

WEEK 2 Outline
Stellar and Galactic ...

Astronomy

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The Naked – Eye Universe

Constellations and Asterisms

Constellation: a designated region in the sky containing one or more historical star patterns.

Asterism: a recognizable pattern of stars.

Ex) Orion

Ex) Ursa Major

Ex) Taurus

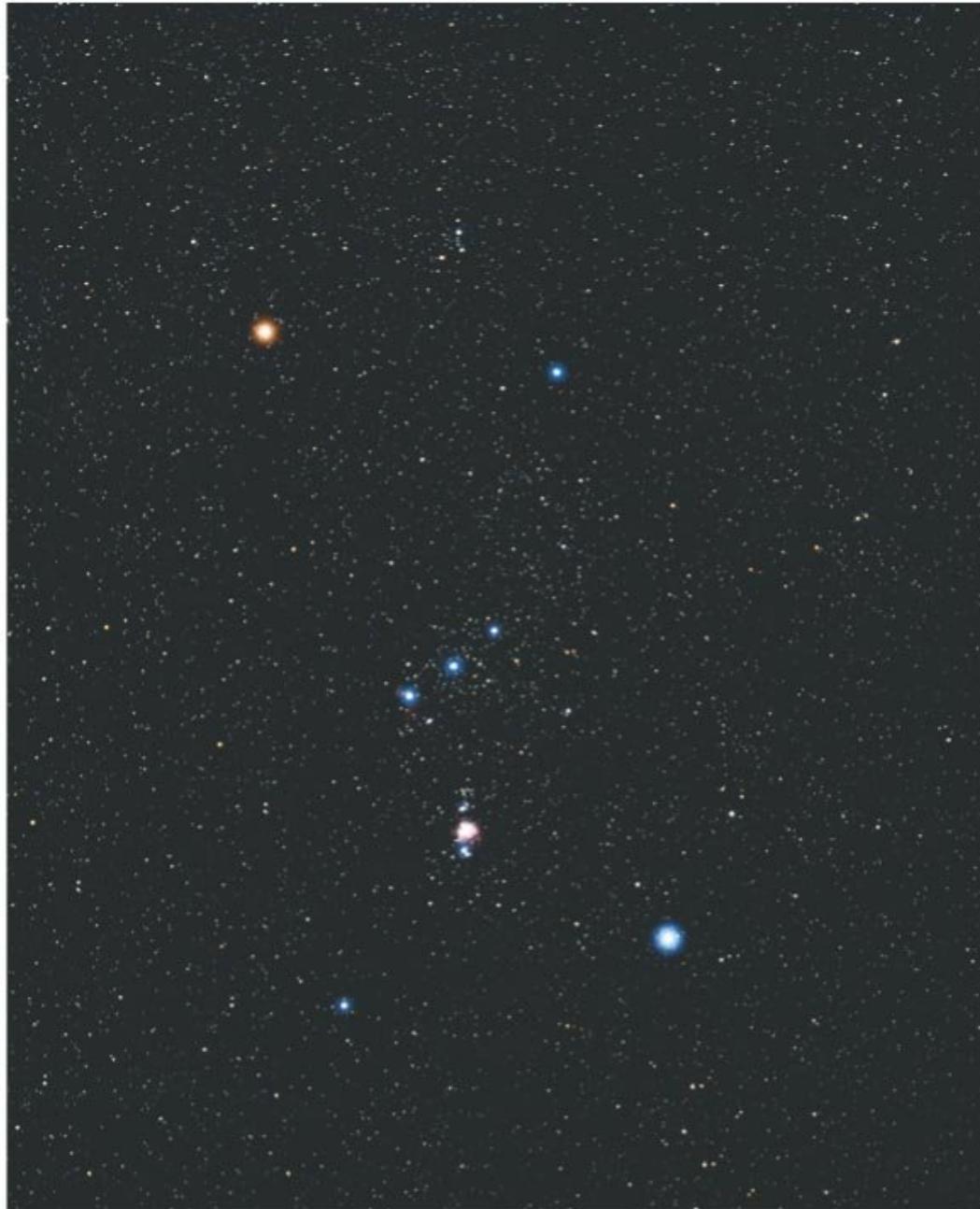
* 88 total constellations

* Northern constellations named after Greek Mythological characters

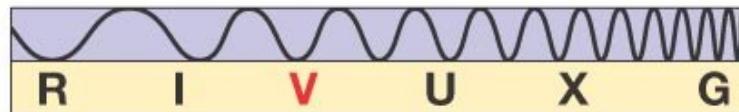
**Example:
Orion.**

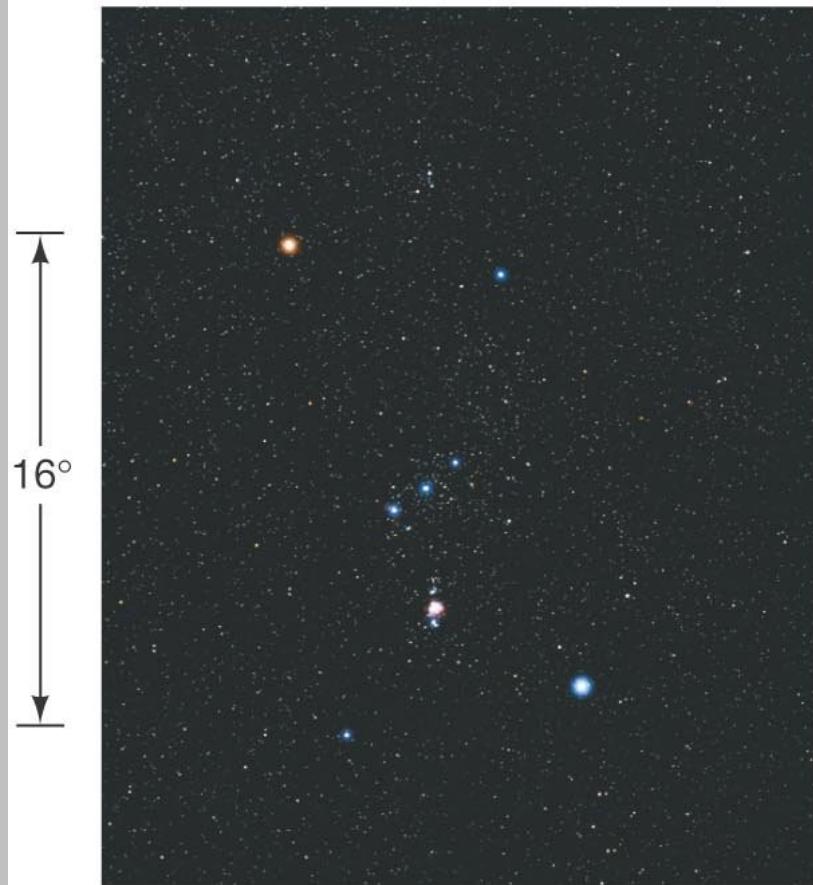
**An easily
recognized
asterism and
constellation!**

16°

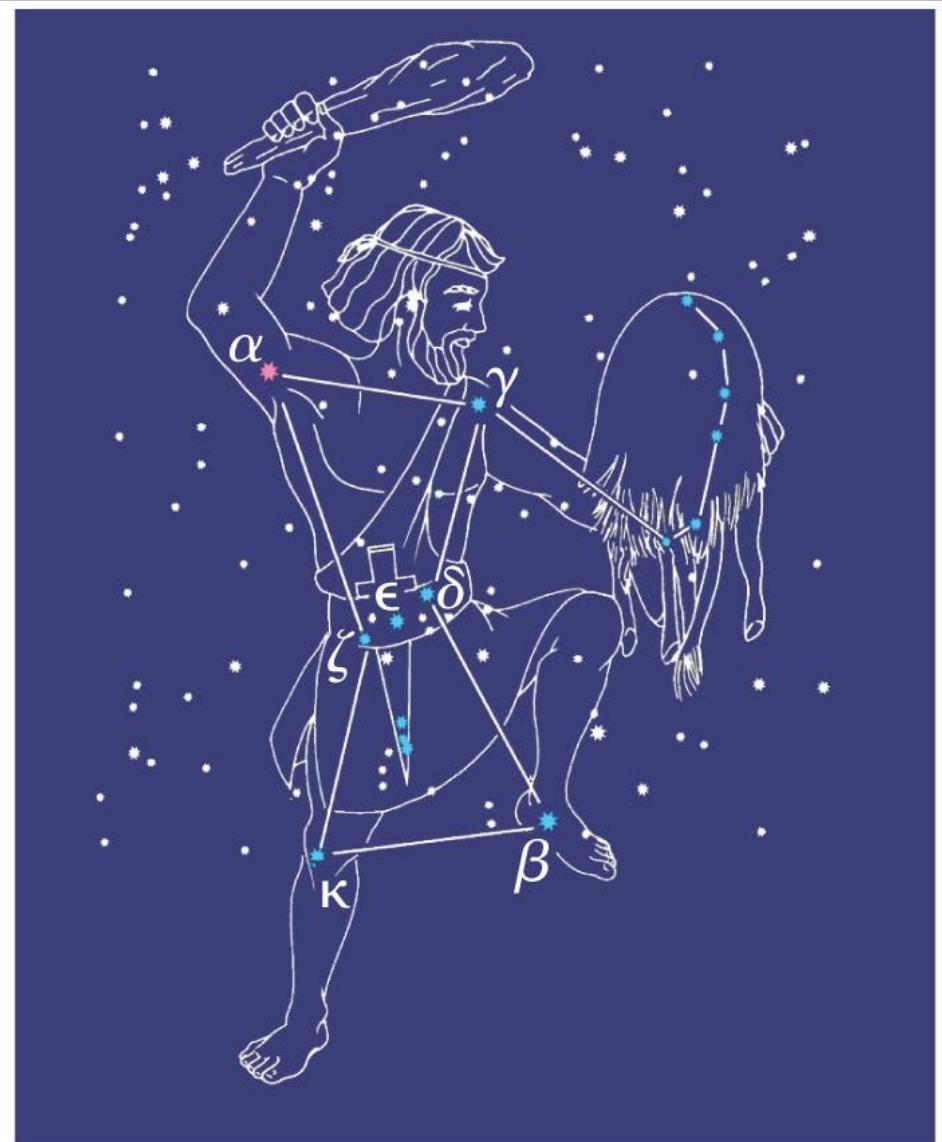
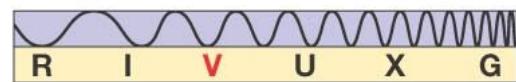


(a)

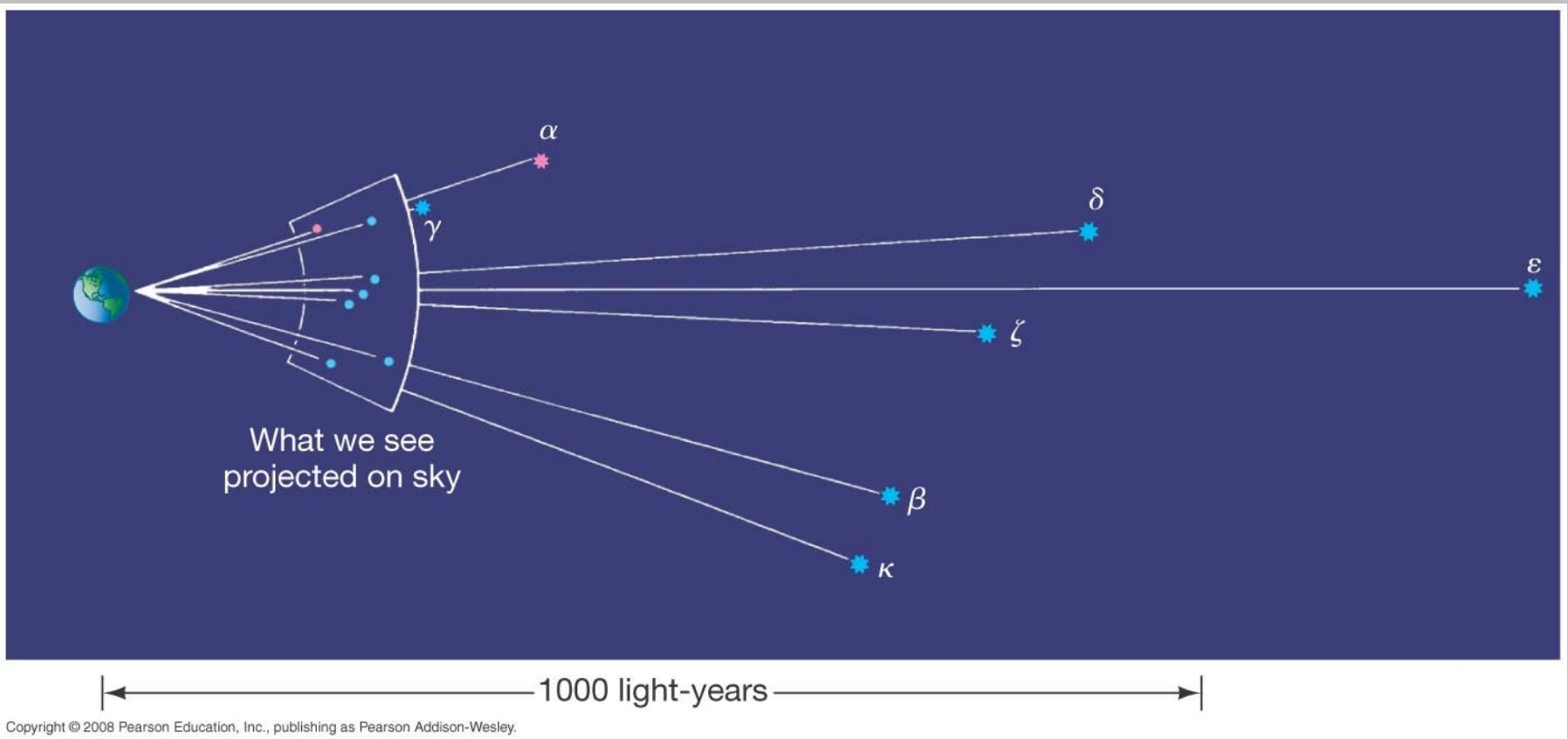


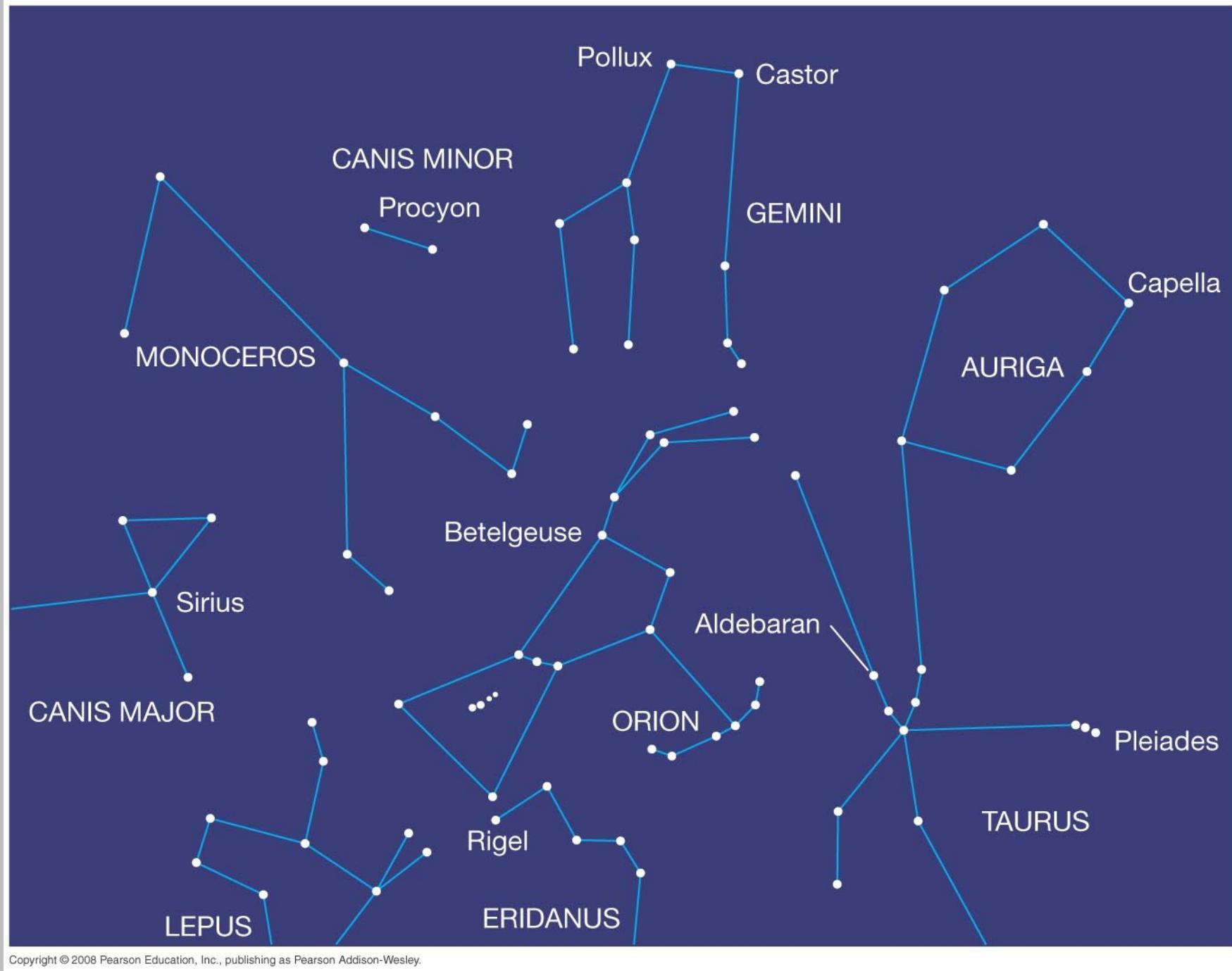


(a)



(b)

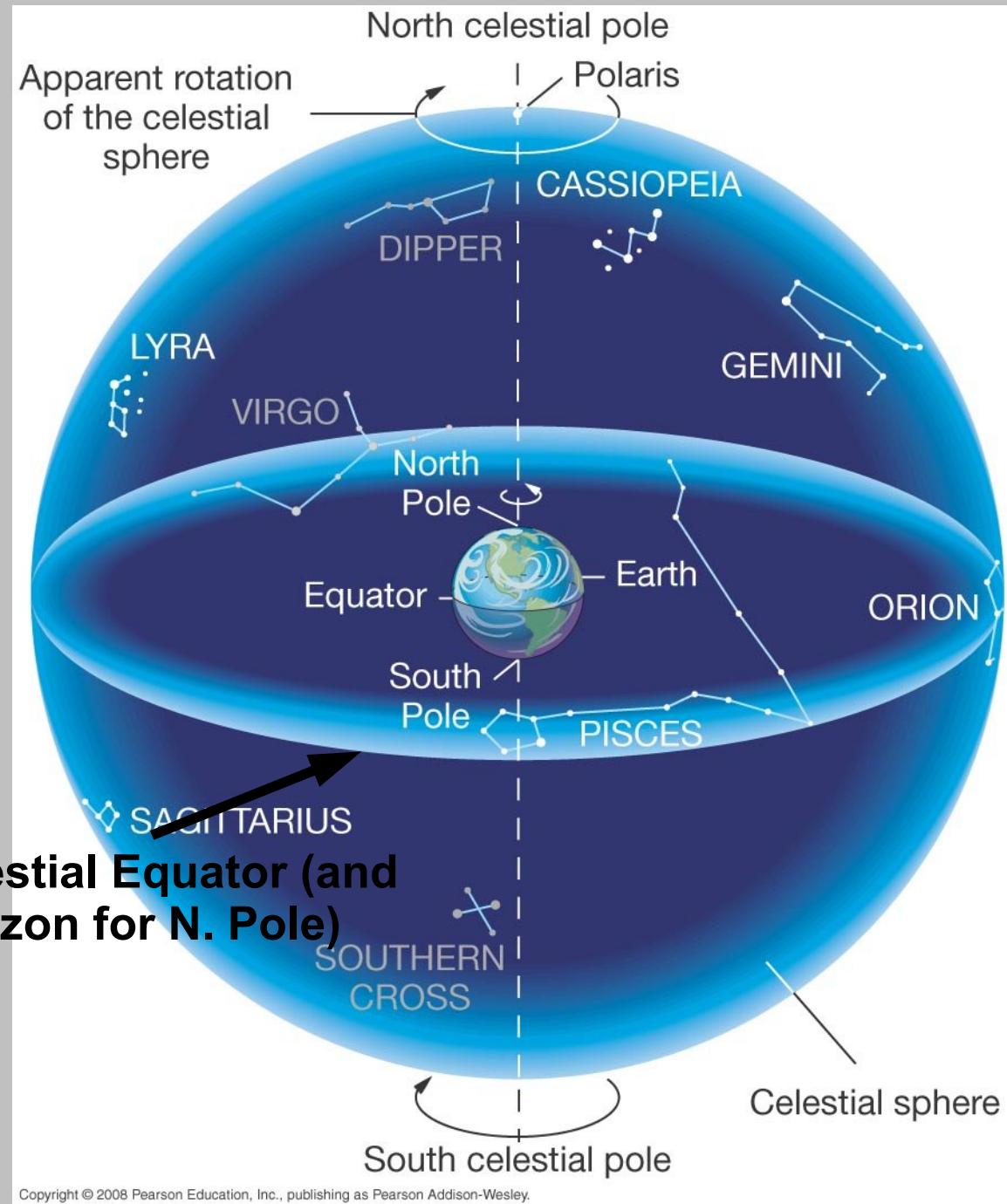




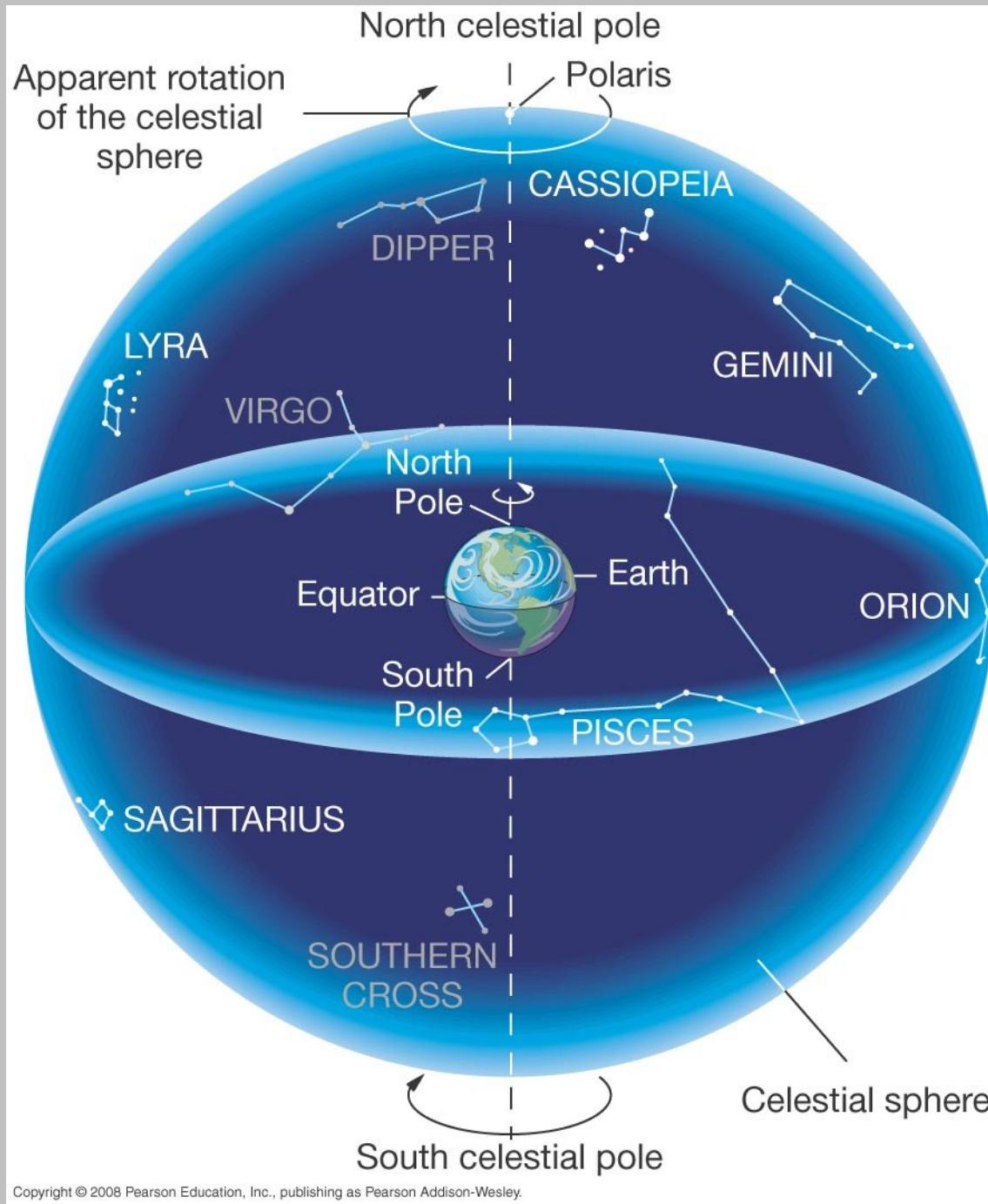
Try a planetarium program like “Stellarium” or “Skychart III” or “Celestia” to see the sky in motion.

The Celestial Sphere

- a conceptual model of the sky.
- geocentric (wrong)
- all stars at same distance (wrong)
- a distortion-free sky map
- reproduces daily rising and setting motions for any latitude on Earth
- Cel. Sphere is infinitely bigger than the Earth.



The Celestial Sphere

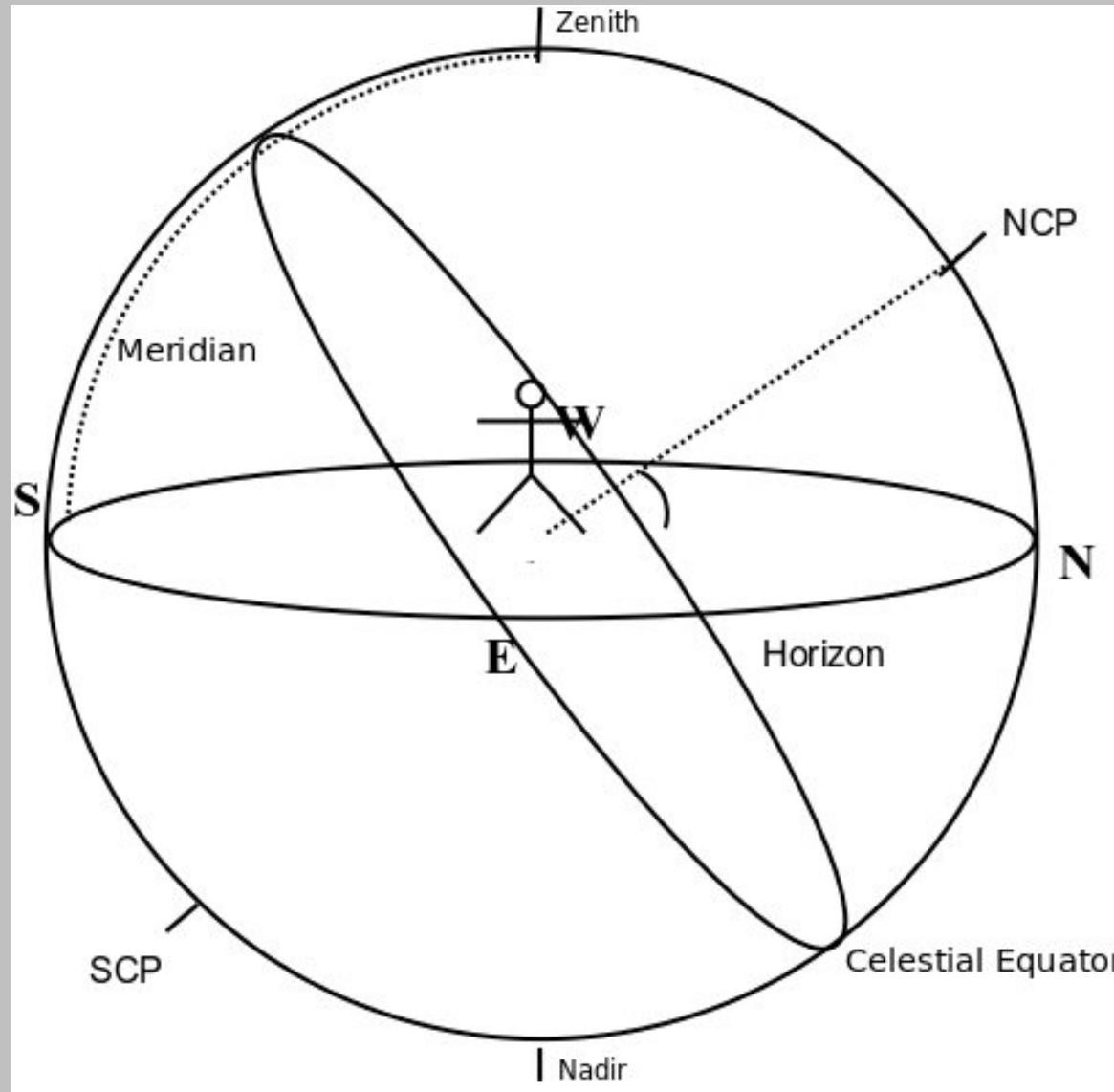


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Features:

1. stars
2. Earth/observer
3. N. Celestial Pole
4. S. Celestial Pole
5. Celestial Equator

The Celestial Sphere



More Features:

1. stars
2. Earth/observer
3. N. Celestial Pole
4. S. Celestial Pole
5. Celestial Equator
6. Horizon
7. Cardinal points, (N,S,E,W)
8. Zenith
9. Nadir
10. Meridian

See <http://astro.unl.edu/classaction/animations/coordsmotion/celestialhorizon.html> for animation that switches between horizon diagram view and celestial sphere view.

Coordinate Systems for the sky

Location-dependent marks on Cel. Sphere:

These marks move relative to the stars.

Horizon

Cardinal points (N,S,E,W)

Zenith

Nadir

Meridian

→ Altazimuth coordinate system uses these marks.

Location-independent marks on Cel. Sphere:

These marks are fixed relative to the stars (on a daily basis).

Celestial Equator

NCP and SCP

ecliptic, vernal equinox, autumnal equinox

→ Equatorial coordinate system uses these marks.

Coordinate Systems for the sky

Altazimuth coordinate system

Uses the horizon for it's zeropoints.

A star's coordinates are different for observers on different parts of Earth, i.e., location dependent.

Altitude = angle measured above (or below) the horizon in degrees.

Azimuth = angle measured along the horizon in degrees such that 0° azimuth is due North, 90° is due East, etc.

Ex) Polaris

Altitude = 40.75 degrees (our latitude)

Azimuth = 0 degrees (straight above N on horizon)

Coordinate Systems for the sky

Altazimuth coordinate system

- **Uses the horizon for its zeropoints.**
- A star's coordinates are different for observers on different parts of Earth
- **Altitude** = angle measured above (or below) the horizon in degrees.
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Ex) Polaris

Altitude = 40.75 degrees (our latitude)

Azimuth = 0 degrees (straight above N on horizon)

Equatorial (or Celestial) coordinate system

- **Uses the Celestial equator and ecliptic to define zeropoints.**
- A star's coordinates are the same for all observers!
- **Right Ascension**, RA = distance measured in hours, minutes and seconds along the celestial equator such that RA=0h at the vernal equinox and RA=6h at the Summer Solstice.
- **Declination**, DEC = Angle measured in degrees, arcminutes and arcseconds above the celestial equator such that DEC = 0° on the cel. equator, increasing to $+90^\circ$ at the NCP and -90° at the SCP.

Coordinate Systems for the sky

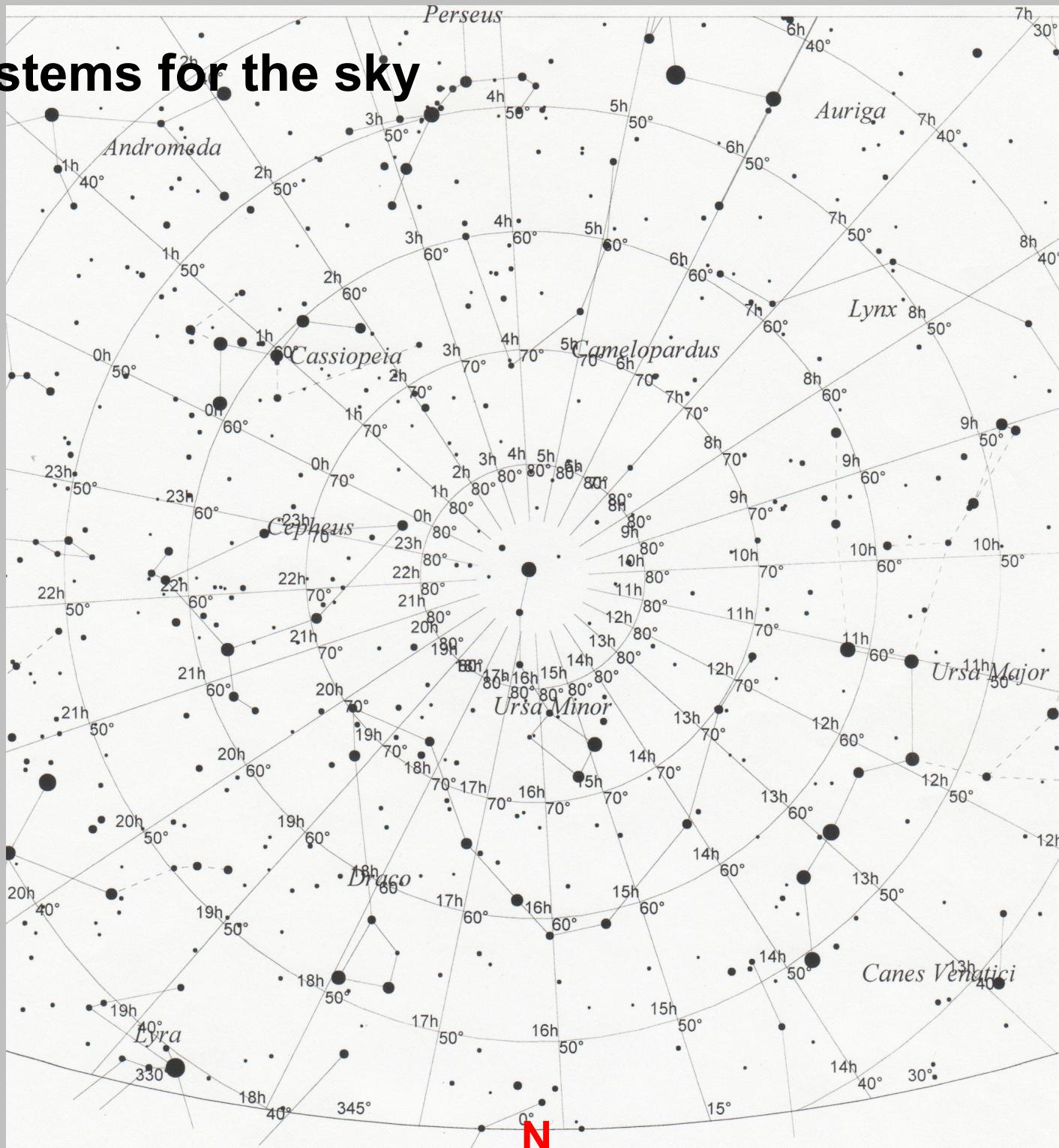
Example 1)

Equatorial:

Polaris at
Dec=90°
RA = ~2hr

Altazimuth:

Polaris has
Alt = 46°
Azim = 0°



Coordinate Systems for the sky

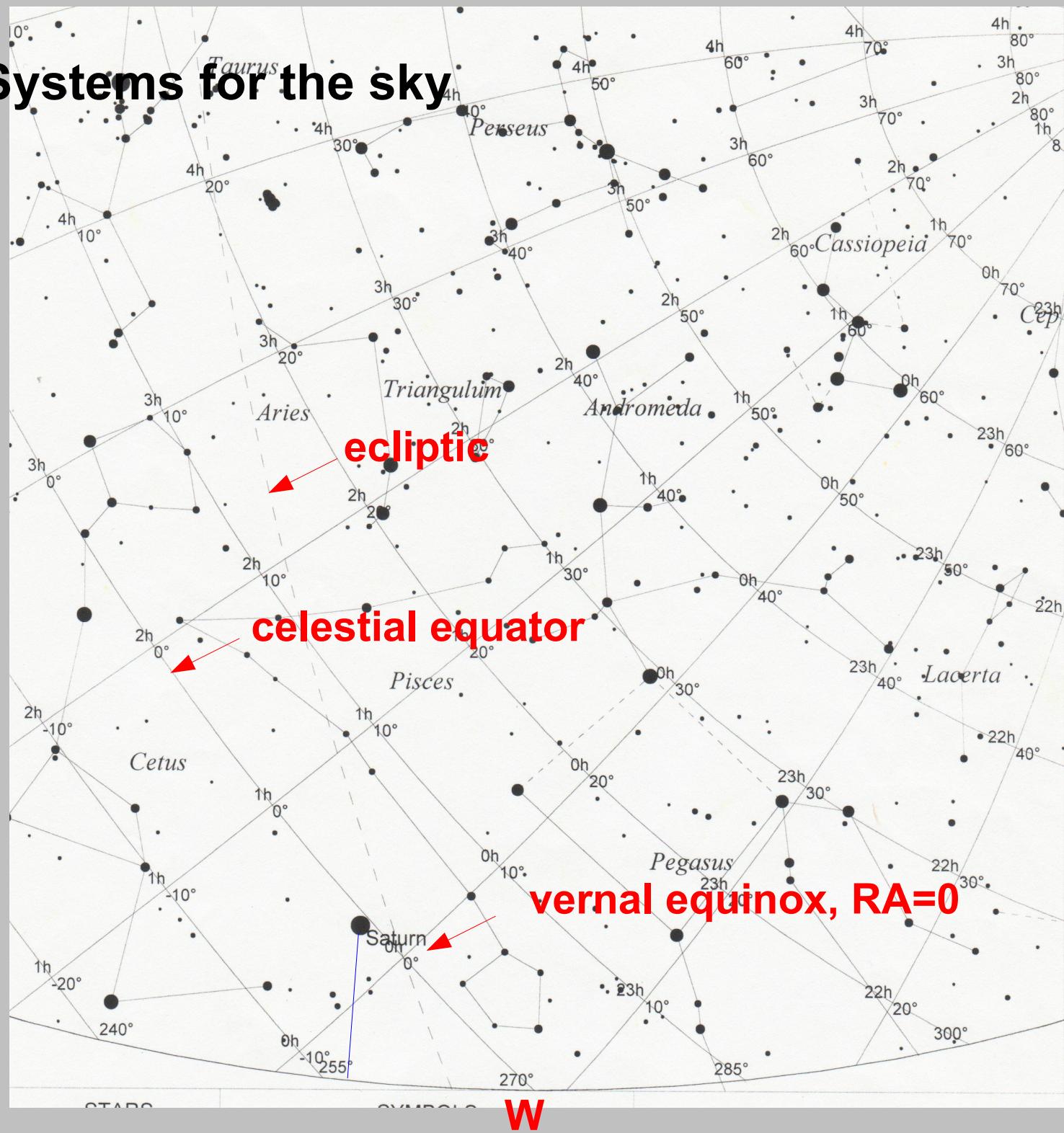
Example 2)

Equatorial:

Saturn has
Dec= -1°
RA = 0h 15m

Altazimuth:

Saturn has
Alt = 13°
Azim = 257°



Angles, distances and widths

Angles are measured in degrees, arcminutes, and arcseconds.

1 degree ($^{\circ}$) is $1/360$ of a complete rotation

1 arcminute ($'$) is $1/60$ of a degree

1 arcsecond ($''$) is $1/60$ of an arcminute

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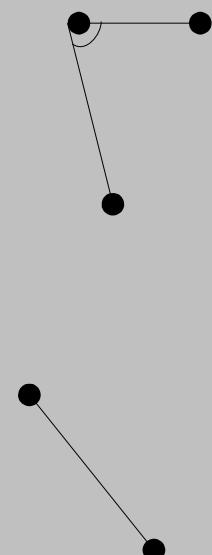
1 arcsecond ($''$) is 1/60 of an arcminute

Angles on the sky can be defined in two ways:

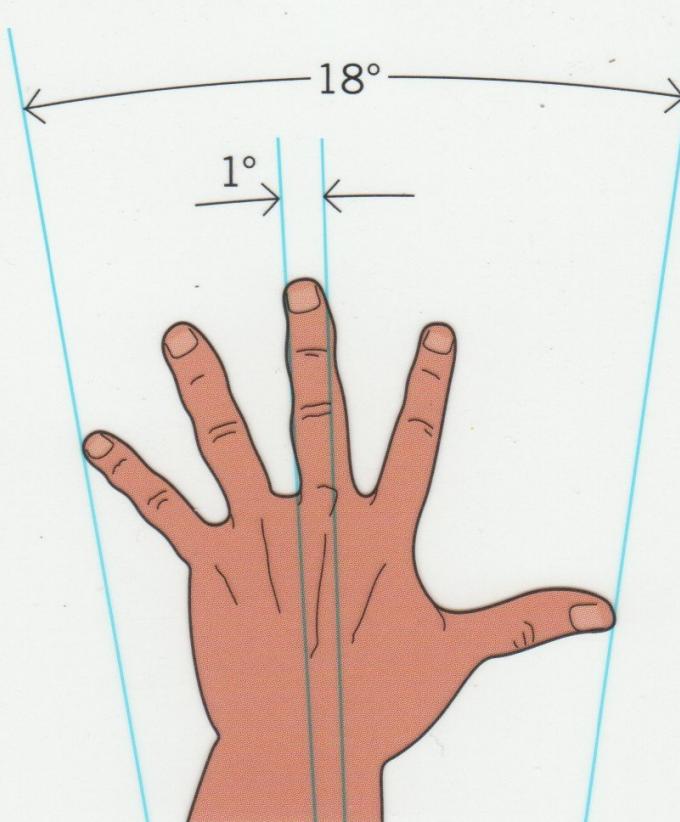
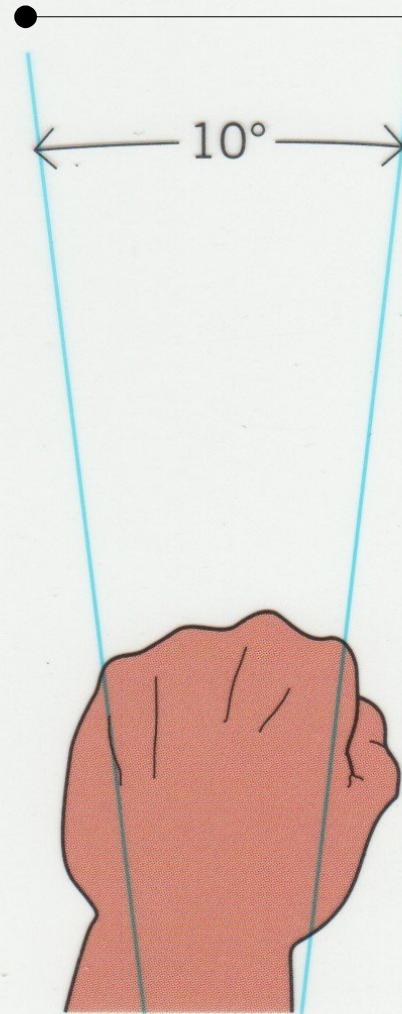
1) Think of the sky as a flat paper with lines connecting one star to two others. An angle can be drawn between those two lines where they intersect.

2) As angular separations between two stars, such as you would estimate using your fist at arm's length.

Mostly we use #2.



Angles, distances and widths



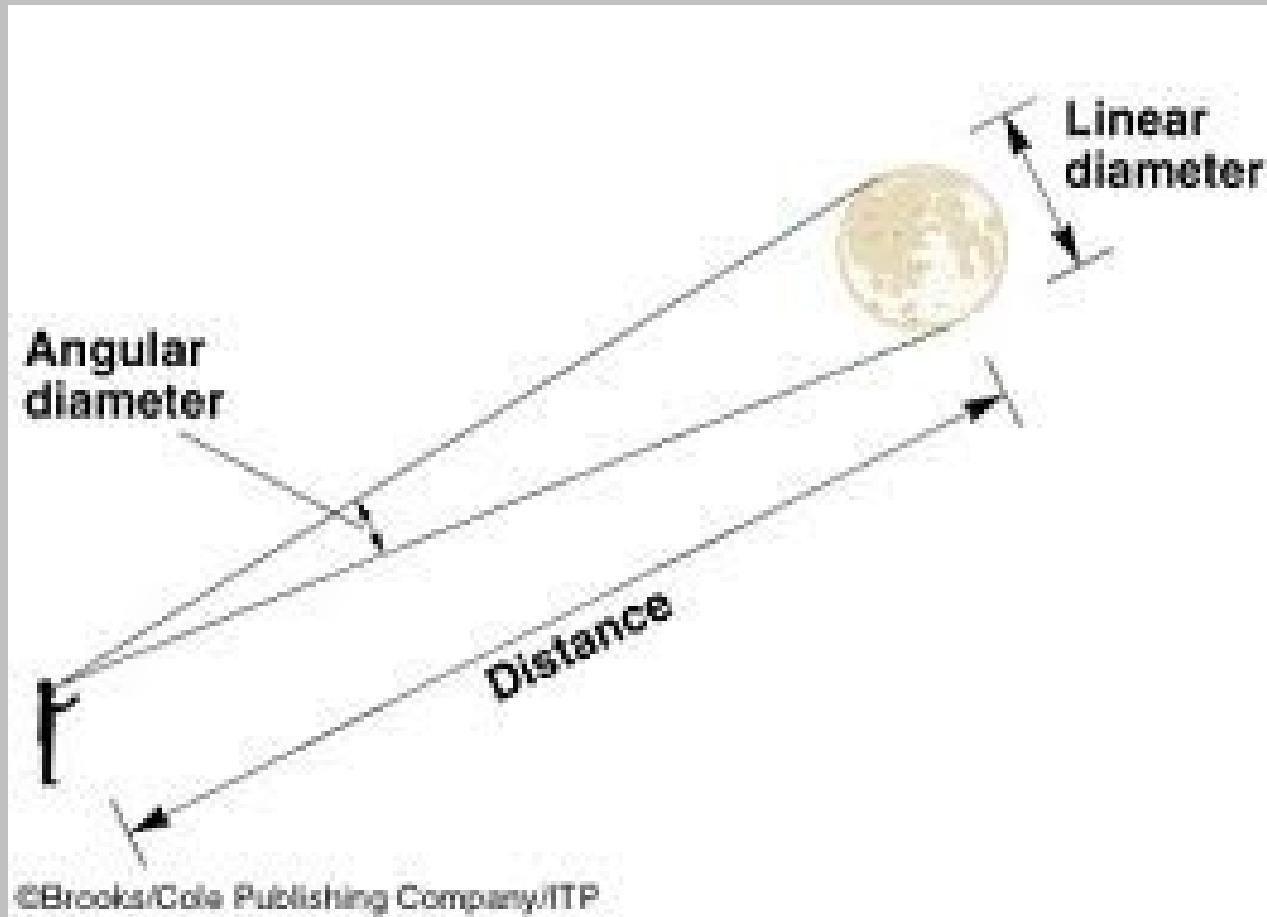
Angles, distances and widths

Calibrate using the Big Dipper!



Angles, distances and widths

Relationship between linear diameter and angular diameter

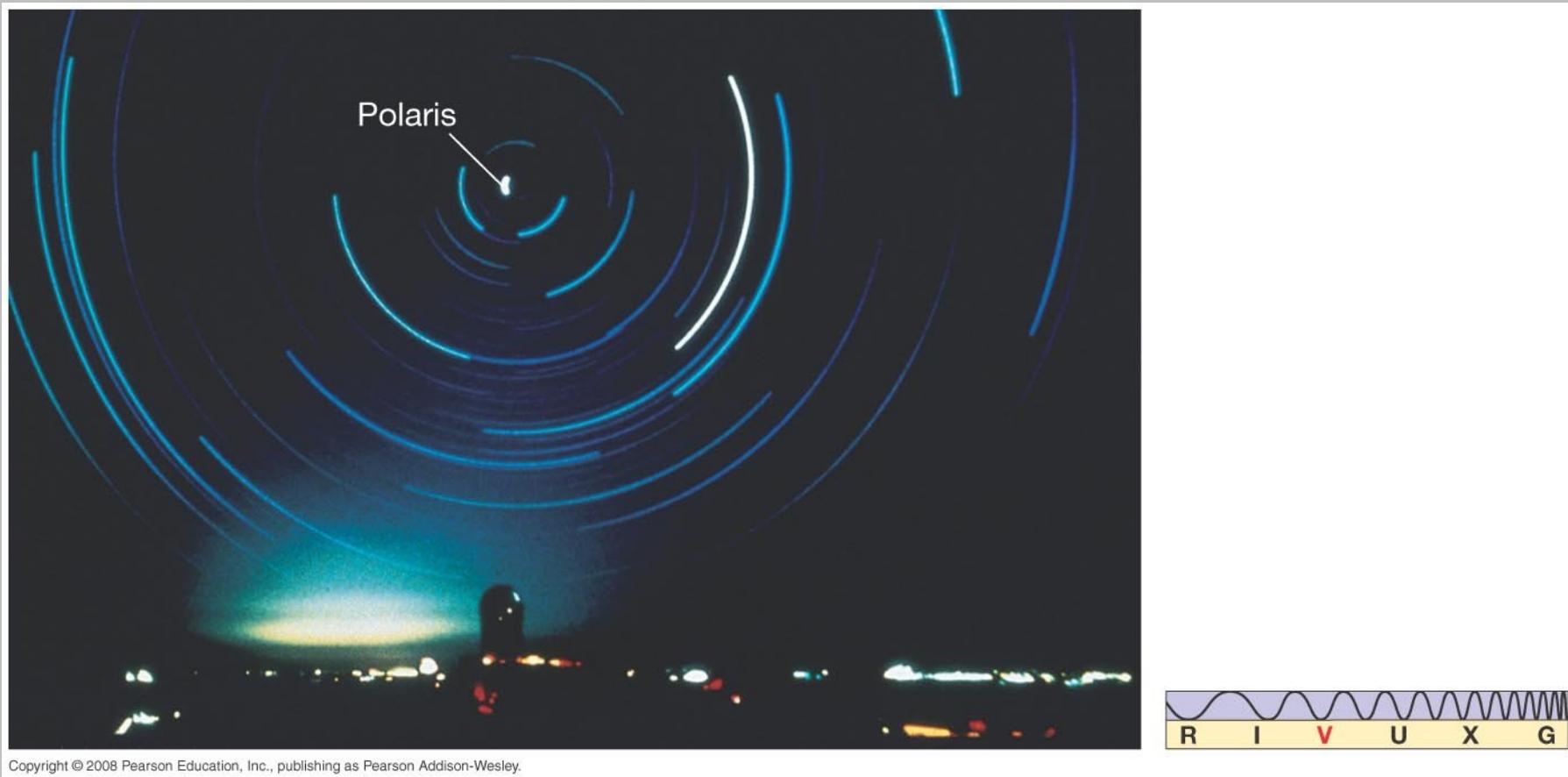


$$AD(\text{radians}) = LD/D$$

$$AD(\text{degrees}) = (57.3)LD/D$$

Motion of the Earth - Daily

Star Trail – an actual photo of Northern horizon. Exposure time was about 5 hours.



Now show the daily rotation with a Celestial Globe, and with
<http://astro.unl.edu/classaction/animations/coordsmotion/celhorcomp.html>

Motion of the Earth – Daily

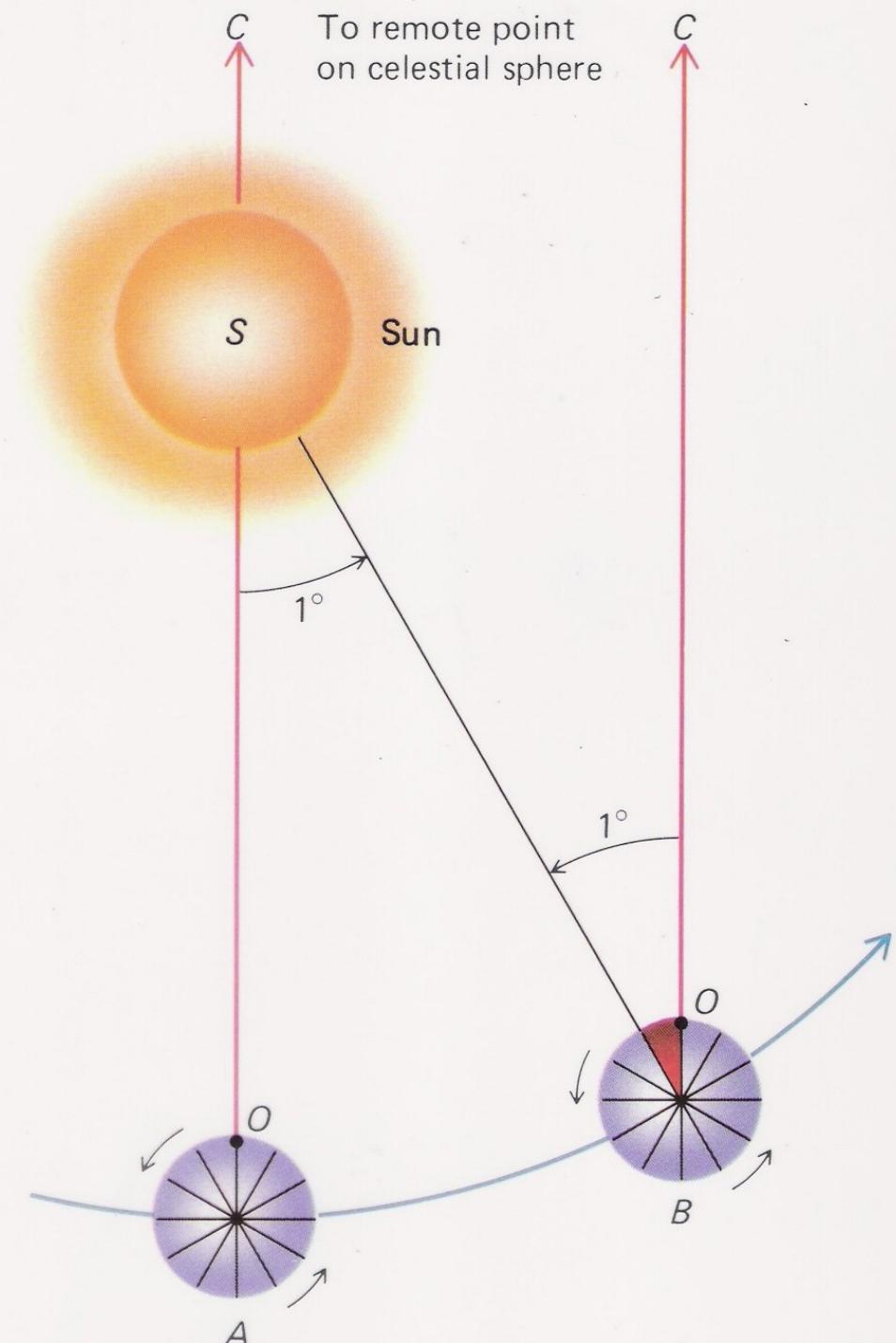
The Day

Sidereal Day: the time that it takes for the Earth to rotate 360 degrees relative to the distant stars

Mean Solar Day: the average time that it takes for the Earth to rotate relative to the Sun. (E.g., from one noon to the next.)

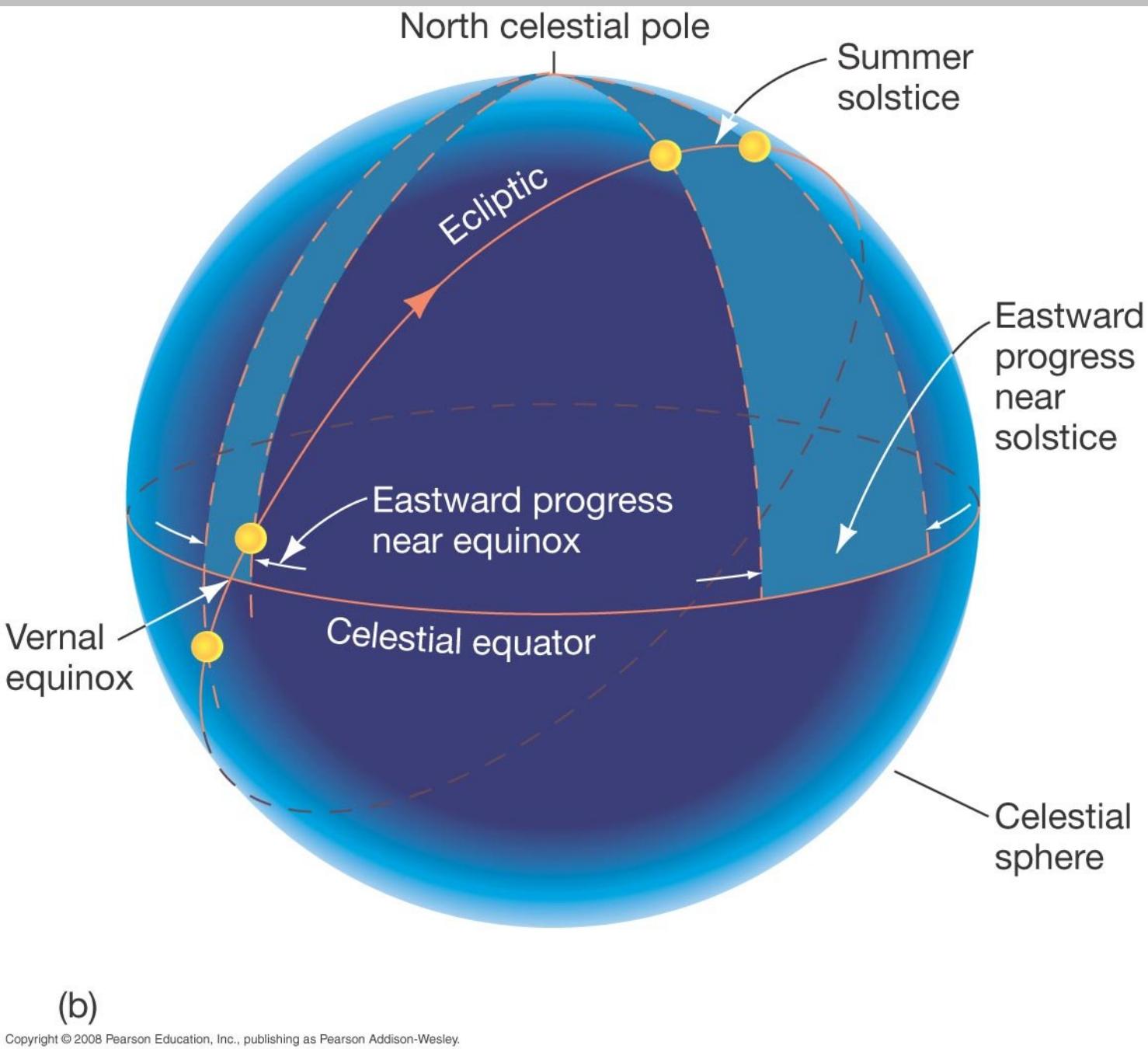
- * What your watch tells you
- * 3 m 56 s longer than the sidereal day
- * “Mean” because the time between local noons varies.
 - Obliquity (tilt) of ecliptic
 - Elliptical orbit

<http://astro.unl.edu/classaction/animations/coordsmotion/siderealSolarTime.html>



Motion of the Earth - Yearly

Since the ecliptic is tilted the rate of the Sun's apparent motion *Eastward* relative to the stars changes. It is fast during the solstices and slow during the equinoxes.

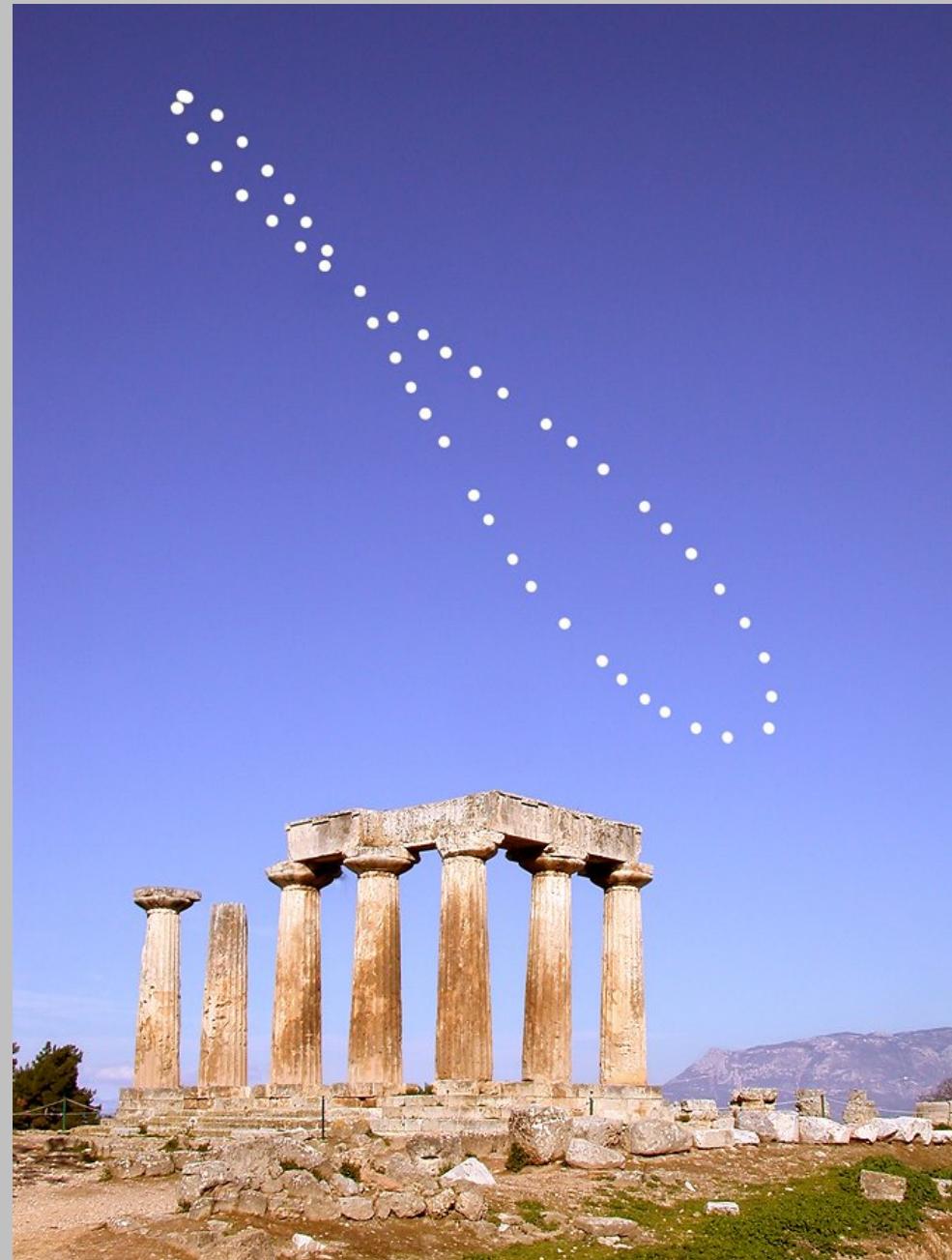


Motion of the Earth – Daily

Here's what you get when you take a picture of the Sun at the same time (standard time) once every couple of weeks for a year.

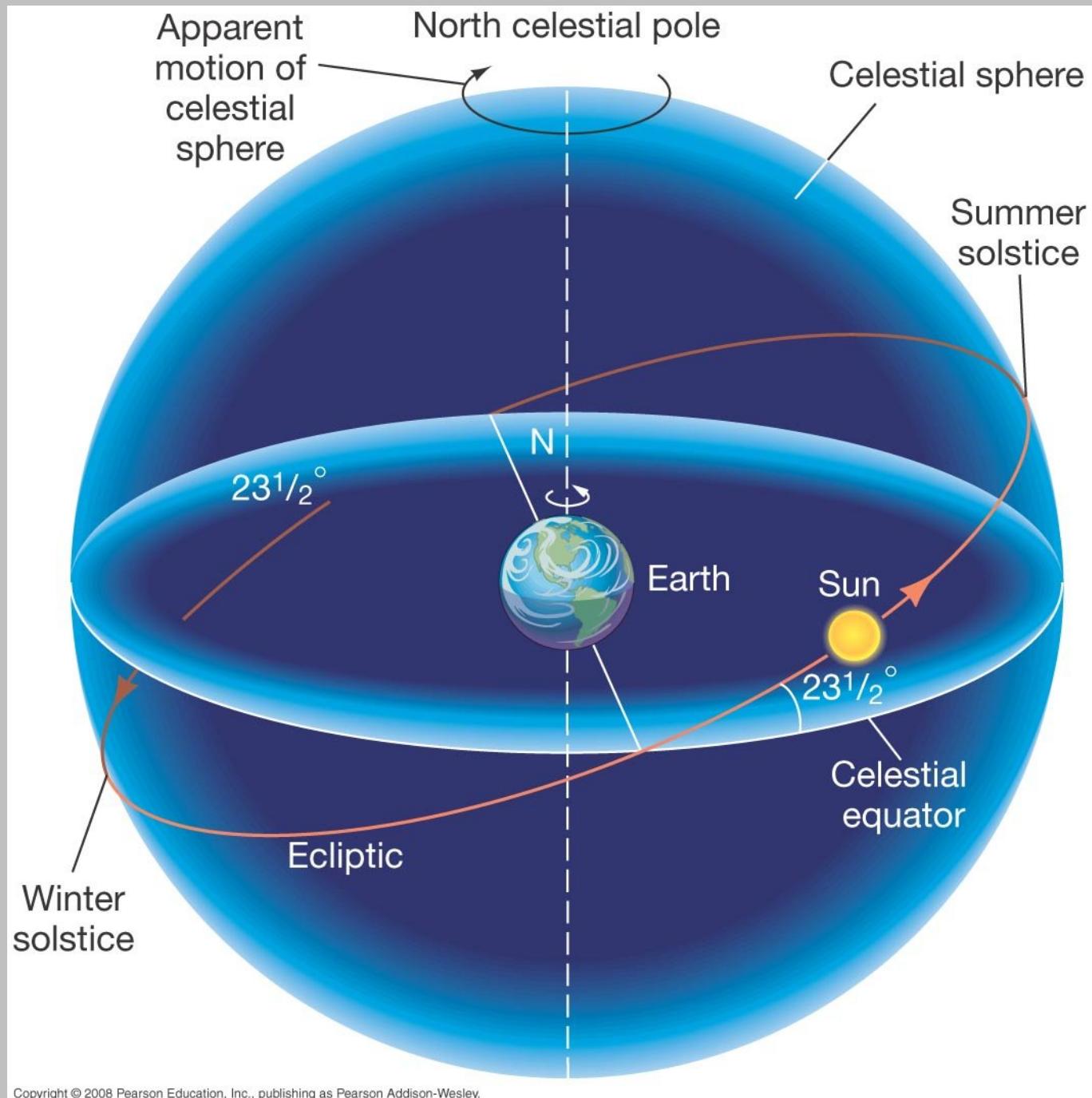
The ***analemma*** is asymmetric because the Earth's orbit is an ellipse.

The summer solstice is a little before aphelion (when we are farthest from Sun). The winter solstice is a little before perihelion (Jan 4, when we are closest to the Sun.)



Motion of the Earth - Annual

The Sun appears to go around the Earth once per year, but it is the Earth that goes around the Sun.



Motion of the Earth – Annual

The Year

Sidereal year: the time it takes for the Earth to revolve around the Sun with respect to the stars.

* 365.2564 mean solar days

Tropical Year = time between two successive passages of the Sun past the *Vernal Equinox*

* 365.2422 days

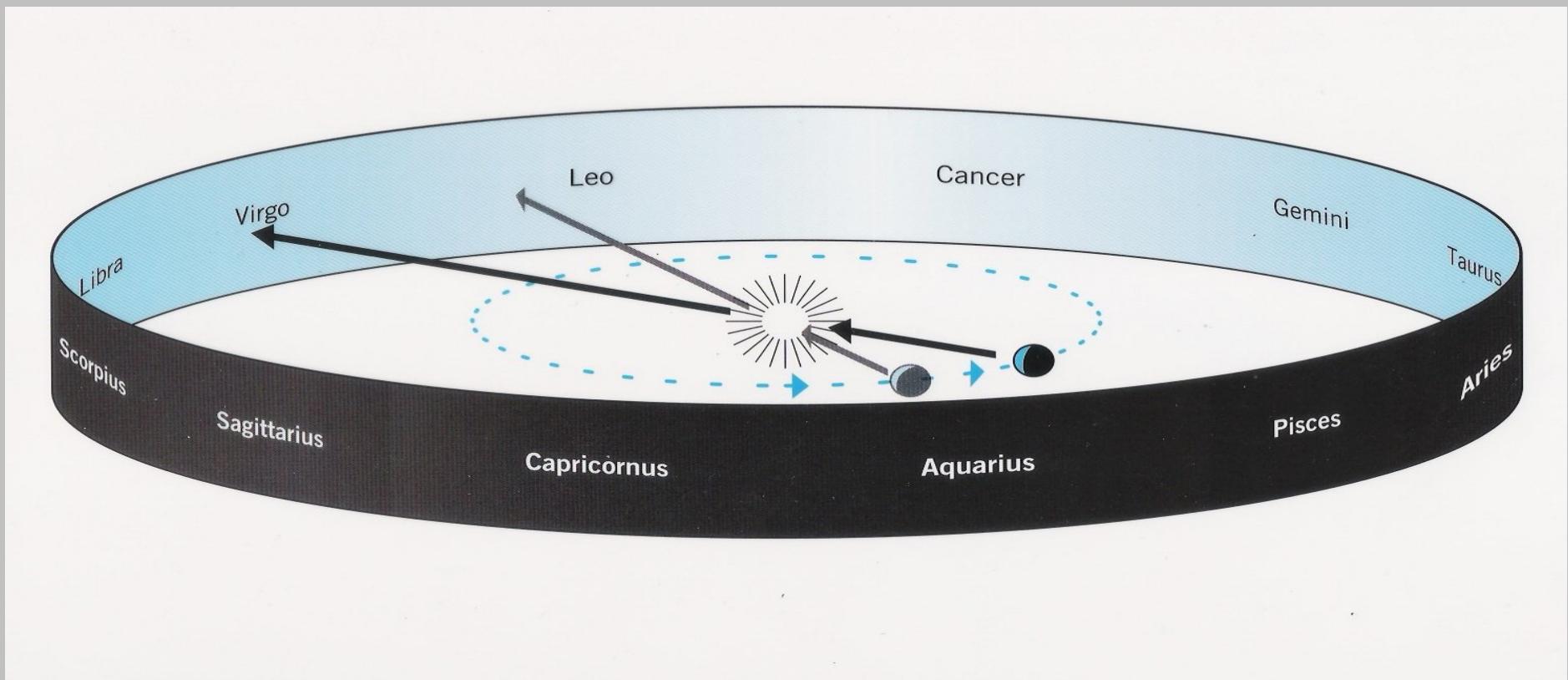
Q: Why is the tropical year shorter than the sidereal year?

A: Precession

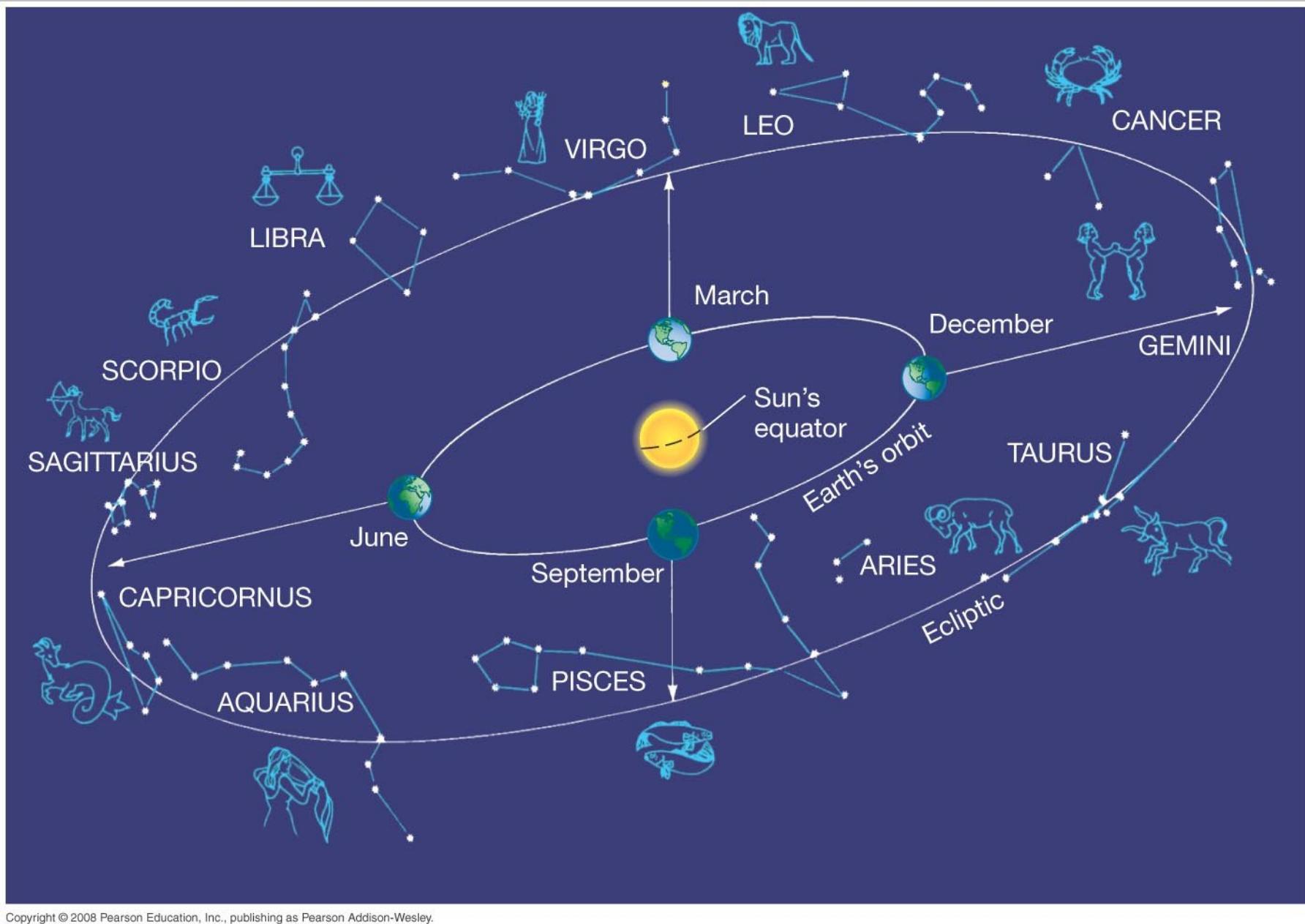
Motion of the Earth – Annual

The Zodiac = the 12 (or 13 counting Ophiuchus) constellations through which the Sun passes in a year.

Ecliptic = The apparent path of the Sun on the sky as seen from Earth.



Motion of the Earth - Annual

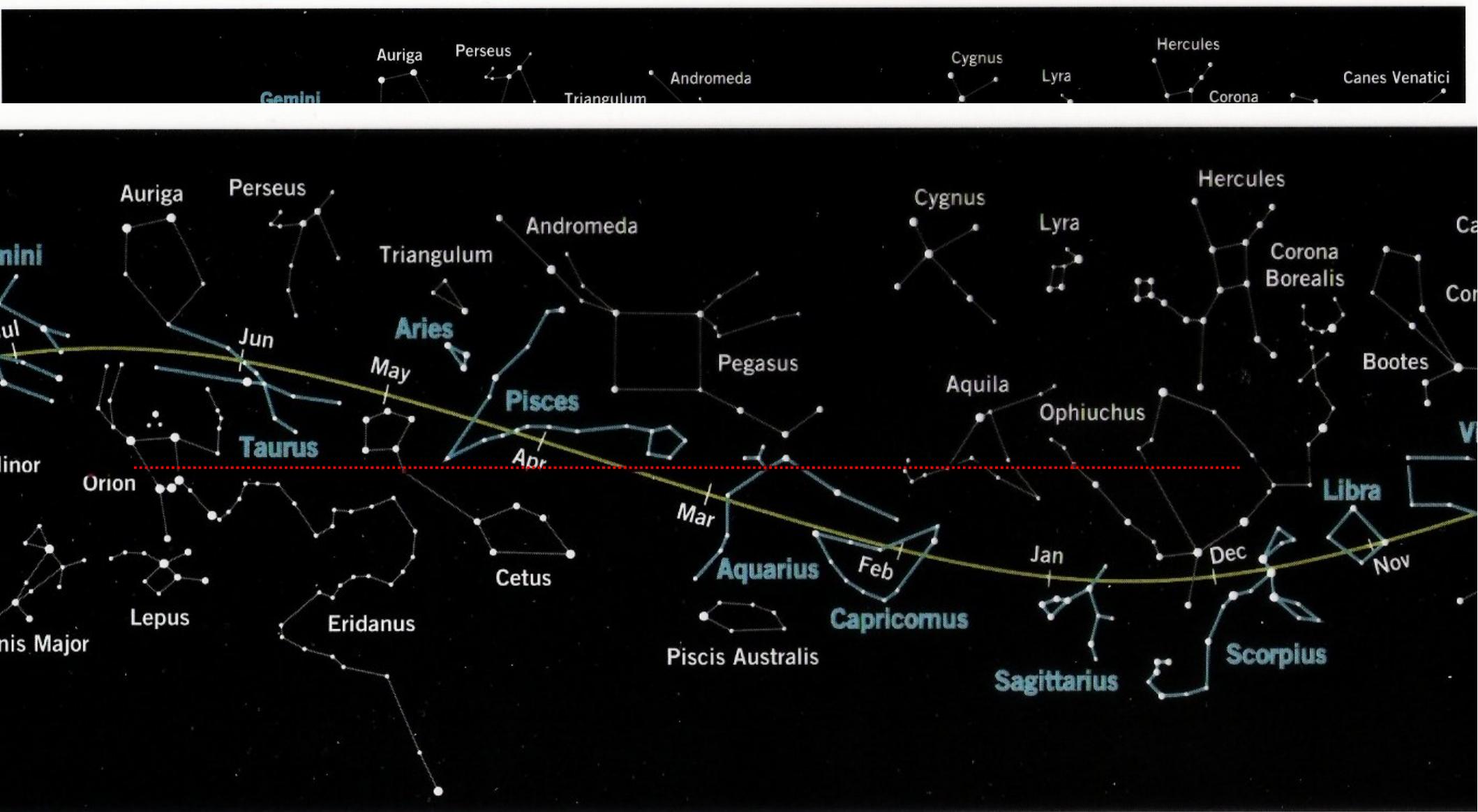


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The Zodiacal Constellations

Motion of the Earth – Annual

Ecliptic = The apparent path of the Sun on the sky as seen from Earth.



Motion of the Earth and Seasons

Seasons: an oscillation of average temperature with a period of 1 tropical year.

There are two main reasons for the seasons:

1. The Earth's axial tilt causes seasonal changes.
2. The Earth's orbit around the Sun.

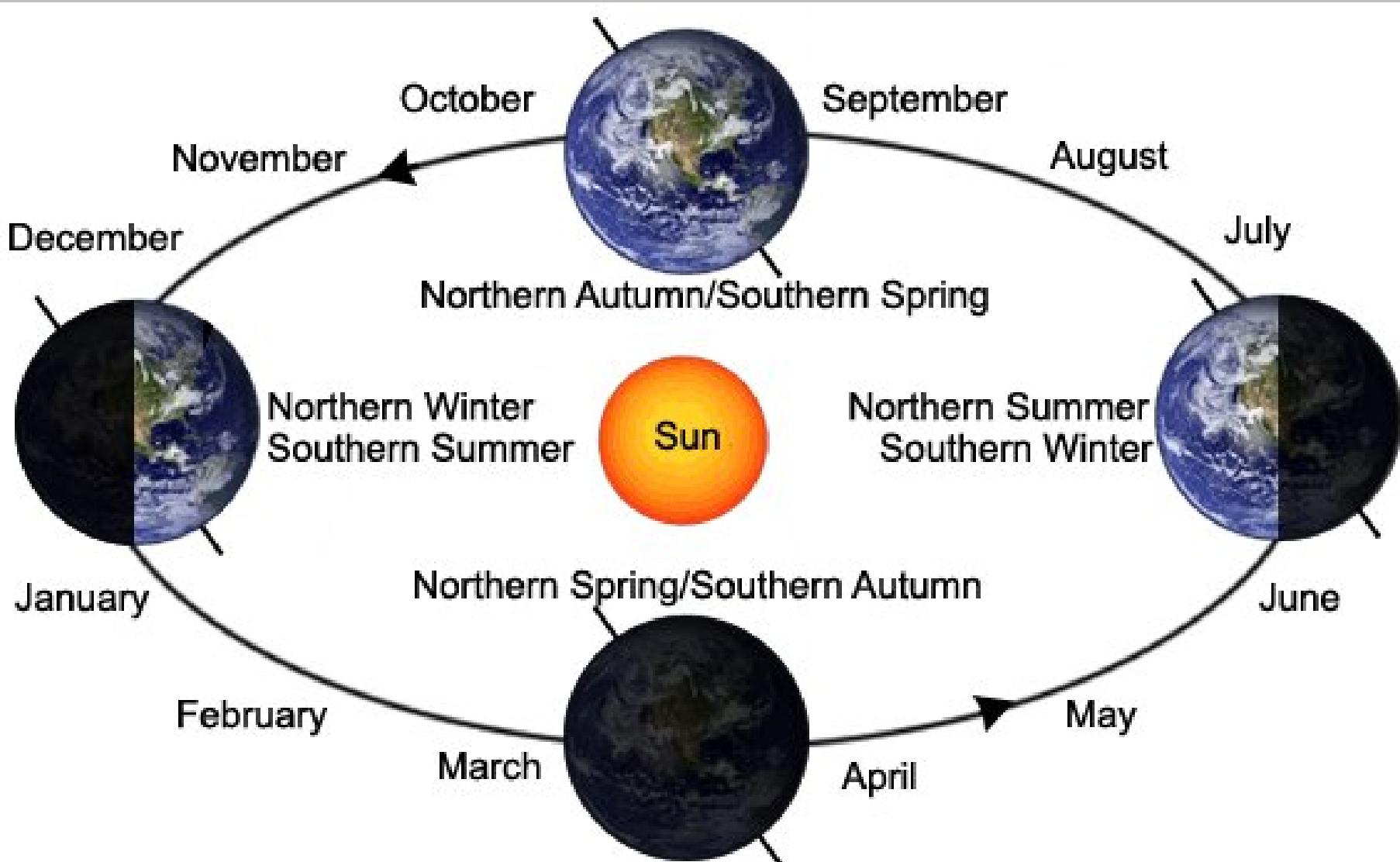
Astronomy

- * Spring (March 21)
- * Summer (June 21)
- * Fall (September 21)
- * Winter (December 21)

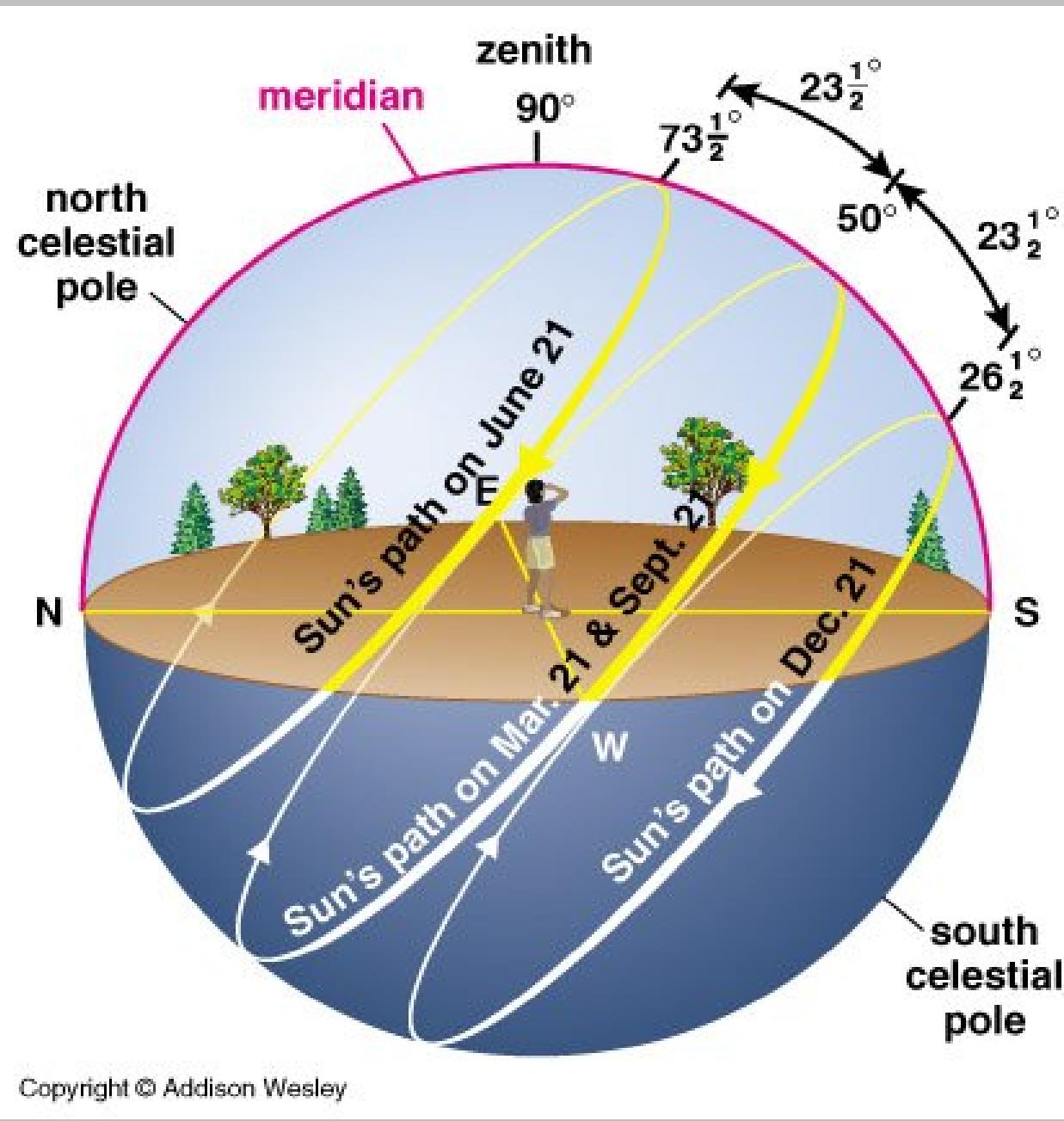


Motion of the Earth and Seasons

Seasons: an oscillation of average temperature with a period of 1 tropical year.



Motion of the Earth and Seasons



See: <http://astro.unl.edu/classaction/animations/coordsmotion/sunmotions.html>

Precession of the Equinoxes

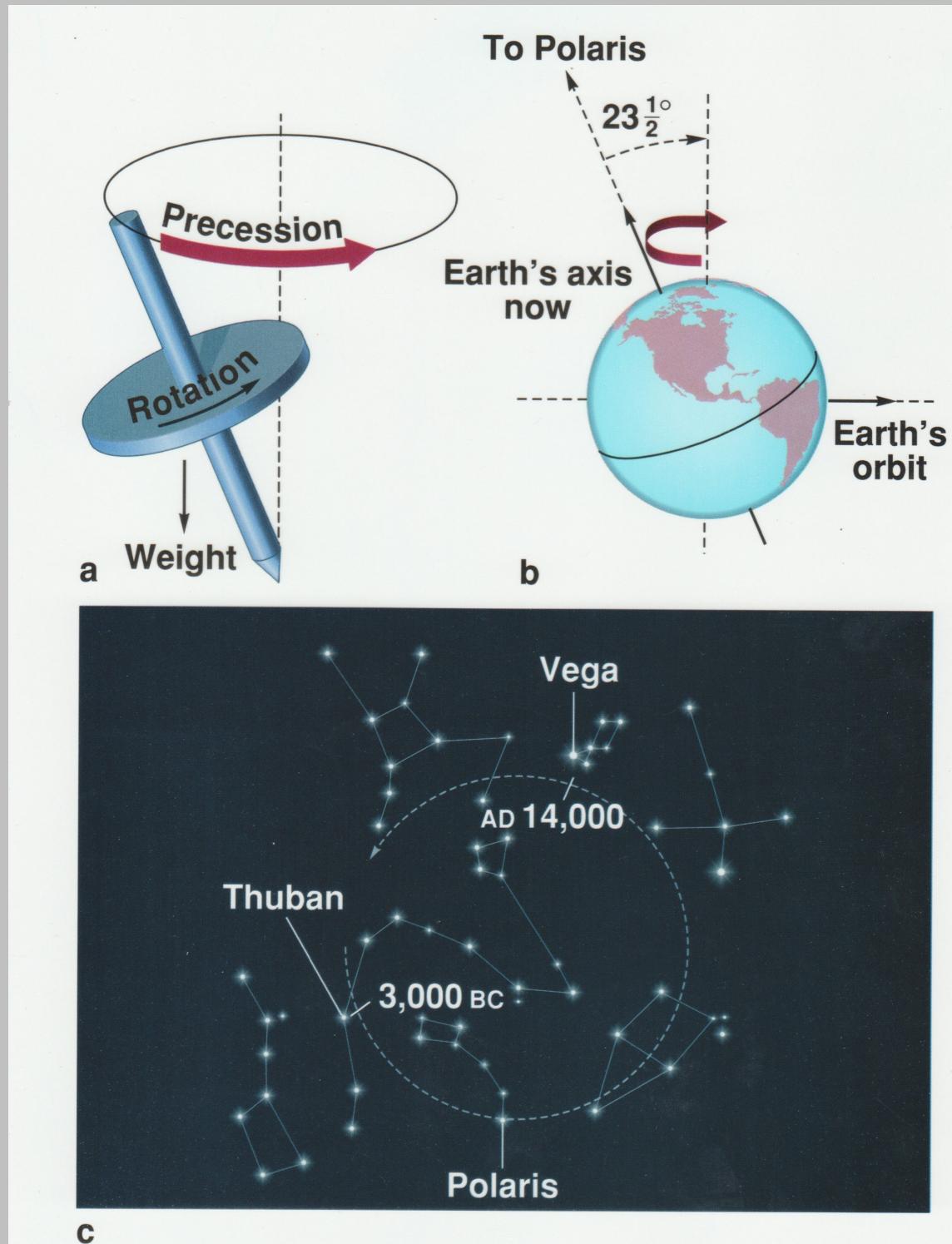
The reason for the tropical year being shorter than the sidereal year.

The Earth's spin axis is “wobbling”.

- 26,000 year period
- Tilt remains 23.5 degrees
- Seasons remain the same severity

Precession

Gradual change of the NCP position.
Polestar was not always Polaris!

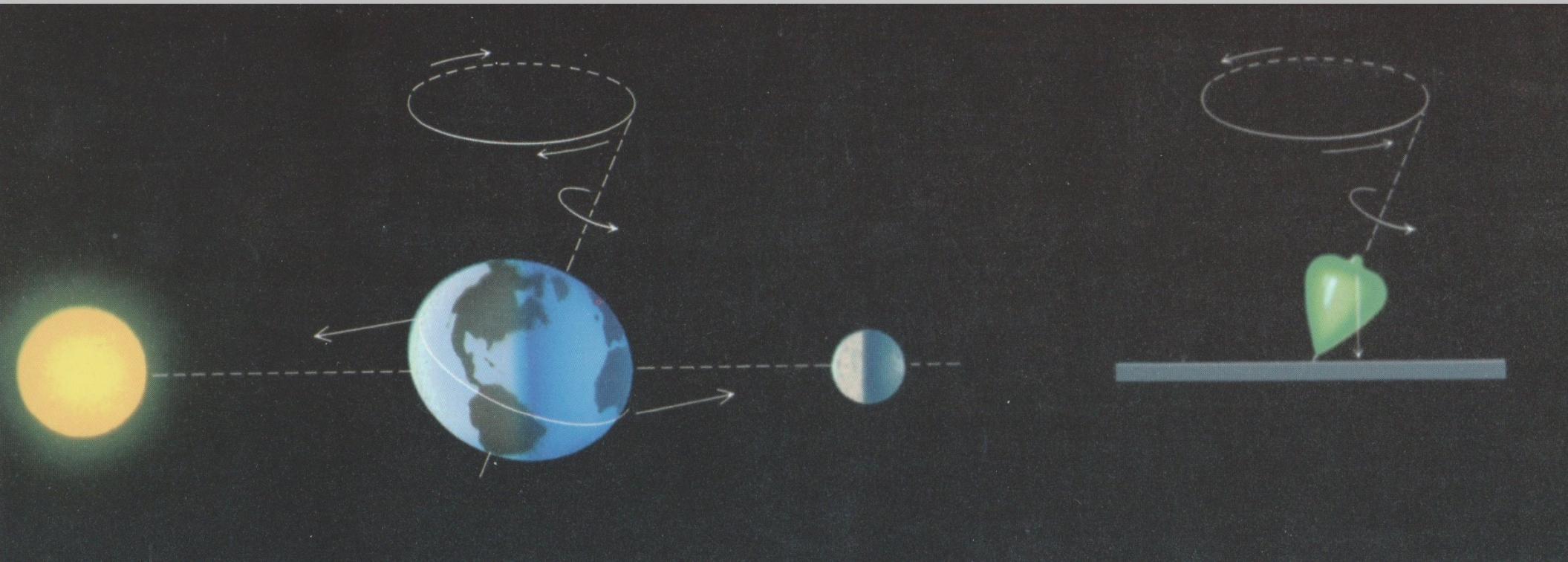


Precession



Precession

Cause: the pull of the Moon and Sun on Earth's equatorial bulge exerts a Torque.



**Left: gravity from S and M are trying to tip the spin axis UPRIGHT.
Pole precesses CW seen from above.**

**Right: gravity is trying to tip the spin axis OVER.
Pole precesses CCW seen from above.**

Precession (of the Equinoxes)

Consequences

- 1) The NCP is changing position rel to stars
- 2) The equatorial coordinates (RA and DEC) of stars slowly change with time. → We need to specify “Epoch” of coordinates.