[03] The Night Sky (9/5/17)

Upcoming Items

1. Homework #1 due now!
2. Read Ch. 2.2–2.3 and do self-study quizzes
3. Homework #2 due in one week.

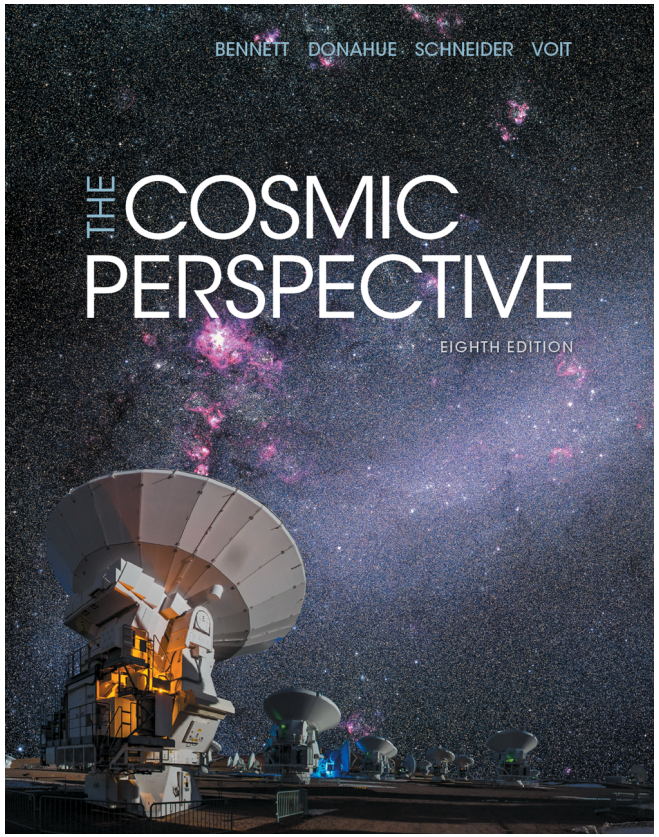
https://iso.500px.com/wp-content/uploads/2013/08/11834033-1170.jpeg

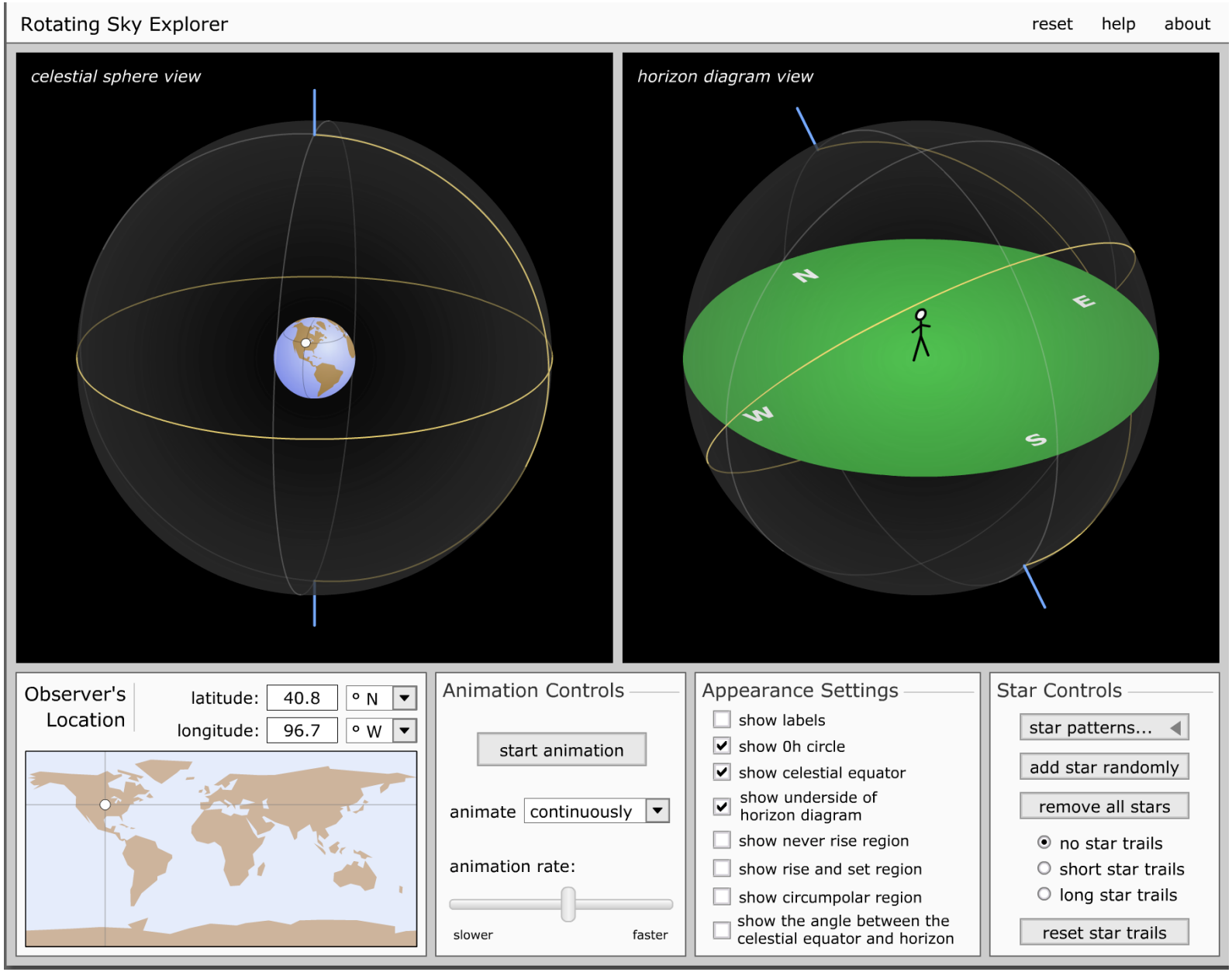
LEARNING GOALS

Chapter 2.1

For this class, you should be able to…

- … *convert from radians to degrees/minutes/seconds of arc, and vice versa;*
- … *describe the basic components of the celestial sphere (poles and equator, and ecliptic), your local sky (altitude, azimuth/direction, horizon, zenith, meridian), and your place on Earth (latitude, longitude).*
- … *sketch how stars appear to move in the sky throughout the night and year depending on your location on Earth.*



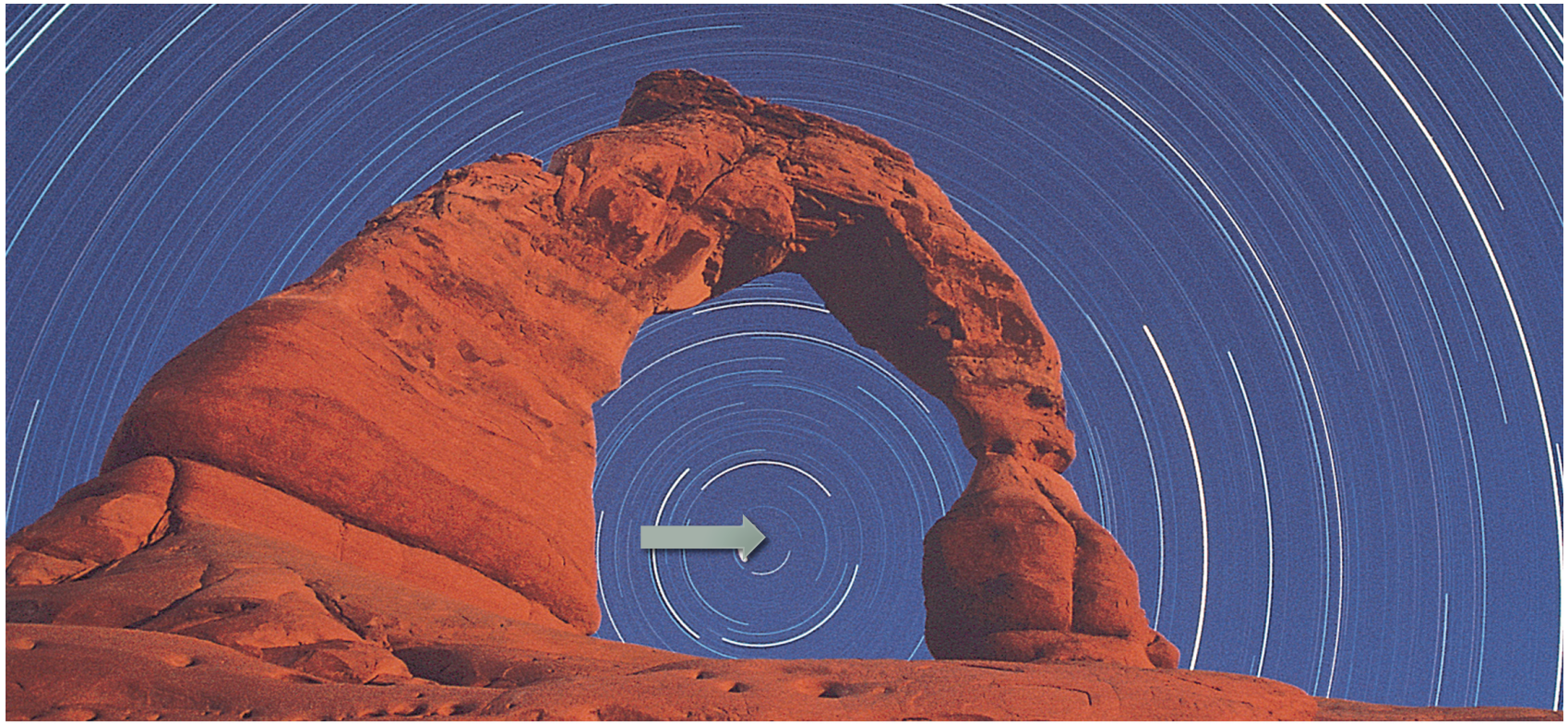

Rotating Sky Explorer
reset
help
about
celestial sphere view
horizon diagram view
N
E
S
W
Observer's Location
latitude:
40.8
° N
longitude:
96.7
° W
Animation Controls
start animation
animate
continuously
animation rate:
slower
faster
Appearance Settings
show labels
show 0h circle
show celestial equator
show underside of horizon diagram
show never rise region
show rise and set region
show circumpolar region
show the angle between the celestial equator and horizon
Star Controls
star patterns...
add star randomly
remove all stars
no star trails
short star trails
long star trails
reset star trails

What is the arrow pointing at?

A. The zenith.

B. **The north celestial pole.**

C. The celestial equator.



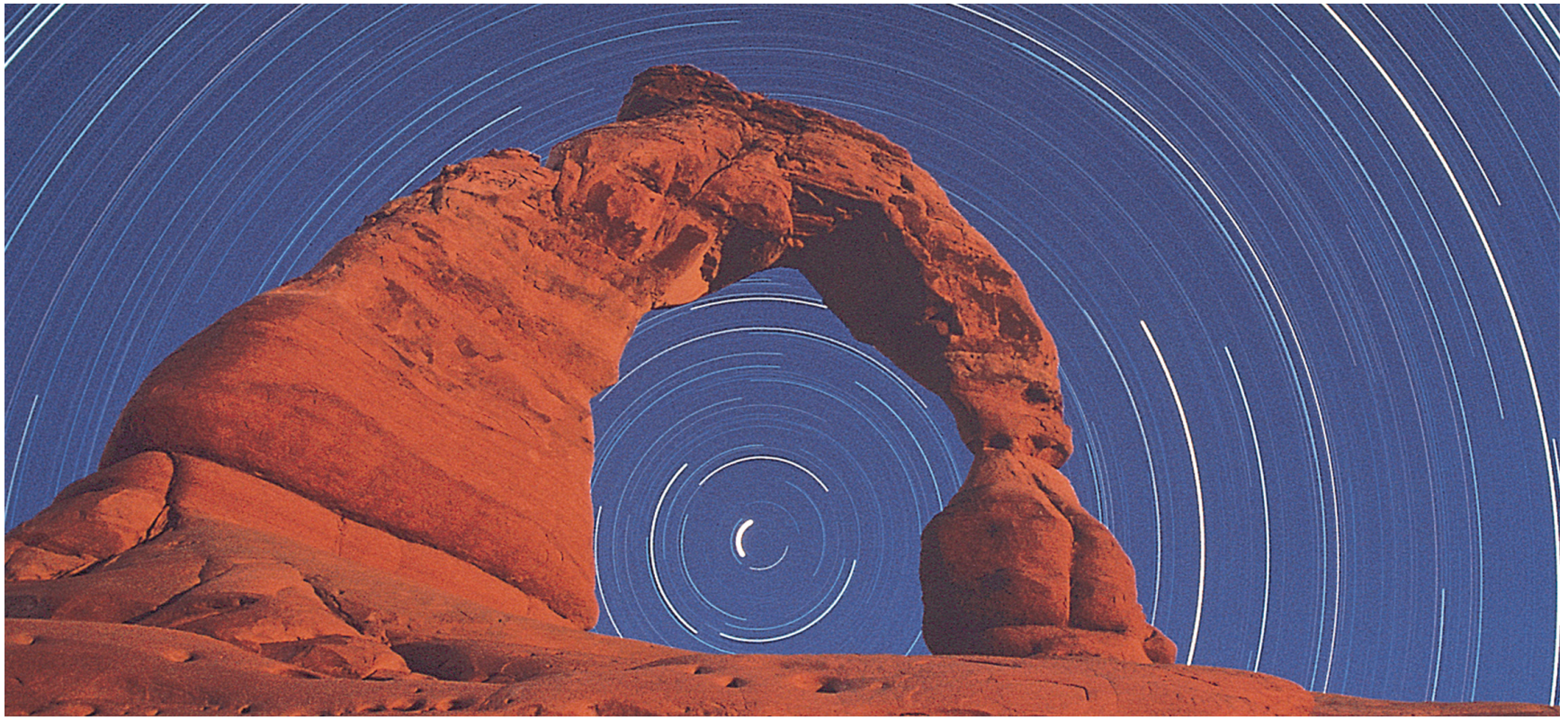
You observe a star rising due east. When this star reaches its highest position above the horizon, where will it be?

A. High in the northern sky.
B. High in the eastern sky.
C. **High in the southern sky.**
D. High in the western sky.
E. Directly overhead.

NOTE: this is for an observer in the northern hemisphere.

In which direction is the photographer facing? (Assume they are in the northern hemisphere.)

A. **North.**
B. East.
C. West.



In which direction is the photographer facing? (Assume they are in the northern hemisphere.)

A. North.
B. East.
C. **West.**

Imagine you are standing in the northern hemisphere. Looking directly north, you see a star just above the horizon. A little later you notice that it has shifted position slightly. Which way did it move?

A. **To the right (east).**
B. To the left (west).
C. Up (rising).
D. Down (setting).

You are looking toward the north and see the Big Dipper to the right of the North Star. Fifteen minutes later, the Big Dipper will appear to have moved in roughly what direction?

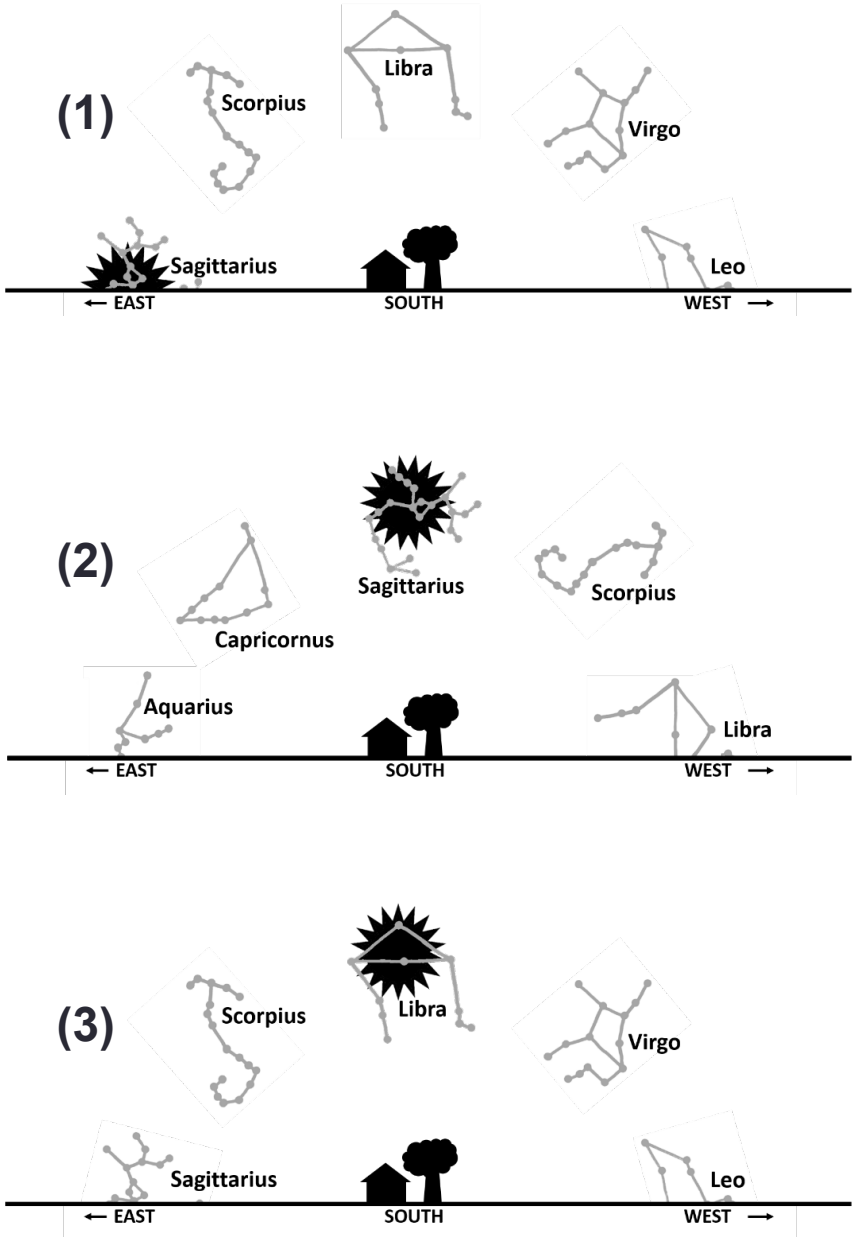
A. East (to your right).
B. West (to your left).
C. **Up (away from the horizon).**
D. Down (closer to the horizon).

How much time is there between when a star rises and when it sets?

A. Less than twelve hours.
B. About twelve hours.
C. More than twelve hours.
D. **It depends on the star.**

What about other locations?

- Are there locations on the Earth where ALL stars rise and set? Where?
- Are there locations on the Earth where NO stars rise and set? Where?



- The first picture (1) shows the horizon as you see it one morning. Pictures 2 and 3 show the same horizon at two different later points in time. Which occurred first, 2 or 3?
  - A. **2.**
  - B. 3.
  - C. They show the same time.
  - D. It is impossible to tell.

The Night Sky

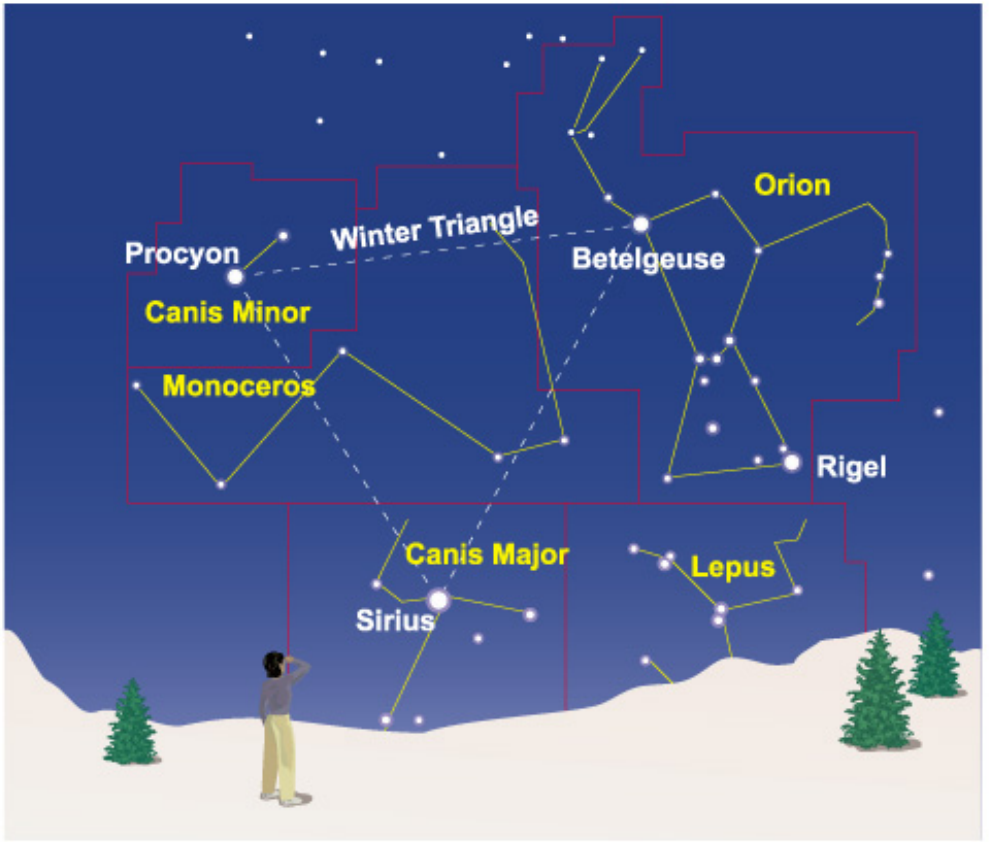
- The night sky is mostly stars, grouped in constellations.
- The celestial sphere is the projection of Earth's surface on the night sky. Special points are the *poles* and *equator*.
- The Sun & planets lie in the ecliptic tilted 23.5° to equator.
- Objects in the local sky are located by their *altitude* and *azimuth* (direction), relative to *horizon*, *zenith*, & *meridian*.
- Objects on Earth are located by their latitude & longitude.
- Over the course of one night, stars rise in the east, transit the meridian, and set in the west due to Earth's rotation.
- Over the course of one year, different stars are visible at night because of Earth's orbit around the Sun.

What does the night sky look like?

- With the naked eye, we can see more than 2000 stars, as well as the Milky Way.

What are constellations?

- A constellation is a *region* of the sky.
- 88 constellations fill the entire sky (north & south).

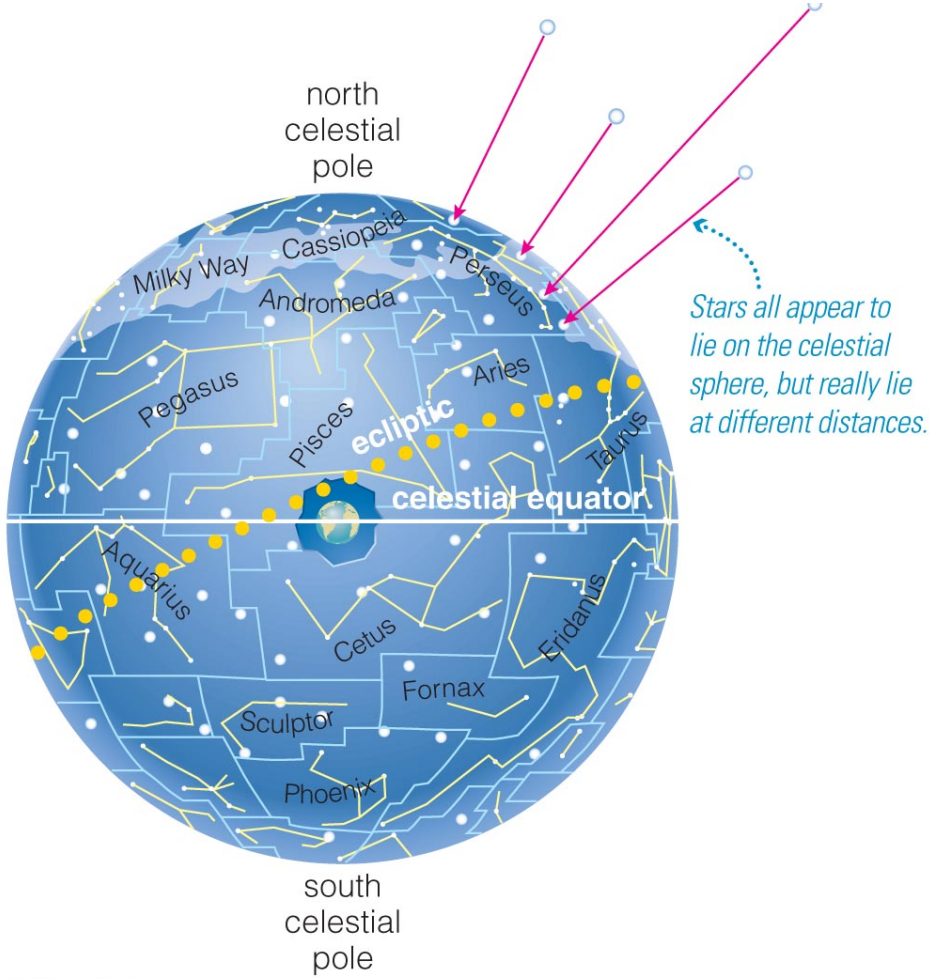


SkyGazer 5
http://in-the-sky.org/skymap.php

Why Constellations?

- Constellations are traditional groupings of stars that are near each other in the sky.
- In modern astronomy, the sky is divided into 88 jigsaw puzzle pieces that fill the sky.
- But they don't have to have particular meaning.
- For example, is it necessarily true that all stars in a constellation are physically near each other?
- Constellations are fun (Greek mythology!), but mostly they aren't useful in professional astronomy
- Instead, we use a system similar to latitude and longitude: the celestial sphere

The Celestial Sphere

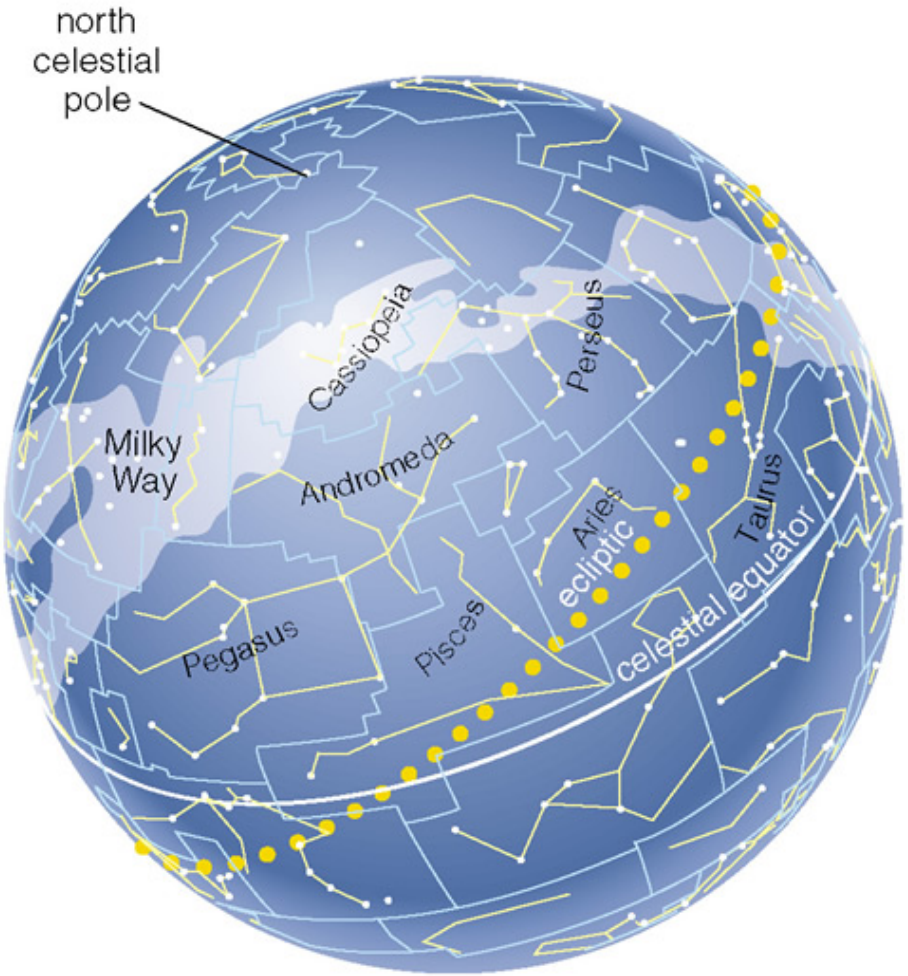


- Stars at different distances all appear to lie on the celestial sphere.
- The 88 official constellations cover the celestial sphere.

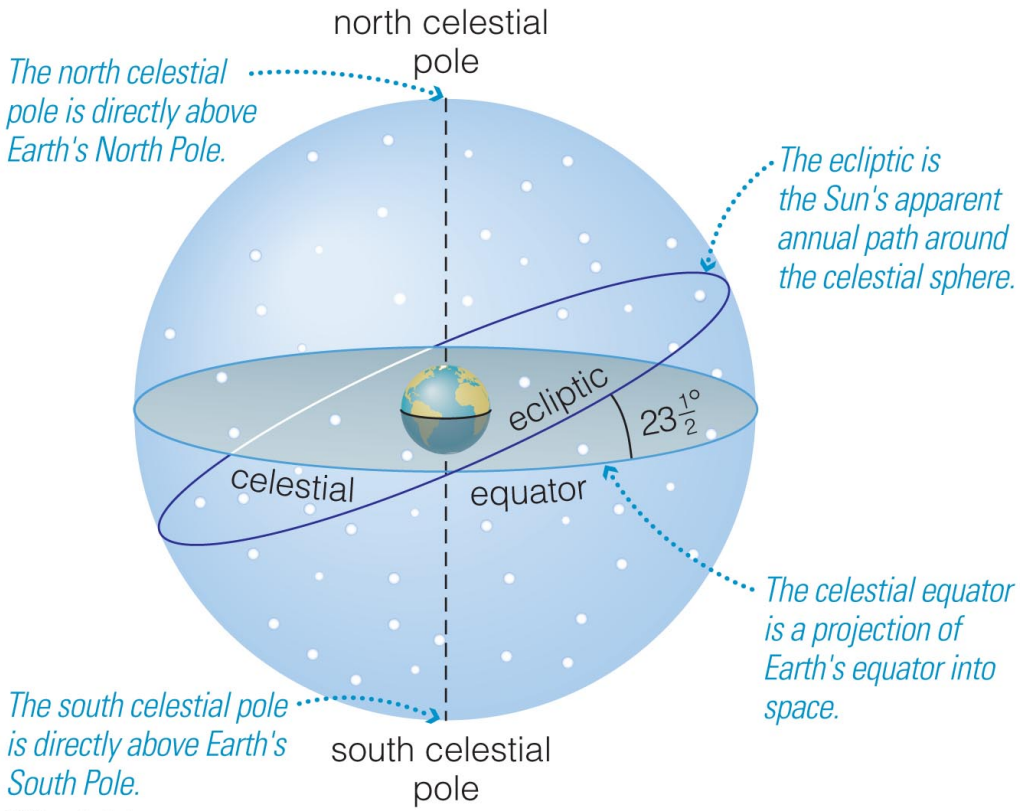
How Could We Set Up Coordinates?

- This will be a group question for discussion.
- If the Earth did not rotate and remained fixed relative to the distant stars, then we could define directions to the stars once and for all: draw the line between the star and the center of the Earth, and assign the star the same latitude and longitude as where that line intersects Earth's surface. Does that make sense?
- But in reality (1) the Earth rotates, (2) even the direction of Earth's rotational axis changes over thousands of years, and (3) the stars do move over long times.
- For your group question: how could you deal with this? If you want to identify the direction to a star, what do you do?

The Celestial Sphere

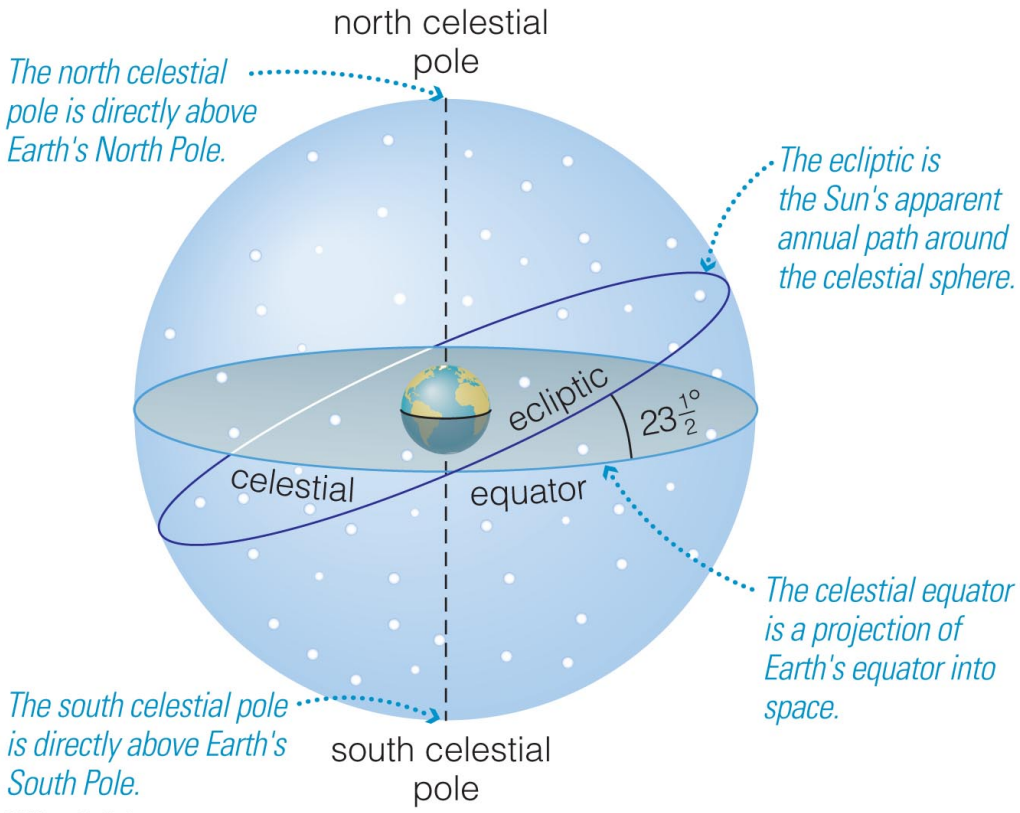


The Celestial Sphere



- The **Ecliptic** is the Sun's apparent path through the celestial sphere.

The Celestial Sphere



- **North celestial pole** is directly above Earth's North Pole.
- **South celestial pole** is directly above Earth's South Pole.
- **Celestial equator** is a projection of Earth's equator onto sky.

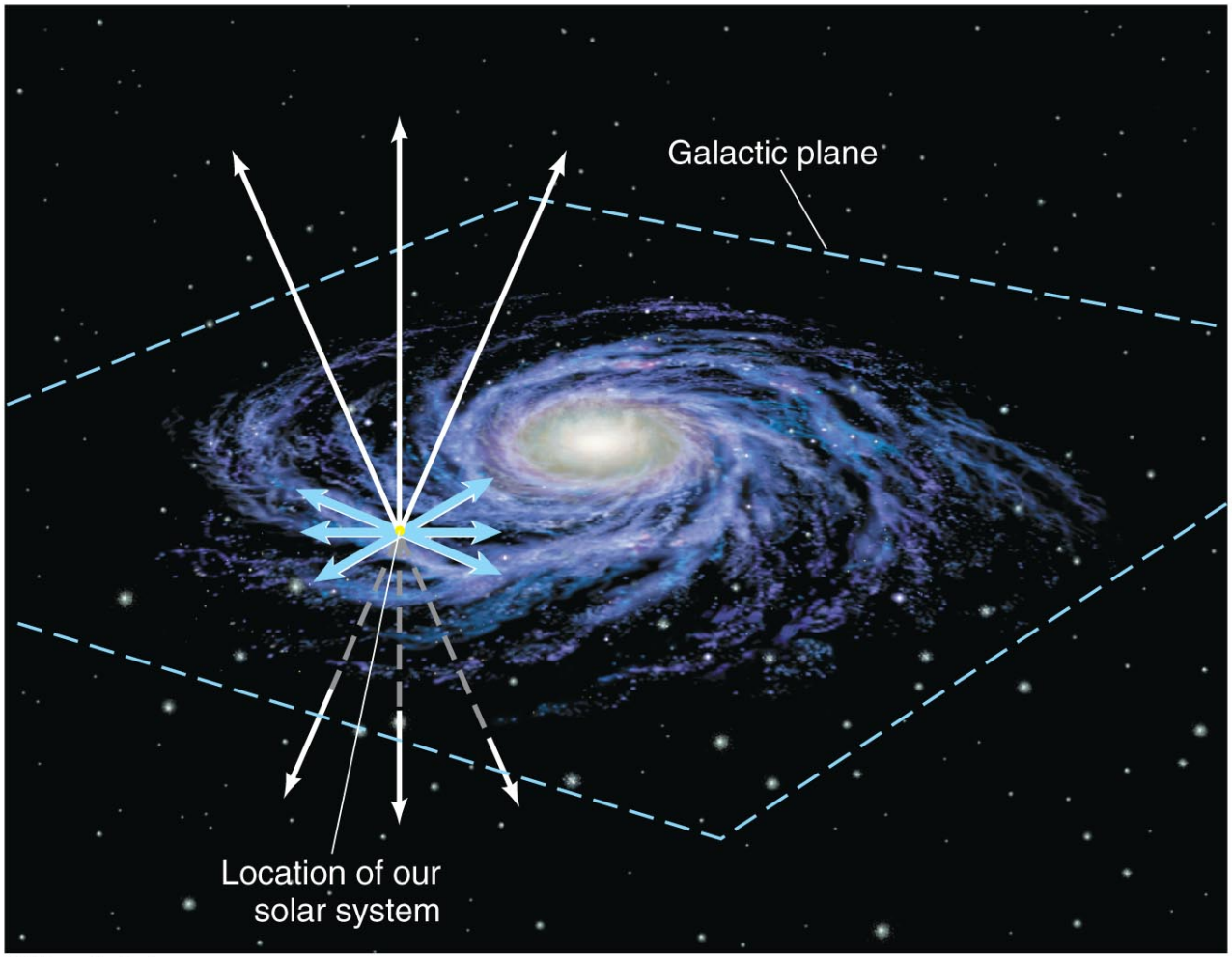
The Milky Way

- A band of light making a circle around the celestial sphere.

What is it?

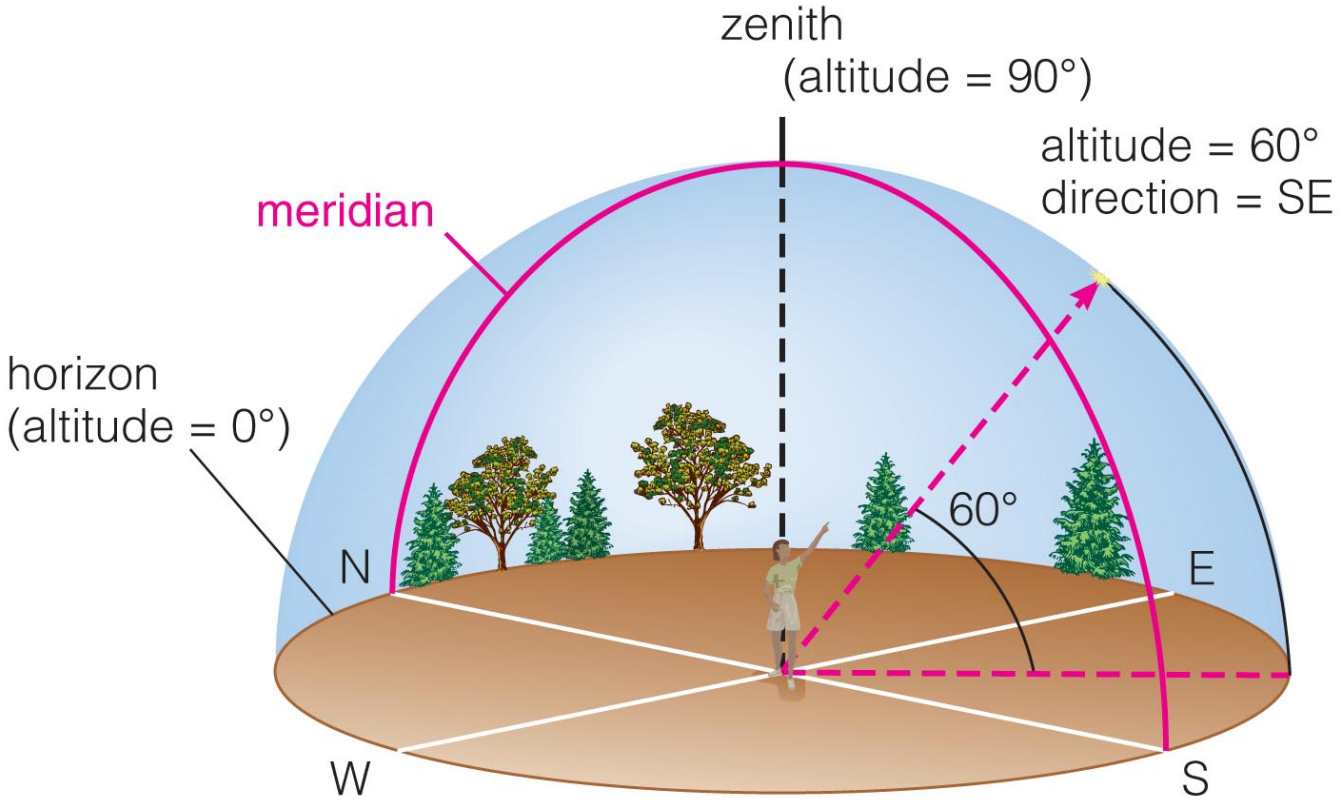
- Our view into the plane of our galaxy.

The Milky Way

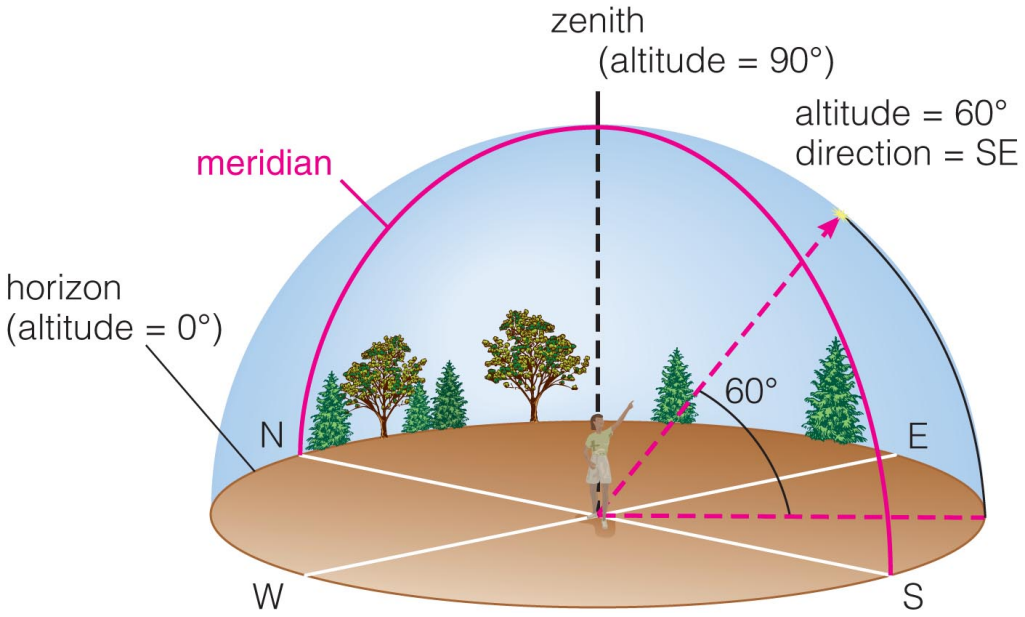


The Local Sky

- An object's **altitude** (above horizon) and **direction** (along horizon) specify its location in your local sky.



The Local Sky

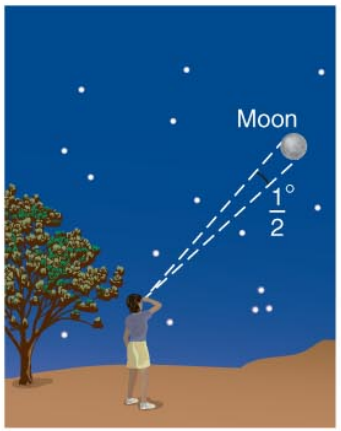


- **Meridian:** line passing through zenith and connecting N and S points on horizon.

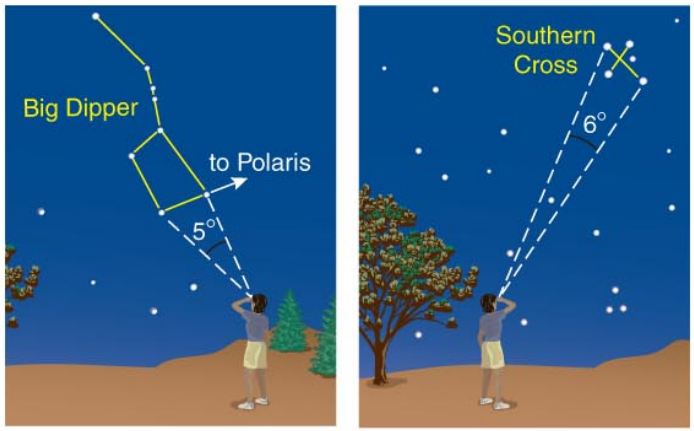
- **Zenith:** the point directly overhead.

- **Horizon:** all points 90° away from zenith.

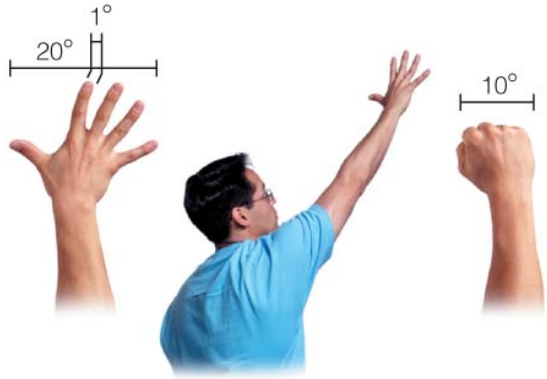
We measure the sky using angles…



a The angular sizes of the Sun and the Moon are about 1/2°.



b The angular distance between the "pointer stars" of the Big Dipper is about 5°, and the angular length of the Southern Cross is about 6°.



Stretch out your arm as shown here.

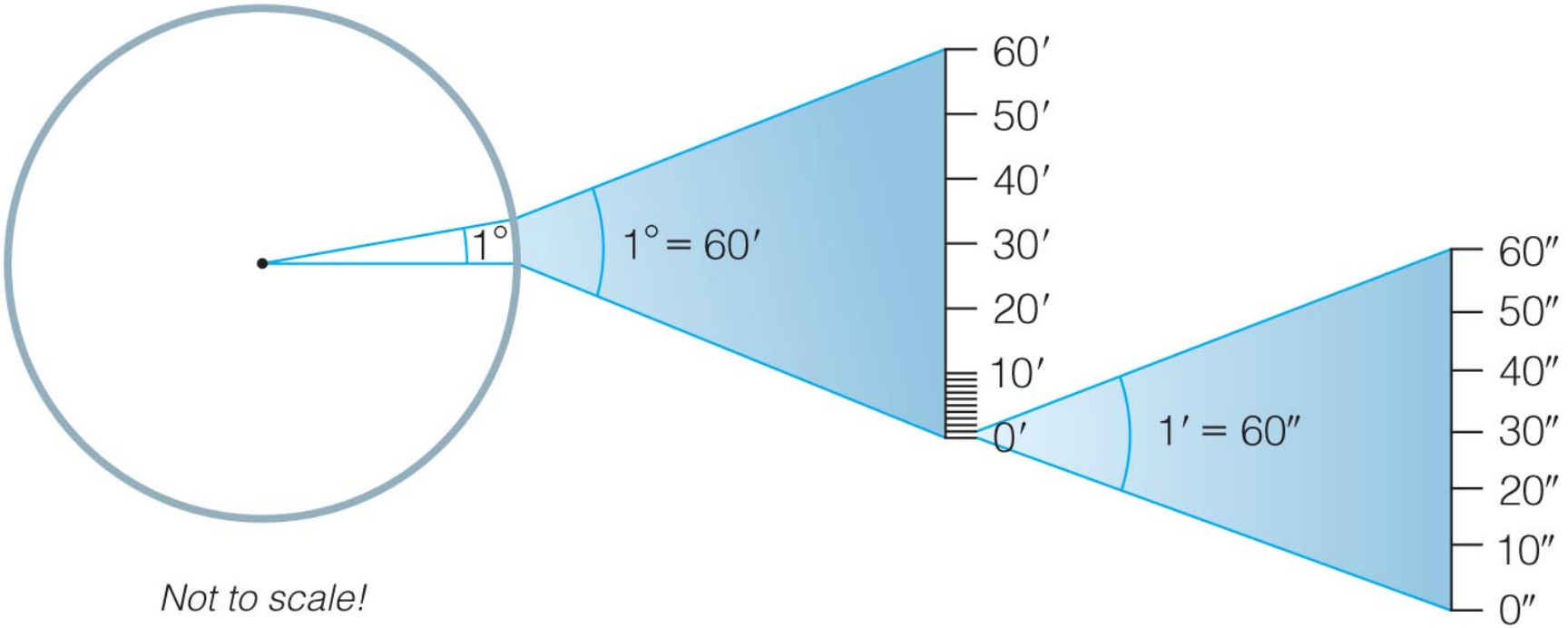
c You can estimate angular sizes or distances with your outstretched hand.

Angular Measurements

Full circle = 360º.

1º = 60′ (arcminutes or arcmin).

1′ = 60″ (arcseconds or arcsec).



Not to scale!

Thought Question

The angular size of your finger at arm's length is about 1°. How many arcseconds is this?

A. 60 arcseconds.
B. 600 arcseconds.
C. **60×60 = 3,600 arcseconds.**

Thought Question

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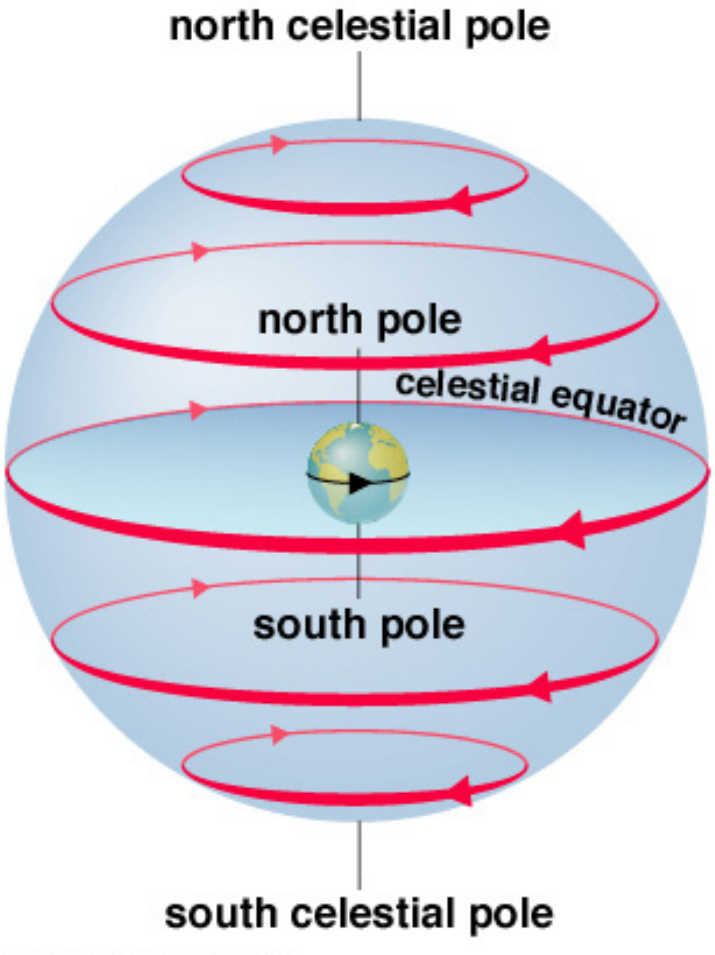
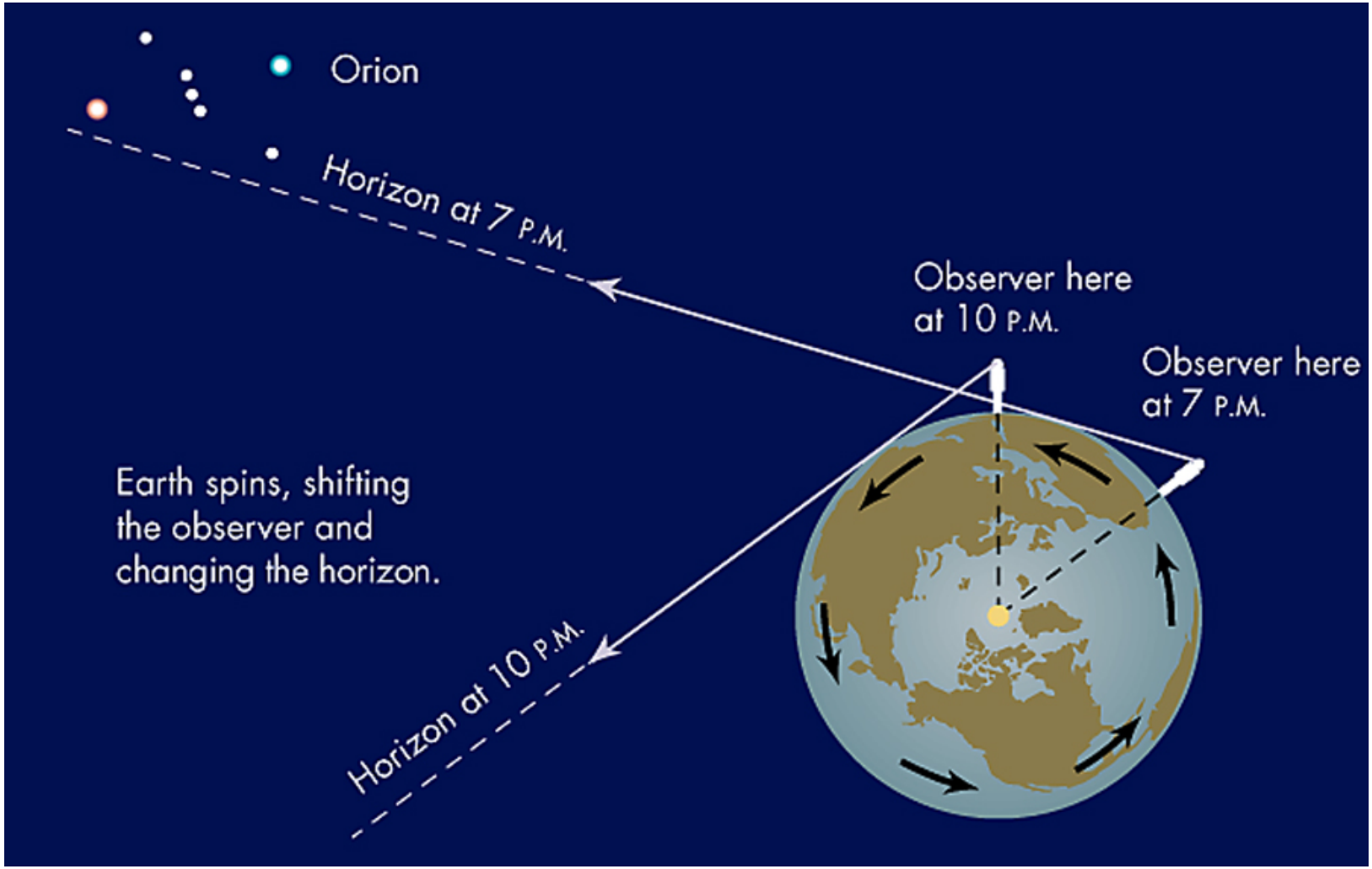
I.e., 1 deg × 60 arcmin/deg × 60 arcsec/arcmin = 3,600 arcsec.

Why do stars rise and set?



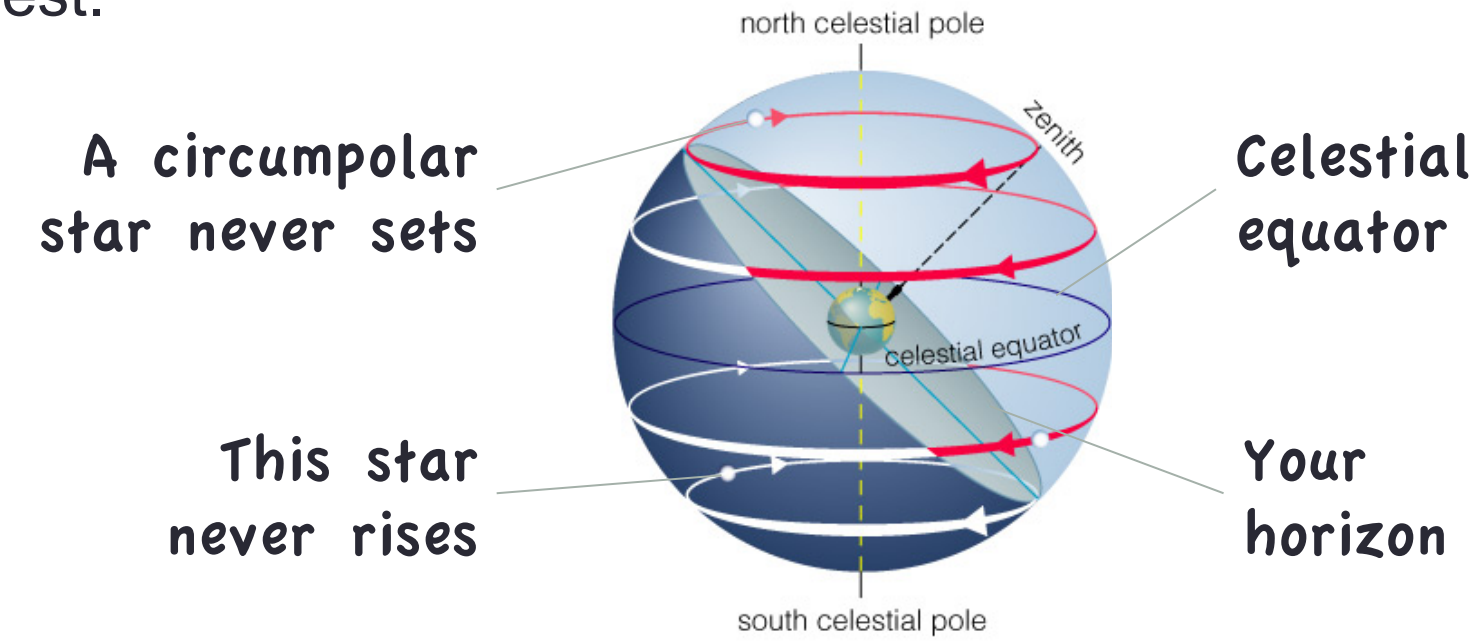
- Earth rotates west to east, so stars appear to circle from east to west.

What moves? Earth or sky?



Our view from Earth

- Stars near the north celestial pole are circumpolar and never set.
- We cannot see stars near the south celestial pole.
- All other stars (and Sun, Moon, planets) rise in east and set in west.

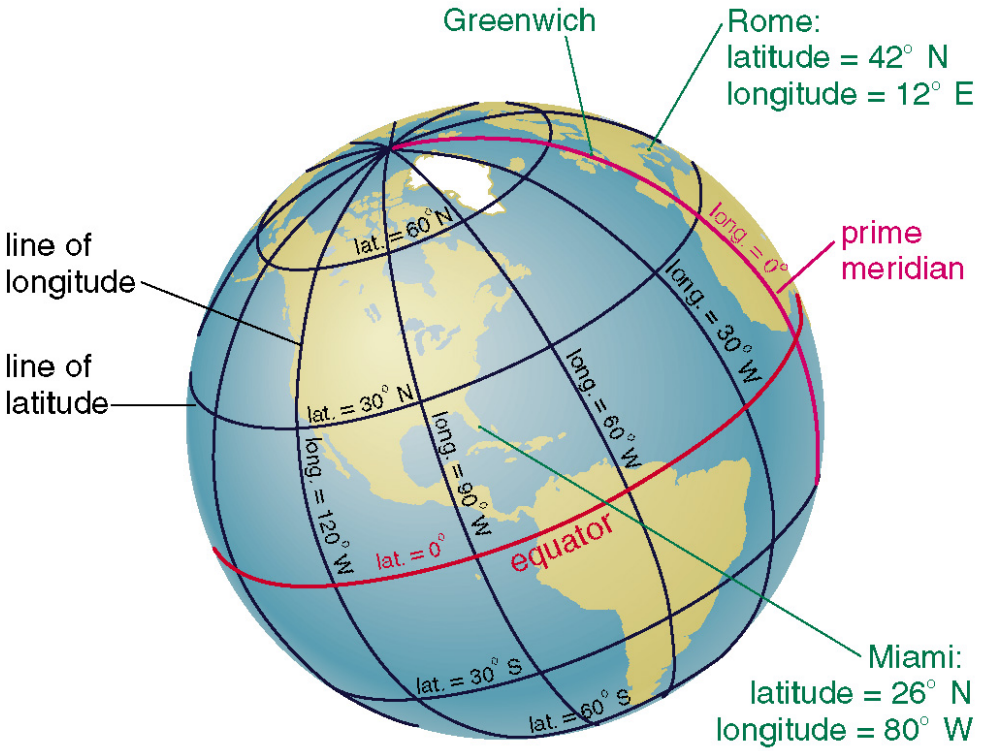


Why do the constellations we see depend on latitude and time of year?

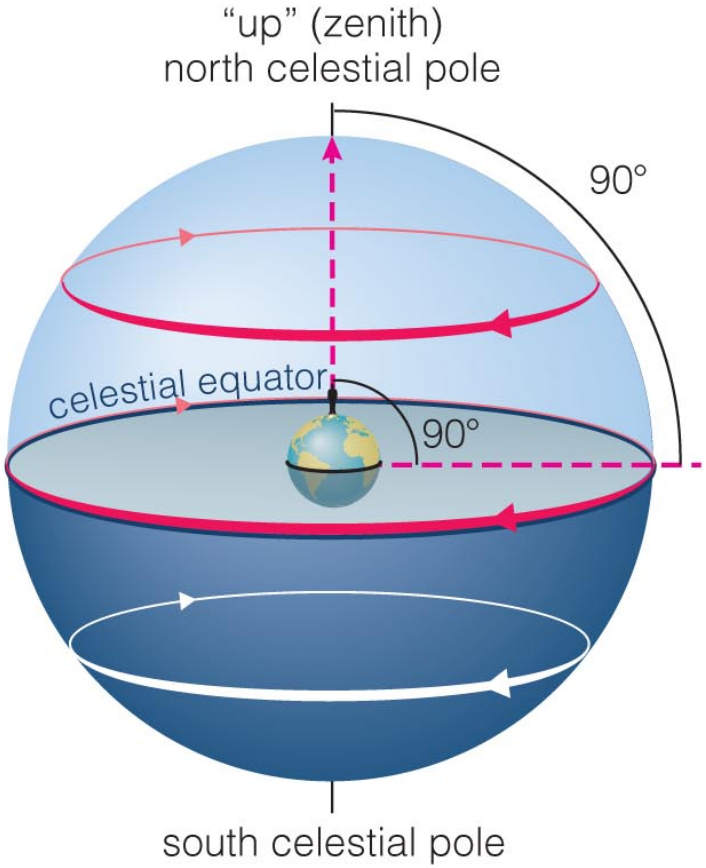
- They depend on latitude because your position on Earth determines which constellations remain below the horizon.
- They depend on time of year because Earth's orbit changes the apparent location of the Sun among the stars.

Coordinates on Earth

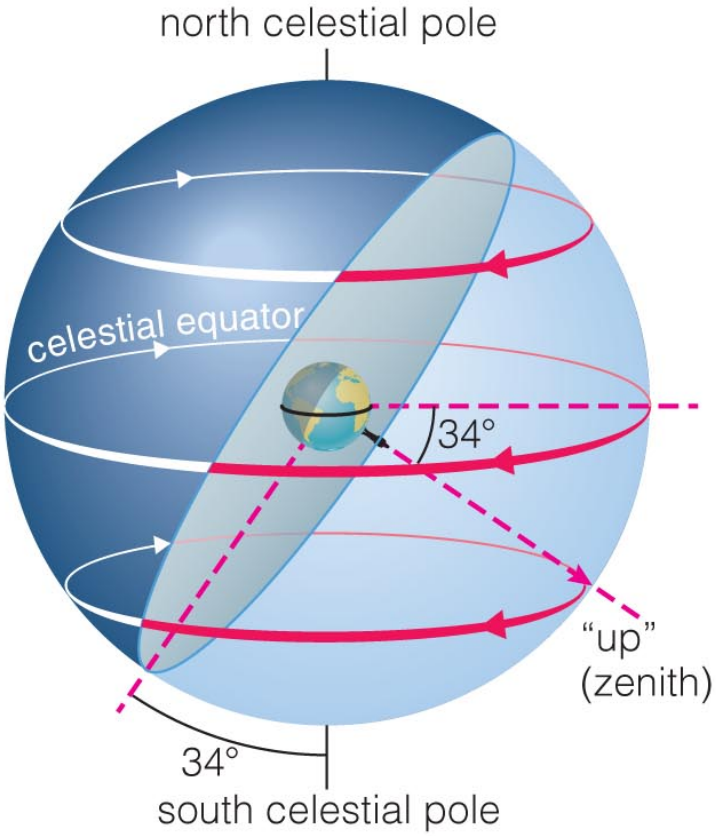
- **Latitude:** position north or south of equator.
- **Longitude:** position east or west of *prime meridian* (runs through Greenwich, England).



The sky varies with latitude but not with longitude.

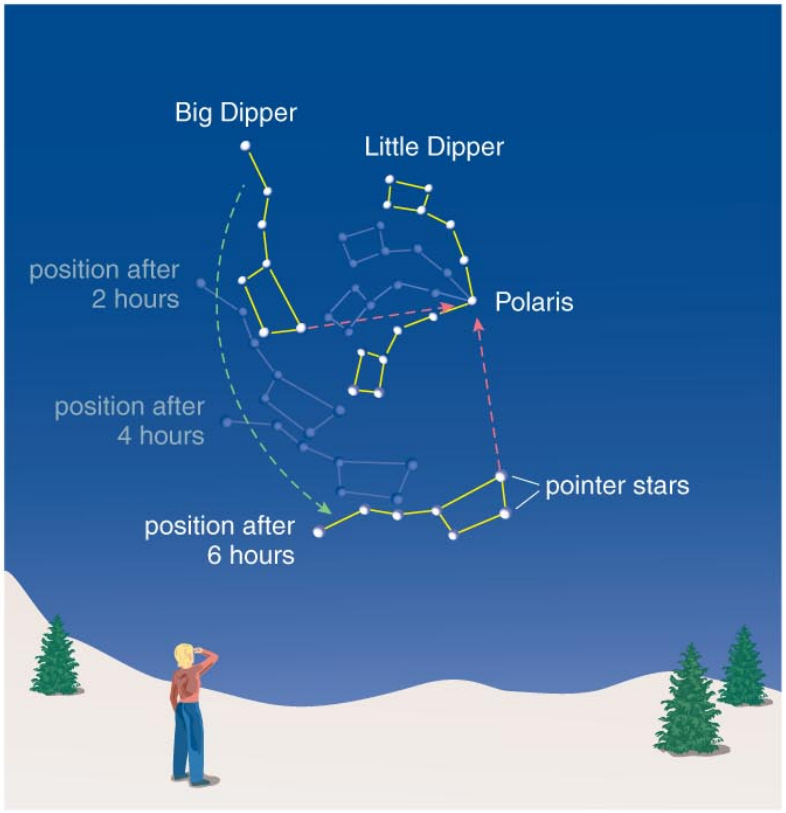


a The local sky at the North Pole (latitude 90°N).

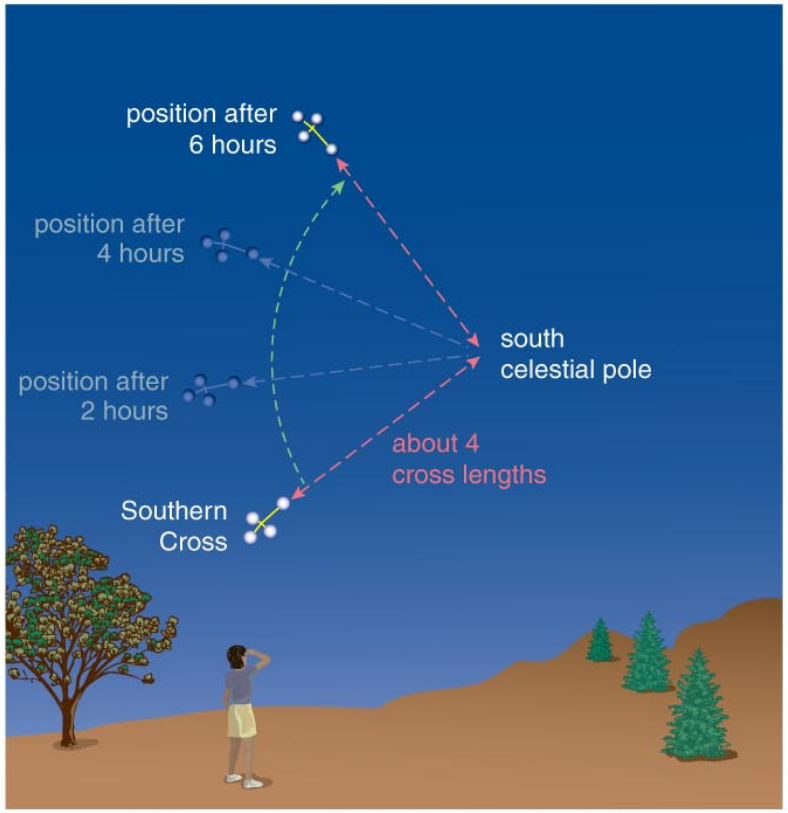


b The local sky at latitude 34°S.

Altitude of the celestial pole = your latitude



looking northward in the Northern Hemisphere



looking southward in the Southern Hemisphere

Interactive Figure

Thought Question

The North Star (Polaris) is 50° above your horizon, due north. Where are you?

A. You are on the equator.
B. You are at the North Pole.
C. You are at latitude 50°N.
D. You are at longitude 50°E.

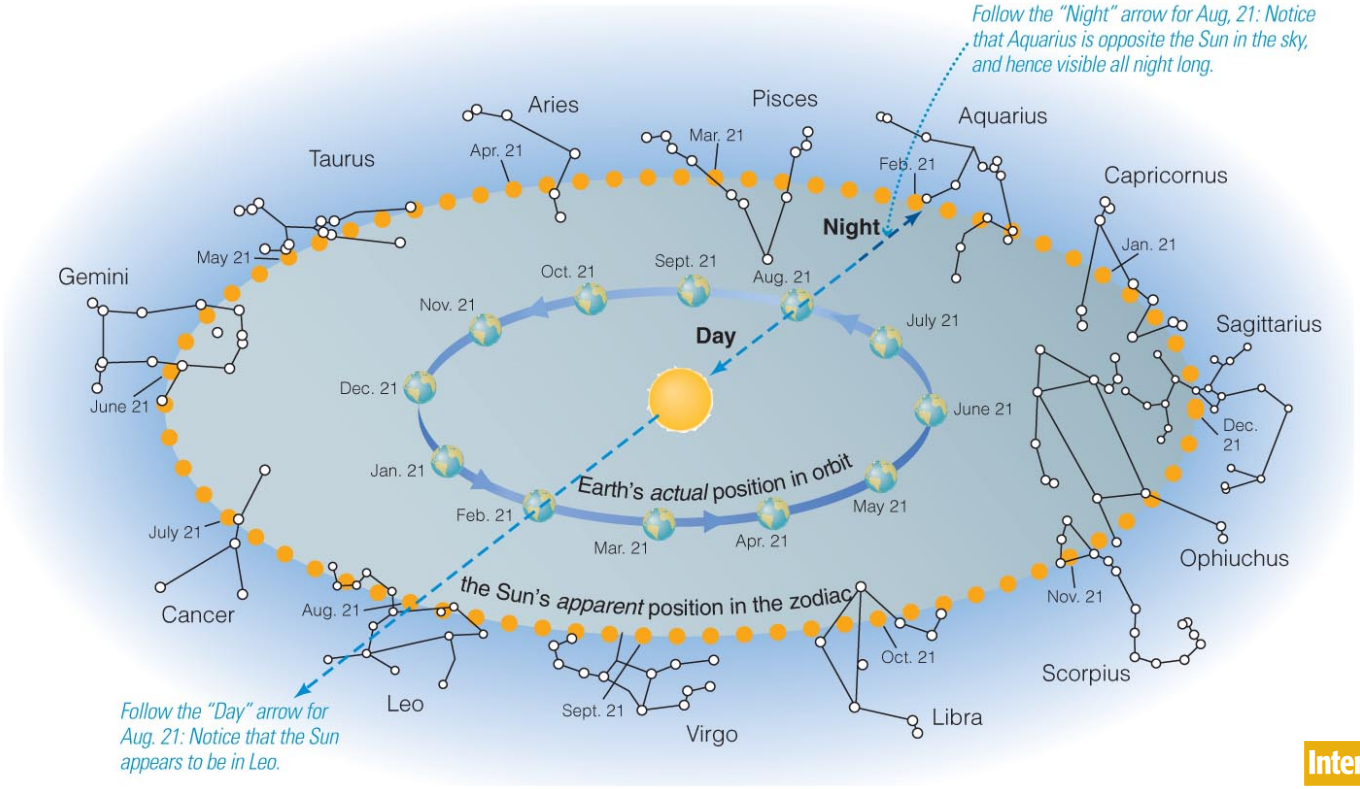
Thought Question

The North Star (Polaris) is 50° above your horizon, due north. Where are you?

A. You are on the equator.
B. You are at the North Pole.
C. **You are at latitude 50°N.**
D. You are at longitude 50°E.

The sky varies as Earth orbits.

- As the Earth orbits the Sun, the Sun appears to move east along the ecliptic.



Interactive Figure

Question for Group Discussion

- We noted that the stars appear to move due to Earth's rotation.
- But the Earth also orbits around the Sun.
- Why haven't we focused on the effect that has on the apparent direction to stars?
  Will it have *any* effect?

Review

- Sketch how stars appear to move in the sky throughout the night and year.

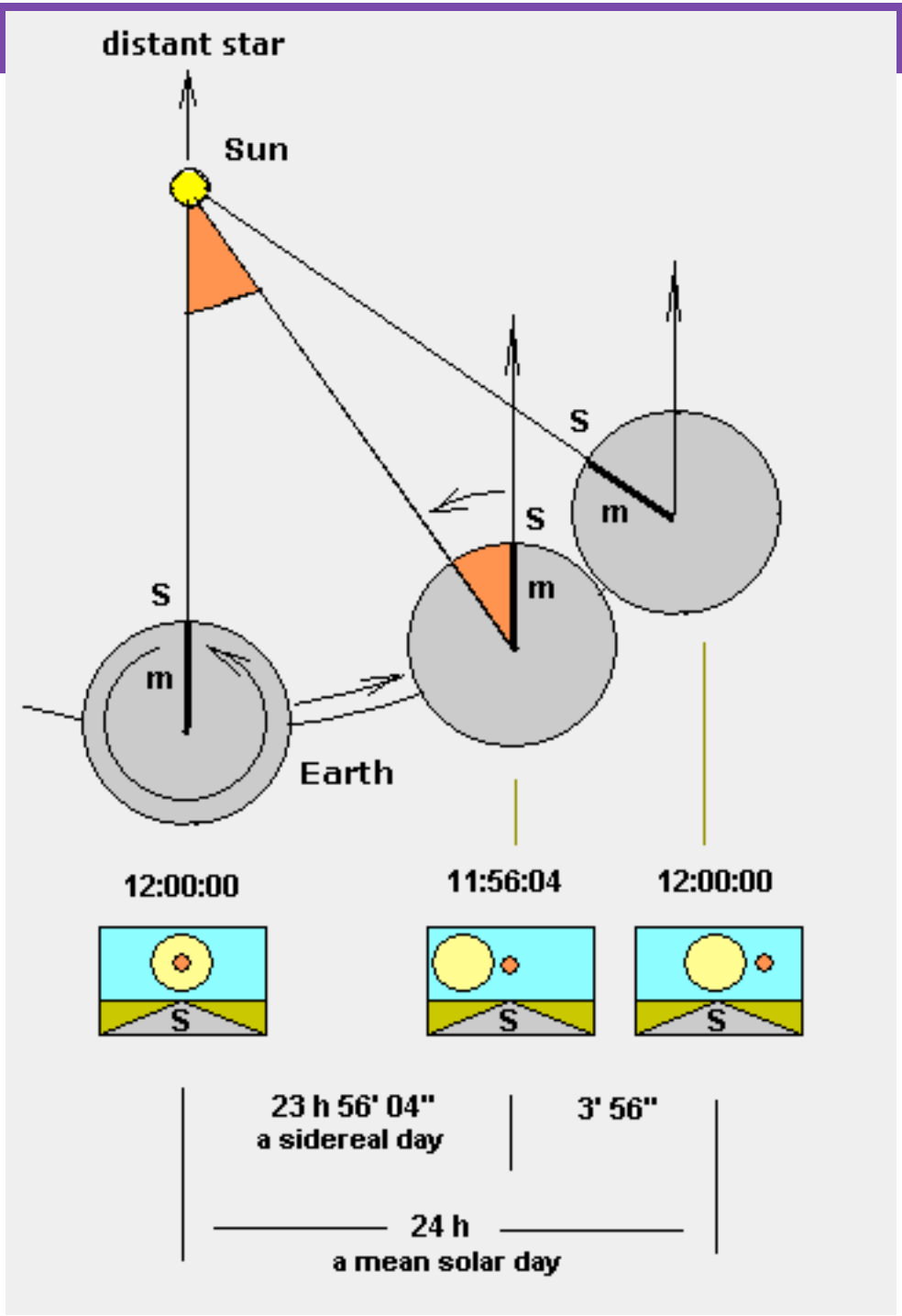
Also see Chapter S1: Celestial Timekeeping and Navigation

Celestial Coordinates

- Positions in sky measured using two angles:
  - Declination δ (celestial latitude): position above (+) or below (–) celestial equator, in degrees.
  - Right ascension (RA) α (celestial longitude): position "east" of the *vernal equinox*, where ecliptic crosses equator going north ("up").
    - Measured in hours, not degrees (1 h = 15 deg). Why? Intimate association between time, longitude, and RA—see next slides!
    - By definition, at local noon "on" the vernal equinox (around March 21), the Sun has coordinates $\alpha = 0^{\mathrm{h}}$, $\delta = 0°$.
  - E.g., the North Star (Polaris) currently has celestial coordinates $\alpha = 02^{\mathrm{h}}31^{\mathrm{m}}48.7^{\mathrm{s}}$, $\delta = +89°15'51''$.

Earth's True Rotation Period

- The average time between local noon and the next local noon is the "mean solar day" = 24 hours exactly.
- But that's not Earth's true rotation period! Why?
  - During the course of a day, Earth moves a little bit (~1 deg) along its orbit, so Earth must rotate a little bit more to bring the Sun back to the same point in the sky.
  - True *sidereal* period ≅ 23h 56m 4s.


distant star
Sun
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Earth
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23 h 56' 04"
a sidereal day
3' 56"
24 h
a mean solar day