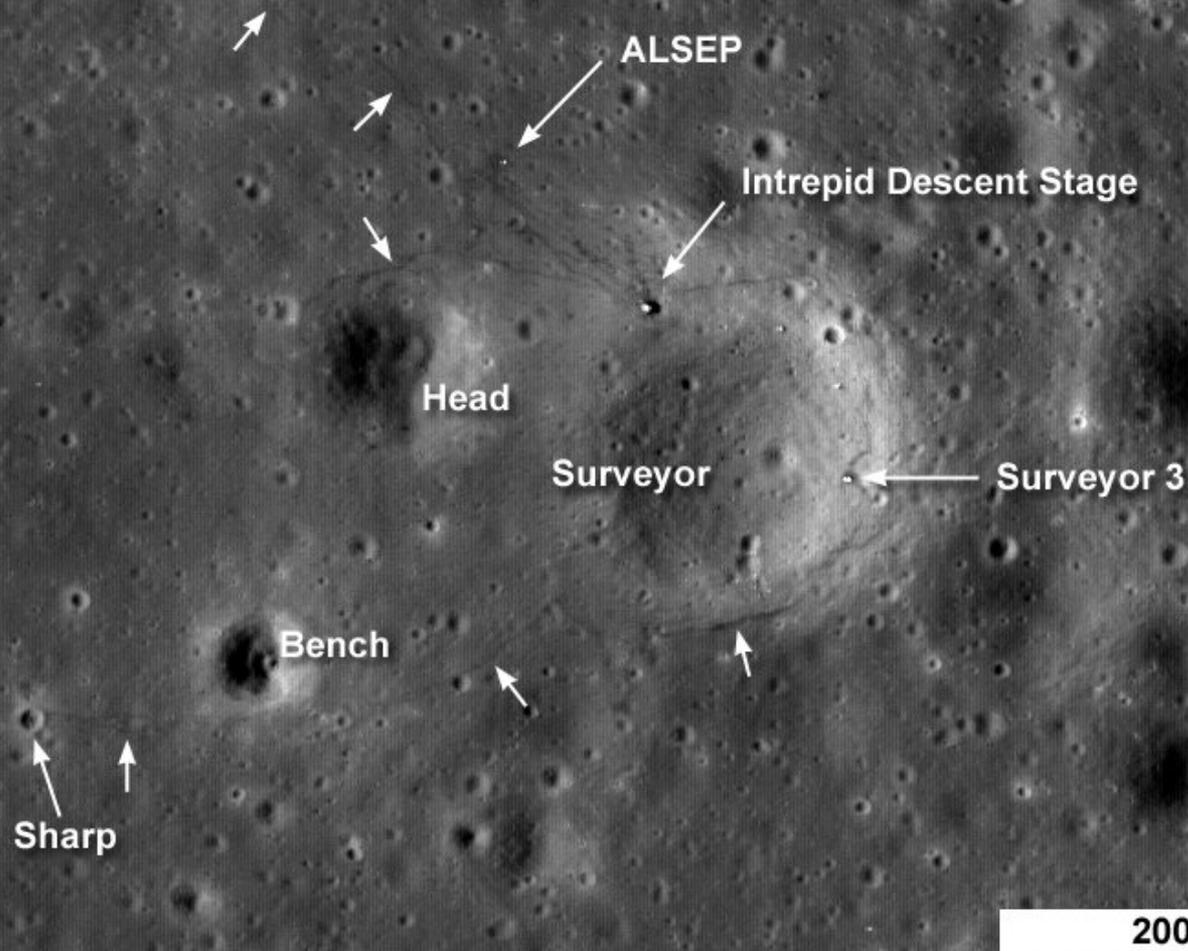
# Rise of Earth as seen from Moon



Reconstruction of Earthrise as seen by Apollo 8 on Dec 24, 1968

Source: <http://en.wikipedia.org/wiki/Earthrise>

# Apollo 12



# Eclipses



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



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

# Lunar eclipse: Eclipse of the Moon

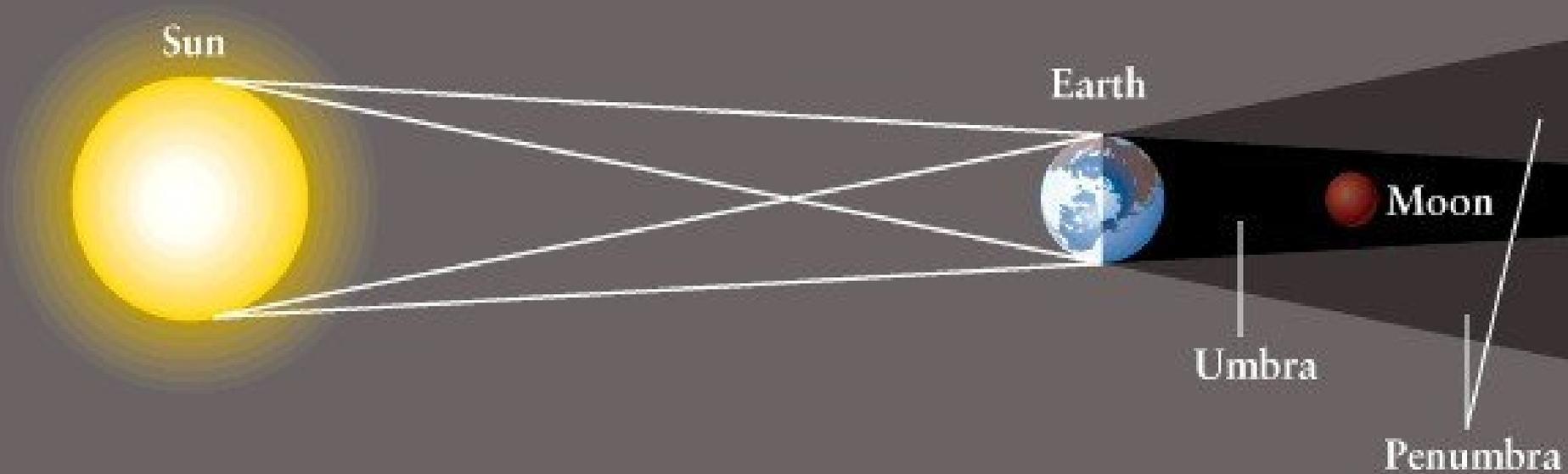
Happens when Earth's shadow falls on Moon



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.

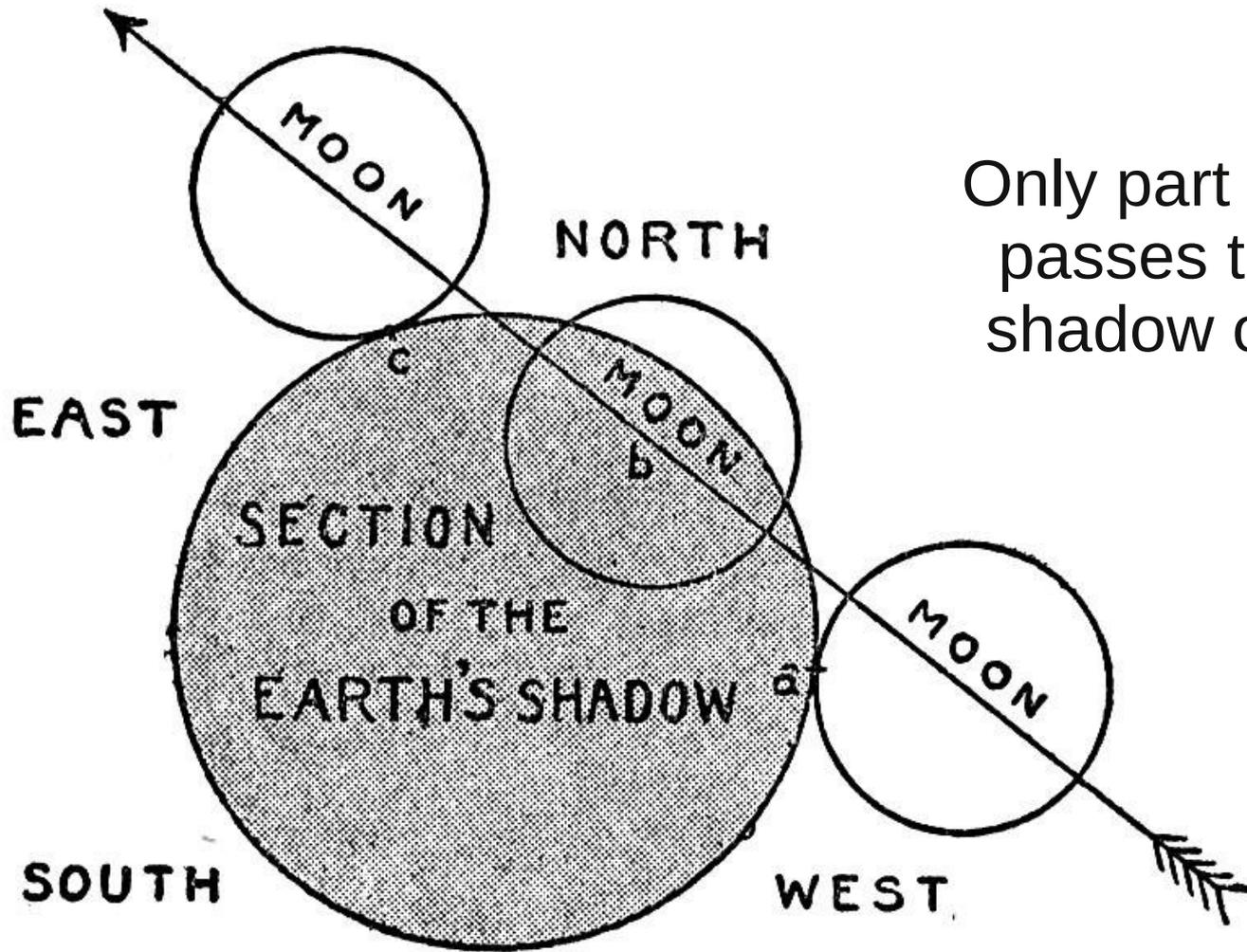
You see a sequence of images of the Moon during a period of about five hours. It moves about  $\frac{1}{2}$  degree each hour, taking about 3 hours to cross the Earth's shadow. You can see from the figure that the Earth's shadow has a diameter about 3 times the diameter of the Moon.



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



Only part of Moon passes through shadow of Earth

# Photo of partial eclipse of Moon



# Eclipse of Moon

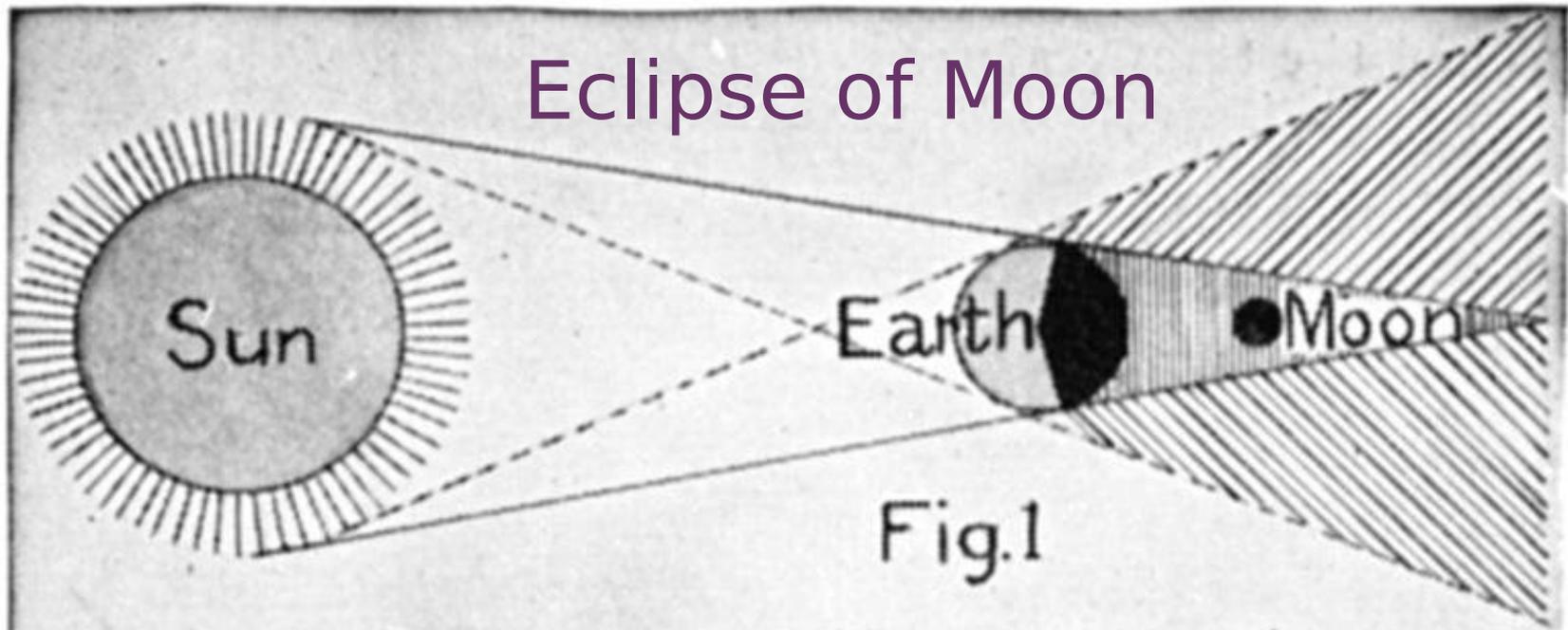


Fig.1

# Eclipse of Sun

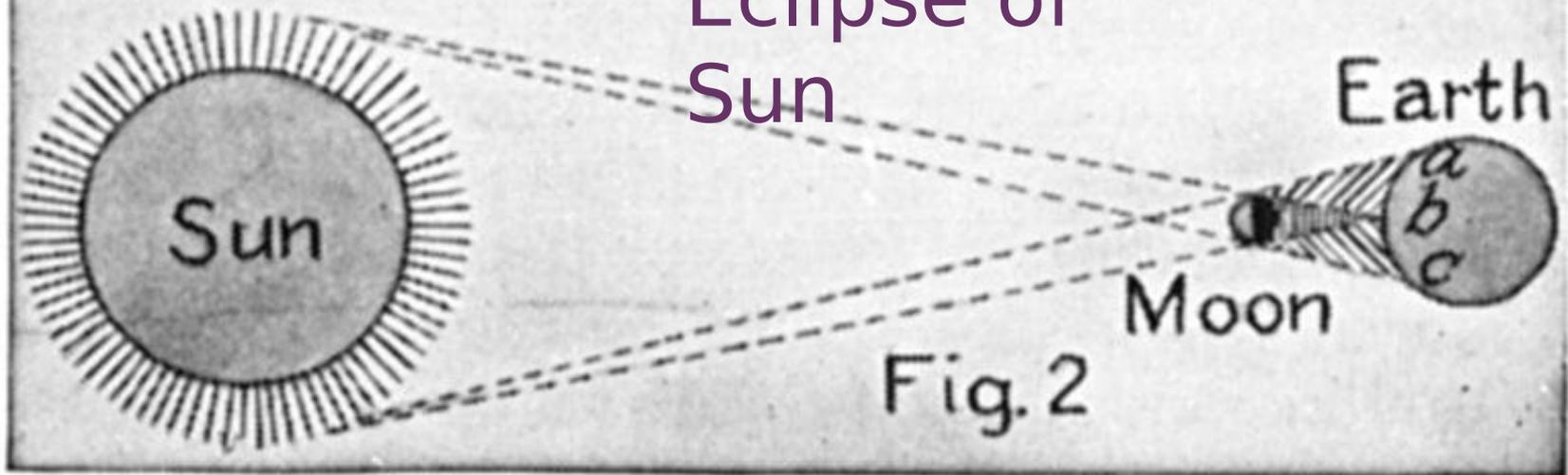
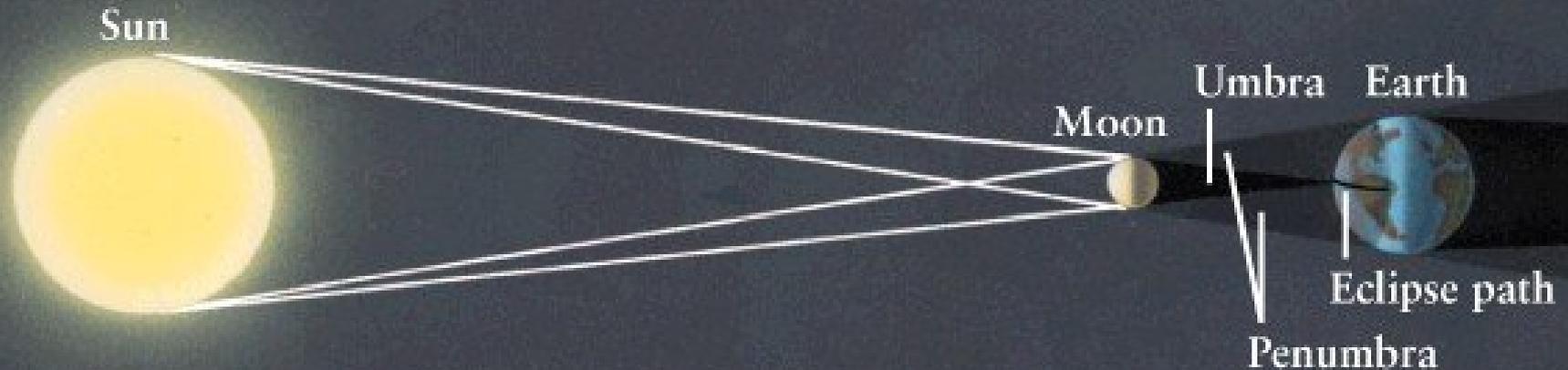


Fig.2

# 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)



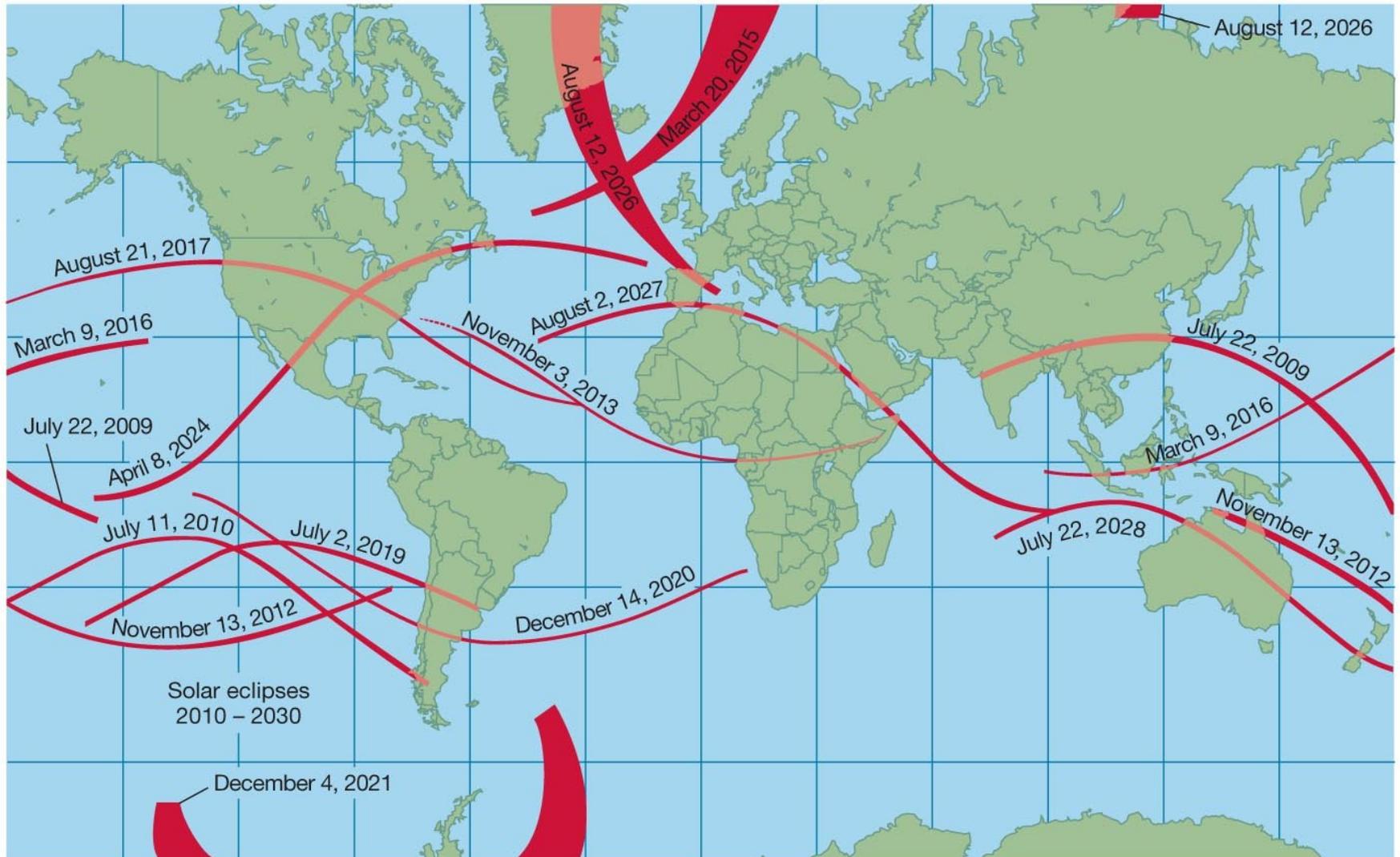
Total eclipse of the Sun



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

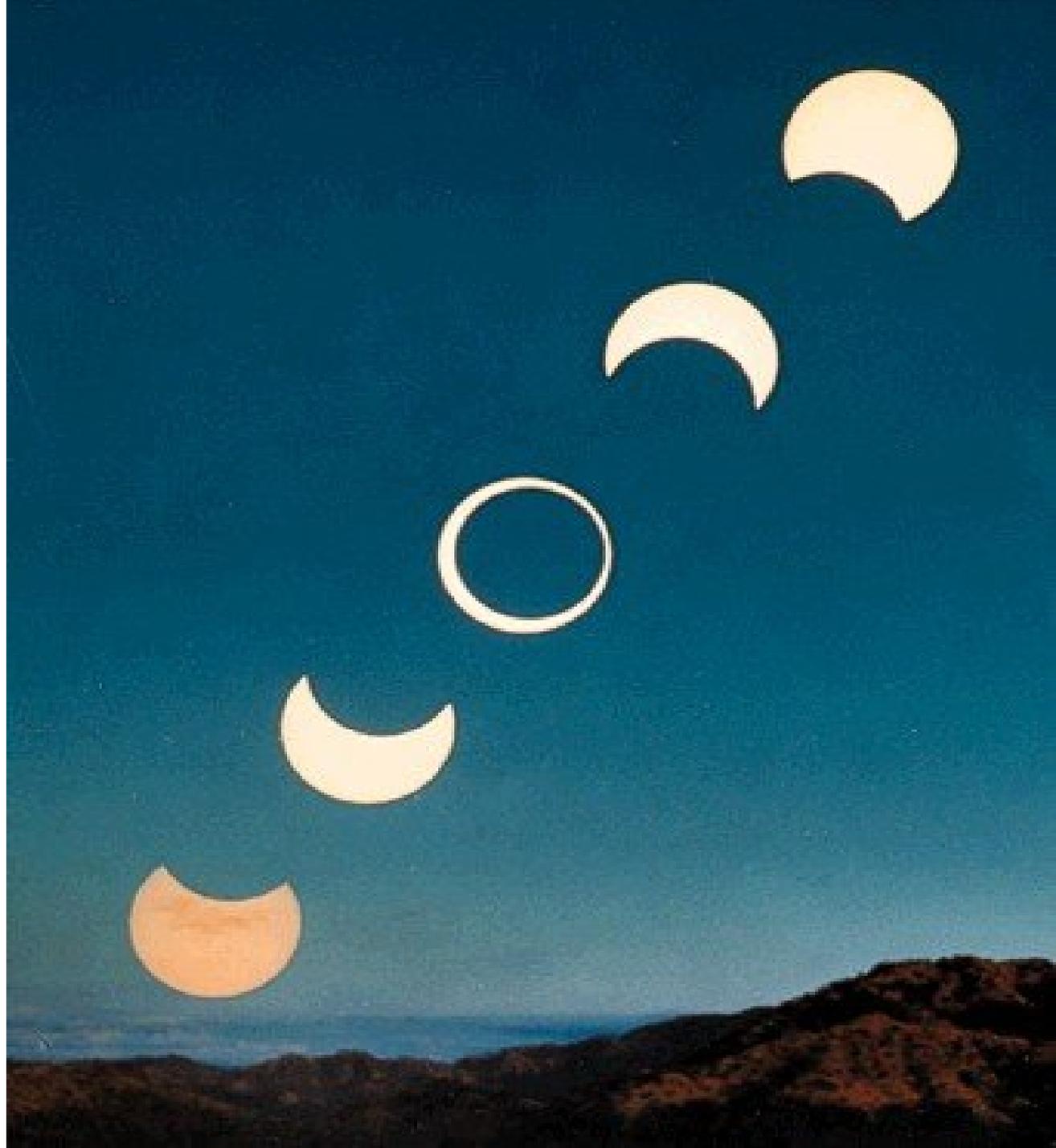


# Recent and future paths of total eclipses of the Sun



# Annular Eclipse

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?

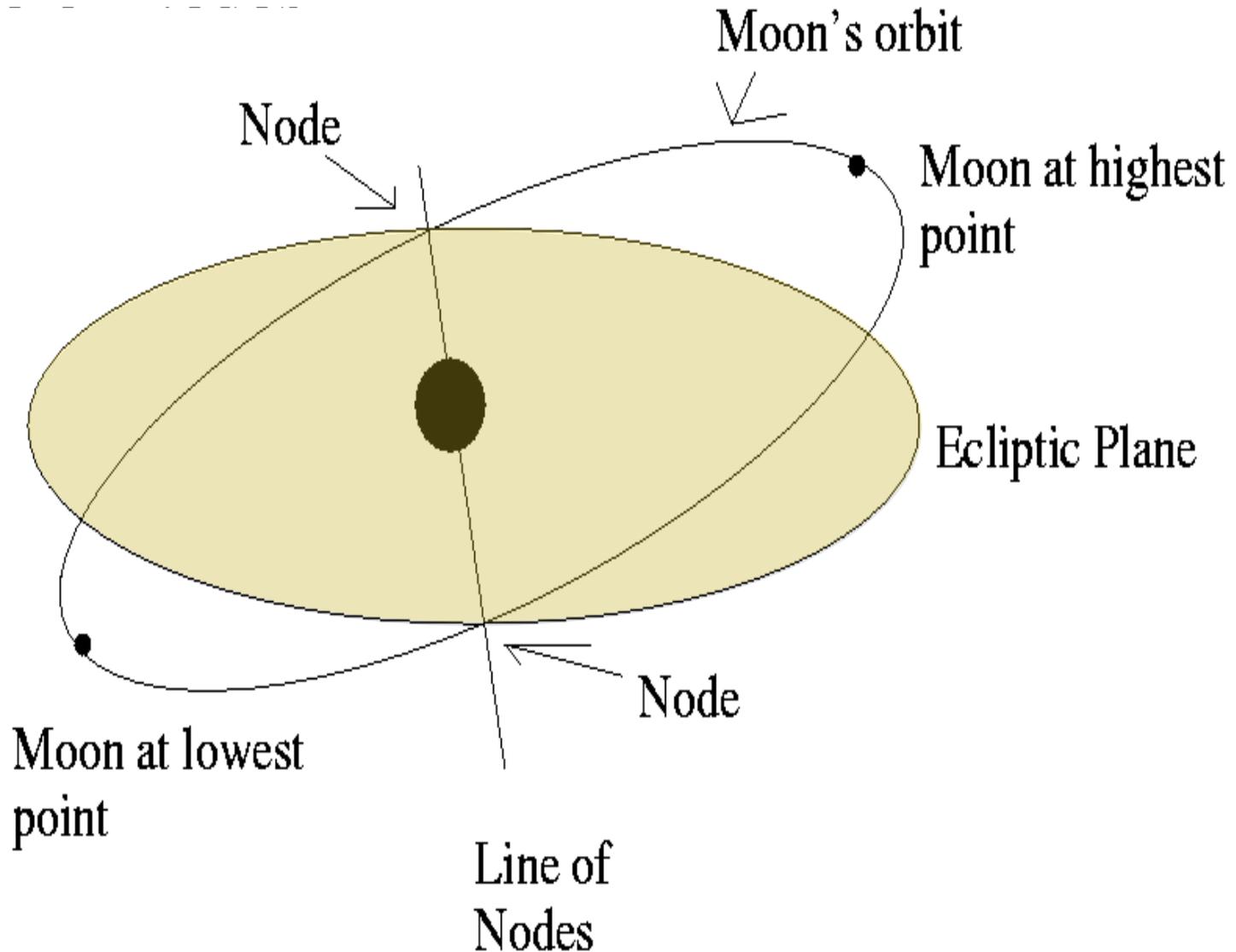
## Why isn't there an eclipse every month?

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:

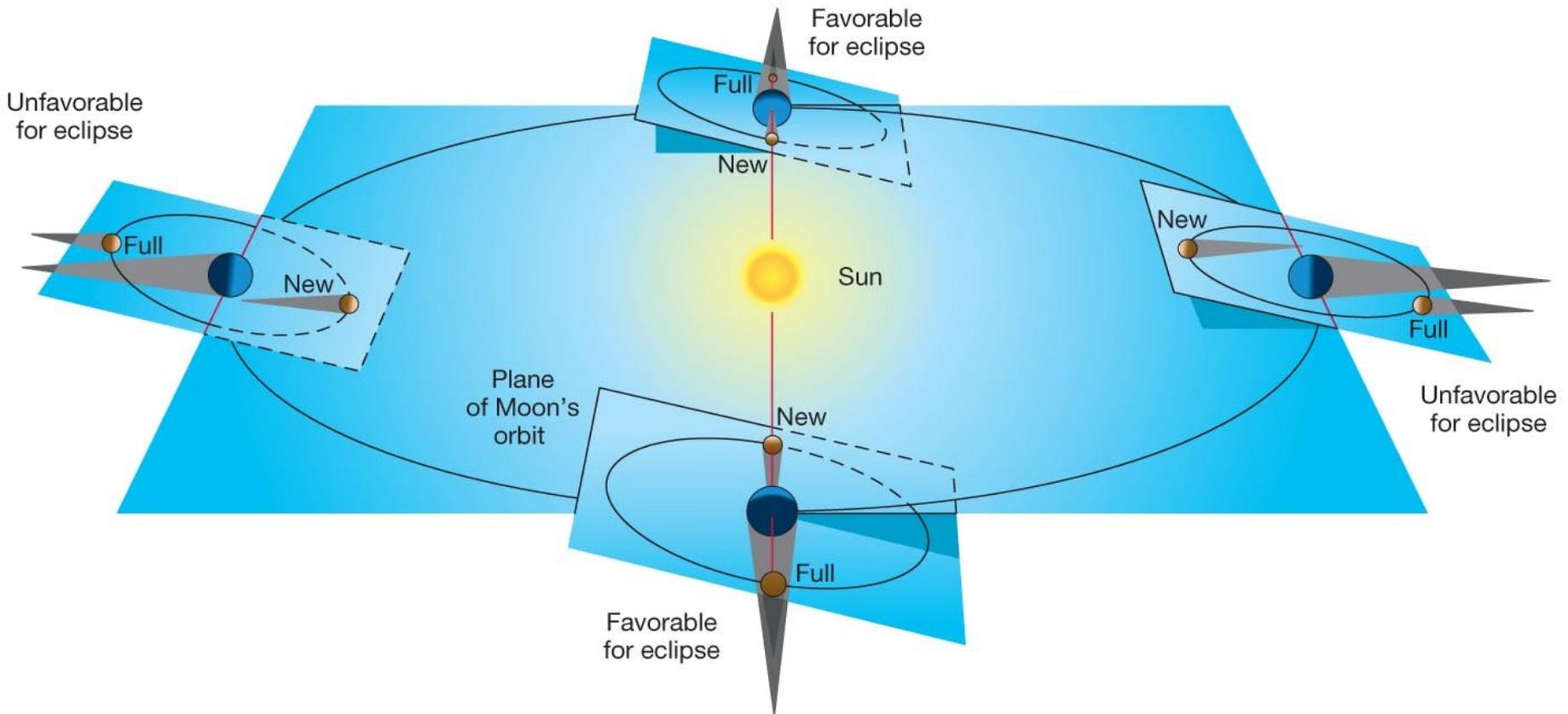
- Solar eclipse at each new moon
- Lunar eclipse at each full moon

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



# Upcoming eclipses

- Total lunar eclipse: October 7-8, 2014  
<http://earthsky.org/tonight/total-lunar-eclipse-blood-moon-hunters-moon-october-7-8-2014>
- Partial solar eclipse: October 23  
<http://earthsky.org/tonight/partial-solar-eclipse-for-north-america-on-october-23>

## Warning:

- Do NOT STARE AT THE SUN!!!
- Do NOT USE BINOCULARS WITHOUT PROPER FILTERS

# Solar eclipses not caused by the moon

Can you see solar eclipses not caused by the moon?

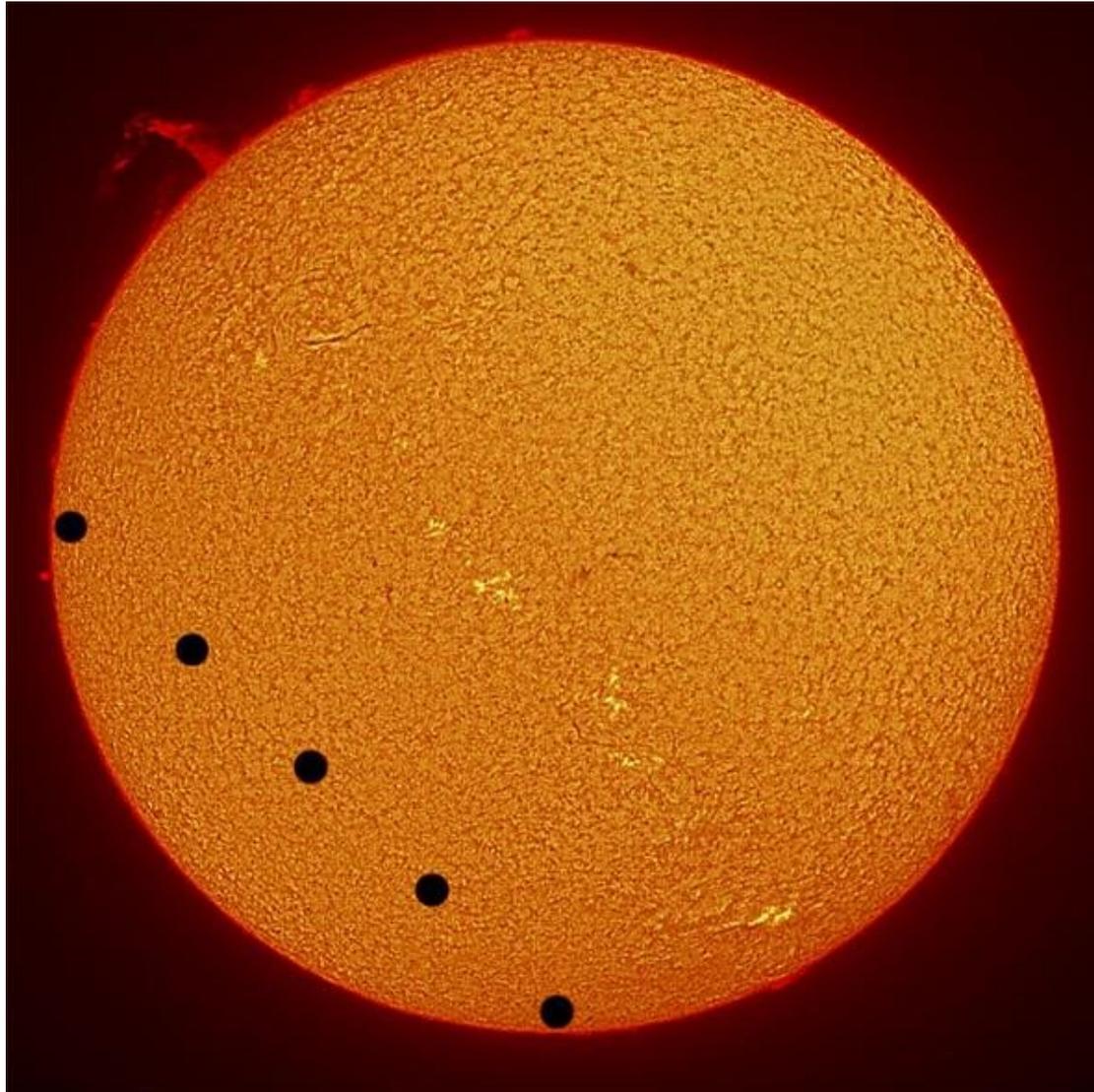
A

Yes, of course

B

No way!

# Transit of Venus – June 5<sup>th</sup>, 2012



Did you see it?

It was your last  
chance!

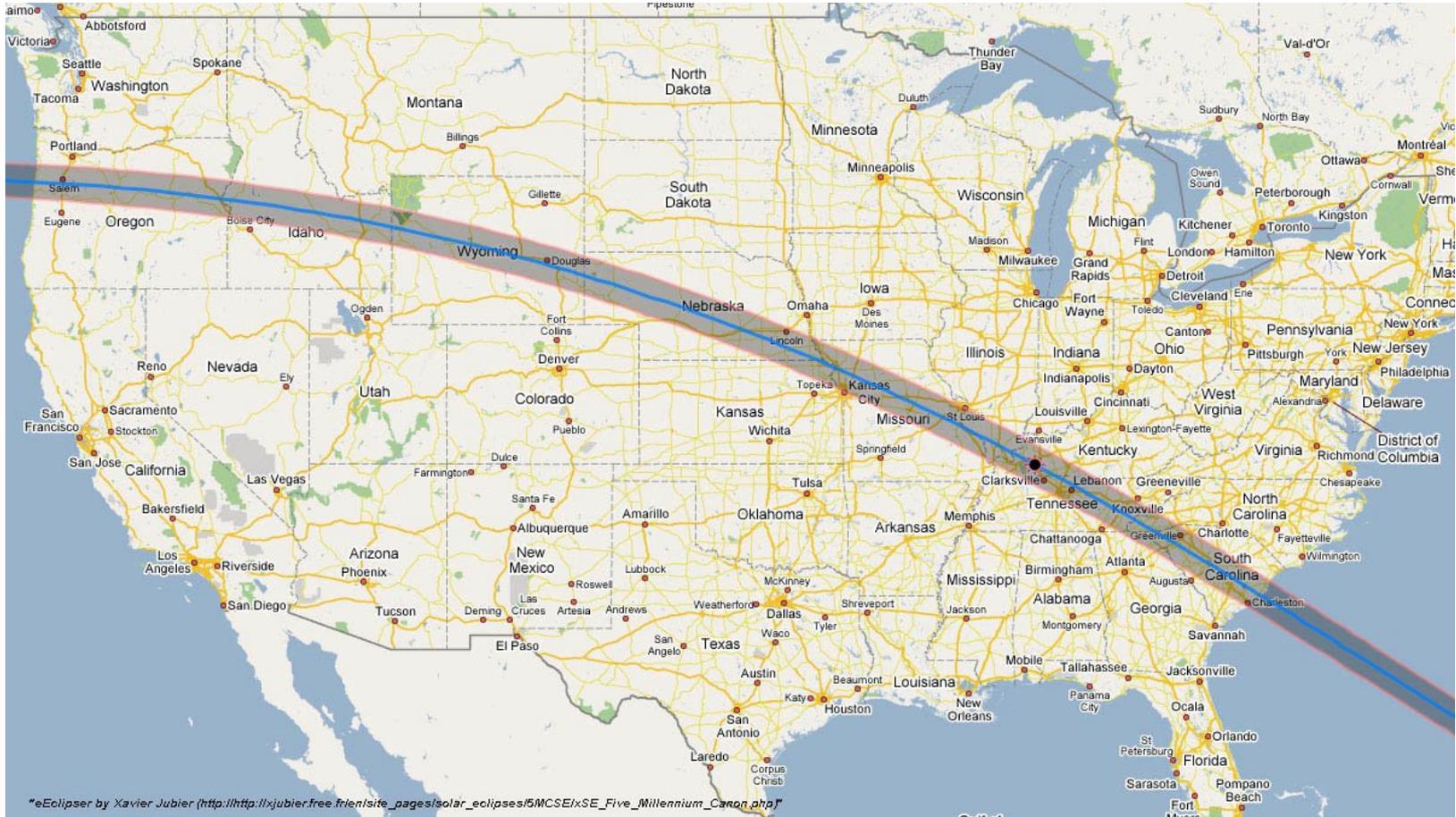
Next transit:  
Dec. 10-11, 2117

# Solar eclipse as seen from Mars

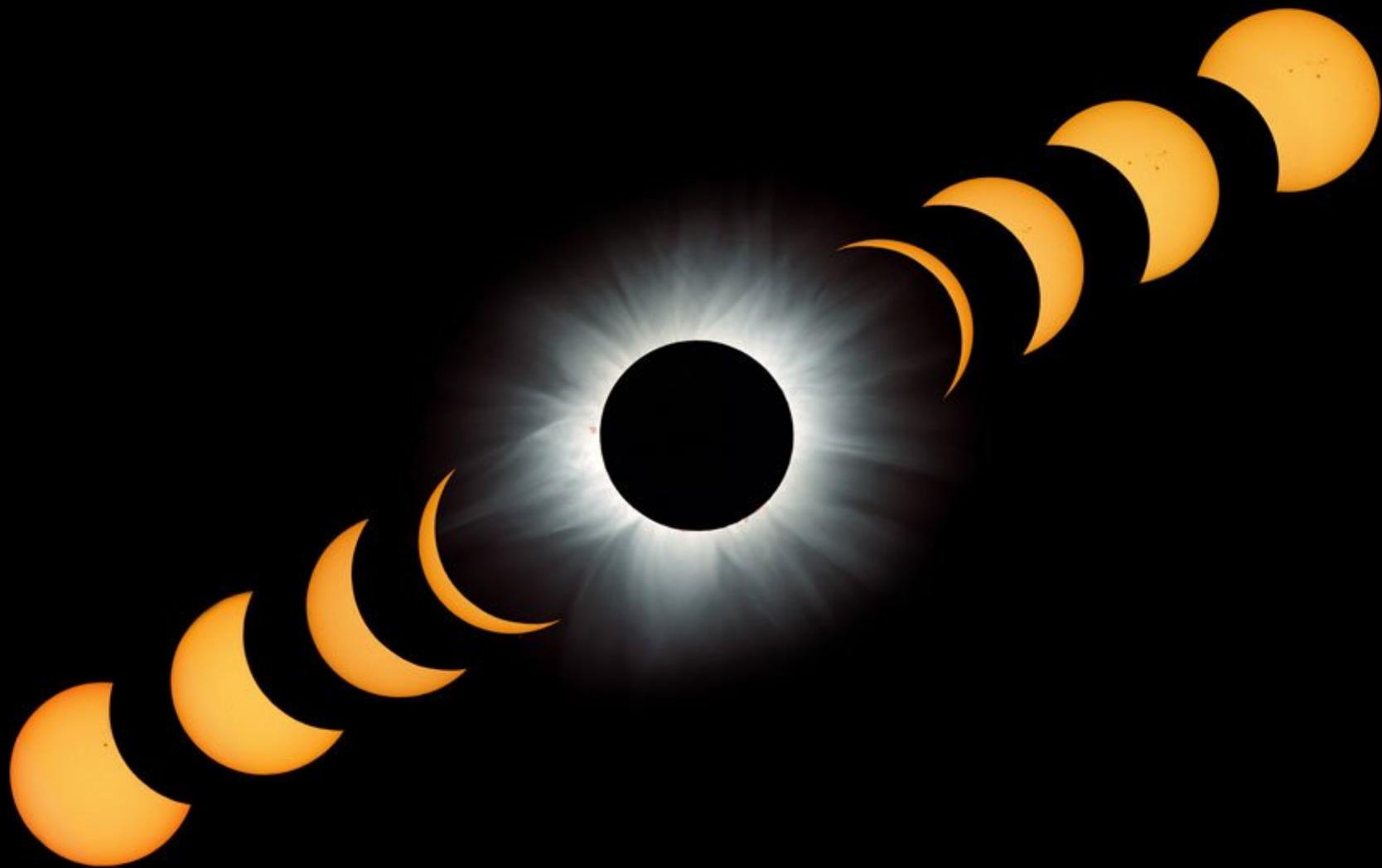


watch online: <https://www.youtube.com/watch?v=OyZoD7BRTtg>

# 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



August 21, 2017  
Start planning!

A

C

B

D