1F03: Logistics

Most information is/will be posted on *Avenue*

- **Outline (read it), assignments, dates/schedules, office hours, marks …**

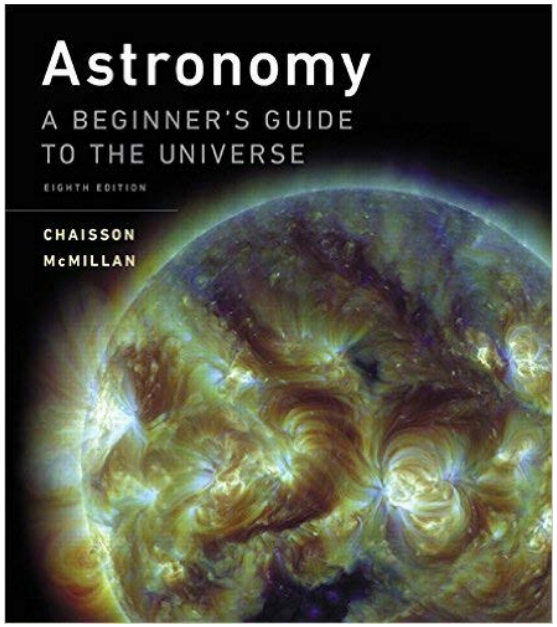
We will use iClickers – get one and register it asap

Assessment:

- **25% Labs (in class ~6); Homework problems (~4)**
- **15% Participation: observing, planetarium, iClickers**
- **20% Midterm**
- **40% Final exam**

1F03: Logistics

Text book:



5th, 6th or 7th editions will also do

8th edition gives access to online resources, which will help you understand but which are not required for 1F03

1F03: Logistics

How to use the class:

- **Focus on the themes discussed. Don't try to get every last word recorded. Round out by reading the book.**
- **Laptops/tablets are strongly discouraged:**
  - **http://www.scientificamerican.com/article/a-learning-secret-don-t-take-notes-with-a-laptop/**
- **Please take a 50 minute break from social media during class**
- **Ask questions!**

Charting the Heavens

Preliminaries

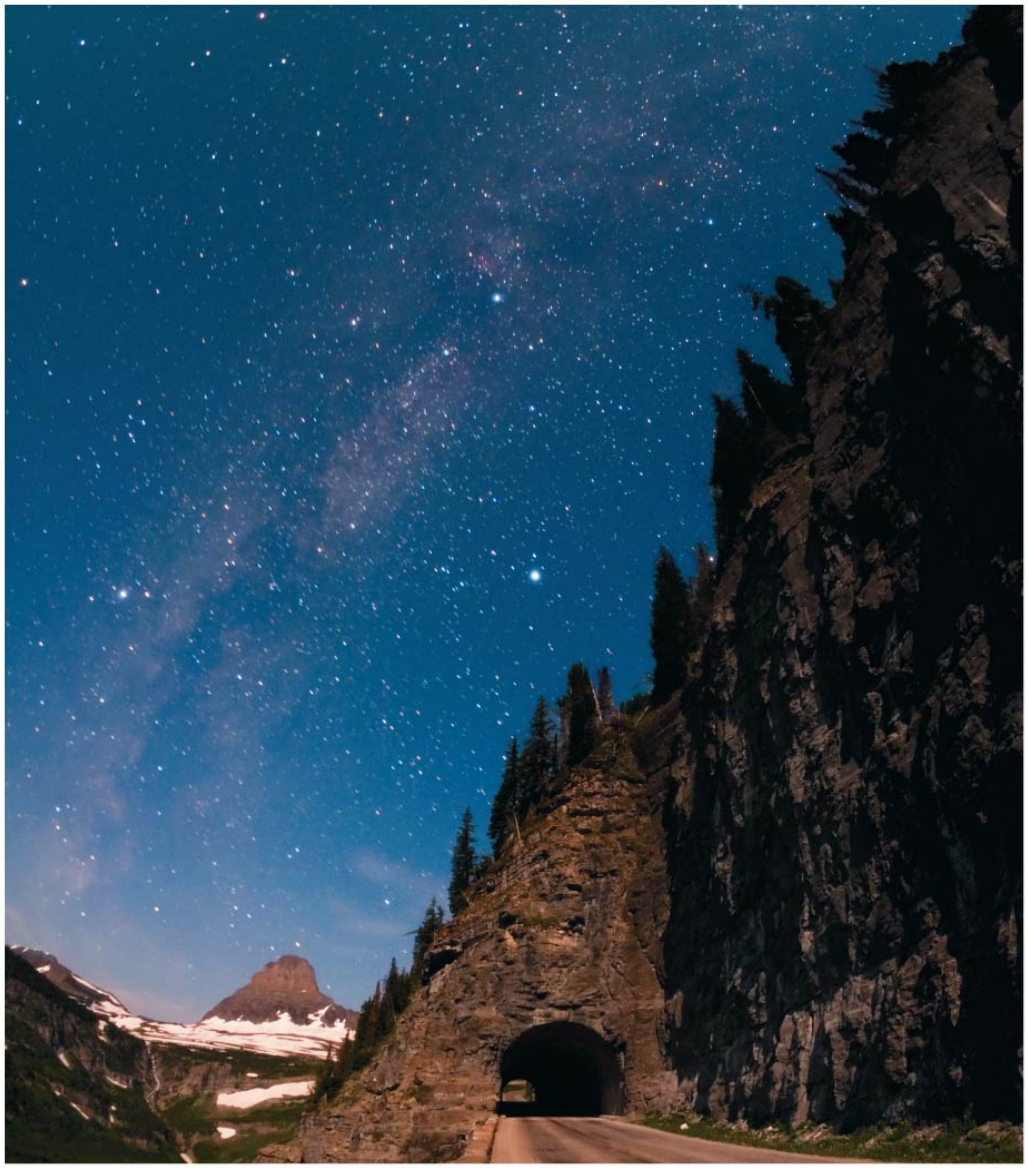
Why does the week have seven days?

- **Objects in heavens divided into fixed stars and the *seven* wandering stars known in antiquity**

English	French	“Wandering stars”
Monday	lundi	Moon
Tuesday	mardi	Mars
Wednesday	mercredi	Mercury
Thursday	jeudi	Jupiter
Friday	vendredi	Venus
Saturday	samedi	Saturn
Sunday	dimanche	Sun

Preliminaries

What are we looking at?

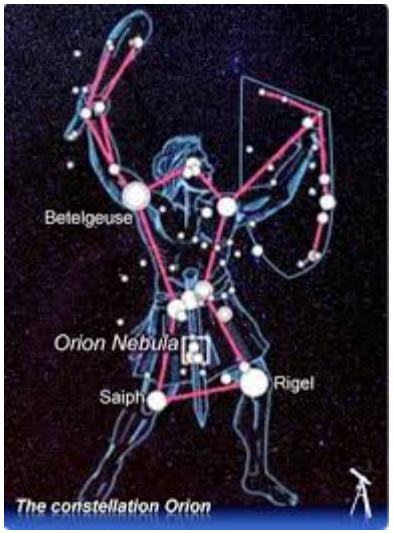


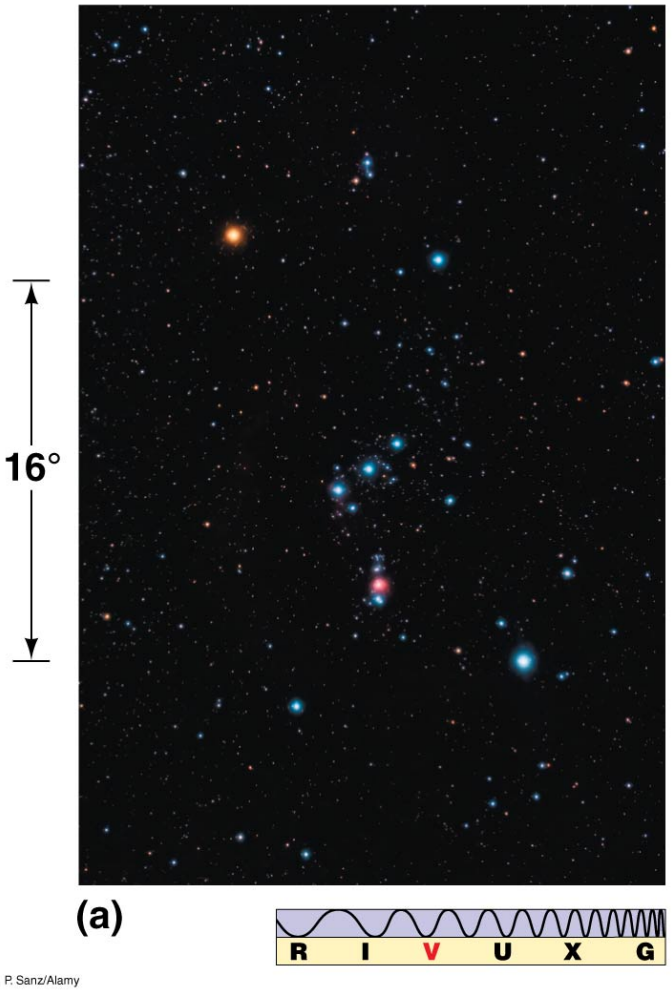
Tyler Nordgren

Astronomy in human culture

Astronomical influences:

- **Time**
  - **Year, Month, (Week,) Day**
- **Constellations (star groupings)**
  - **Myths**
  - **Astrology (even if it is nonsense)**
- **Eclipses**





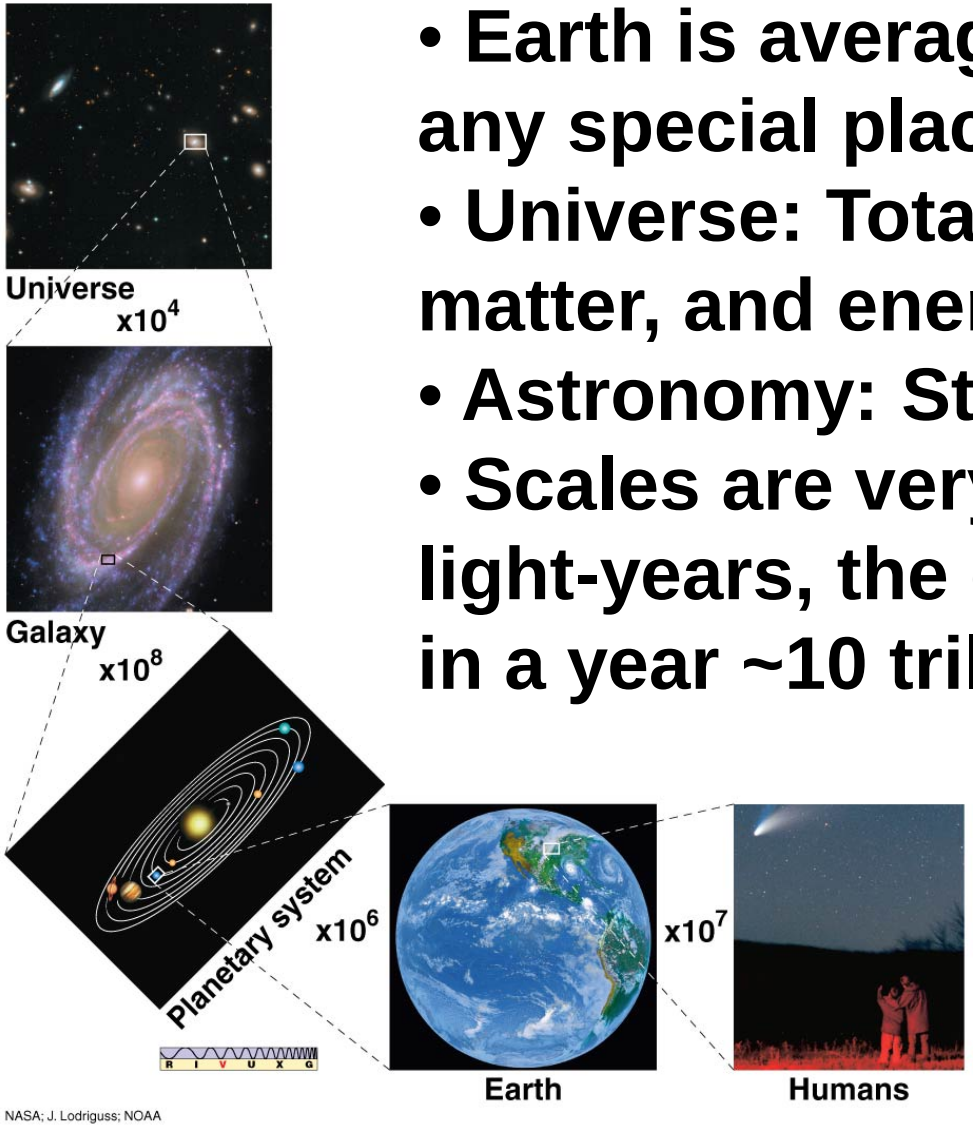
Structure of the course

We will generally follow the historical development of astronomy from small scales (Earth and solar system) to the large (galaxies and the universe) and discuss the corresponding enabling scientific advances.

In this chapter:

- **The scale of the universe**
- **Earth's Orbital Motion**
- **The Motion of the Moon**
- **The Measurement of Distance**
- **Science and the Scientific Method**

Scales in the universe

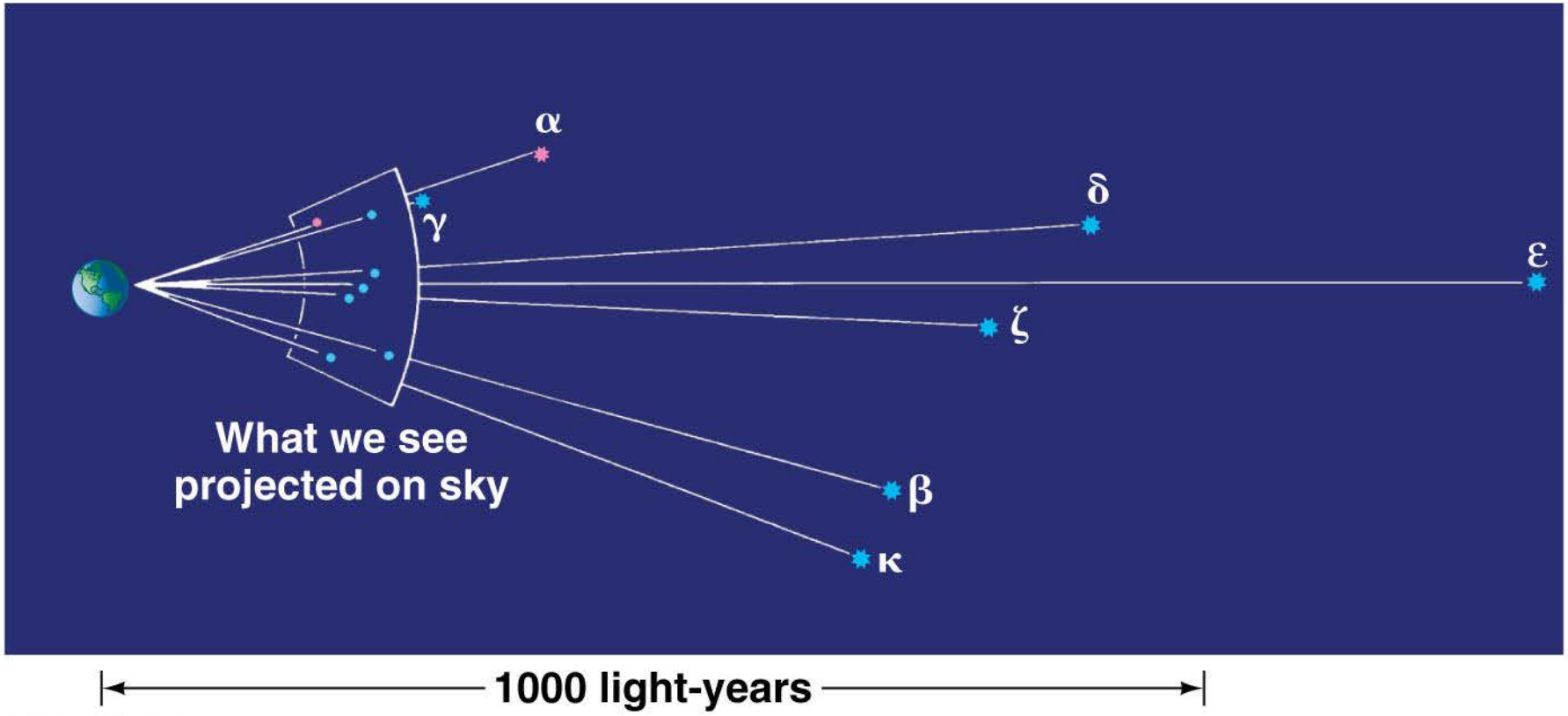


- **Earth is average – we don't occupy any special place in the universe**
- **Universe: Totality of all space, time, matter, and energy**
- **Astronomy: Study of the universe**
- **Scales are very large, measured in light-years, the distance light travels in a year ~10 trillion km (10^{13} km)**

See "Powers of Ten" Charles & Ray Eames (youtube)

The Naive View of the Universe

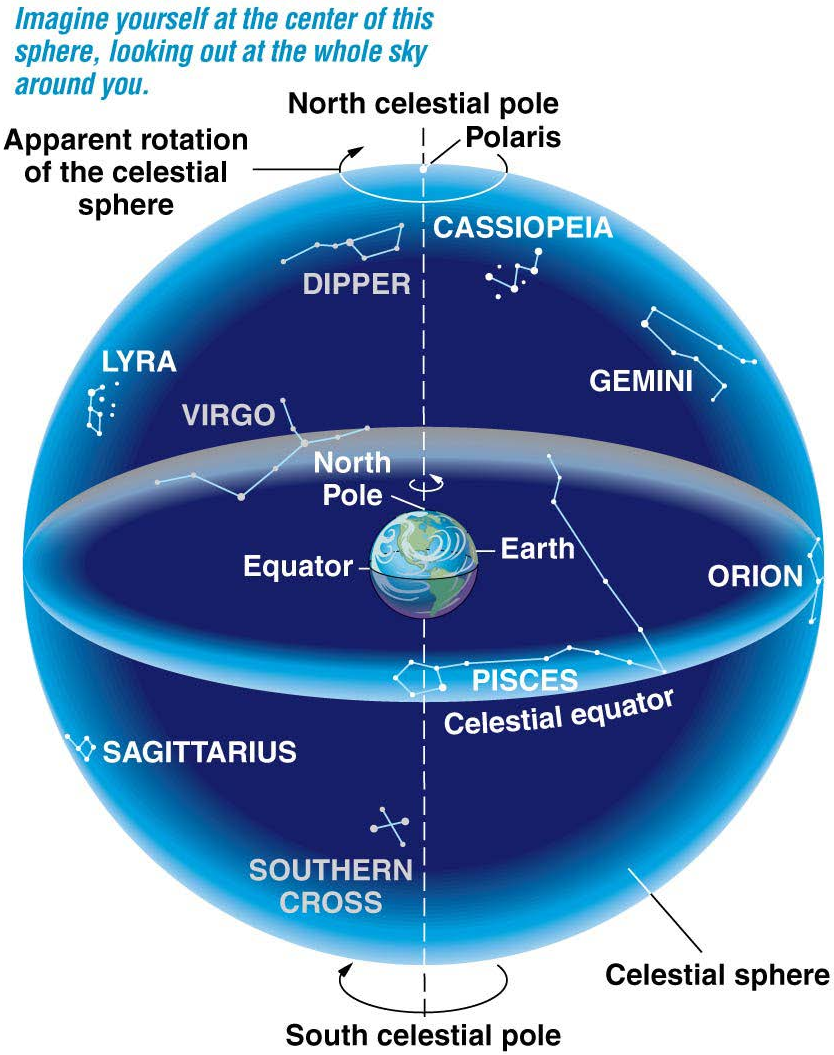
Stars that appear close in the sky may not actually be close in space. Objects are so distant it is hard to perceive depth



The Celestial Sphere

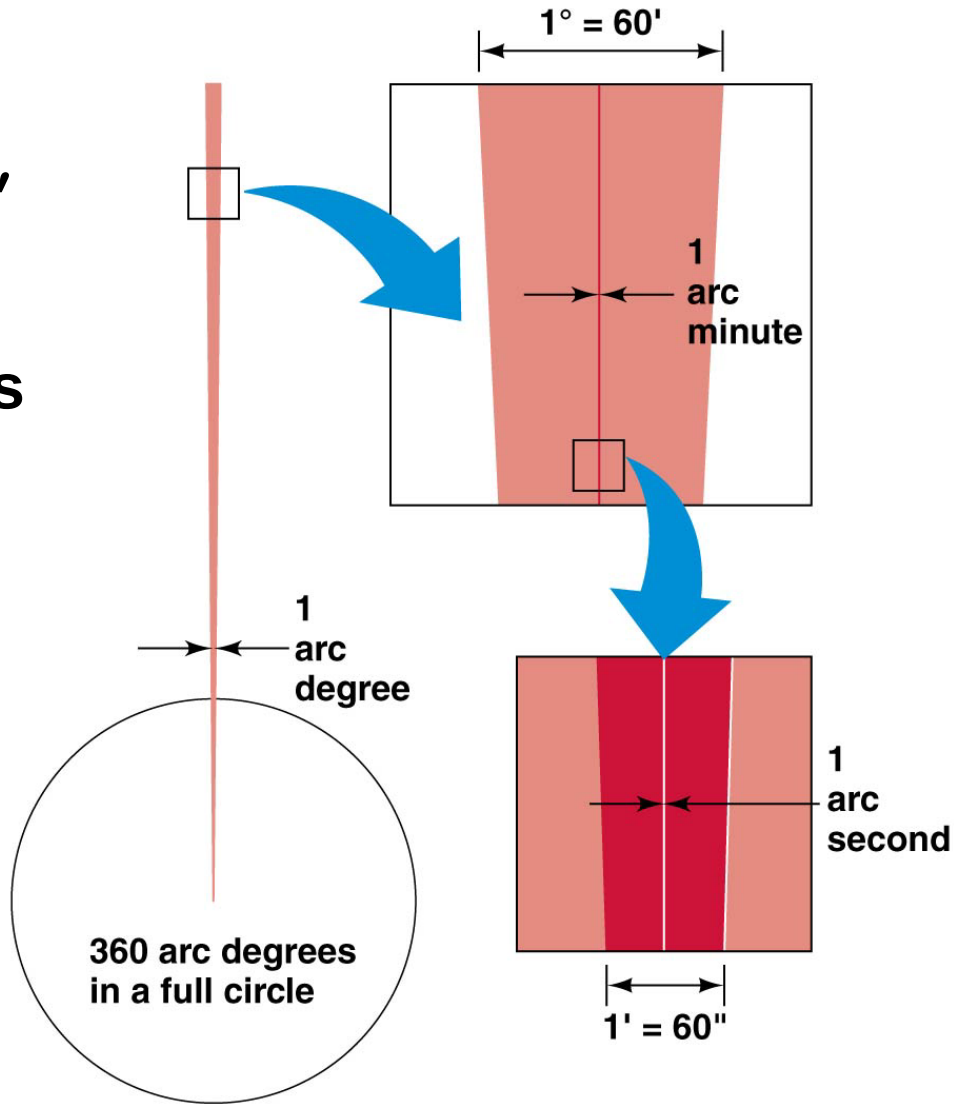
Stars *seem* to be on the inner surface of a sphere surrounding the Earth.

- **They aren't, but we can use two-dimensional spherical coordinates (similar to latitude and longitude) to locate sky objects.**



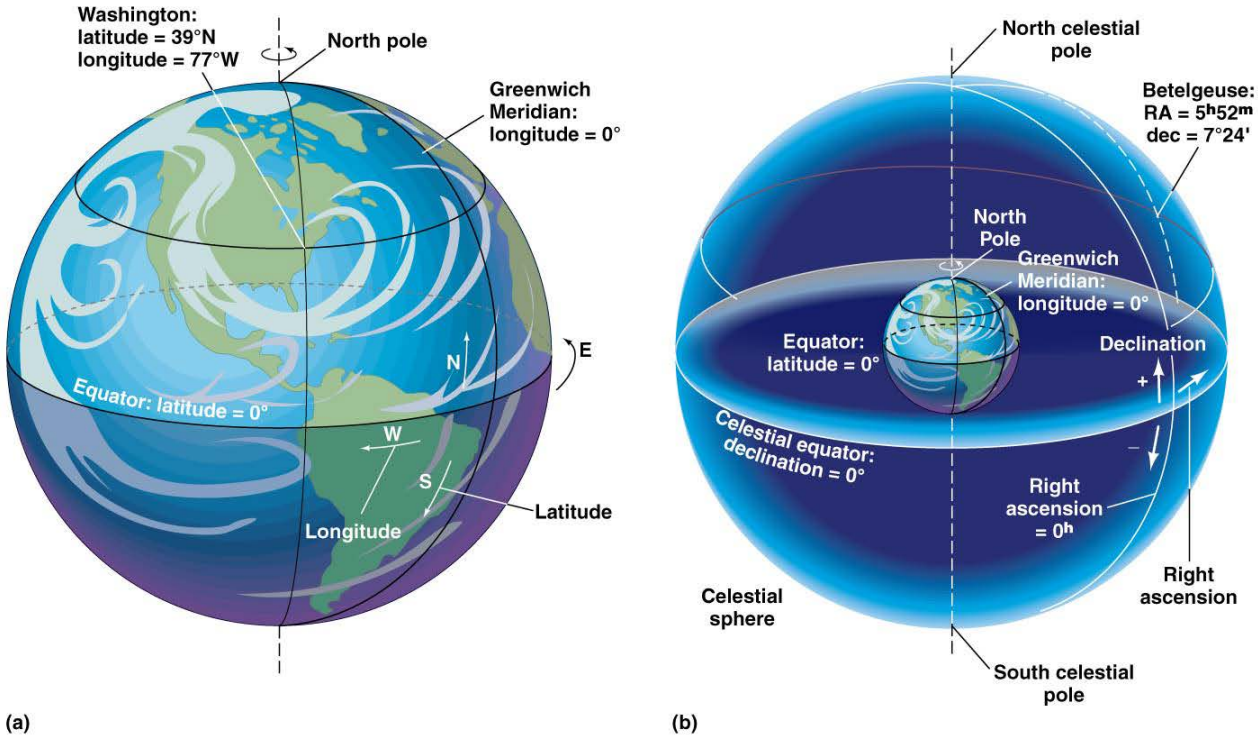
Angles in Astronomy

- Full circle contains 360° (degrees).
- Each degree contains 60′ (arc-minutes).
- Each arc-minute contains 60″ (arc-seconds).
- Angular size of an object depends on actual size and distance away.
- A finger held at arm's length subtends ~1°; the Moon subtends ~ 30′



Angular coordinates on the celestial sphere

- **Declination: Degrees north or south of celestial equator**
- **Right ascension: Measured in hours, minutes, and seconds eastward from the vernal equinox**



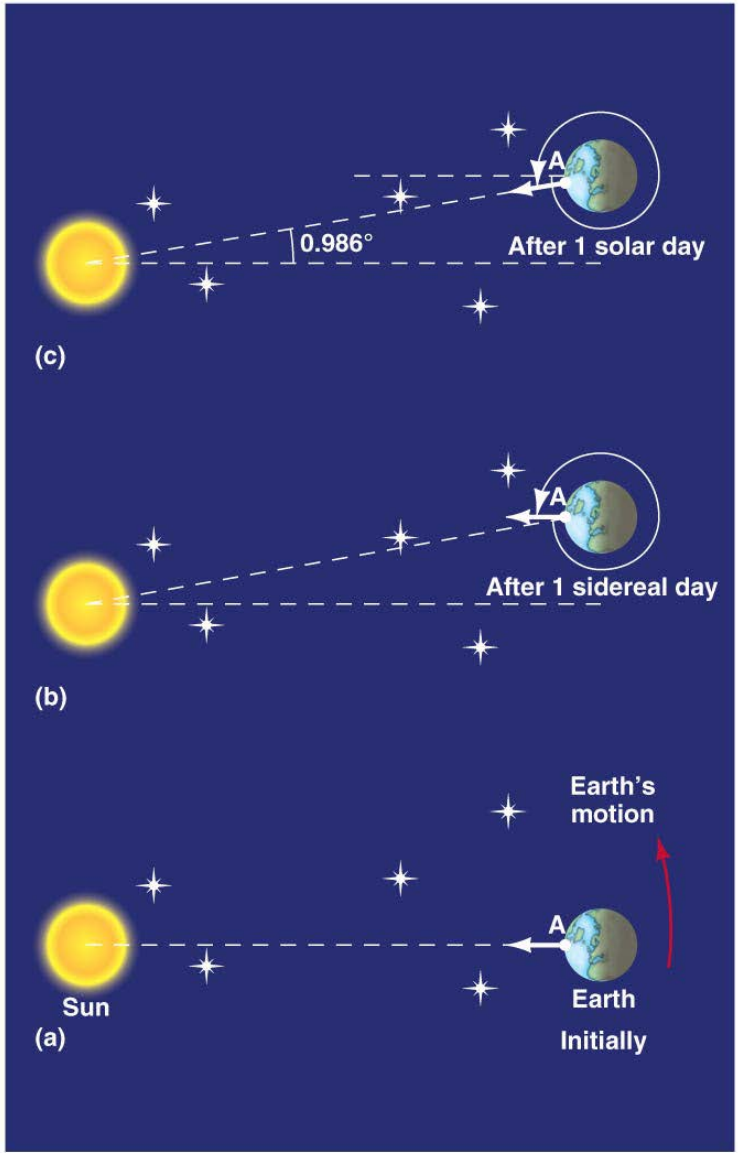
Earth's Orbital Motion

- Daily cycle, noon to noon, is diurnal motion – solar day.

- Stars aren't in quite the same place 24 hours later, though, due to Earth's orbit around the Sun; when they were in the same place again, one sidereal day had passed.

- Earth rotates 1° in ~60 × 24/360 = 4 minutes.

- Solar day is ~4 minutes longer than sidereal day.



iClicker Question

Suppose that the Earth orbits the Sun as now but that it rotates on its axis in the opposite sense (at the same rate). Which of the following is true of the lengths of the sidereal & solar days?

a) They both remain the same as now.

b) The sidereal day remains the same.

c) The solar day remains the same.

d) The solar day is ~8 minutes longer than before.

e) Sidereal & solar both decrease by ~4 minutes.

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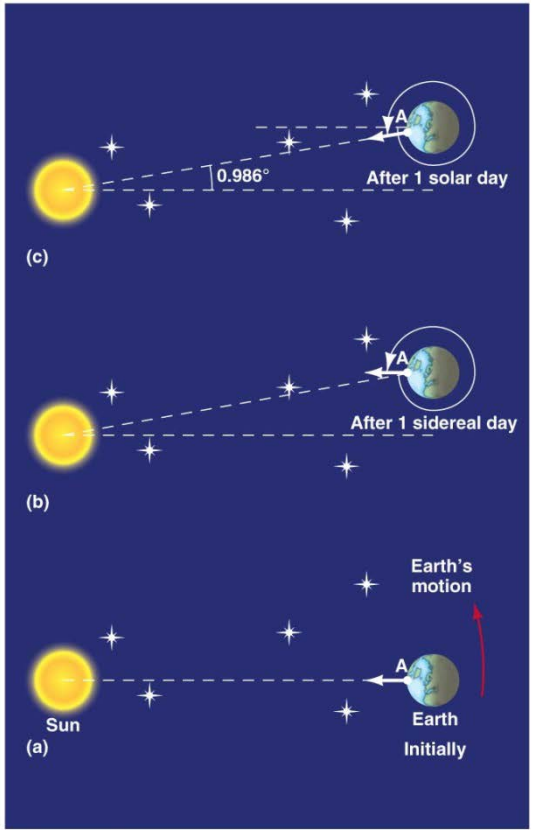
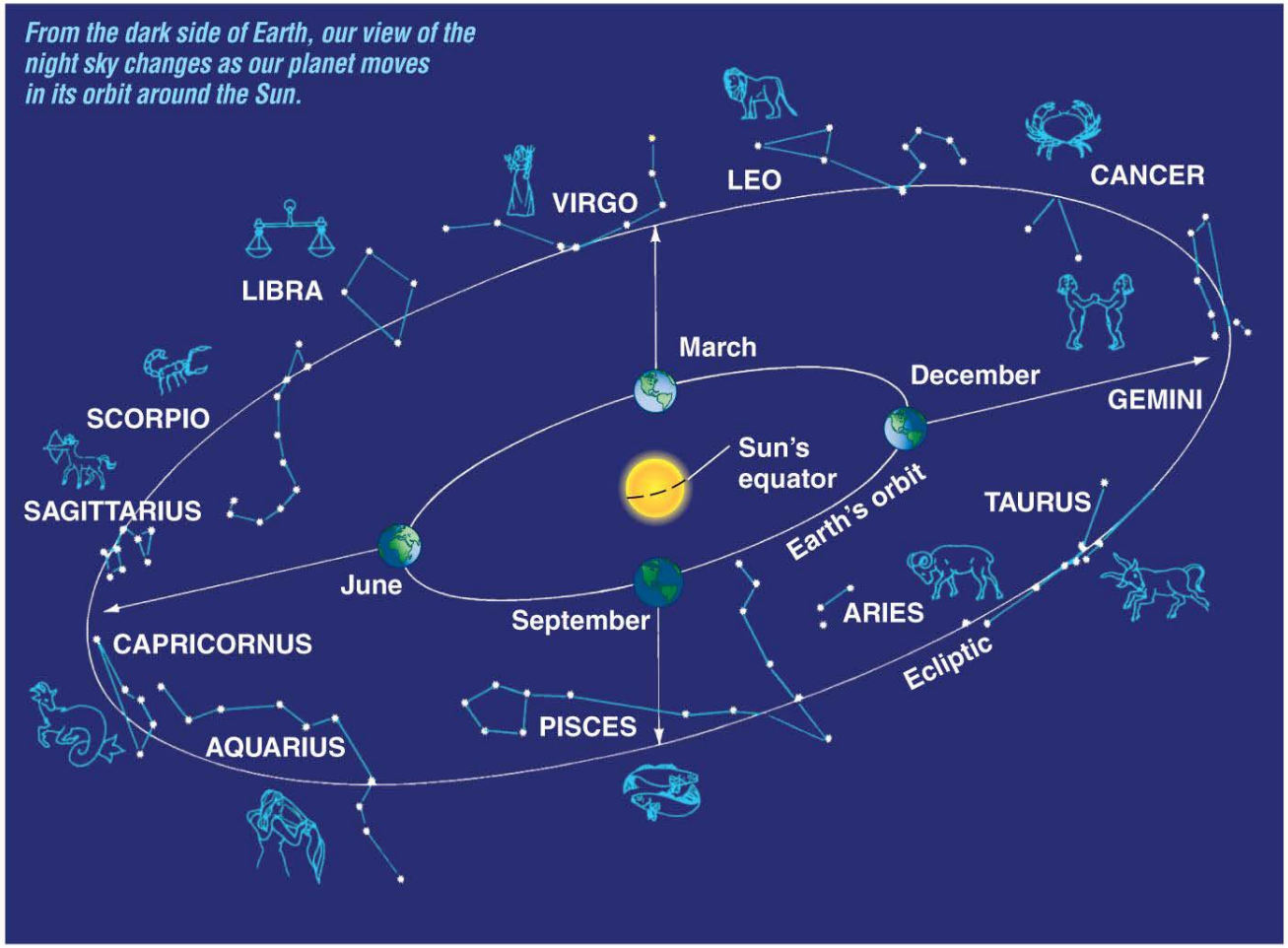


Earth's Orbital Motion

The 12 constellations the Sun moves through during the year are called the zodiac; path is ecliptic.



iClicker Question

What causes Earth's seasons?

a) Wobble of Earth's rotation axis

b) the greenhouse effect

c) 23.5° tilt of Earth's rotational axis

d) movement of Earth closer to or farther from the Sun

e) global warming and cooling

iClicker Answer

What causes Earth's seasons?

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c) 23.5° tilt of Earth's rotational axis

d) movement of Earth closer to or farther from the Sun

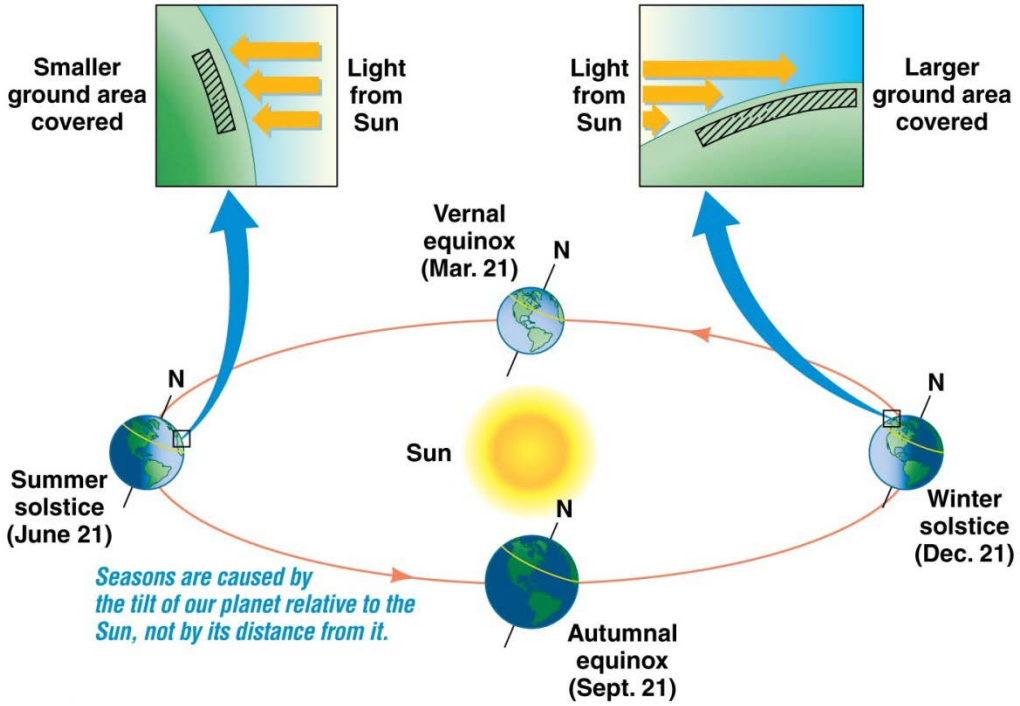
e) global warming and cooling

Explanation:

Our planet's tilt, and not its changing distance from the Sun, creates seasons.

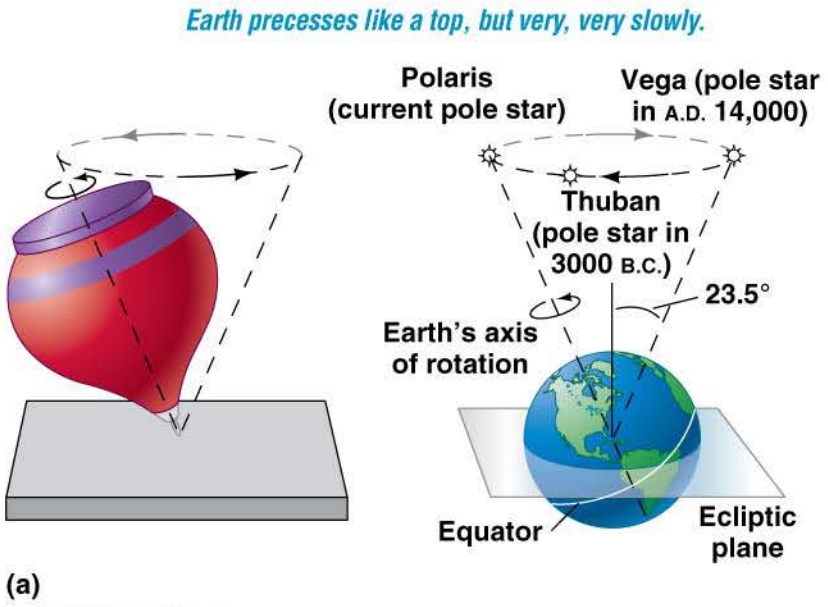
Earth's Orbital Motion

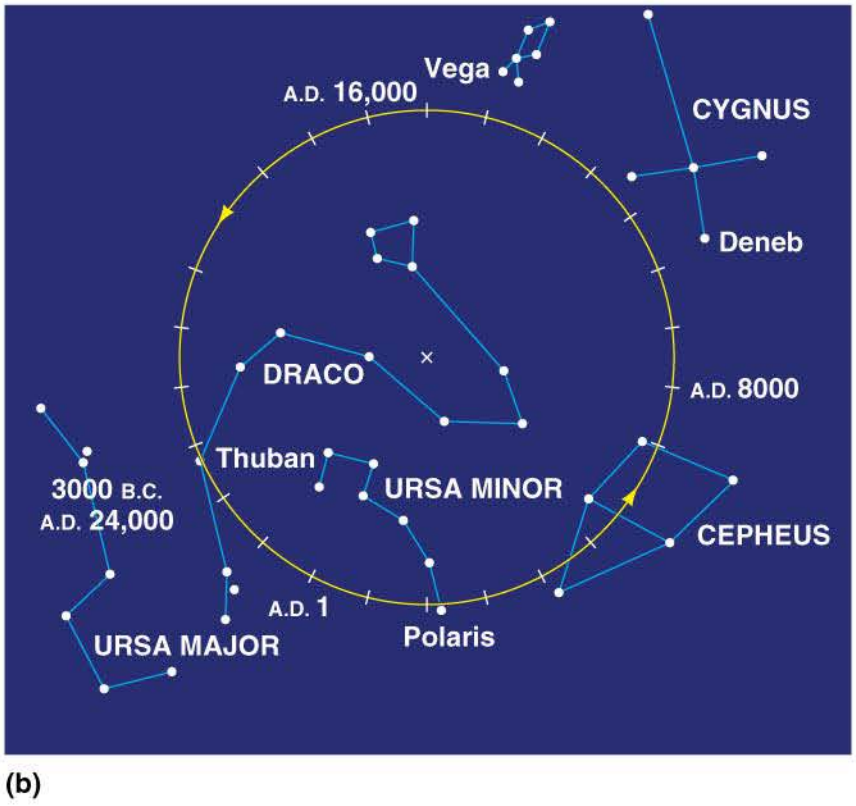
- **Ecliptic is plane of Earth's path around the Sun; at 23.5° to celestial equator.**
- **Northernmost point (above celestial equator) is summer solstice; southernmost is winter solstice; points where path crosses celestial equator are vernal and autumnal equinoxes.**
- **Combination of day length and sunlight angle gives seasons.**
- **Time from one vernal equinox to next is tropical year.**



Earth's Orbital Motion

Precession: Rotation of Earth's axis itself; makes one complete circle in about 26,000 years (due to tidal effect of Moon & Sun on Earth's rotational bulge).





Earth's Orbital Motion

Time for Earth to orbit once around the Sun, relative to fixed stars, is sidereal year.

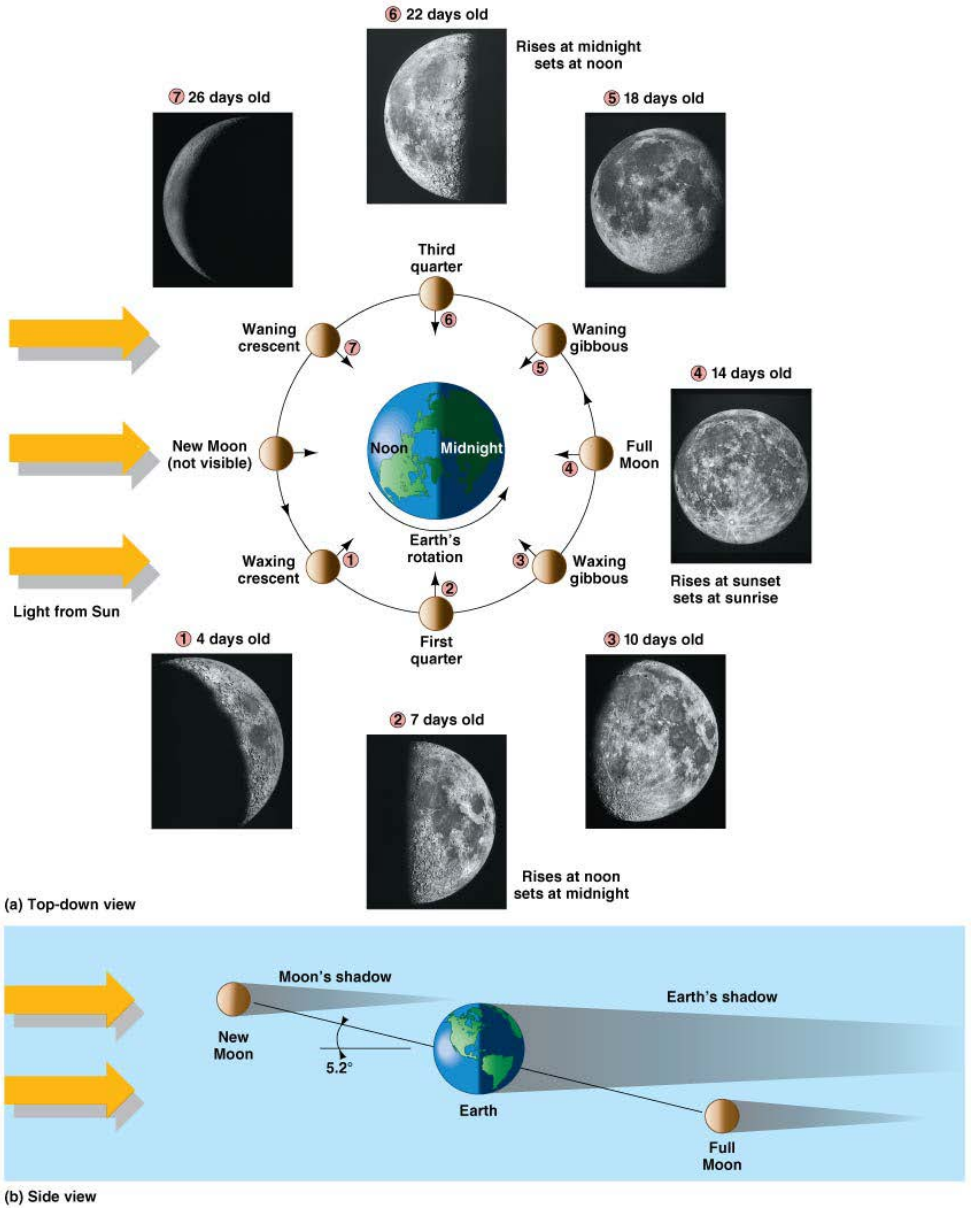
Tropical year follows seasons; sidereal year follows constellations – in 13,000 years July and August will still be summer, but Orion will be a summer constellation.

The Motion of the Moon

The Moon takes about 29.5 days to go through whole cycle of phases – synodic month.

Phases are due to different amounts of sunlit portion being visible from Earth.

Time to make full 360° around Earth, sidereal month, is about 2 days shorter than synodic month.



iClicker Question

Considering the Moon's phases, everyone on Earth sees

a) the same phase in 24 hours.
b) different phases in 24 hours.
c) a lunar eclipse once a month.
d) different sides of the Moon.

iClicker Answer

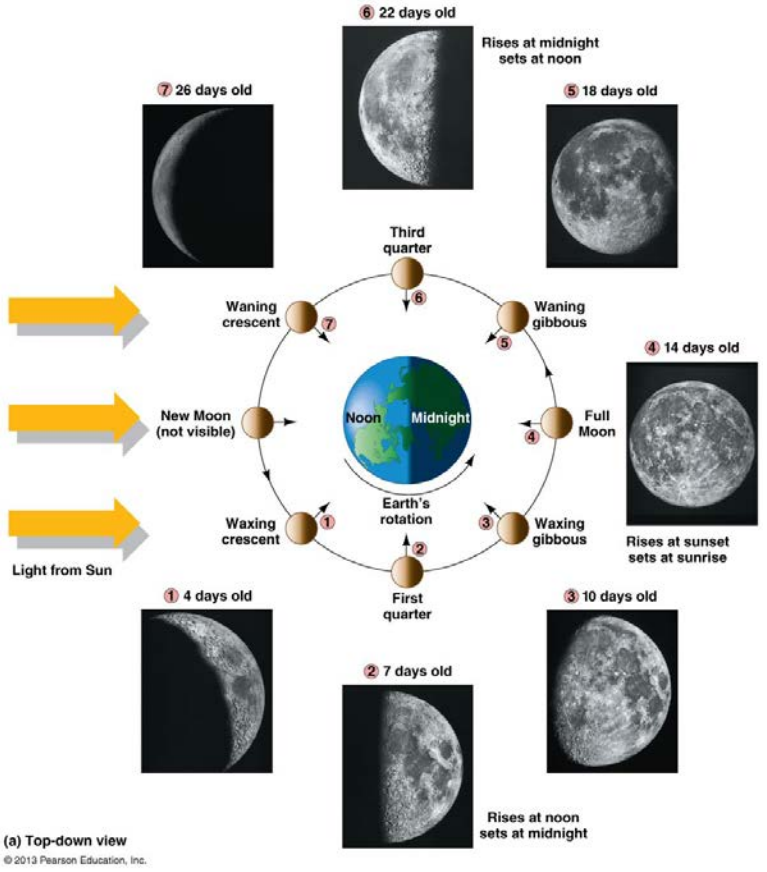
Considering the Moon's phases, everyone on Earth sees

a) the same phase in 24 hours.
b) different phases in 24 hours.
c) a lunar eclipse once a month.
d) different sides of the Moon.

Explanation:

The Moon goes through its cycle of phases in about 30 days; the Earth rotates once in only 24 hours.

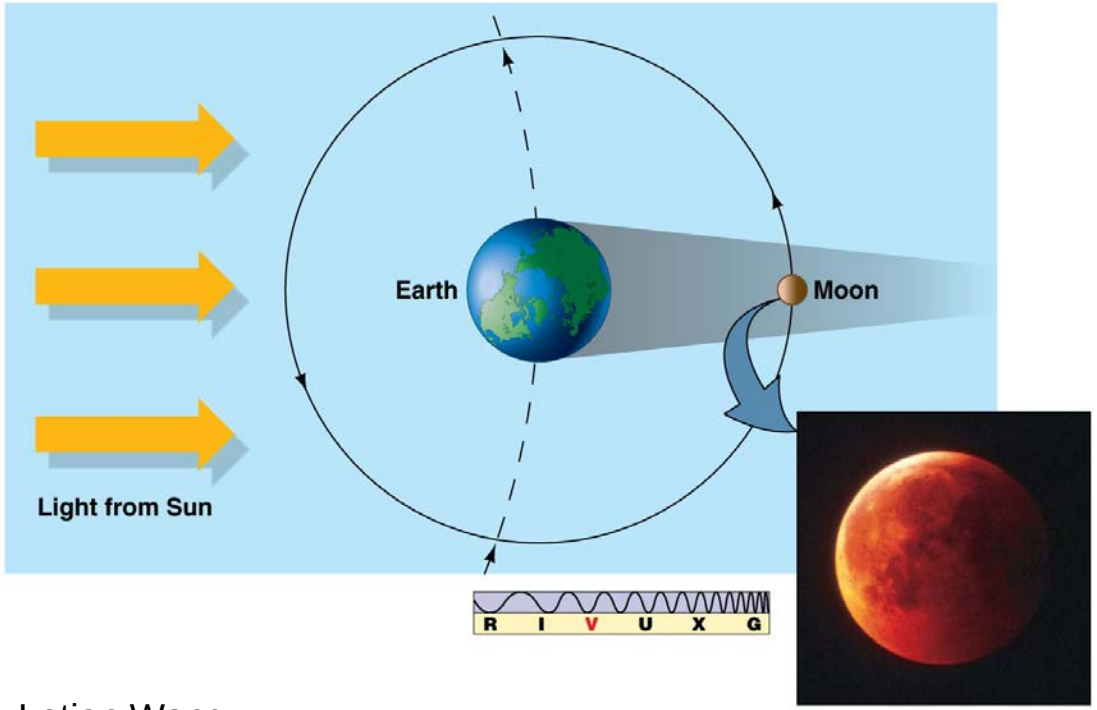
So everyone has a chance to see the same phase!



The Motion of the Moon

Lunar eclipse:

- **Earth is between the Moon and Sun**
- **Partial when only part of the Moon is in shadow**
- **Total when all is in shadow**

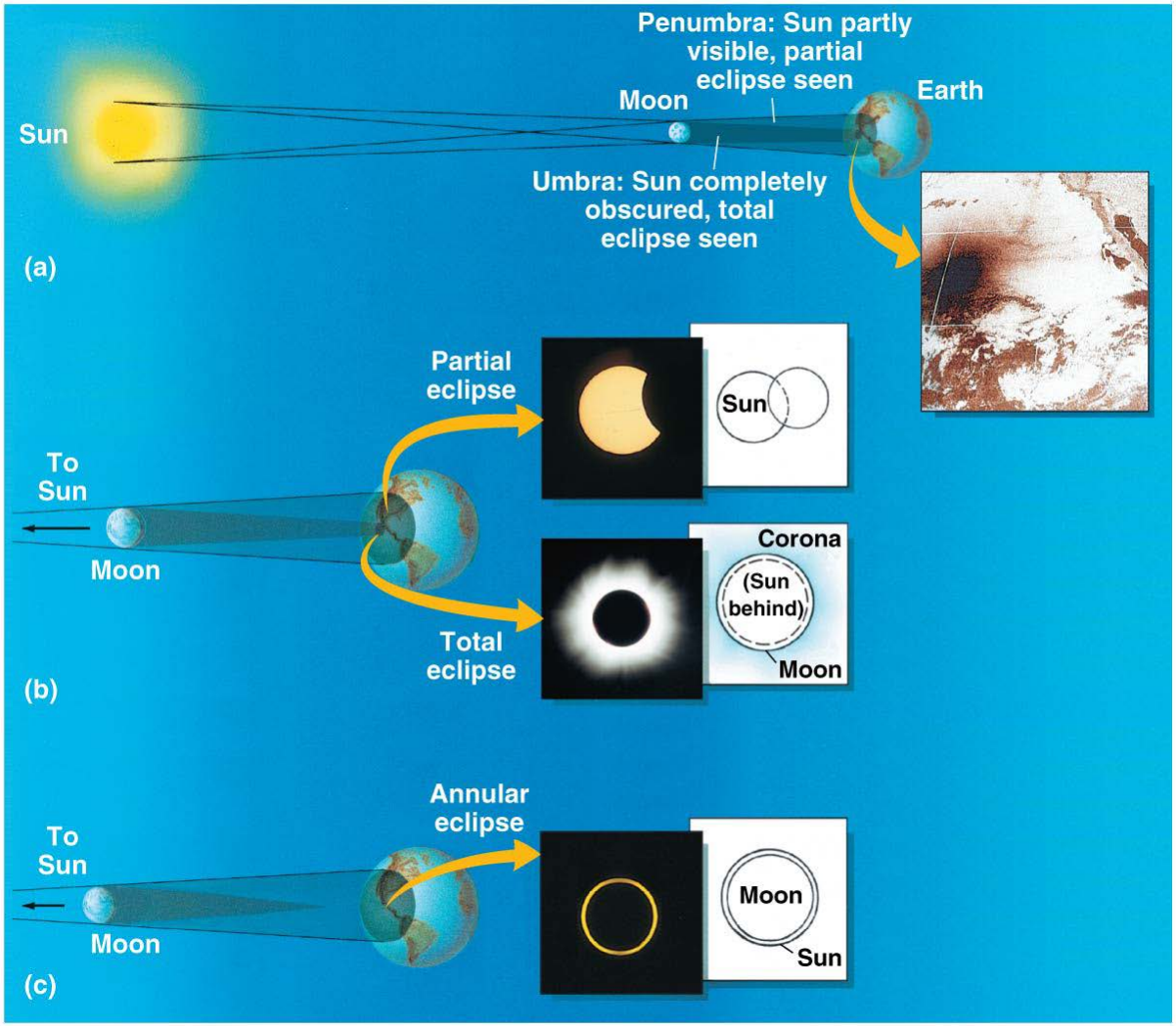


Letian Wang

This is an actual photo of the eclipsed Moon, one of the great light shows visible to the naked eye.

The Motion of the Moon

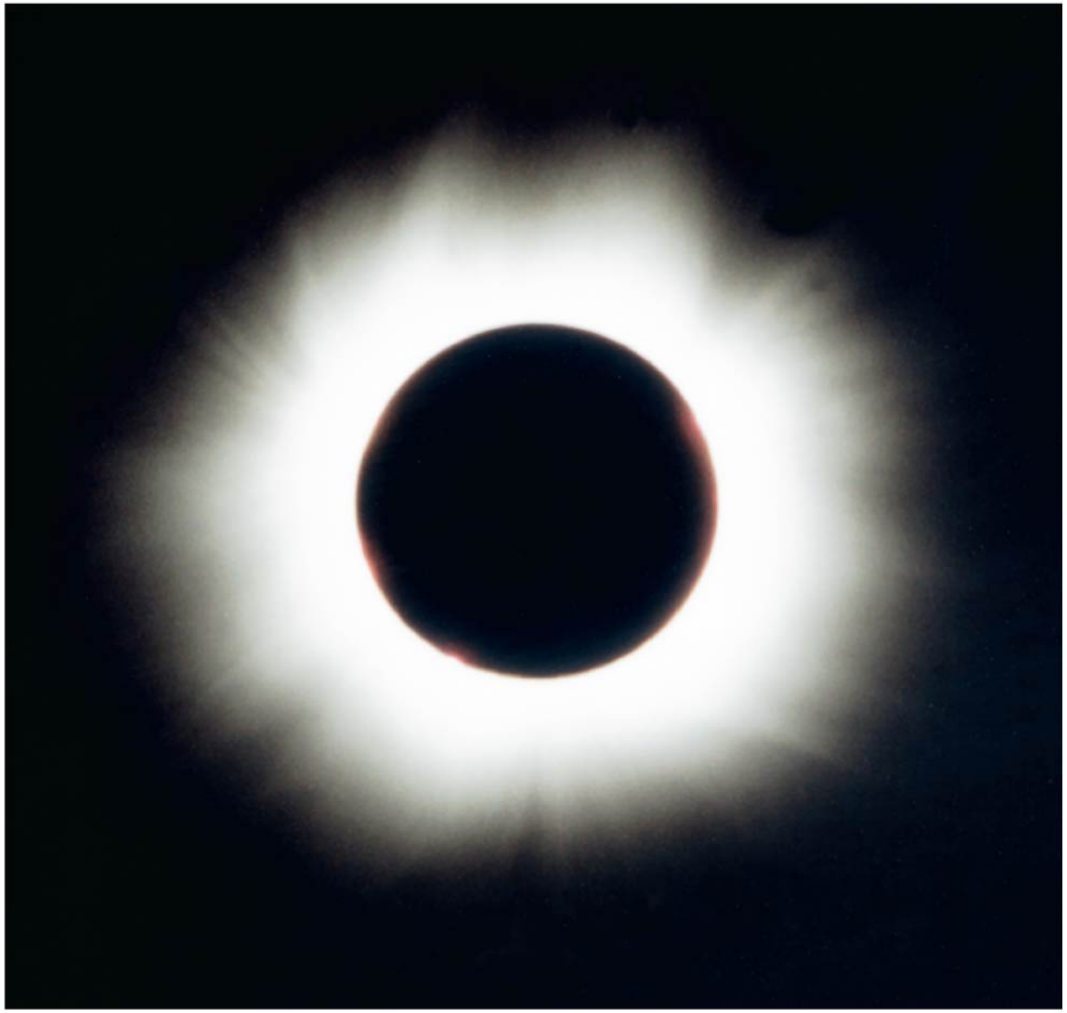
Solar eclipse: the Moon is between Earth and Sun



The Motion of the Moon

Solar eclipse is partial when only part of the Sun is blocked, total when all is blocked, and annular when the Moon is too far from Earth for total.

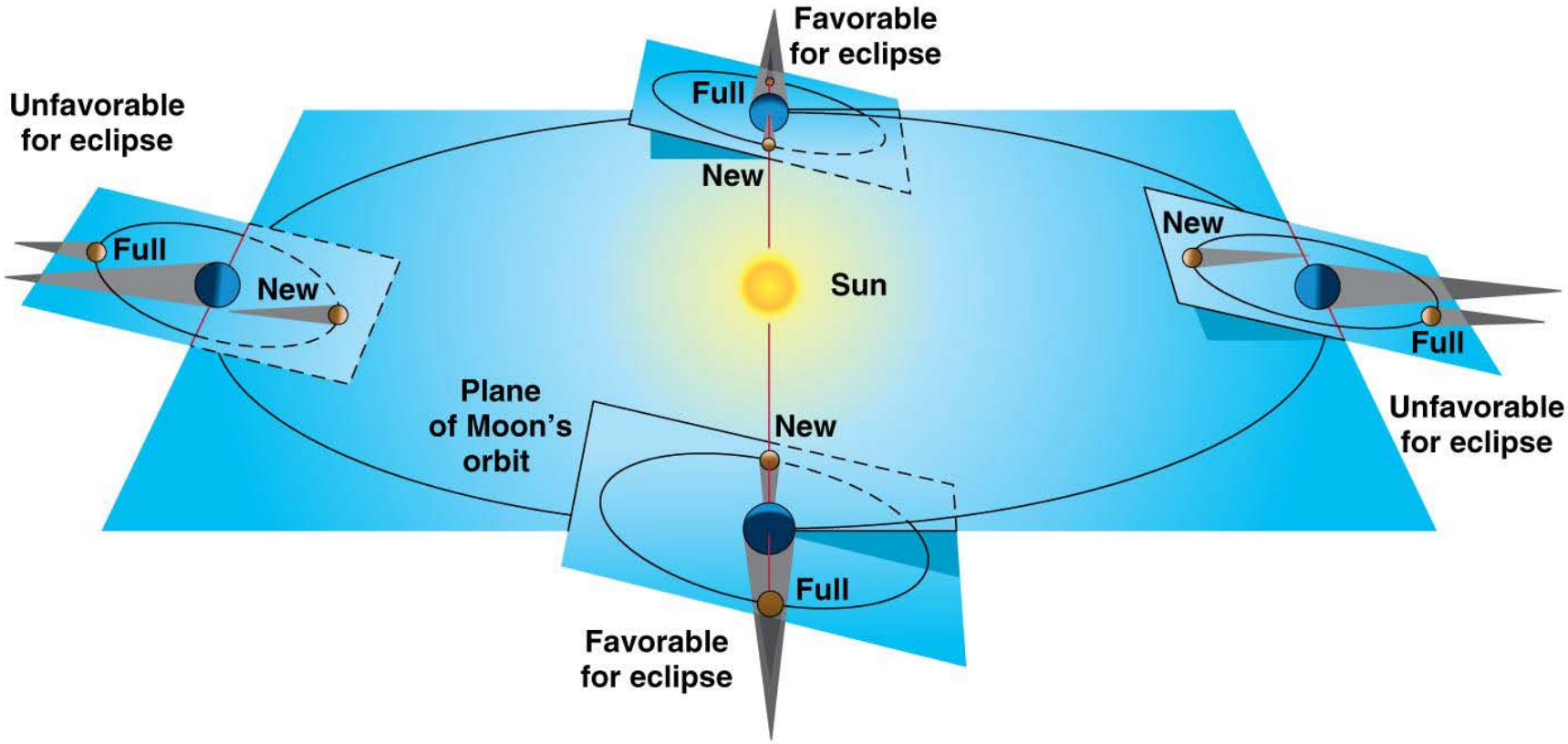
Rich variety of solar eclipses because Moon and Sun subtend nearly the same angle from Earth.



Bencho Angelov

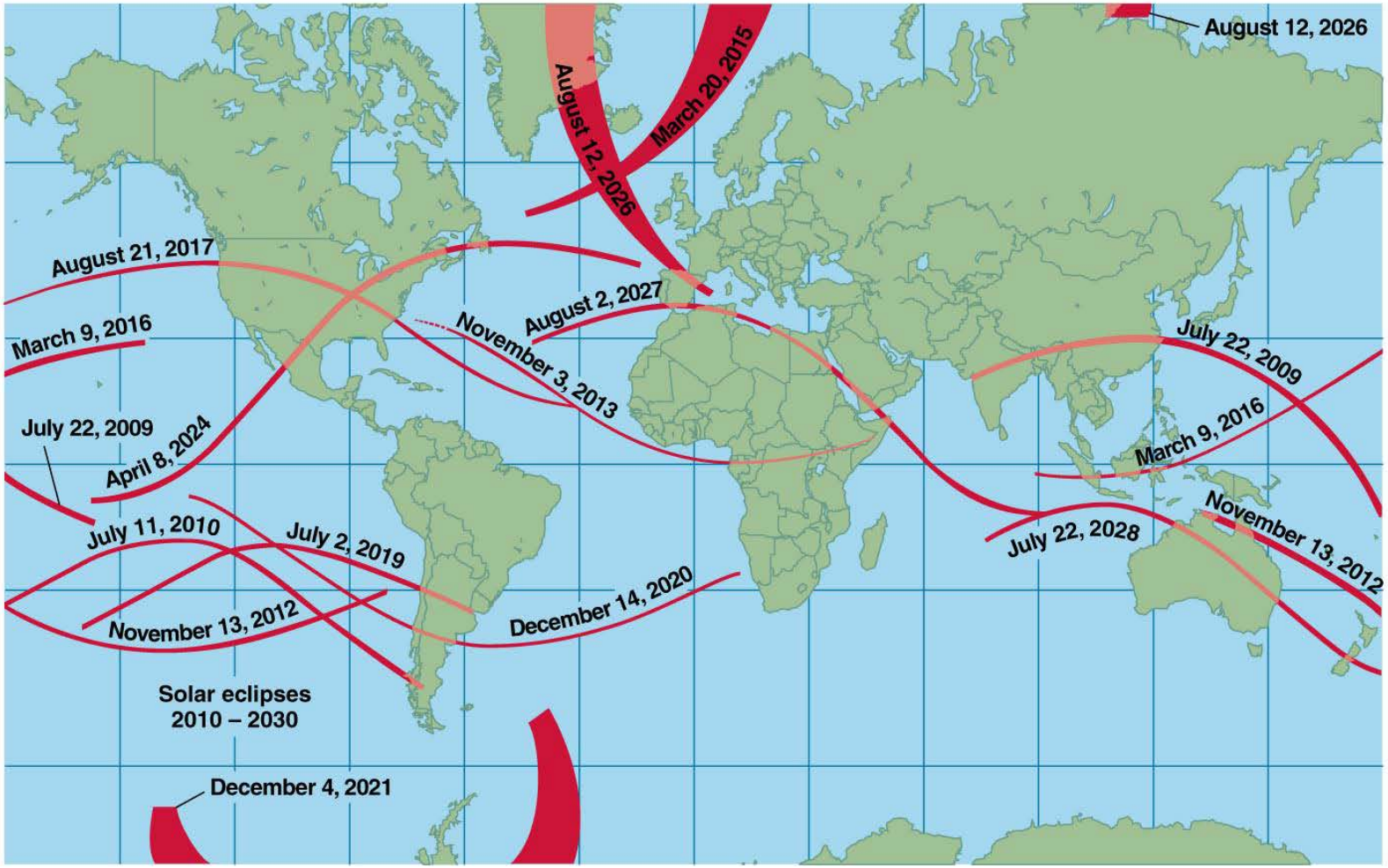
The Motion of the Moon

Eclipses don't occur every month because Earth's and the Moon's orbits are not in the same plane (~5° tilt).



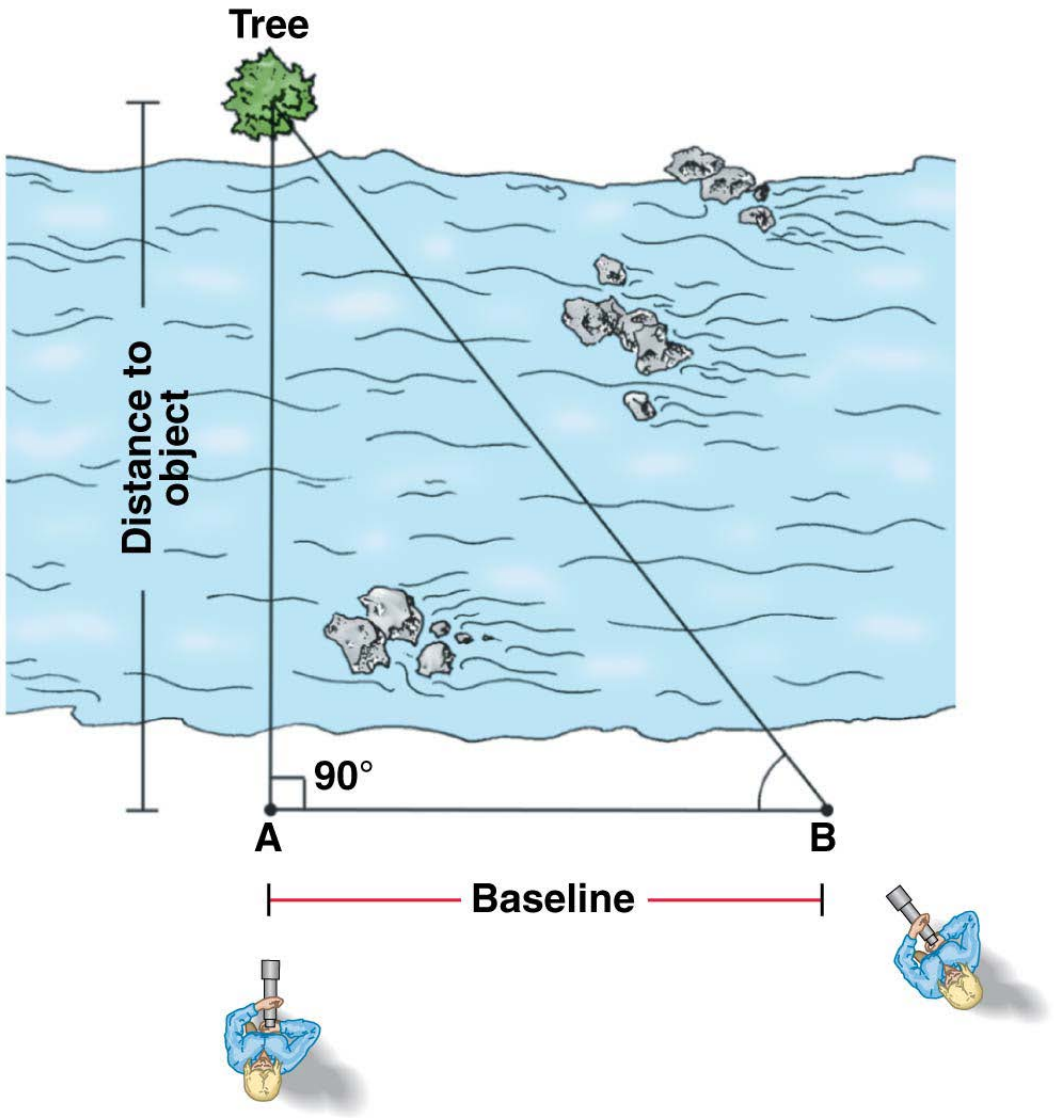
The Motion of the Moon

Solar eclipse tracks, 2010 - 2030



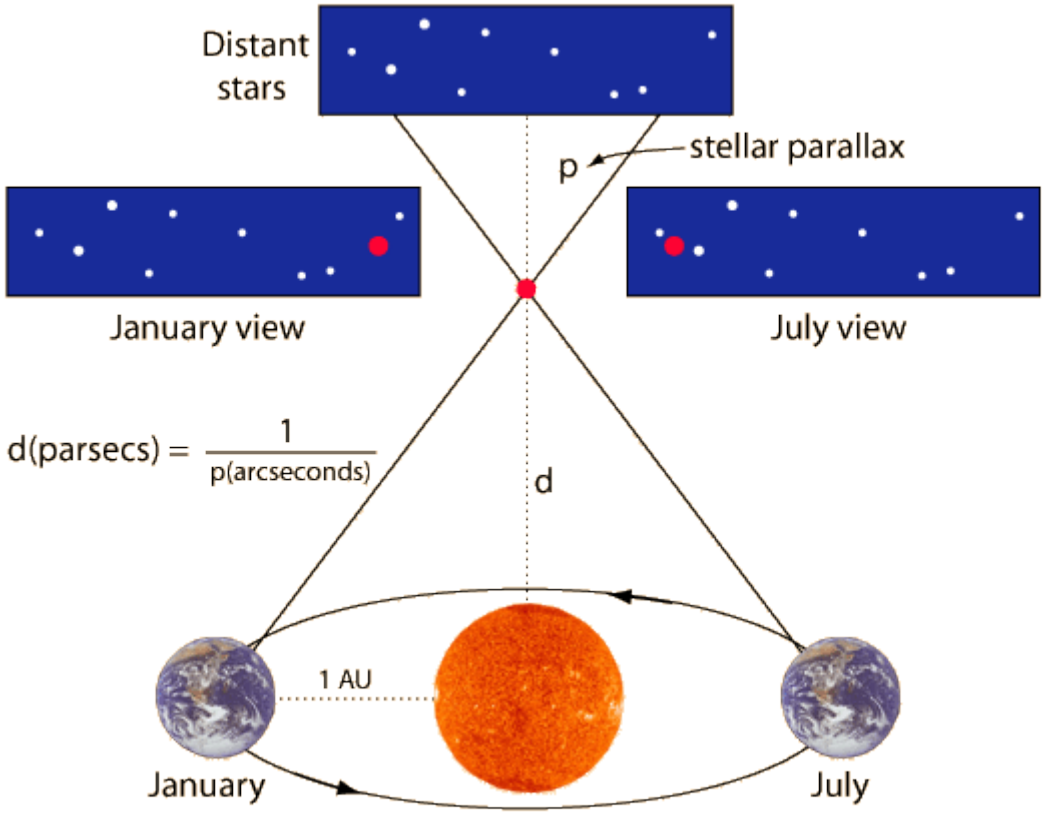
Measuring Distances

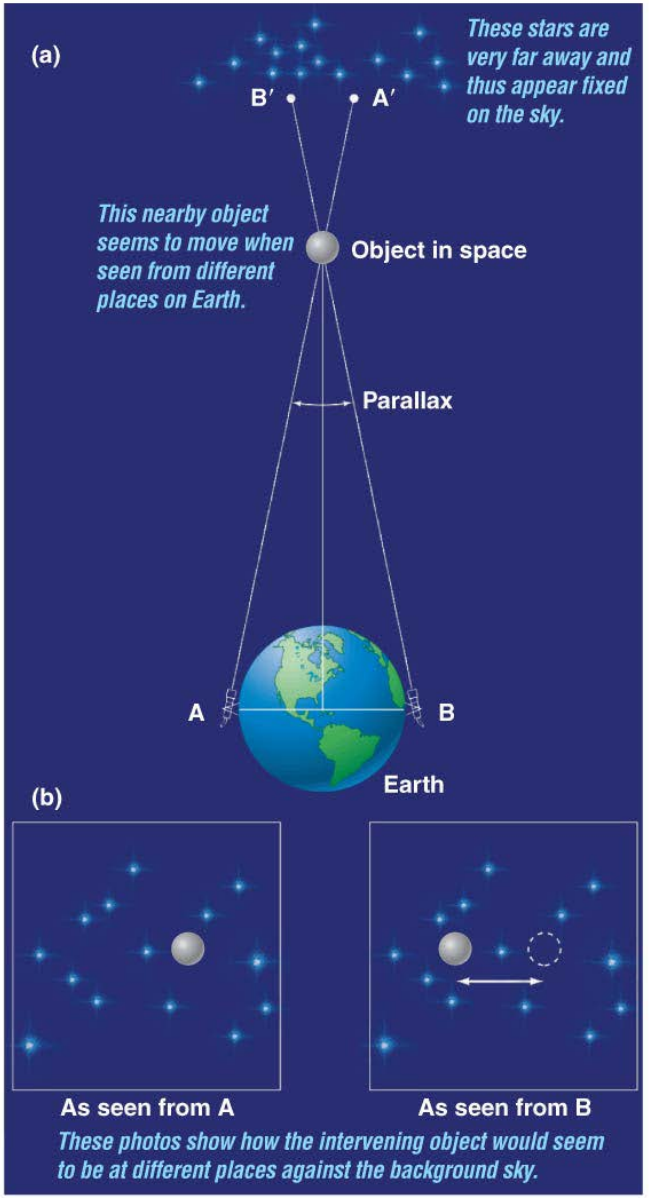
Triangulation: Measure baseline and angles, and you can calculate distance.



Measuring Distances

Parallax: Similar to triangulation, but looking at apparent motion of object against distant background from two vantage points





1 pc ~3.26 lyr ~206,000 AU

Science and the Scientific Method

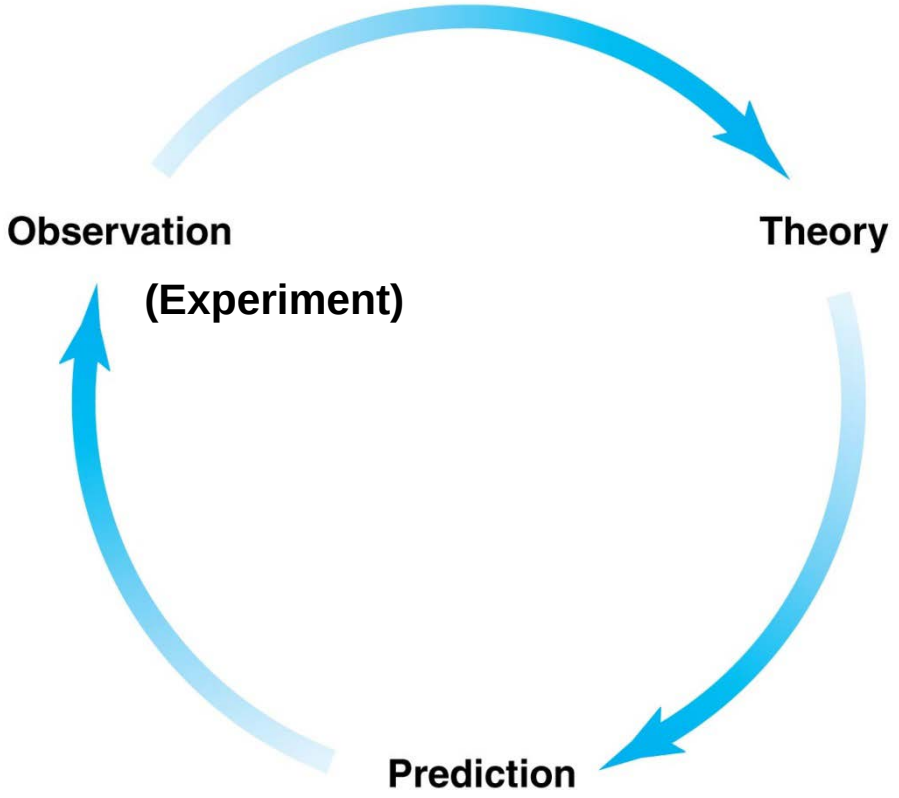
Scientific theories:

- **Must be testable**
- **Must be continually tested**
- **Should be simple (Occam's razor)**
- **(Should be elegant!!)**

Scientific theories can be proven wrong, but they can never be proven right with 100% certainty.

Science and the Scientific Method

- **Observation** leads to theory explaining it.
- **Theory** leads to predictions consistent with previous observations.
- Predictions of new phenomena are observed. If the observations agree with the prediction, more predictions can be made. If not, a new theory must be made.



Astronomy & Astrophysics

Observation; measurement; what's out there? Telescopes, data analysis, software tools

Physical understanding; what's going on inside? Computer modelling, simulation, interpretation

In astronomy/astrophysics cannot perform experiments in the normal way (distances and timescales too large)

- **Often must look at populations to understand evolution etc.—frequently cannot see evolution in individual objects**
- **Basic assumption of unity of structure and behaviour throughout the universe – supported by observation**

iClicker Question

Constellations appear to move across the sky at night because

a) the Earth orbits the Sun.
b) the Moon orbits the Earth.
c) stars are in constant motion.
d) the Sun orbits the Earth.
e) the Earth spins on its axis.

iClicker Answer

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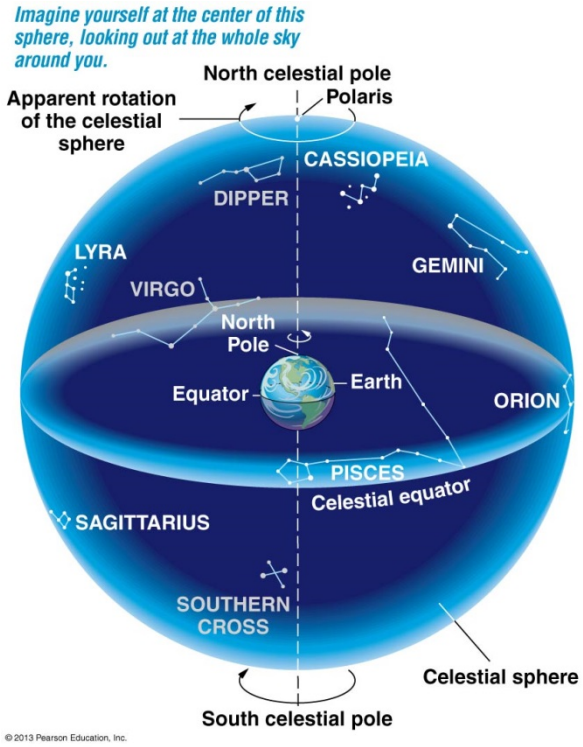


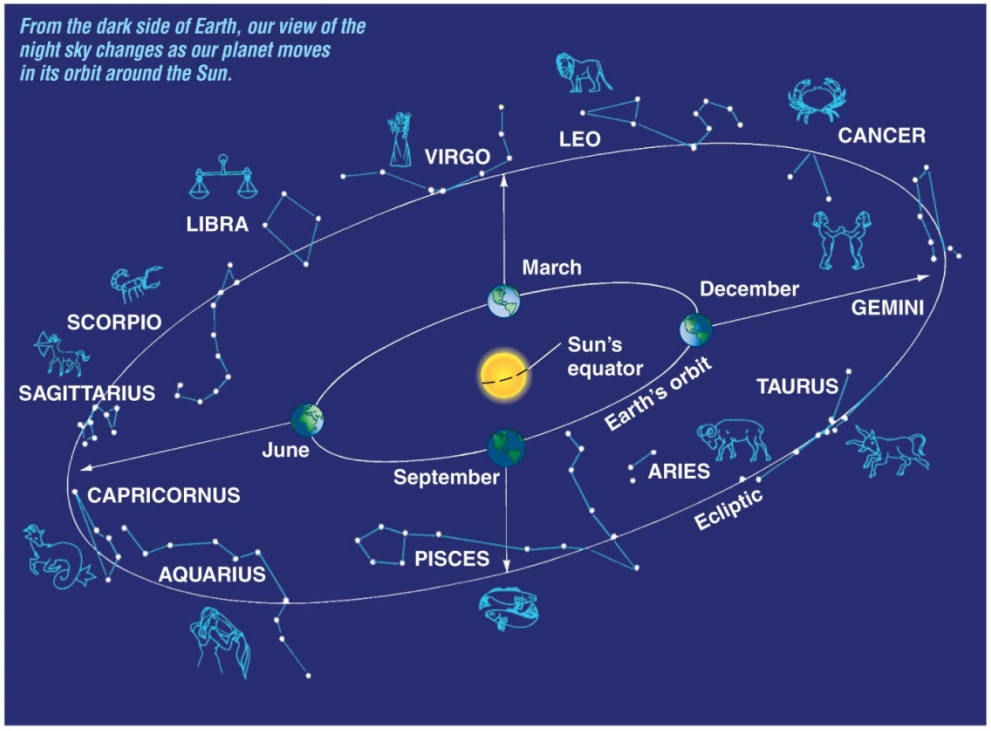
Explanation:

The Sun, Moon, planets, and stars all rise and set because our planet rotates once each day.

iClicker Question

What is the path that the Sun, Moon, and planets follow through the constellations?

a) the celestial equator
b) the north celestial pole
c) the Milky Way
d) the zodiac
e) the ecliptic



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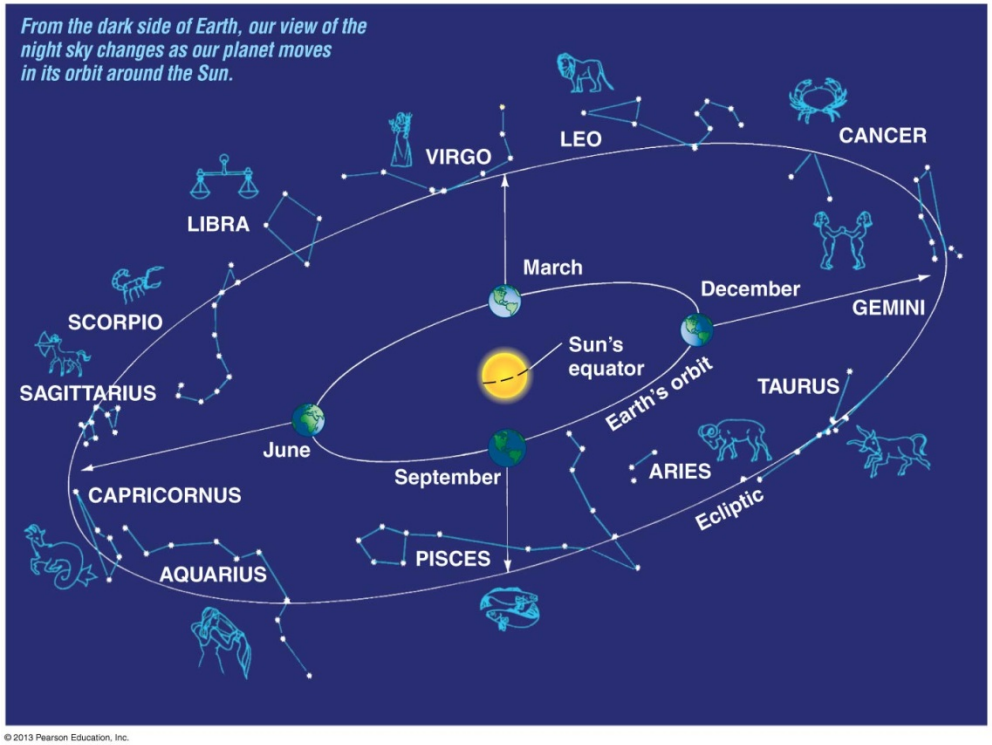
Explanation:

The ecliptic also marks the plane of Earth's orbit around the Sun.



iClicker Question

How long does it take the Sun to complete one circuit of the ecliptic?

a) one hour

b) one day

c) one month

d) one year

e) one decade

iClicker Answer

How long does it take the Sun to complete one circuit of the ecliptic?

a) one hour

b) one day

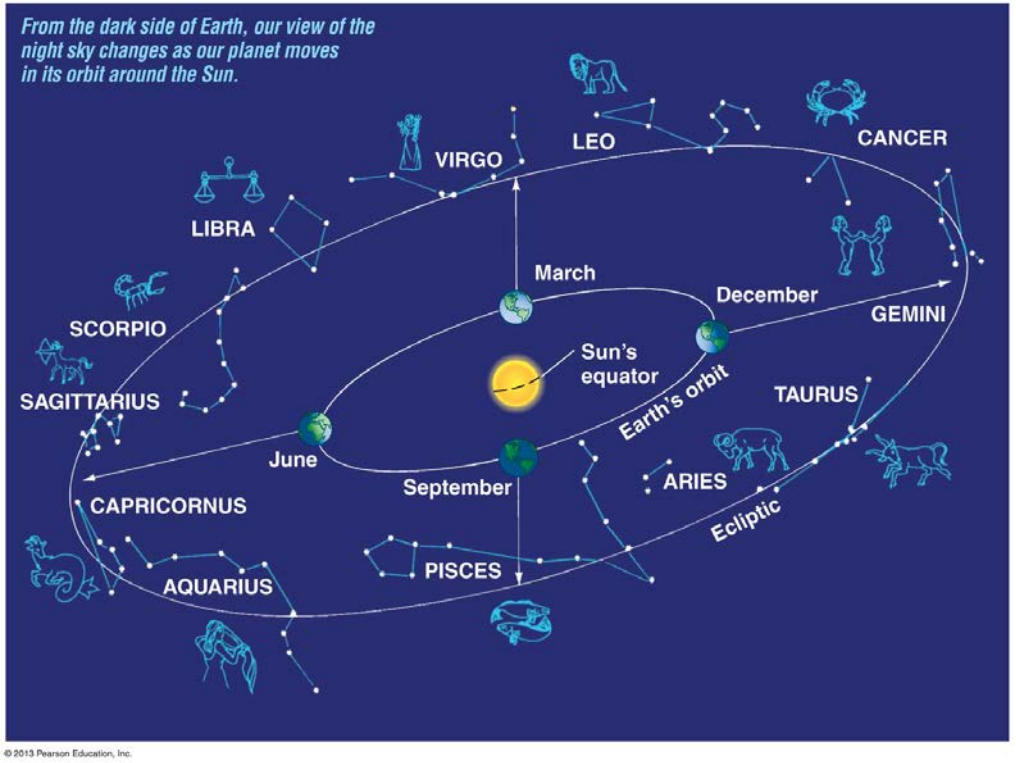
c) one month

d) one year

e) one decade

Explanation:

The Sun moves around the ecliptic once as the Earth orbits in one year.



iClicker Question

How long does it take the Moon to go around the ecliptic?

a) one day
b) one hour
c) one week
d) one month
e) one year

G. Schneider

iClicker Answer

How long does it take the Moon to go around the ecliptic?

a) one day

b) one hour

c) one week

d) one month

e) one year

G. Schneider

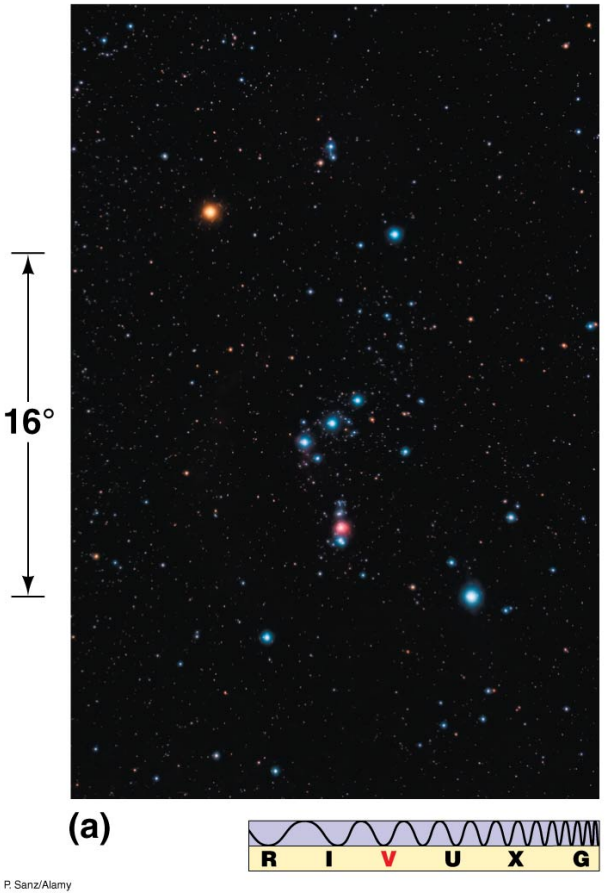
Explanation:

The Moon orbits Earth in a month,
and passes in front of the constellations
of the zodiac, which are arranged around the ecliptic.

iClicker Question

Stars in a constellation are

a) physically close to each other.
b) usually equal in brightness.
c) about the same age.
d) about the same distance away.
e) in the same part of the sky.



iClicker Answer

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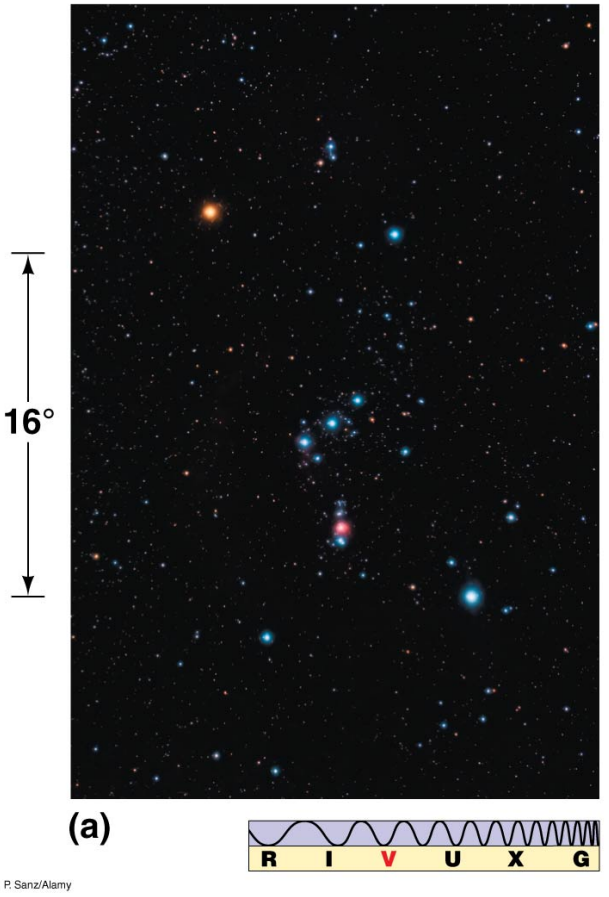
a) physically close to each other.
b) usually equal in brightness.
c) about the same age.
d) about the same distance away.
e) in the same part of the sky.

Explanation:

Stars within a constellation might be very different distances, ages, types, and brightnesses.



iClicker Question

A total *lunar* eclipse occurs

a) during the new moon phase.

b) when the Sun blocks the Moon.

c) during the full moon phase.

d) always around the summer solstice.

G. Schneider

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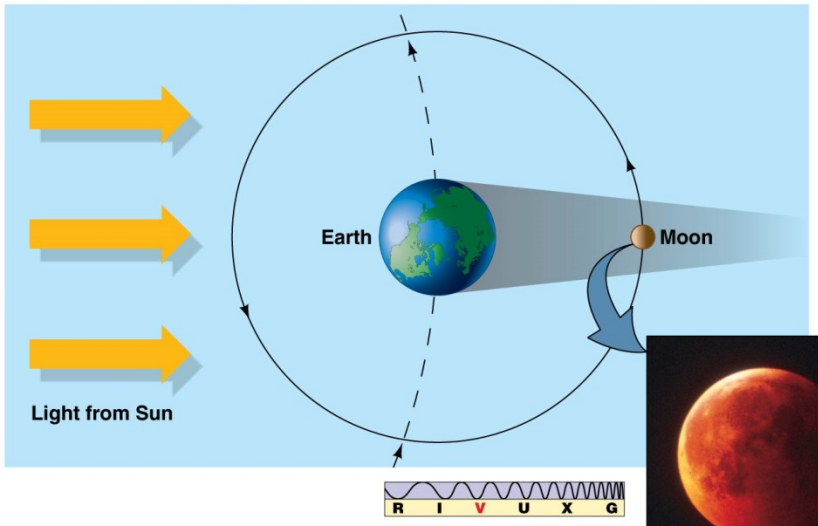

This is an actual photo of the eclipsed Moon, one of the great light shows visible to the naked eye.

iClicker Question

The *vernal equinox* marks the beginning of

a) summer.

b) fall.

c) winter.

d) spring.

iClicker Answer

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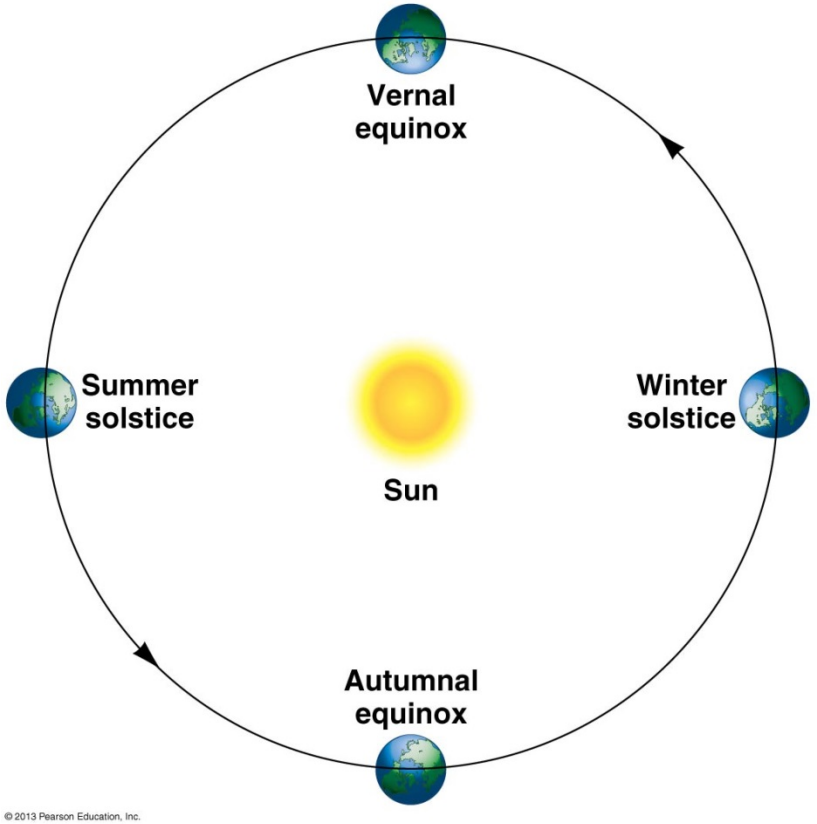


Explanation:

The vernal equinox occurs around March 21–22.

iClicker Question

Conditions are favorable for a solar eclipse

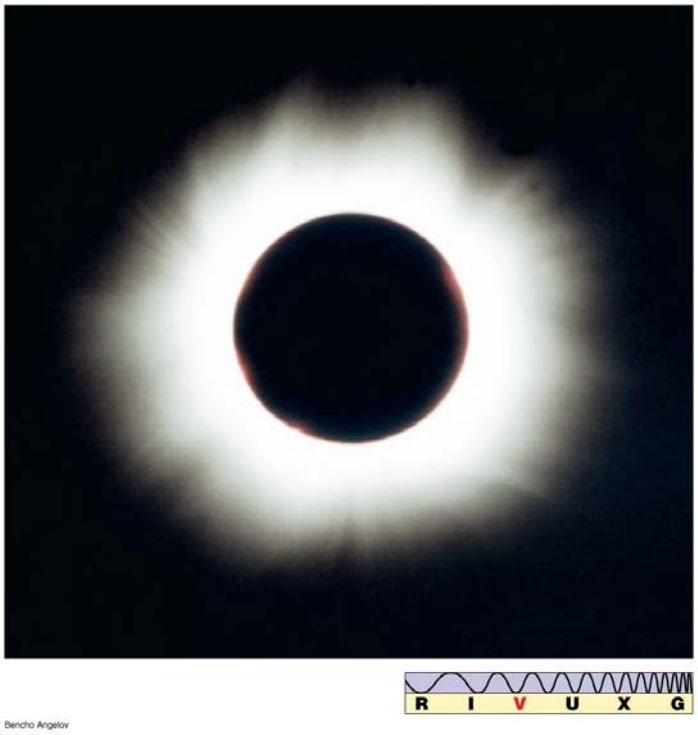
a) every month at new moon.

b) every week at the quarter phases.

c) every month at full moon.

d) about every six months
at new moon.

e) every year
at new moon.



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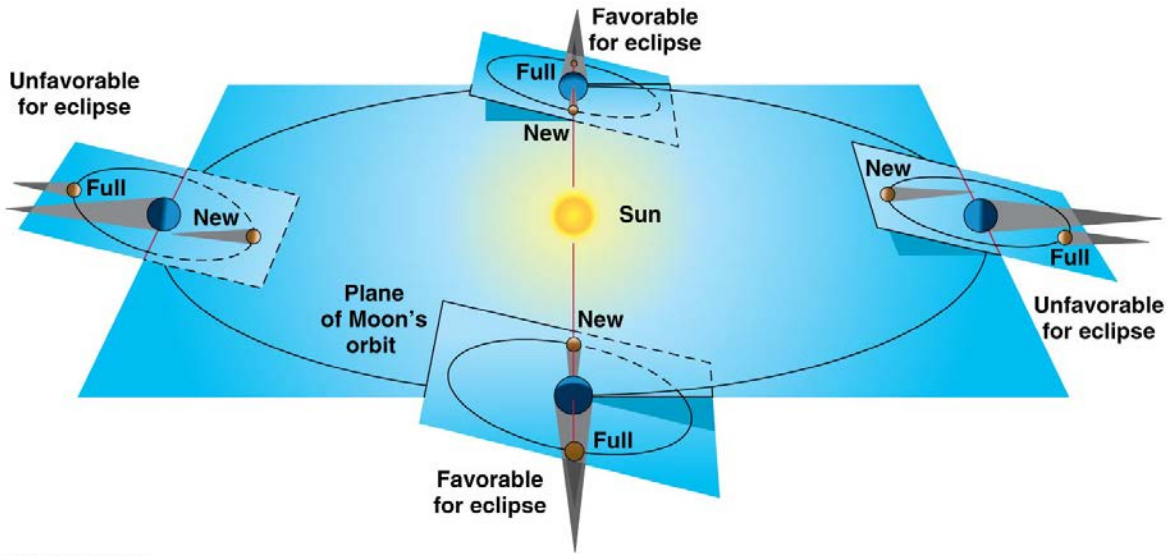
b) every week at the quarter phases.

c) every month at full moon.

d) about every six months at new moon.

e) every year at new moon.



iClicker Question

The angle of *parallax* increases as

a) distances to stars increase.

b) the baseline gets larger.

c) the baseline gets smaller.

d) the Earth moves faster in its orbit.

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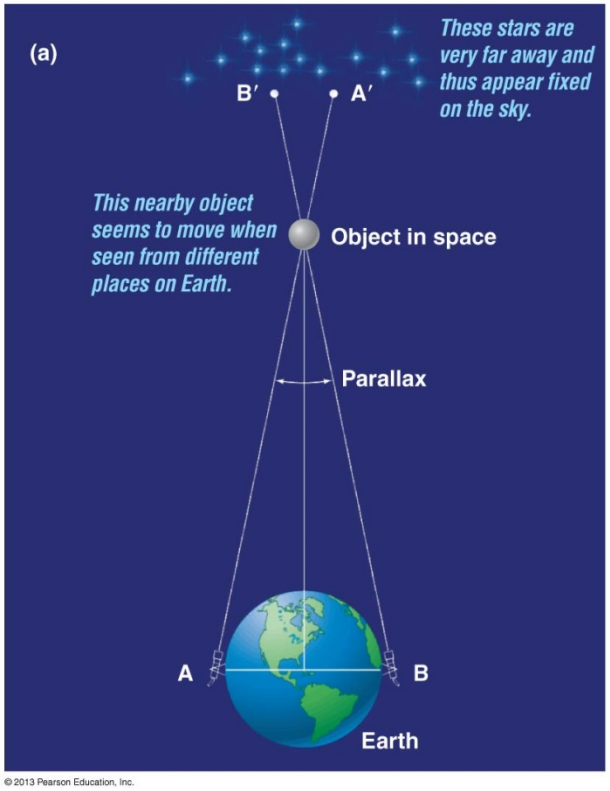


Explanation:

The greater the distance between two observation points (the baseline), the larger the angle of parallax.

iClicker Question

Precession is caused by

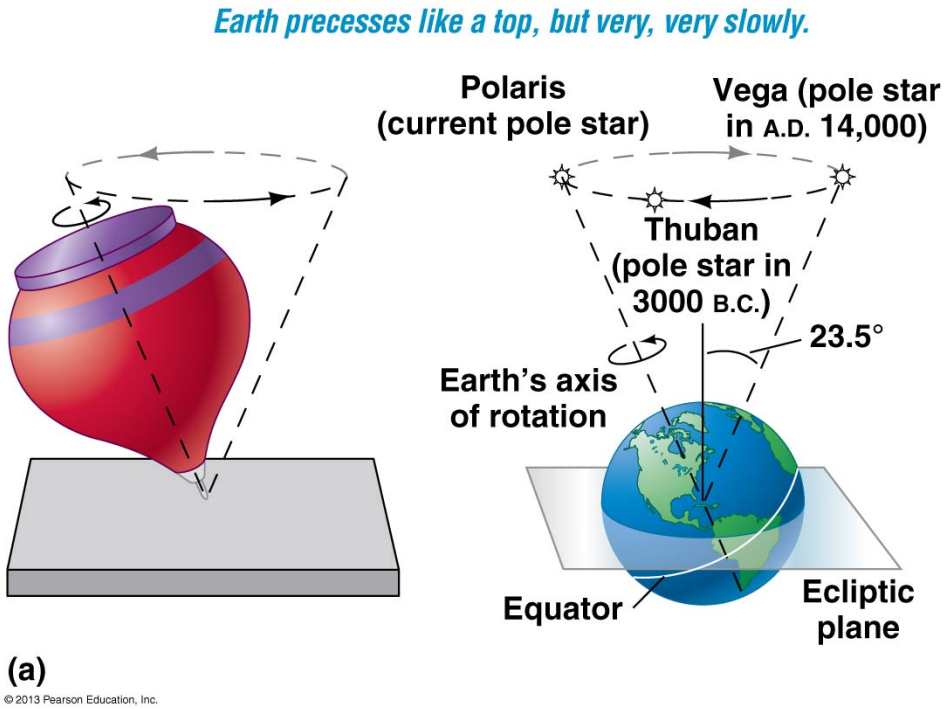
a) the rotation of Earth's molten core.

b) the slow movement of the continents (plate tectonics).

c) the gravitational pull of the Sun & Moon.

d) the weight of the ice at the poles.

e) gravitational attractions from comets.



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Explanation:

The Moon's tug creates a slow "wobble" that takes 26,000 years for one rotation.