

Clicker time—come up front, get form/clicker!

- You, too, will be as happy as these students...



- Or more like her



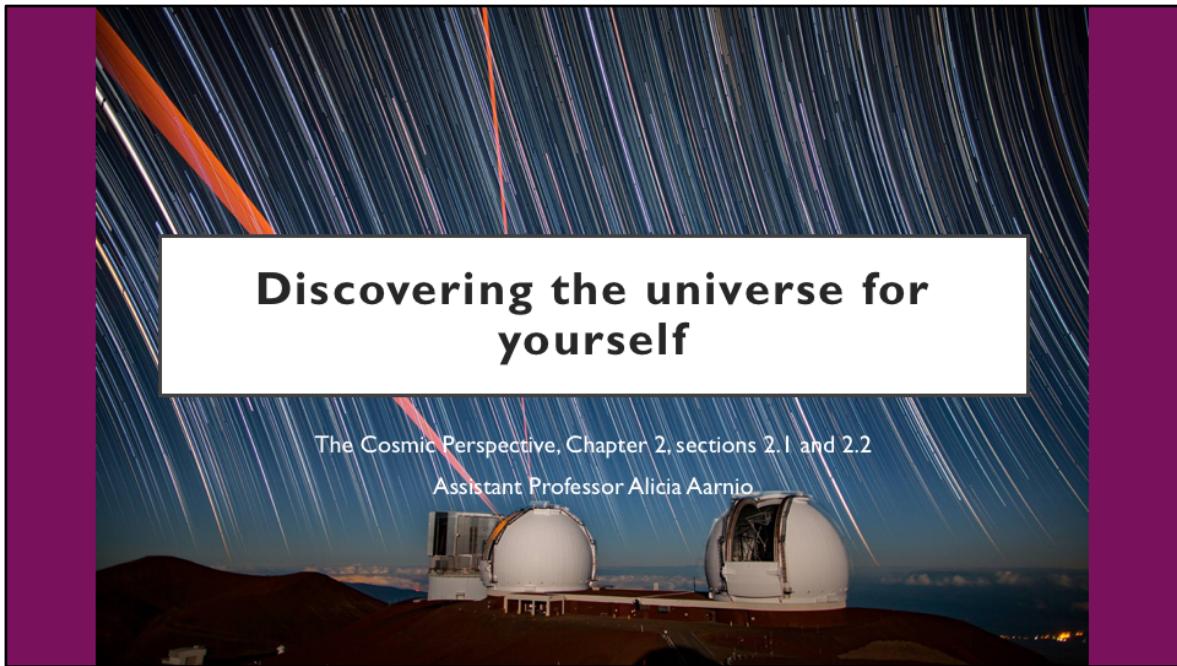
GIS for stock images of clickers in classrooms

**Did you get to
see the eclipse
Sunday night?**

- A. Yes!!!
- B. No



Clicker test– a really big today in science!
<https://twitter.com/WXKnapper/status/1087398494556602368>
We will talk about eclipses on Thursday!



Discovering the universe for yourself

The Cosmic Perspective, Chapter 2, sections 2.1 and 2.2

Assistant Professor Alicia Aarnio

Photo credit: Dr. Joe Llama, Lowell Observatory

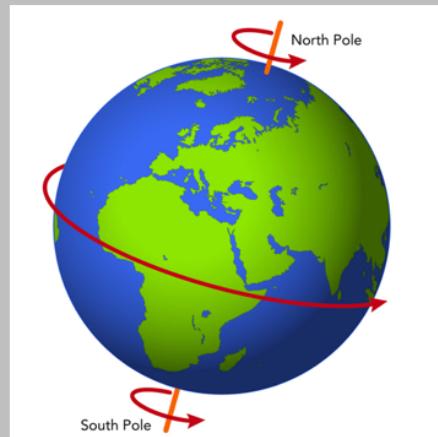
Photo is of star trails over Keck Observatory. Yes, those are laser beams coming out of the telescope dome!

Recap from last week

- Spaceship Earth:
 - Rotates once per 24 hours
 - Orbits the Sun once per 365.25 days
- The moon is orbiting the earth
- Solar system orbits the Milky Way
- Milky Way moves within Local Group
- Local Group of galaxies part of a supercluster of galaxies
- Clusters of galaxies within filaments in an expanding universe

Earth's rotation

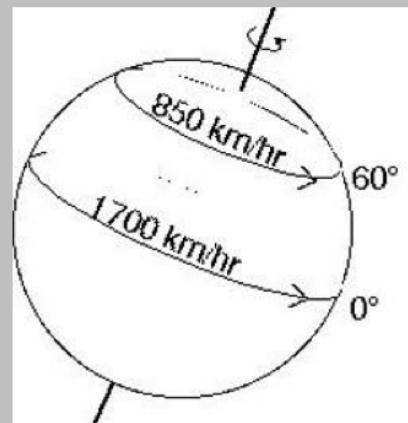
- Looking down from North Pole, Earth rotates counter-clockwise (West→East)
- Rotation speed is 0 at the poles, 1700km/hr (1056mph) at equator



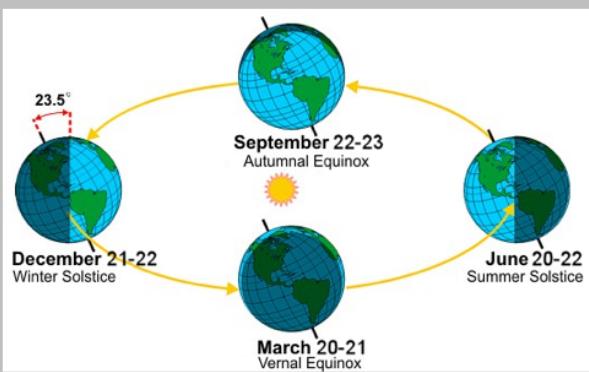
© Siyavula Education. Illustration used in Gr 4-6 Natural Sciences and Technology (Earth and Beyond strand).

Earth's rotation

- Looking down from North Pole, Earth rotates counter-clockwise (West→East)
- Rotation speed is 0 at the poles, 1700km/hr (1056mph) at equator
 - If you couldn't remember this, how would you calculate it?
 - Speed = distance/time
 - distance = circumference of Earth ($2\pi \times \text{radius}$)
 - time = 24 hours



The equinoxes and solstices



- Solstice is from latin *sol* (sun) + *stit* (stopped)
- Equinox is from latin *aequi* (equal) + *nox* (night)

<https://www.weather.gov/cle/seasons>

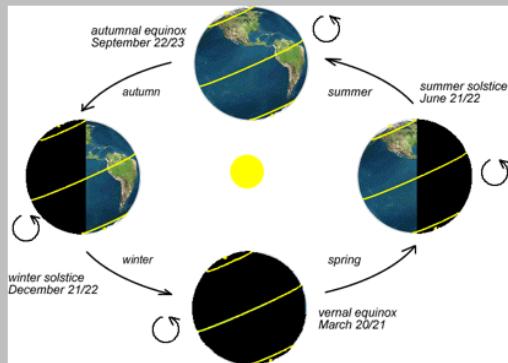
What causes the seasons?

- A.** The tilt of Earth's rotation axis
- B.** Solar cycles
- C.** The distance between Earth and the Sun changes throughout Earth's orbit
- D.** Geothermal cycles in Earth's interior

Seasons!



- Common misconception:
- Distance of Earth from Sun causes seasons

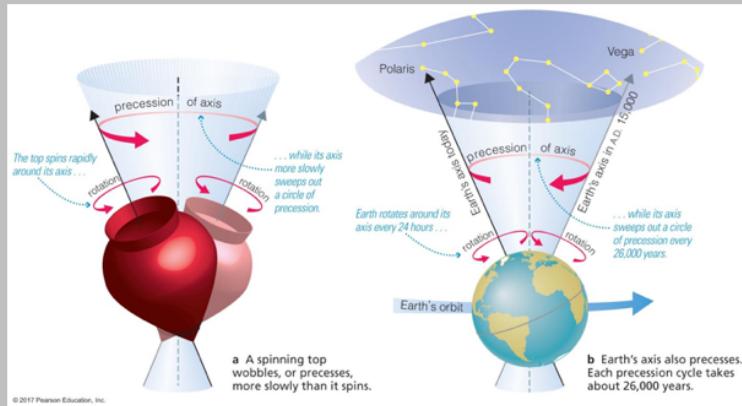


Not an advertisement, just where I found this graphic!

<https://www.teepublic.com/t-shirts/axial-tilt-is-the-reason-for-the-season-sweater>

<http://astronomy.nmsu.edu/geas/lectures/lecture06/slide05B.html>

Precession of Earth's rotation axis



The wobble of Earth's rotation axis is because both the Sun and the Moon are gravitationally interacting with the Earth, tugging on it, trying to line up Earth's rotation axis with the plane of the solar system.

Why is Polaris so special?

- A.** It's the brightest star in Ursa Minor
- B.** It's a triple system
- C.** Earth's rotation axis is aligned with it
- D.** It's very blue

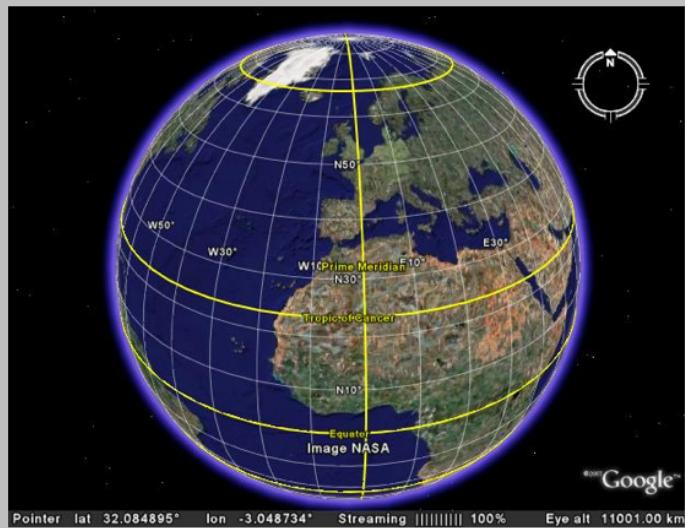
The Celestial Sphere

Navigating our night sky



<http://www.physics.smu.edu/jcotton/ph1311/ch00a.htm>

On Earth, we use latitude and longitude

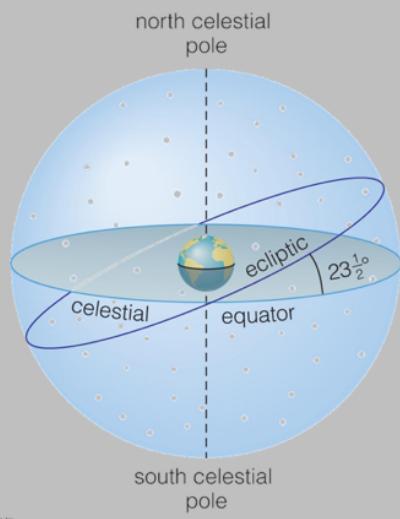


Project that coordinate system onto sky



The Celestial Sphere

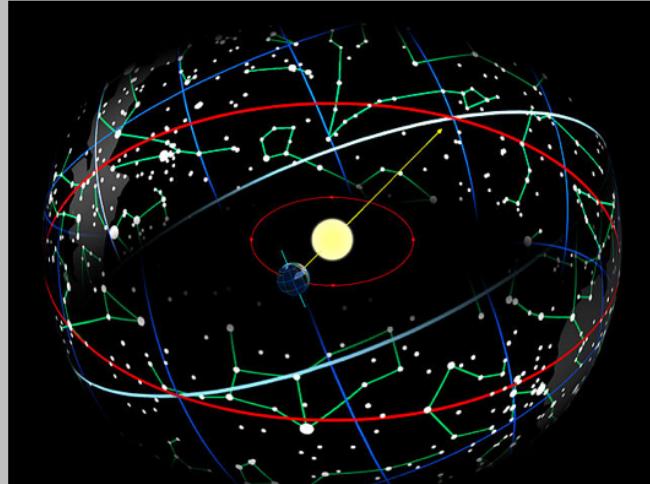
- From Earth's surface to the sky:
 - Equator → Celestial Equator
 - North Pole → North Celestial Pole
 - South Pole → South Celestial Pole
- New in the sky: the **ecliptic**



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The Celestial Sphere

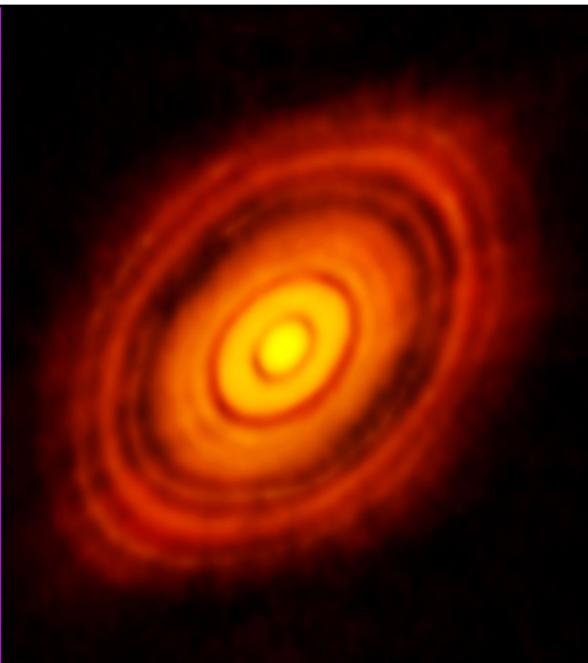
- The ecliptic is the Sun's path in our sky



<http://earthsky.org/space/what-is-the-ecliptic>

What is the ecliptic, really? Why?

Motion due to the
Sun's formation!!

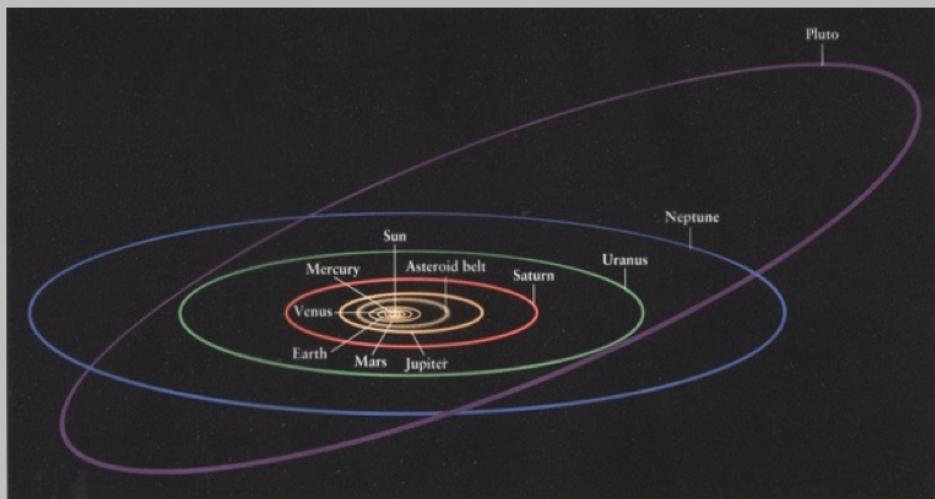


[https://aasnova.org/2016/12/19/selections-from-2016-gaps-in-hl-taus-
protoplanetary-disk/](https://aasnova.org/2016/12/19/selections-from-2016-gaps-in-hl-taus-protoplanetary-disk/)

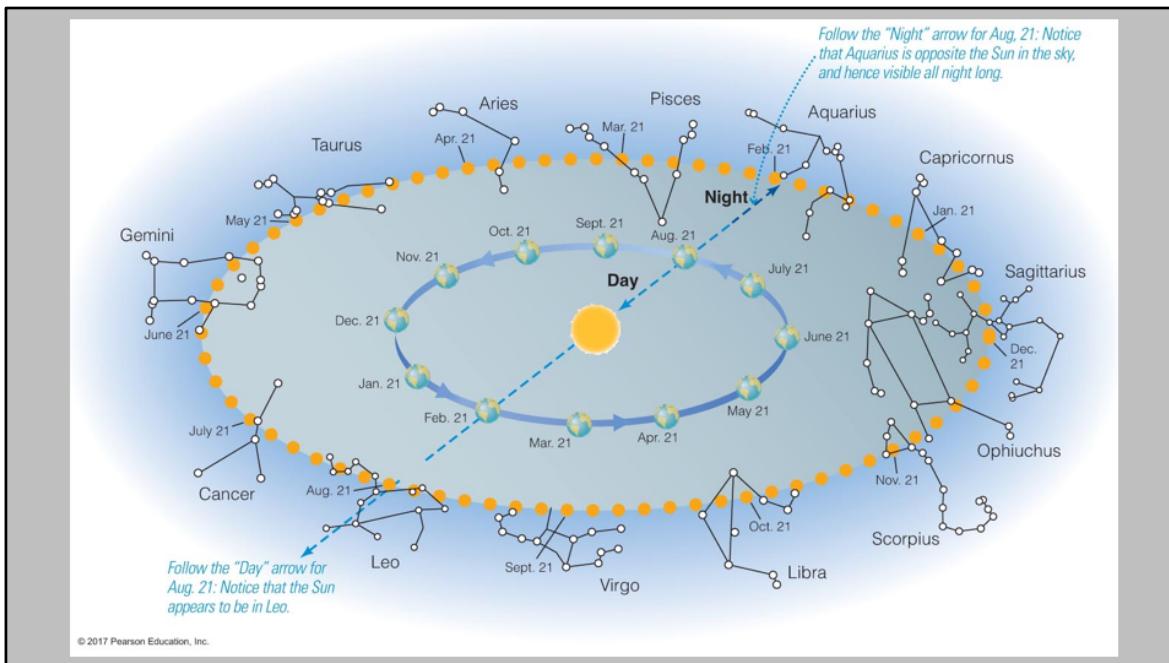
Dude with the dough:

https://www.huffingtonpost.com/2015/03/02/toss-pizza-dough_n_6770618.html

The ecliptic



The ecliptic is the plane in which (most of) the planets lie. It is this way because of the way we believe the solar system formed, from a rotating, collapsing cloud of gas and dust.

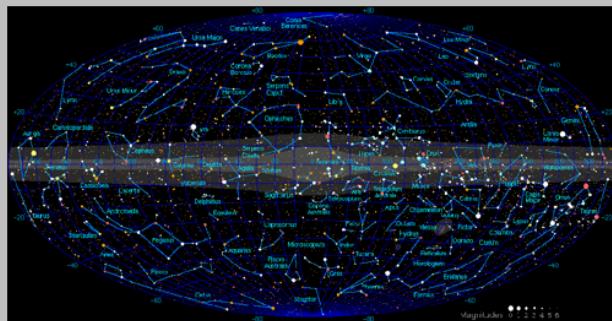


Today, the Sun is "in" (projected against) the constellation Leo. Your zodiac sign, per astrology, is where the Sun was when you were born.

These are the 12 signs of the zodiac (plus Ophiucus, what's that doing in there..), but how many more constellations are there?

88 Constellations

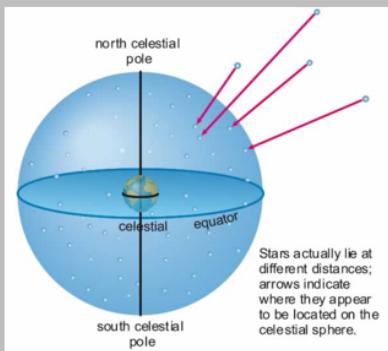
- Defined in 1928 by members of the International Astronomical Union (IAU)
- Northern hemisphere constellations largely held their Middle Eastern origins
- Southern hemisphere constellations generally named by 17th century European explorers



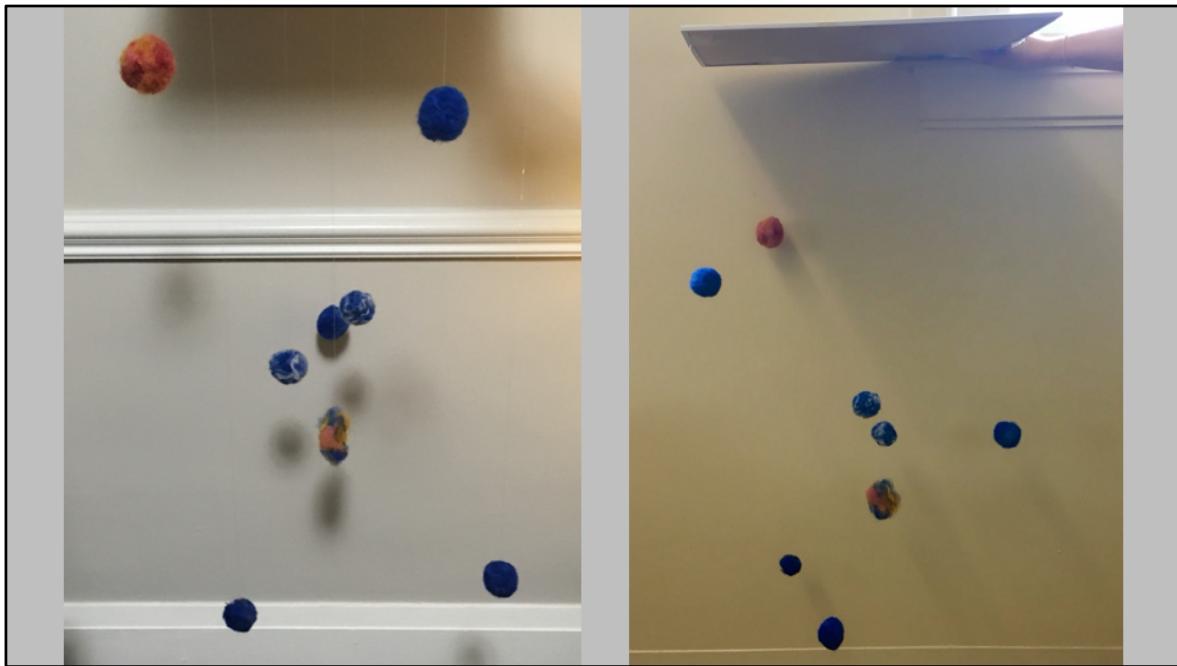
<http://www.go-astronomy.com/constellations.htm>

Constellations

How would Orion look to the inhabitants of a planet around another star in the Milky Way?



<https://apod.nasa.gov/apod/ap030207.html>



I made a Thing for class. For Science!

Constellation vs Asterism?

- Ursa Major



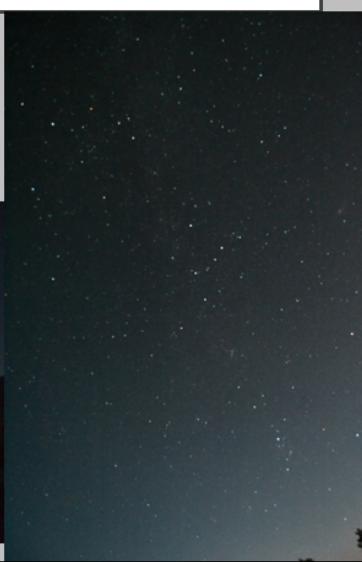
- The big dipper



<http://www.futura-sciences.us/dico/d/space-constellation-ursa-major-50005604/>
<http://earthsky.org/favorite-star-patterns/big-and-little-dippers-highlight-northern-sky>

Our local sky

- Let's zoom back in to the surface of the Earth and consider how to think about the sky above us right now.
- What do you notice in these photos?



I took these photos at Horsehead Reservoir in Colorado. It's near Fort Collins. It was a full moon that night.

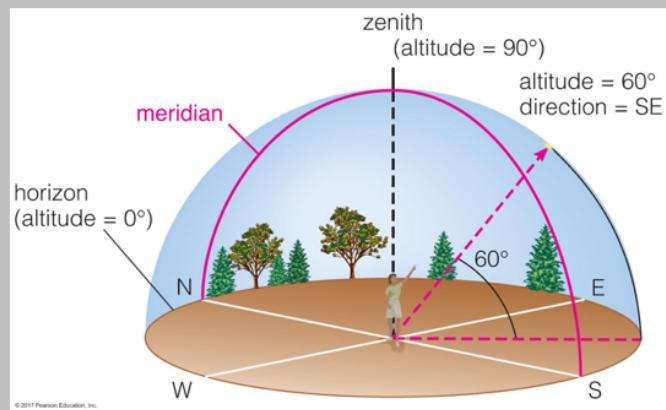
Our local sky – what we might see

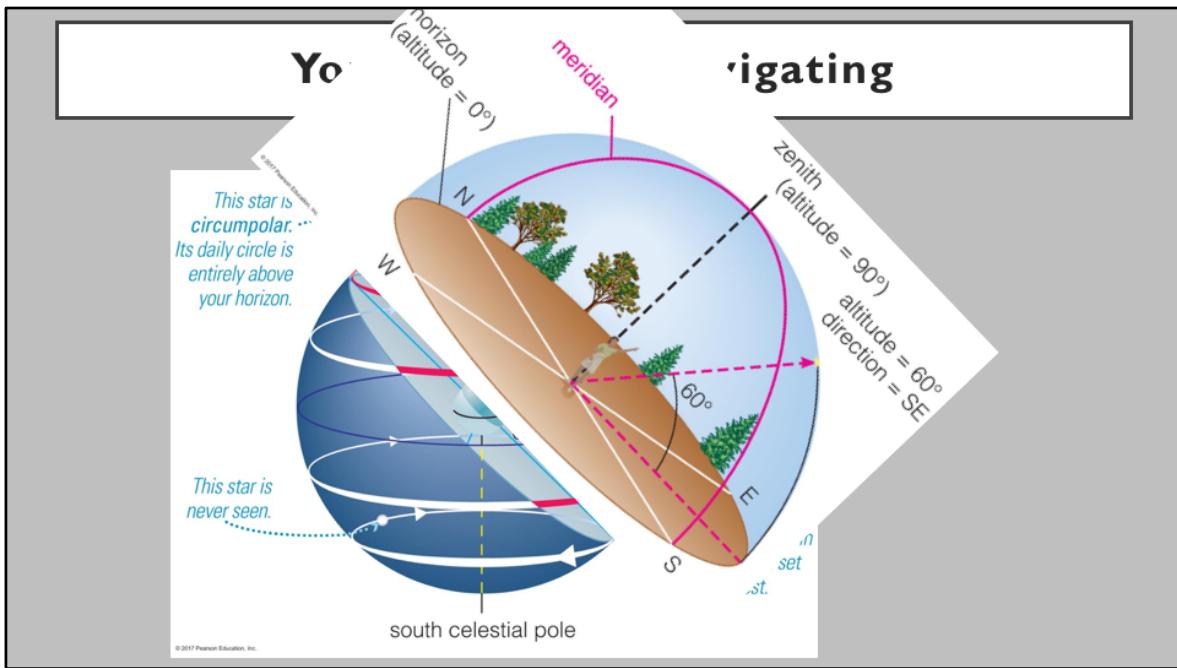
- “On clear, moonless nights far from city lights, more than 2000 stars may be visible to your naked eye, along with the whitish band of light that we call the Milky Way.”
(p25 in text)
- What do we usually see? →



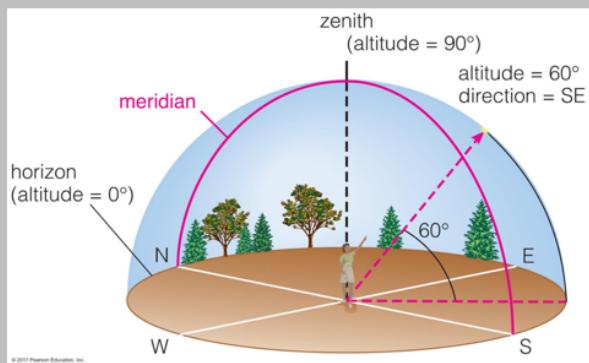
<http://darksky.org/light-pollution/>

Your local sky – navigating





Your local sky – navigating



- Terms to know:

- Horizon
- Altitude
- Zenith
- Meridian

Meridian, kind of like the prime meridian, is an imaginary line going directly from North to South through your local zenith.

Apparent Motion of the Sky

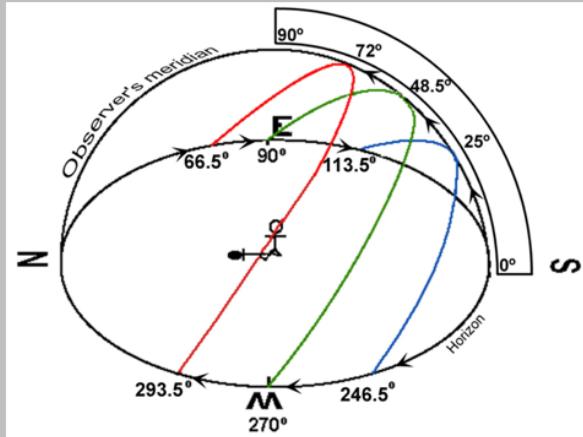


**The Sun always
rises due East and
sets due West**

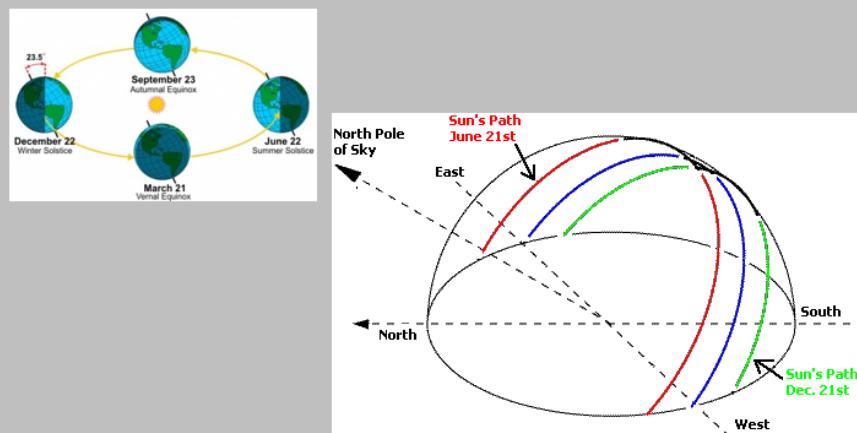
- A. True
- B. False

The Sun's motion

- Where is this observer?



The Sun's motion



The analemma



- The path taken in the sky by the Sun over the course of a year
- Each dot is the Sun on a different day of the year
- The shape and angle of the analemma depend on your latitude

'analemma' was the word for a sundial

<https://dept.astro.lsa.umich.edu/resources/ugactivities/Labs/analemma/index.html>

The analemma



<https://www3.nd.edu/~lent/Astro/IndividualPages/NDAnalemma.html>

Important announcements!

- Thursday: Planetarium!
 - If your last name is in the alphabetical range **Adams-Jakubsen**, report directly to the Planetarium (Petty 310) at 11am.
 - **Johnson-Younger**: come to this room at 11
 - I will have roster copies for sign-in