



1,000 kilometers (106 m)
m)



1,000 kilometers (106 m)
m)





**10 kilometers (104 m)
m)**



**100 meters (102 m)
m)**

How old is the Universe?

The Cosmic Calendar

- if the entire age of the Universe were one calendar year
- one month would be approximately 1 billion real years

Jan. 1
The Big Bang

Feb.
The Milky Way forms.

Sept. 3
Earth forms.

Sept. 22
Earliest evidence of life on Earth

59 seconds:
Kepler and Galileo prove Earth orbits the Sun.

49 seconds:
Pyramids are built.

35 seconds:
Agriculture arises.

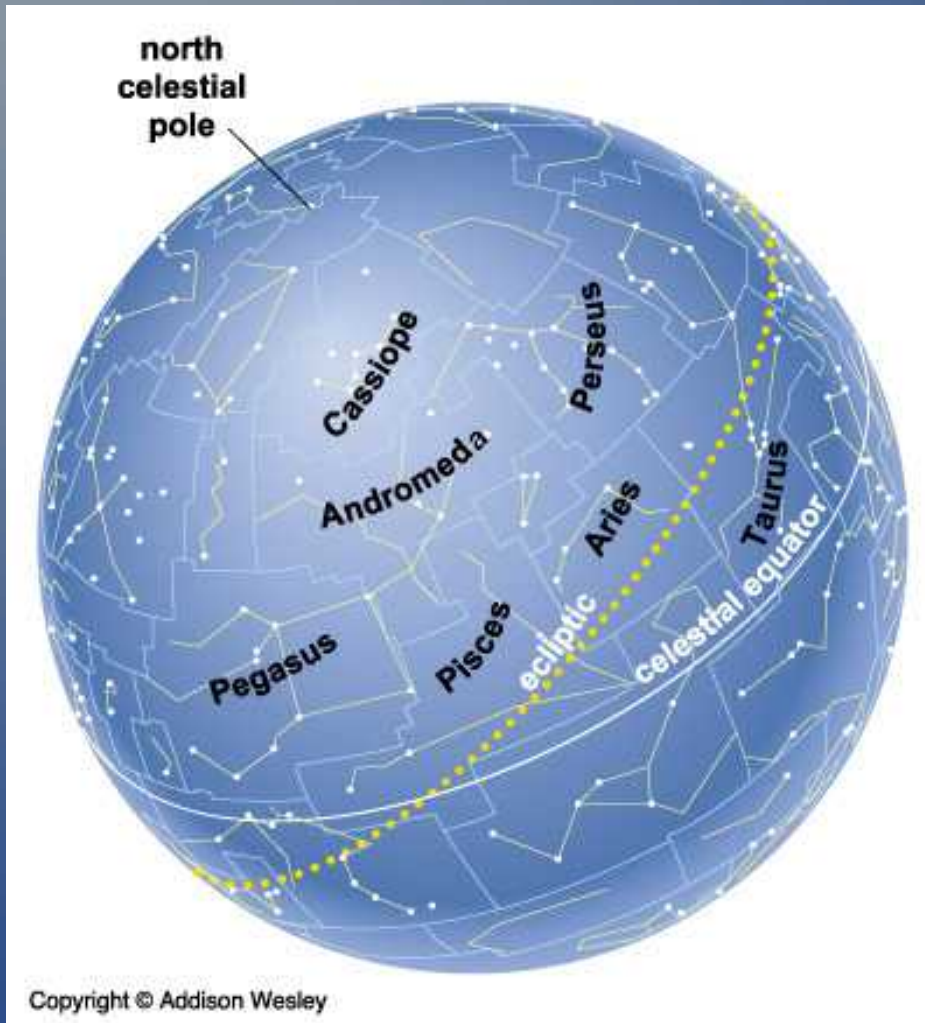
DECEMBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17 Crucifixion	18	19	20	21
22	23	24	25	26 Rise of the dinosaurs	27	28
29	30 Dinosaur extinct	31				

DECEMBER 31

Morning...
12:00 pm
1:00 pm
2:00 pm
3:00 pm
4:00 pm
5:00 pm
6:00 pm
7:00 pm
8:00 pm
9:00 pm Early humans
10:00 pm
11:00 pm
11:56 pm Modern humans evolve.
11:59 pm
12:00 am

The Celestial Sphere



- The sky above looks like a dome...a hemisphere..
- If we imagine the sky around the entire Earth, we have the **celestial sphere**.
- This 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

North & South celestial poles

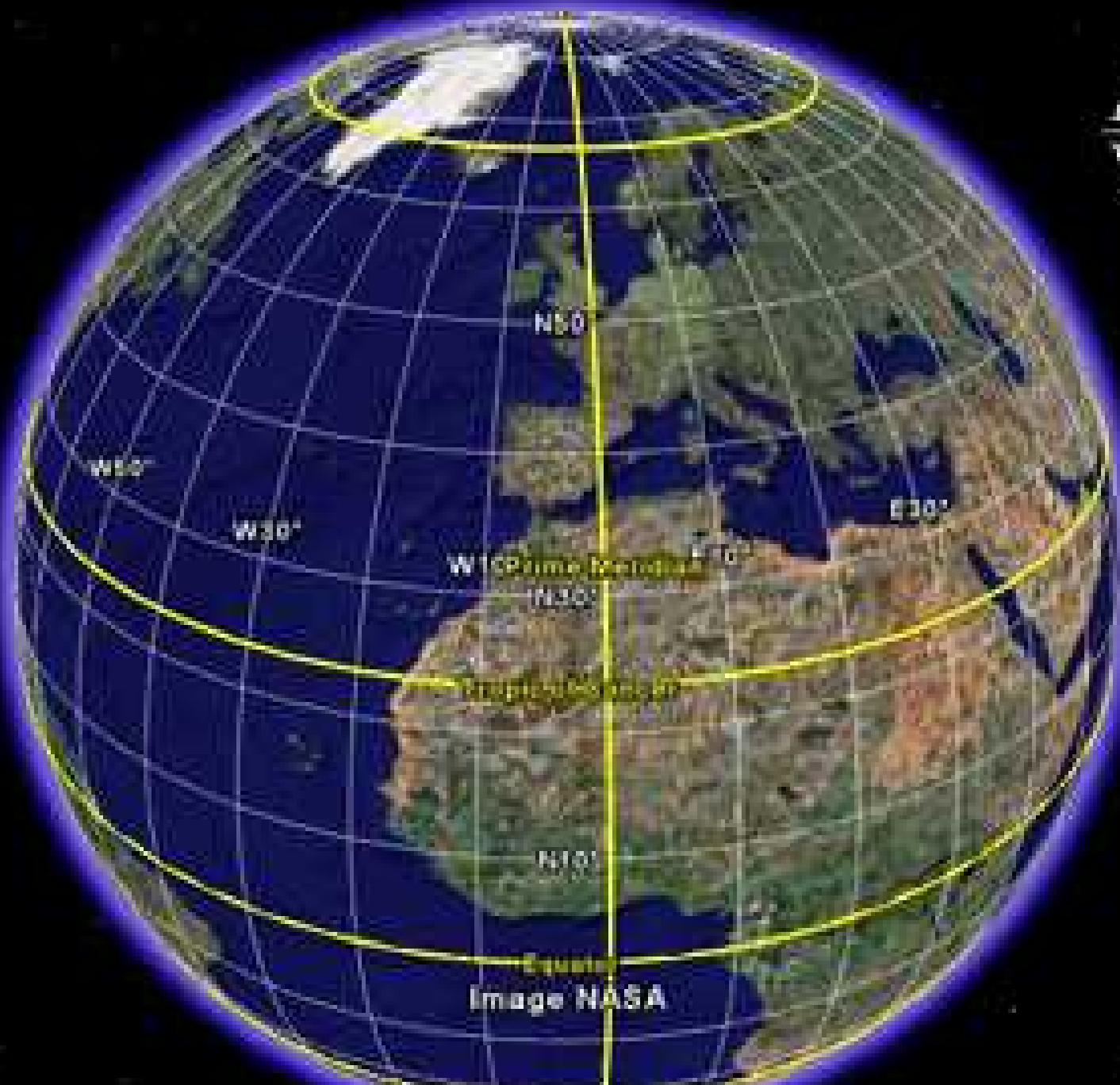
the points in the sky directly above the Earth's North and South poles

celestial equator

the extension of the Earth's equator onto the celestial sphere

ecliptic

the annual path of the Sun through the celestial sphere, which is a projection of ecliptic plane



N50

W50

W30

W10 Prime Meridian

N30

E30

Tropic of Capricorn

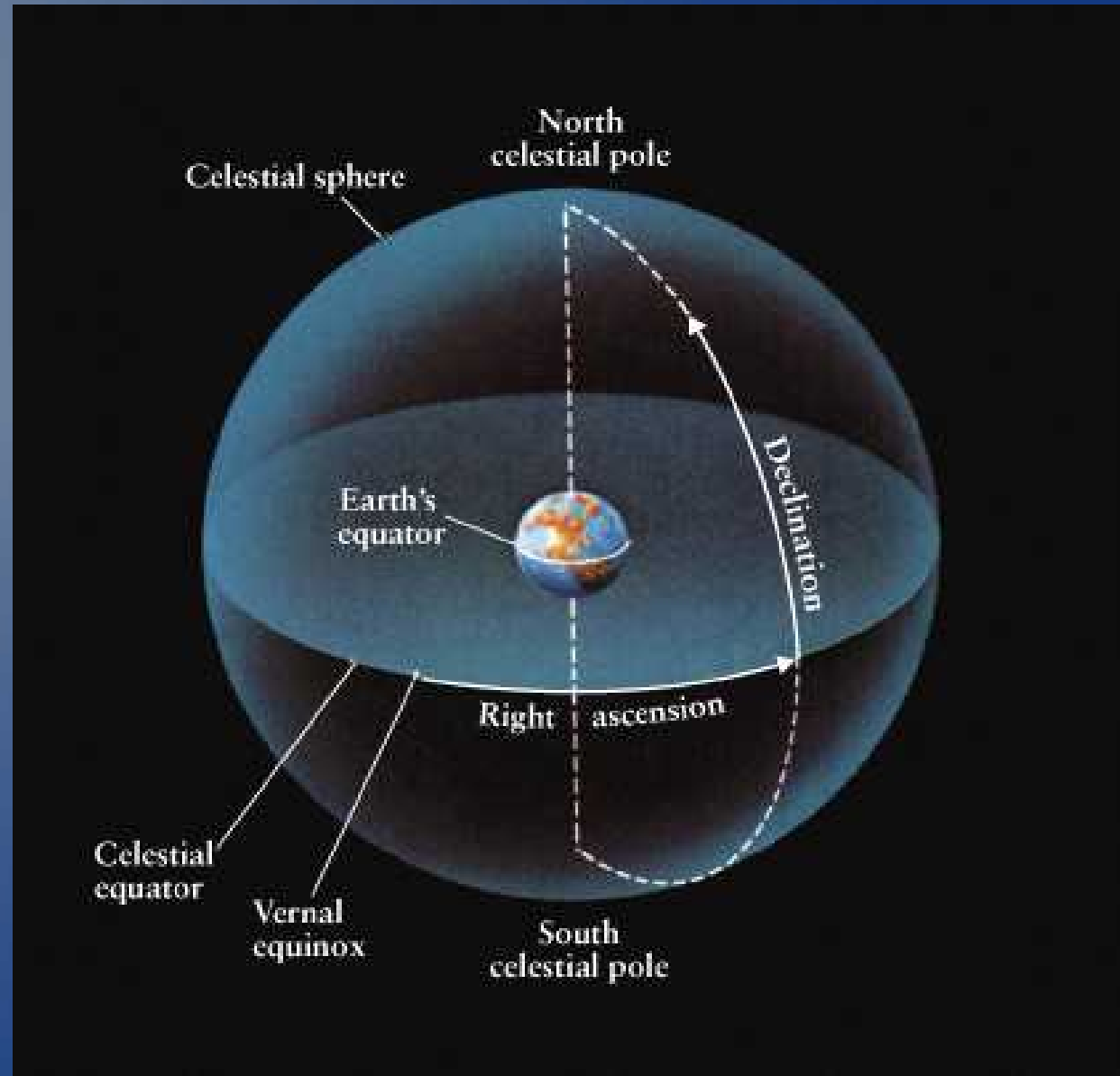
N10

Equator

Image NASA

A spinning
imaginary
*Celestial
Sphere*

surrounding
Earth aids in
navigating
the sky



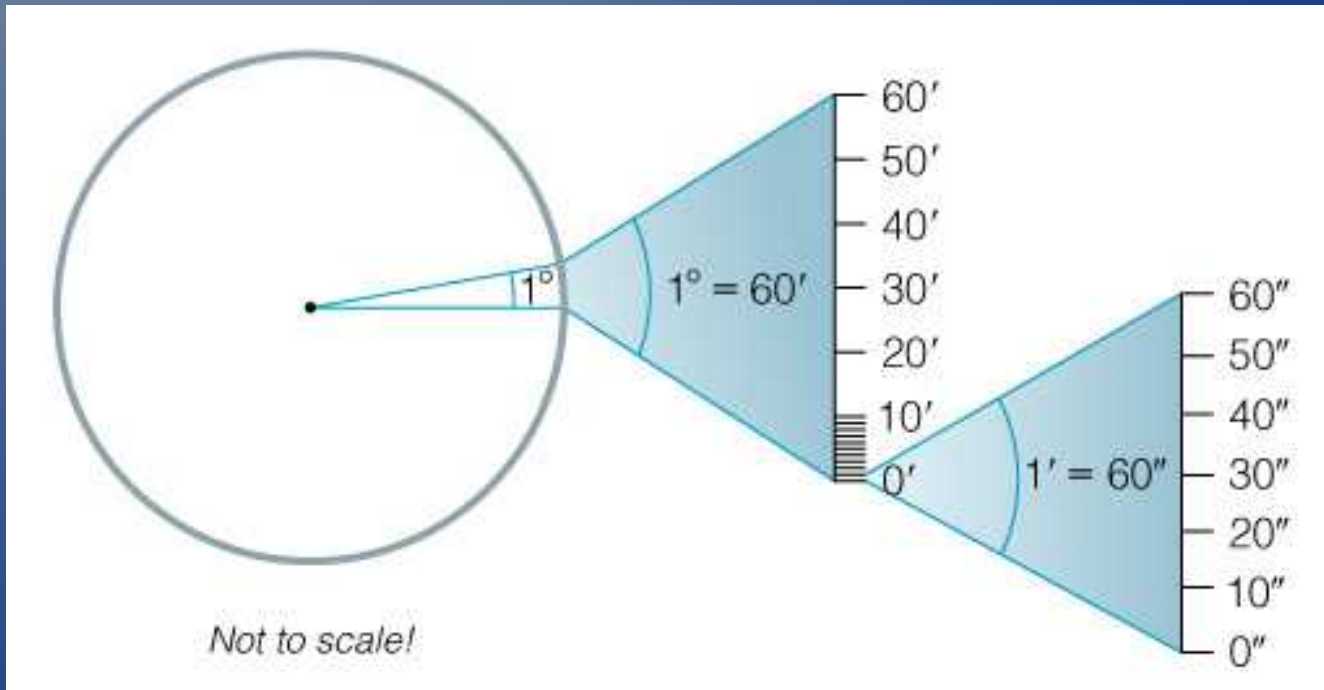
Measuring the Sky

We measure the sky in *angles*, not distances.

- Full circle = 360°
- $1^\circ = 60$ arcmin
- 1 arcmin = 60 arcsec

Angular Measurements and Notation:

- Full circle = 360°
- $1^\circ = 60$ (arcminutes)
- $1' = 60$ (arcseconds)



What is 55.435 degrees in degrees-
minutes-seconds notation?

55 deg

0.435(60) 26.1 *arcmin* 26 *arcmin*

0.1(60) 6 *arcsec*

so, 55°26'06"

What is 73°45'33.56 in decimal degrees?

73 deg

45/60 .75

33.56/3600 0.009322

73.759322

Problem

- 45.635 degrees is how many degrees, arcminutes, and arcseconds?
- How many degrees, arcminutes, and arcseconds does the moon move across the sky in one hour? (the lunar day is 24 hours and 48 minutes long)
- The moons diameter is about 30 arcminutes, so find out how long it takes for the moon to travel its diameter.

Answer

- 45.635 degrees is how many degrees, arcminutes, and arcseconds?

45 deg

$$0.635(60) \quad 38.1 \text{ arcmin} \quad 38 \text{ arcmin}$$

$$0.1(60) \quad 6 \text{ arcsec}$$

- How many degrees, arcminutes, and arcseconds does the moon move across the sky in one hour? (the lunar day is 24 hours and 48 minutes long)

24 hours 48 minutes = 24.8 hours

The moon moves 360 degrees during that time so :

$$\frac{360 \text{ deg}}{24.8 \text{ hours}} \quad 14.516129 \text{ deg/ hour} \quad 14^{\circ} 30' 58.06''$$

- The moons diameter is about 30 arcminutes, so find out how long it takes for the moon to travel its diameter

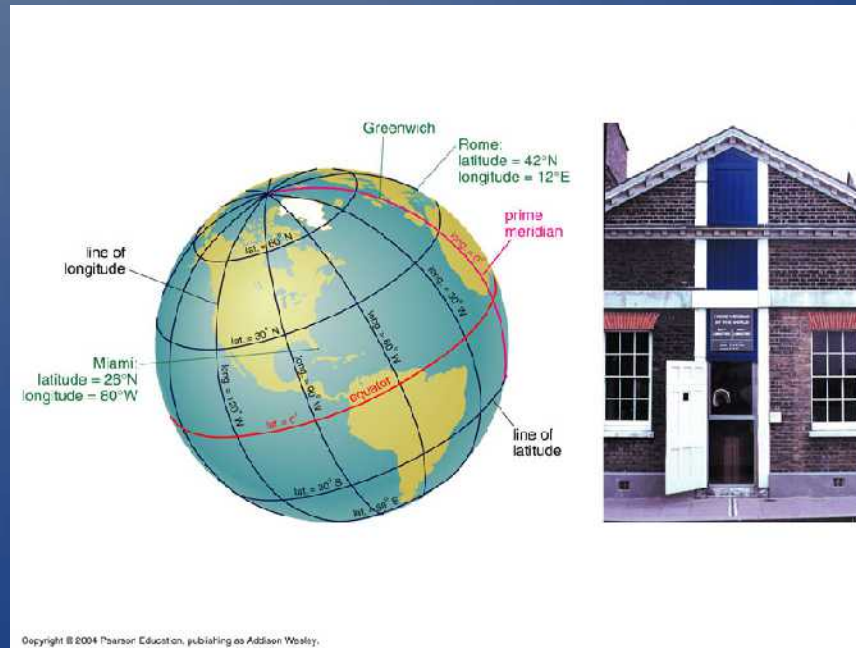
0.5 deg

$$\frac{0.5 \text{ deg}}{14.516129 \text{ deg/ hour}} \quad 0.034 \text{ hour}$$

$$(0.034 \text{ hour}) \quad (60 \text{ minutes/hour}) \quad 2.1 \text{ minutes} \quad 26$$

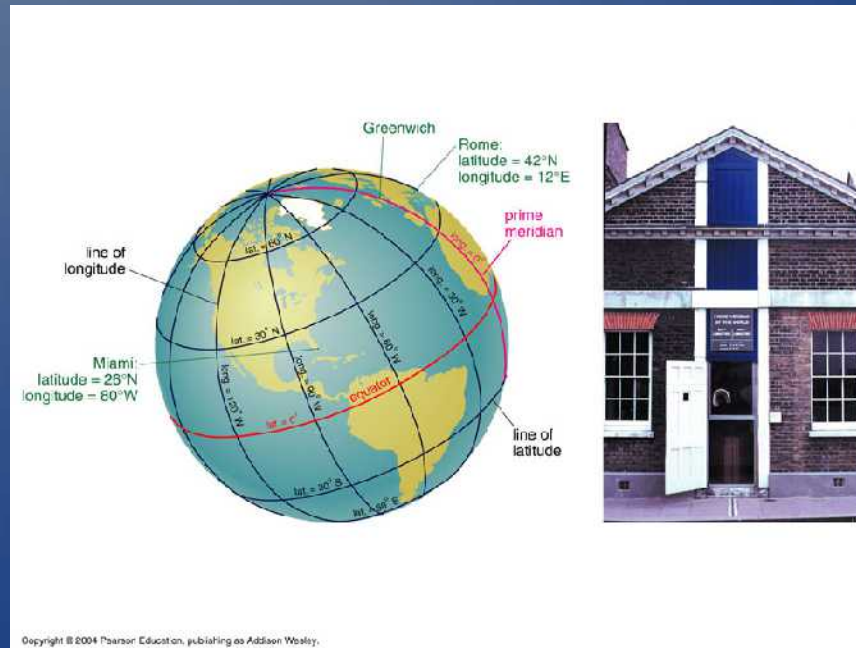
Review: Coordinates on the Earth

- **Latitude:** position north or south of equator
- **Longitude:** position east or west of prime meridian (runs through Greenwich, England)



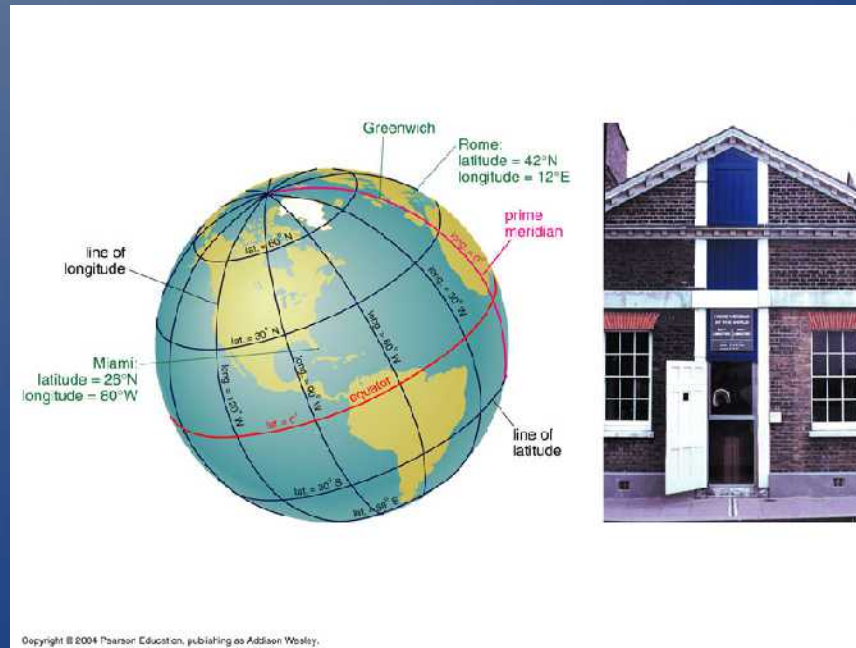
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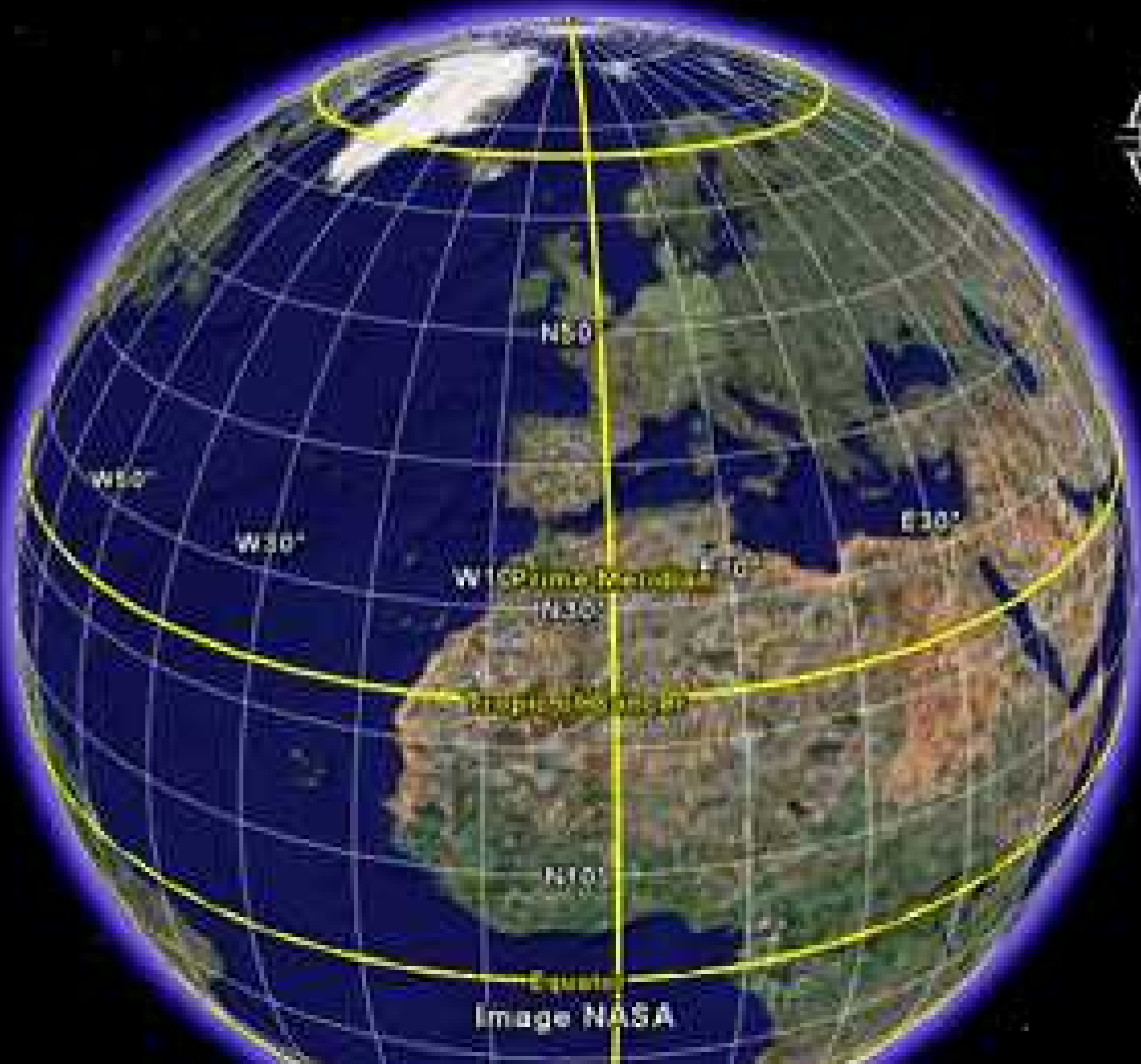
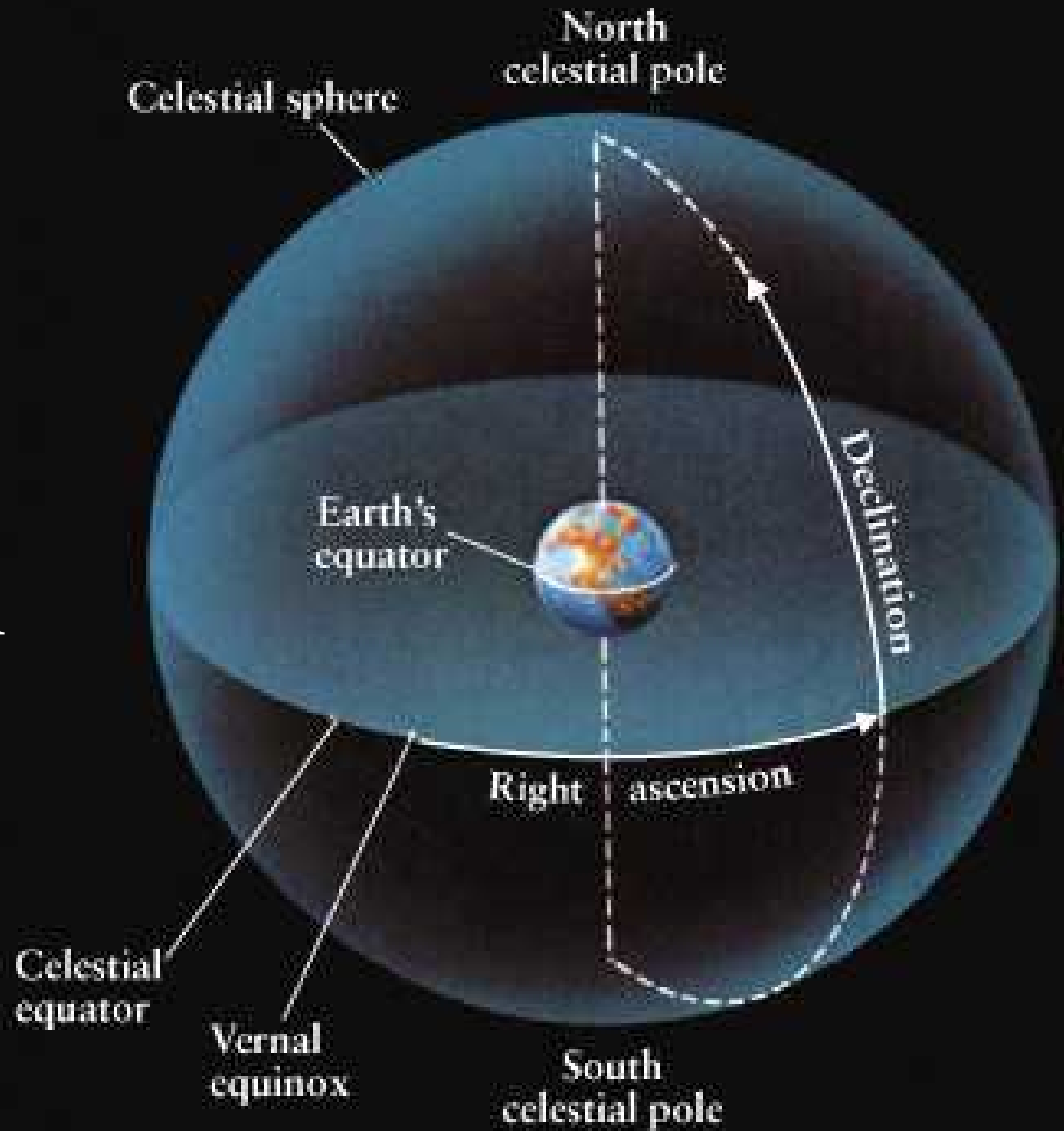


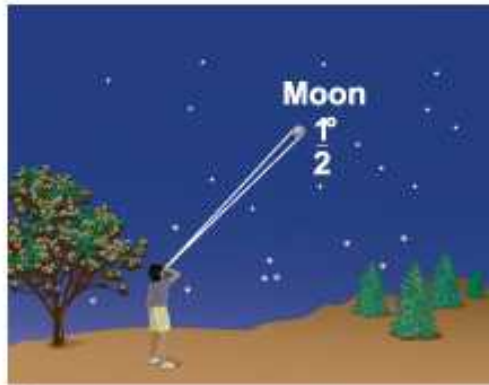
Image NASA

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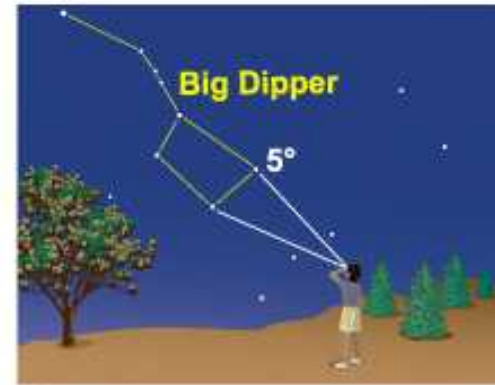
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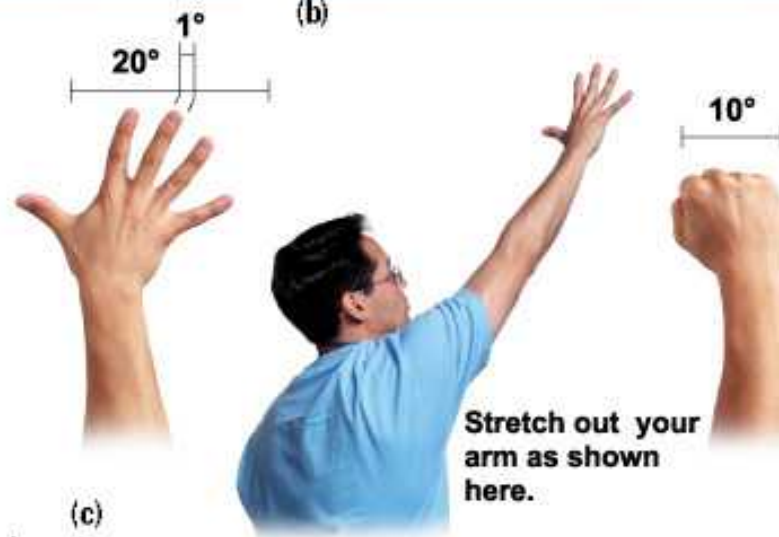
Measuring Angles in the Sky



(a)



(b)



(c)

The Local Sky

zenith

the point directly above you

horizon

all points 90° from the zenith

altitude

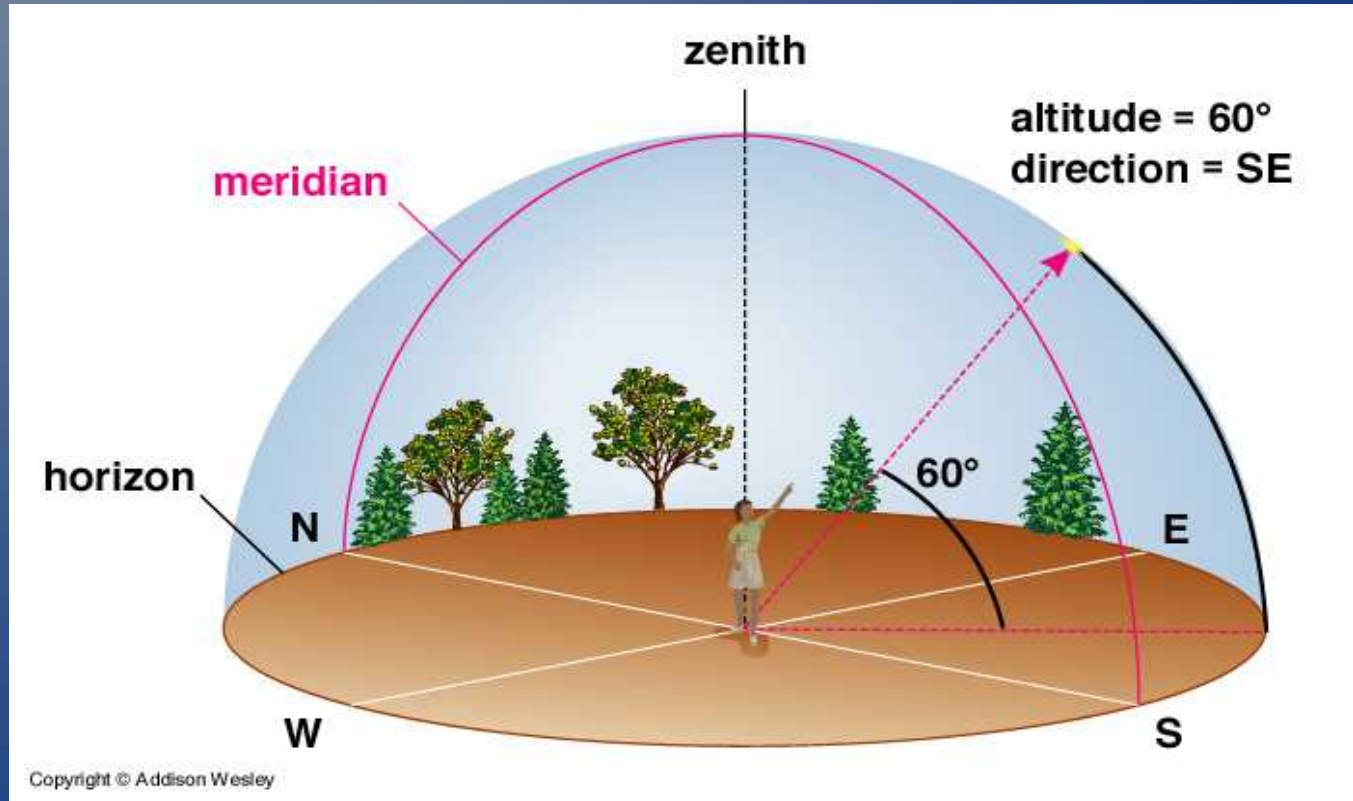
the angle above the horizon

meridian

due north horizon zenith due south horizon

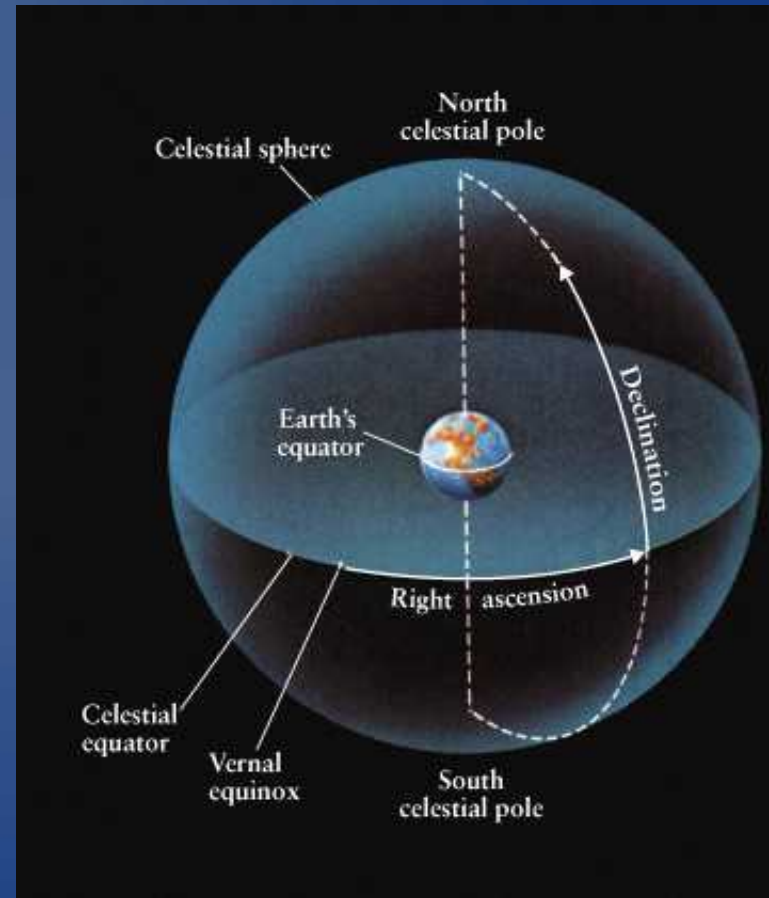
To pinpoint a spot in the local sky:

Specify **altitude** and **direction** along the horizon

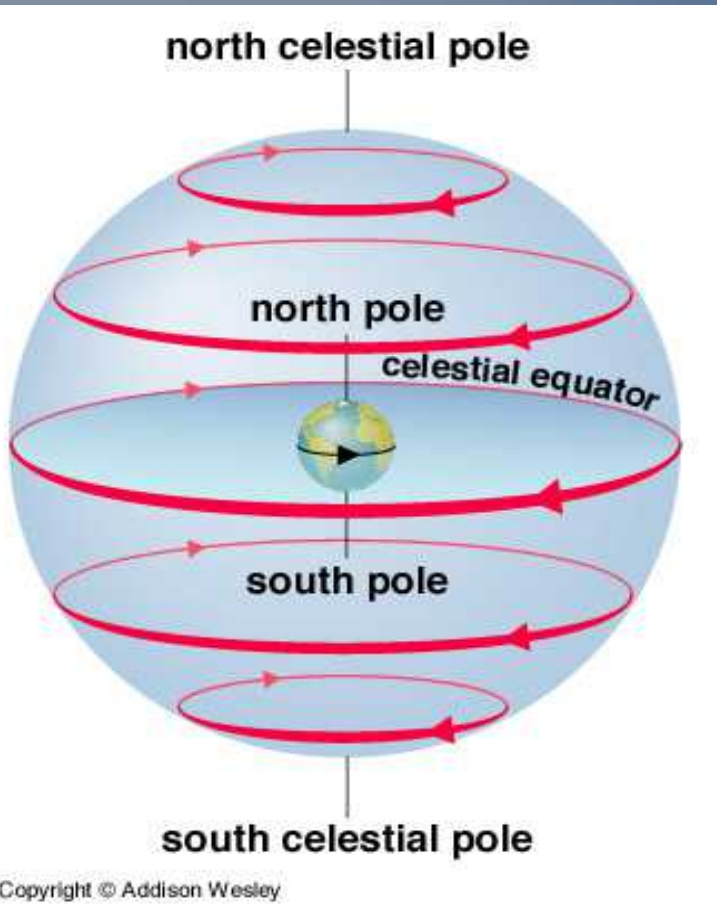


Elements of the equatorial coordinate system on the celestial sphere

- *Vernal Equinox*: The position of the Sun on the first day of spring (Sets the prime meridian)
- *Right Ascension*: How far east of the Vernal Equinox an object is located (longitude)
- *Celestial Equator*: The line separating the celestial sphere into northern and southern halves.
- *Declination*: How far above or below the celestial equator an object is located. (latitude)

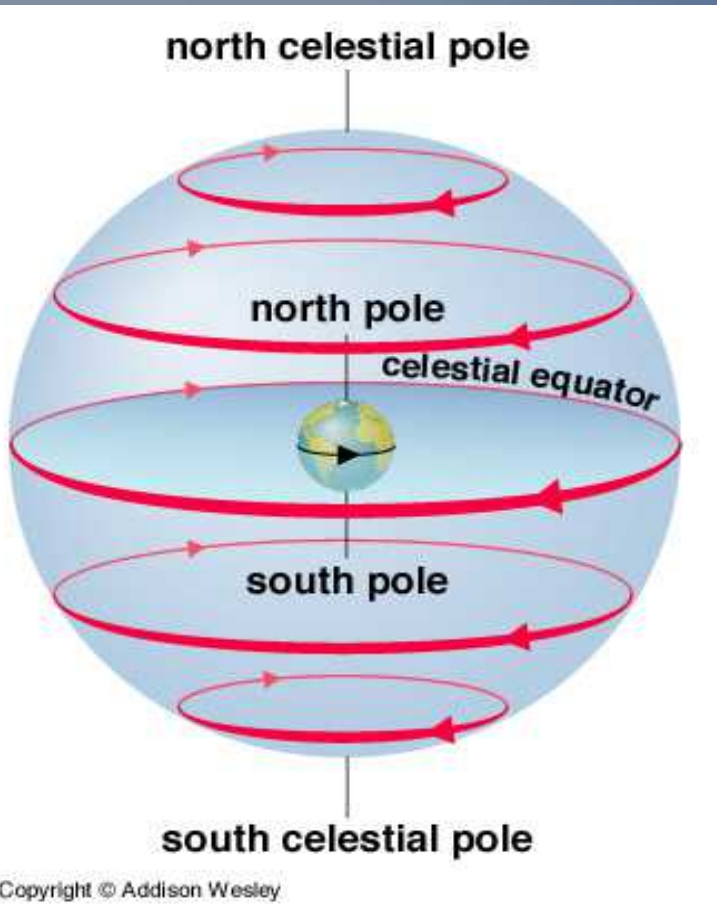


The Daily Motion



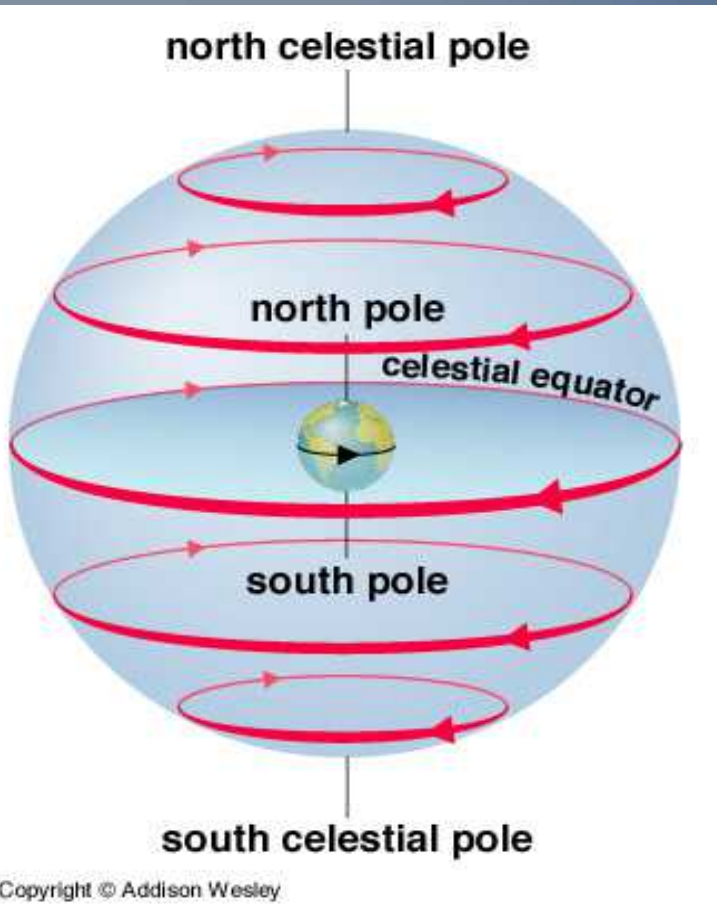
- As the Earth rotates, the sky appears to us to rotate in the opposite direction.
- The sky appears to rotate around the N (or S) celestial poles.
- If you are standing at the poles, nothing rises or sets.
- If you are standing at the equator, everything rises & sets 90° to the horizon.

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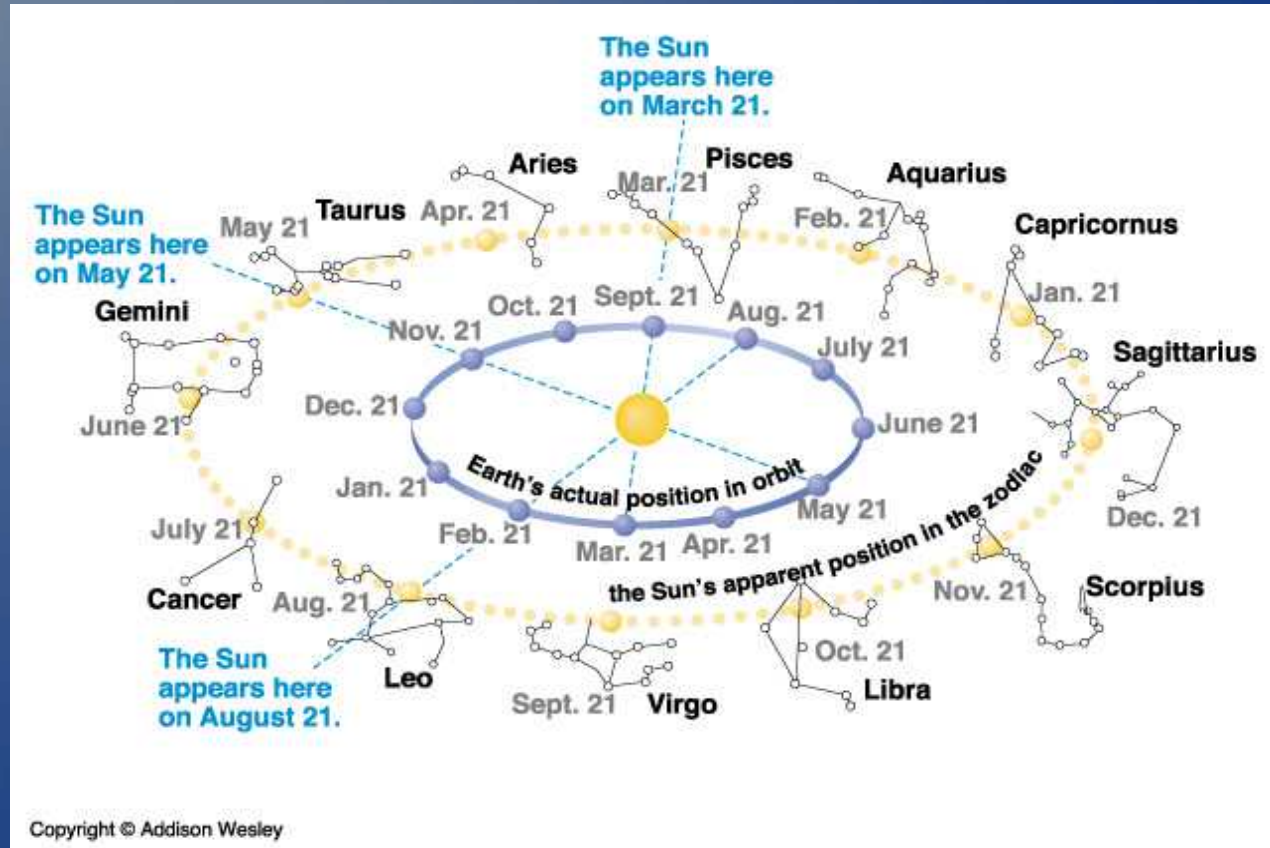
Time Exposure Photograph:

- Estimate the exposure time
- Which direction did stars move?



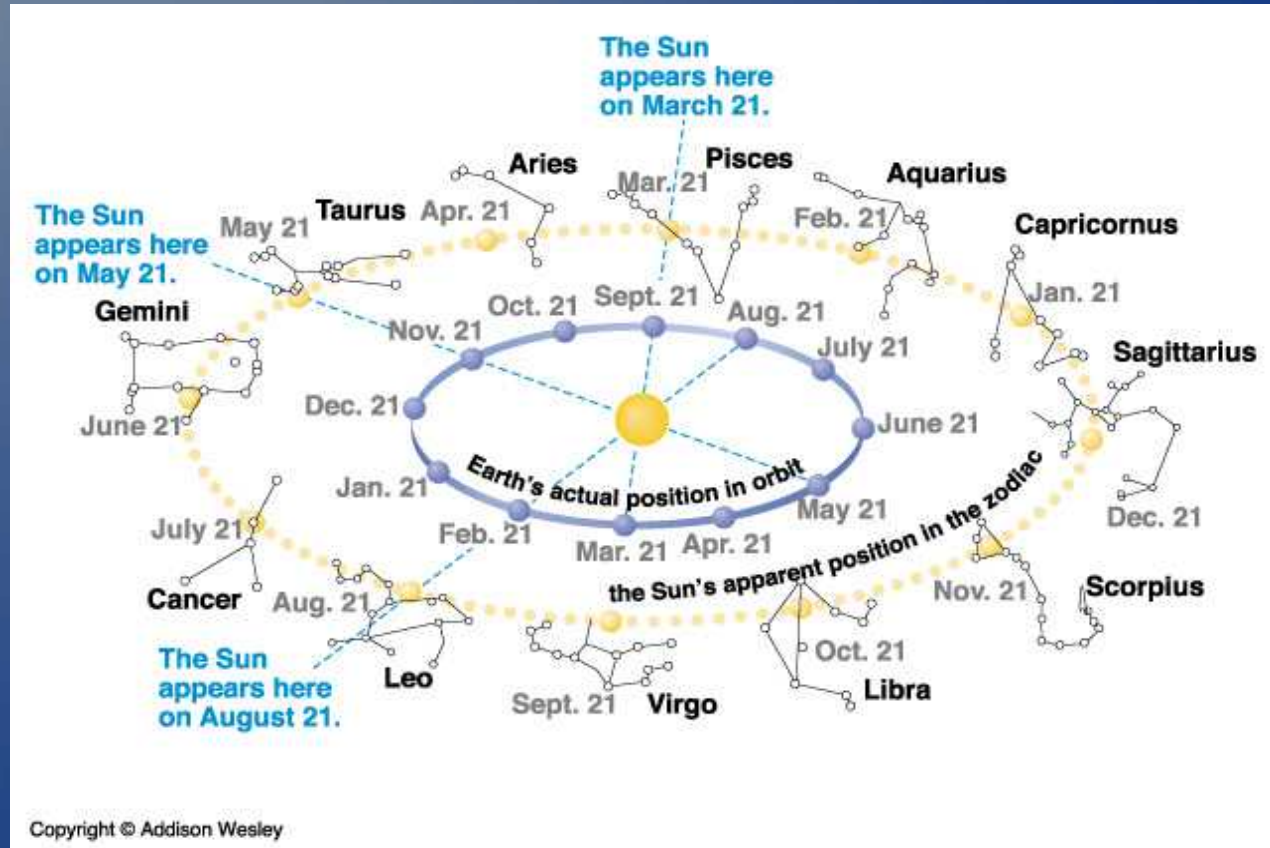
Annual Motion

- As the Earth orbits the Sun, the Sun appears to move eastward with respect to the stars.
- The Sun circles the celestial sphere once every year.



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