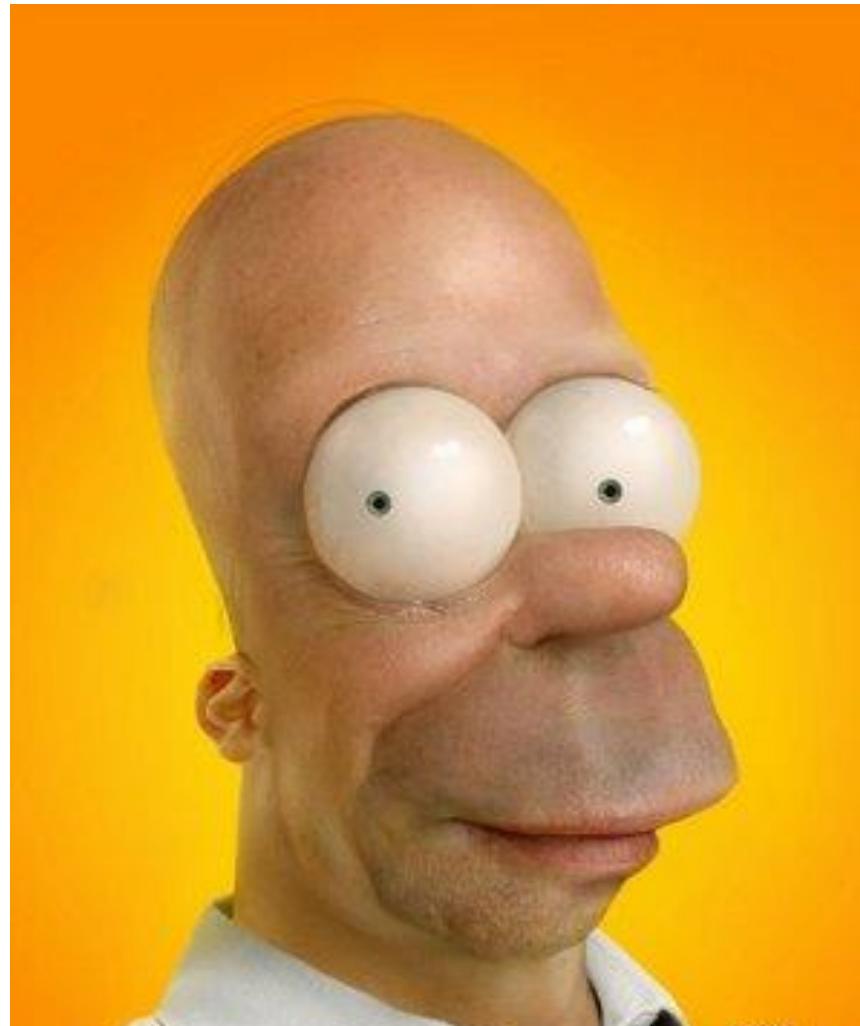


# ASTRONOMY EXPLORING SPACE & TIME



Night Sky

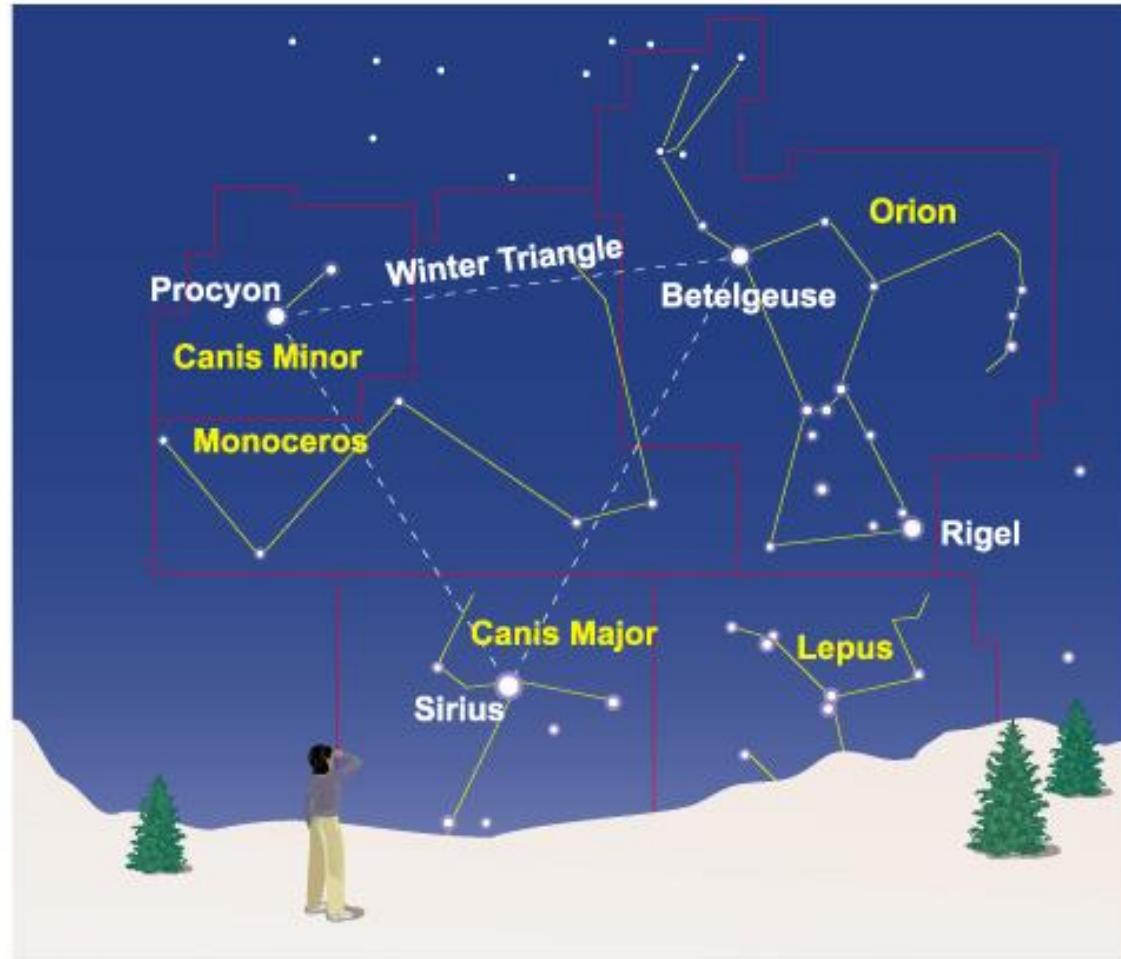
# Naked Eye

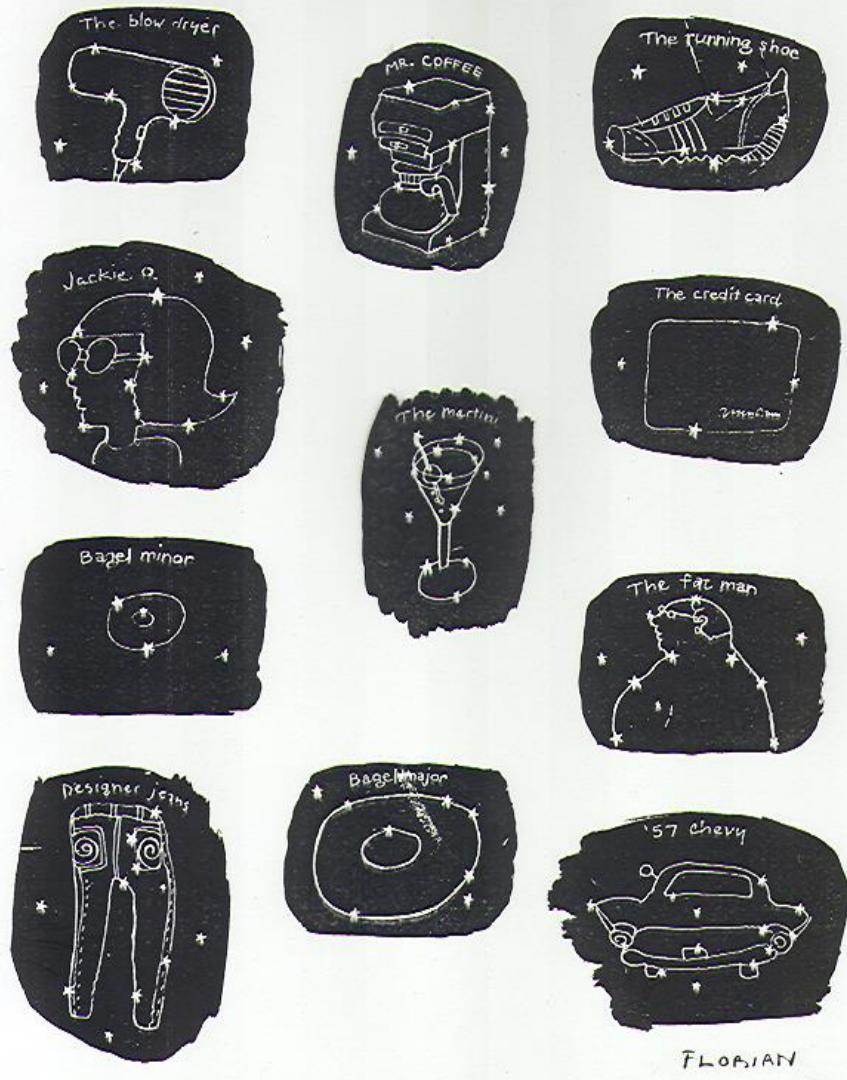


# Constellation

It's a *region* of the sky,  
within official borders  
set in 1928 by the IAU.

- Often recognizable  
by a pattern, asterism,  
or grouping of stars.
- There are 12 zodiac  
constellations, 88 in all  
parts of the sky.

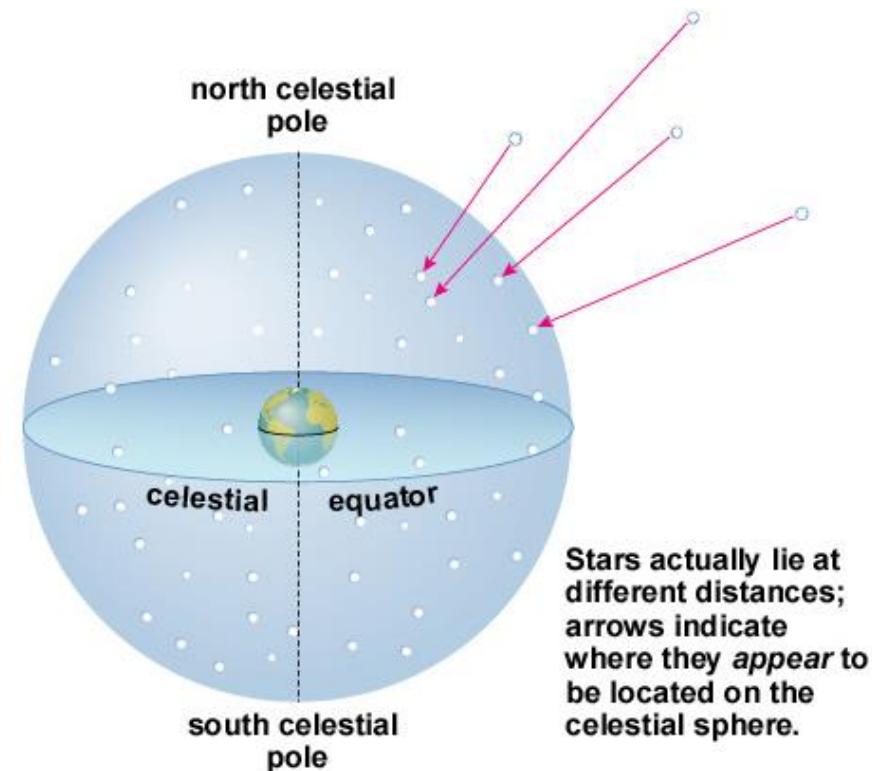




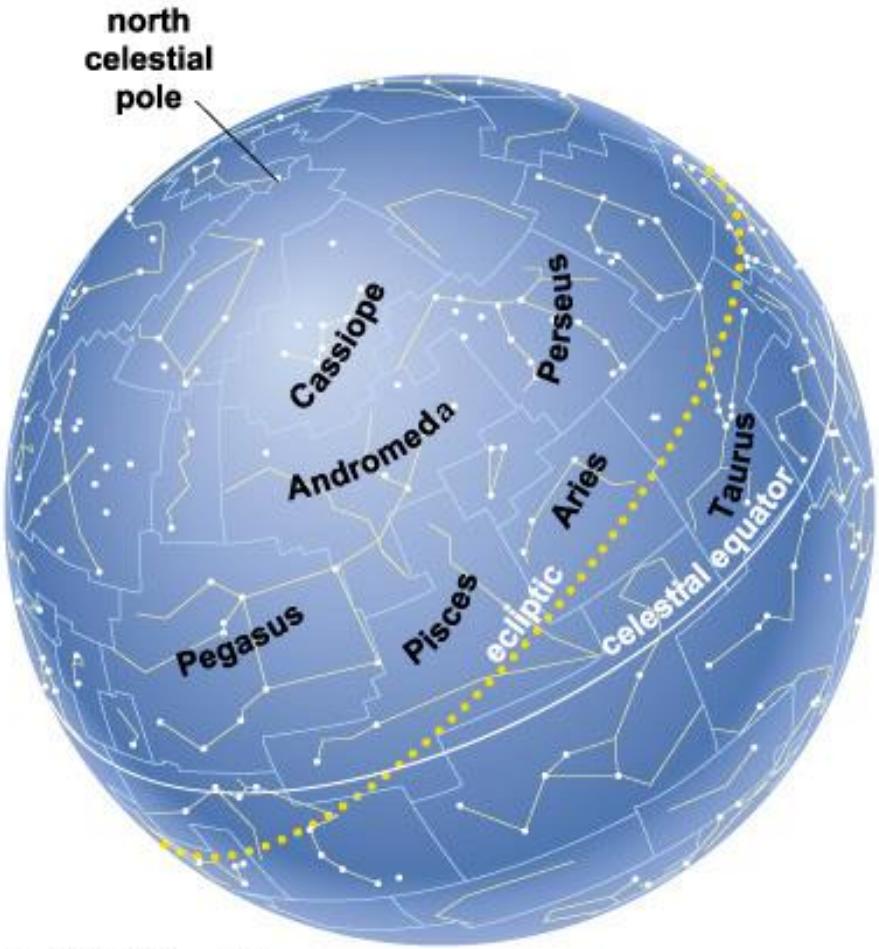
"Now try to find a few that look like a bear  
or a dog or something."

# Origin of Constellations

- Most official constellation names come from antiquity. Some constellations in the southern hemisphere were named by European explorers in the 17<sup>th</sup> & 18<sup>th</sup> centuries.
- The patterns of stars have no physical significance! Stars that appear close together may lie at very different distances.

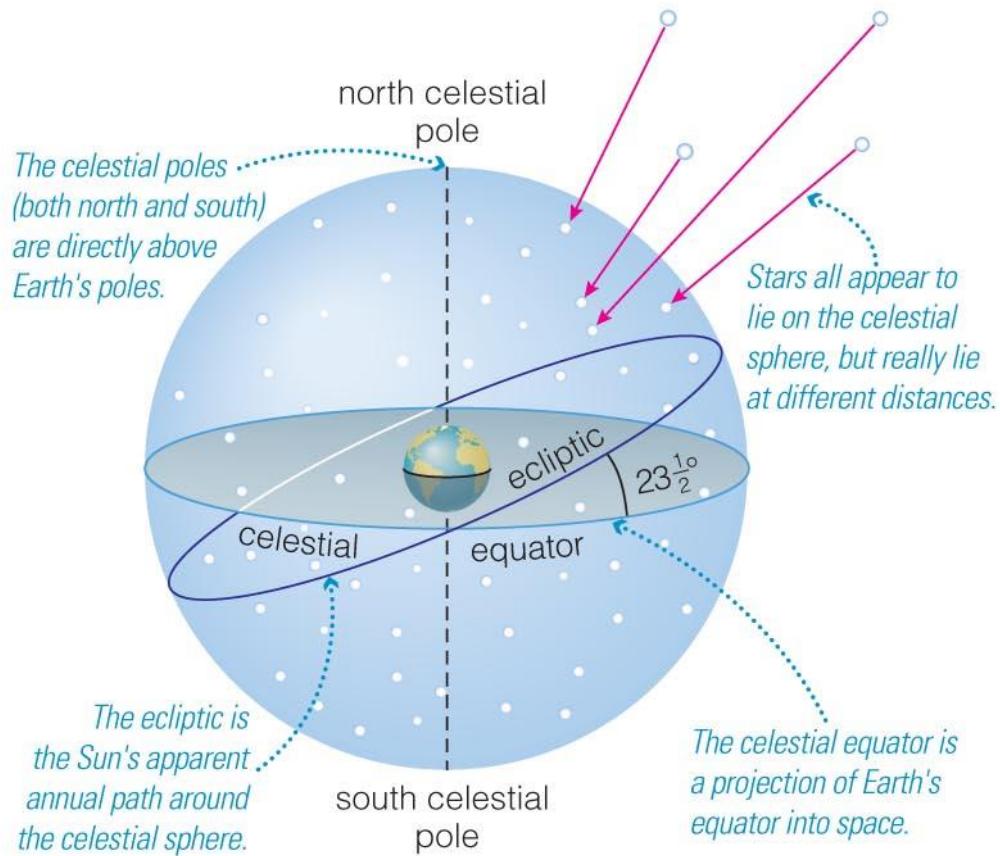


# The Celestial Sphere

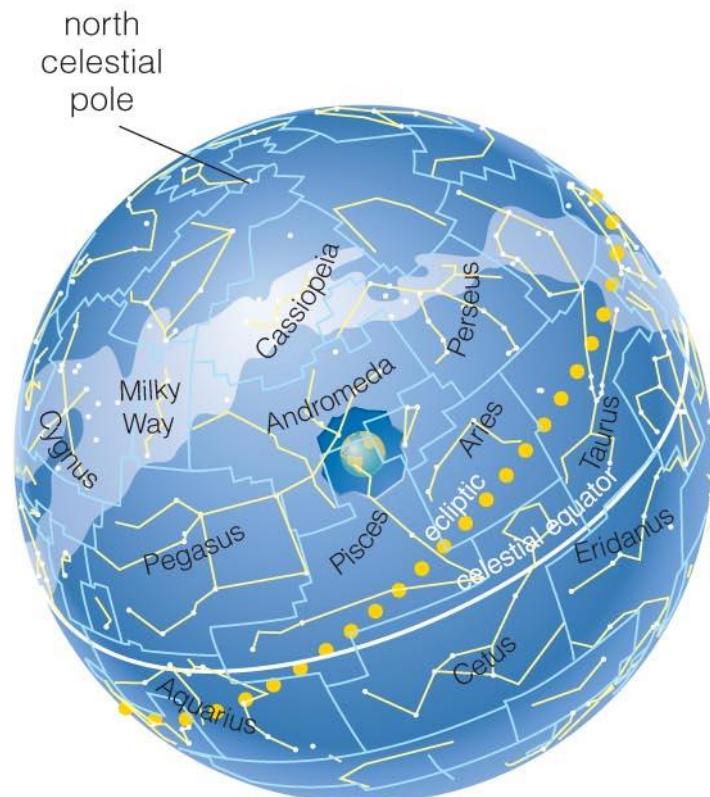


- The sky above looks like a dome...a hemisphere
  - If we imagine the sky around the entire Earth, we have the concept of the **celestial sphere**.
  - This is a 2-dimensional representation of the sky
- ← Because it represents our view from Earth, we place the Earth in the center of this sphere.

# The Celestial Sphere



a Key reference points on the celestial sphere.

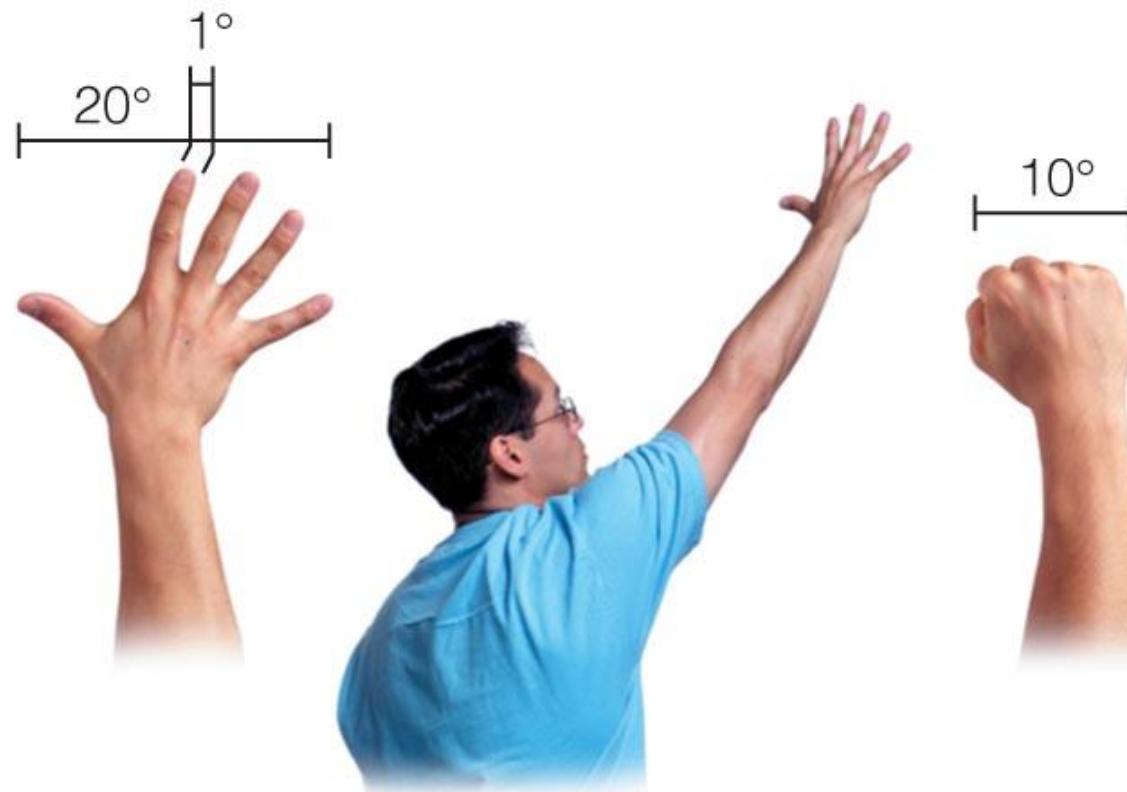


b A model of the celestial sphere, showing constellation borders and more.

**3 Planes:**

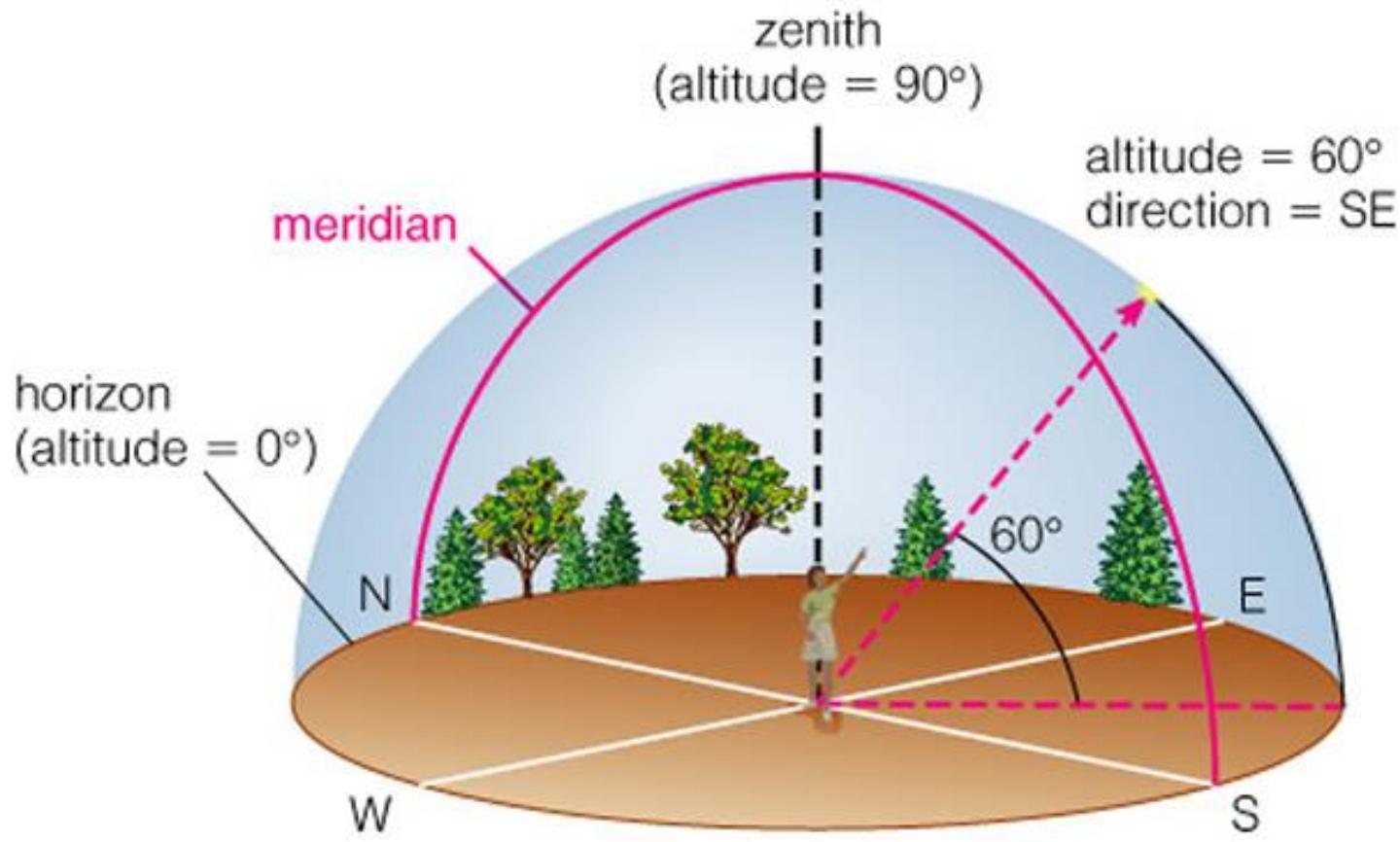
- 1. Celestial Equator (Earth's rotation)**
- 2. Ecliptic (Earth's orbit of the Sun)**
- 3. Milky Way (disk of our galaxy)**

# Measuring Angles



Stretch out your arm  
as shown here.

- c You can estimate angular sizes or distances with your outstretched hand.



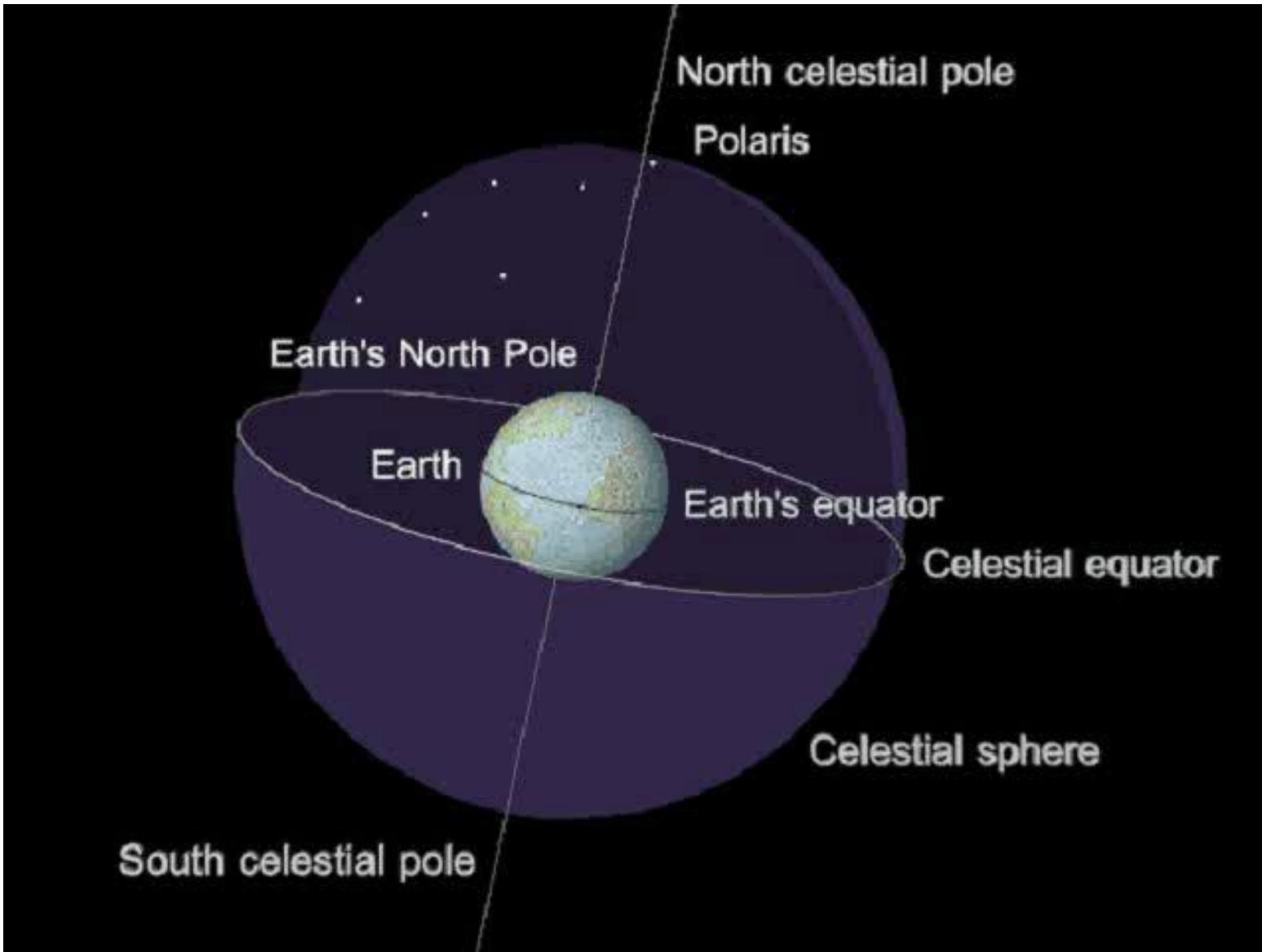
Objects in the sky can be measured with two angles: the **altitude** above the horizon, and the **azimuth** around the horizon. Zenith is straight overhead and the line joining the zenith to due south and due north is the meridian.

# Daily Motion

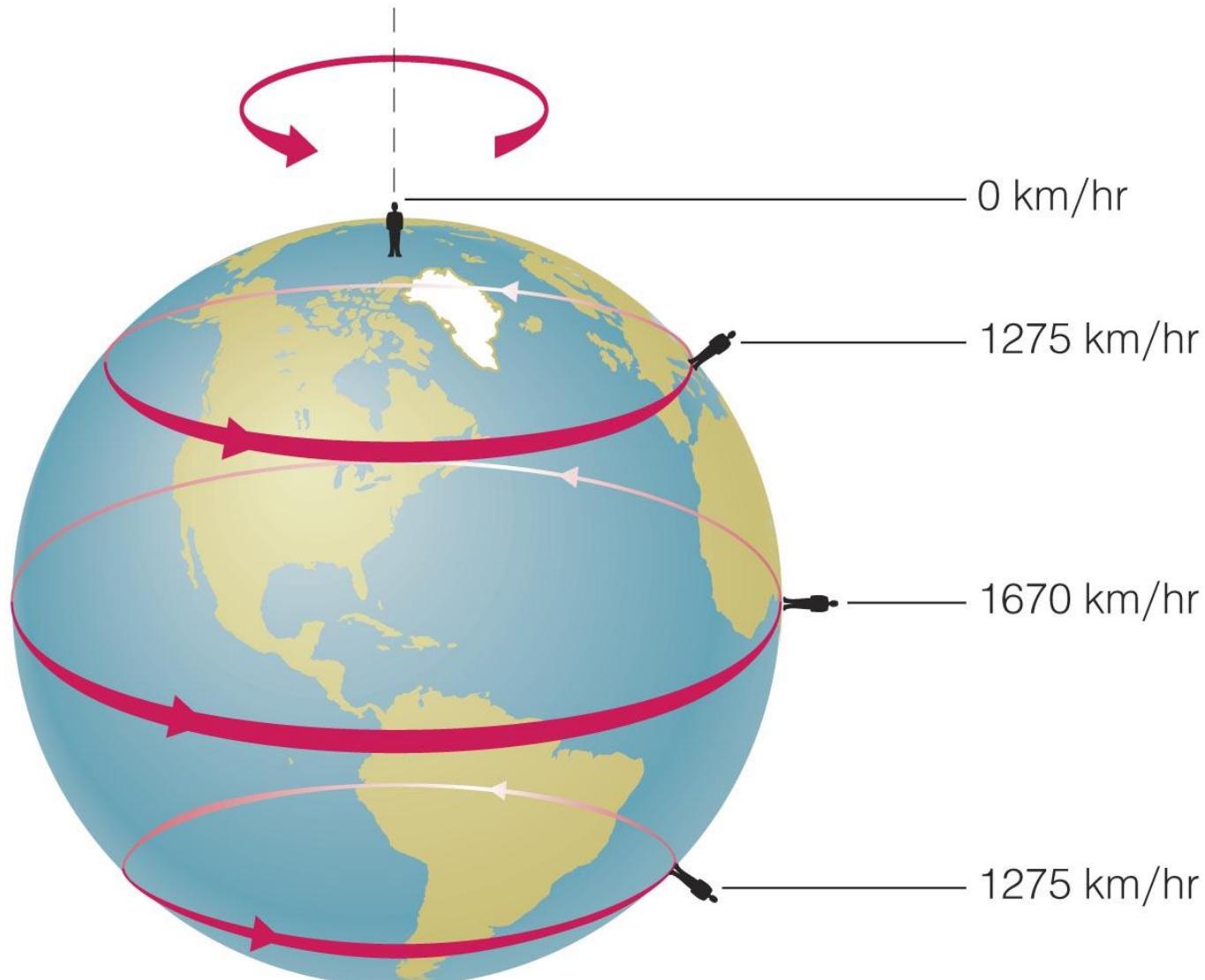


# Diurnal Motion

# Diurnal Motion



# Earth's Rotation



(explaining, for example, why KSC is in Florida not Maine)

# Diurnal Motion

N & S celestial poles

the points in space directly above the Earth's poles

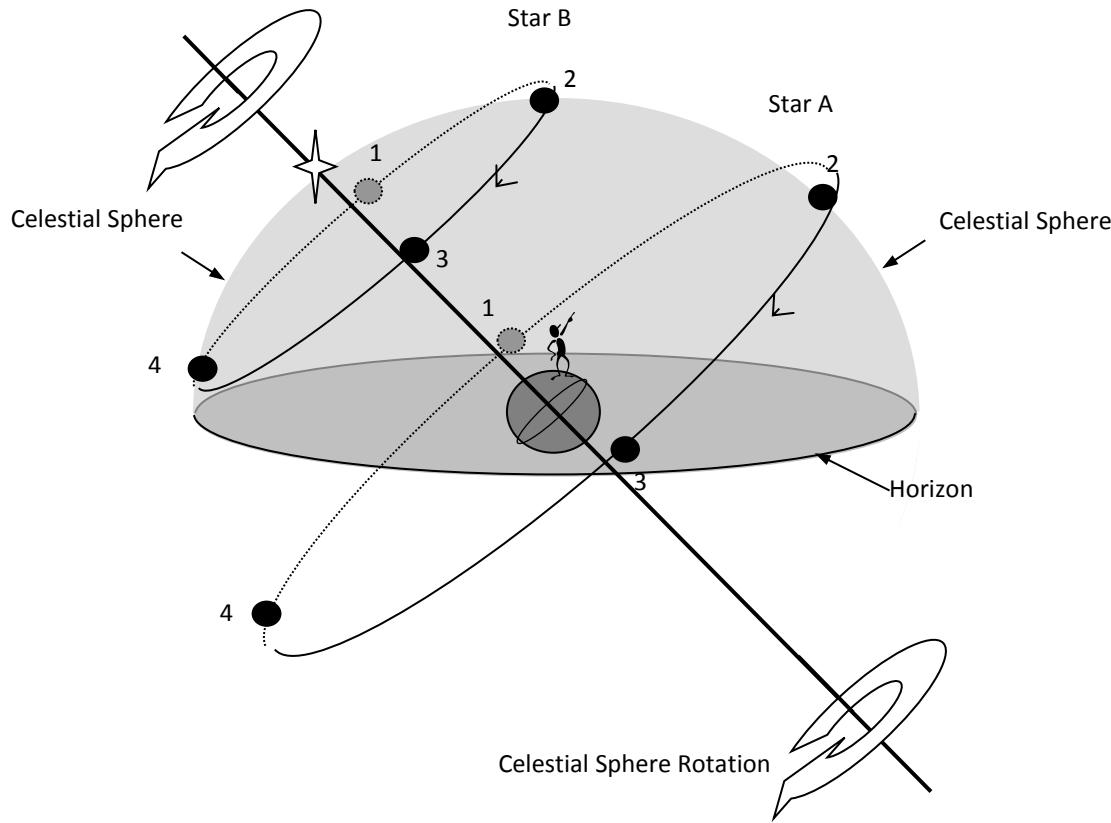
celestial equator

the line in space directly above the Earth's equator

sidereal day = 23 hours 56 min 4.1 sec

solar day = 24 hours

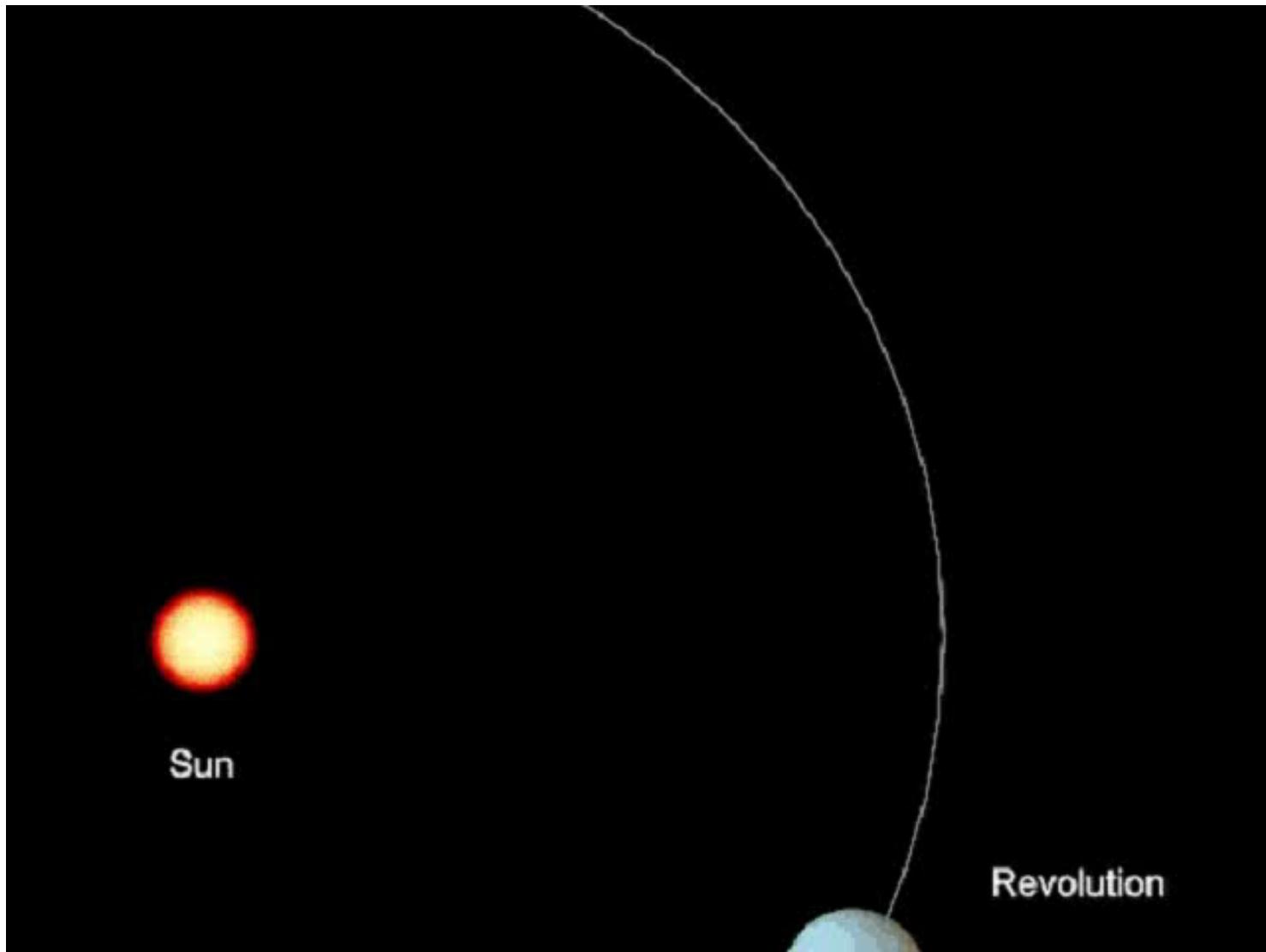
Celestial Sphere Rotation



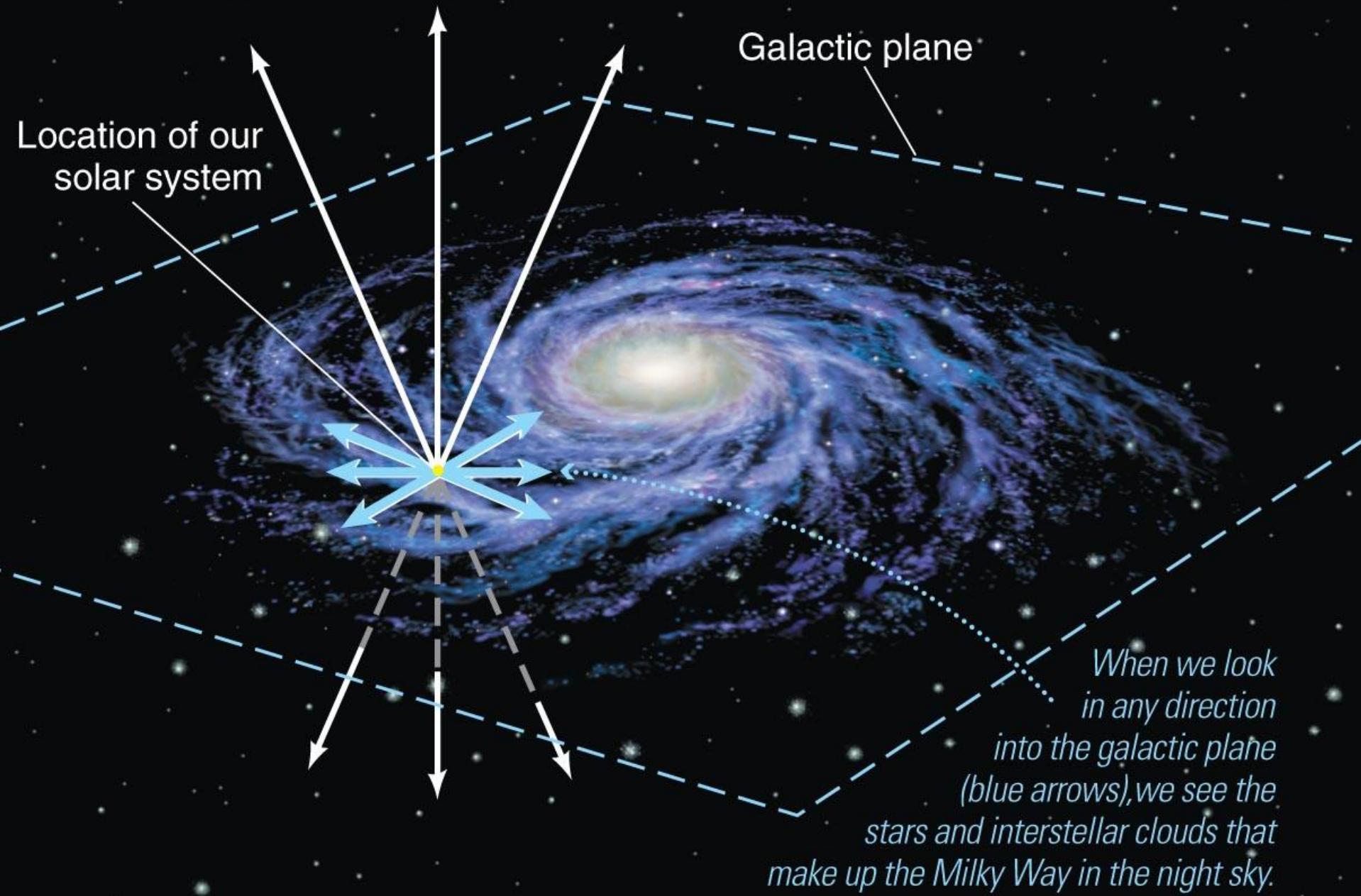
Due to the Earth's rotation, stars rise in the east and set in the west. They move in circles around the **celestial pole**, the projection of the Earth's pole into space. The angle of the celestial pole above the horizon is the local **latitude**.

# Solar vs. Sidereal Day

# Solar vs. Sidereal Day



*When we look out of the galactic plane (white arrows), we have a clear view to the distant universe.*



# Annual Motion



Approximate time:  
Direction:

Midnight  
due north

6:00 A.M.  
due east

Noon  
due south

6:00 P.M.  
due west



# Annual Motion

ecliptic

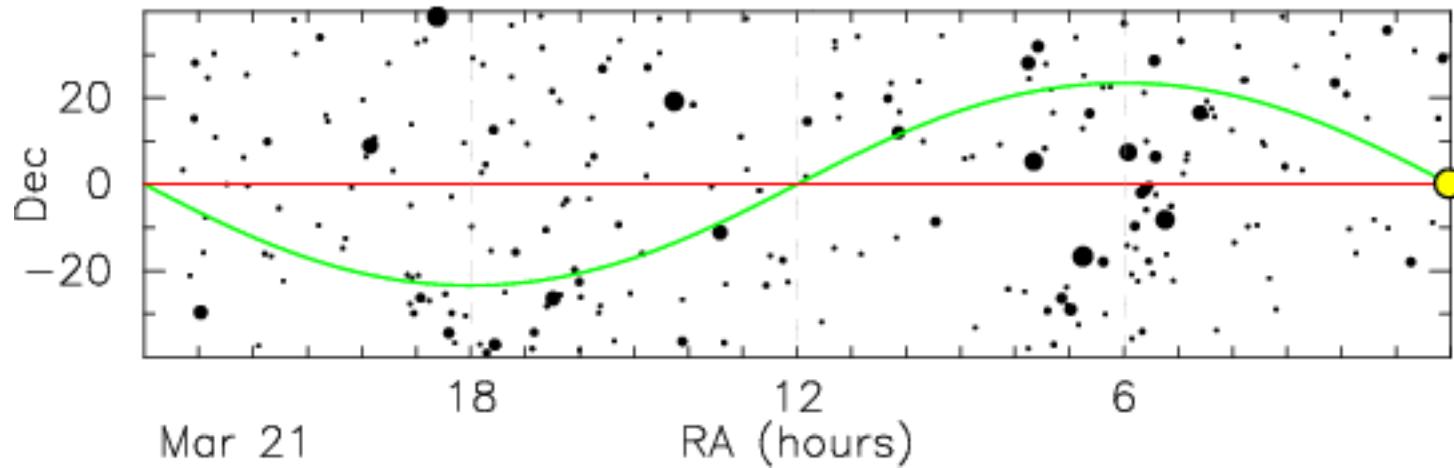
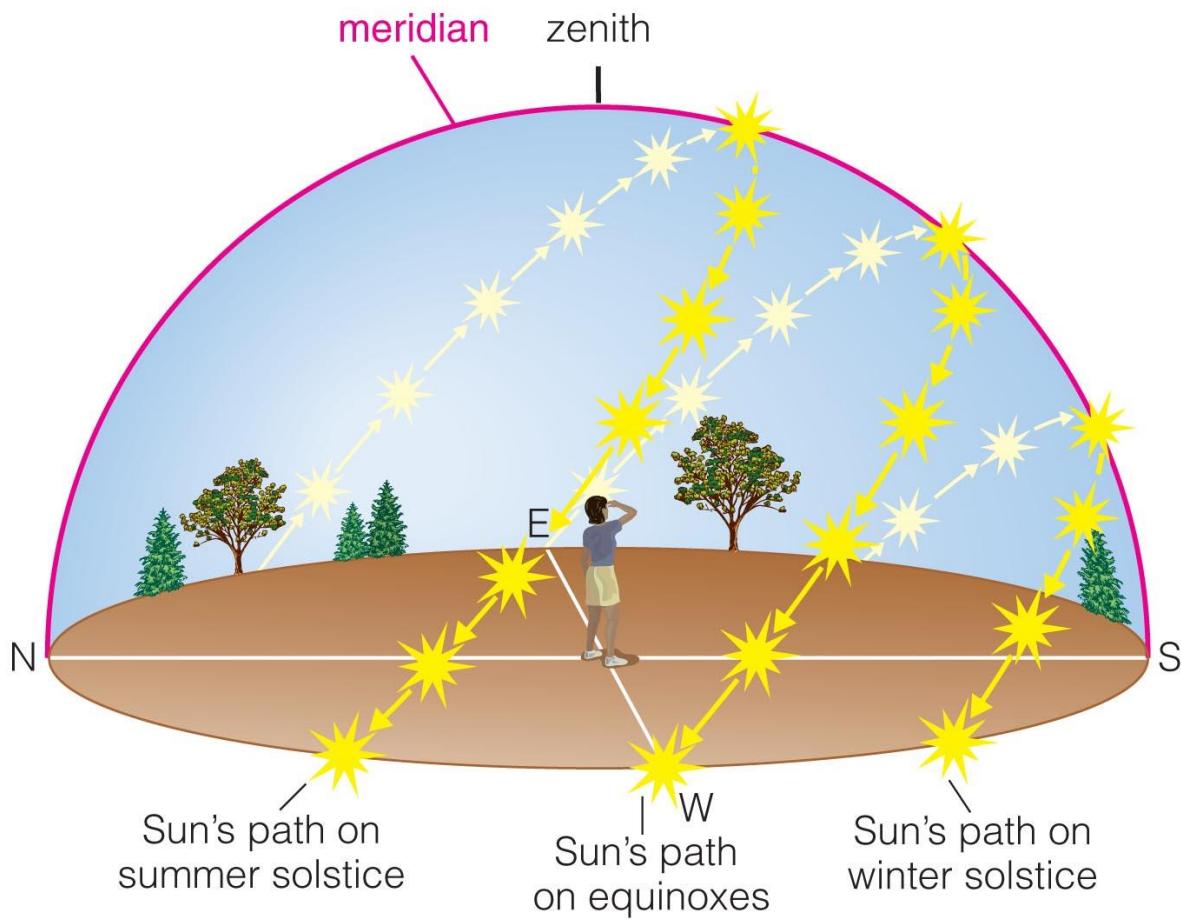
the apparent path of the Sun through the sky

equinox

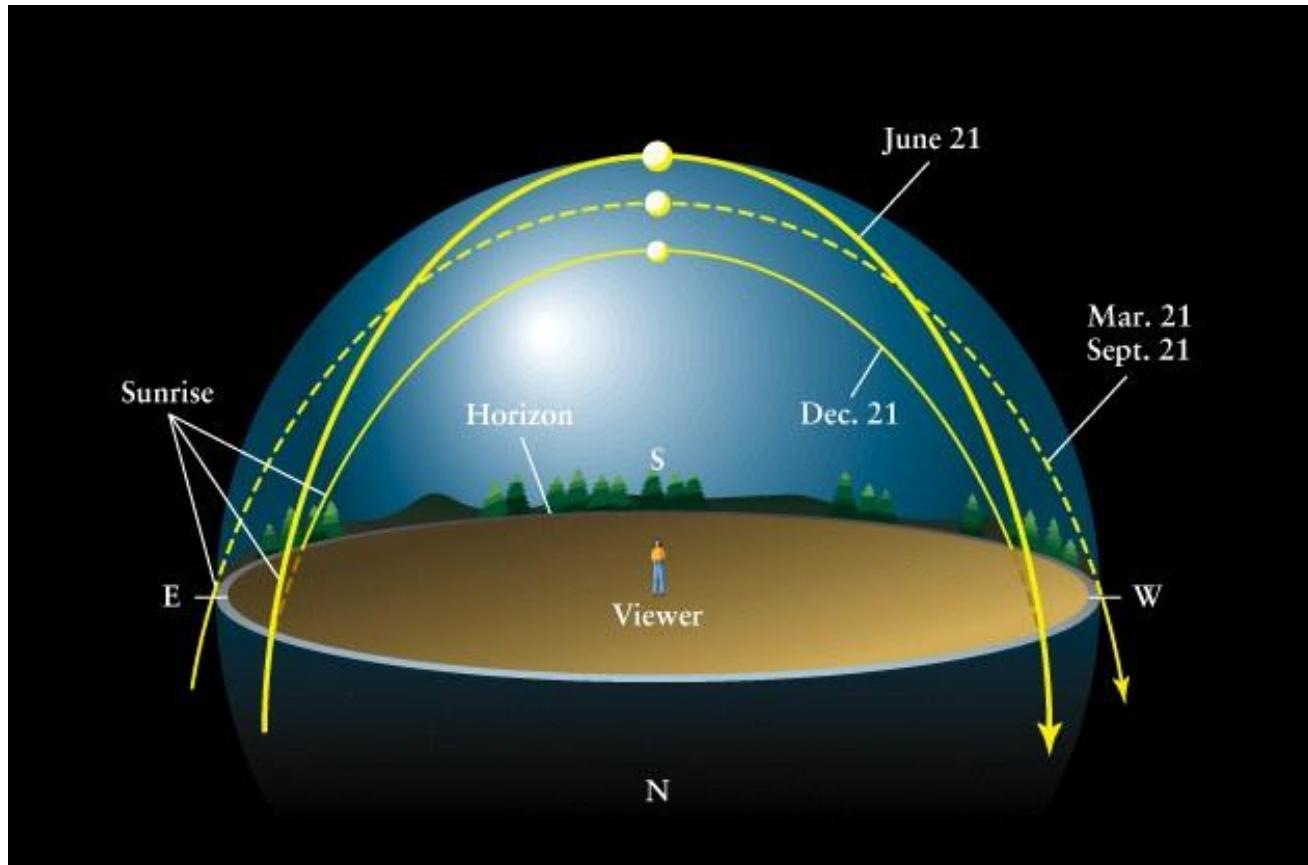
where the ecliptic intersects the celestial equator

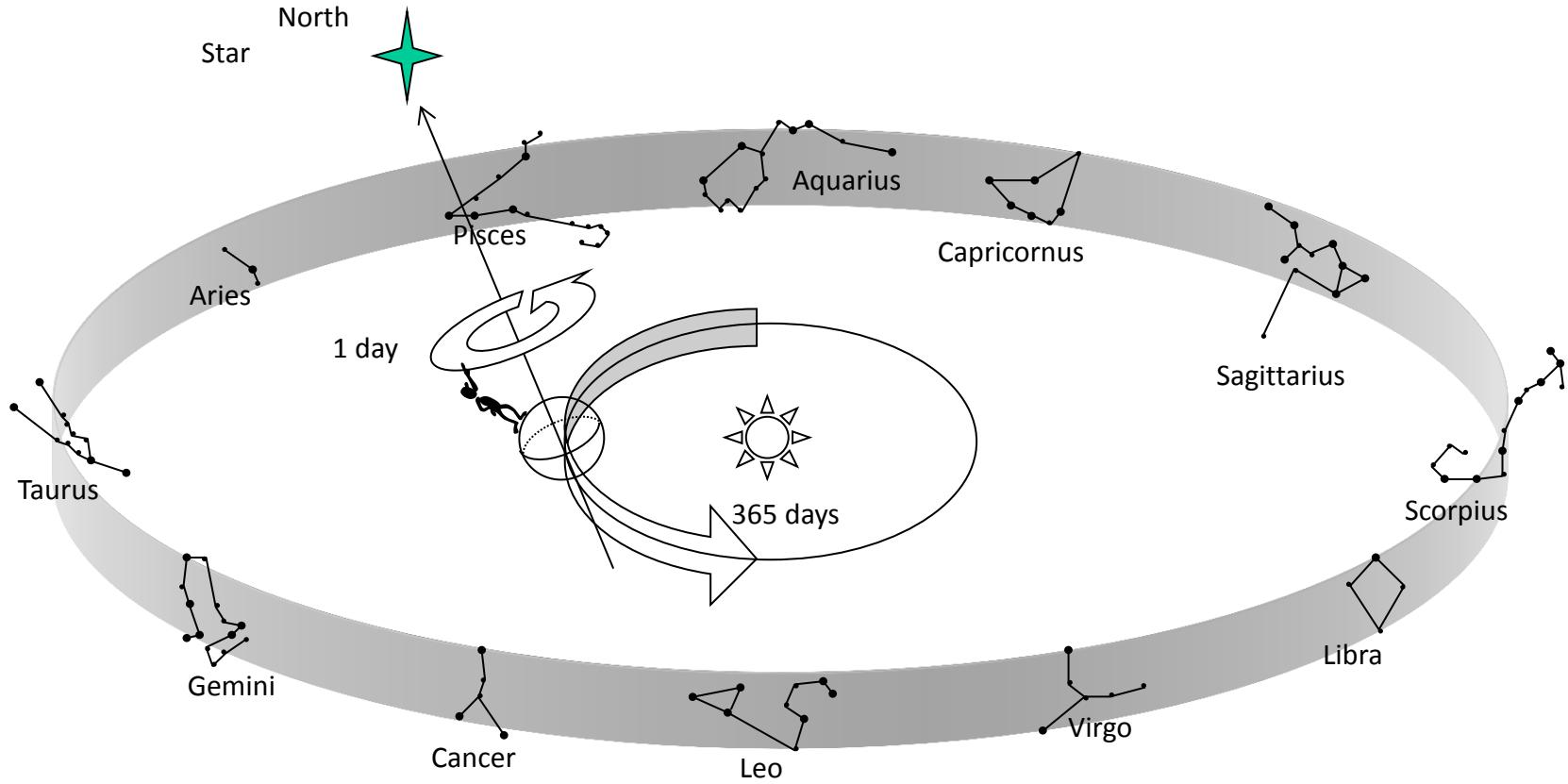
solstice

where the ecliptic is farthest from the celestial equator



In the northern hemisphere, the Sun rises due east and sets due west on the **equinoxes** (equal day and night). It rises and sets north of due east and west on the summer **solstice** and south of due east and west on winter solstice.

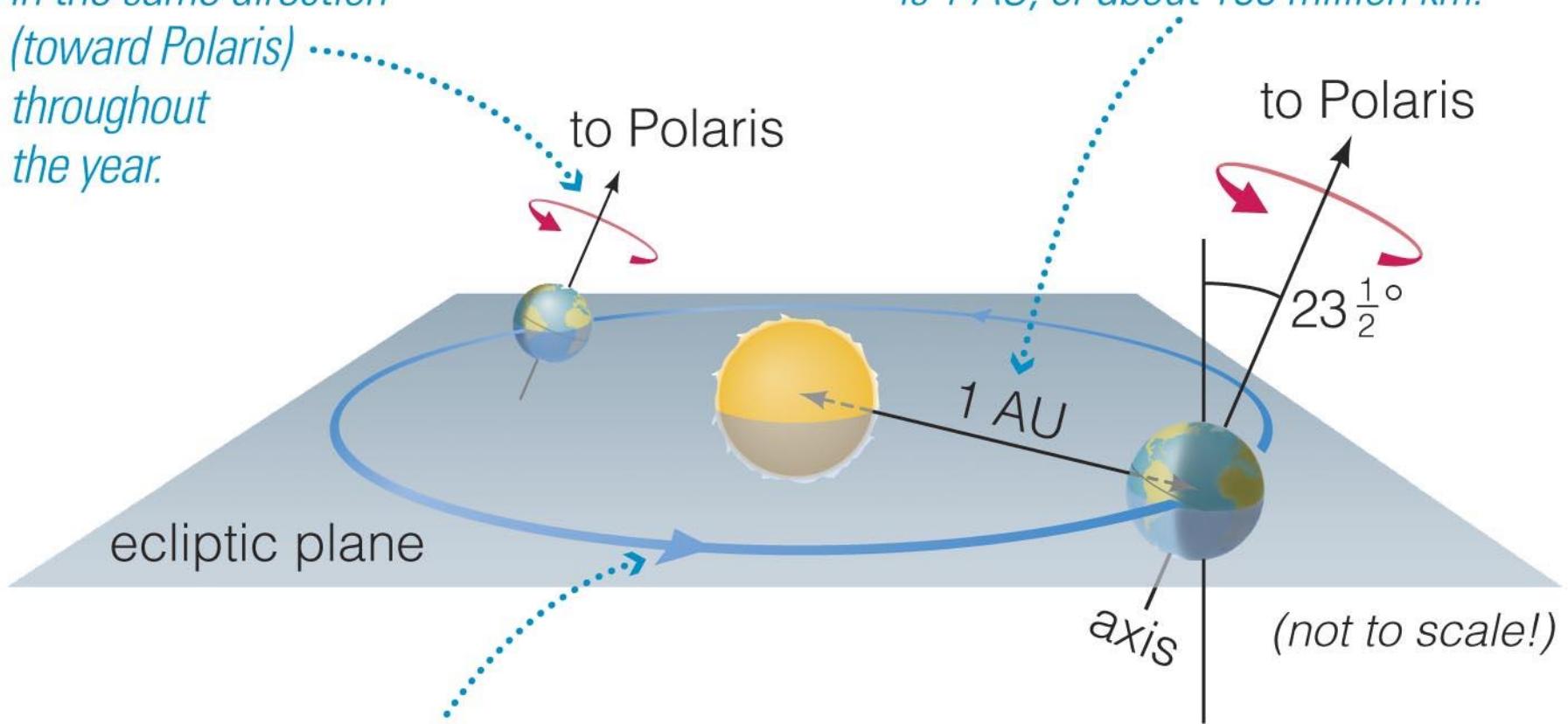




Due to the Earth's orbit of the Sun, the constellations all migrate through the night sky each year. Each star rises and sets four minutes earlier each day. Constellations on the path traveled by the Sun (the **ecliptic**) are the **zodiac**.

# Earth's Orbit

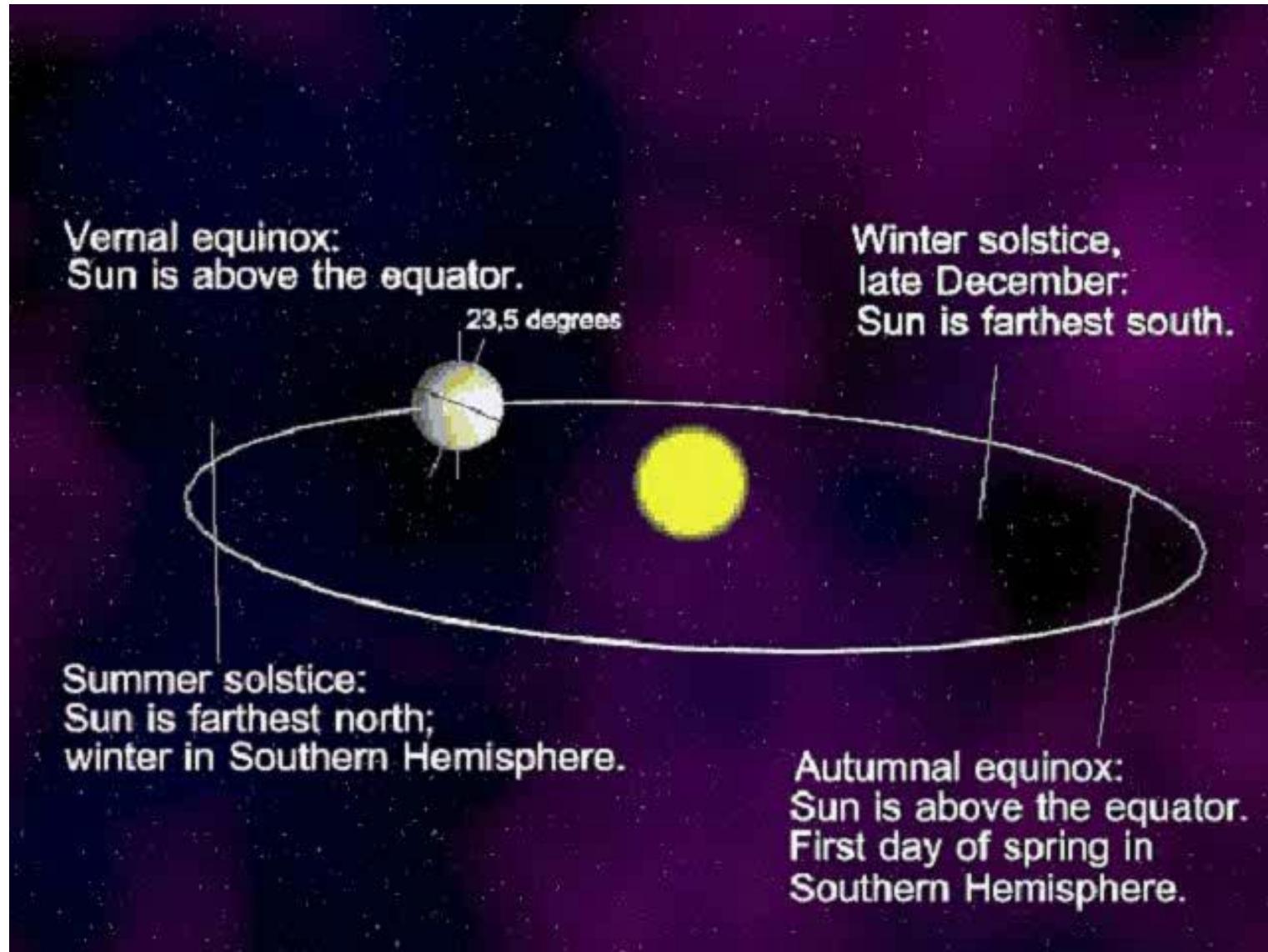
*Earth's axis remains pointed in the same direction (toward Polaris) throughout the year.*



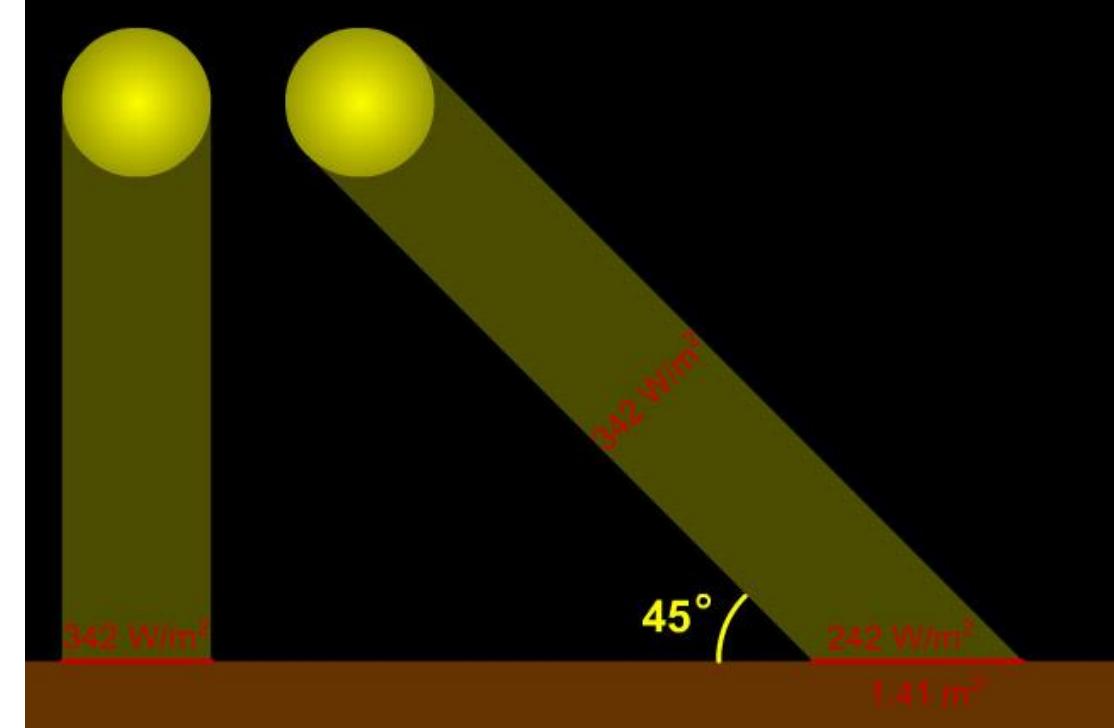
*Earth takes 1 year to orbit the Sun at an average speed of 107,000 km/hr.*

# Seasons

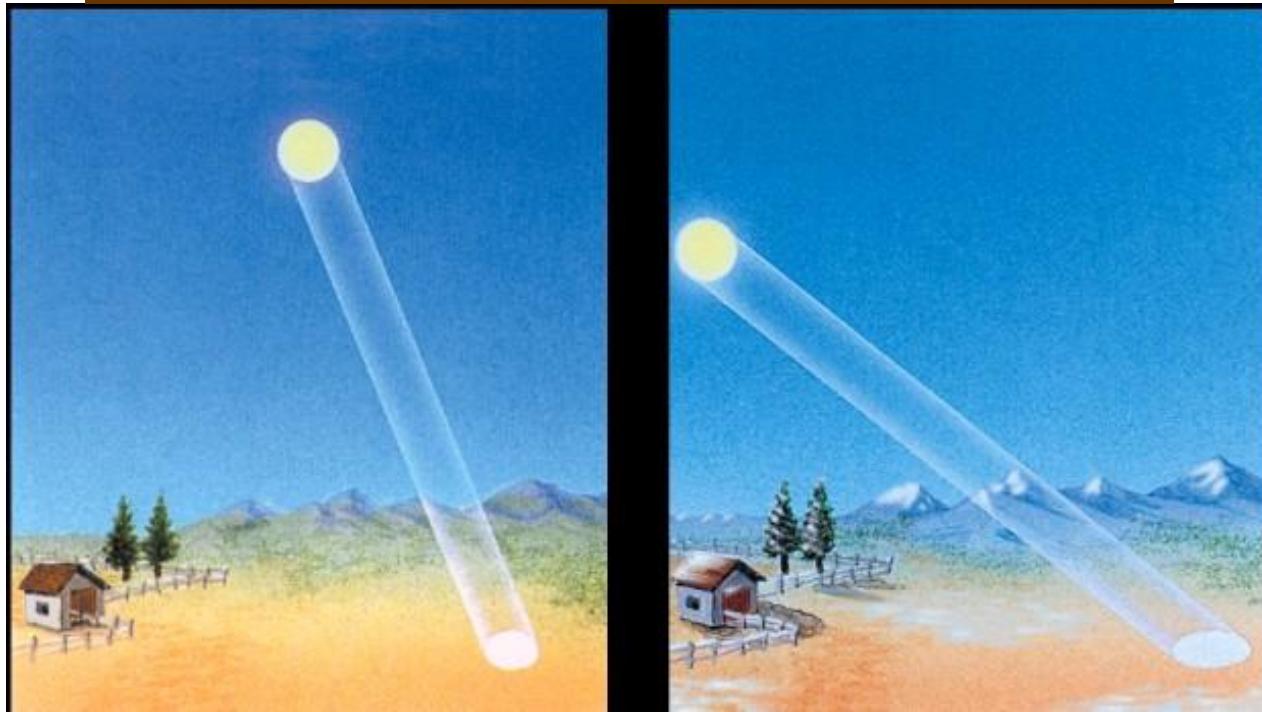
# Seasons

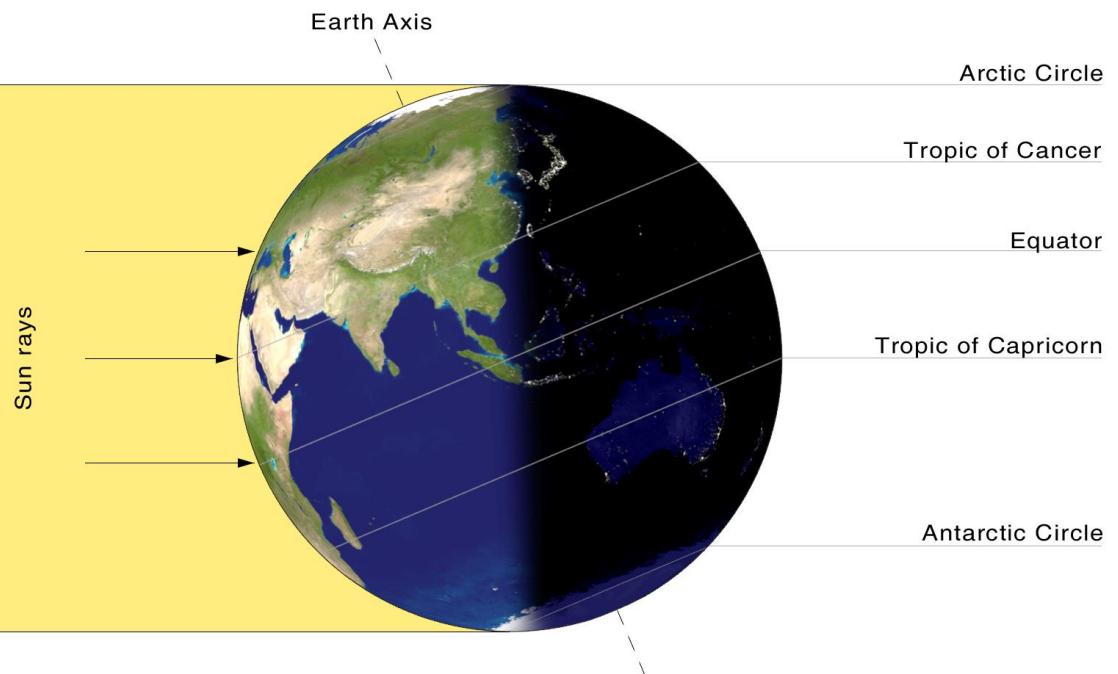


The tilt of the Earth's spin axis causes the angle of illumination of the Sun at noon vary over a year.



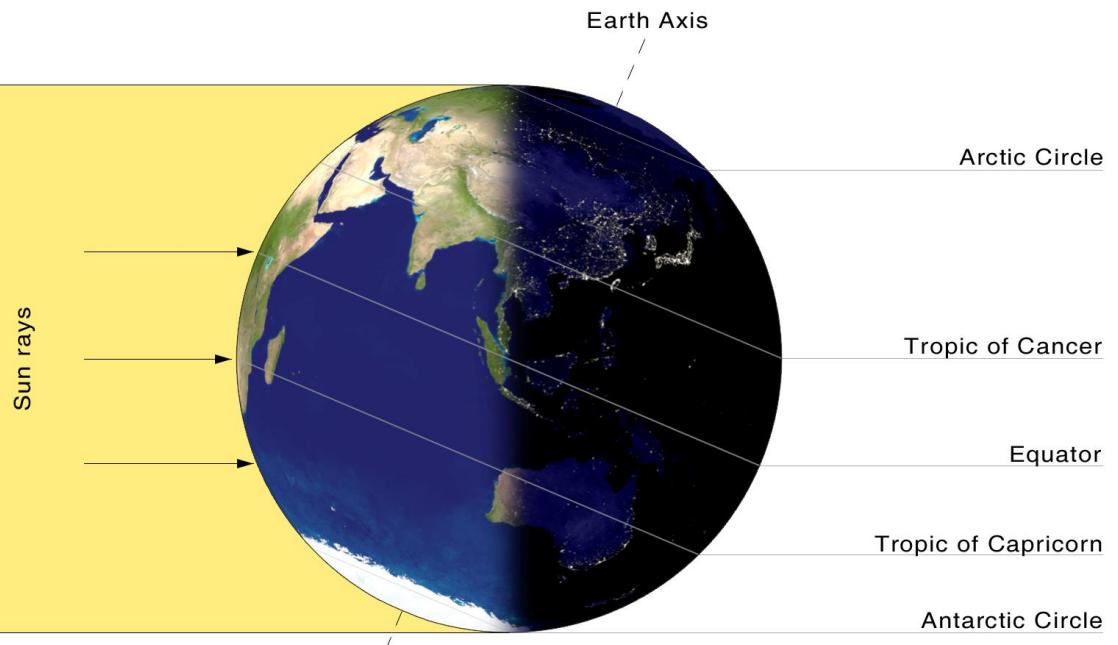
When the mean illumination angle is shallower, the heating effect is less, when larger, the heating effect is greater.





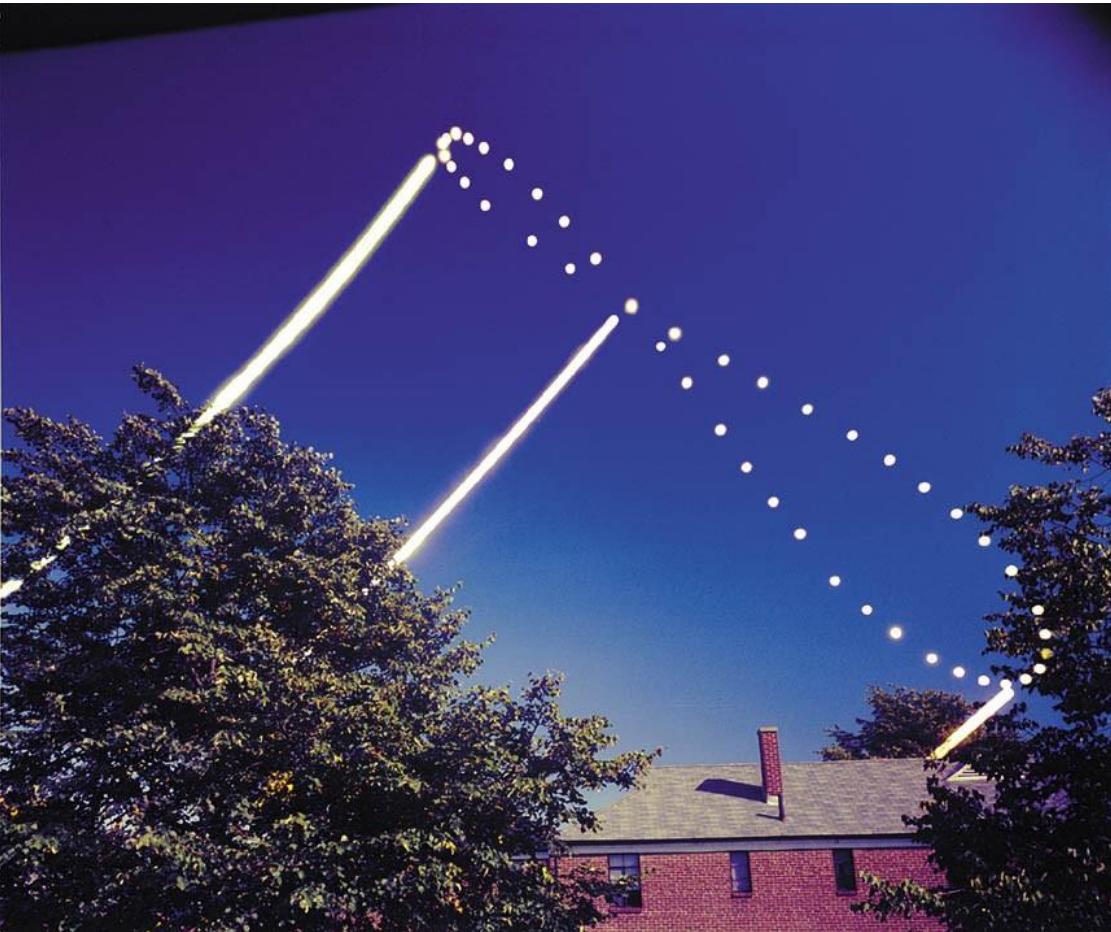
Summer in the N  
= Winter in the S

Note: the Earth's orbit is slightly elliptical but the effect is too small to cause seasons (they're opposite in the N and S...)

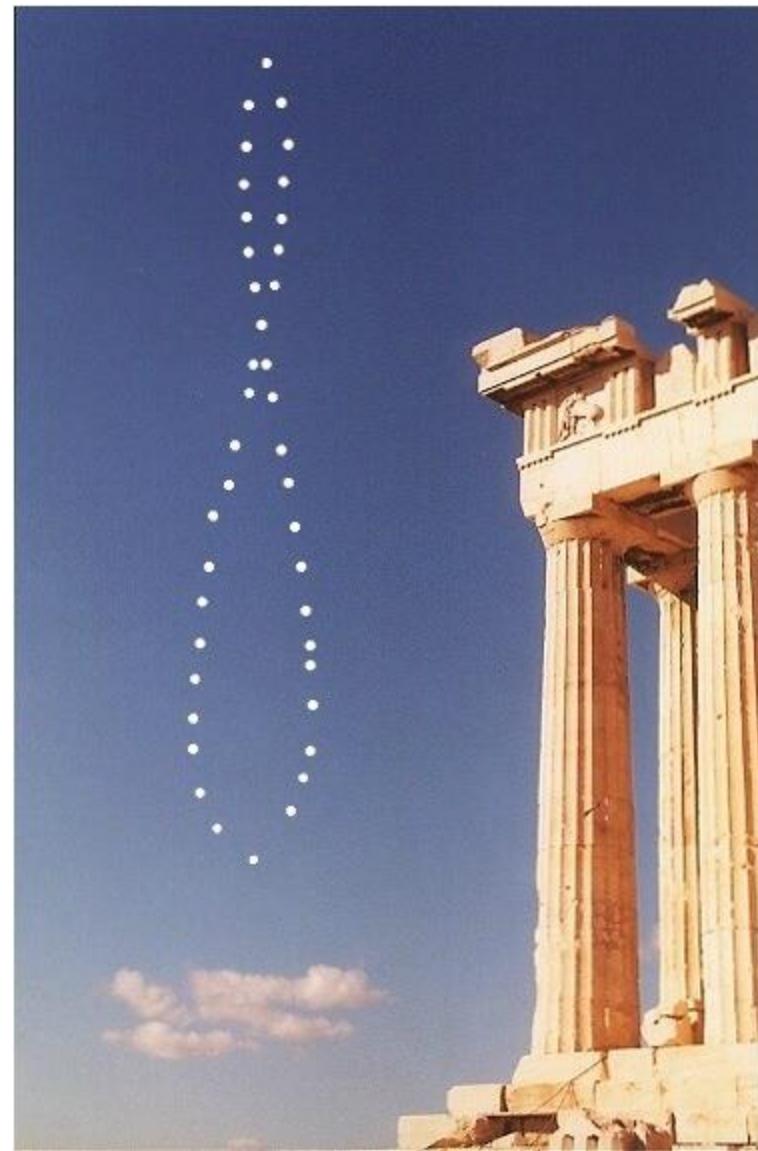


Winter in the N =  
Summer in the S

# Analemma



If the Earth had a circular orbit and no axial tilt, the analemma would be a point. Tilt gives the vertical size, eccentricity gives lobe asymmetry, speed variation in orbit give horizontal extent.

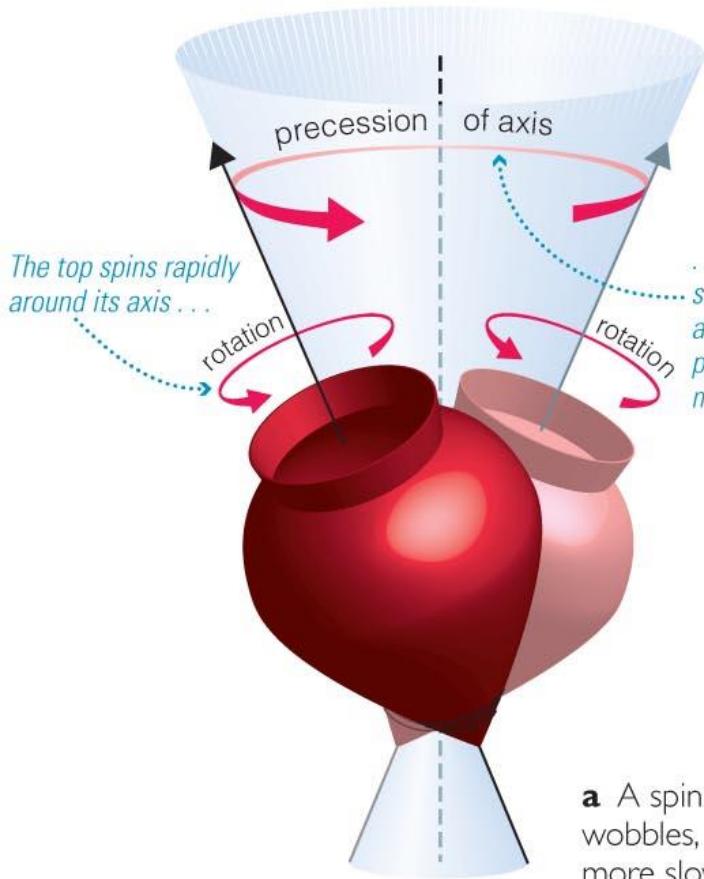




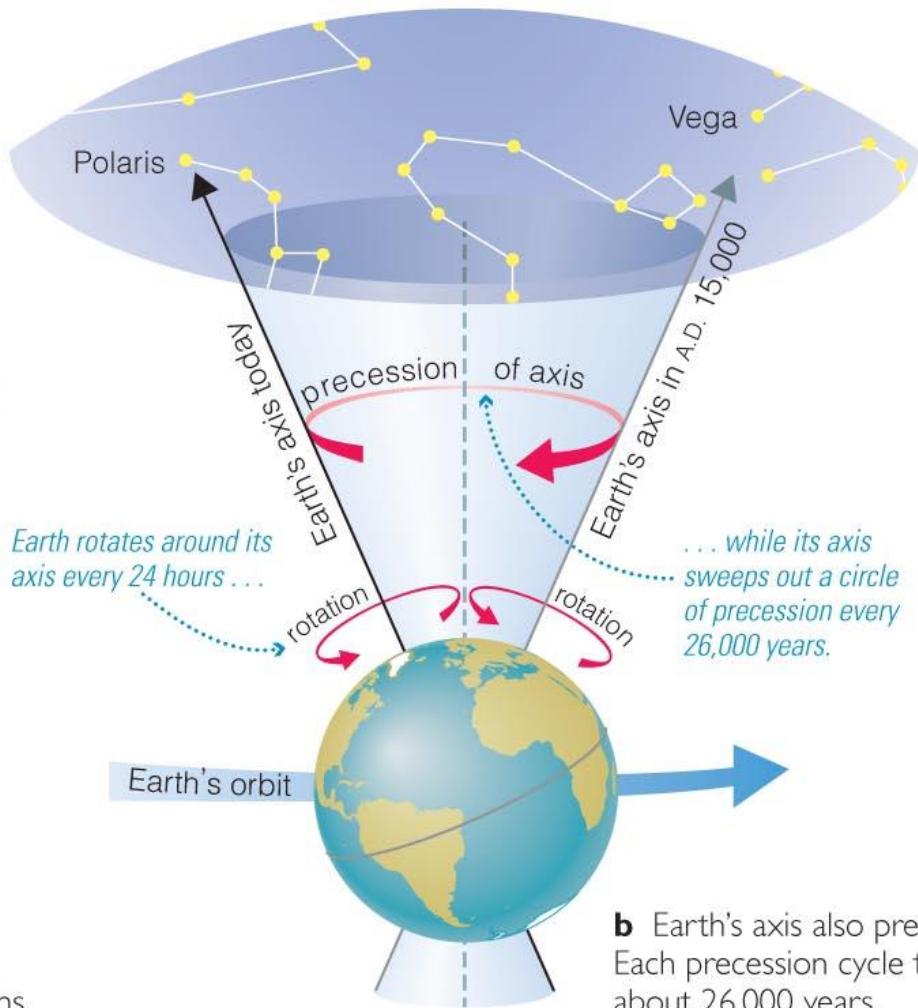
Cenk E. Tezel

(C) 2005-6 Cenk E. Tezel

# Precession



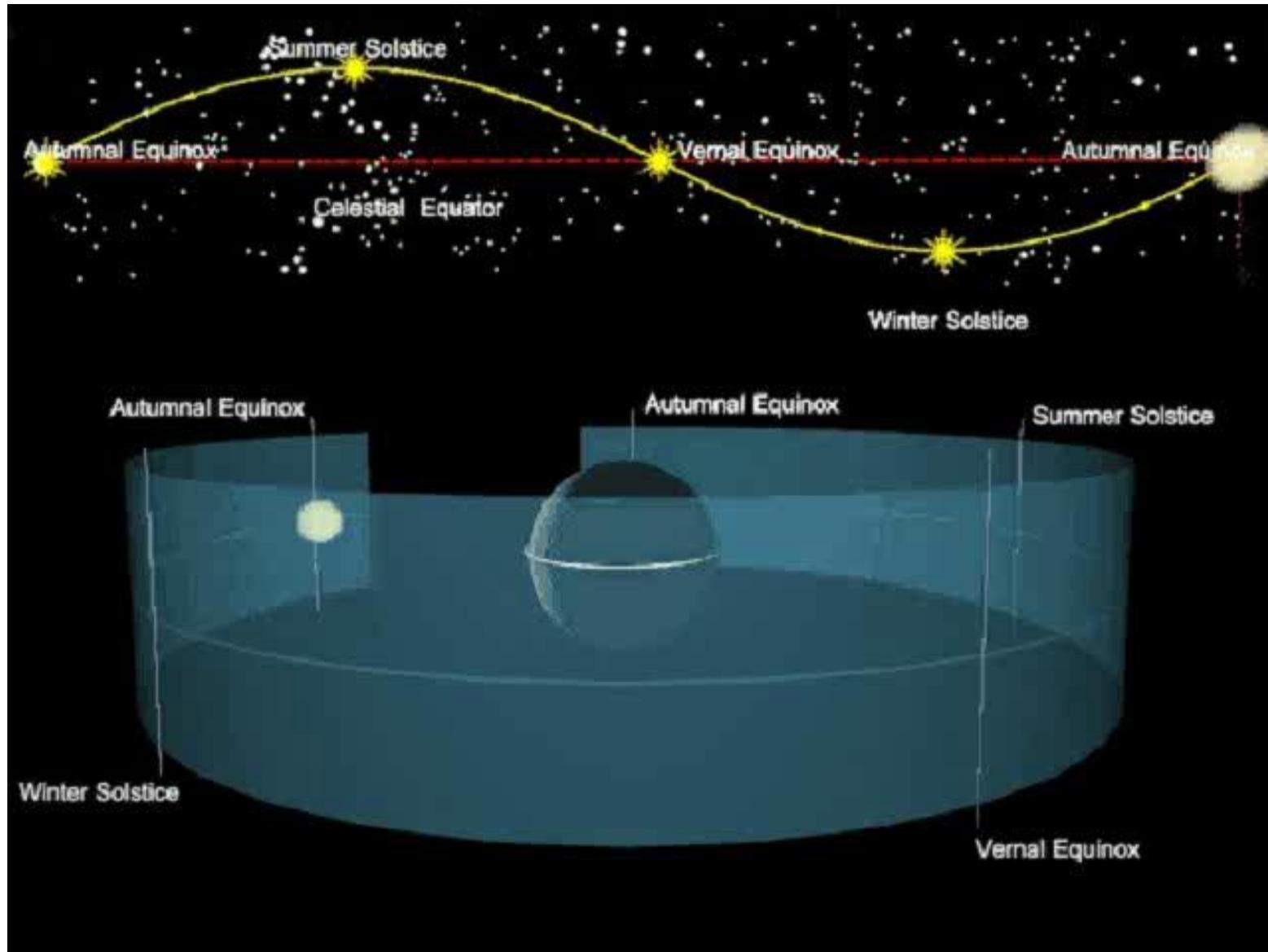
**a** A spinning top wobbles, or precesses, more slowly than it spins.



**b** Earth's axis also precesses. Each precession cycle takes about 26,000 years.

# Annual Motion

# Annual Motion



# Annual Motion

## zodiac

the constellations which lie along the ecliptic

**solar year** = 365d 5h 48m 45s

(= 365.24219 days)

SEASONS are caused by the  $23.5^\circ$  tilt of the Earth's axis with respect to the ecliptic, ***not*** the distance from the Earth to the Sun!

# Moon



# Lunar Motion

## Phases of the Moon:

How long does it take the Moon to complete 1 cycle?

sidereal period = 27.3 days

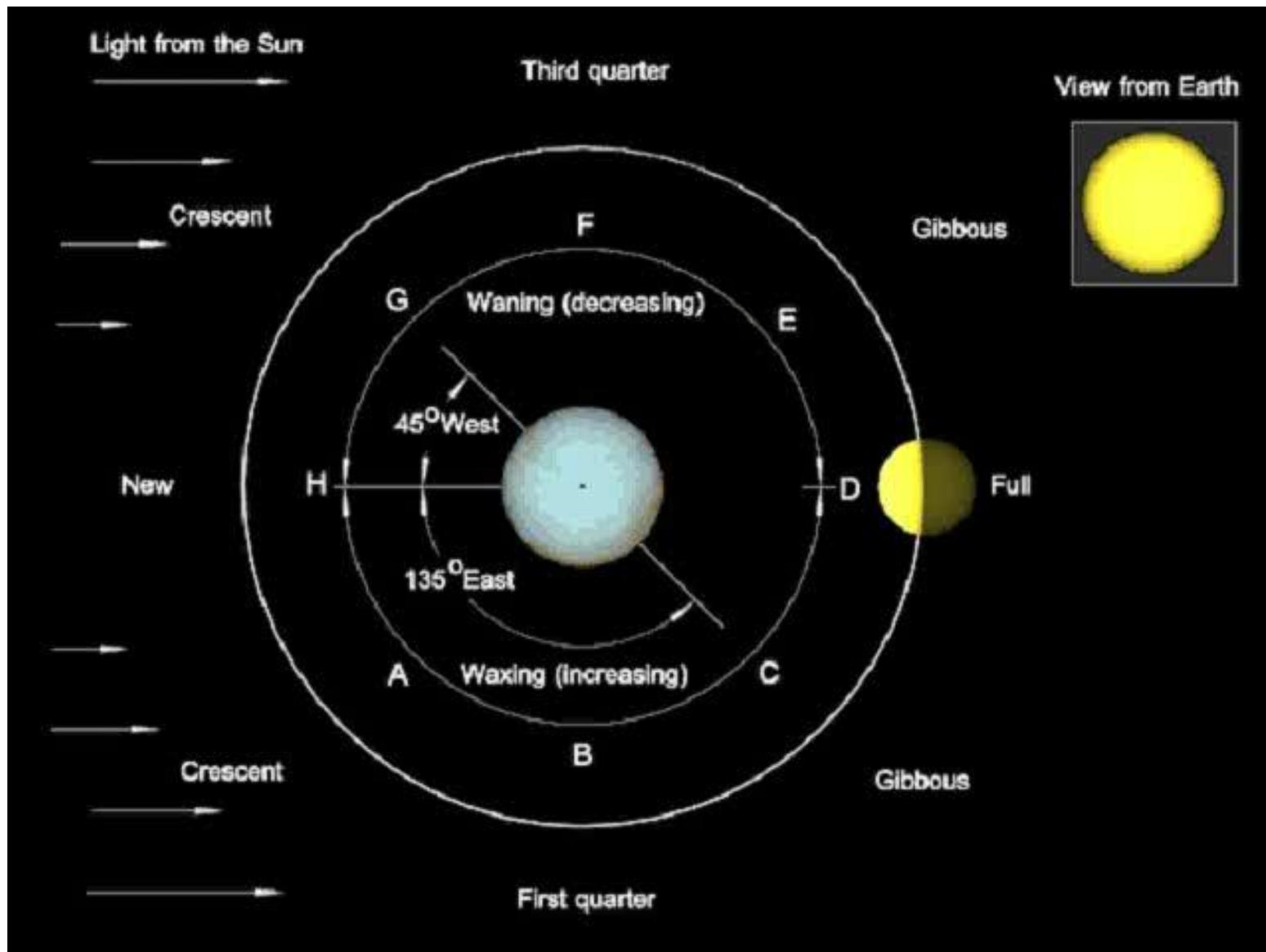
time it actually takes the Moon to orbit the Earth

synodic period = 29.5 days

time between one full moon and the next

# Phases of the Moon

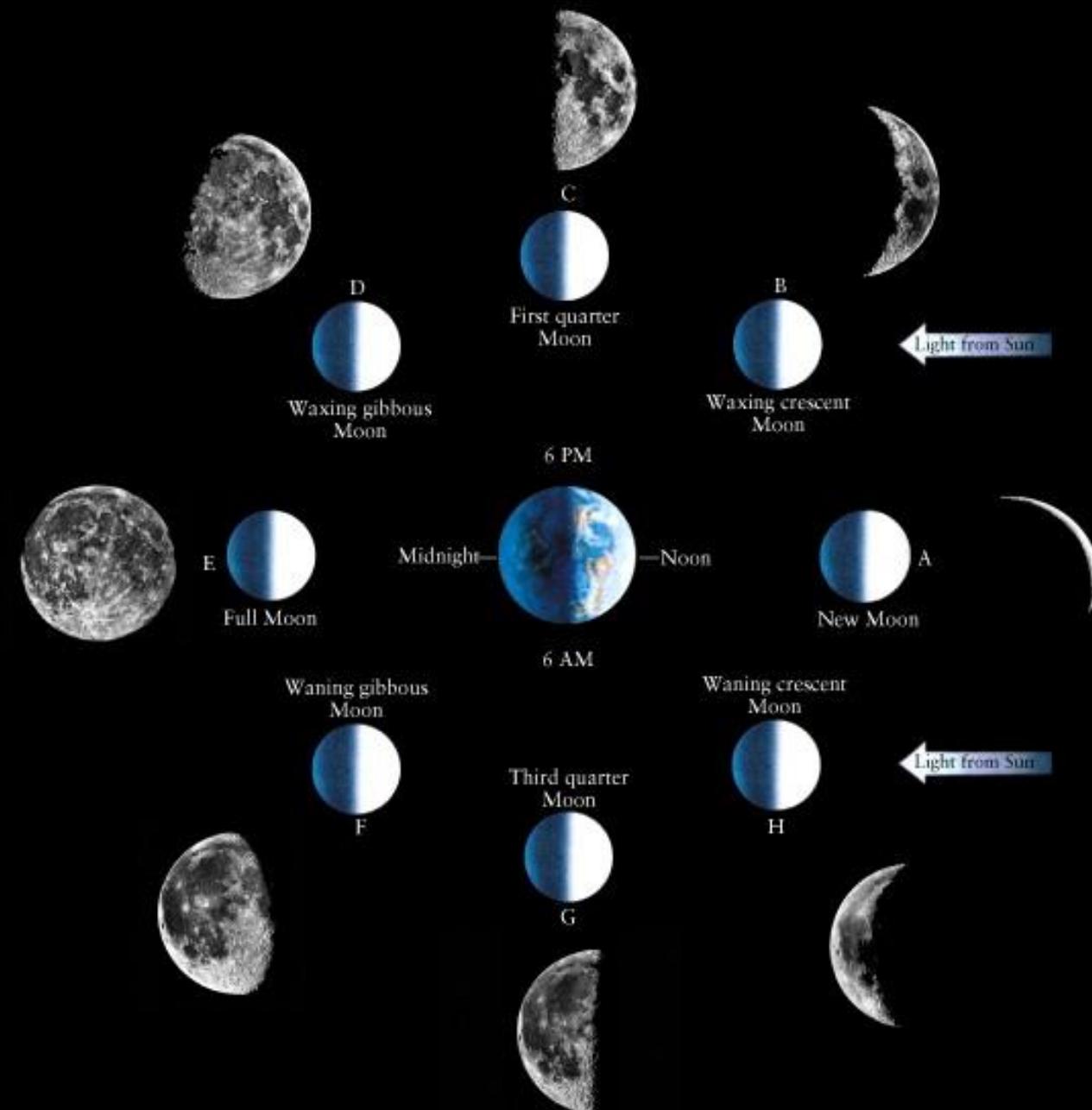
# Phases of the Moon





Animation at [http://antwrp.gsfc.nasa.gov/apod/image/9911/lunation\\_ajc.gif](http://antwrp.gsfc.nasa.gov/apod/image/9911/lunation_ajc.gif)

## Phases of the Moon



The Moon is always half lit by the Sun but we see varying proportions of the lit part from Earth depending on where the Moon is in its orbit of Earth.

# Lunar Motion

When the Moon's orbit intersects the ecliptic  
(called the node):

at new moon                    solar eclipse

(you must be in Moon's shadow to see it)

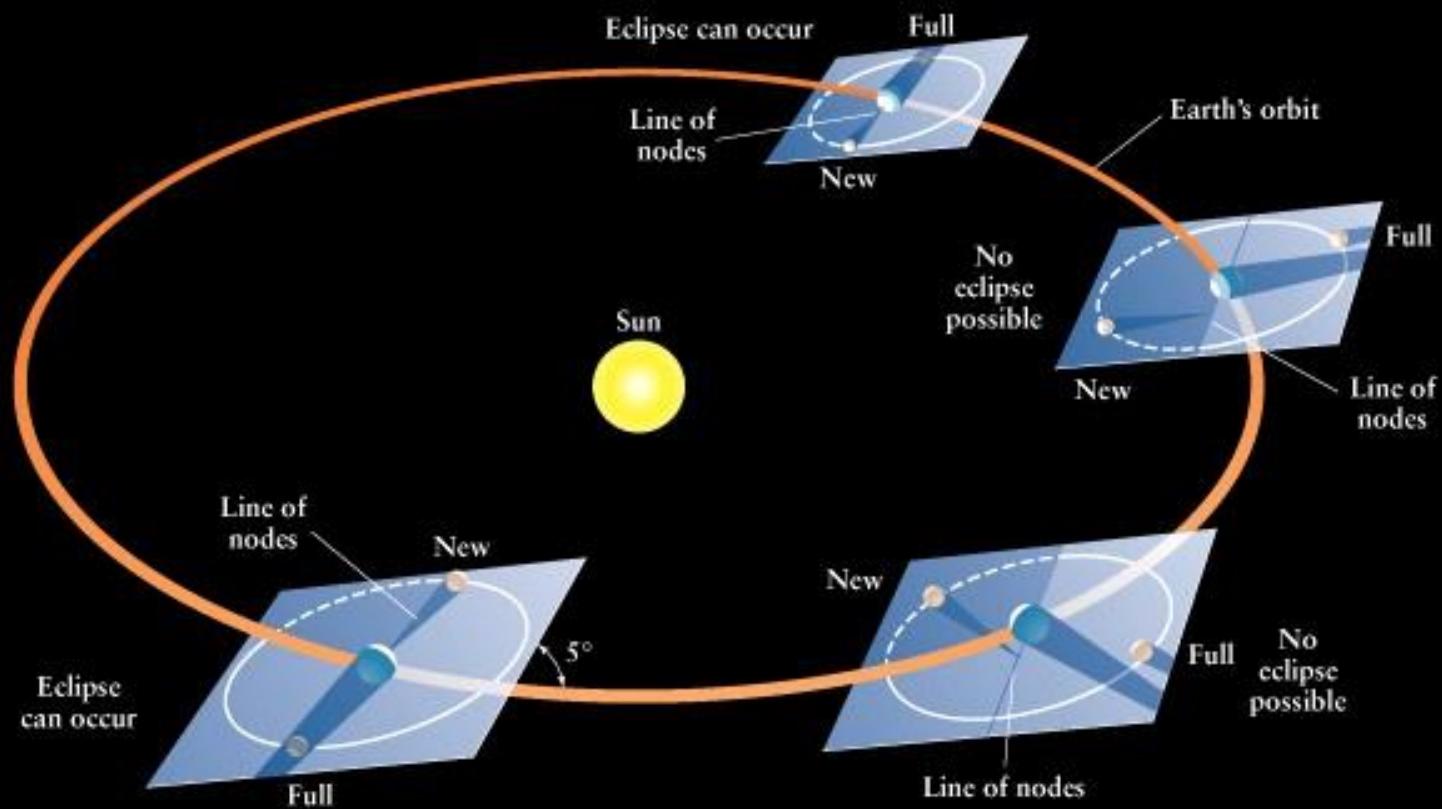
at full moon                    lunar eclipse

(everyone on the night side of Earth can see it)

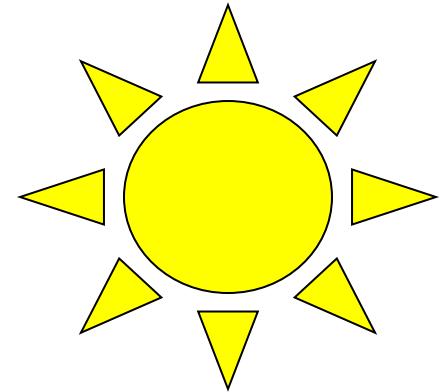
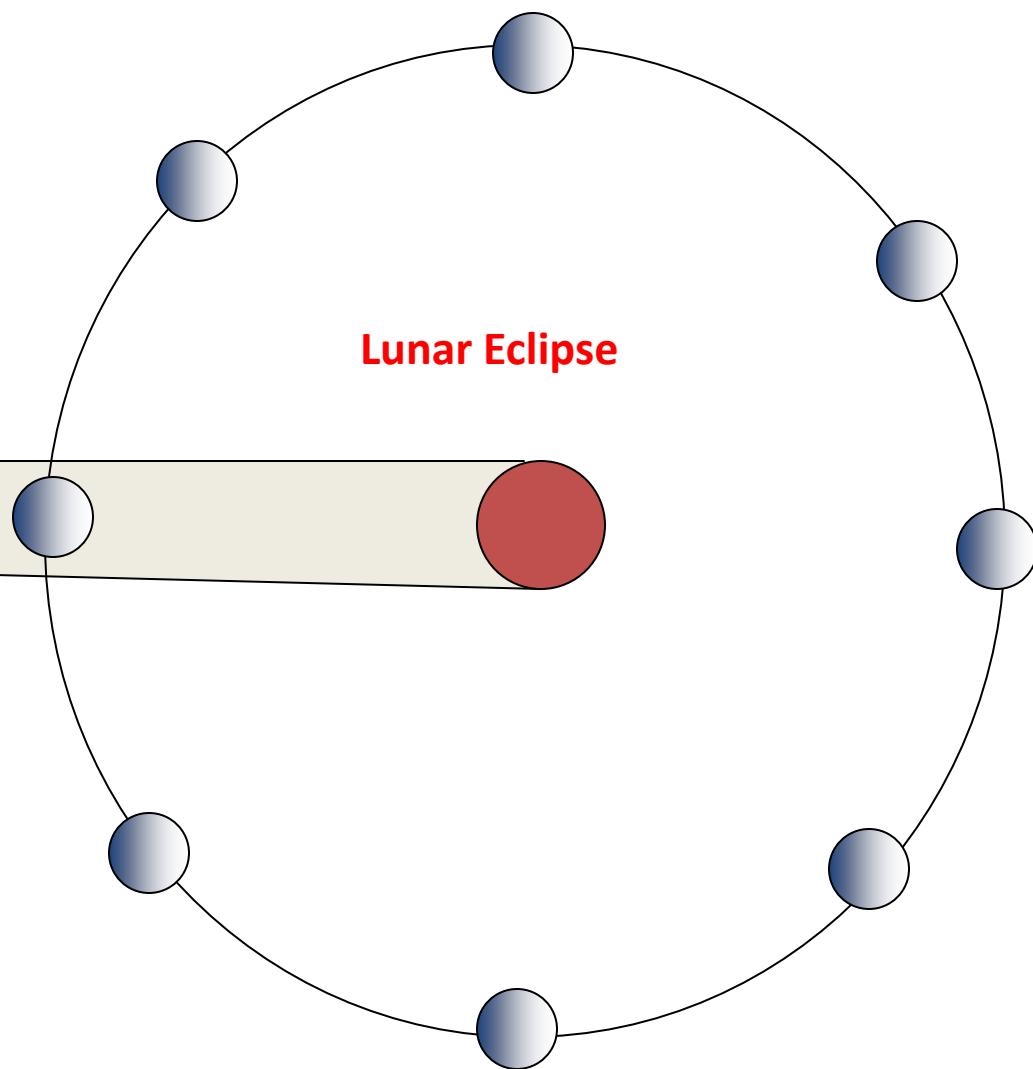
# Eclipses



Eclipses occur ONLY when the Moon crosses the plane of the Earth's orbit around the Sun and ONLY during the NEW or FULL phases.

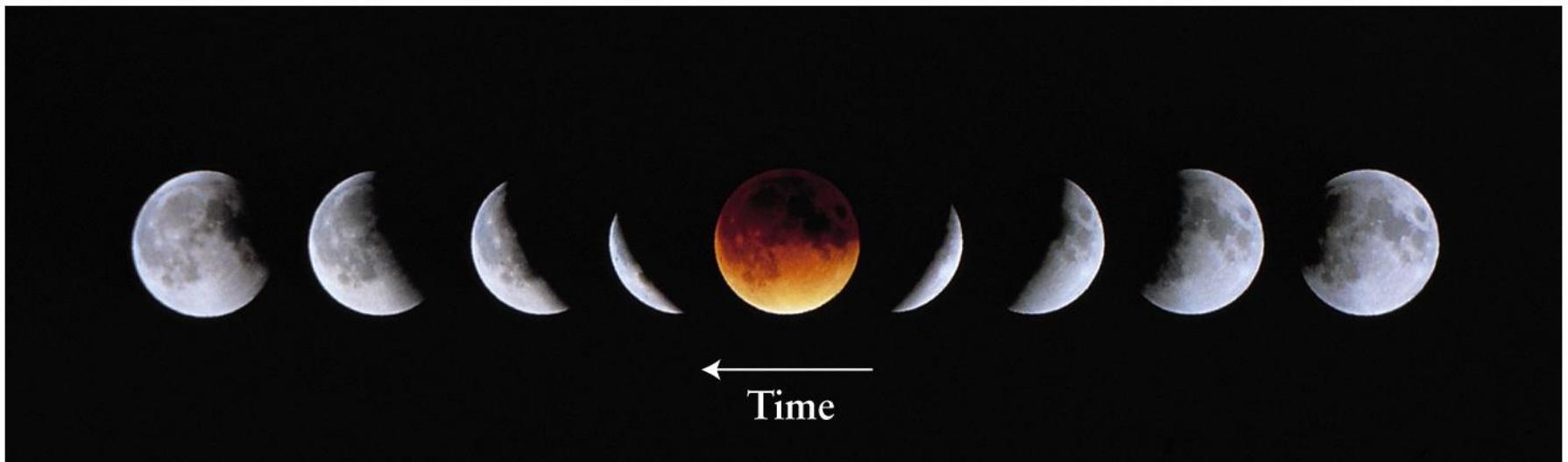


When the Earth's shadow hits the Moon we have a .....

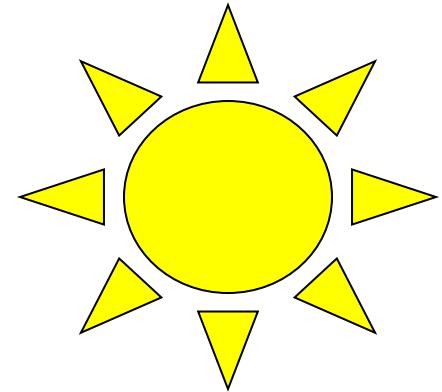
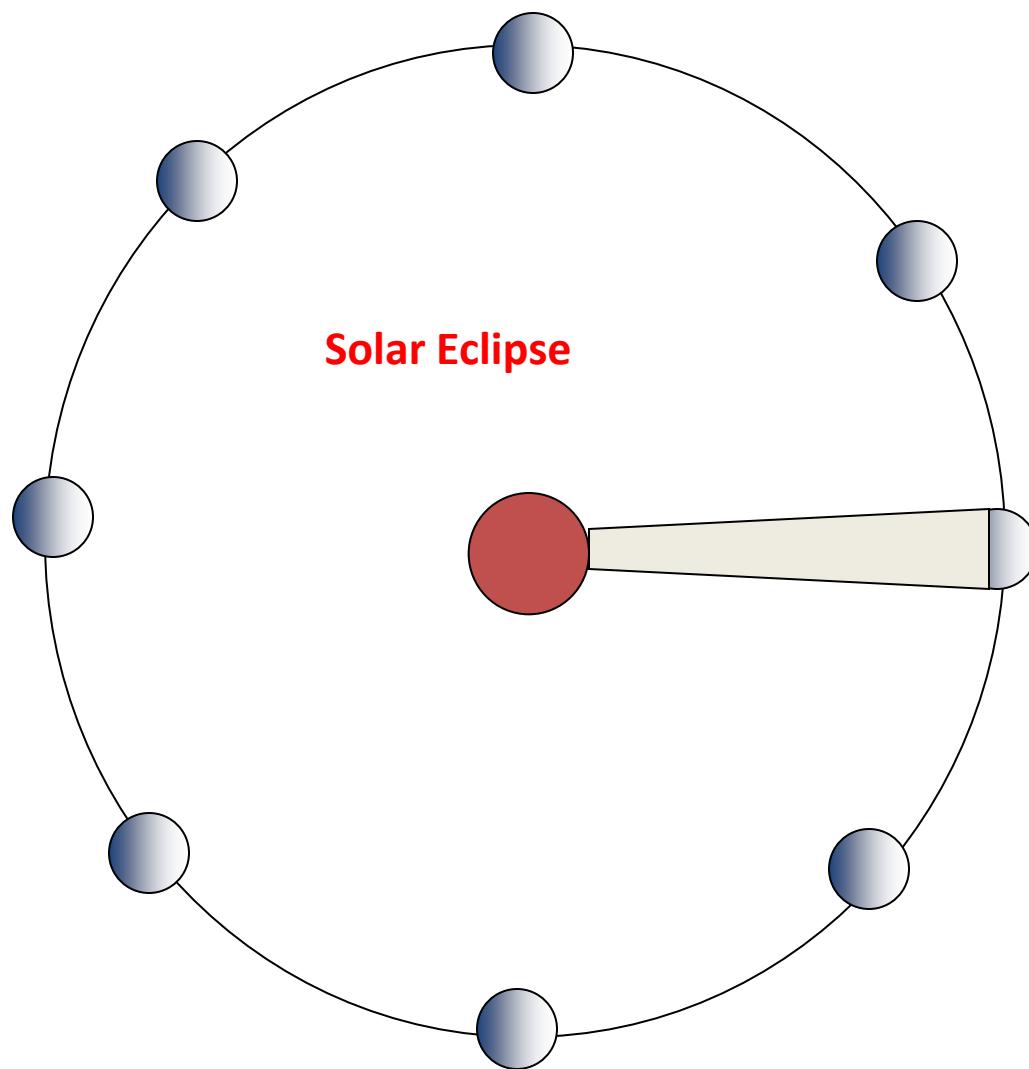


# Lunar Eclipse

- When Earth blocks most of the sunlight from illuminating the Moons surface for several hours when in the full moon phase



**When the Moon's shadow hits the Earth, we have a ....**

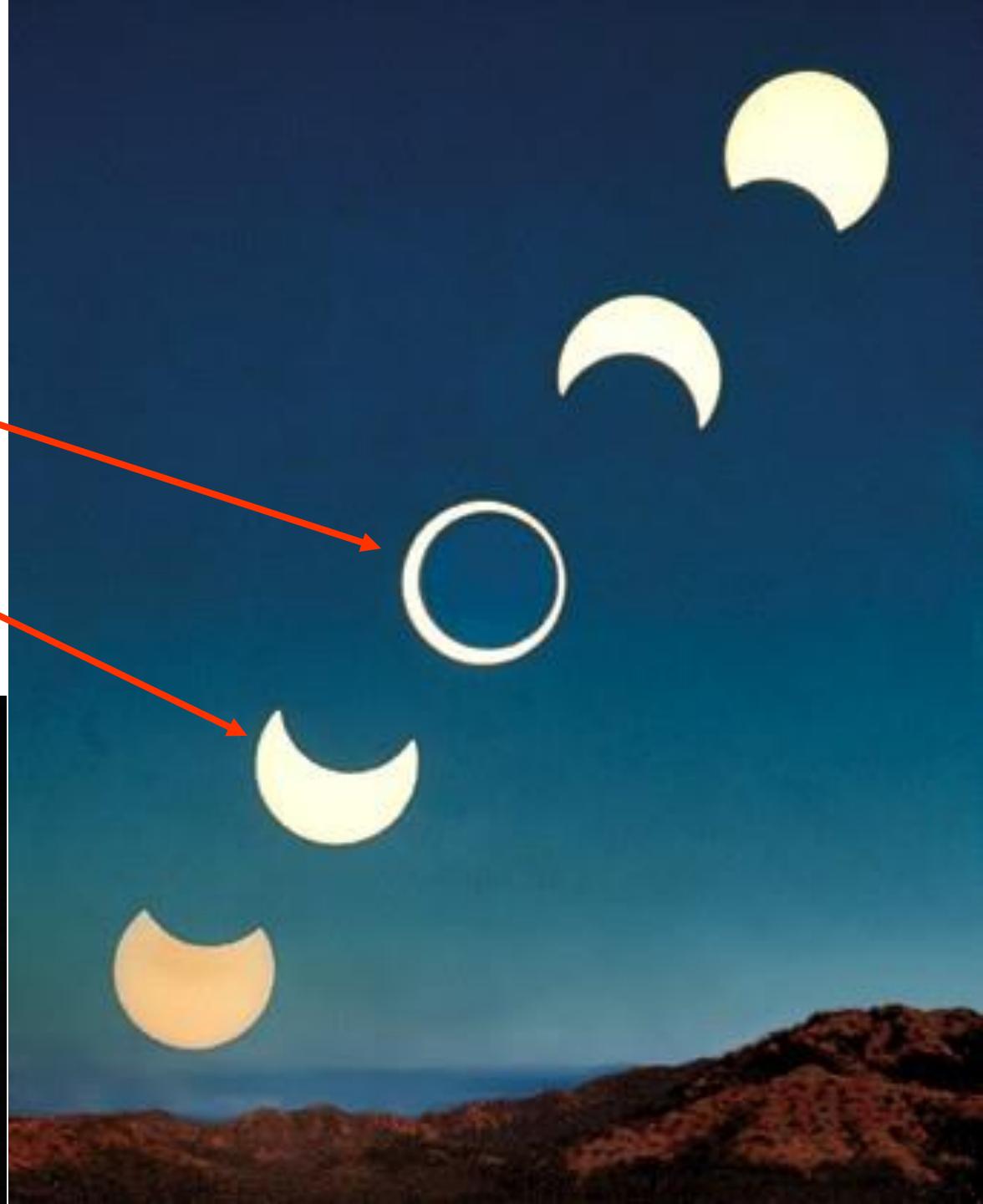
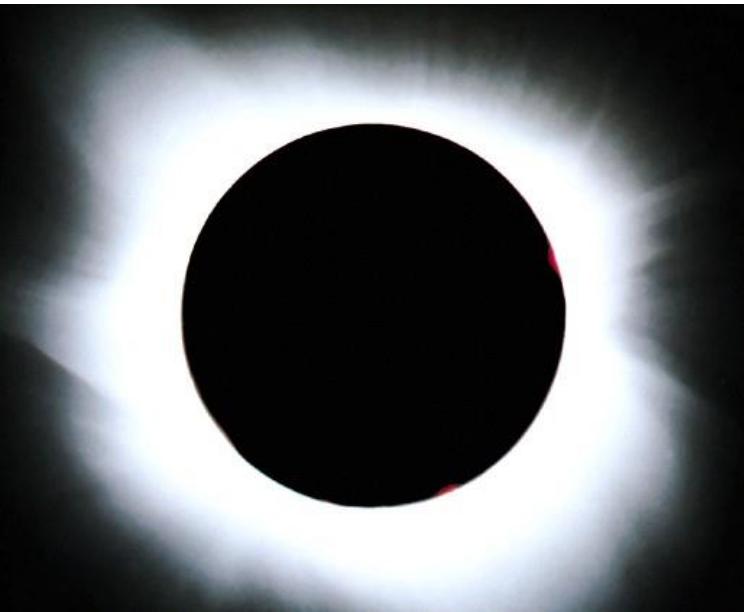


# Solar Eclipse

Annular Eclipse

Partial Eclipse

Total Eclipse

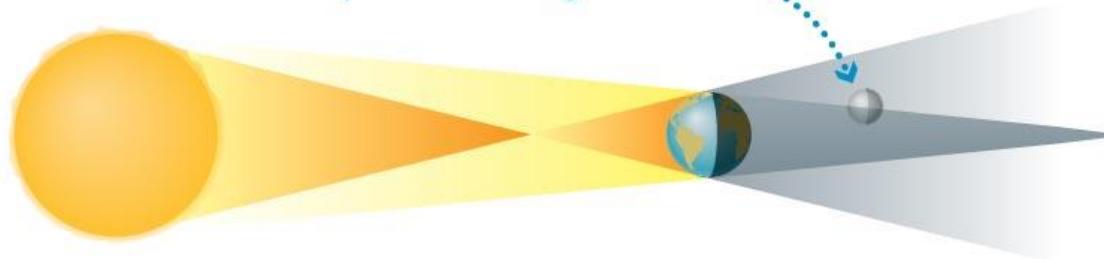


*Moon passes entirely through umbra.*



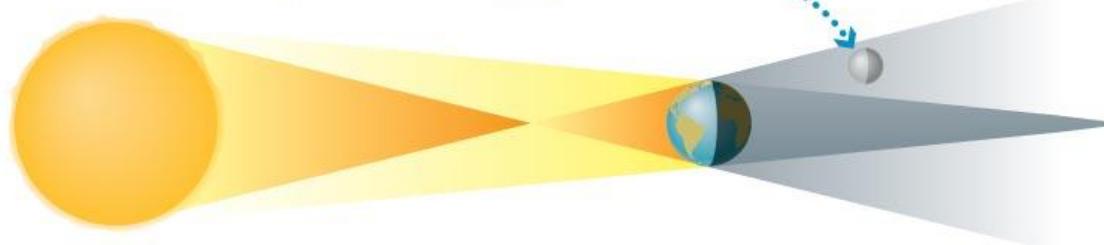
## Total Lunar Eclipse

*Part of the Moon passes through umbra.*

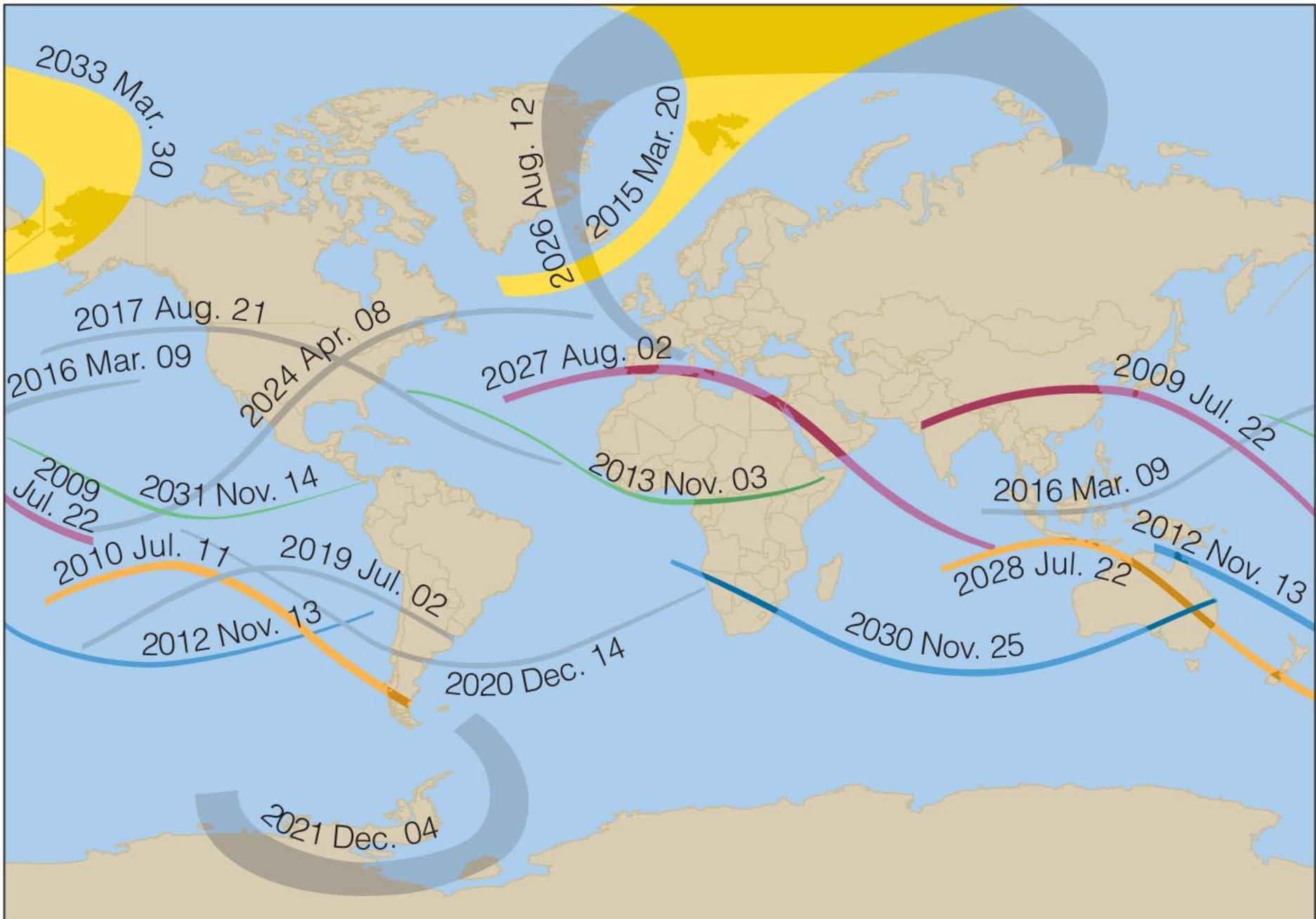


## Partial Lunar Eclipse

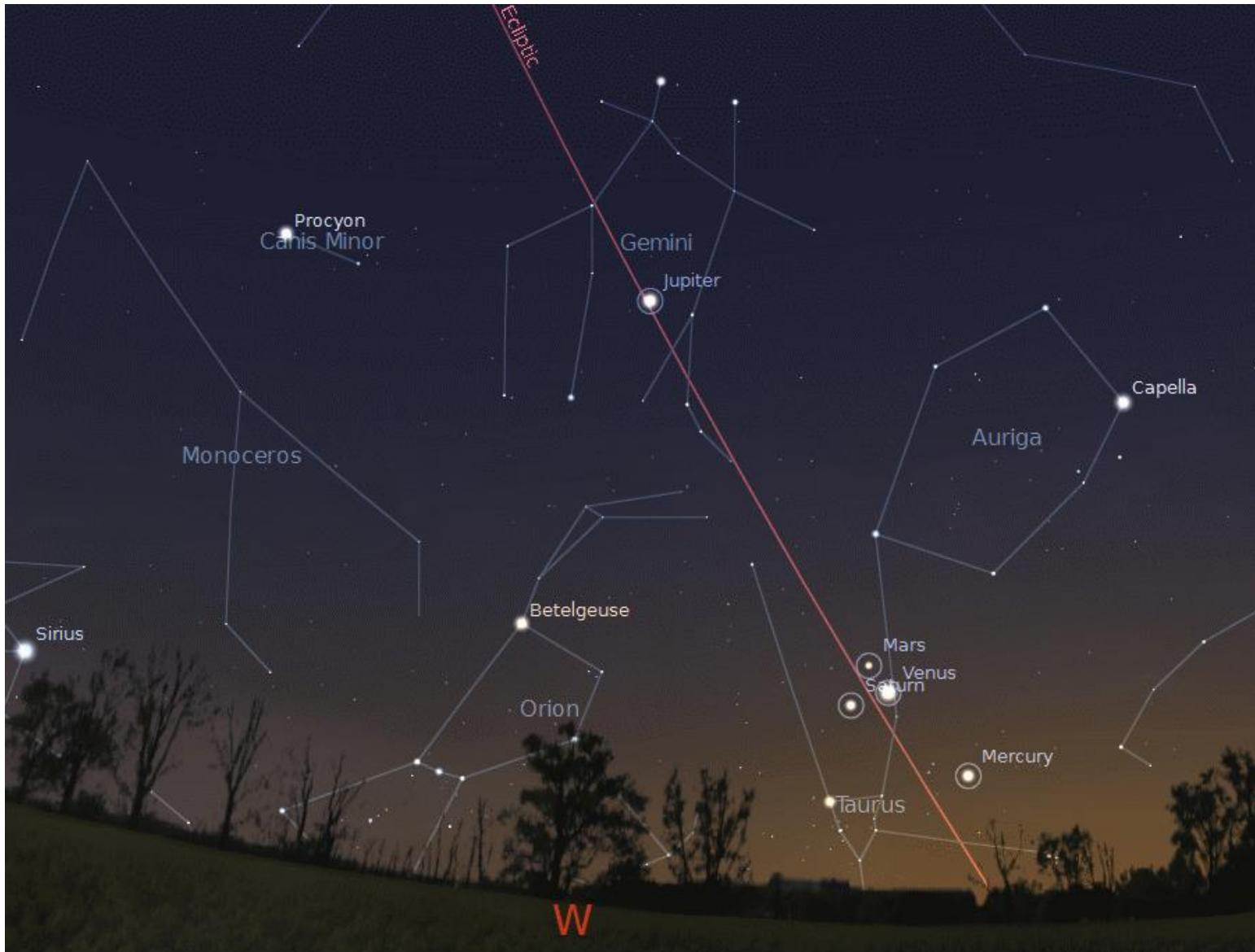
*Moon passes through penumbra.*



## Penumbral Lunar Eclipse



# Planets



# Planets in the Sky

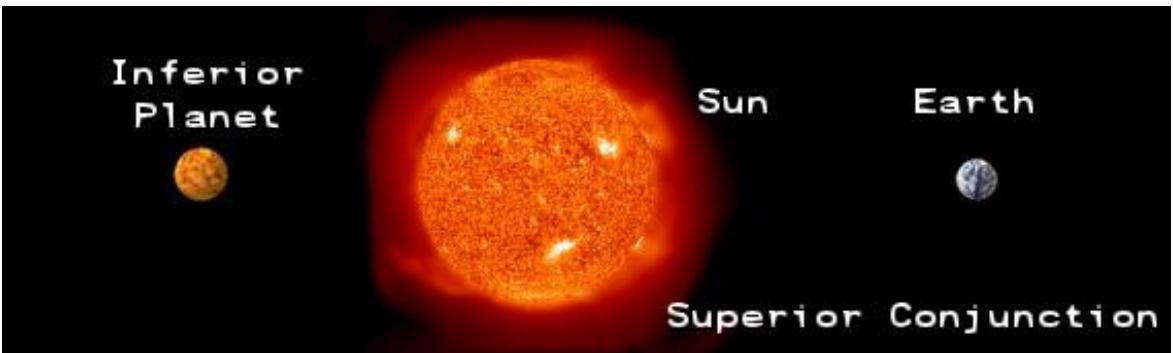
- Inferior Planets

- Mercury
  - Venus



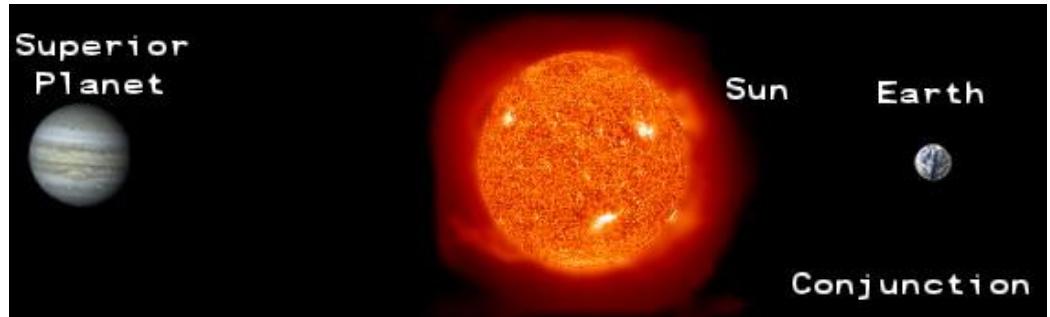
- Superior Planets

- Mars
  - Jupiter
  - Saturn



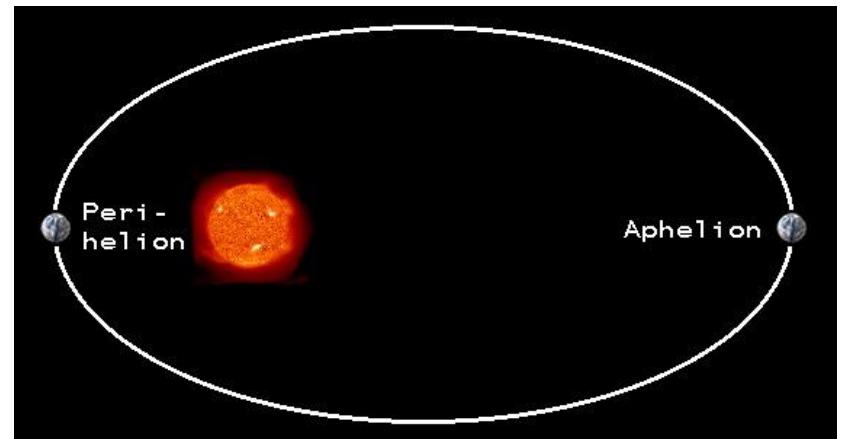
# Conjunction

Same position as Sun



# Maximum Elongation

Planet at farthest point from Sun

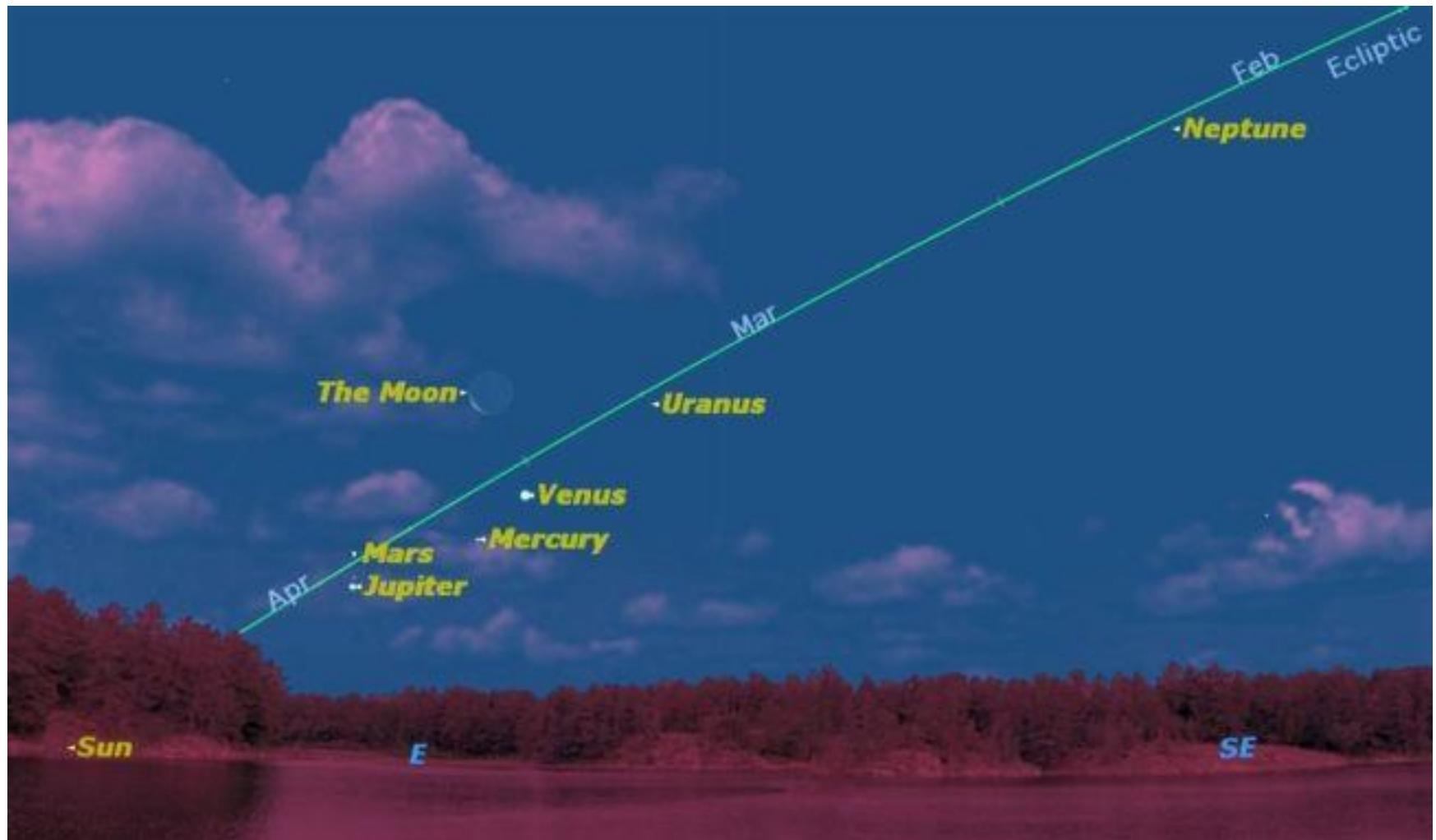


# Opposition

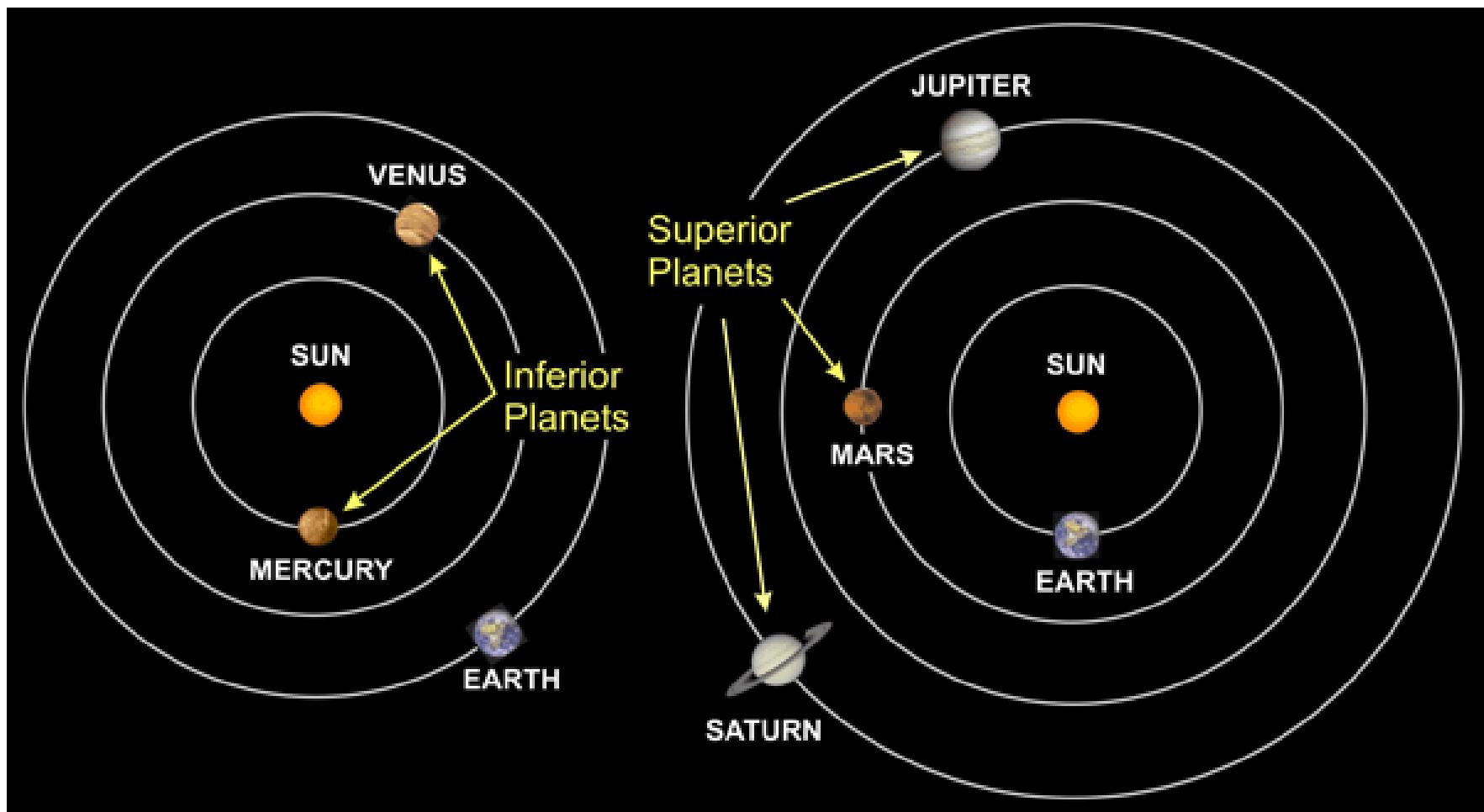
Planet is  $180^\circ$  from Sun



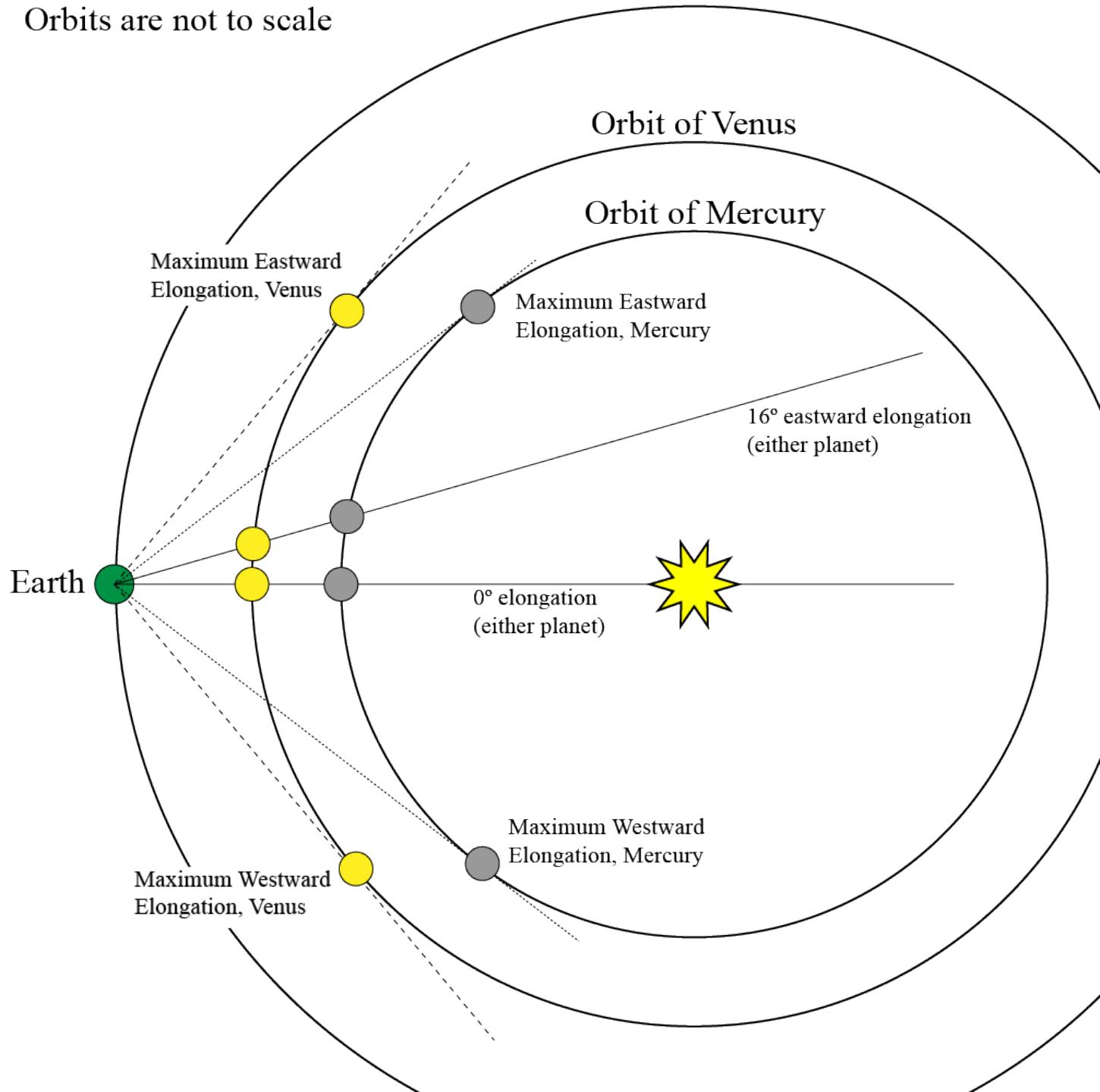
The planets orbit the Sun in nearly a plane, so they are always seen near the ecliptic, the apparent path of the Sun in the sky.



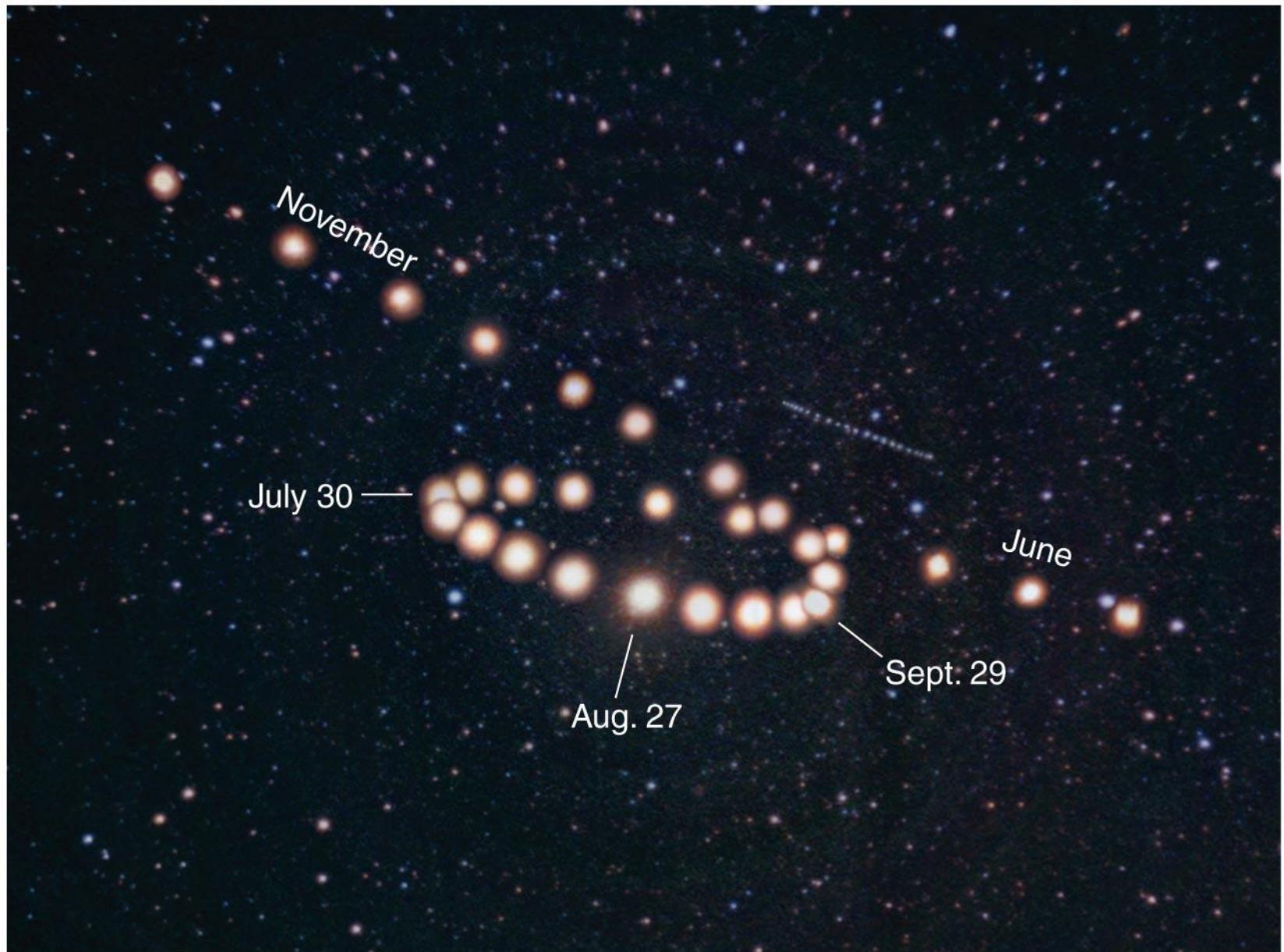
Planets that are **inferior** have interior orbits to the Earth, so are always seen relatively close to the Sun in the sky. Planets that are **superior** have exterior orbits to the Earth, so can be seen in any position along the ecliptic.

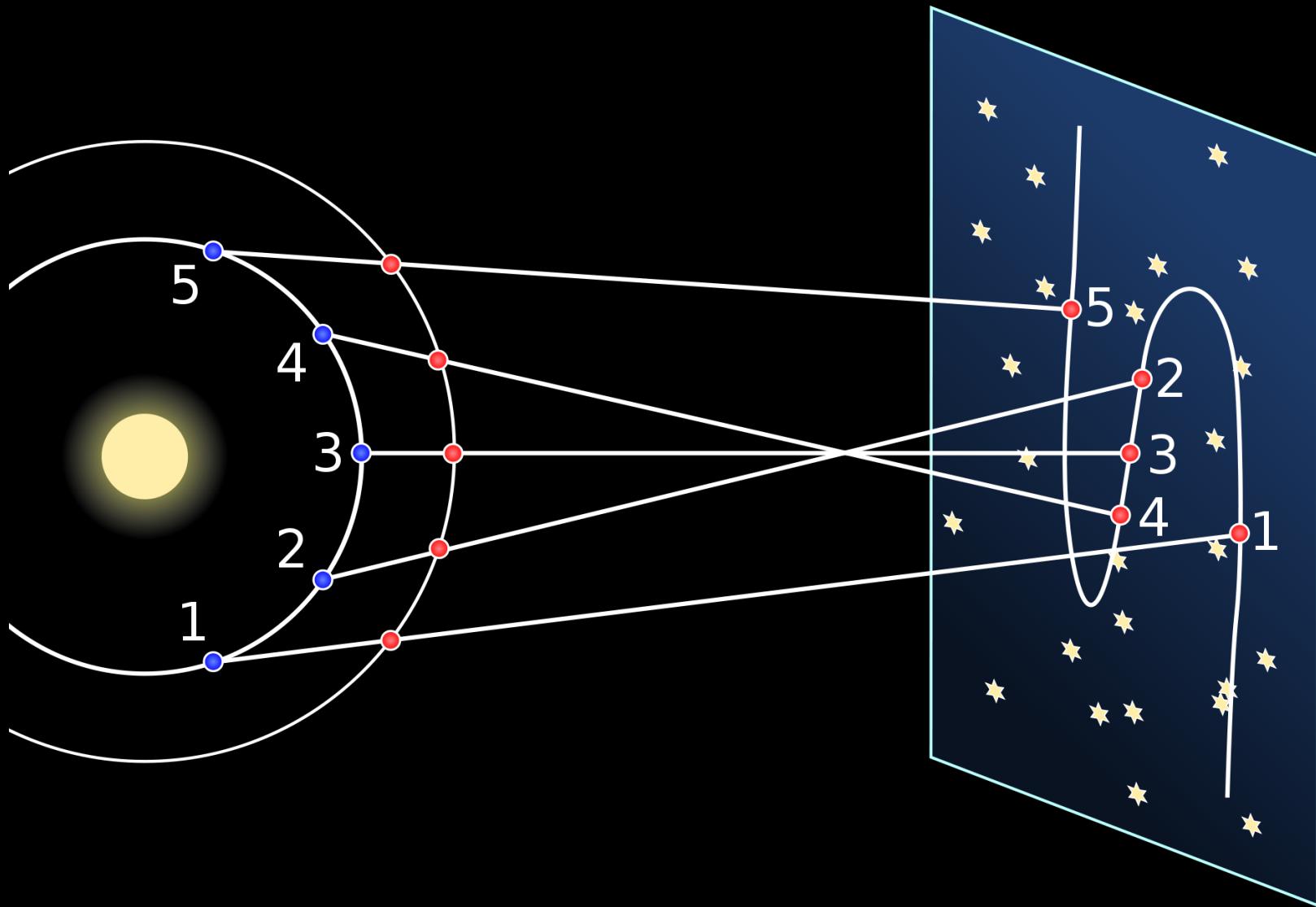


Orbits are not to scale



# Mars Retrograde





As was realized during the Copernican Revolution, retrograde motion occurs when the Earth “overtakes” a slower moving outer planet.



# THE GRUMPY ASTRONOMERS GUIDE TO THE NIGHT SKY

IDENTIFYING STAR CLUSTERS:



THIS IS THE PLEIADES, ASSHOLE.



# THE GRUMPY ASTRONOMERS GUIDE TO THE NIGHT SKY

ORION'S BELT:



ONLY A MORON COULDNT FIND IT



# THE GRUMPY ASTRONOMERS GUIDE TO THE NIGHT SKY

THIS IS THE BIG DIPPER

WHAT THE HELL IS WRONG WITH YOU?

# Discover for Yourself

