PLANETARIUM SHOWS

- Seeing the “what does stuff do in the sky” things we’re going to talk about is way easier in the planetarium than in class or the book
- Go to one of the four shows scheduled over the next couple weeks
  - This is a required, if ungraded, assignment
- More info here, first two shows are tomorrow at 4pm and 6pm!

MORE TERMS

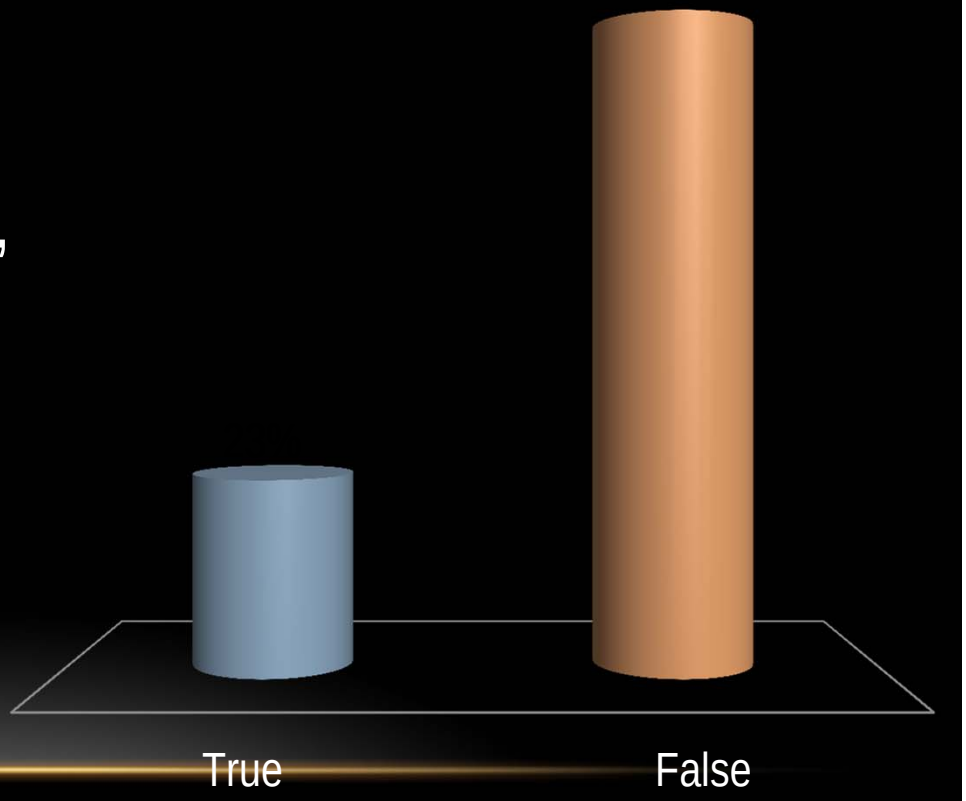
- Zodiac – the 13 constellations whose areas in the sky the sun crosses
  - Sun is currently “in” Leo (gets into Virgo Sept. 16)
- Terminology has been borrowed by Astrologers
  - Many studies have shown no correlation between which stars were on a line with the Sun when you were born and anything (*besides when you get birthday presents*) – the predictions of the Astrology theory don’t stand the test of observation
  - Note that *precession* over the last 2000 years has changed which “sign” it is and where the sun actually is, and added a 13th (Ophiuchus, Nov. 30-Dec.18) to the mix.

EARTH IS CLOSER TO THE SUN IN THE SUMMER AND FARTHER AWAY IN THE WINTER

A. True

B. False

Hint: when it's summer in the US, it is winter in Australia



SEASONS

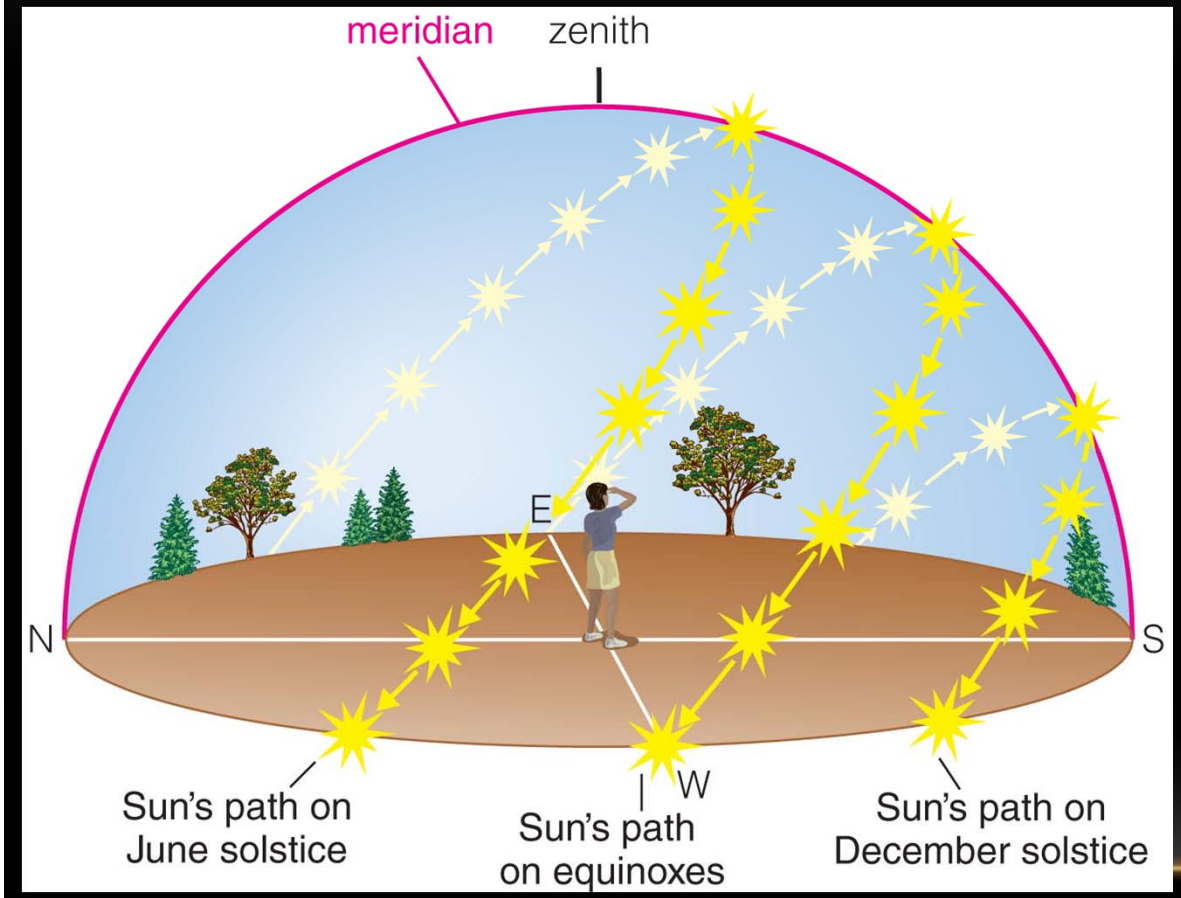


Fig.2.16

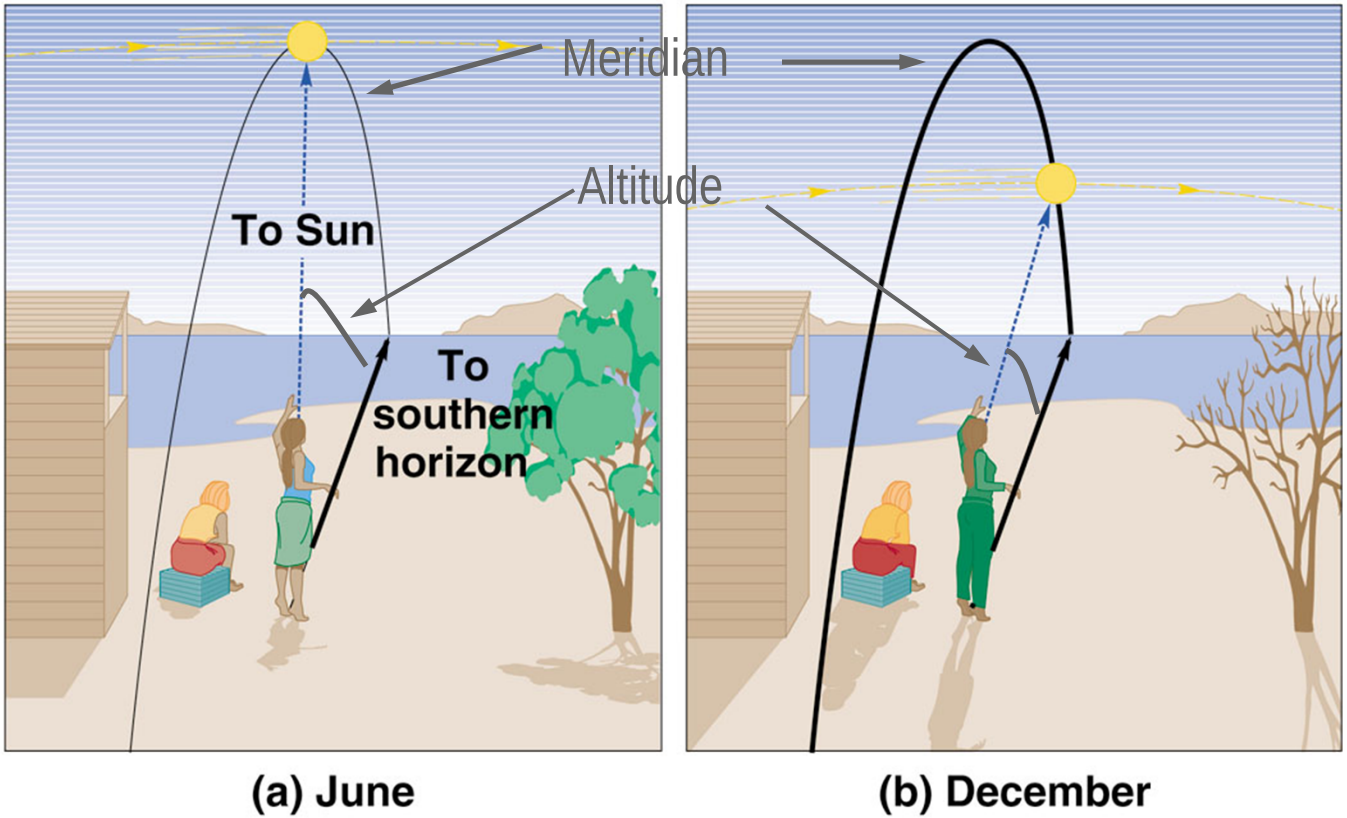
- In Summer, sun is higher in the sky. More daylight, more direct sun, warmer
- In Winter, sun is low, short days, very angled sun, colder

WHY DOES THE SUN MOVE NORTH & SOUTH?

- Due to the Earth's 23.5^{o} tilt
  - sometimes the North pole is tilted away from the Sun
    - Sun appears further to the South
    - Shorter day, less direct light makes winter cold
  - 6 months later, the North Pole is tilted towards the Sun
    - Sun appears to be further to the North
    - Longer Day, more direct light makes summer warm

PLAY

SEASONS



Distance from Earth to Sun has little to do with Seasons!

THE “ANALEMMA”

- Snapshots of where the sun is in the sky at the same time each day over a whole year

Fig.2.17

SOME RELATED QUESTIONS:

- Why do people living near the equator not experience major seasonal changes? Also, why are the Earth's poles so cold?

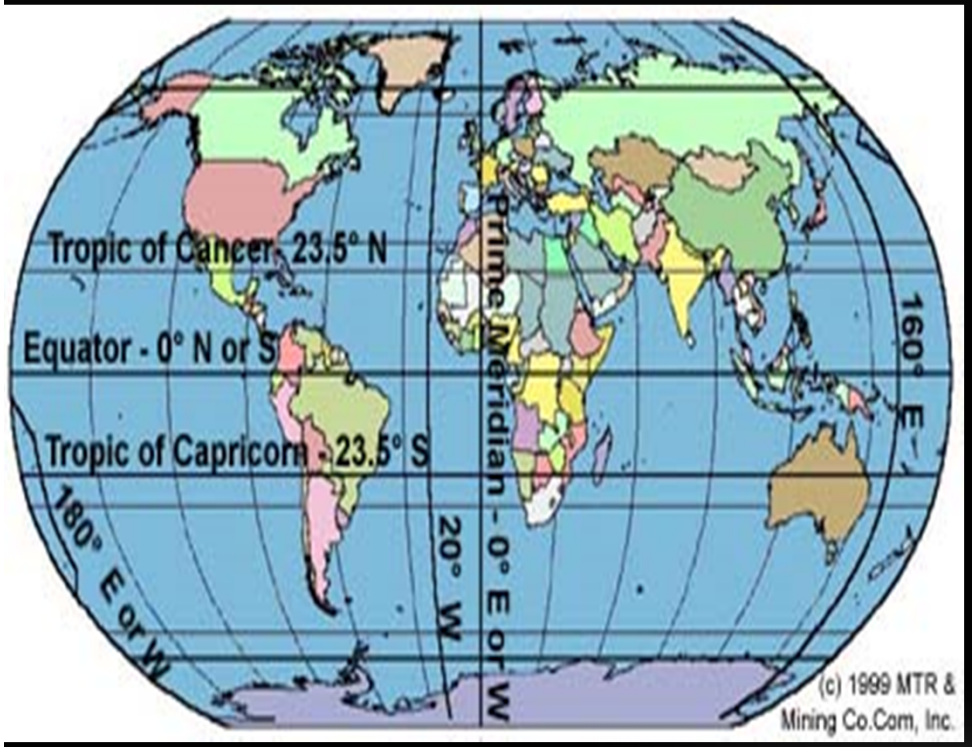
EQUATOR

- Not only the half-way line, but:
  - Where the Sun is directly overhead on the equinoxes
- Sun is never more than 23.5^{o} away from going directly above you
  - Toasty!

SOME RELATED QUESTIONS:

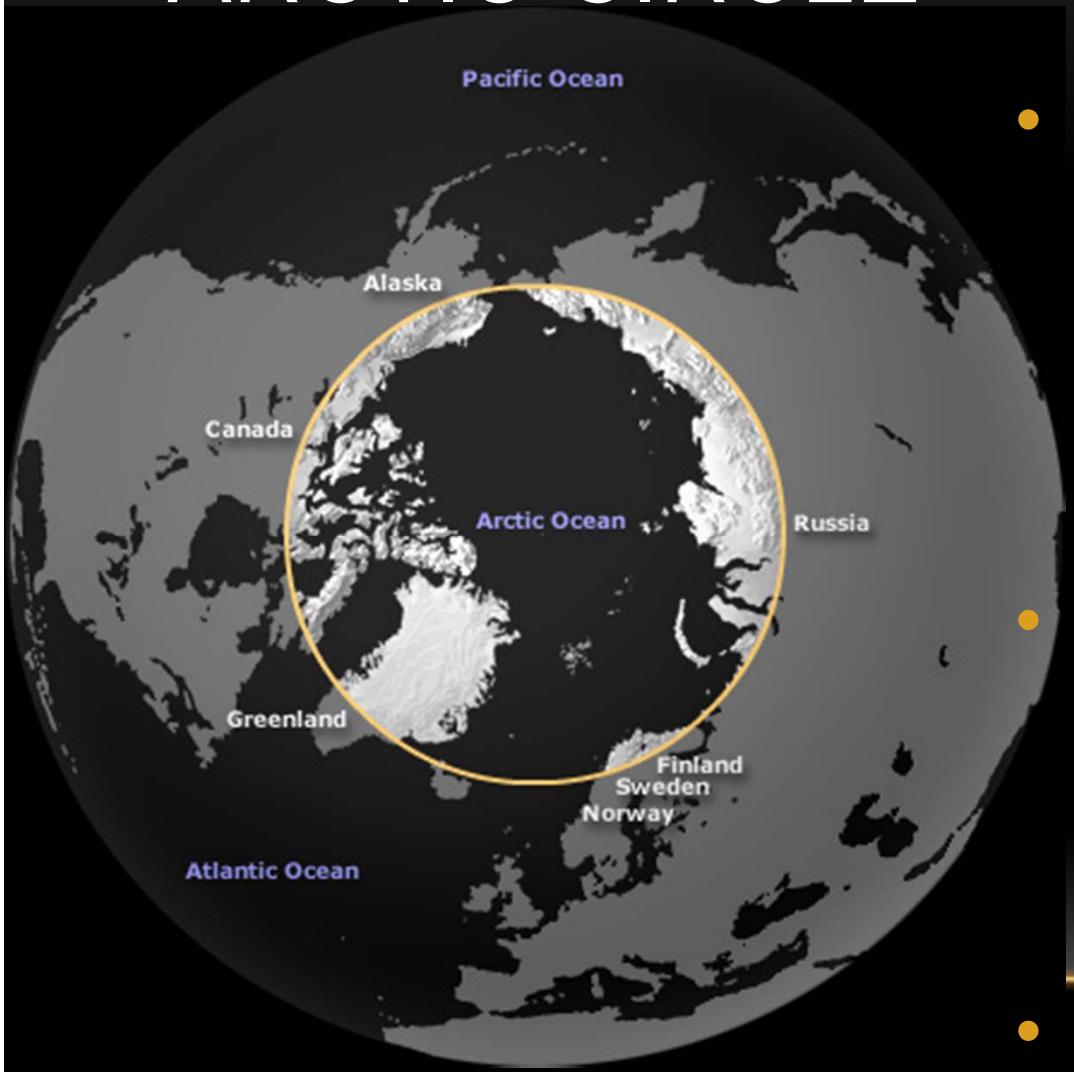
- Why do people living near the equator not experience major seasonal changes? Also, why are the Earth's poles so cold?
- What's the significance of the Arctic and Antarctic Circles? How about the Tropics of Capricorn and Cancer?

TROPIC OF CANCER



- The line at 23.5º N latitude
- At the Summer Solstice, the Sun will be directly overhead
- Named for the constellation the sun was in at the time (2000 years ago – now it's in Gemini)
- Similarly for tropic of Capricorn, 23.5º S (Sagittarius)

ARCTIC CIRCLE



- At 66.5^{0}N
  - *Why? 90^0-23.5^0=?*
- Defined as the line where at the winter solstice, the sun is too far south to rise
  - 24h of night!
- Or, at the summer solstice, the sun is so far north it doesn't set
  - Land of the midnight sun
- Antarctic Circle similar

SOLSTICE AT THE ARCTIC CIRCLE

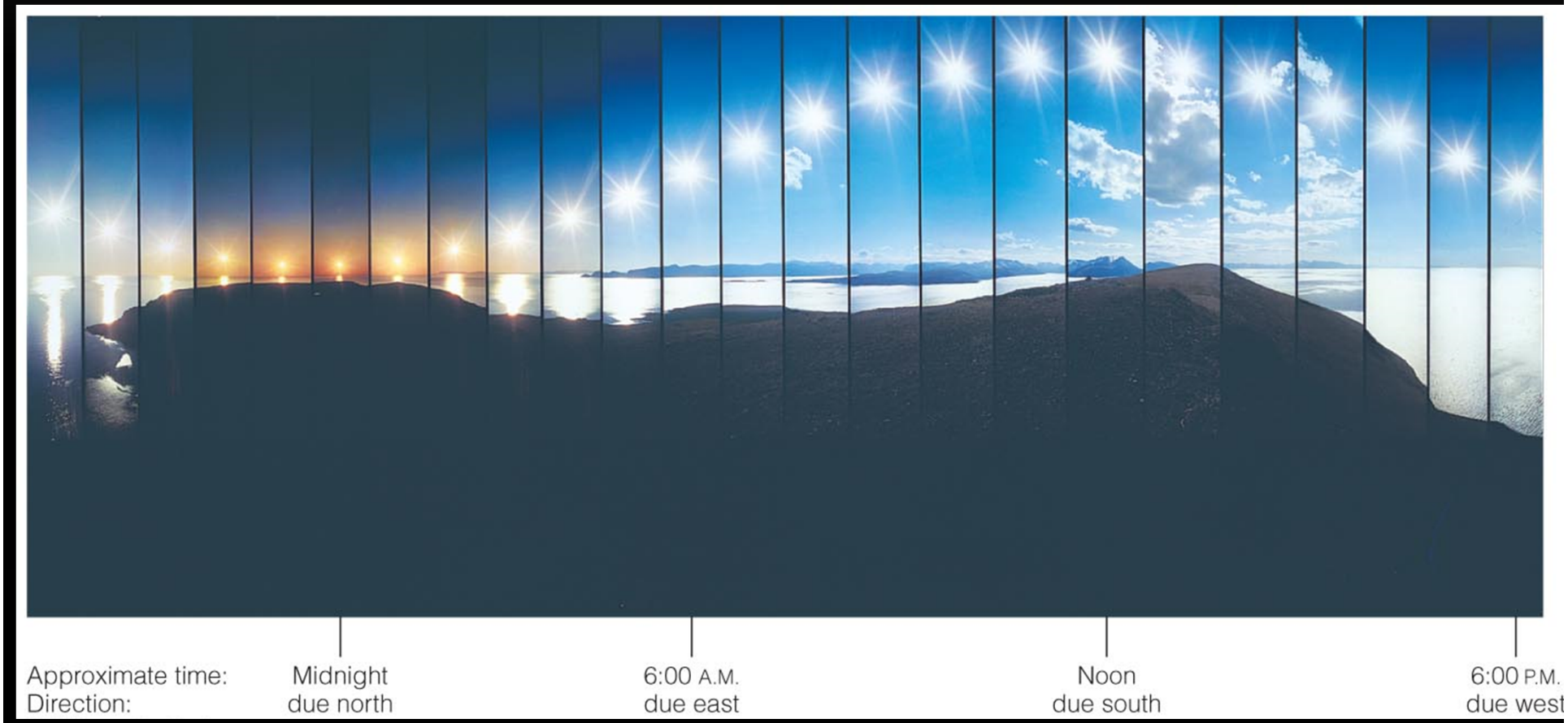
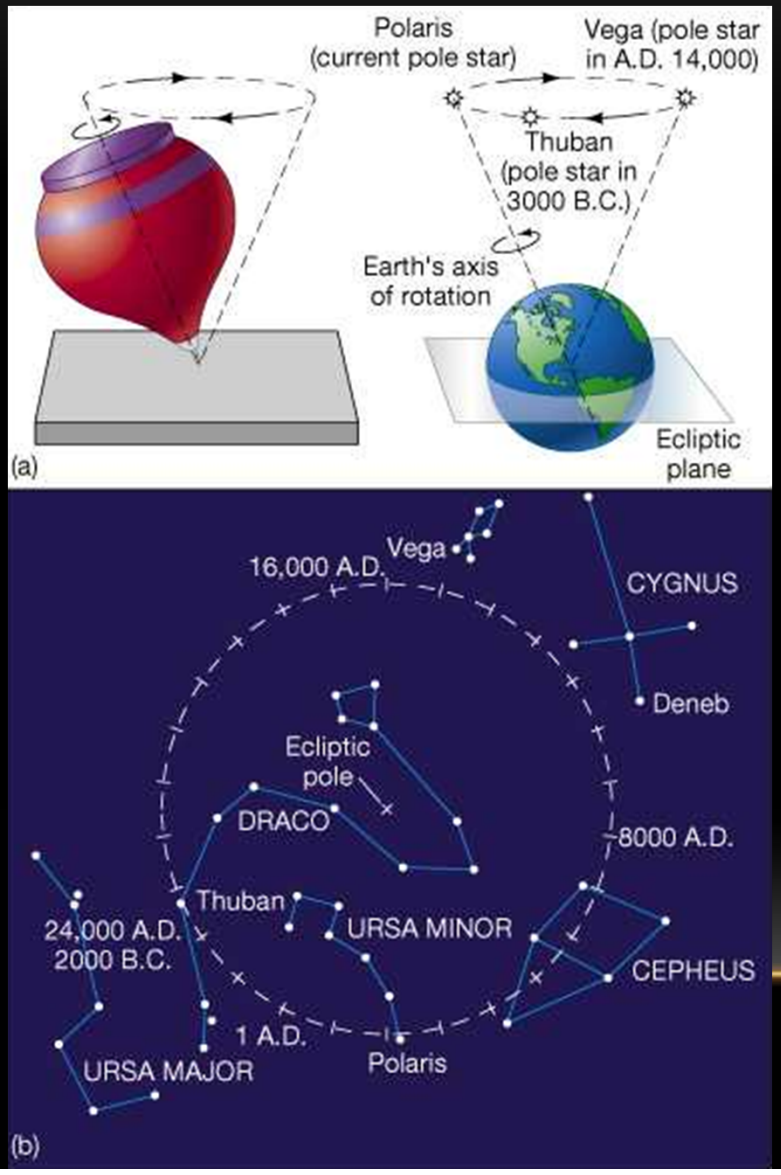


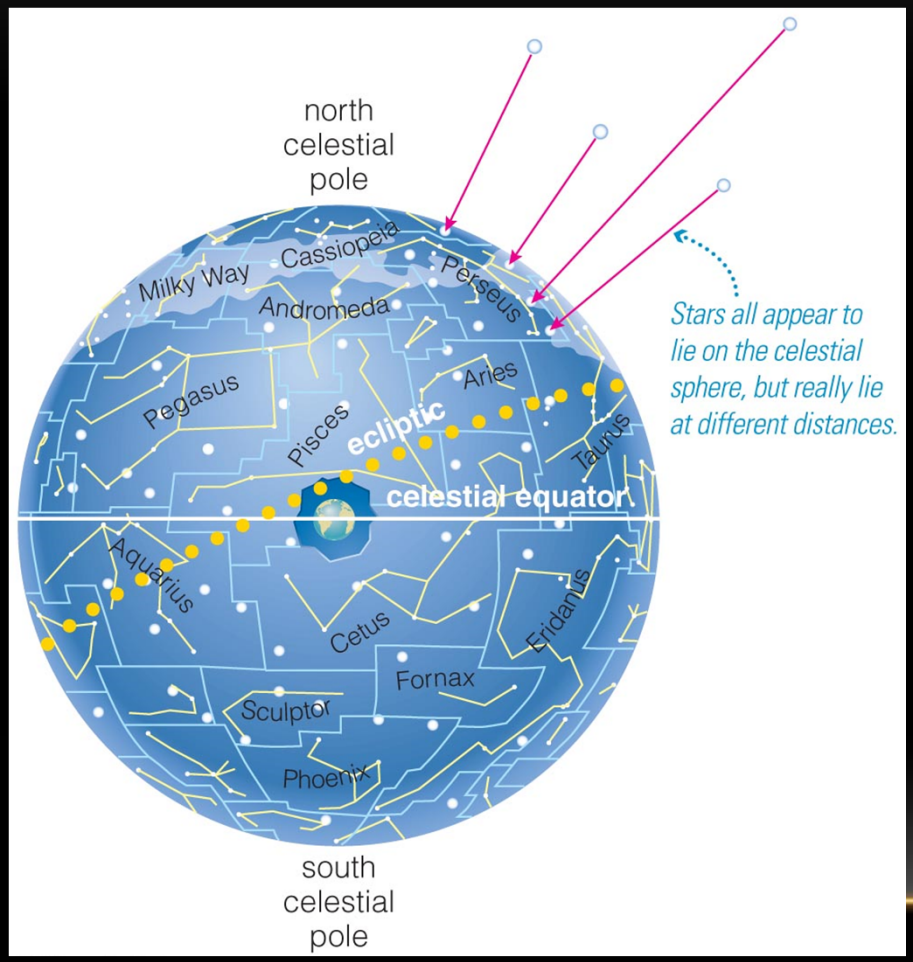
Fig.2.17

PRECESSION



- The spinning earth, like a spinning top, *precesses*
  - The axis of rotation wobbles
- This wobble takes 26,000 years
- So different stars appear to be “pole stars” at different times

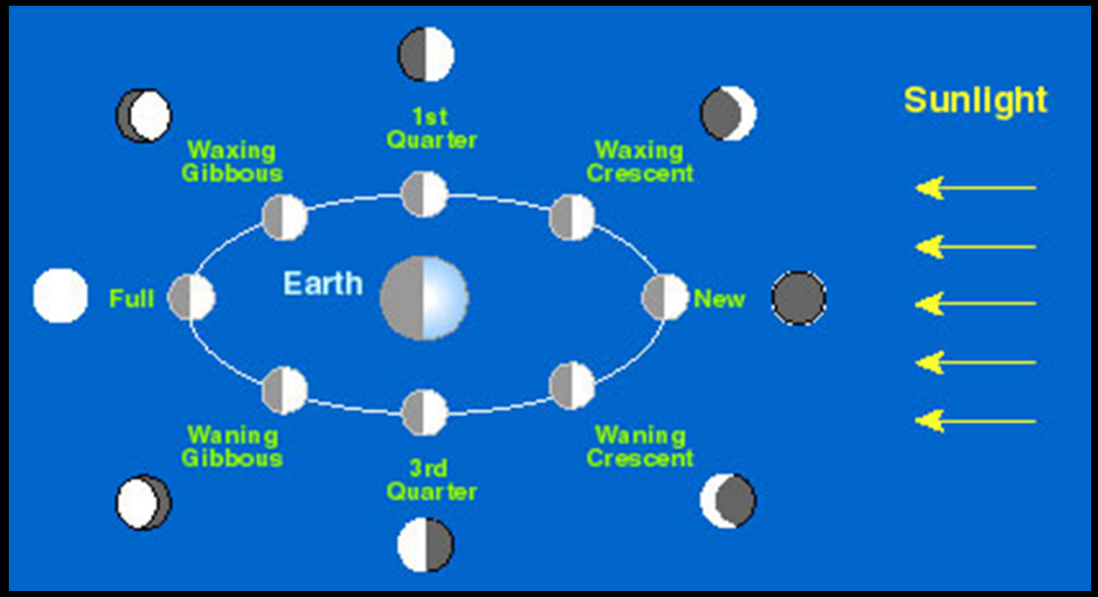
PRECESSION AND THE ZODIAC



- Wobble where the celestial pole lies, and the ecliptic slips into different constellations at different times

Fig.2.3

PHASES OF THE MOON



- As moon orbits Earth, we see more or less of the surface illuminated
- Waning
  - Getting smaller
- Waxing
  - Getting bigger

Full – Gibbous – 3rd ¼ - Crescent – New – Crescent – 1st ¼ - Gibbous - Full

Diagram from from Univ. of Tennesee's online astro course, animation linked to on class website

PLAY

PERIODS OF REVOLUTION

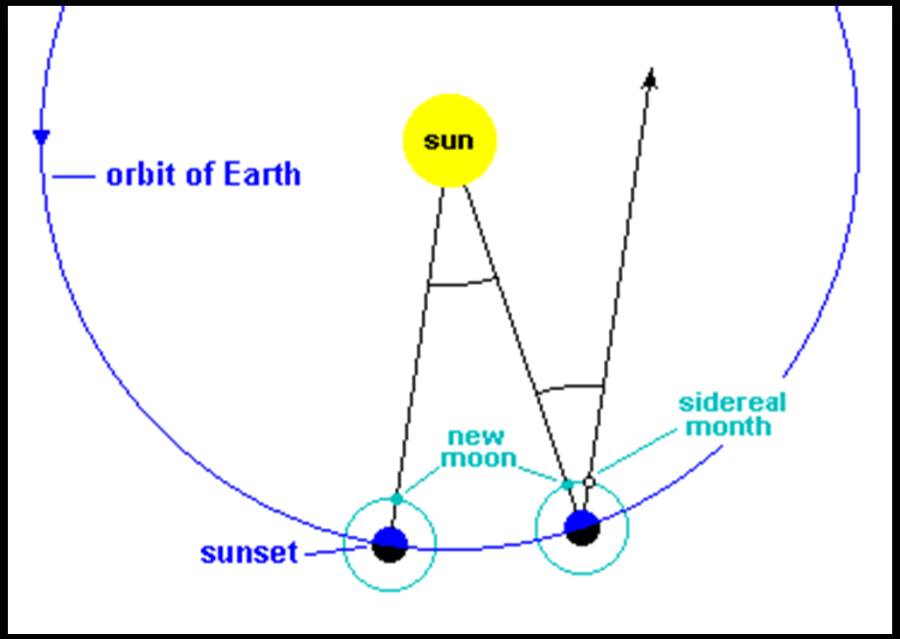


Diagram by Bruce Stewart

- Sidereal
  - Time it takes moon to return to the same place in the sky compared to background stars
  - 27 1/3 days
- Synodic
  - Time it takes the moon to get back to the same phase
  - 29 ½ days
  - The Lunar Month

LUNAR ECLIPSES

- When the Moon passes through the Earth's shadow, it dims
  - Not a lot if in "penumbra"
  - Sometimes a bunch if in "umbra"
- Red color is light being bent around Earth by the atmosphere
  - Red for the same reason as sunsets are red!

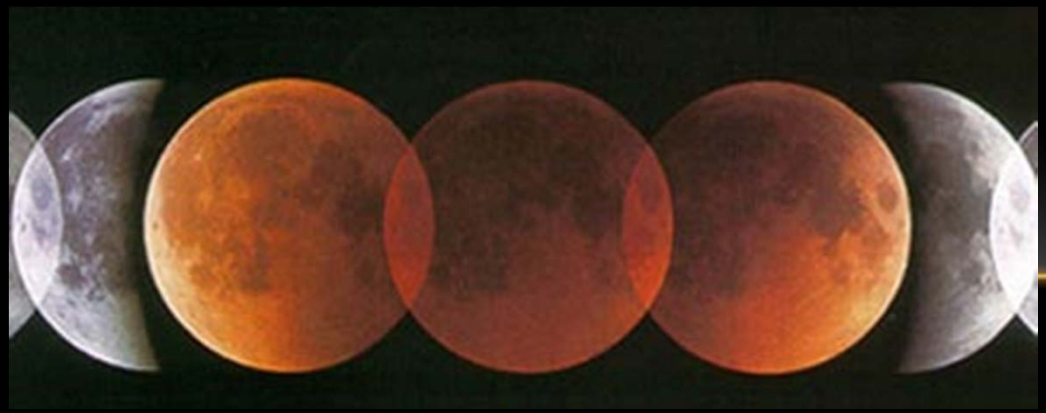
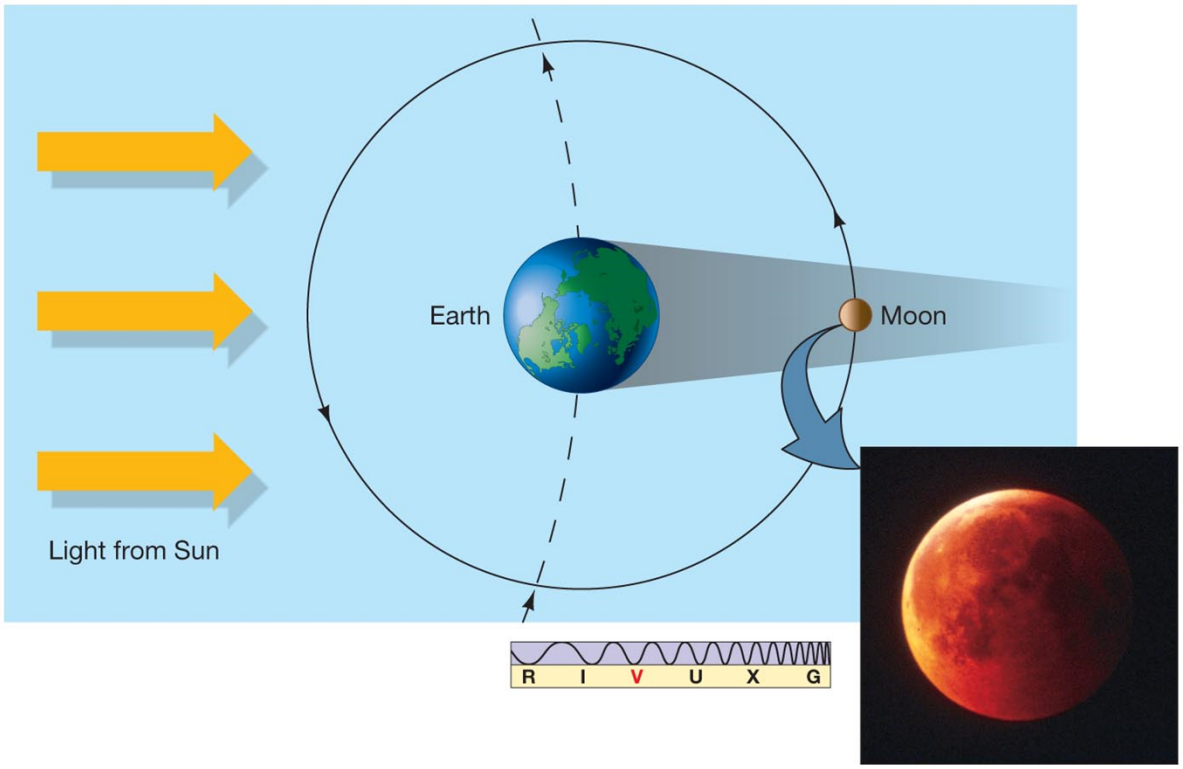


Photo of July 2000 lunar eclipse
by Akira Fujii For *Sky & Telescope*

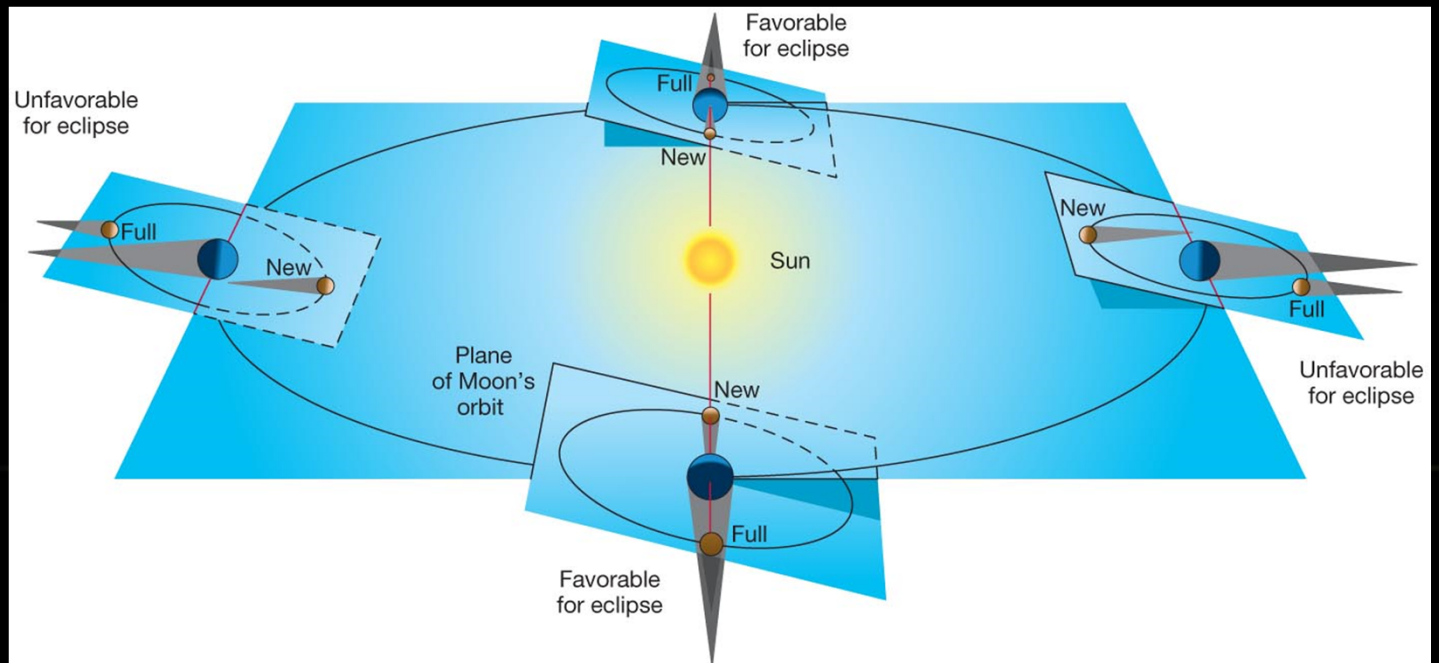
WHEN DO THEY OCCUR?

- At full moon
  - When the Earth is between the Moon and Sun

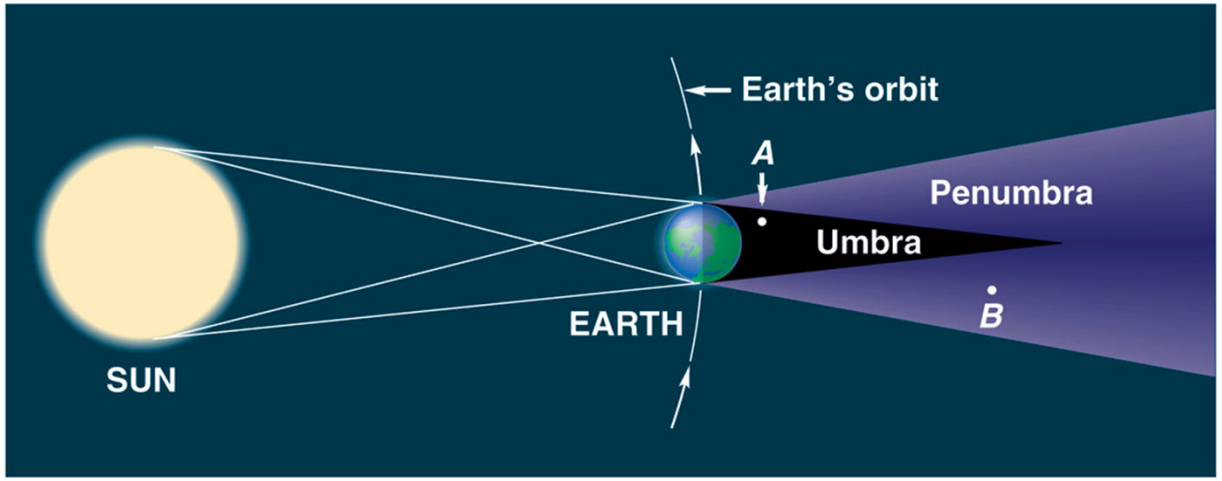


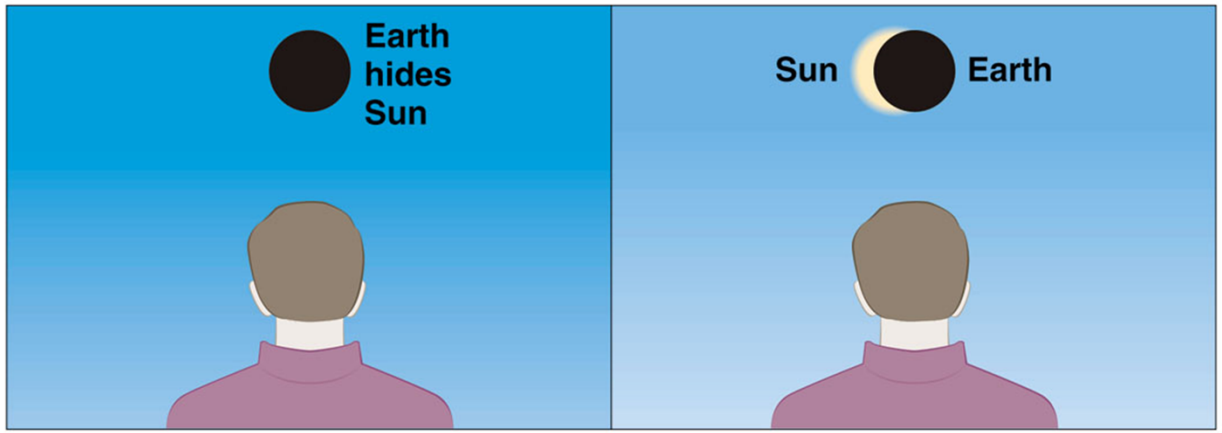
WHEN DO THEY OCCUR?

- Why not every full moon?
  - The Moon's orbit is tilted compared to the ecliptic
  - Can happen only each 6 months
- Why not every 6 months?
  - Must be full moon while in position
  - If Moon is near apogee, it's too far out to hit umbra



UMBRA VS. PENUMBRA





This observer is looking at the Earth and Sun from point *A*, in the umbra of the Earth's shadow.

This observer is looking at the Earth and Sun from point *B*, in the penumbra of the Earth's shadow.

WHEN CAN YOU SEE ONE?

- For any Lunar Eclipse, everyone on the night side of the Earth can see it, since everyone sees the same moon
  - Needs to be nighttime and clear at our location
- The next eclipse: Jan 31 2018, a penumbral lunar eclipse you'll have to go out west to see
  - http://eclipse.gsfc.nasa.gov/eclipse.html

SOLAR ECLIPSE

Animation of a
Total Solar Eclipse
(Distances not to scale)

From UTK

- When the Moon blocks the view of the Sun
  - Earth passes through Moon's (pen)umbra
- Occurs at New Moon
  - When Sun/Moon/Earth is lined up
- Moon's shadow is small
  - Only people in the path of the shadow can see a Solar Eclipse

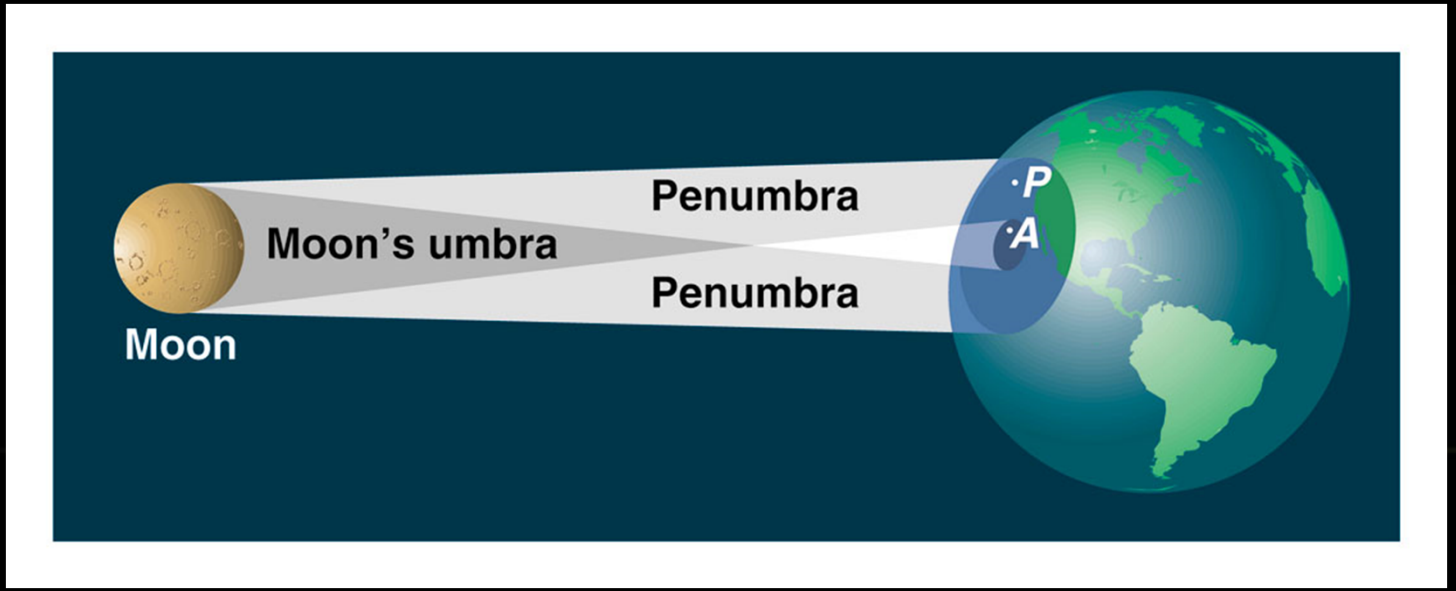
TOTAL ECLIPSE

- Total Eclipse
  - When Moon is close enough that it's angular size is just a bit bigger than the Sun's
  - And you are in Moon's umbra (~100 mi wide path)
  - Outside the umbra, you see a partial eclipse
- When the Sun's disk is completely covered, we can see the fainter corona (the Sun's outer atmosphere)

PLAY

DIAGRAM OF PENUMBRA

- If the Moon is to far away for the umbra to reach Earth, we see one of:
  - Annular eclipse
  - Partial eclipse



ANNULAR AND PARTIAL ECLIPSES

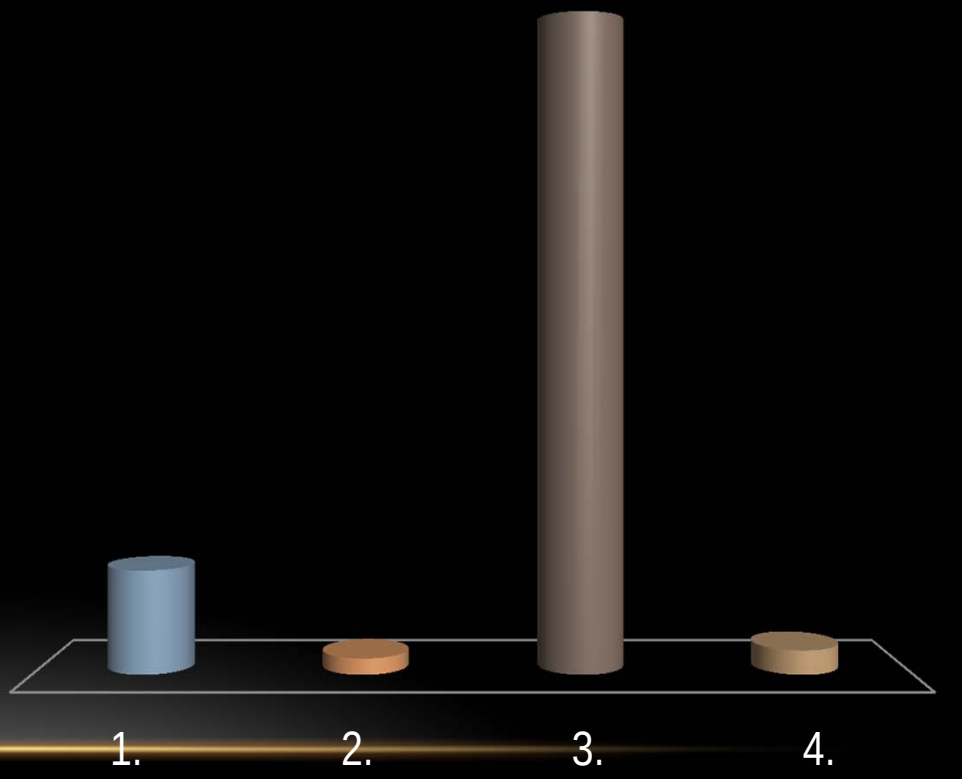
- Annular Eclipse
  - The Moon is a bit further away, we see a ring of the Sun's disk
- Partial Eclipse
  - Things don't line up just right
  - We are in Moon's penumbra

SEEING A SOLAR ECLIPSE

- Since you have to be in the shadow and the shadow is small, these are harder to see
  - Just had one Aug. 21, 2017
  - Next one in the US is April 8, 2024
  - People travel to the shadow, good excuse for vacations in exotic places

WHAT PHASE MUST THE MOON BE IN FOR A LUNAR ECLIPSE TO OCCUR?

1. New Moon
2. First Quarter
3. Full Moon
4. Third Quarter

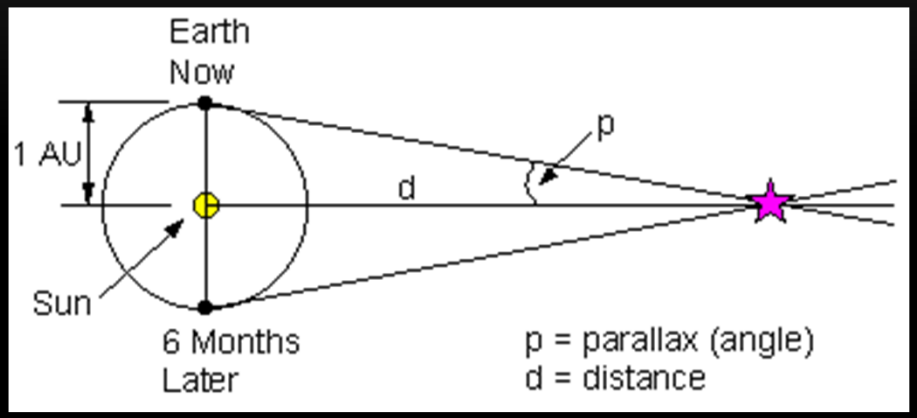


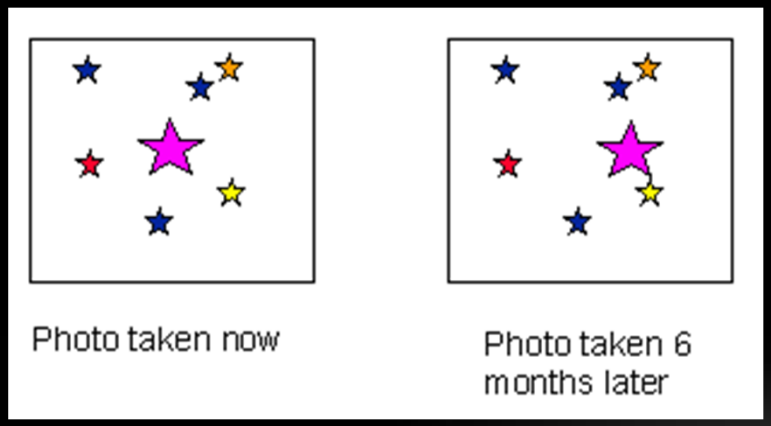
PLANETS

- Are all going around sun too, in about the same plane
  - So move around compared to the stars, hang out near the ecliptic
    - In fact, the word planet comes from the root word “wanderer” in greek
- However, when Earth “laps” a planet, it appears to go backwards (*see animated figure from the book*)
  - Much more on this in the next chapter

PLAY

PARALLAX





- Parallax is the different apparent position of something nearby compared to something far as one moves back & forth
  - Your thumb as you blink, for example
- For nearby stars, you compare to far away stars as the earth moves around

Diagram by Dr. Terry Herter, Cornell

Animation by R. Pogge, OSU

EXAGGERATED PARALLAX

Distance at which a star subtends
1 second of arc is called 1 *parsec*
(3.26 ly, it turns out)

- 1 AU is only 1/63,000 ly
- Nearest star is 4.2 ly
- Most stars you see are dozens to hundreds of ly
- So even biggest parallaxes are only about 1 arc-second! Too small to see without good equipment
- What if the earth's orbit was 1.5 ly instead of only 1AU?