

Astronomy 100

Chapter 2 The night sky

Vera Gluscevic

Image: Miguel Claro

Plan for this lesson:

Constellations

Celestial sphere

Apparent motion of stars

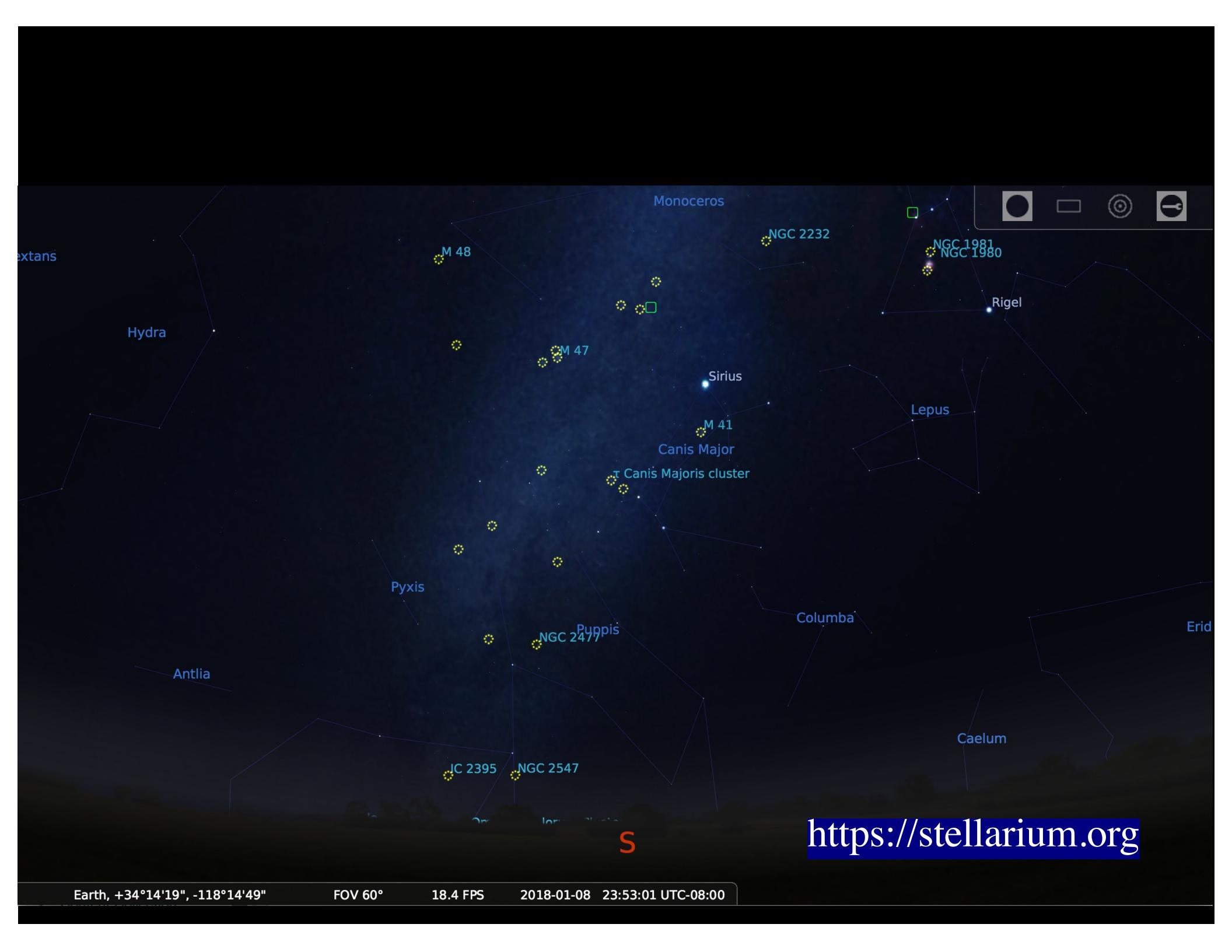
Apparent motion of the Sun

Distance in the sky

Coordinates

Seasons

Precession



<https://stellarium.org>

Constellations

Constellations

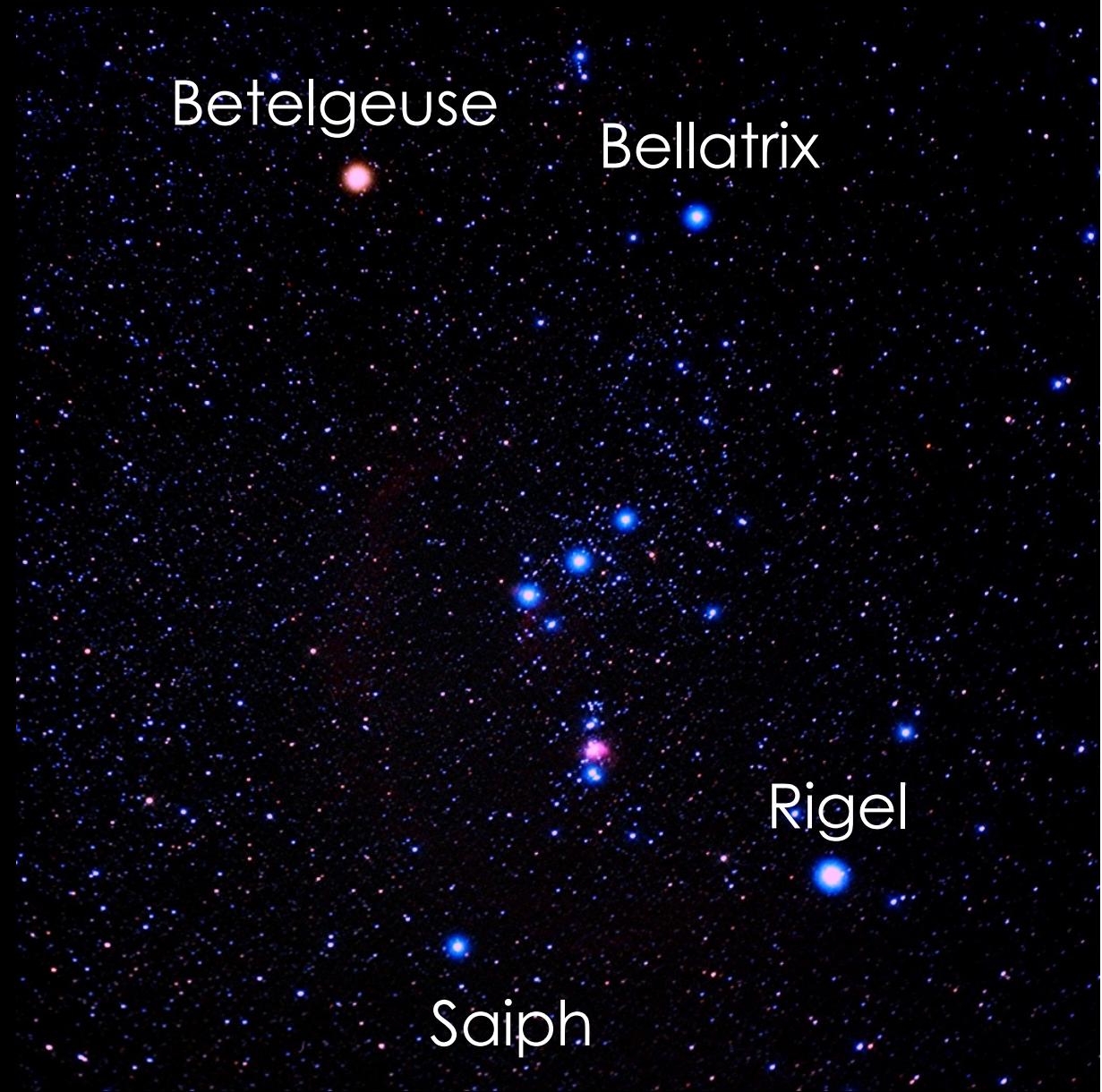


Constellations



Constellation = specific region of the sky with well-defined borders, where ancients saw a star pattern.

Orion: most prominent in winter months



Canis Major: Orion's hunting dog



Constellations



Shaula

Scorpius

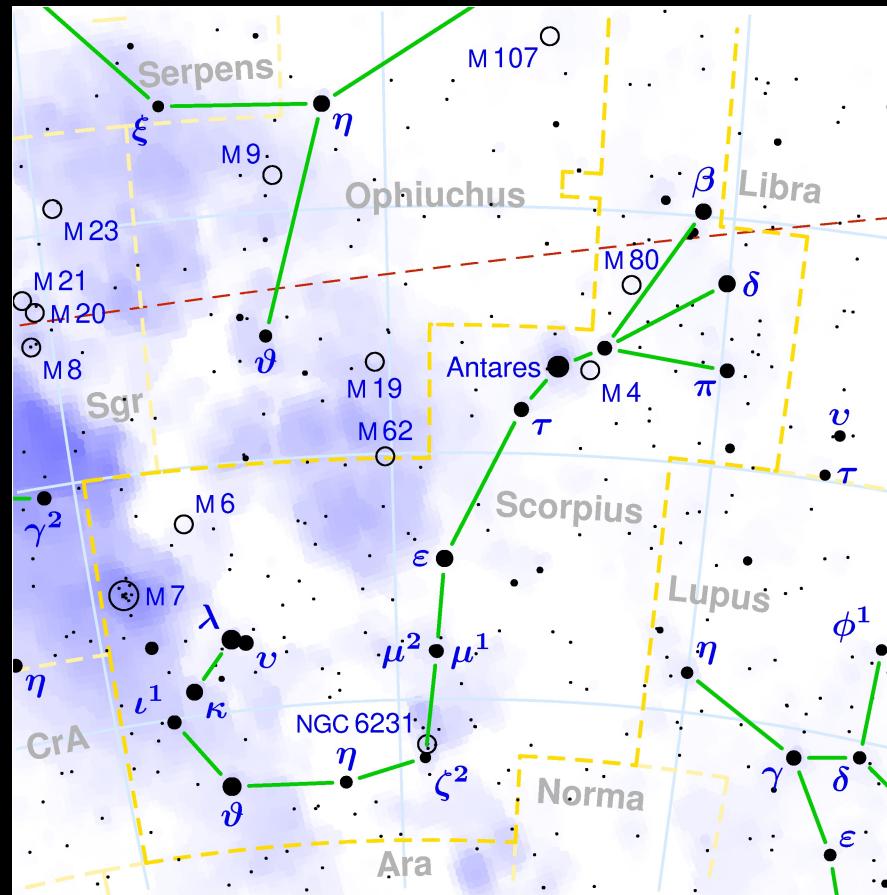
α -Scorpiids

Antares

Lupus

Constellations are specific regions of the sky with well-defined borders, centered on the “Greco-Roman” star patterns.

Constellations



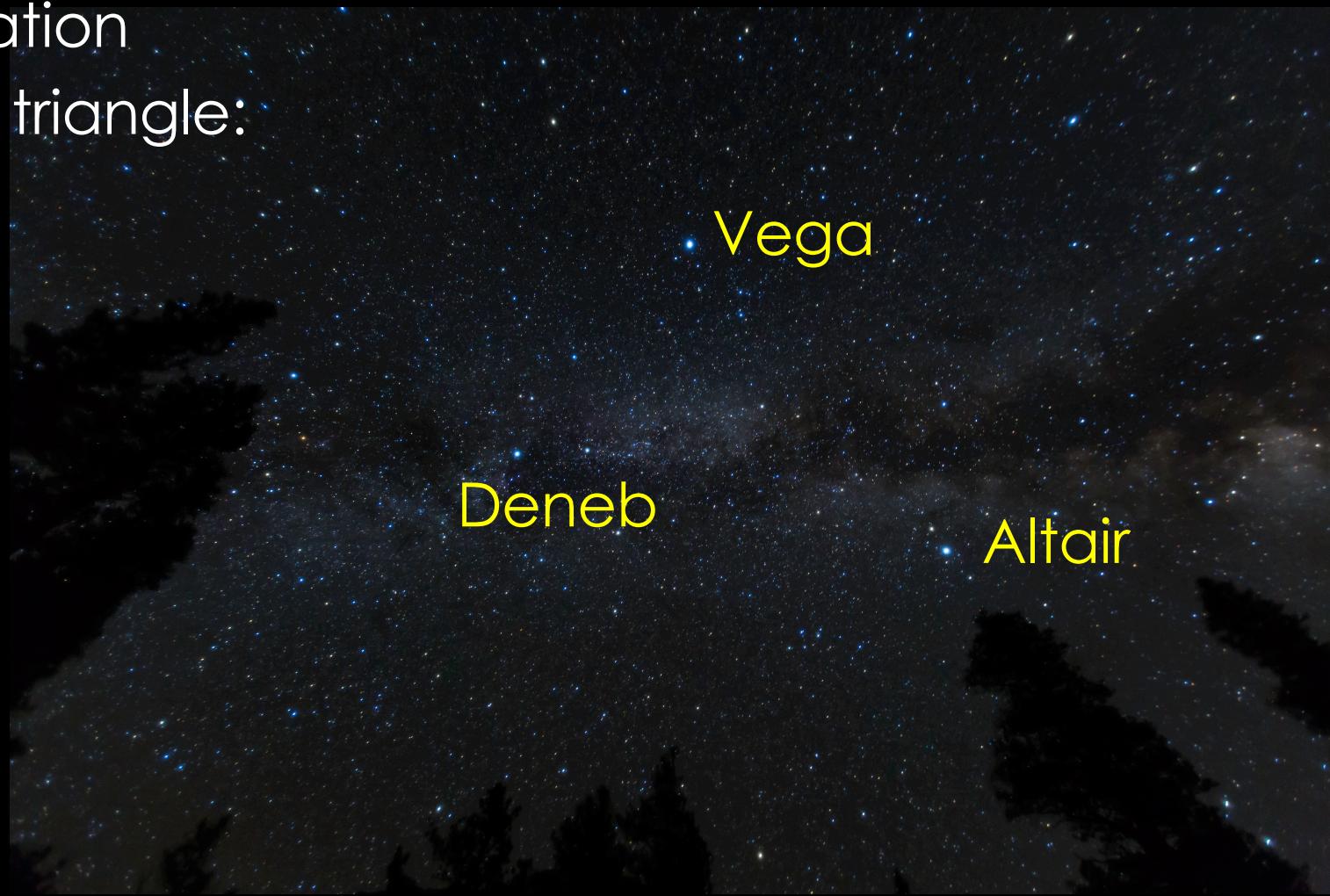
88 astronomical constellations are specific regions of the sky with borders defined by the International Astronomical Union, and they cover up the sky.

Constellations

- Northern constellations have Latinized Greek-mythology names: Orion, Cygnus, Leo, Ursa Major, Canis Major, Canis Minor, etc.
- Southern constellations have Latin names: Telescopium, Sextans, etc.

Constellations vs. Asterisms

- An asterism is a pattern of stars that is not an official constellation, or is only part of a constellation
- Summer triangle:



Ursa Major includes the “Big Dipper”

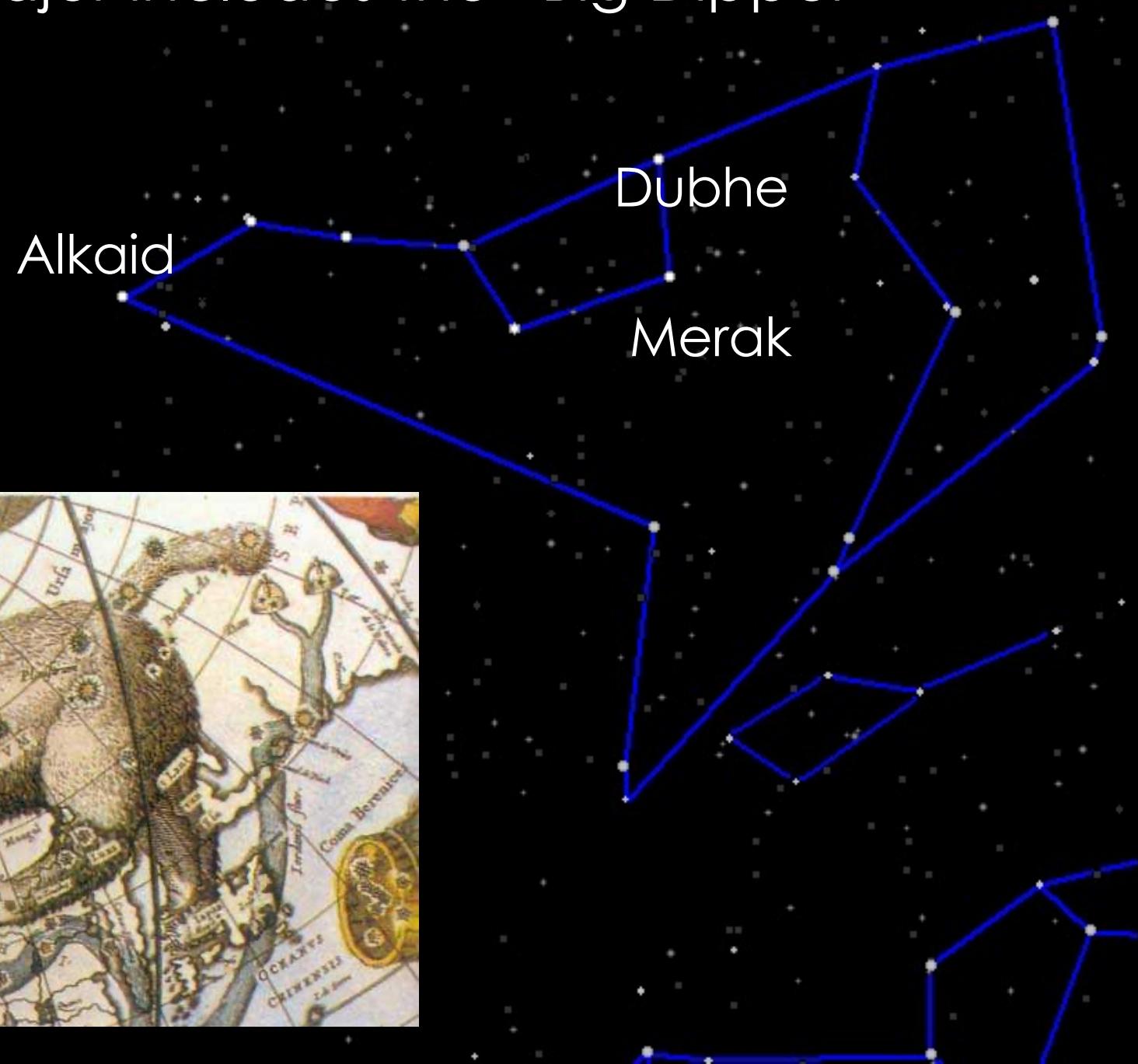




Image: Miguel Claro

question for you



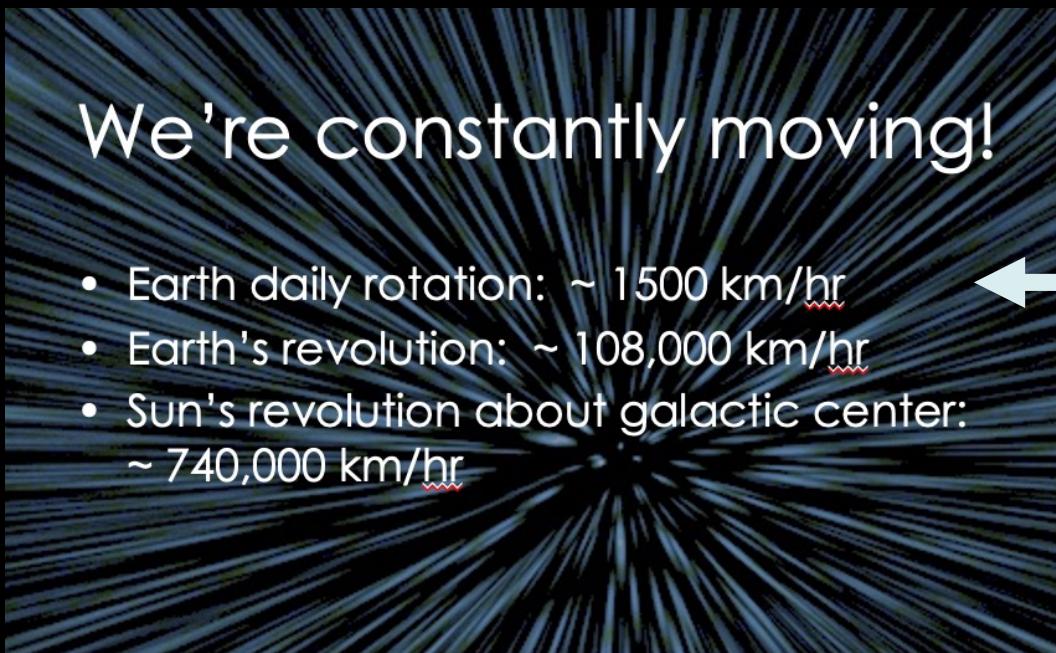
Imagine you are in Argentina, and you are facing South, as shown by your compass. What side of the world is to your right?

- A. South.
- B. East.
- C. West.
- D. I have no idea.

Celestial sphere

What do you think?

- Do the stars stay in the same position in the sky all day/night long?
- Do we see the same stars all year round every night?
- Is the daily motion of the Sun different from the stars?



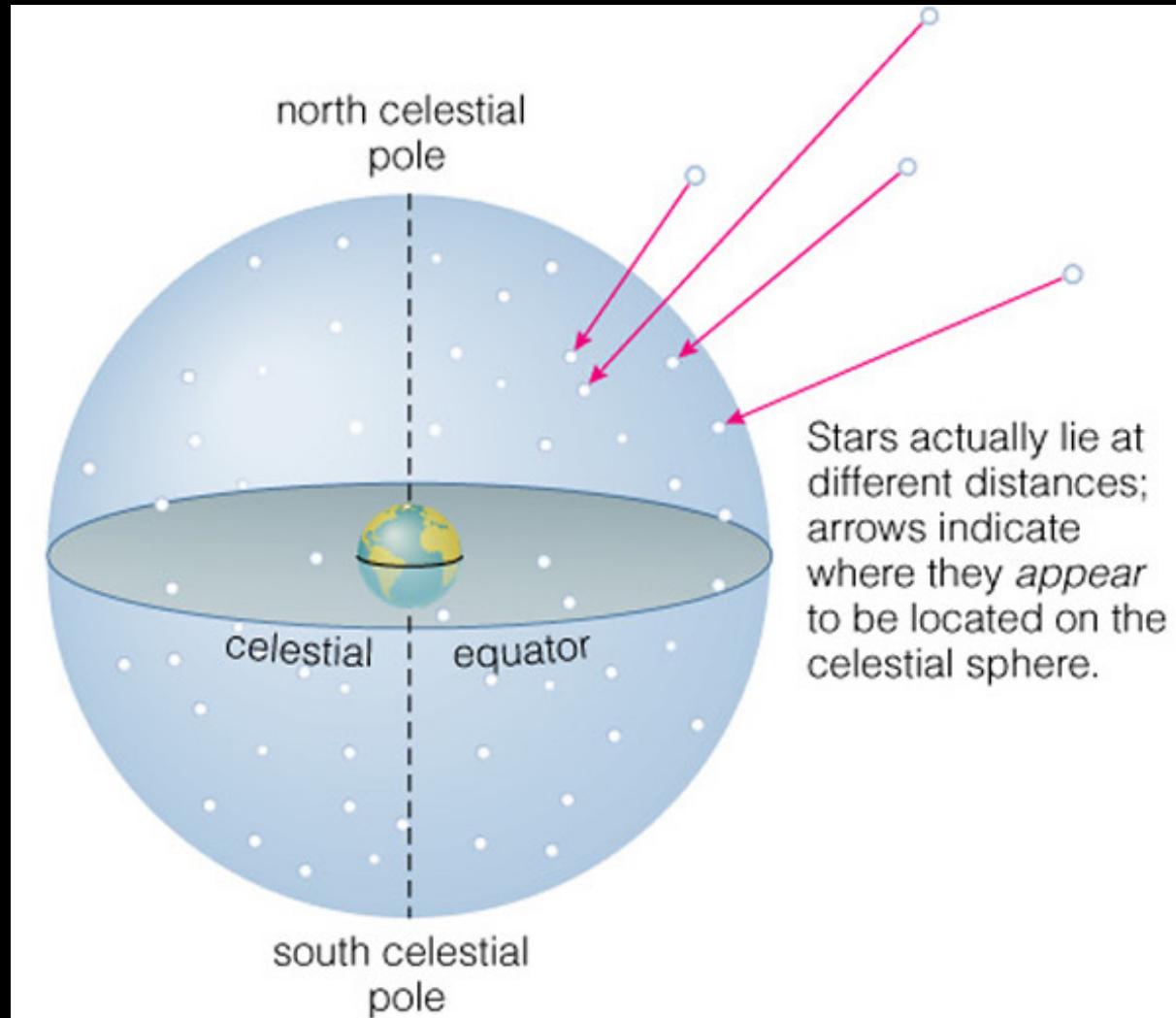
We're constantly moving!

- Earth daily rotation: ~ 1500 km/hr
- Earth's revolution: ~ 108,000 km/hr
- Sun's revolution about galactic center:
~ 740,000 km/hr

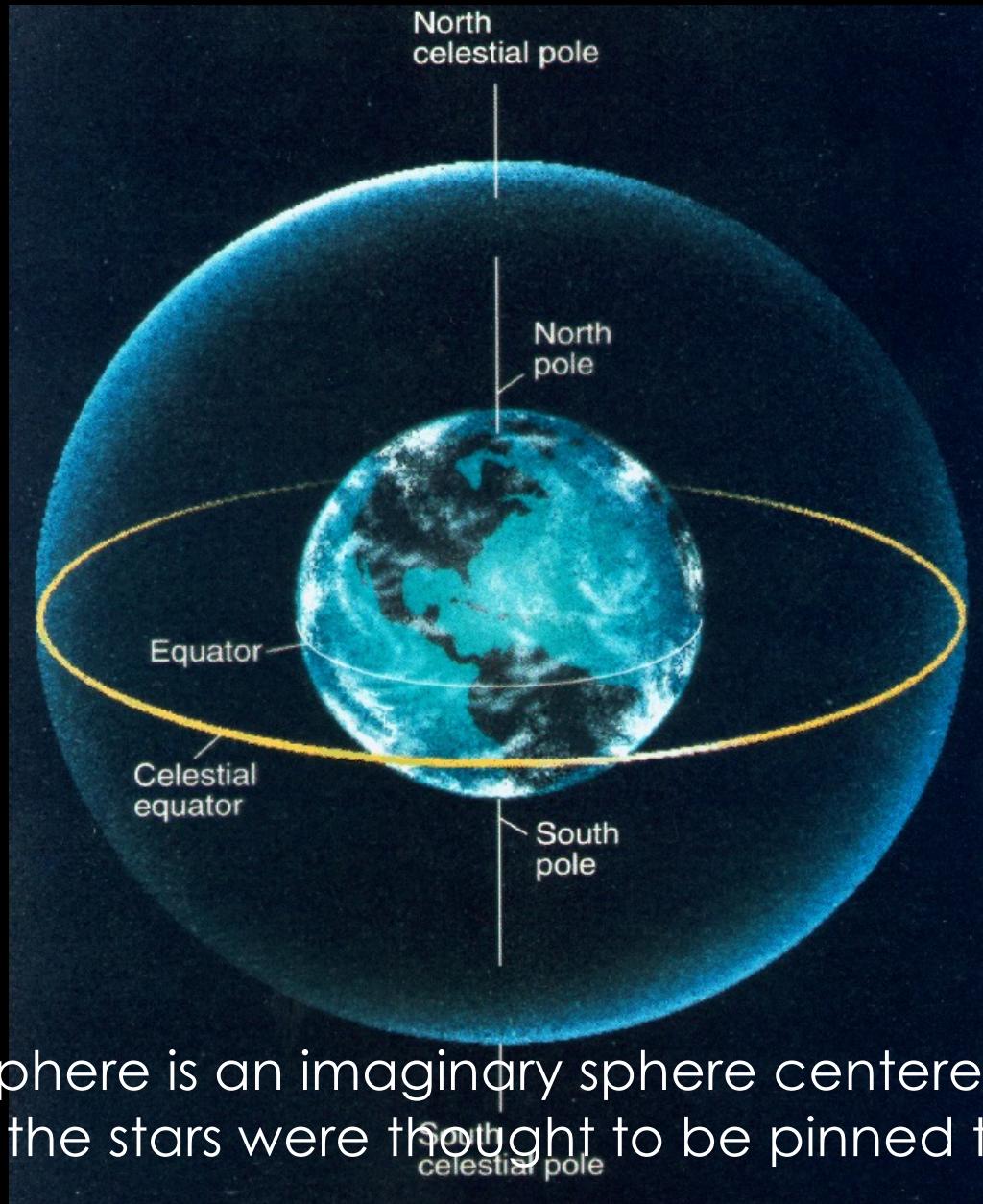


Image: Miguel Claro

The Celestial Sphere



The Celestial Sphere

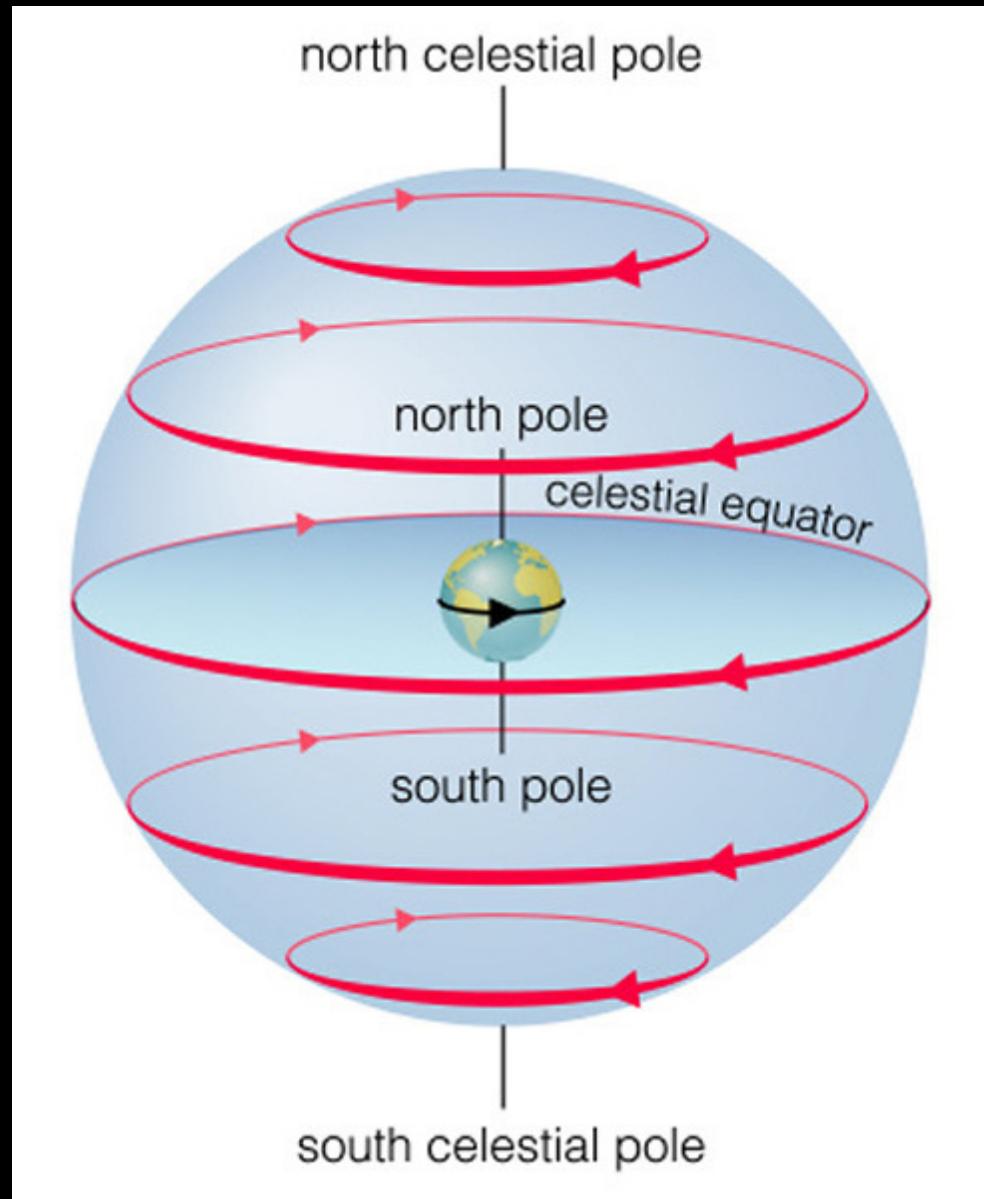


question for you

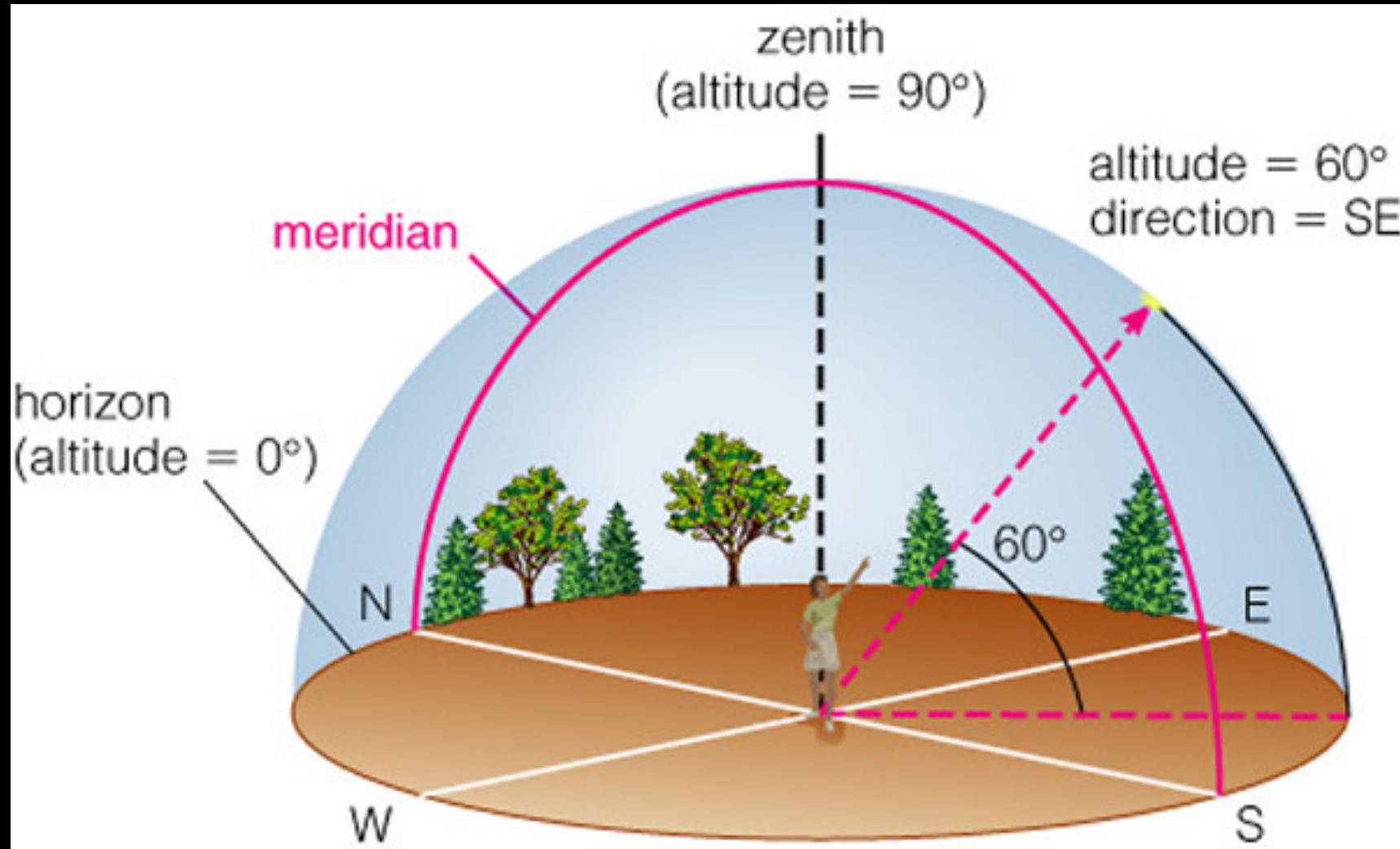


From the point of view of someone on Earth, are stars moving through the day? What shape do their trajectories appear to be?

Earth rotates from west to east, which causes apparent **east-west** rotation of celestial sphere.

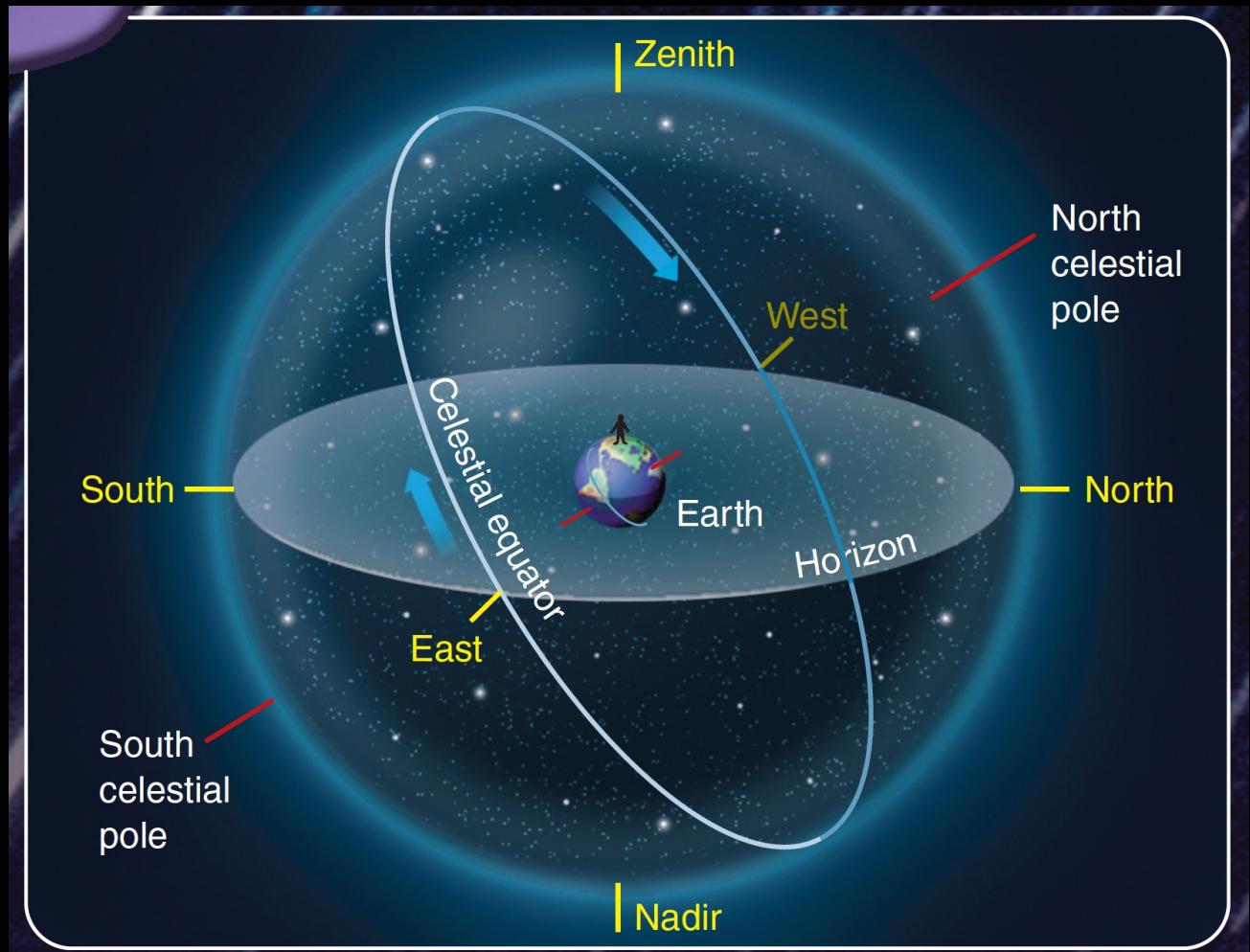


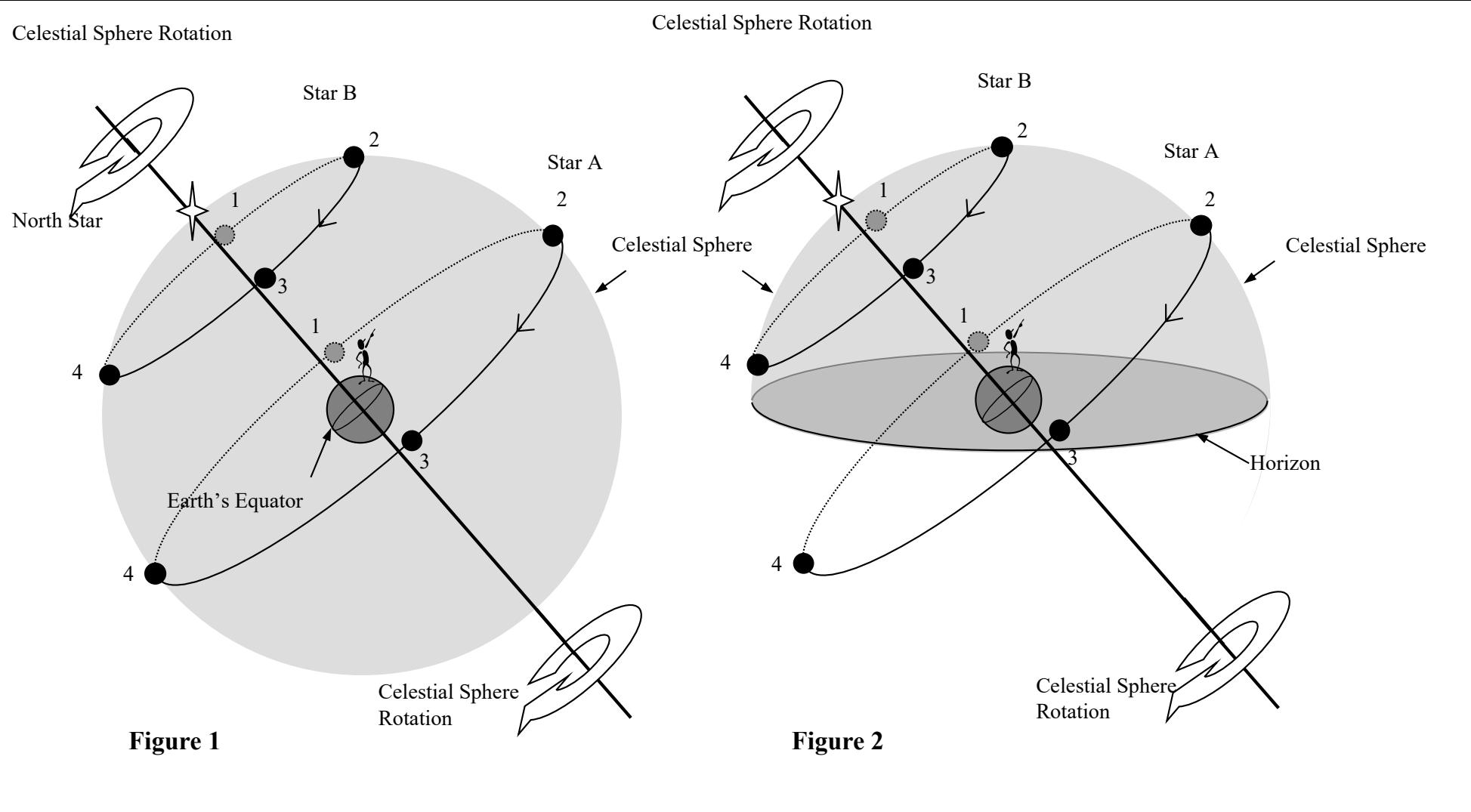
How much of the sphere do we see?



The Celestial Sphere

From an arbitrary location, the celestial sphere projects onto the night sky at an angle.





question for you



In what direction is the observer facing?

- A. South.
- B. North.**
- C. East.
- D. West.
- E. I have no idea.

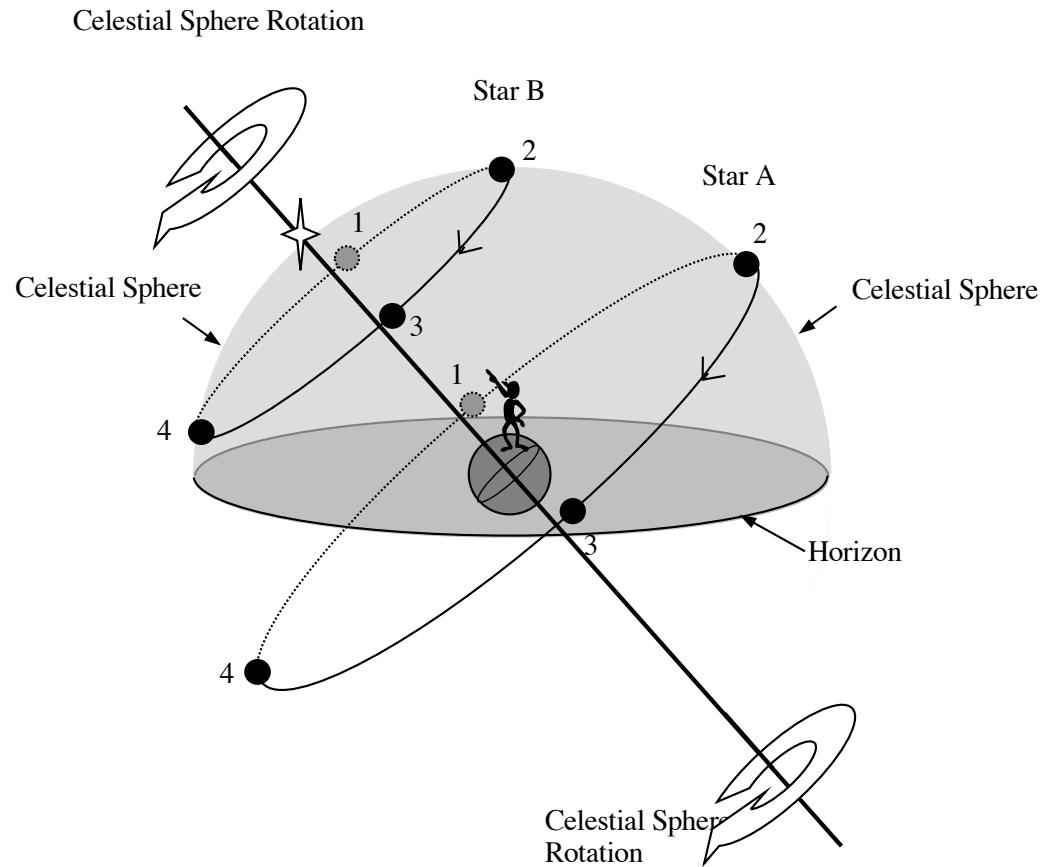


Figure 2

question for you



You observe a star rising directly in the east from LA (point 1). When this star reaches its highest position above the horizon, where will it be?

- A. High in the southern sky.
- B. High in the northern sky.
- C. High in the eastern sky.
- D. Directly overhead.
- E. I have no idea.

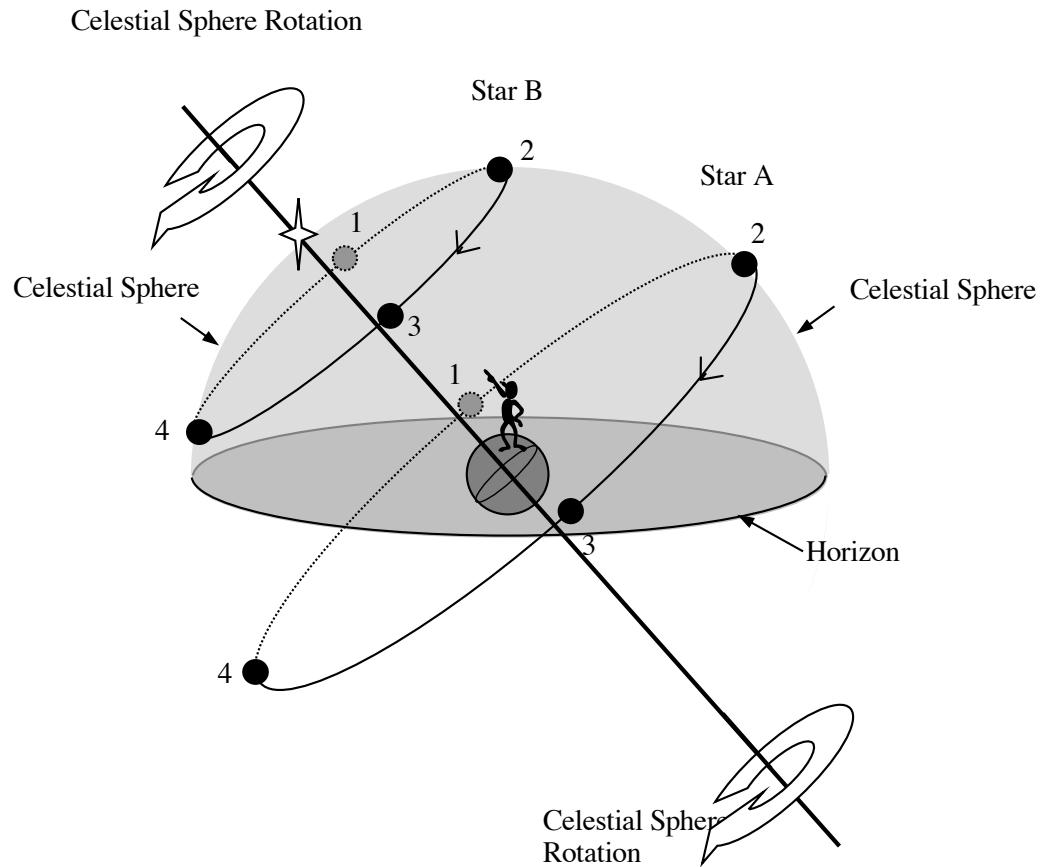


Figure 2

question for you



Where would the observer look to see the star indicated by the arrow?

- A. Northeast.
- B. Southeast.**
- C. Northwest.
- D. Southwest.
- E. I have no idea.

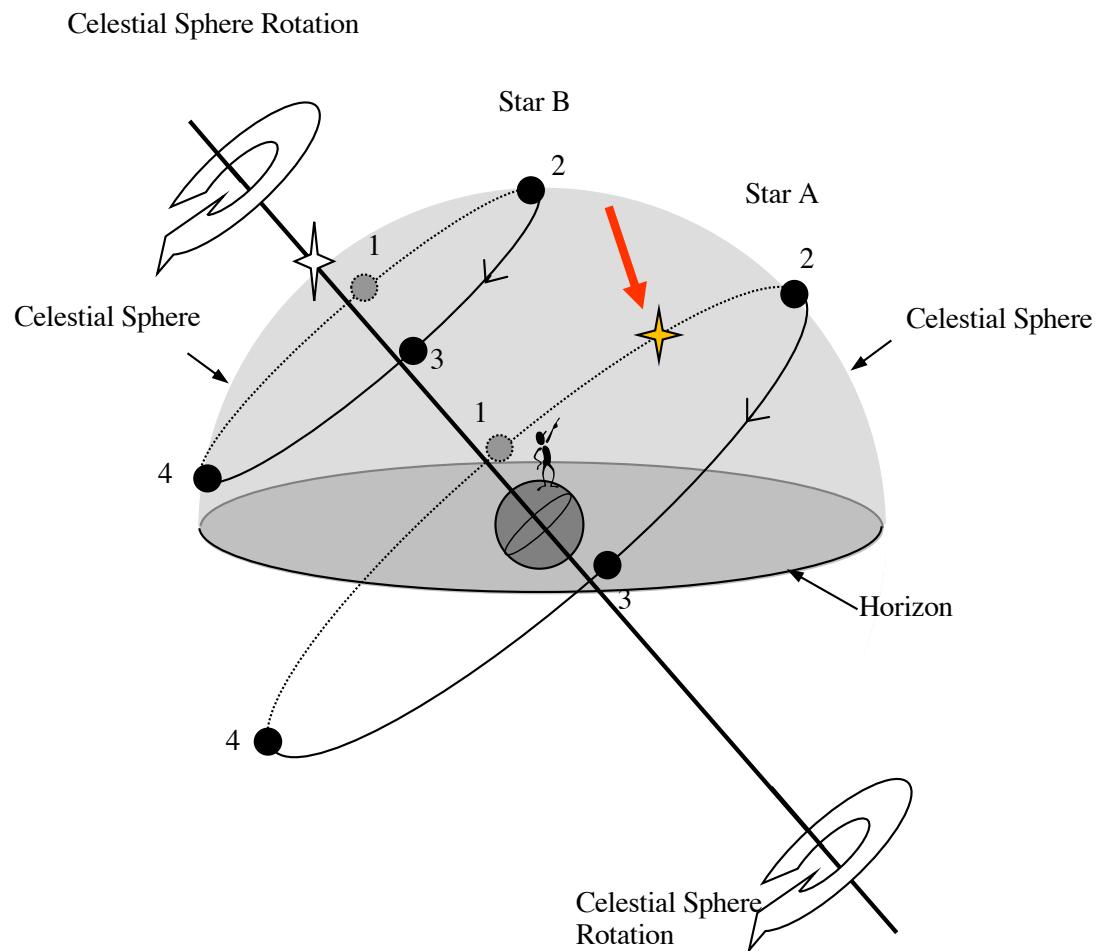
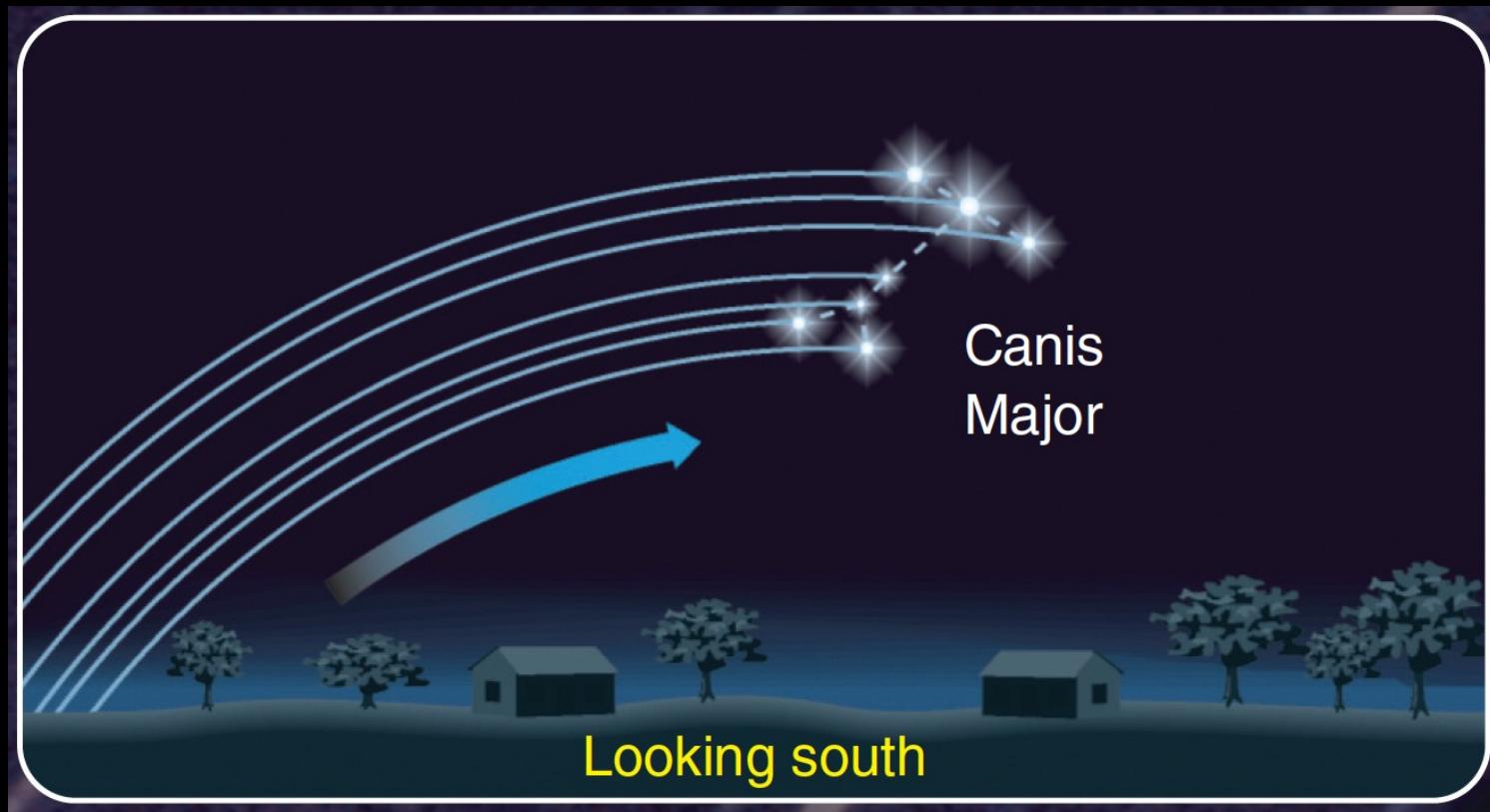


Figure 2

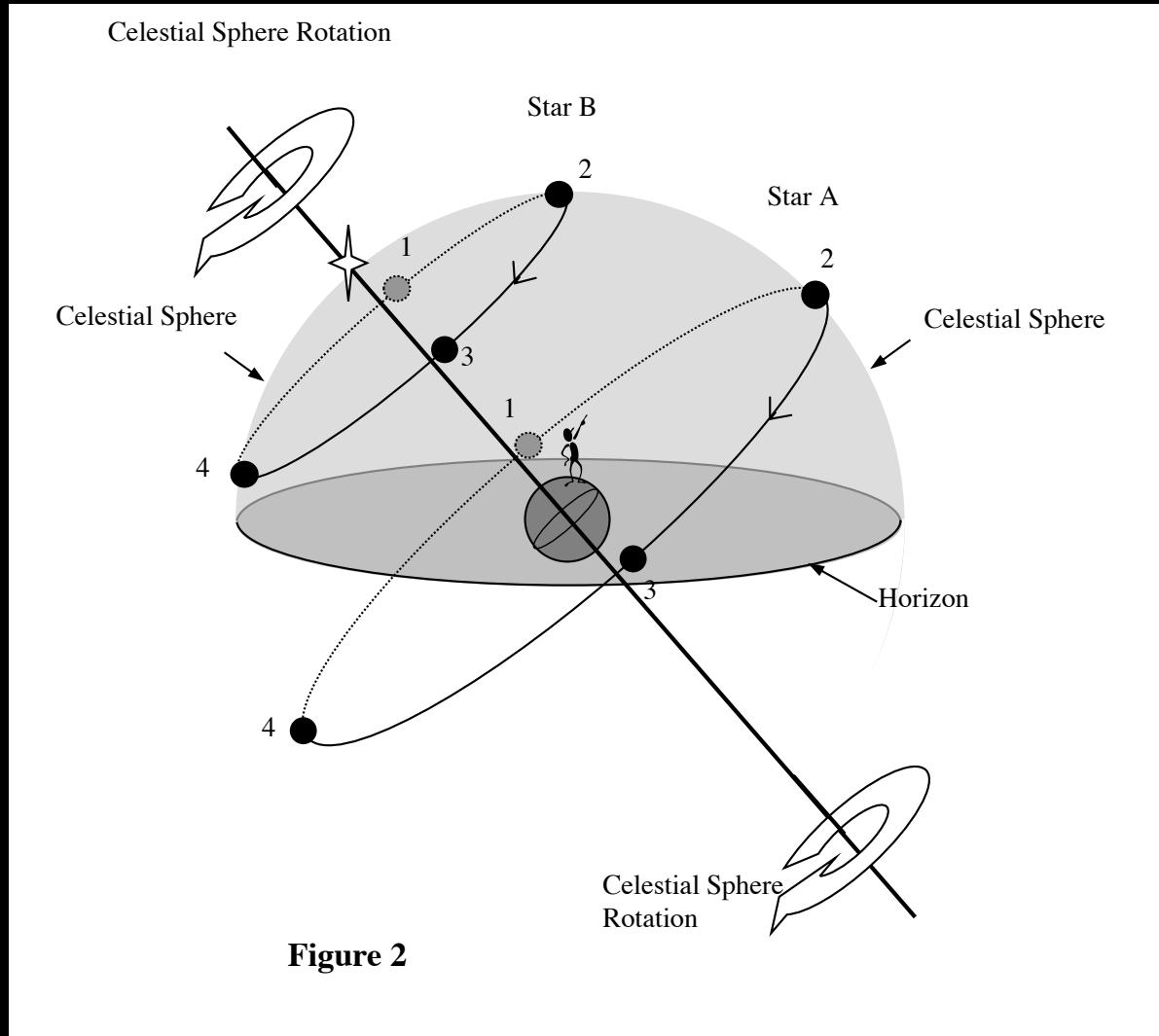
Apparent motion of stars

How do Stars Appear to Move?

Objects appearing in the southern sky first rise near the eastern horizon, move upward and toward the south, and then move down and set near the western horizon.



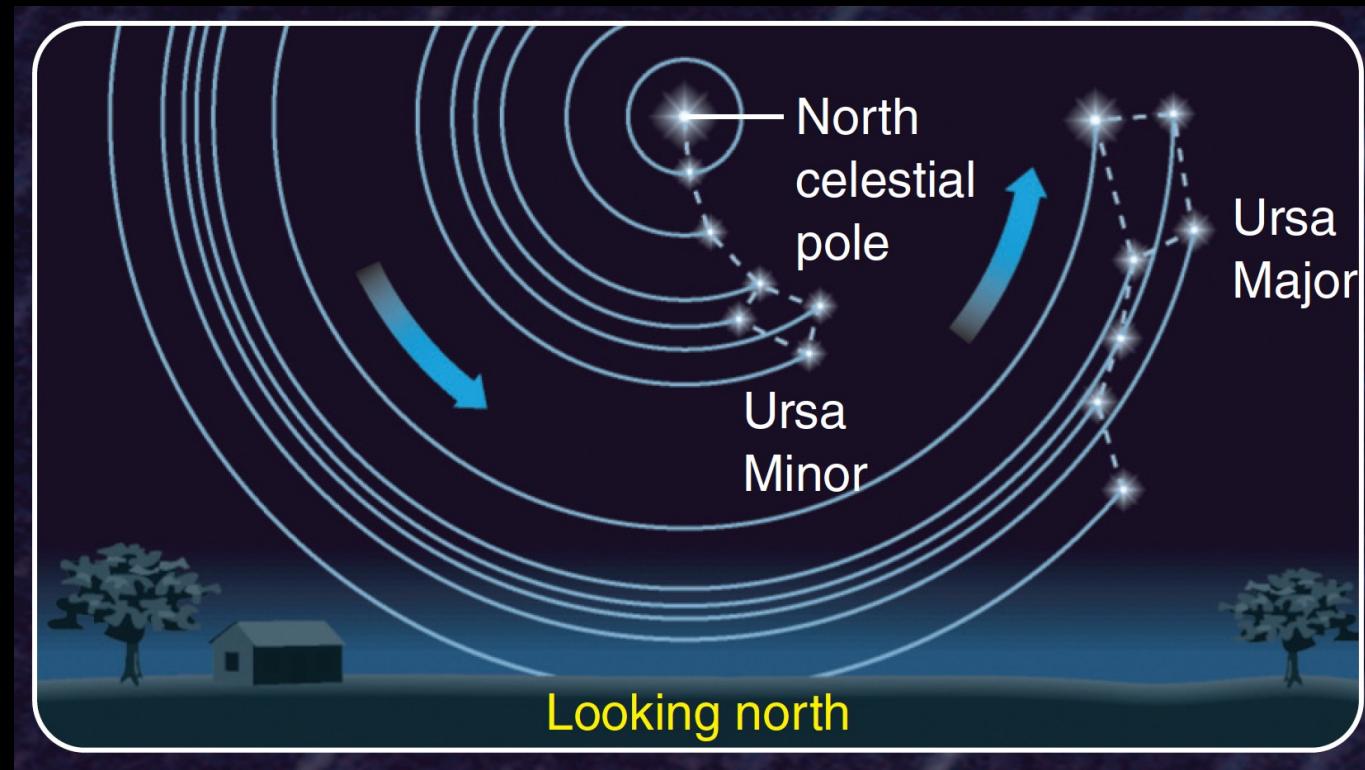
What about the stars in the northern sky?



When does star B set?

How do Stars Appear to Move?

Objects appearing in the northern sky appear to move counter-clockwise around the stationary North Star (Polaris)
—these are **circumpolar stars**. They never rise or set.



question for you



How long is a star above the horizon?

- A. Depends on its position.
- B. Depends on the location of the observer.
- C. A and B.
- D. Exactly 12 hours.
- E. I have no idea.

Celestial Sphere Rotation

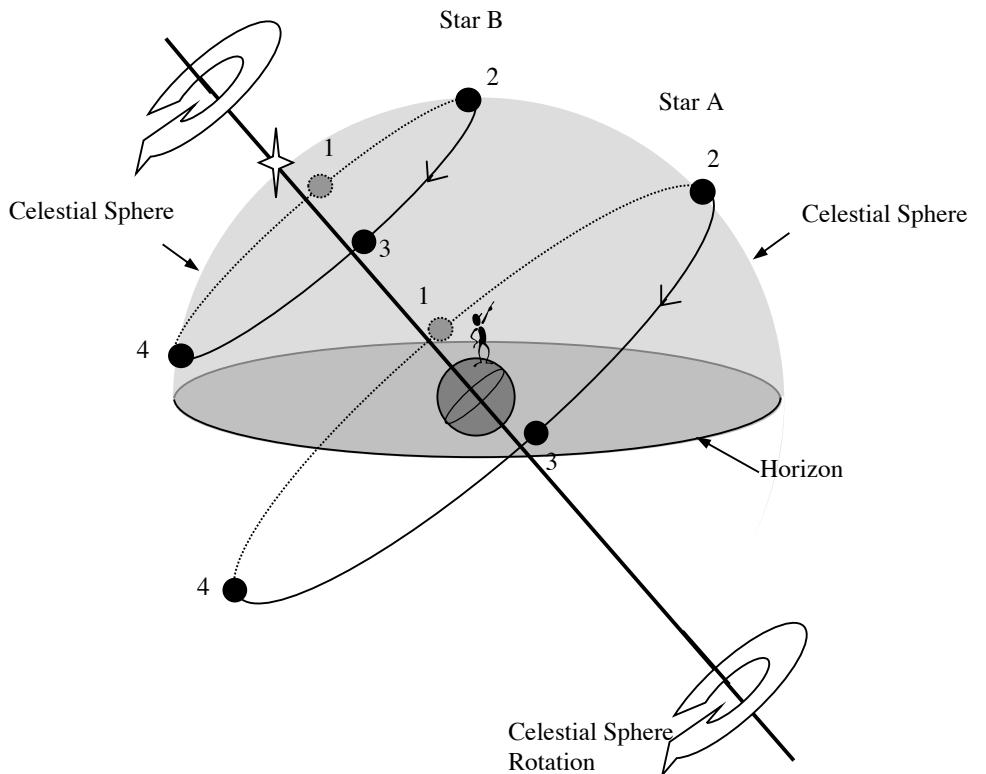
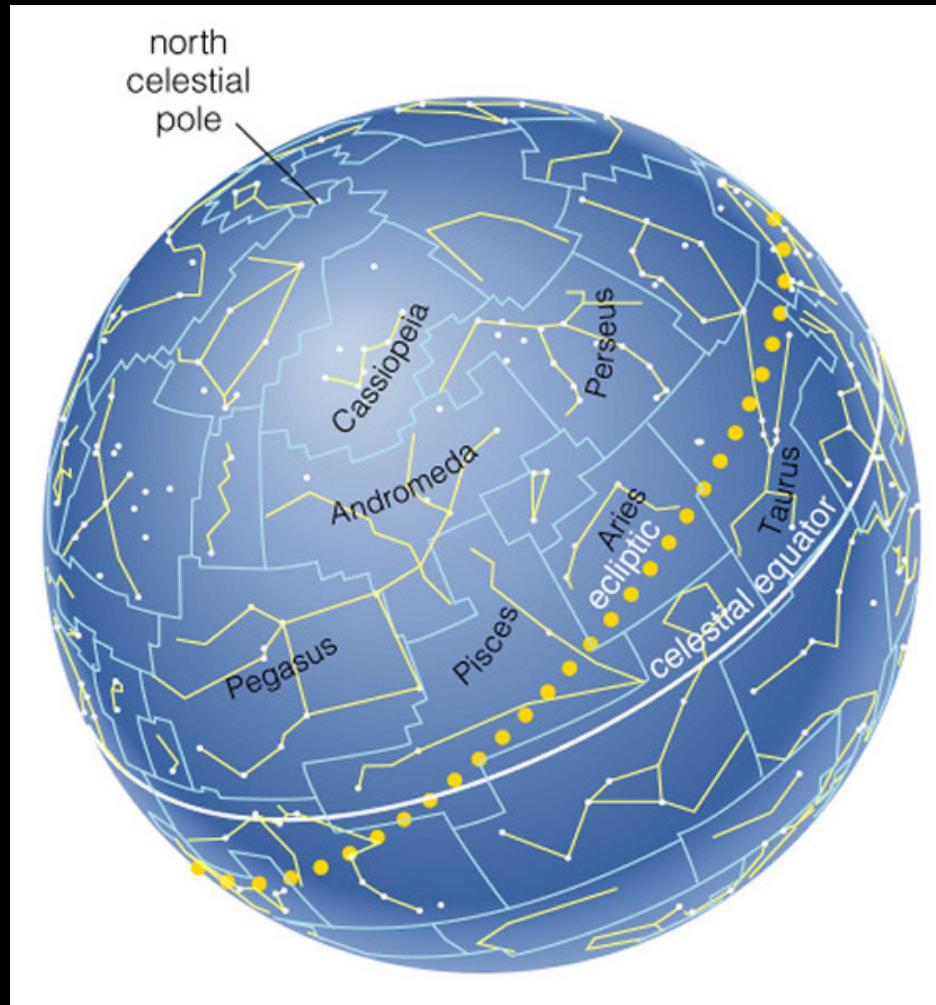


Figure 2

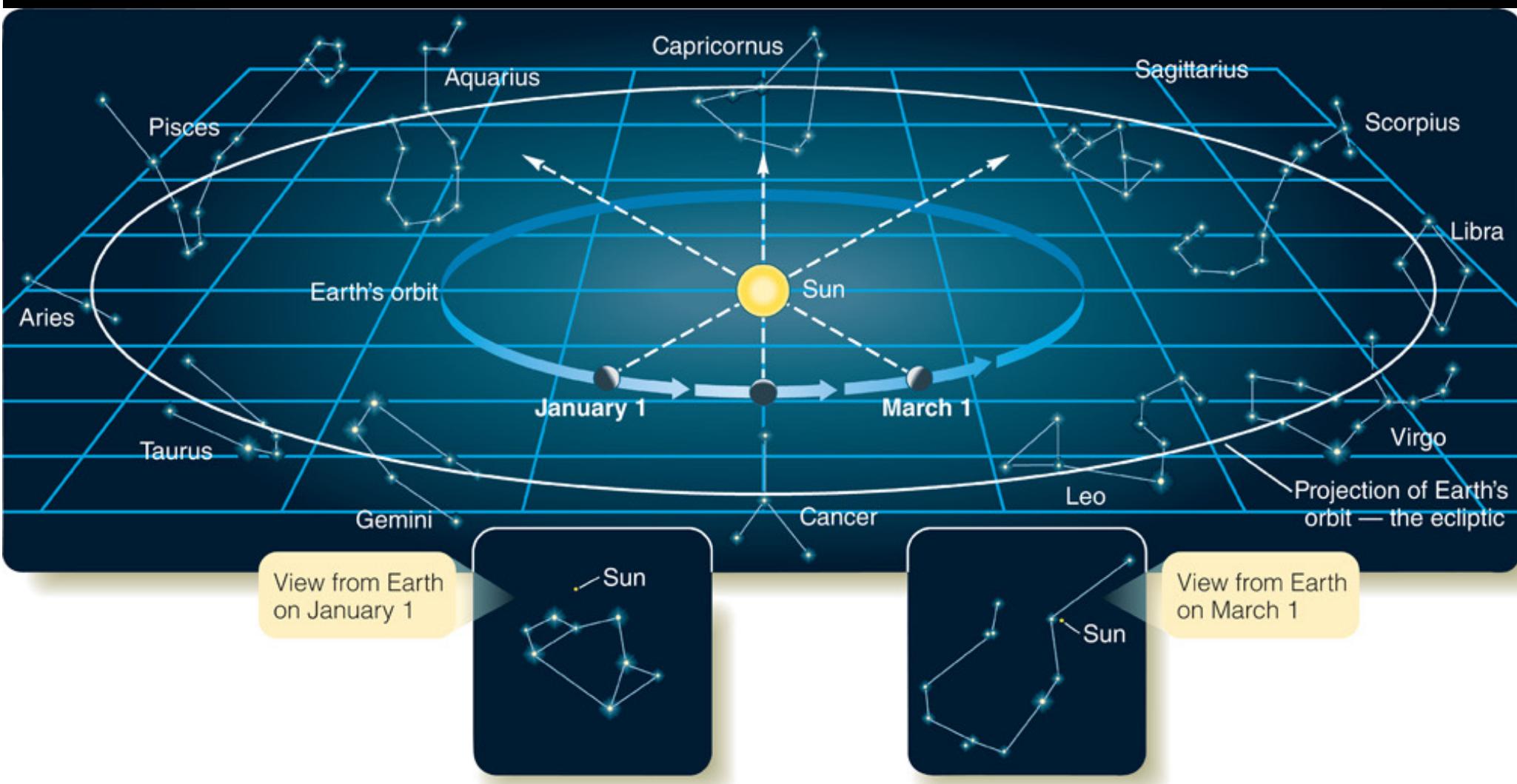
Apparent motion of the Sun

What causes motion of the sun through constellations?

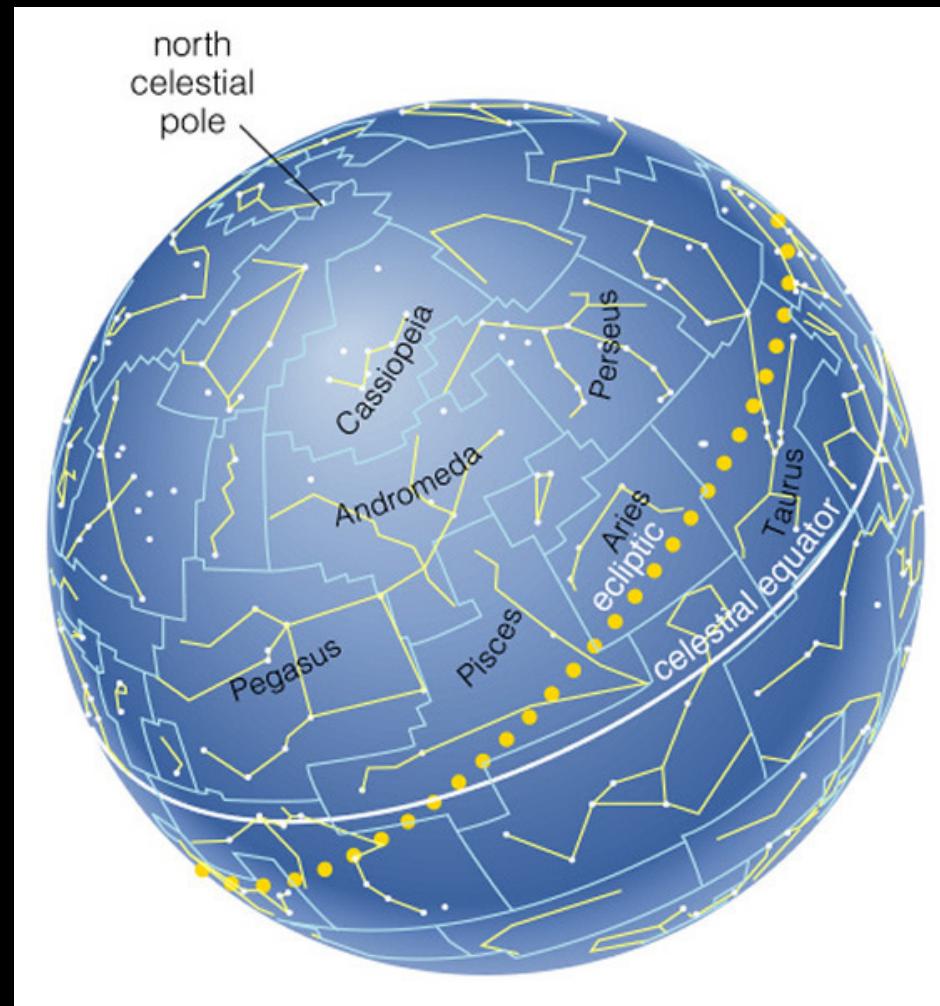


What causes motion of the sun through constellations?

Earth's revolution around the Sun!

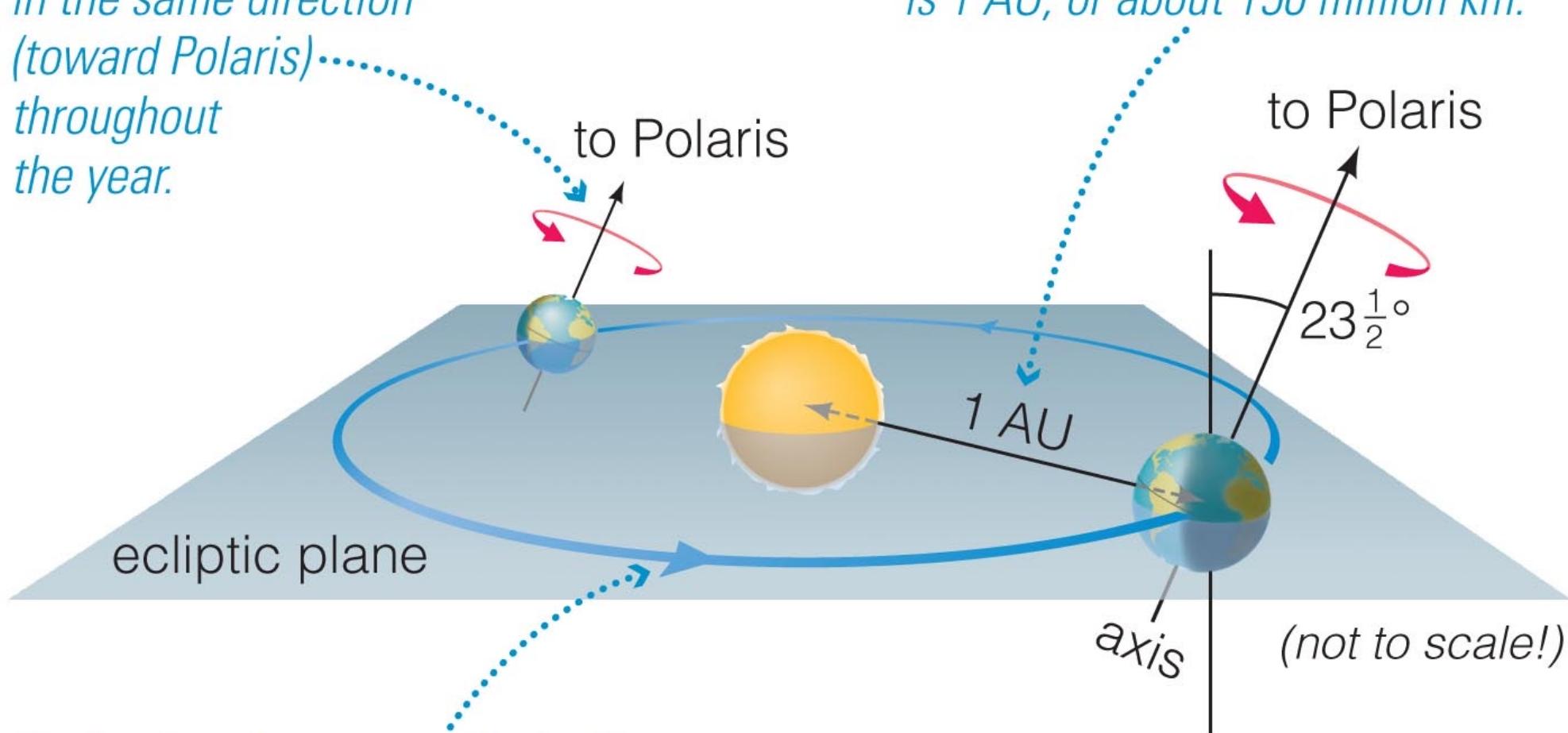


Why is the ecliptic tilted?



Earth's Rotation Axis is Tilted

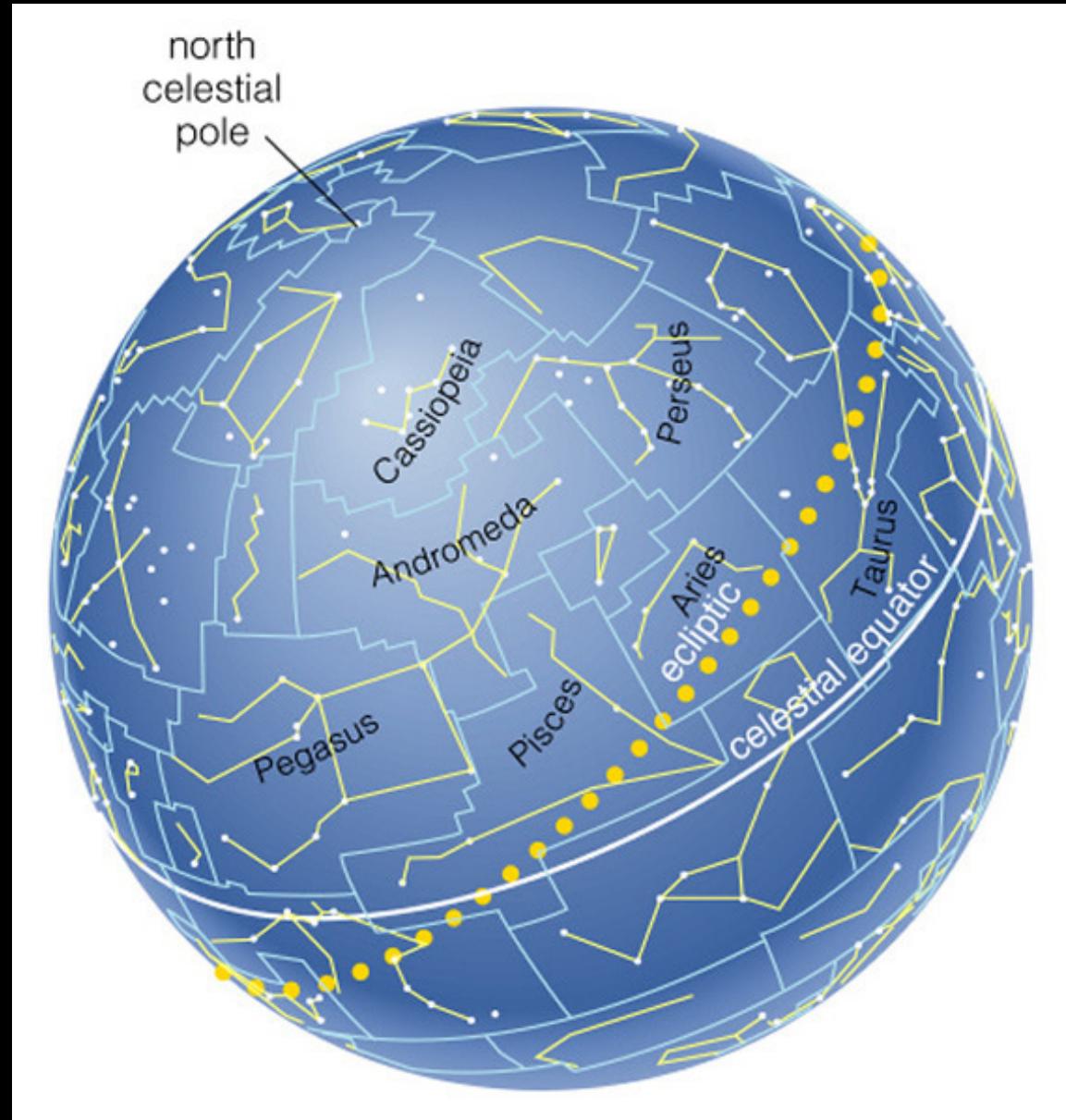
Earth's axis remains pointed in the same direction (toward Polaris) throughout the year.



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

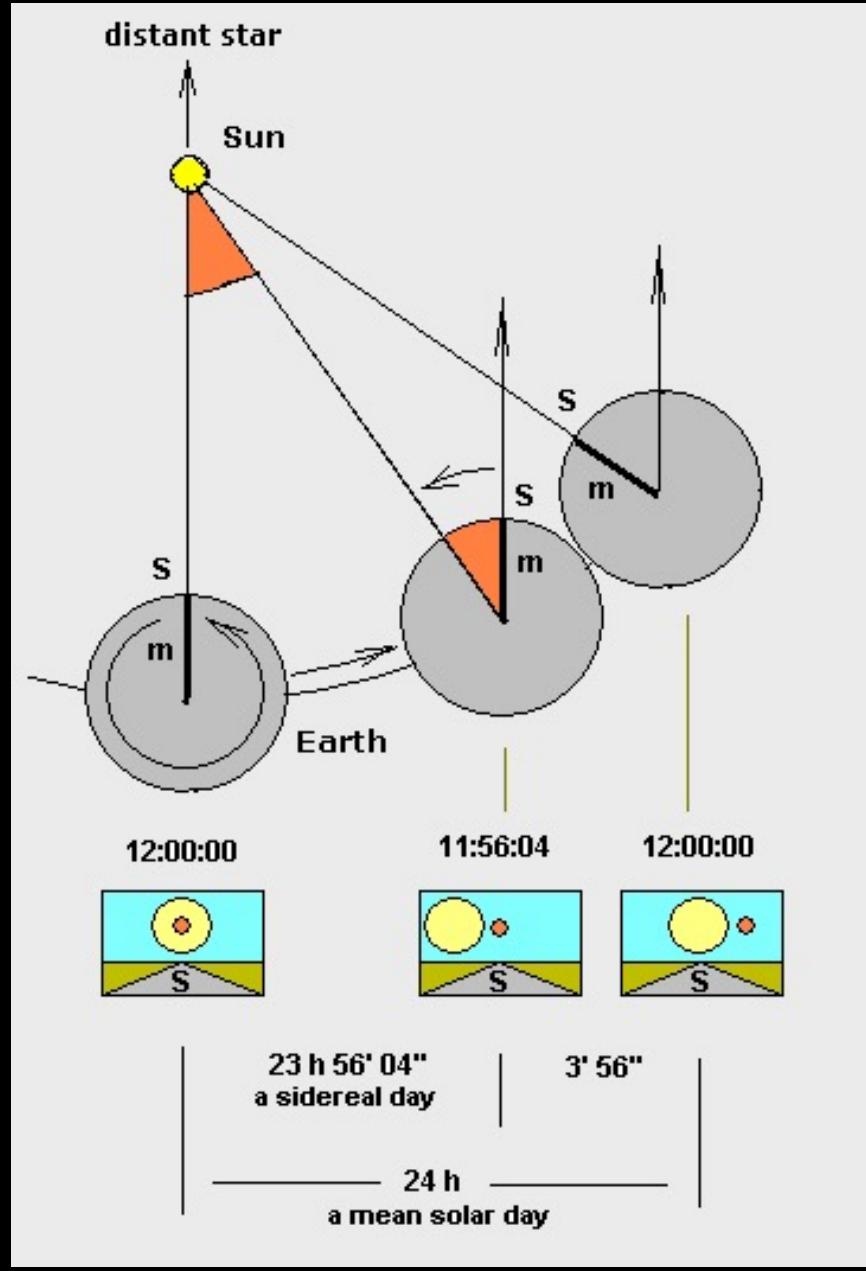
The Ecliptic

- The Ecliptic is the path the sun follows as it circles the Celestial Sphere once each year.
- Because of the 23.5° tilt of Earth's rotation axis, the ecliptic crosses the celestial equator at this same angle.



How long is a day?

- A **solar day** is 24 hours, which is the time it takes the sun to make one circle on the sky.
- A **sidereal day** is 23 hours and 56 minutes long, and is the time it takes for stars to make a full circle on the sky.
- A **star will rise 4 minutes earlier each day**, or 2 hours earlier after one month.



The Night Sky at 10:00pm



Four Minutes Earlier Each Night...

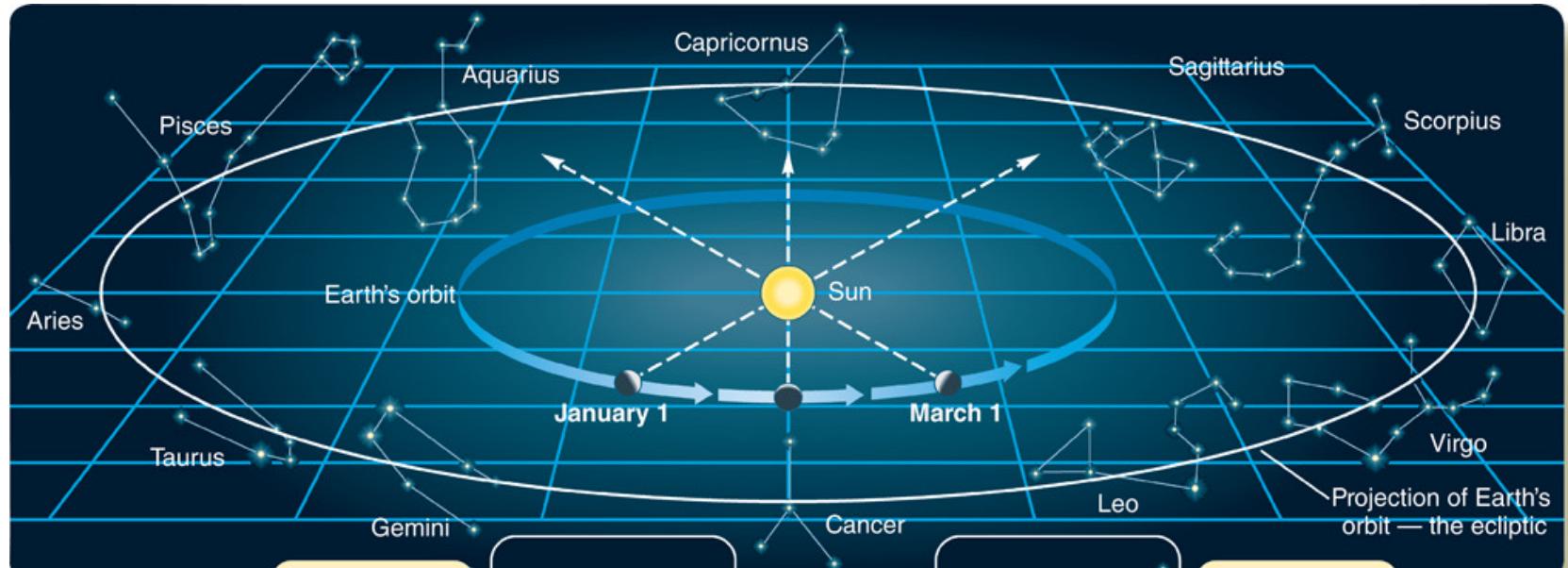


question for you



Which constellation is highest in the sky at midnight on March 1?

- A. Aquarius.
- B. Leo.
- C. Cancer.
- D. Capricornus.
- E. I have no idea.



question for you



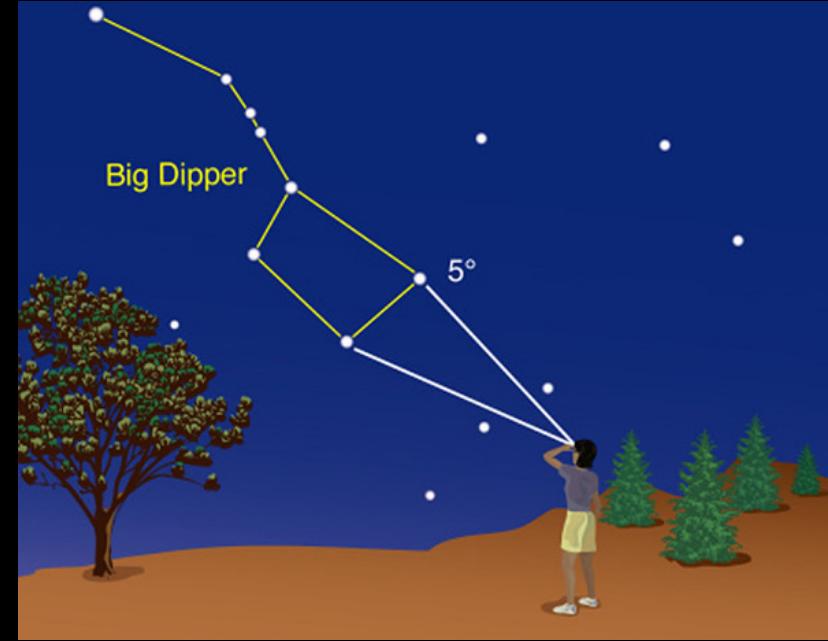
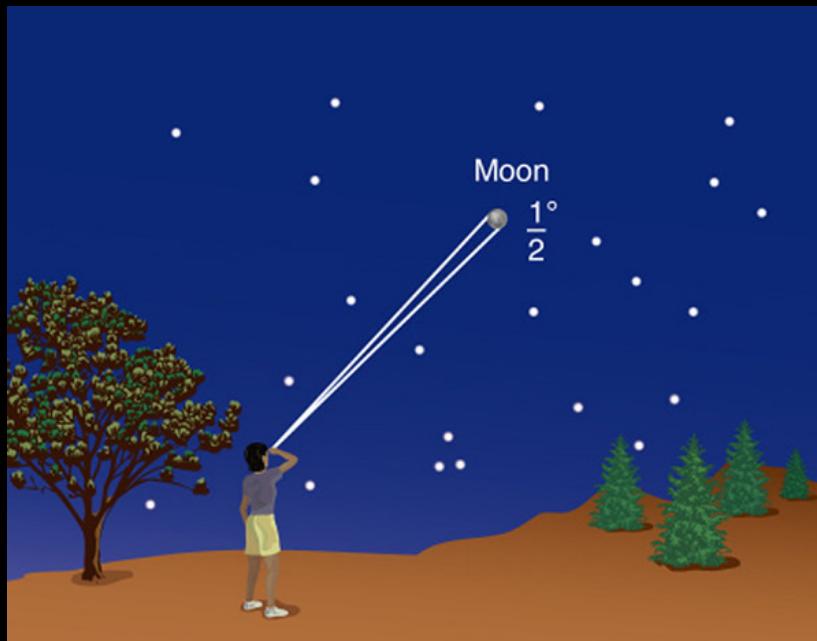
If a star rises at midnight today (January), what time will it rise in 1 month from now (February)?

- A. 1am
- B. midnight
- C. 11pm
- D. 10pm
- E. I have no idea.

Size and distance in the sky

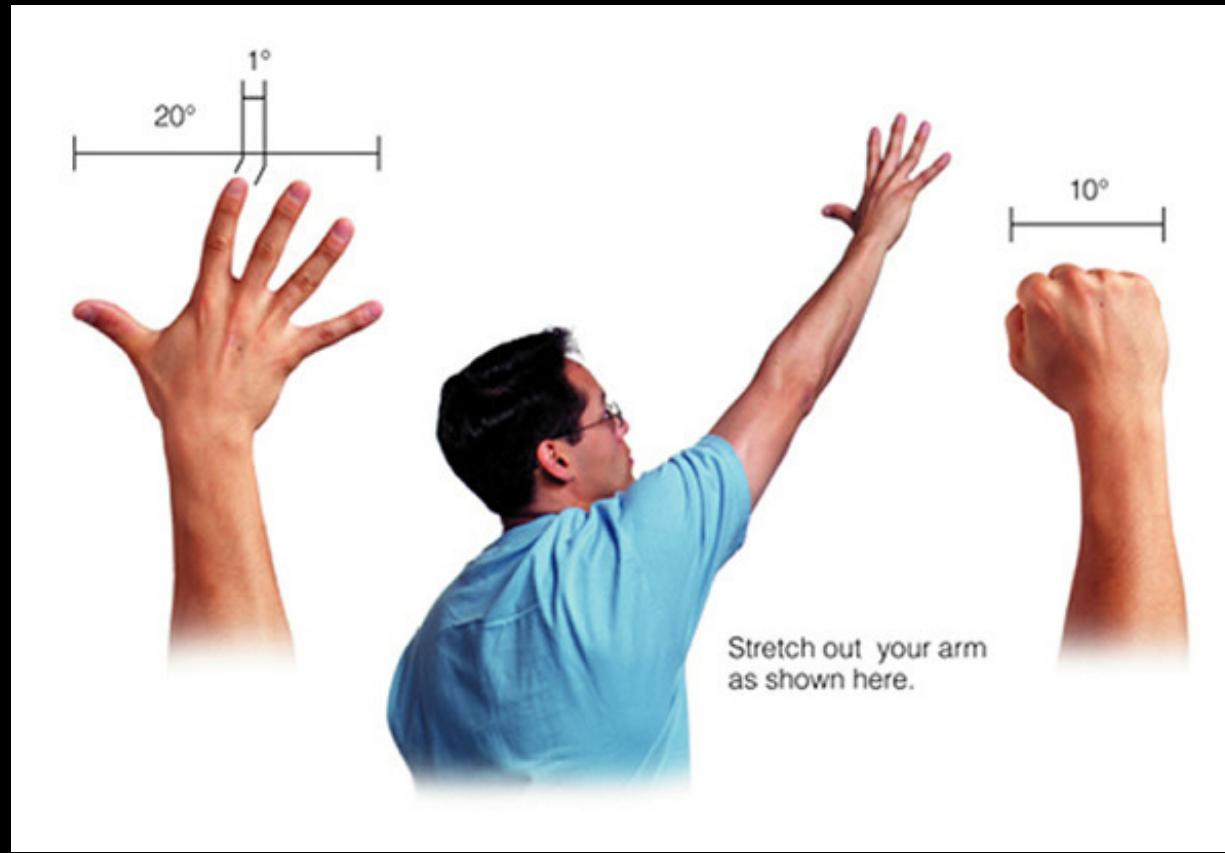
Angular Size and Angular Distance

- The **angular size** of an object is the angle that it appears to extend across in the sky.
- The **angular distance** between two objects is the angle separating them.



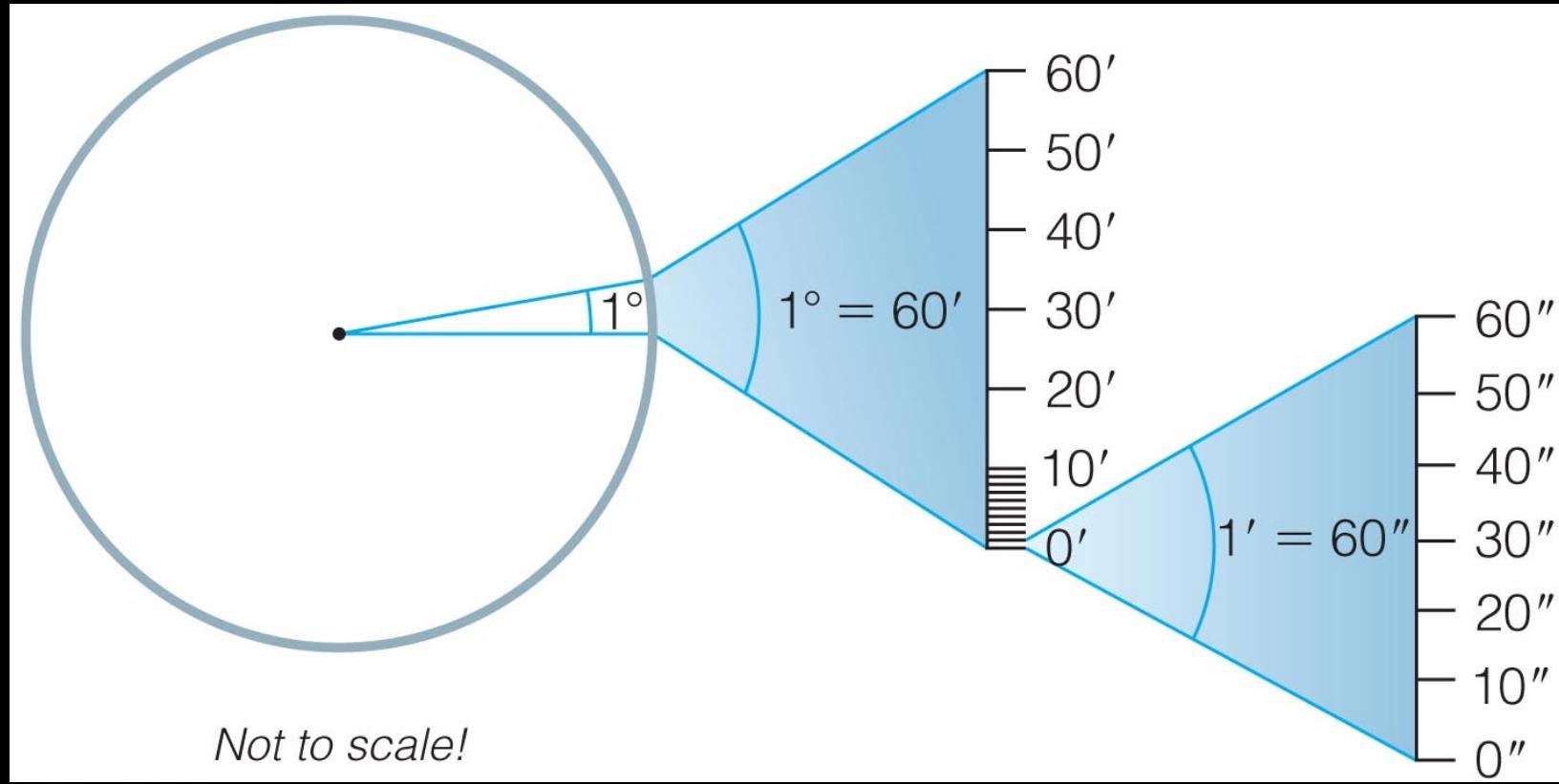
Estimating Angles

With your hand outstretched, the span of your hand is approximately 20° , your fist measures 10° , and one finger measures 1° .



Degrees, Minutes, Seconds

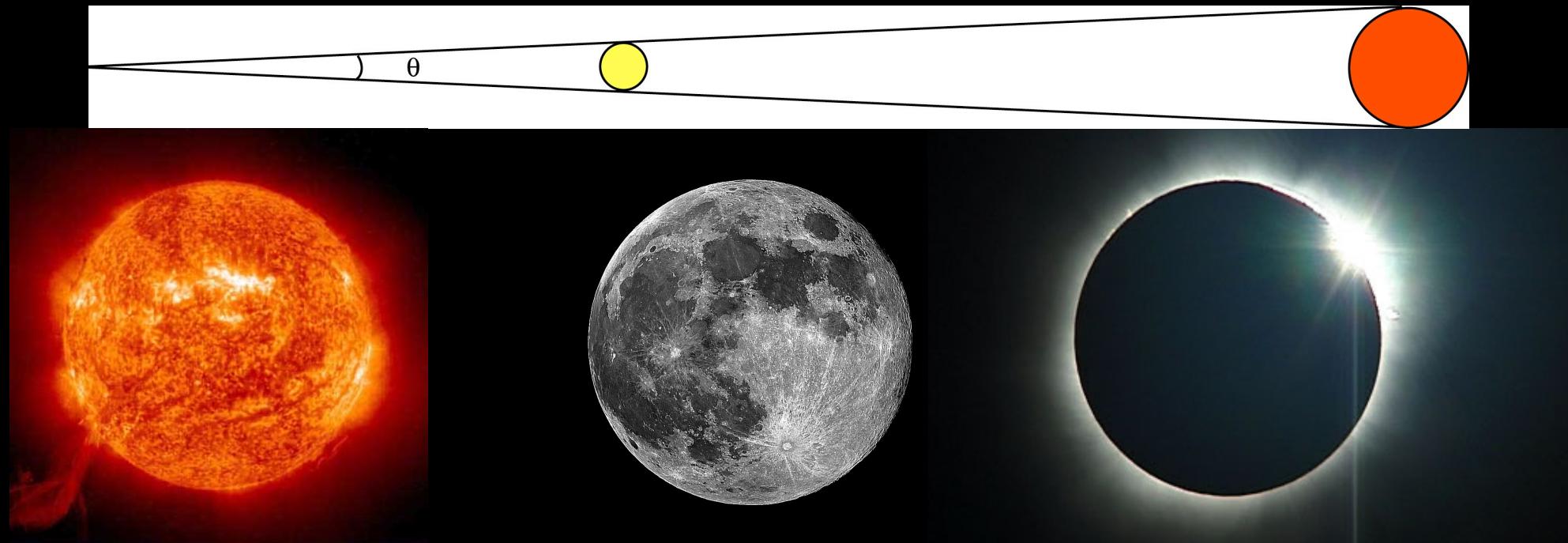
- Angles are measured in degrees ($^\circ$), arcminutes('), and arcseconds(''), or alternatively, in radians (rad).
- A circle has 360° (or 2π radians), each 1° has $60'$, each $1'$ has $60''$.



Angular Size vs. Actual Size

Objects may have the same angular size, but may be different in actual size because of the difference in distance from the observer.

$$\alpha = \text{Diameter}/\text{distance}$$



question for you



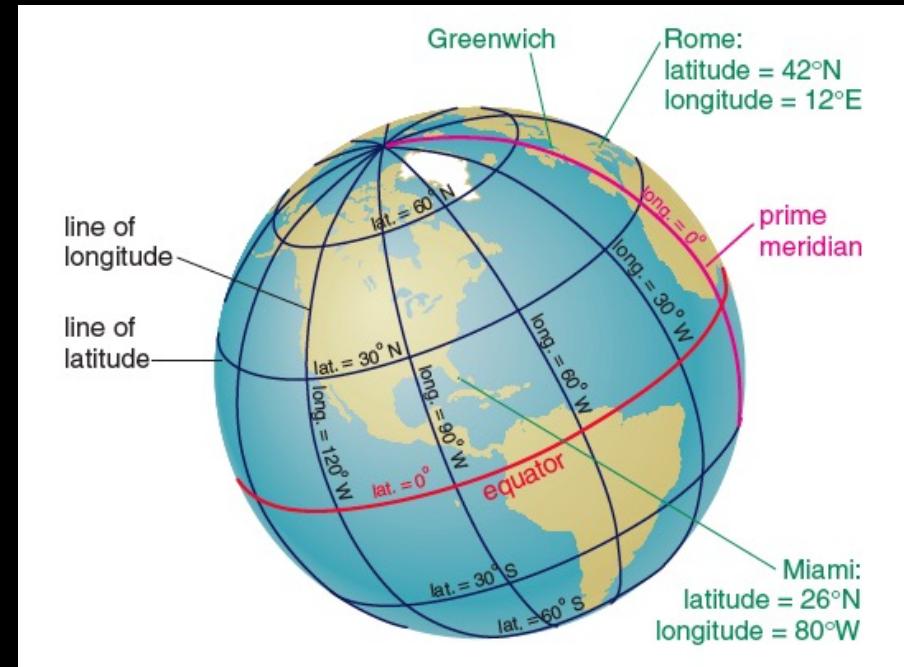
If the Moon is 400 times smaller diameter than the Sun, how much closer is it?

$$\alpha = \text{Diameter}/\text{distance}$$

Coordinates on a sphere

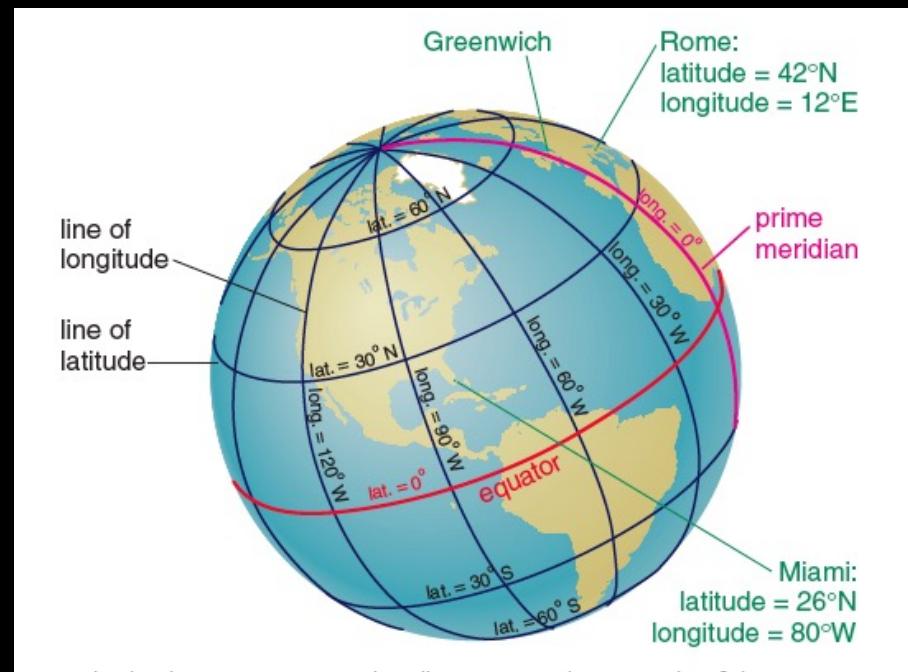
Latitude and Longitude

- Latitude is measured north and south, in degrees, from the **equator** (0°).
- North pole is $+90^{\circ}$ or 90° North, south pole is -90° or 90° South.
- Los Angeles is 34° North latitude.



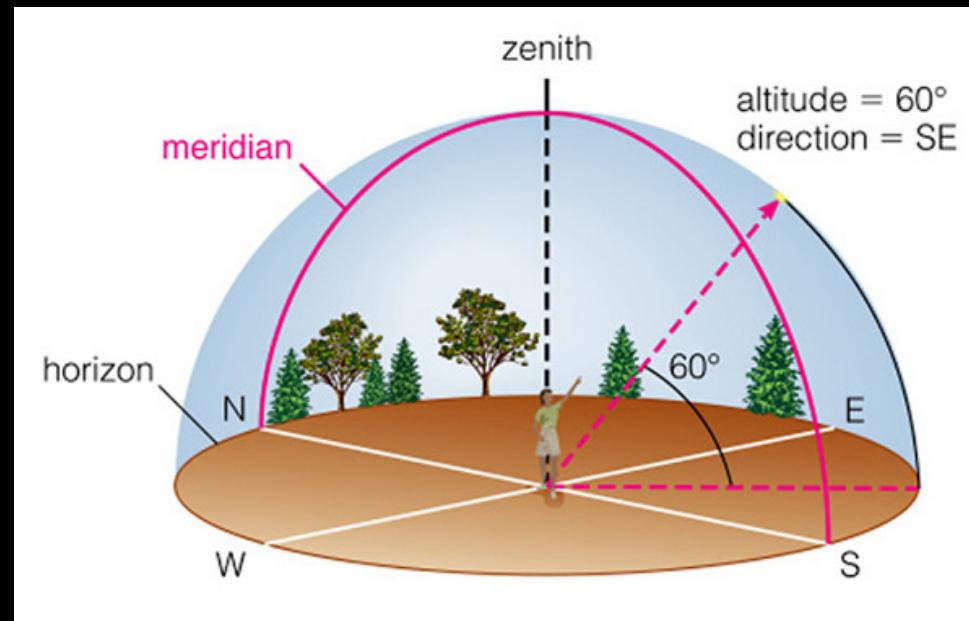
Latitude and Longitude

Longitude is measured east and west, in degrees, from the **prime meridian**, also known as the Greenwich meridian.



The Local Sky

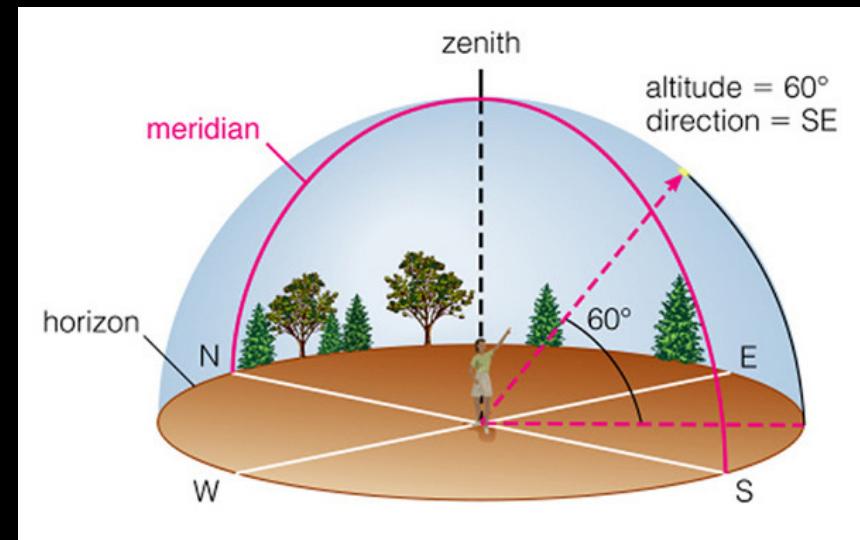
- Point directly above you is your **zenith**.
- Boundary where Earth meets sky is the **horizon**.
- Your **meridian** is an imaginary semicircle stretching from due south to due north, through the zenith.



Pinpointing a location in the sky

Finding a location on the surface of a sphere is done by specifying two angles (like latitude and longitude on Earth):

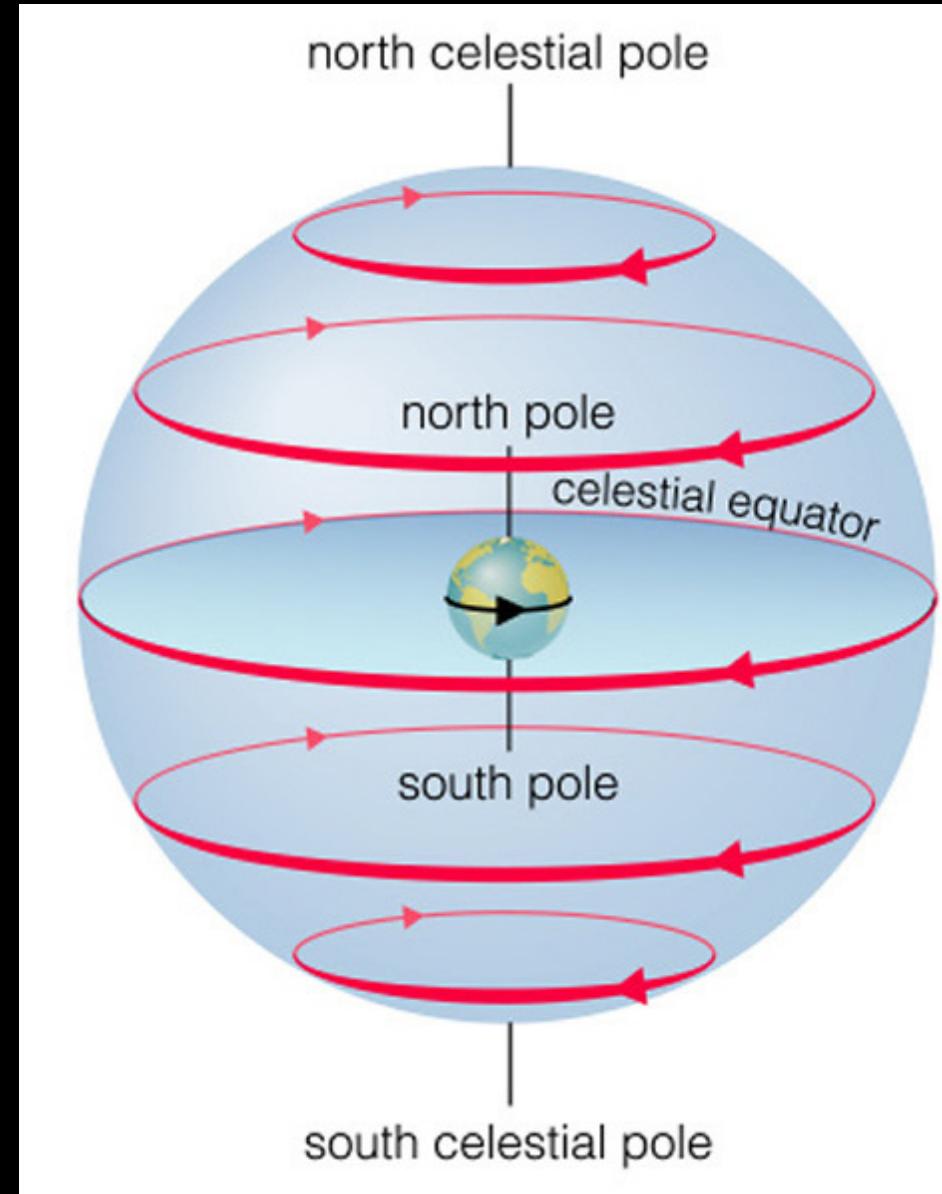
1. **Azimuth**, measured clockwise from North (the compass direction to the point, like North, South, Southeast, etc.)
2. **Altitude**, measured from the horizon (the altitude of objects right on the horizon is 0° , and the altitude of zenith is 90°).



In the northern hemisphere...

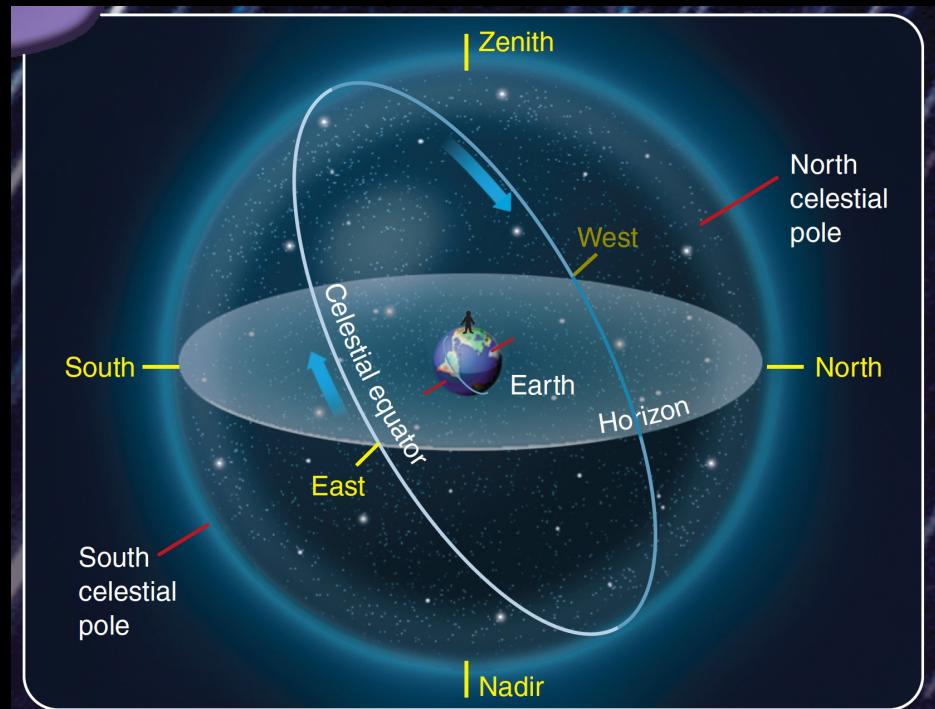
Altitude of the North Star
(Polaris) = your latitude.

Polaris is always above the horizon.



What does latitude have to do with it?

- Except at the poles, the zenith does not coincide with the celestial pole. This affects the apparent path of the stars in our local sky.
- In the northern hemisphere:
 - ✓ Stars near the north celestial pole constantly remain above the horizon and are called **circumpolar**.
 - ✓ Stars near the south celestial pole always remain below the horizon.
 - ✓ All other stars rise in the east and set in the west on a daily basis.



Changes in the night sky

- A long exposure of stars reveals their apparent daily motion. This is in CA...
- altitude of Polaris = your latitude.



Changes in the night sky

This is in Ecuador (near the equator)...



Changes in the night sky

This is in
Iceland, 63.9°
North latitude.



Image: Vahe Peroomian

Changes in the night sky

This is in Armenia, 39.6° North latitude...

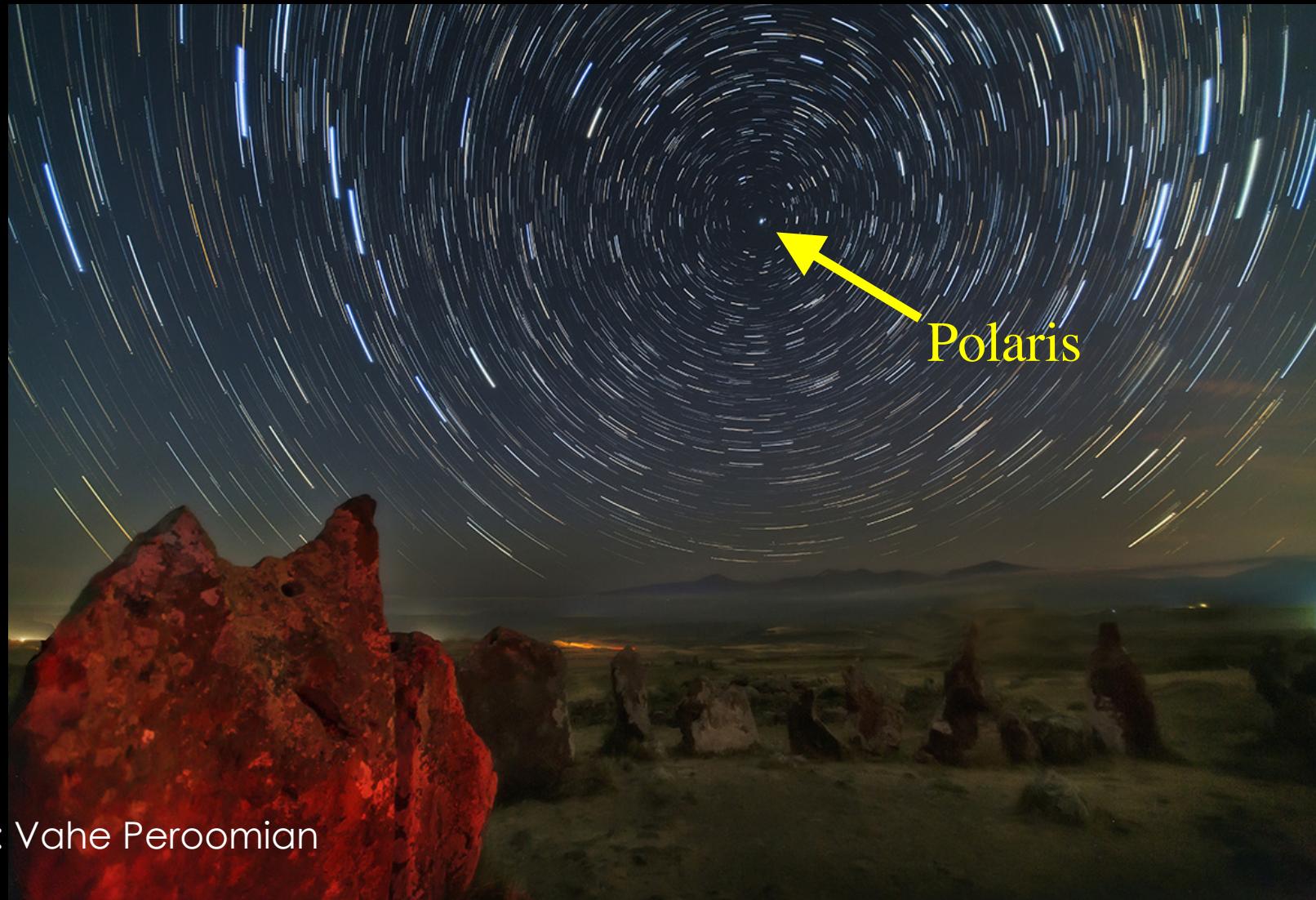


Image: Vahe Peroomian

Why are there no east or west poles?

question for you



Where would you need to go on Earth to see the celestial equator near your horizon?

- A. The poles.
- B. The equator.
- C. To 23.5° degrees geographic latitude.
- D. To 45° degrees geographic latitude.
- E. I have no idea.

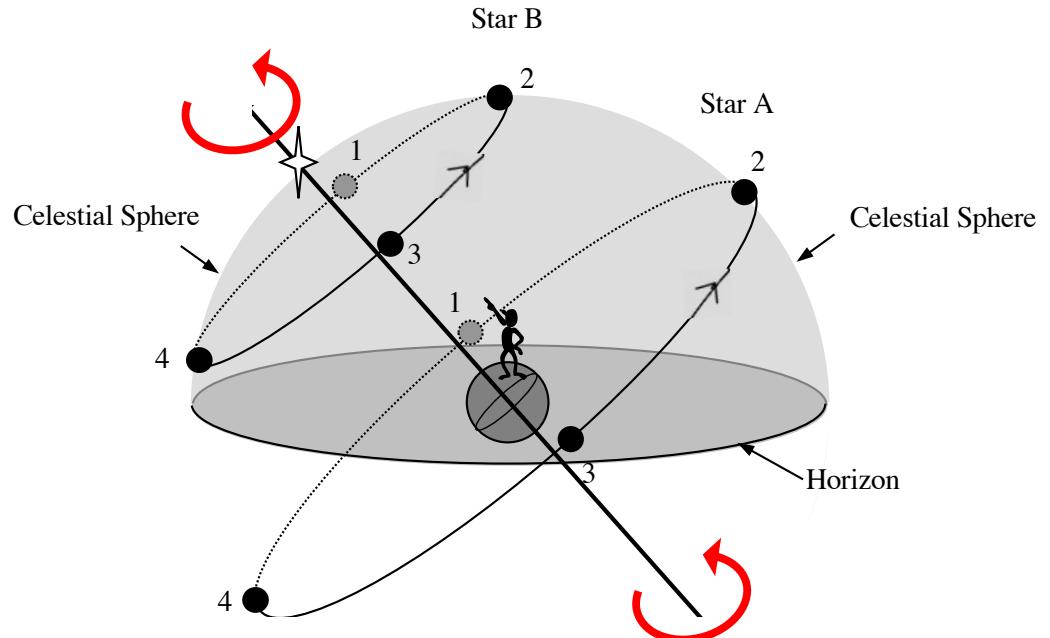
question for you



In what direction is the observer facing? (Note that point 3 is closer to the reader than point 1 on each circle.)

- A. South.
- B. North.
- C. East.
- D. West.
- E. I have no idea.

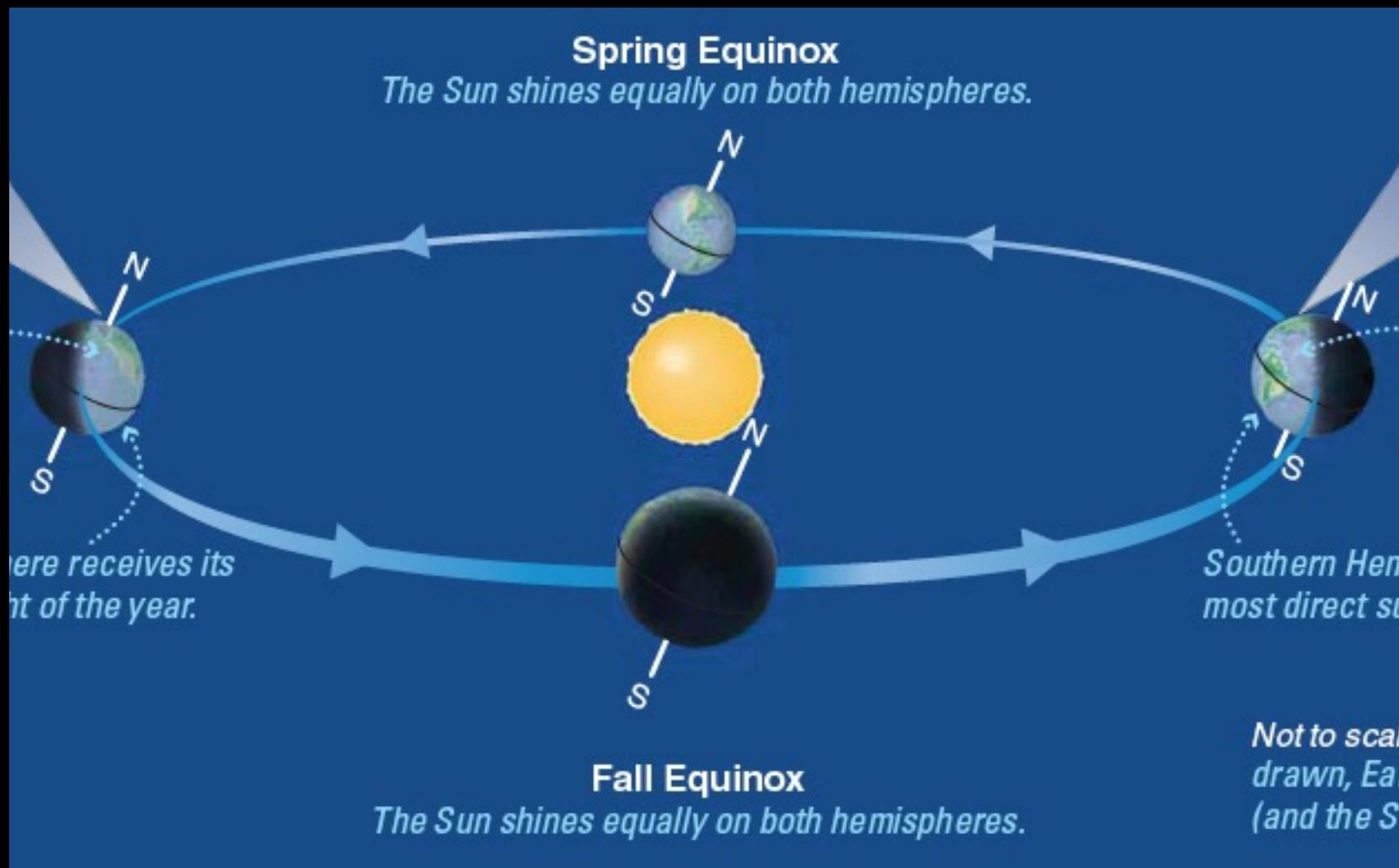
Celestial Sphere Rotation



Seasons

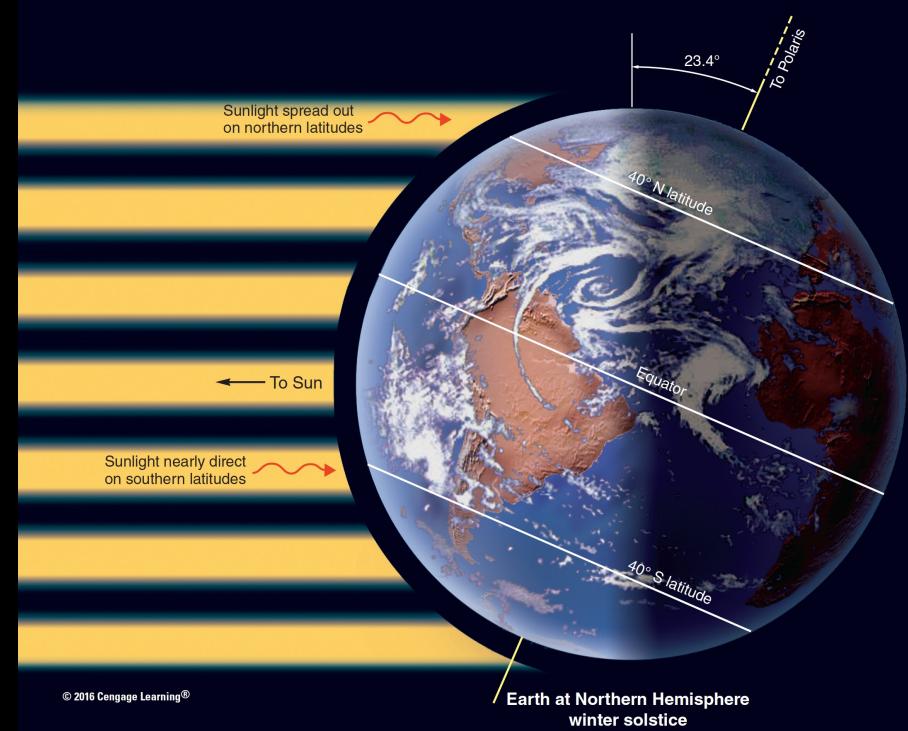
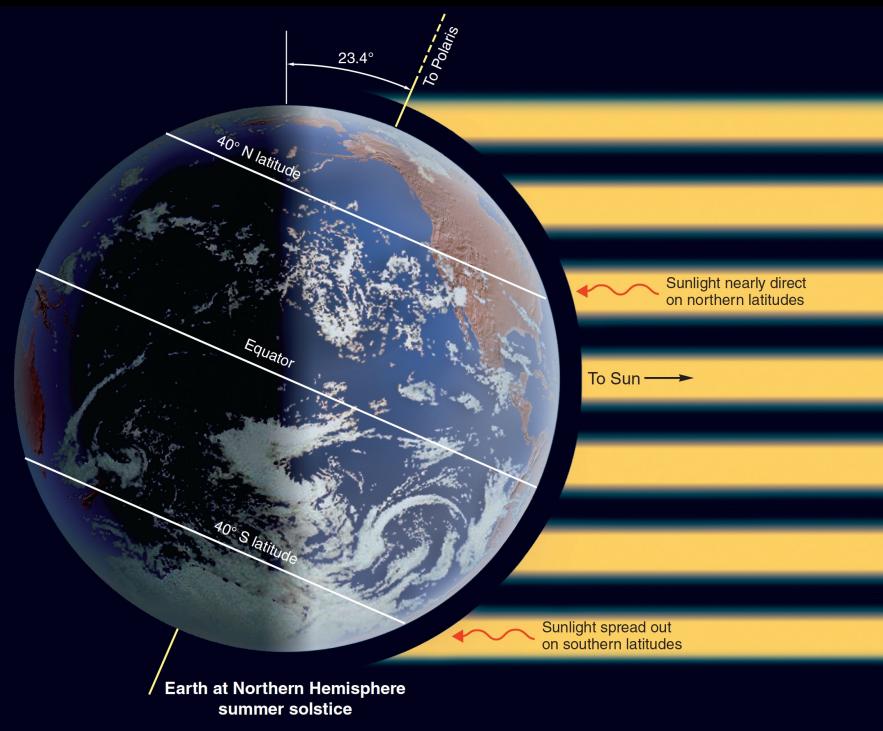
What causes the seasons on Earth?

Contrary to popular belief, it's not a change in the distance between the Sun and the Earth.



What causes the seasons on Earth?

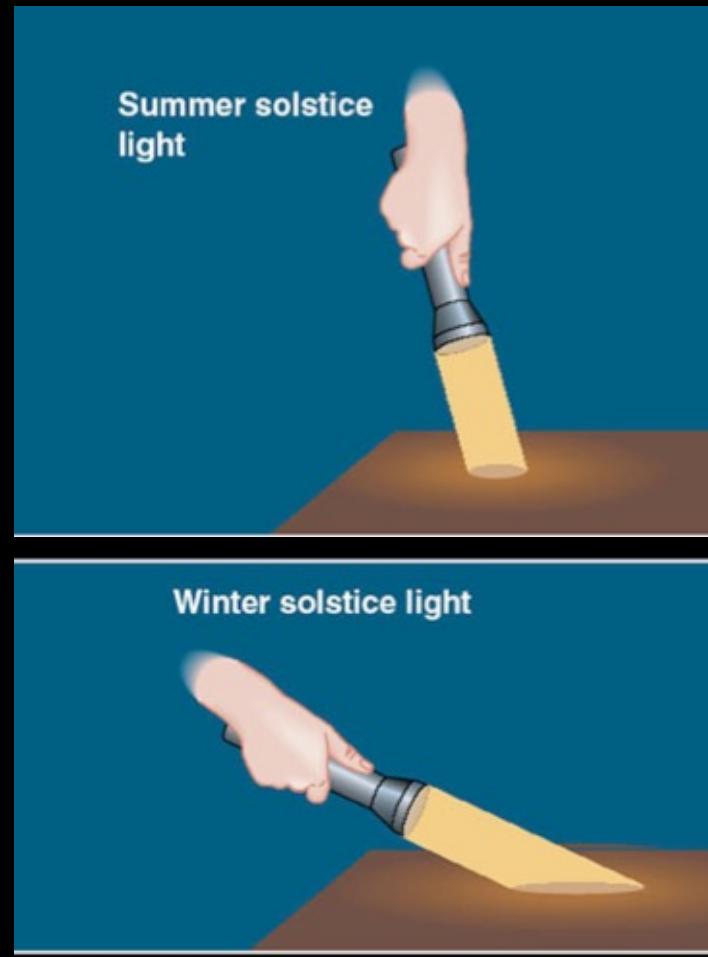
1. Summer occurs in your hemisphere when sunlight hits it more directly, and winter occurs when the sunlight is less direct.
2. Daylight also lasts longer in the summer.



The intensity of sunlight

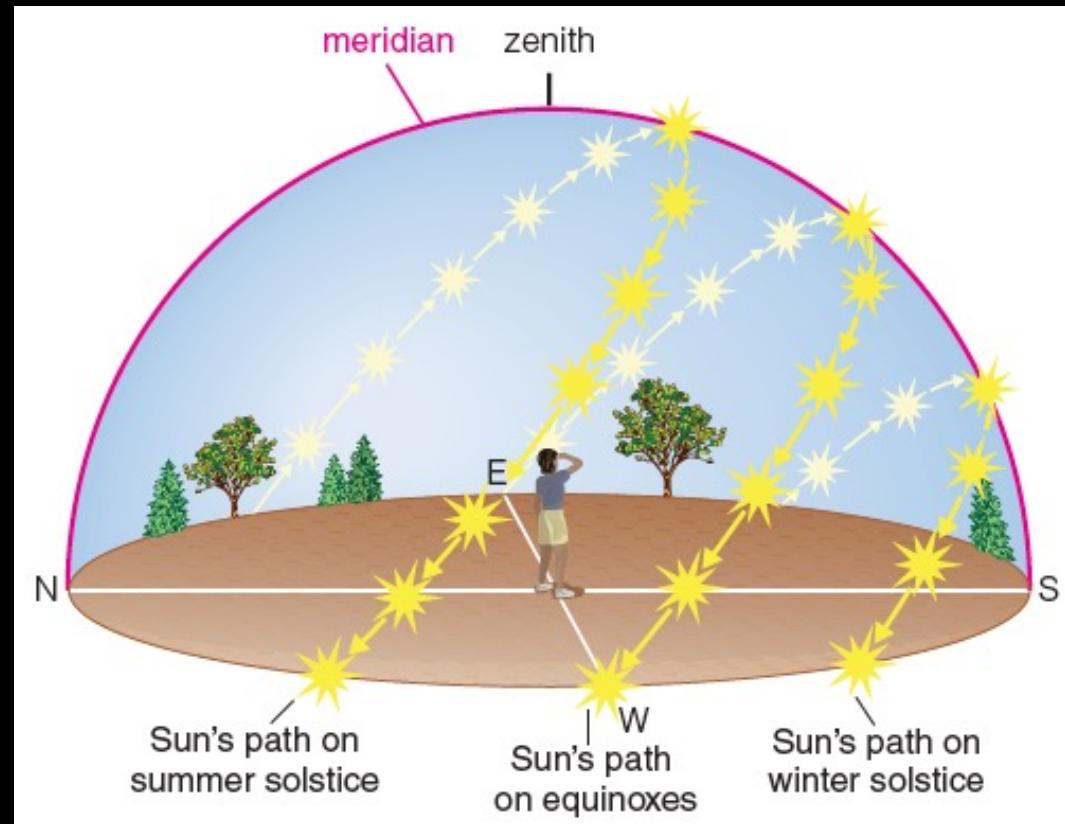
Every square meter facing the Sun directly gets 1370 Watts of power. But if you tilt it, it gets less.

During the summer, the light is full-on, whereas in the winter, it's at an oblique angle: spreads over a larger area.



And the sun rises...

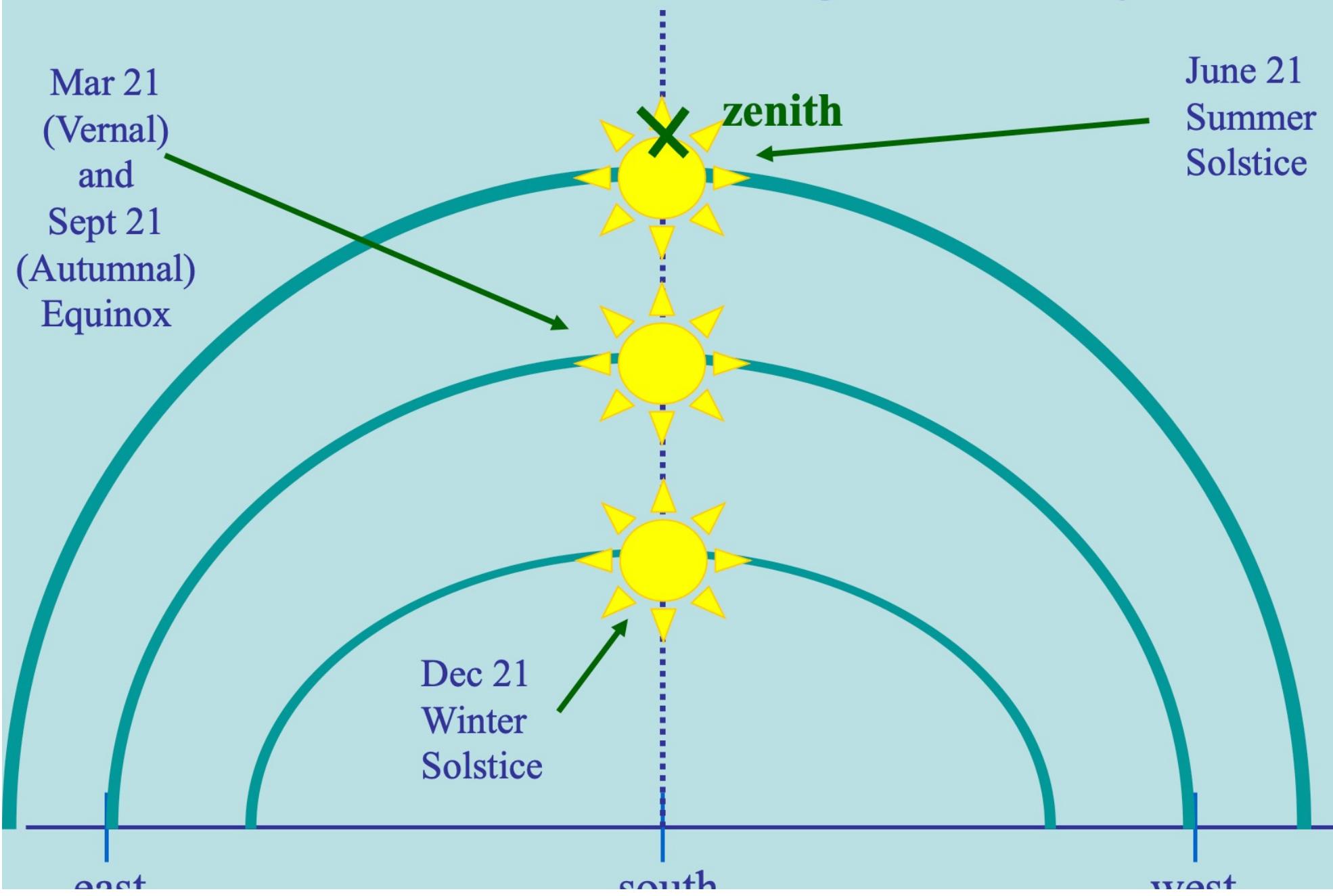
- ❖ The highest point in the sky that the sun reaches each day changes during the year.
- ❖ Sun is highest in the sky at Summer Solstice (June 21) and lowest at Winter Solstice (December 21)



Seasons

- **Vernal equinox** (also known as March or Spring equinox) occurs on **March 21** and marks the first day of spring.
- Length of night and day are equal at equinoxes.
- **Autumnal equinox** (also known as September or Fall equinox) occurs on **September 21** and marks the first day of autumn.
- **Summer solstice** occurs on **June 21** and marks the longest day in northern hemisphere.
- **Winter solstice** occurs on **December 21** and marks the longest night in northern hemisphere.

Sun's apparent position



question for you



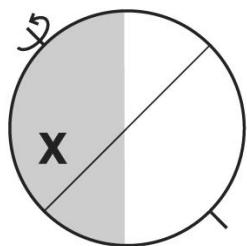
If you are located in the continental U.S. on the first day of October, how will the position of the Sun at noon be different two weeks later?

- A. It will have moved toward the north.
- B. It will have moved to a position higher in the sky.
- C. It will stay in the same position.
- D. It will have moved to a position closer to the horizon.
- E. It will have moved toward the west.

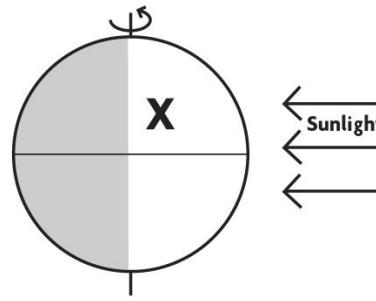
question for you



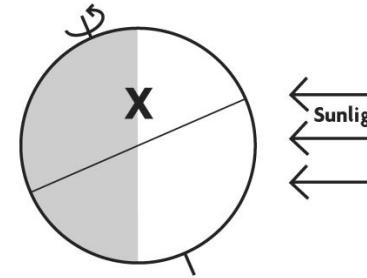
Which of the locations identified with an “x” for each of the situations (A – D) would experience the coolest temperature over the course of one day?



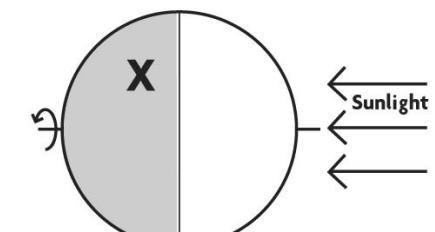
A: Tilt=45°



B: Tilt=0°



C: Tilt=23°



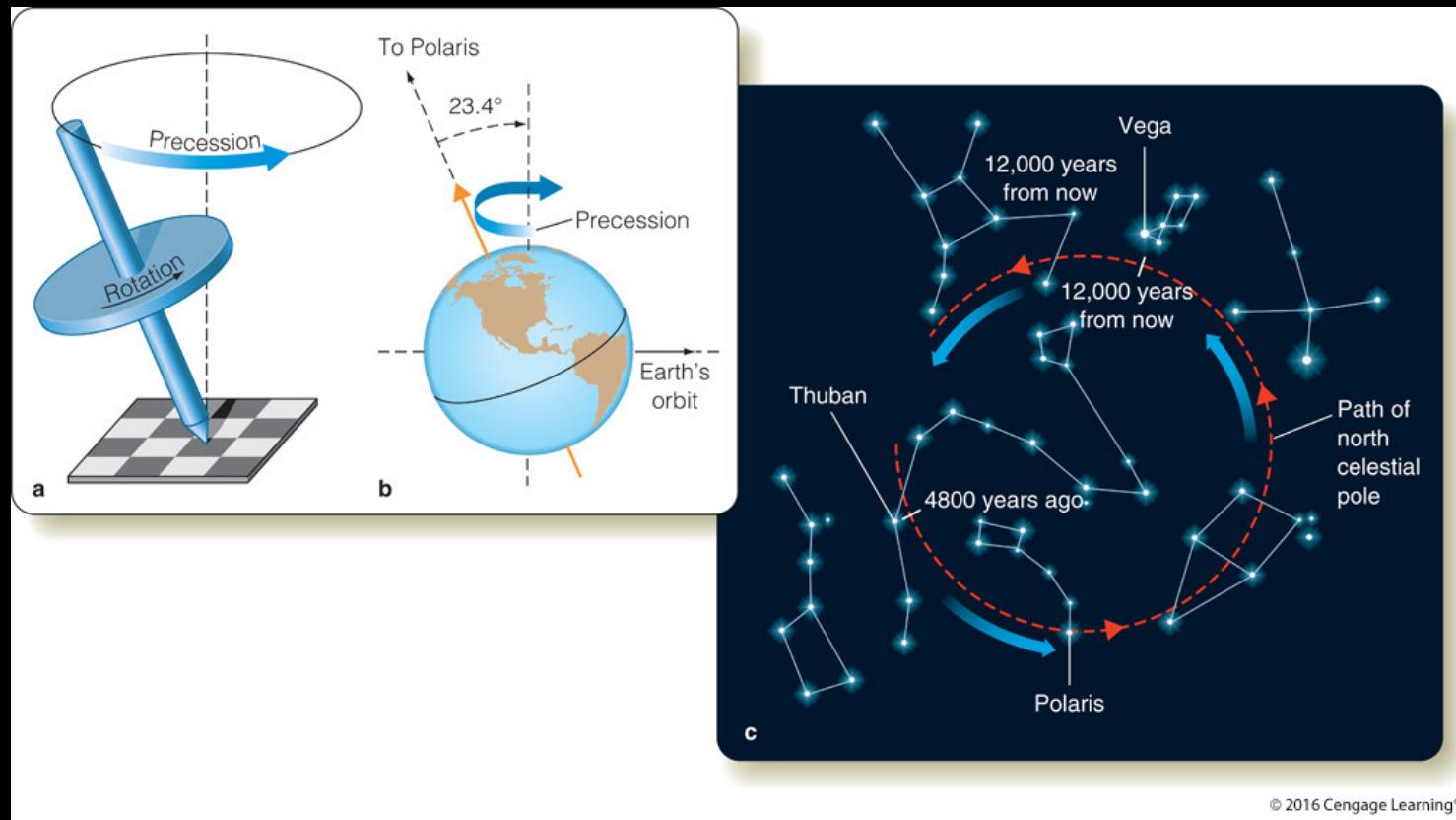
D: Tilt=90°

- A. A
- B. B
- C. C
- D. D**
- E. I have no idea.

Precession

Precession

- Precession occurs when the axis of rotation of an oblate object is not vertical.
- Gravitational pull of the Sun and the Moon tries to “correct” Earth’s tilted axis, causing the axis to **precess** in a circle with a period of 26,000 years.



What did we learn in Chapter 2?

- Constellations are specific regions of the sky.
- There are 88 official constellations.
- An “asterism” is a pattern of stars that may be a portion of a constellation or may have stars from more than one constellation.
- The Celestial Sphere is an imaginary sphere on which the stars were thought to reside.
- The ecliptic is the Sun’s path through the celestial sphere, and is tilted 23.5° to the celestial equator.
- One full circle is 360° . Each degree is 60 arc minutes (or minutes of arc), and each minute of arc is 60 arc seconds (or 60 seconds of arc). $1^\circ = 60' = 3600''$
- Zenith is point above you, meridian is north-south line running through your zenith.
- Altitude (degrees above horizon) and azimuth (degrees from north or cardinal direction) are used to locate an object in the sky.

What did we learn in Chapter 2?

- Circumpolar stars are those that always stay above the horizon at a given latitude.
- In the northern hemisphere, the altitude of the North Star is equal to one's latitude.
- The stars we see at night change because of Earth's rotation and revolution around the Sun.
- A solar day is 4 minutes longer than a sidereal day, and a tropical year is about 20 minutes shorter than a sidereal year.
- Metonic cycle is 19-year cycle when lunar phases fall again on the same day.
- Seasons caused by Earth's axial tilt.
- Equinox = equal day and night (March 21 and September 21).
- Summer solstice = longest day in northern hemisphere (June 21).
- Winter solstice = shortest day in northern hemisphere (December 21).
- Earth's rotation axis precesses with a period of 26,000 years.