

Stars and Planets

- Stars are “fixed” relative to each other. They produce their own light which is independent of Sun’s location (thus indicating they are very far away - the Greeks understood this) TODAY.
- Planets have complicated (but predictable) orbits when viewed from the Earth. Wanderers. Brightness does depend on Sun. Small numbers of such objects (5 planets visible to unaided eye). NEXT LECTURES
- There are about 9000 stars visible to the unaided eye (no telescope) with about 4500 visible any one night. Need “dark” conditions (no human lights, not full moon). In addition 5 planets and 4 galaxies visible to unaided eye.

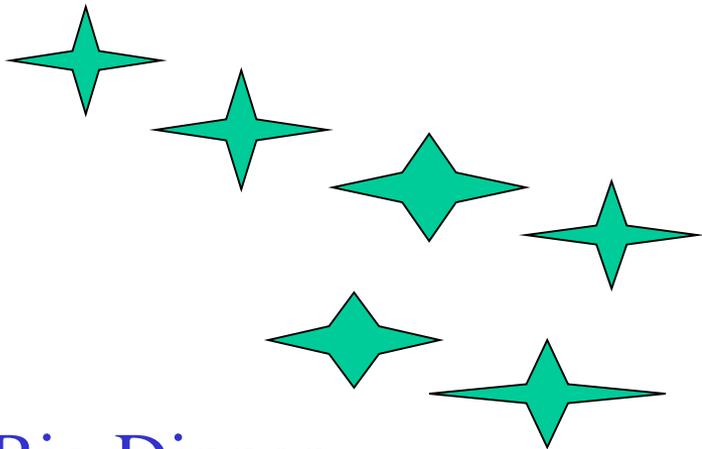
Stars and Planets

- What stars you see in a given night changes through the year. And depends on latitude (North-South location)
 - Planets are located along the ecliptic (Sun's path through sky) and which you can see at any time changes each month/year
- Mostly due to which side of Earth is “night” and this points at different directions, that is at different stars, as Earth travels around the Sun during the year or as the Earth spins during the night

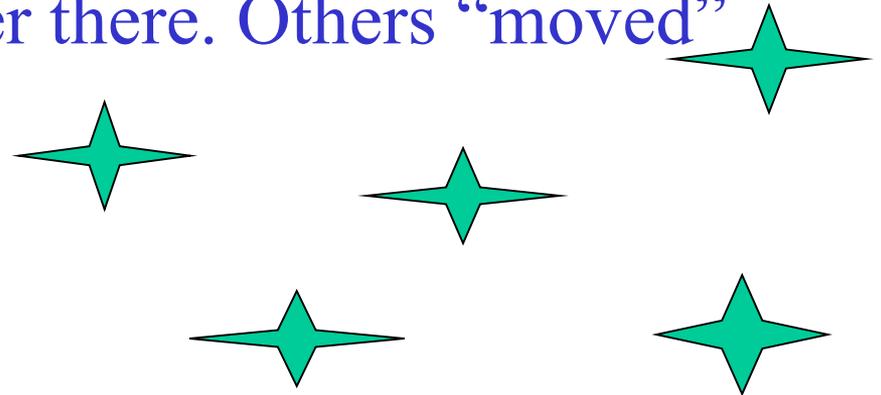
Constellations

- Stars which are “close” to each other (in angle) form patterns called constellations
- Unchanging in 10,000 year timescales but position in sky varies with season: Winter vs Summer, North vs South
- Geological timescales → stars move or “disappear”

10 million AD. One star no longer there. Others “moved”

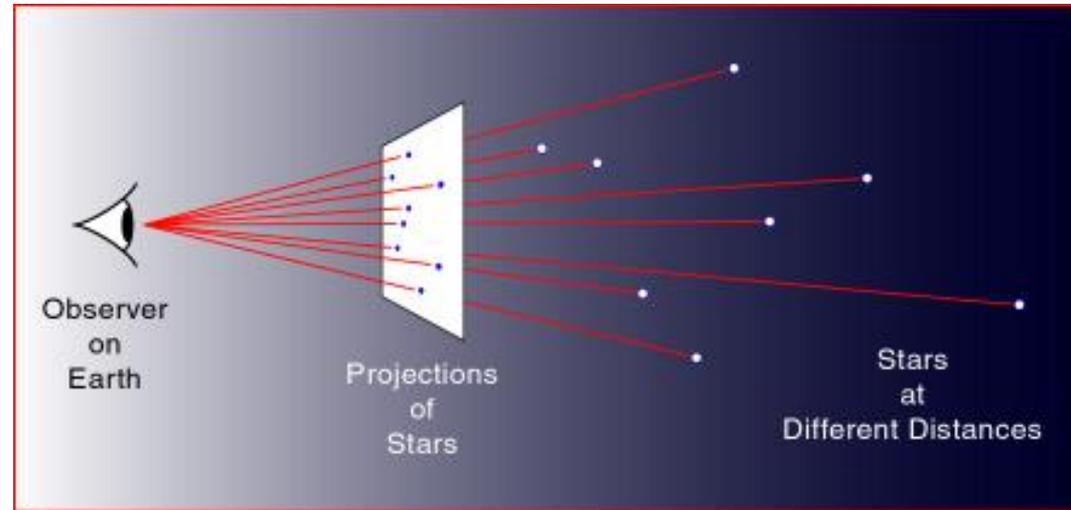


Big Dipper
Today



Very bright constellation to our south but almost directly overhead of Hawaii. Two bright stars which may supernova in next 100,000 years: Betelgeuse (red giant) and Rigel (blue giant). Also has Orion Nebula where new stars are being formed.

Orion – Star Distances



Stars are at different distances. Very far apart but seem close in the sky as in same direction

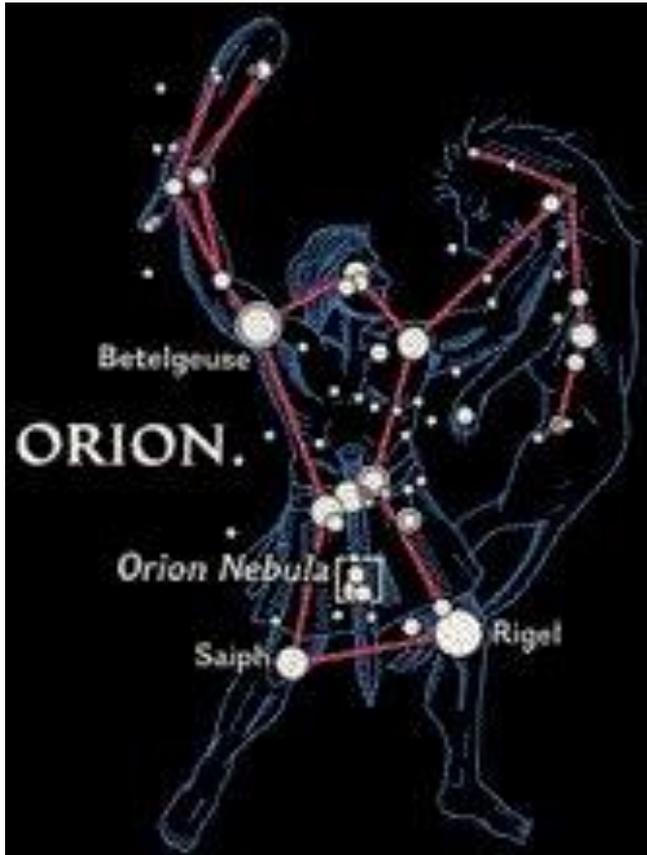
Rigel 773 Light Years (LY)

Betelgeuse 427 LY

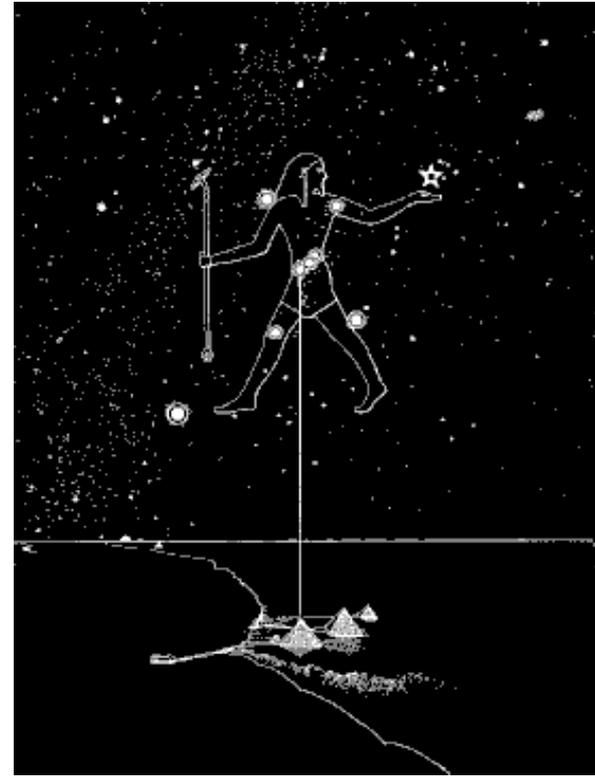
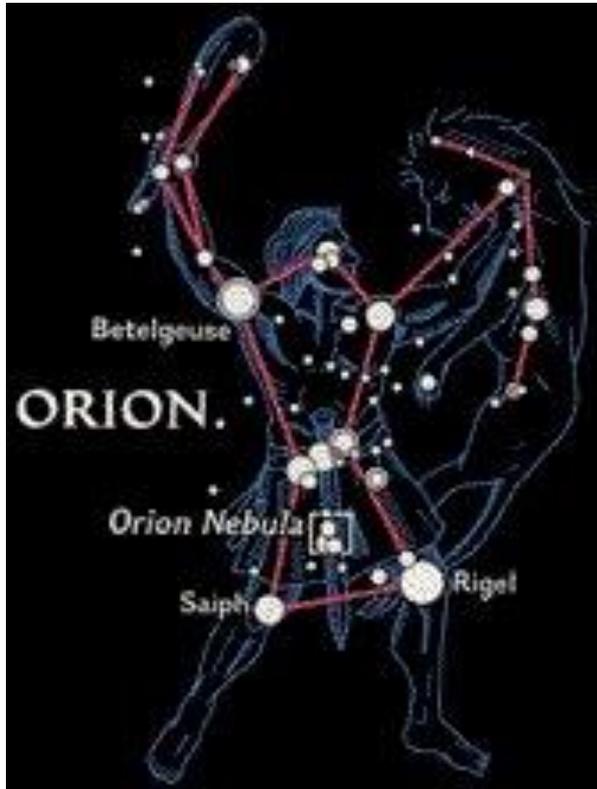
Nebula (sword) 1300 LY

Saiph (right knee) 720 LY

Ballatrix (left shoulder) 243 LY

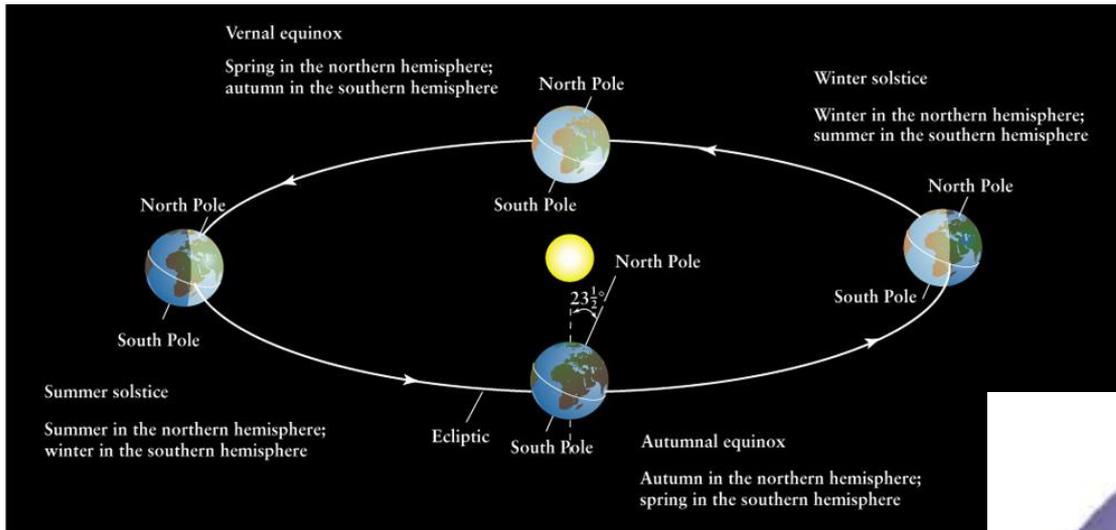


Orion (Greek) or Osiris (Egypt)



looks like a man with 3 stars in line forming a belt. For Greeks, Orion is hunter and chases constellation Taurus the Bull and the Pleiades (7 sisters) and is followed by the 2 hunting dog constellations Canis Major and Canis Minor. For Egyptians, identified with Osiris, god of agriculture and rebirth, and the rising of this constellation in late winter heralded the rising Nile. The great pyramids at Giza seem to be in same pattern with other pyramid remnants at other spots and the Nile overlapping with the Milky Way

Yearly Motion: Earth orbits Sun



Earth moving around Sun.
“night side” points at different directions and so see different stars in different seasons.

“night side” points at Orion in January, Scorpius seen in June

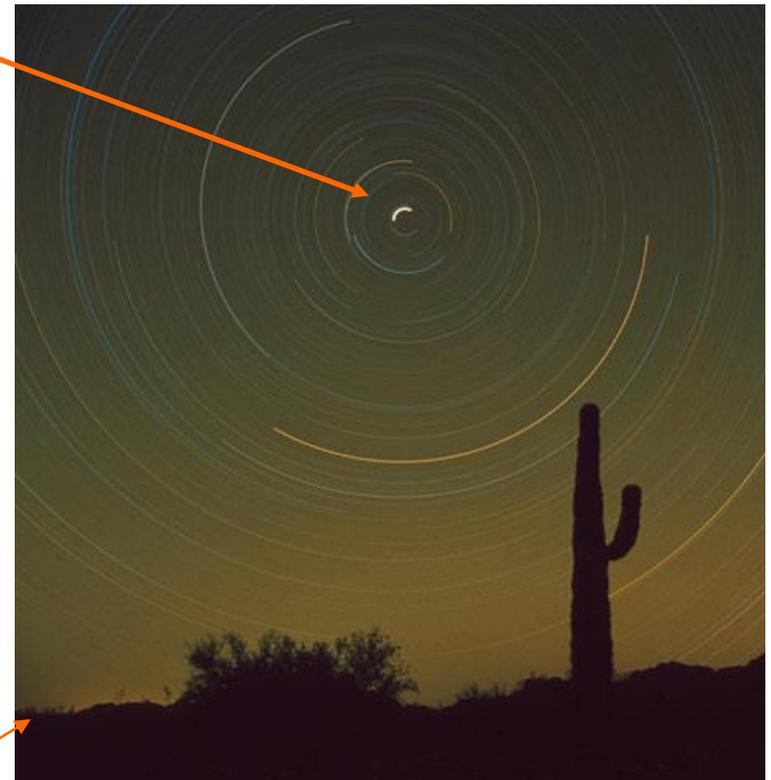
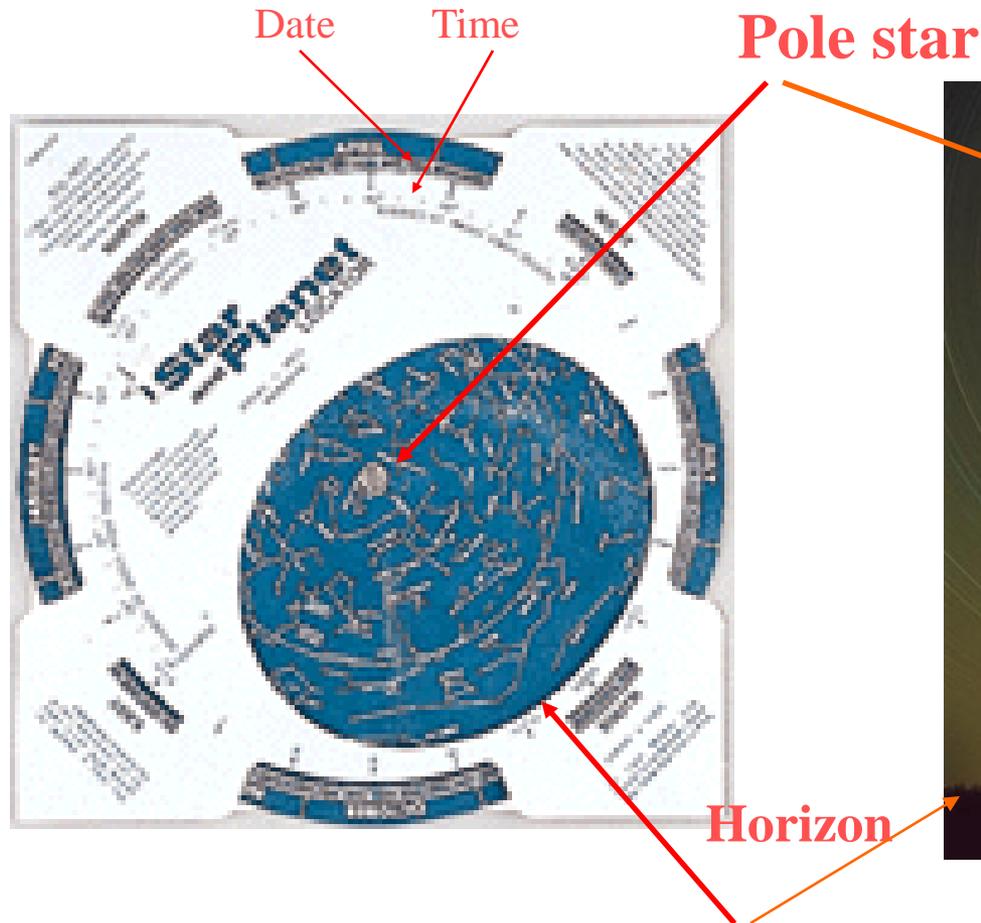


Star Wheel

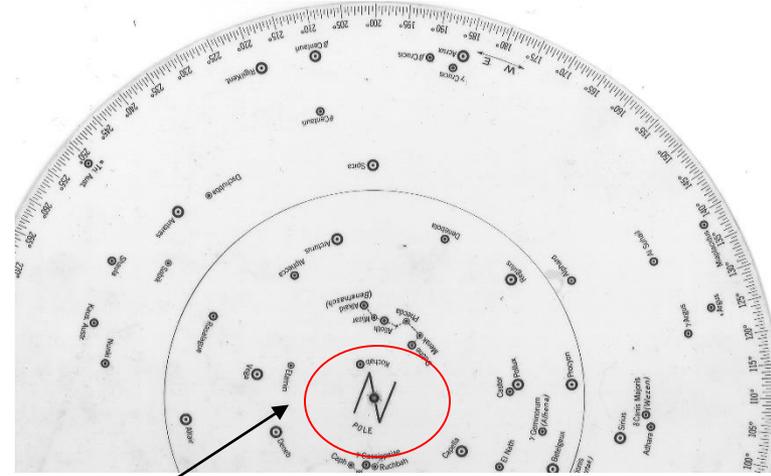
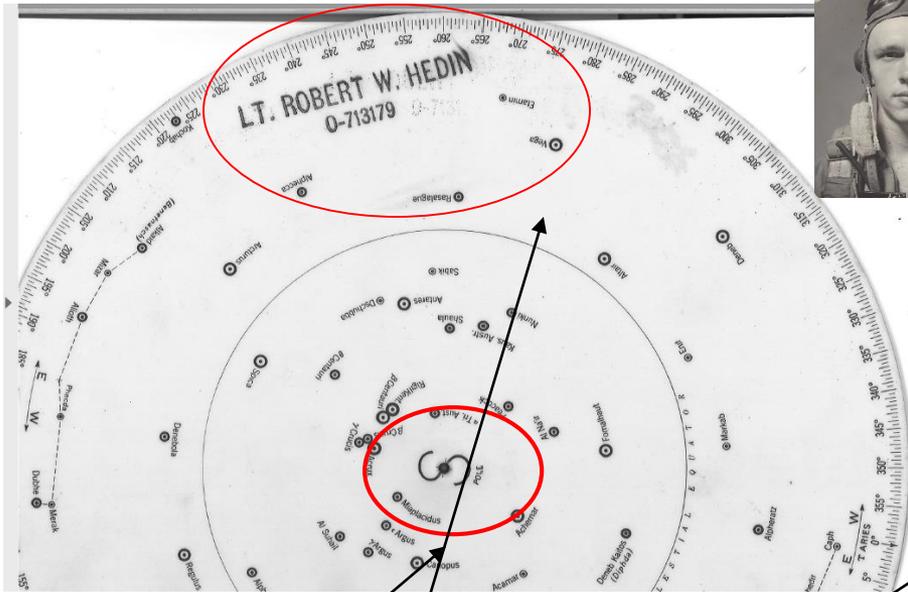
- Stars “move” East to West over the course of one Night (in circle about the North Star)
- Stars “move” East to West by 2 hours per month and “return” to the same position after one Year
- It’s just caused by Earth’s daily spin and yearly orbit about the Sun
- A very simple device, Star Wheel, can show what stars are visible on any night during the year. One ring has 24 hours as scale while the other has 12 months/365 days as scale
- Star wheel depends on latitude. Northern vs southern hemisphere completely different. For Northern, the center is North Star

Star and Planet Locator (aka Planisphere or Star Wheel)

Northern hemisphere. But south of DeKalb as North Star closer to horizon photo (in Arizona)



Star Wheel use in WW II



Southern hemisphere Northern

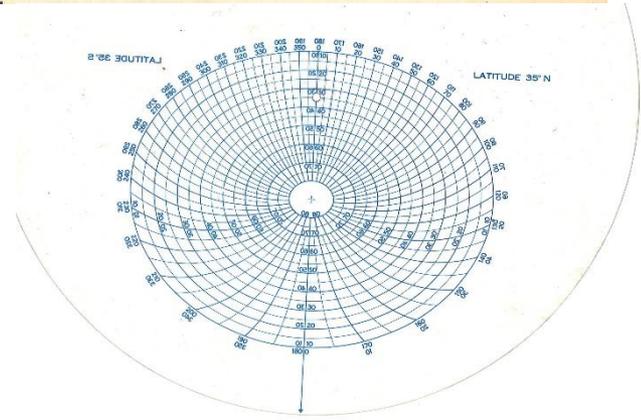
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 HYDROGRAPHIC OFFICE
 RUDE
 STAR FINDER AND IDENTIFIER
 (WITH HYDROGRAPHIC OFFICE MODIFICATIONS)

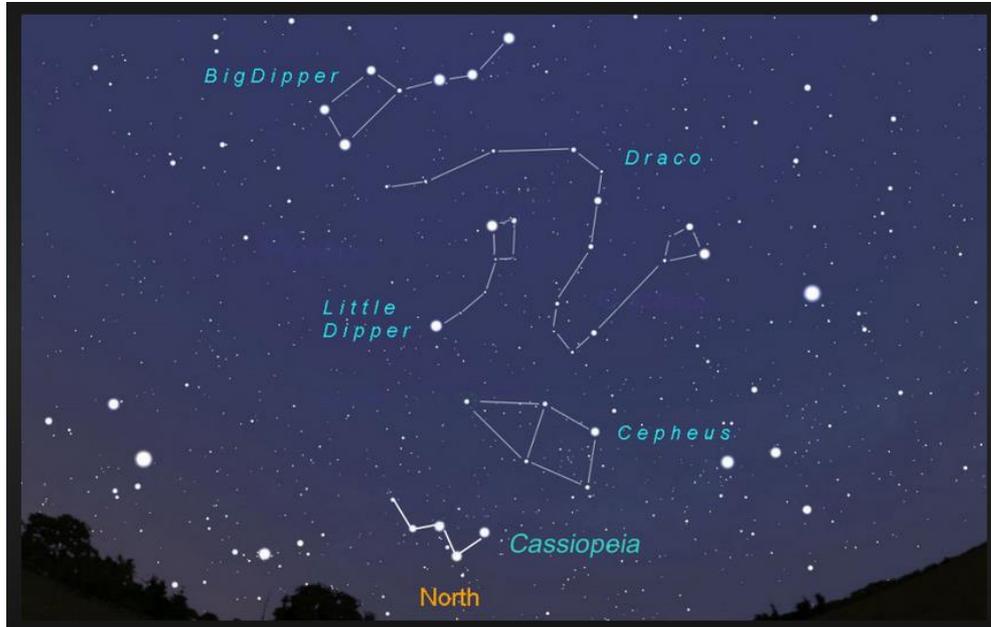
TO PLOT PLANETS OR MOON

Subtract the G. H. A. of the Planet or Moon from the G. H. A. T (plus 360° if necessary). These values are taken from the same line in the Air Almanac. Place the 5° template on the Star Base and set its extended 0°—180° line at the resulting value on the outer periphery of the Base. Through the slot cut in the template, plot the planet or moon at the body's declination.

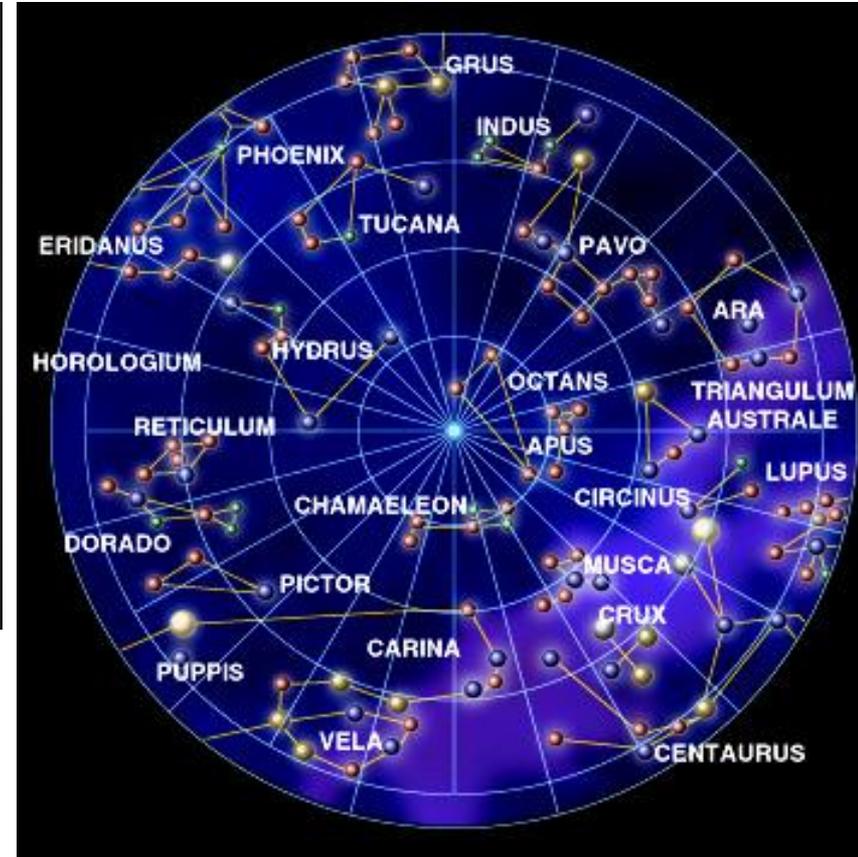


US Army Air Force navigators carried a star wheel in their kit to help them identify stars and calculate their approximate latitude and longitude (with a watch set to Greenwich Mean Time). One side was Northern hemisphere stars and one side Southern hemisphere stars, and there were 7 transparent overlays, for different latitudes, to place over the stars. Shown is the 35 degrees (N or S) overlay from my dad's kit. →

Different hemispheres, different constellations



Sky seen at North pole (up) and South pole (right) have completely different constellations. Point at different regions of space.



Polaris - The North Star

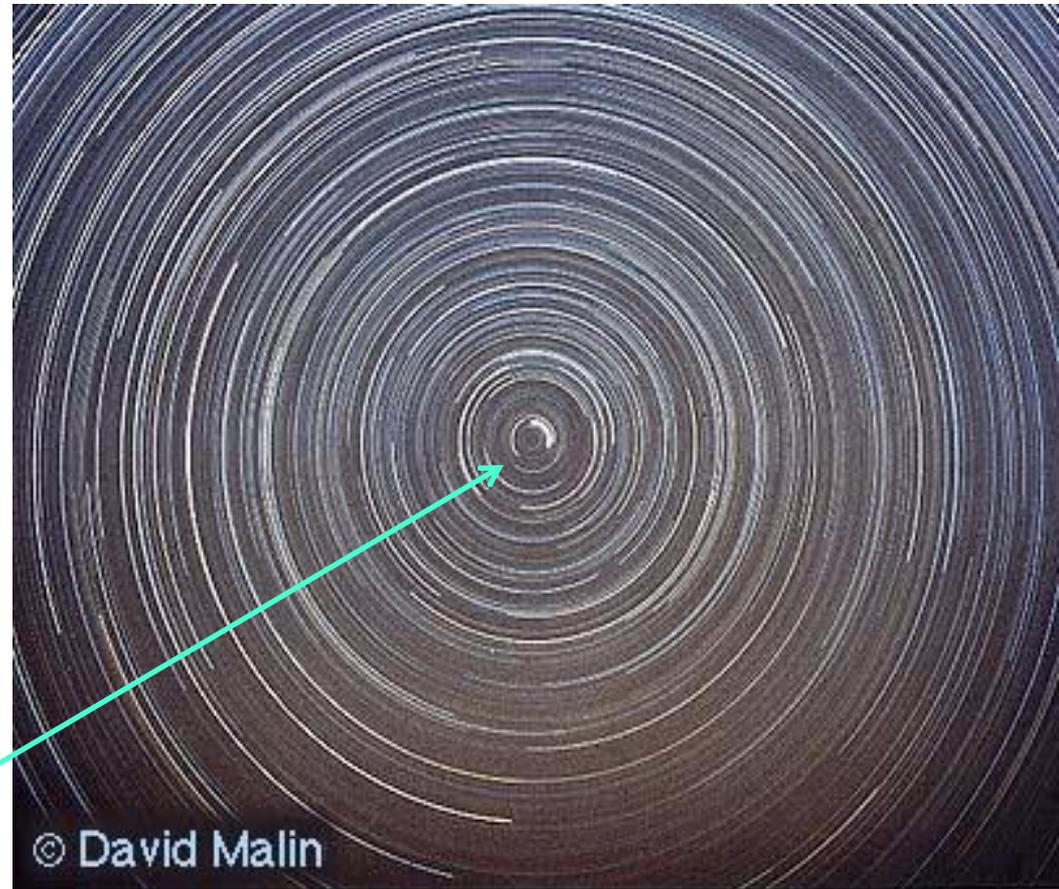
- Polaris is almost directly overhead at the North Pole.
- Polaris is about halfway up from the north horizon in DeKalb.
- Polaris is at the north horizon at the Equator.
- Polaris is not visible south of the Equator.
- Polaris doesn't "move" due to the Earth's rotation.
- No equivalent "South Star"

Rising and Setting Stars

- Other stars “move” in circles about Polaris due to Earth spinning.
- It takes 1 day to complete the circle.
- The rising and setting time of a star changes with the seasons.
- Stars are directly overhead (*zenith*) 2 hours earlier each month.

Star trails in the northern sky

- As the earth spins on its axis, the sky seems to rotate around us. This motion produces the concentric trails traced by the stars in this long time exposure of the night sky. The north celestial pole (NCP) is at the center.



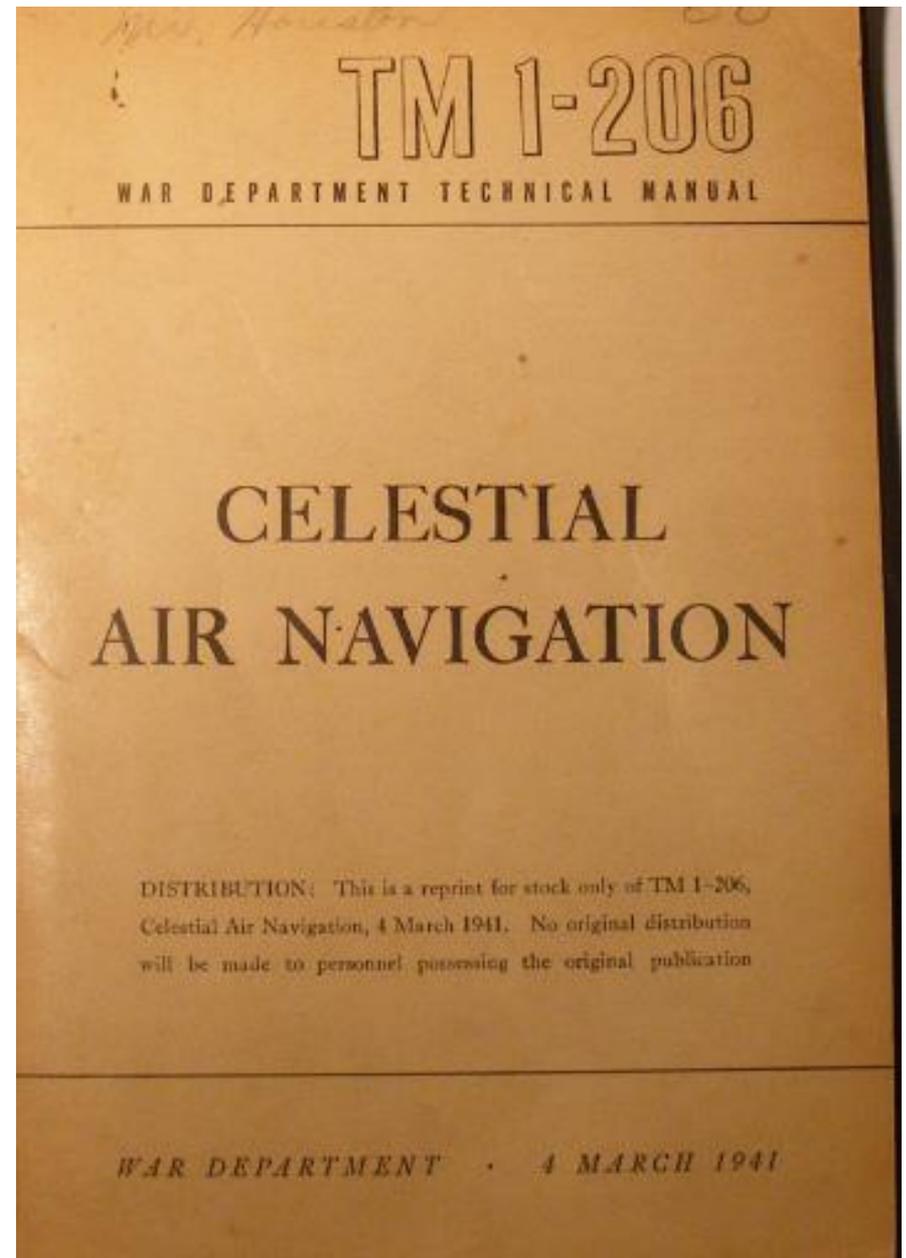
Star trails in the northern sky

- short bright trail near the NCP was made by Polaris
- Show Polaris is not *exactly* due north.
- If use for navigation have correction factor. See Celestial Air Navigation, War Department Technical Manual TM 1-206, 1941 (carried in kit bag by all USAAF navigators)



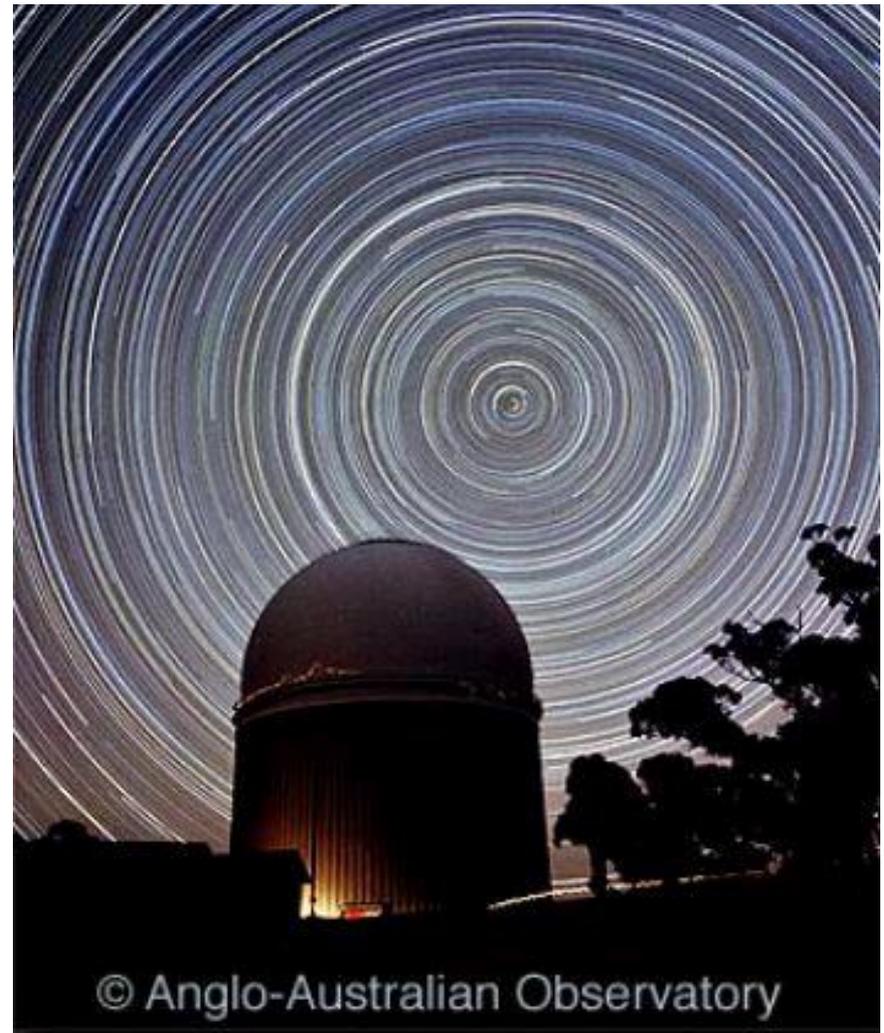
Celestial Navigation

- Extensively taught to US Army Air Force and Navy officers during WW II (larger planes had dedicated navigator). Had beginnings of radio detection finding then. Navigation (including celestial) still taught to USAF officers in case of emergencies
- See Extra slides for examples

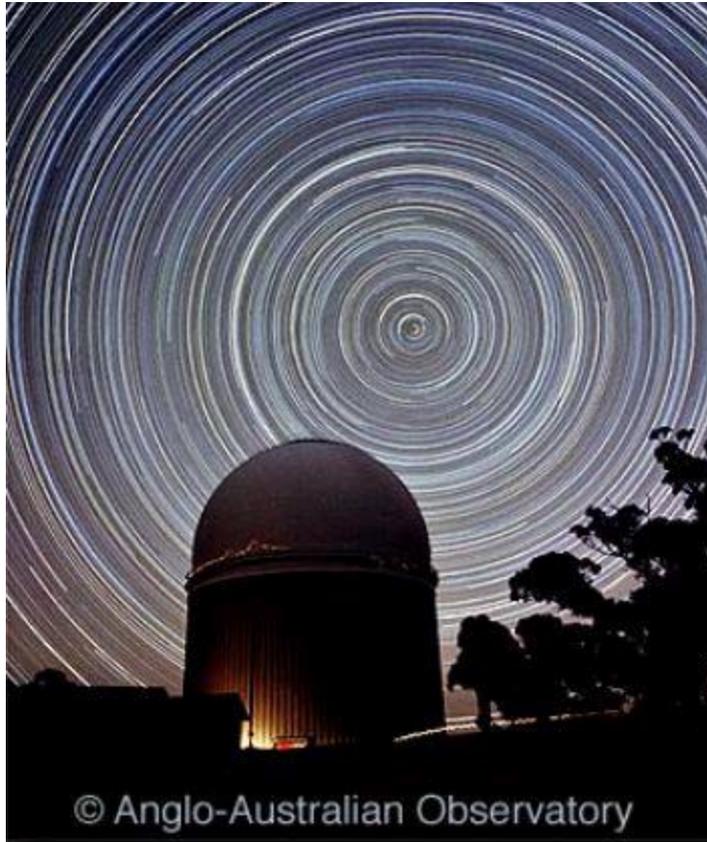


Star trails in the southern sky

- While the bright star Polaris lies conveniently close to the North Celestial Pole, no bright star similarly marks the pole in the South.
- Still, the South Celestial Pole is easily identified in the picture as the point in the sky at the center of all the star trail arcs. Can use location of different stars to determine what direction is South

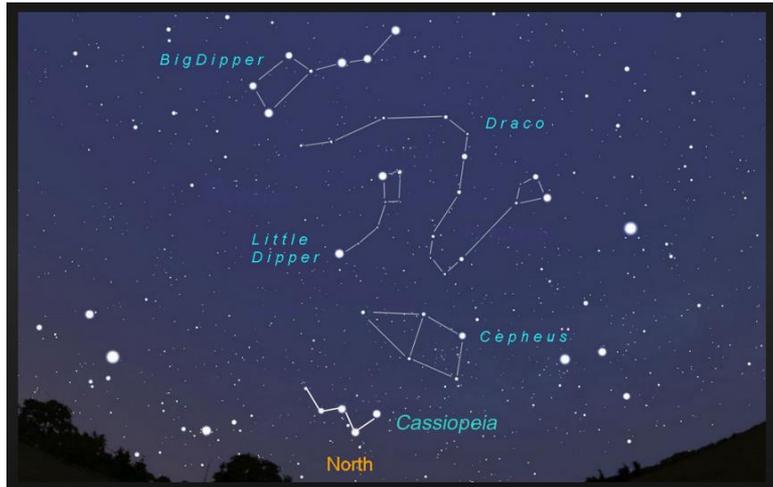


Compare angles to horizon for rising and setting at high and low latitudes → another way of determining latitude



Circumpolar stars – Northern Latitudes

Some constellations are always above the northern horizon and so always visible. They will “move” by 90 degrees in 6 hours due to Earth spin, and by 90 degrees every 3 months due to Earth moving around Sun

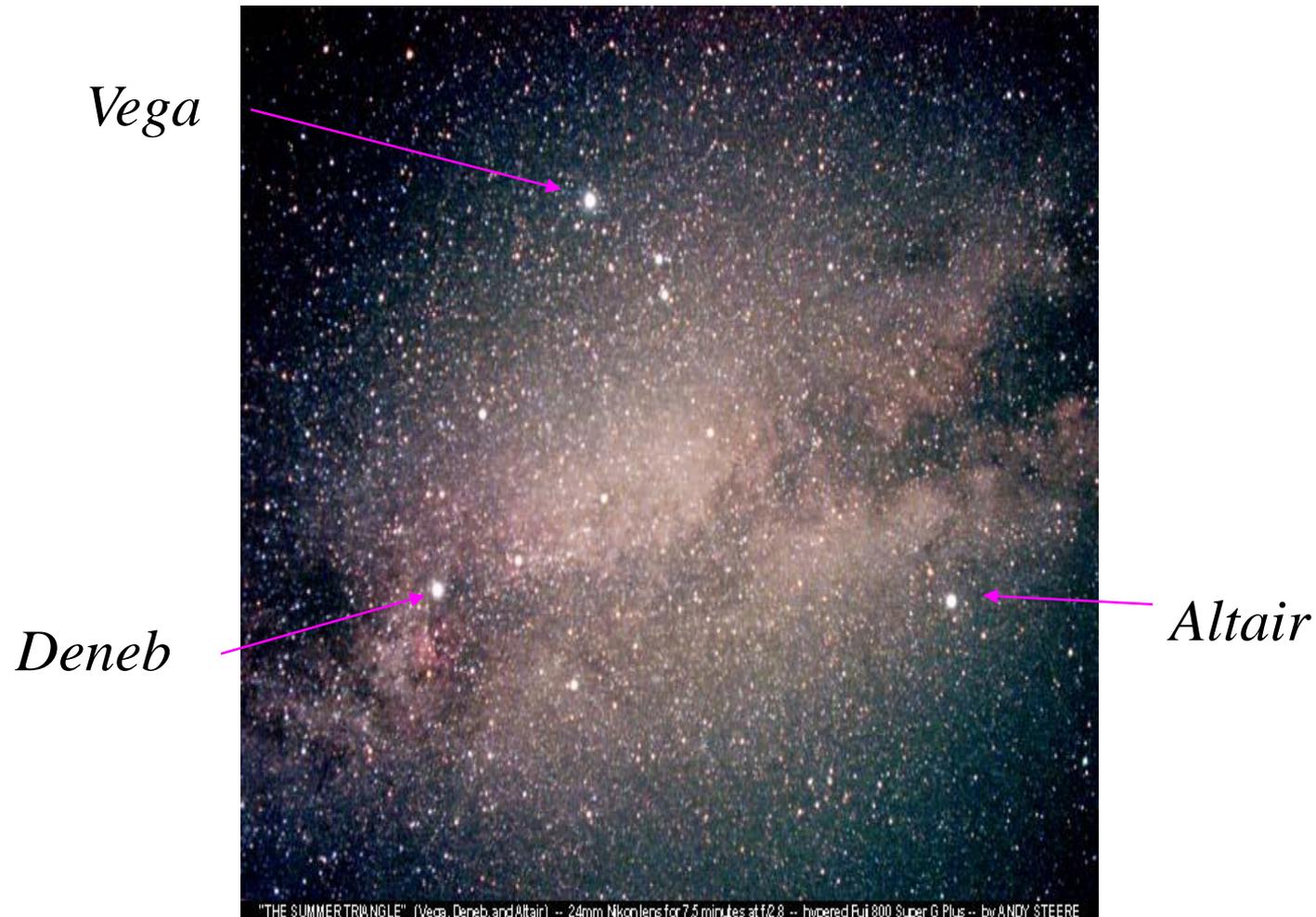


8 PM June. Cassiopeia directly below (to north) of North Star. North Star at end of Little Dipper

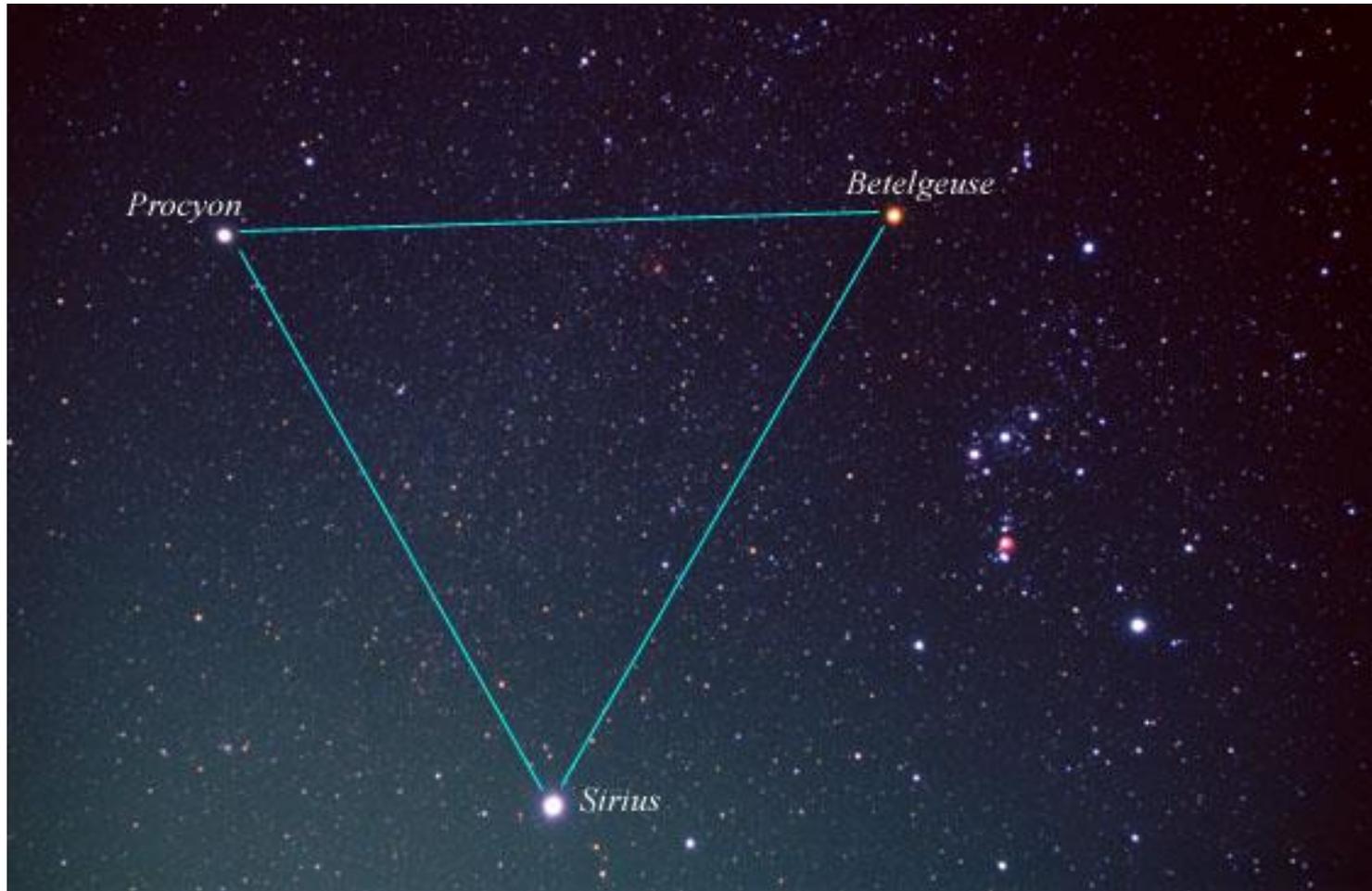


2 AM June. Cassiopeia to East of North Star

Summer triangle – directly overhead in DeKalb. Cloud is Milky Way, tough to see if near city due to light pollution



Winter triangle – to South in DeKalb



What to Remember - NS

- Polaris (the North Star) doesn't "move" due to the Earth's rotation.
- The angle of Polaris to the north horizon gives the observer's latitude

<u>Polaris Location</u>	<u>Latitude</u>
directly overhead	90 ⁰ N (North Pole)
about halfway up	42 ⁰ N (DeKalb)
on horizon	0 ⁰ (Equator)
below horizon	Southern hemisphere

- Other stars "move" in circles about Polaris. 1 day to complete circle. Angle between star and Polaris gives declination (N-S location). Viewing particular constellation at certain time/day also gives observer's latitude

What to Remember - EW

- What time during the day a star rises, is overhead, and sets changes with the seasons
- look up on Star Chart or Table (right ascension is the East-West location)
- Changes 2 hours/month
- Only on the Equator can all stars be viewed from a single location → Hawaii or northern Chile a good place for telescopes (all of northern or southern hemisphere plus a little bit of the other)
- Stars (plus accurate clock) give EW location (longitude). Used for navigation pre-1950 (in WW II)

Extra Slides

Constellations - Orion



Very bright constellation to our south but almost directly overhead of Hawaii. Two bright stars which may supernova in next 100,000 years: Betelgeuse (Red giant) and Rigel (blue giant). Also has Orion Nebula where new stars are being formed. Mostly a Winter constellation as rises in the East at dusk in December. Orion is near the Milky Way which are stars from our own galaxy which are too far away to see as individual stars without a telescope

Betelgeuse

M78

M42

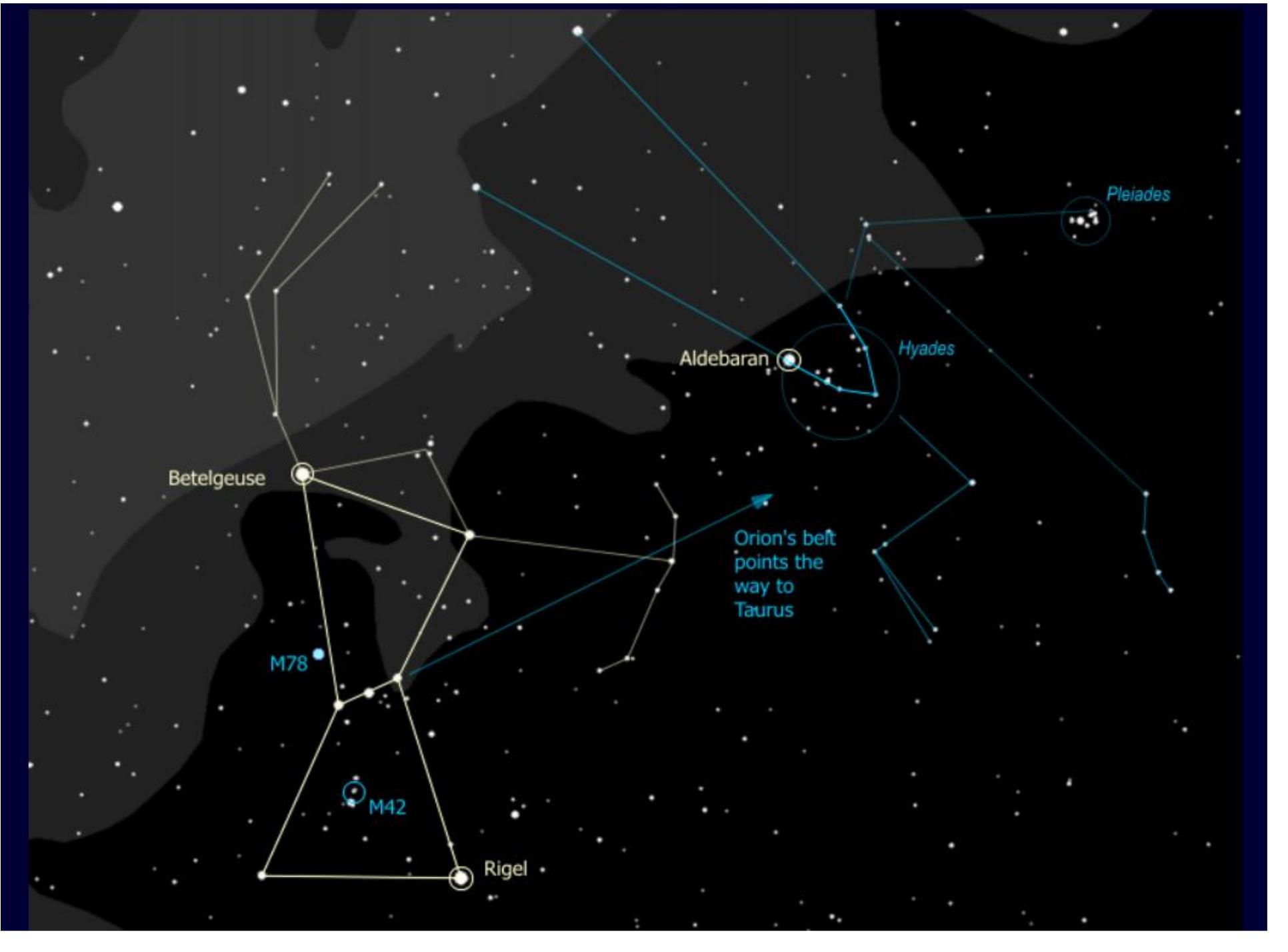
Rigel

Aldebaran

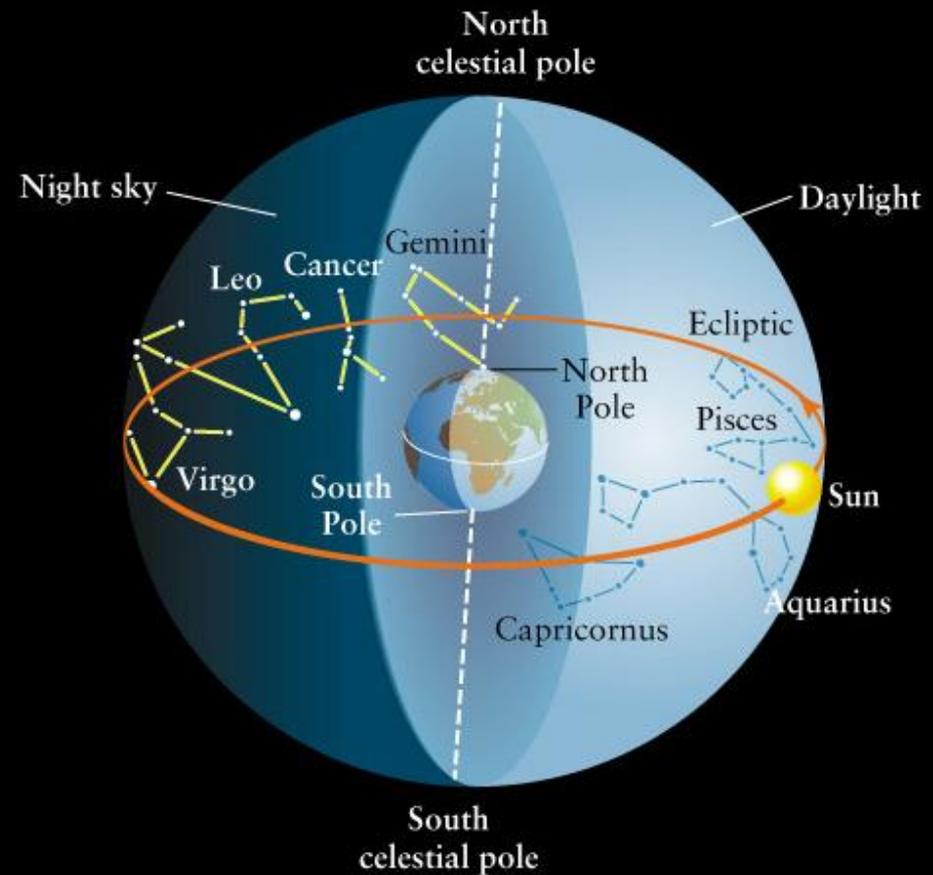
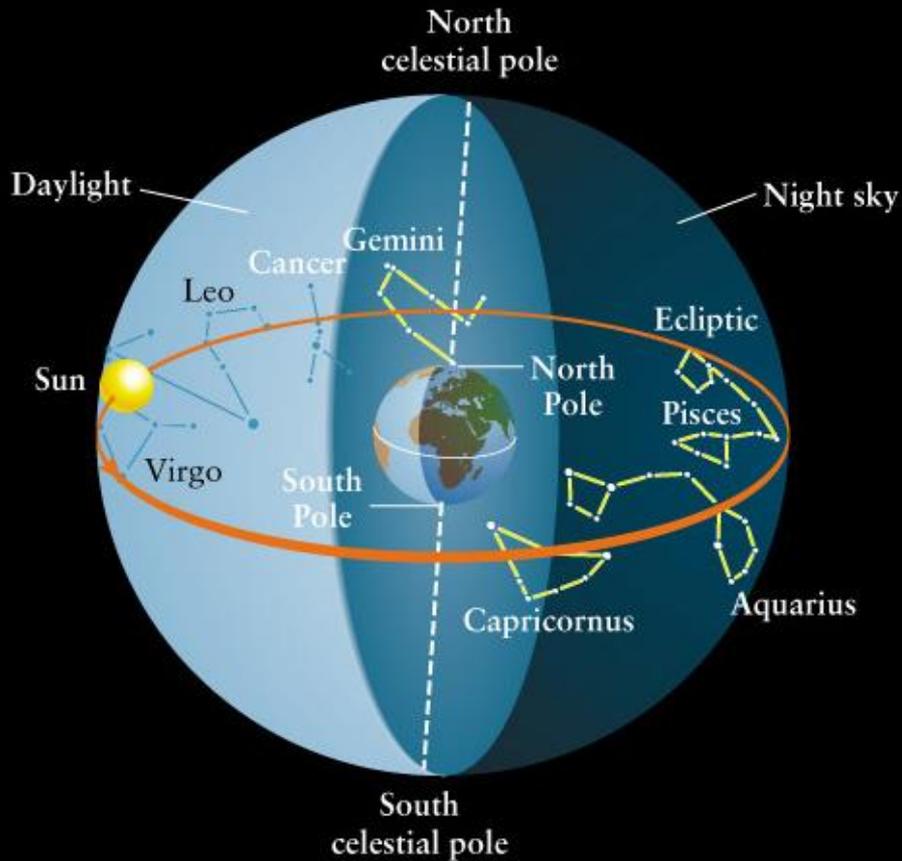
Hyades

Pleiades

Orion's belt
points the
way to
Taurus



Different seasons, different constellations. Seen from Earth. If in northern hemisphere, see North celestial pole, in southern see South celestial pole

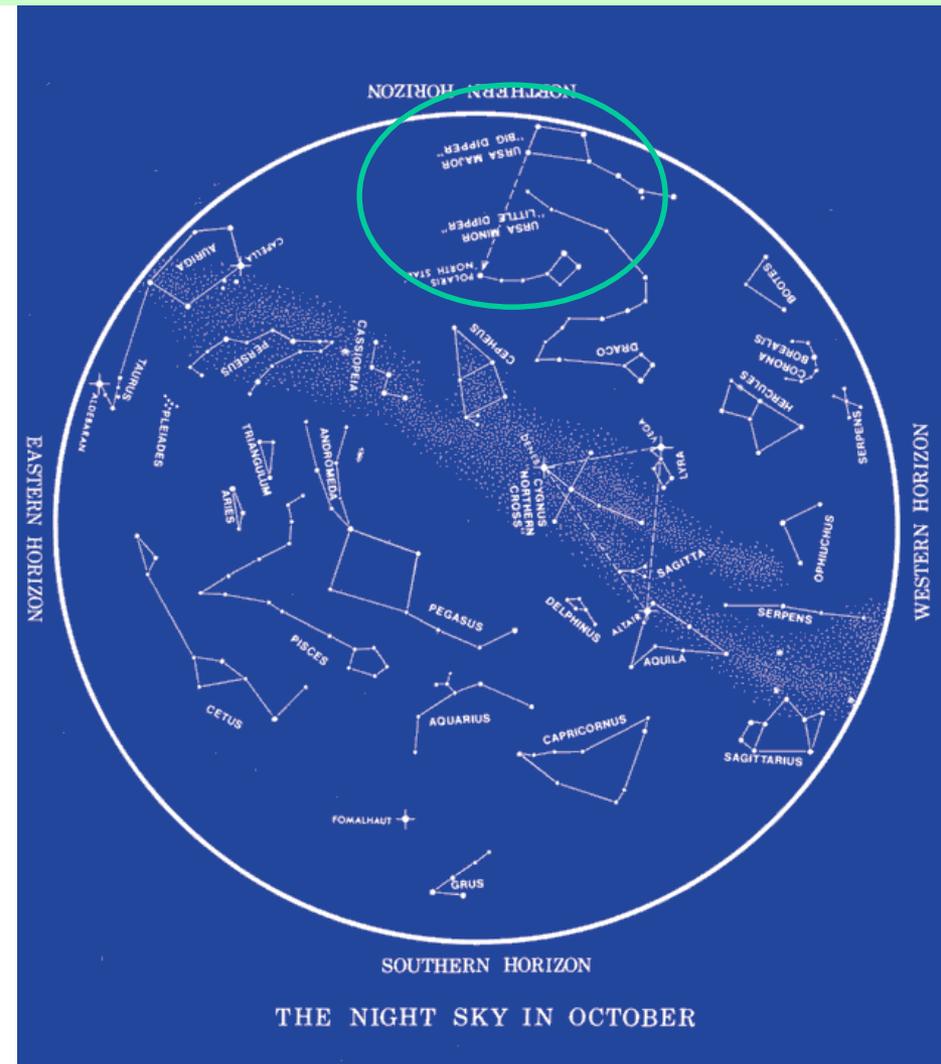
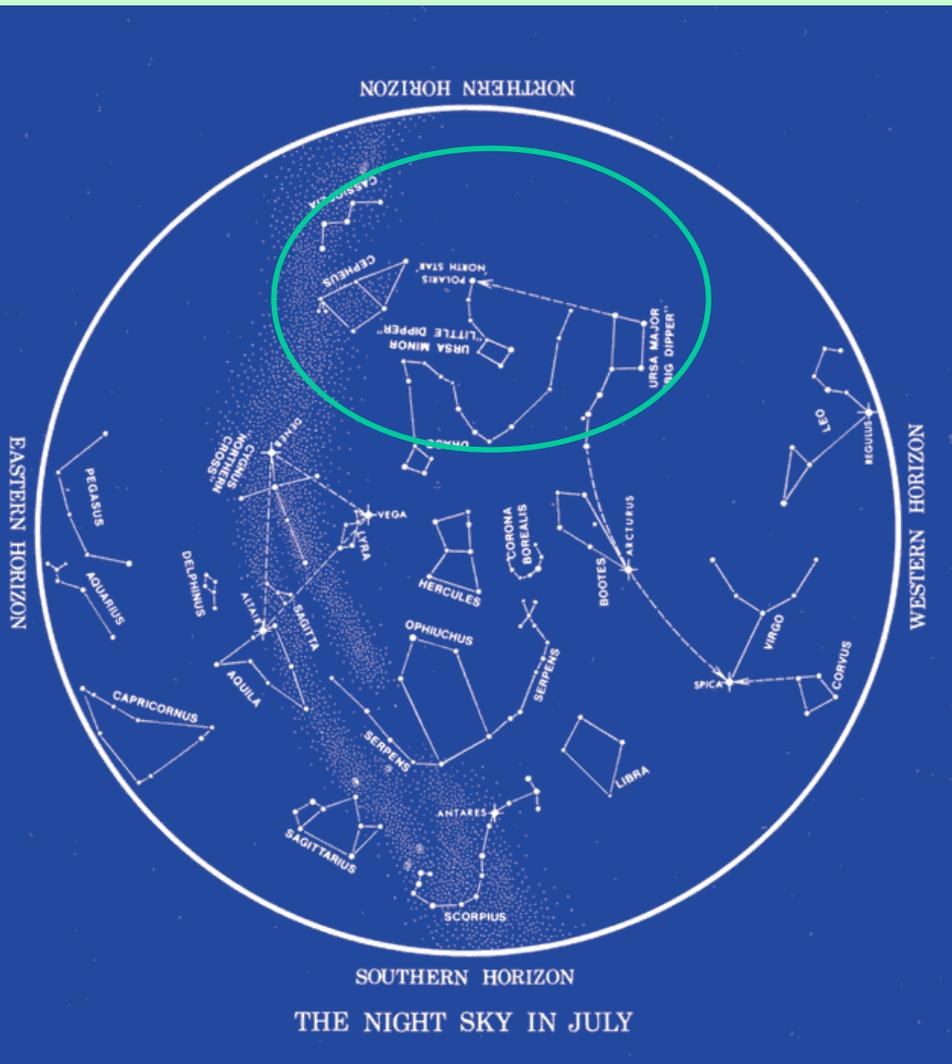


Star trails at mid-latitudes

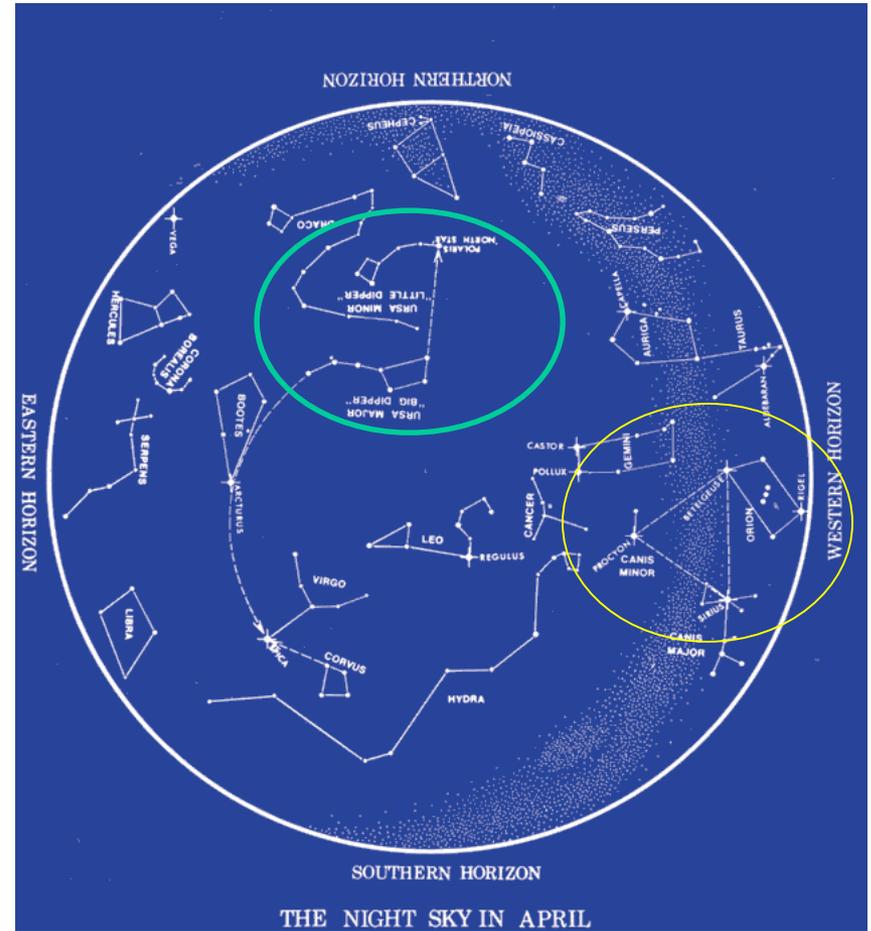
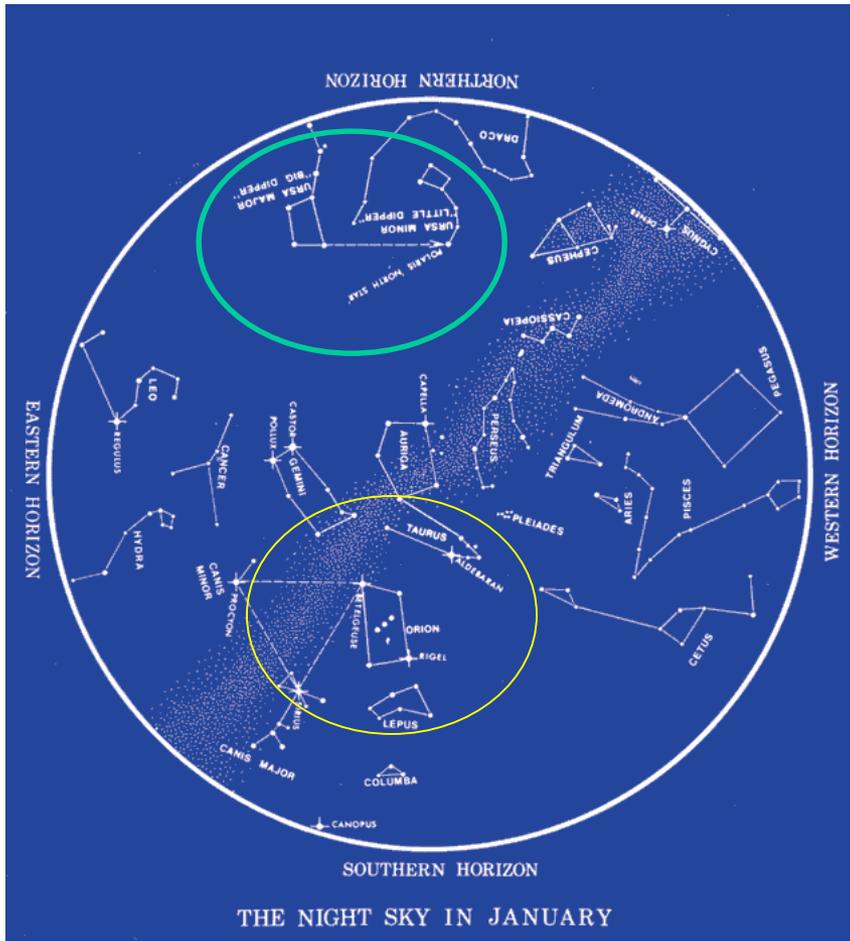
- Star trails from a lower latitude (trails set beneath the horizon)



July and October – near Sunset in LA. Note movement of Big Dipper

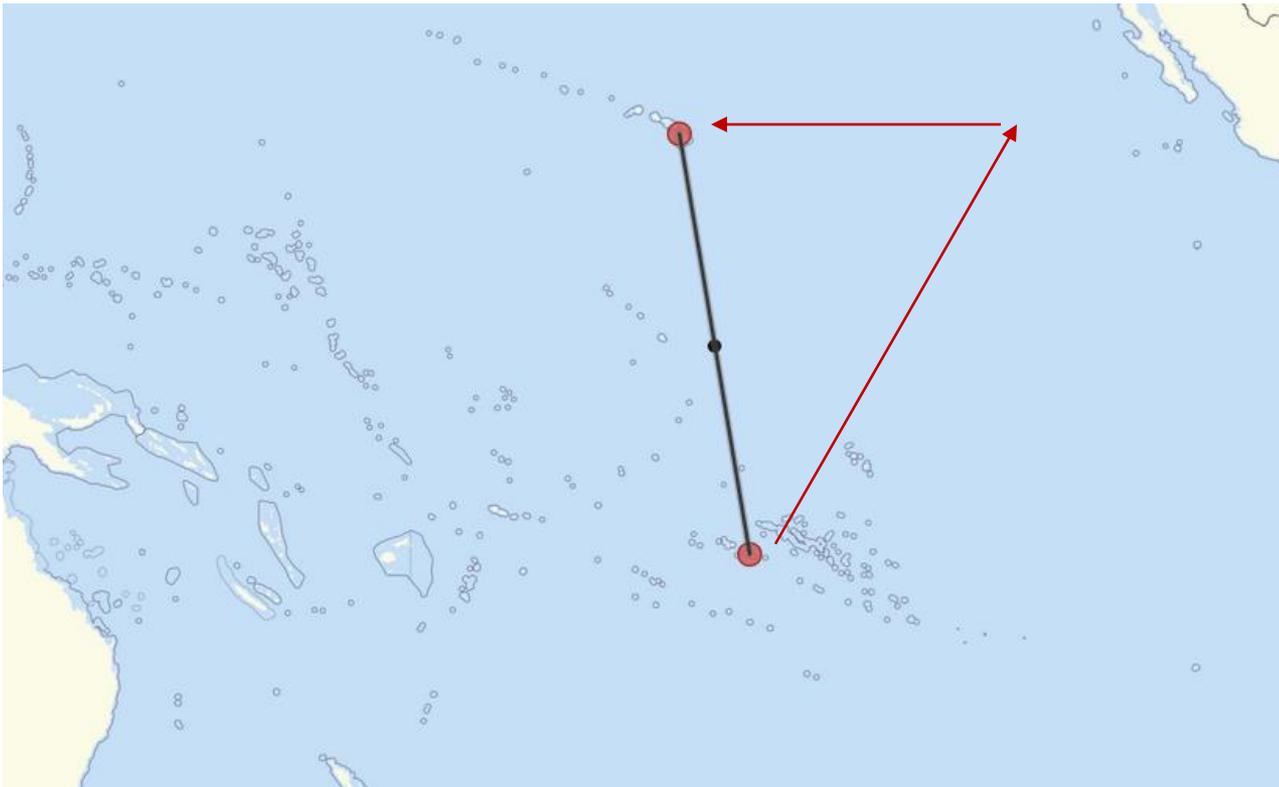


January and April – near Sunset in LA. Big dipper “moves” around circle. Note can now see Orion almost directly overhead in January and near Milky Way



Navigating using Stars – not on tests

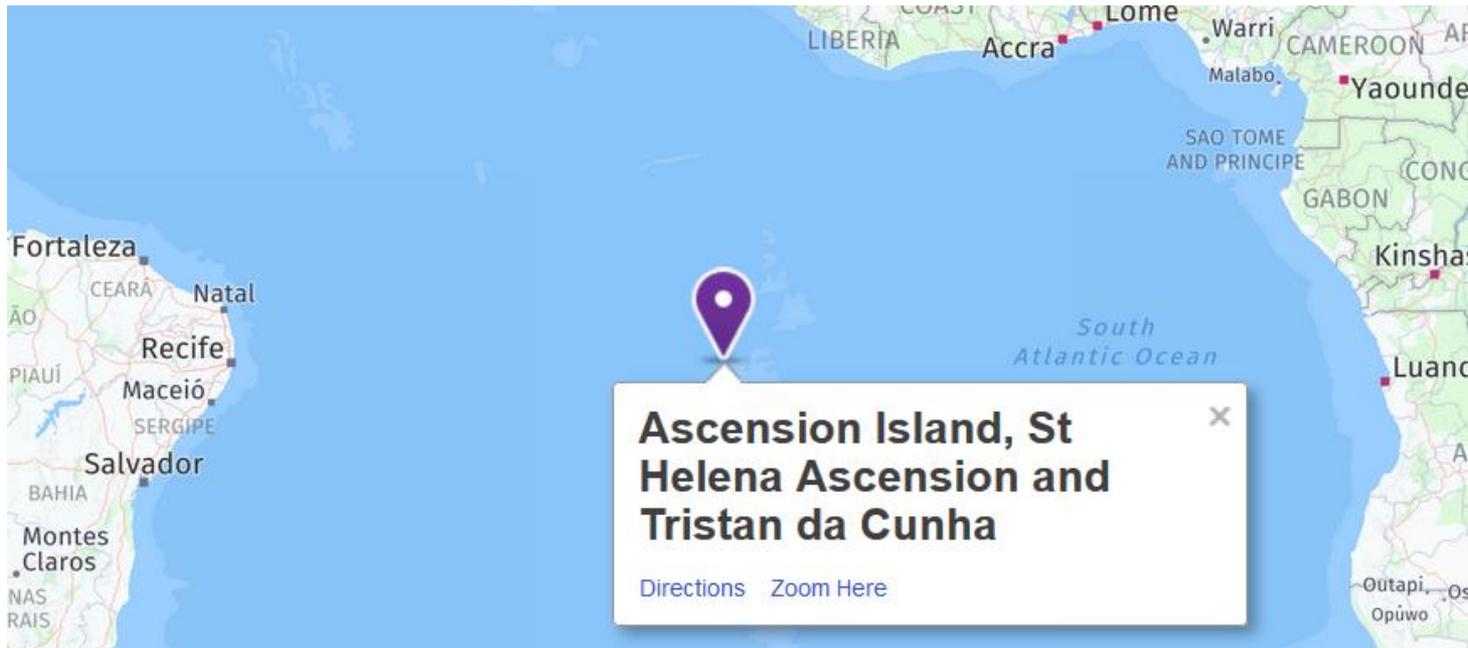
- Historically, the most impressive navigating over long stretches of ocean was the trip from Polynesia to Hawaii. About 2700 miles (direct). Hawaii is very isolated and to find sailed north and east until Orion's belt directly overhead and then sail straight West



Red lines are path used by Polynesians in outriggers. About 4000 miles

Navigating using Stars and Sun

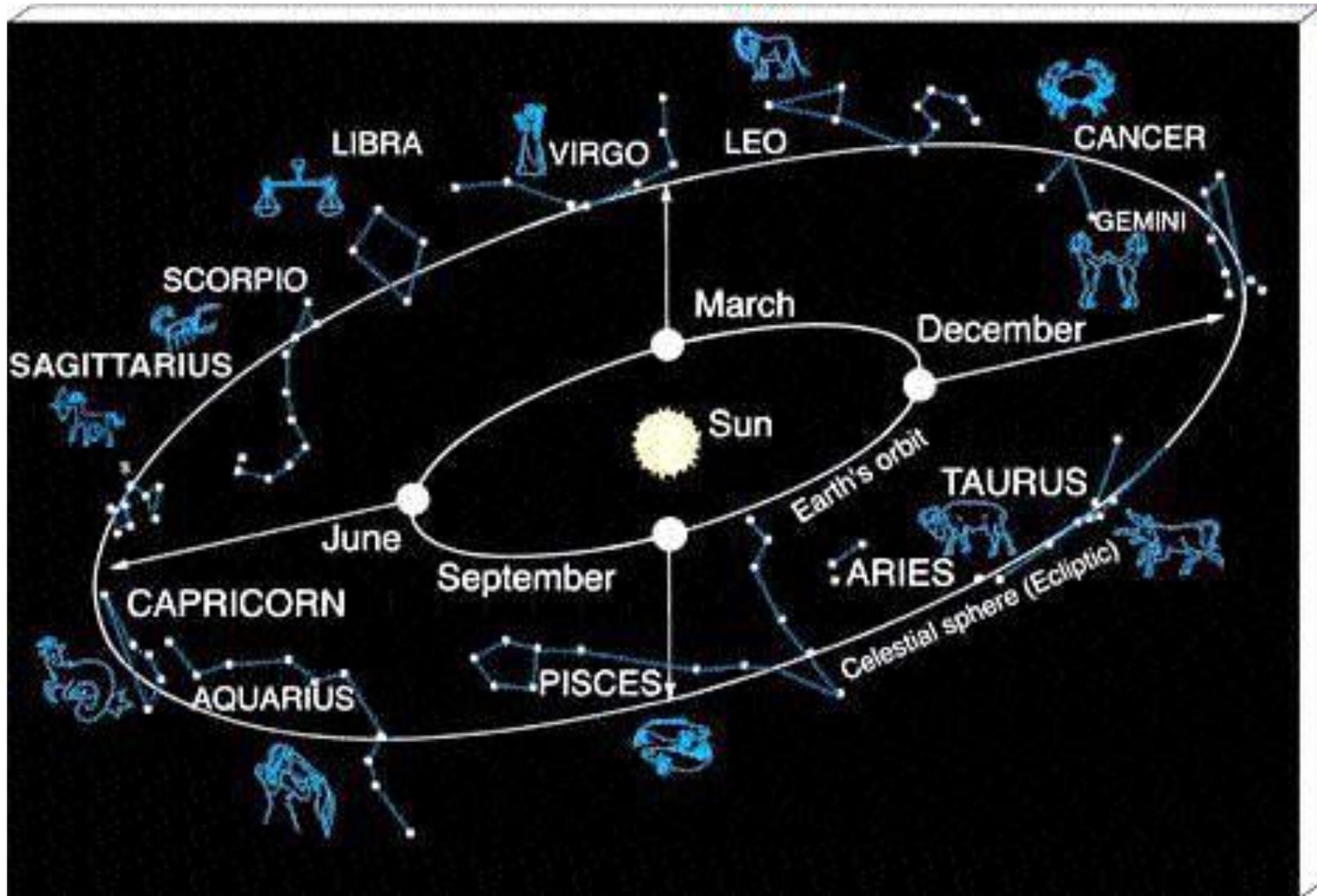
During WW II the US Army Air Force gave exams to officer candidates. See Stephen Ambrose *The Wild Blue*. Those with the highest score became navigators (2nd=bombardiers, 3rd=pilots). My Dad, who went to Lane Tech in Chicago, was a navigator and bombardier and then instructor in New Mexico before being deployed to China in 1945. They flew their B-25 to Florida, Trinidad, Brazil, Ascension Island, West Africa, Morocco, Libya, Egypt, Iran, India, and then China where the war ended. My dad carried navigation books, including star charts, in his kit. While flying across the Atlantic the pilot accidentally dumped most of the fuel in the ocean and as navigator, my dad had to find Ascension Island before the gas ran out. Needed good navigational skills though some early radio direction finder equipment was available

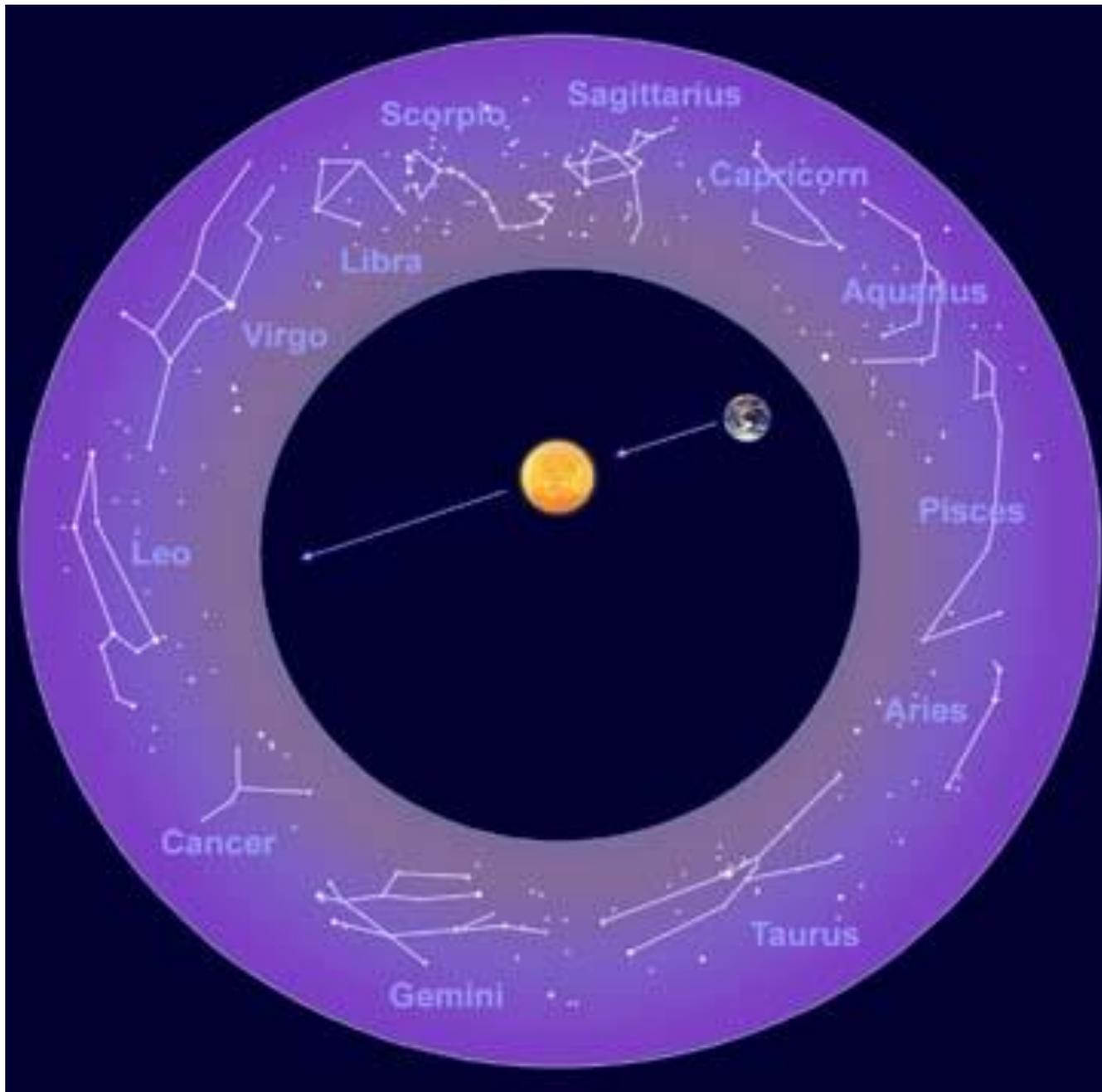


Zodiac Constellations (not on tests)

- a line between the Earth and the Sun traces out a “circle” in the sky
- called the ecliptic
- the 12-13 constellations along the circle are the “signs” of the Zodiac
- changes with the seasons

Zodiac Constellations (not on tests)





Zodiac Constellations

“modern” may add
Ophiuchus between
Sagittarius and
Scorpio