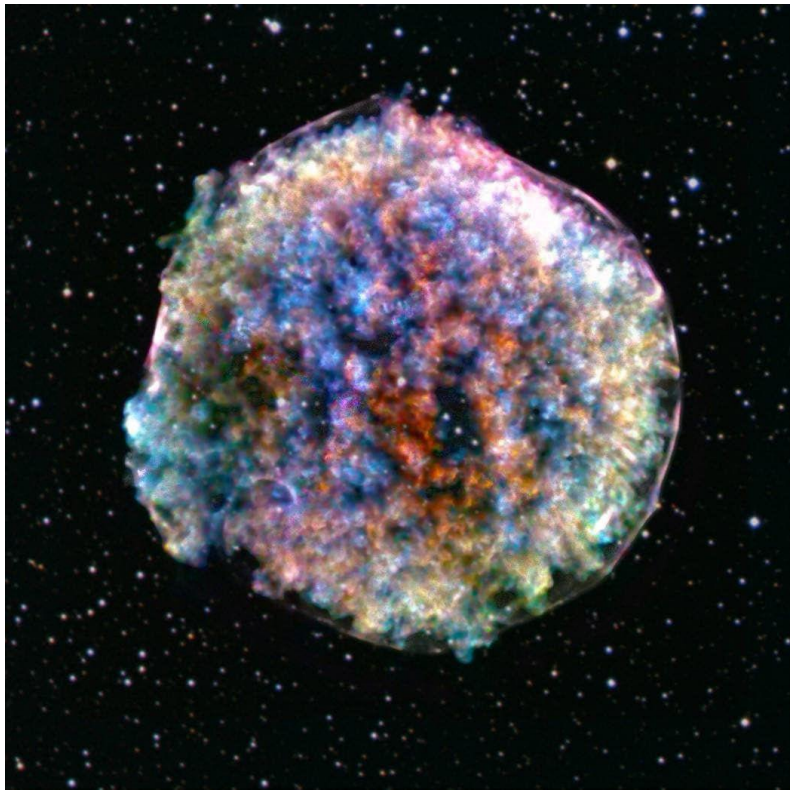
Supernova Remnant

Planetary Nebula

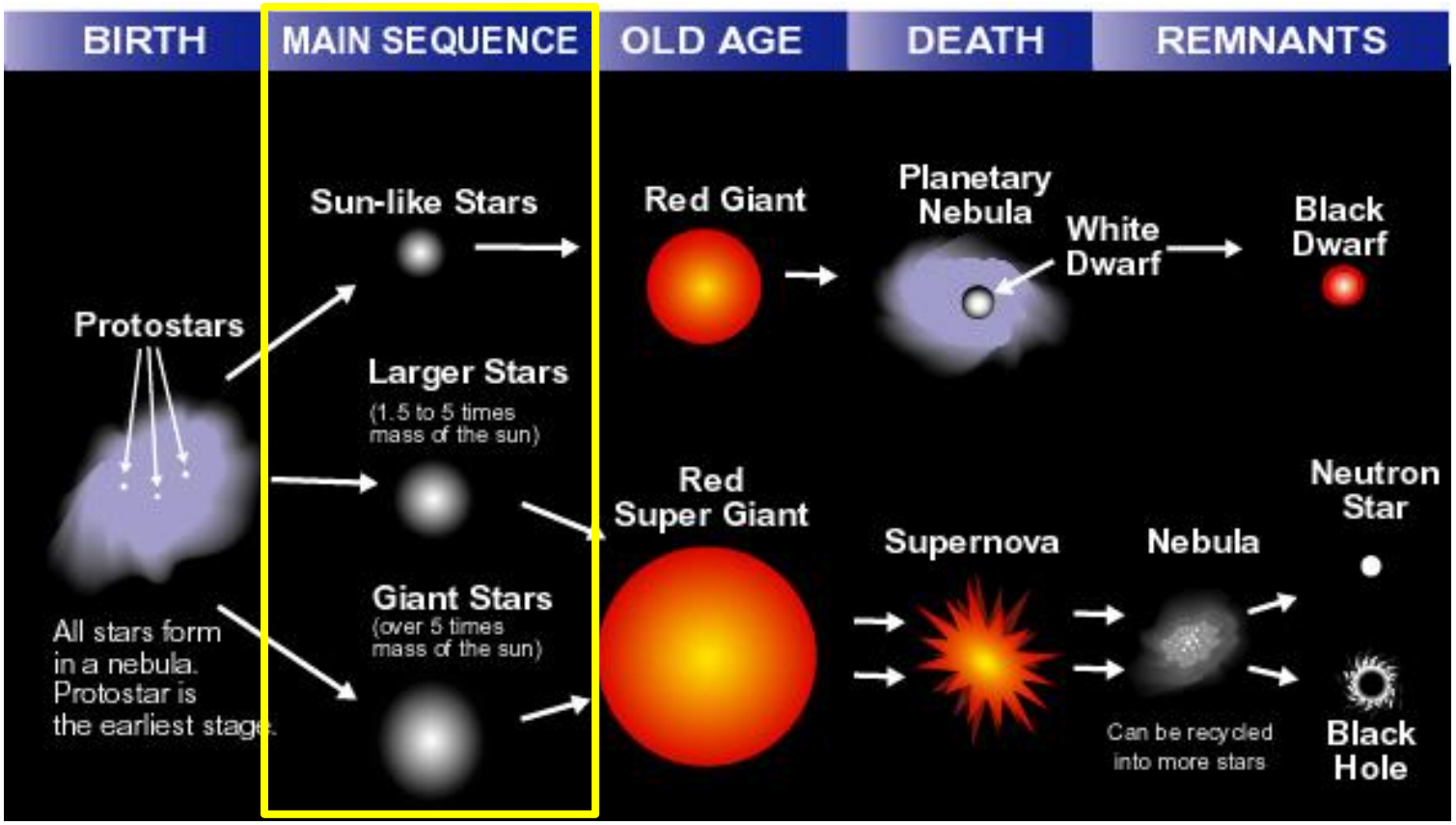


VS

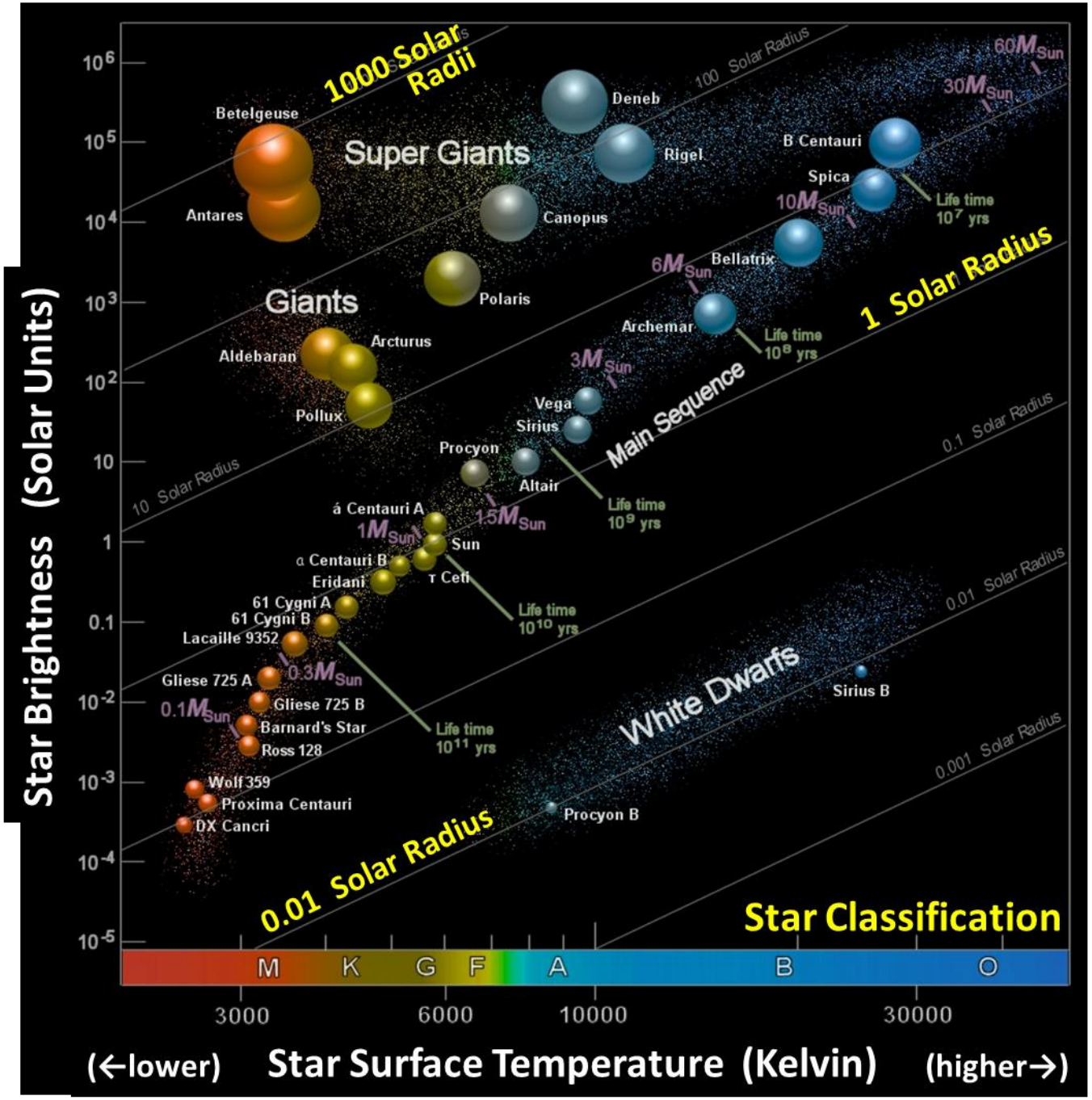
The remnant of a supernova observed in 1572, studied by the Danish astronomer Tycho Brahe (data from Chandra X-ray Observatory).

Four examples of planetary nebulae (data from Chandra X-ray Observatory combined with optical data from Hubble Space Telescope)

Life Cycle of a Star



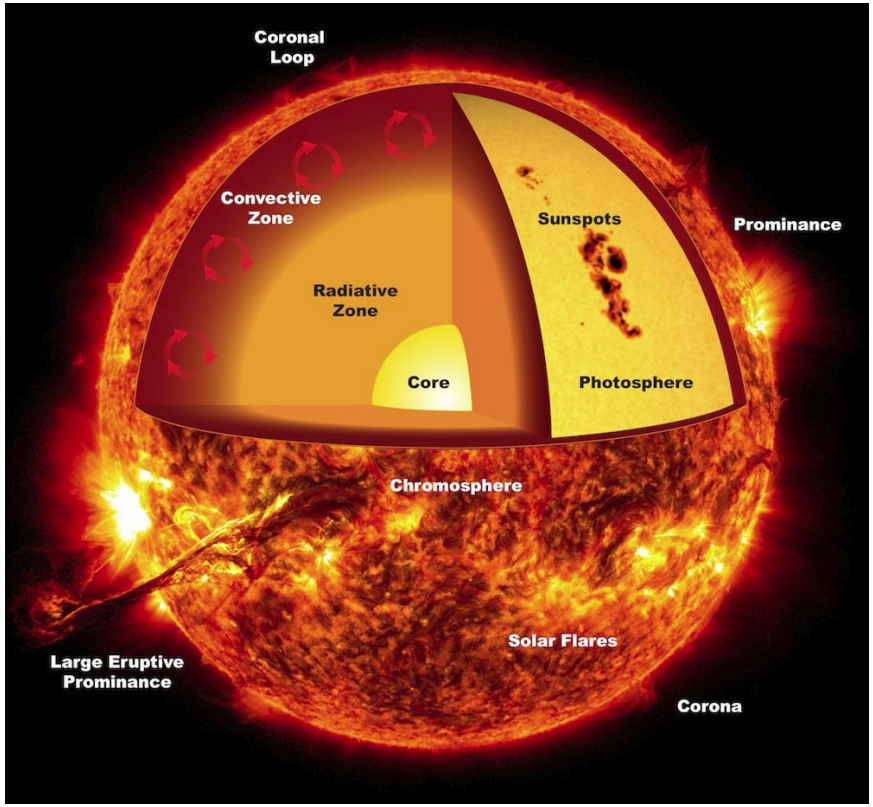
Protostar – superheated gas, earliest stage of a star; Red Giant and Red Super Giant - stars that have exhausted the supply of hydrogen in their cores and are fusing helium to carbon and oxygen; Supernova - a stellar explosion; White Dwarf – very dense stellar remnant that has no energy source and gradually cools down over billions of years to become Black Dwarf, however *no black dwarfs are expected to exist in the Universe yet*!



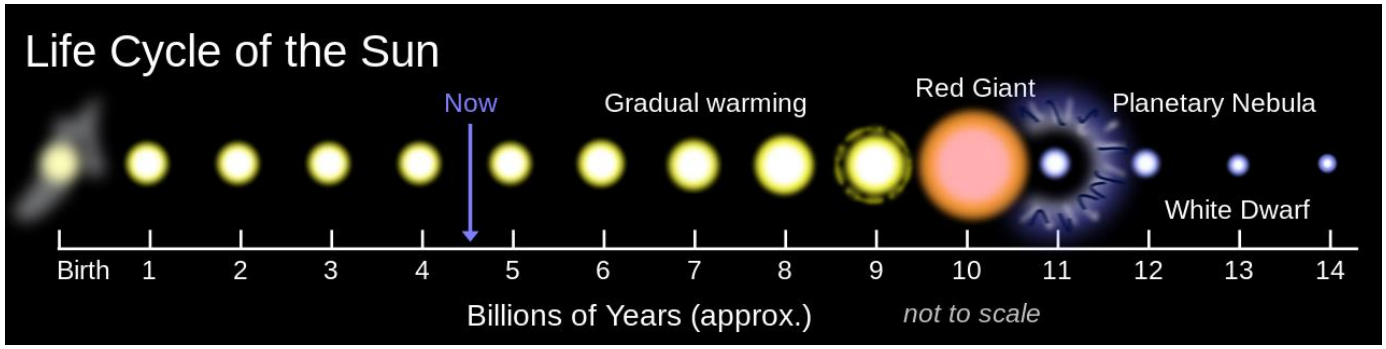
The HR (Hertzsprung-Russell, 1910) Diagram

- A major step towards our understanding of stellar evolution or "the lives of stars".
- Temperature (x) vs Luminosity (y) plot
- Stars tend to group into certain areas.
- Most of the stars occupy the region in the diagram along the line called the main sequence, in the order of their mass (*shown in* M_{Sun}).

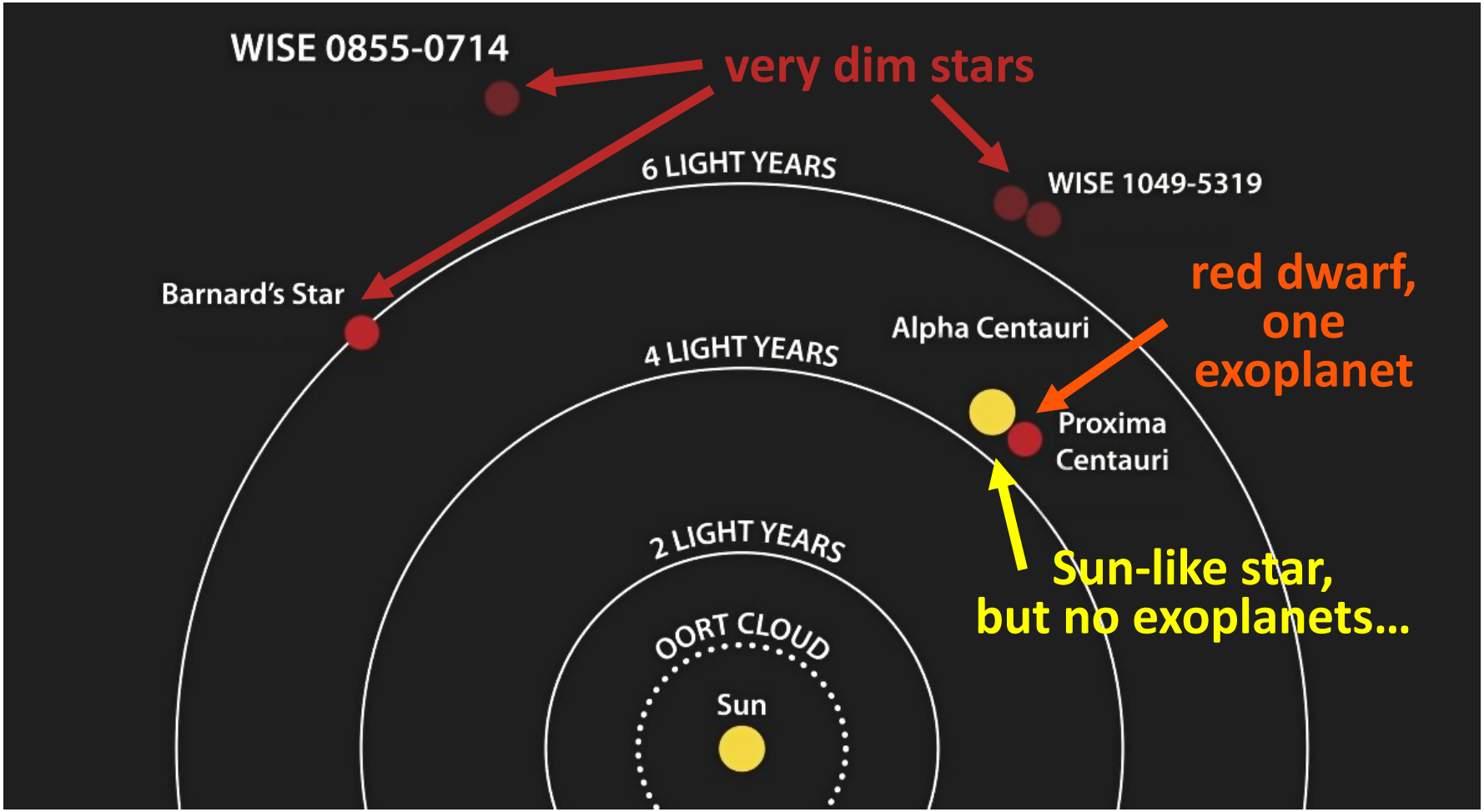
Our star: the Sun



Age: ~4.6 billion years
Shape: near perfect sphere
Rotation: 25.6 days at equator, 33.5 days at poles (due to convection)
Mass: ~330,000 times the Earth's mass
Size: ~109 times that of the Earth
Color: yellow
Temperature: surface ~5700 K, core ~15000000 K
Type: Yellow Dwarf, G-type Main Sequence
Composition: ~75% H, ~23% He, ~1.7% heavier elements including O, C, Ne, Fe ("heavy-element-rich" star)



Sun's Closest Neighbors

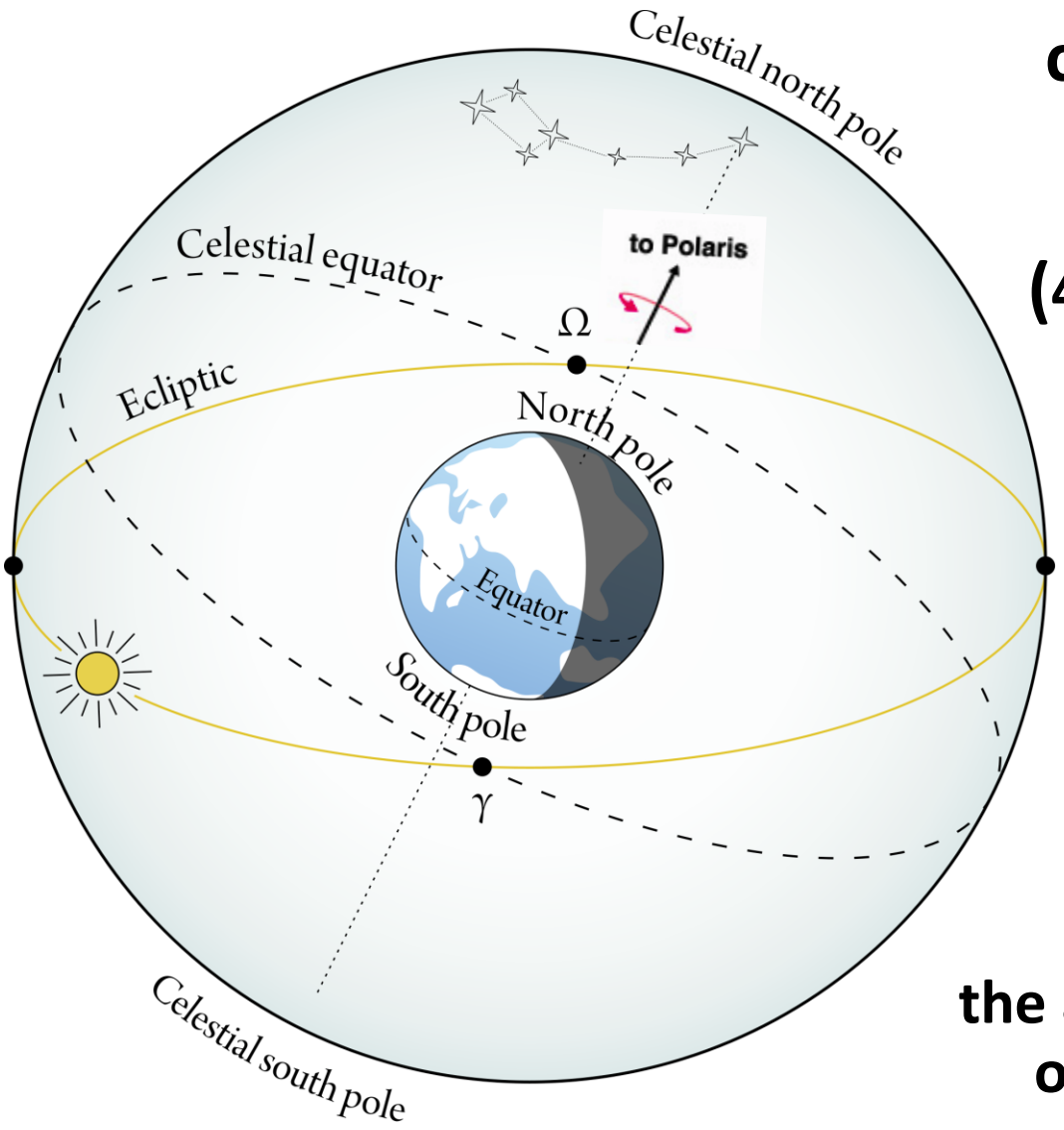


Exoplanet: a planetary body orbiting a star other than the Sun

1 light-year equals **5.88 trillion miles**

Celestial Sphere

is an apparent sphere around Earth which contains "fixed" stars forming 88 official constellations (48 ancient + 40 modern).

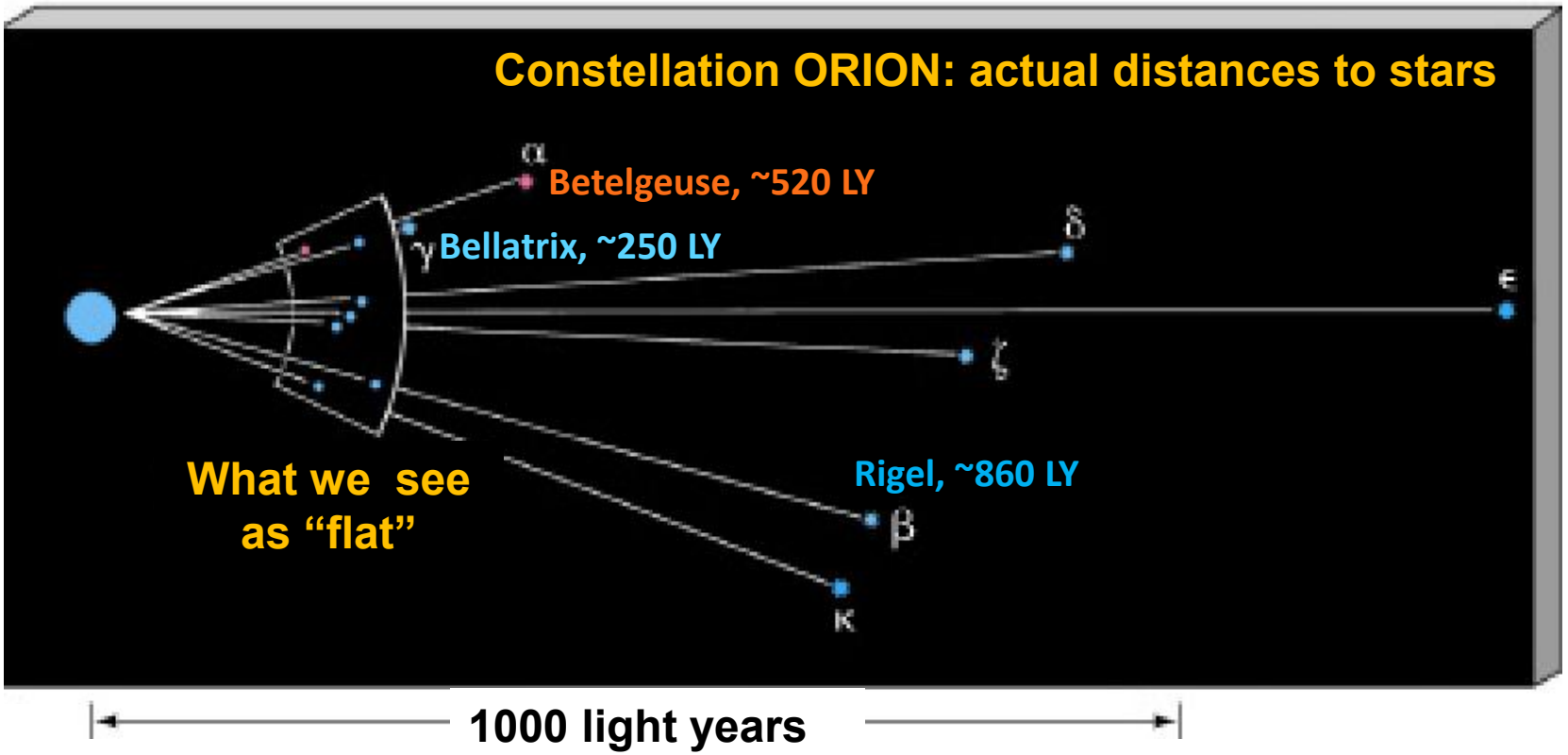


- ***Celestial equator*** **- the projection of the Earth's equator onto the celestial sphere, dividing the sky into two hemispheres.**

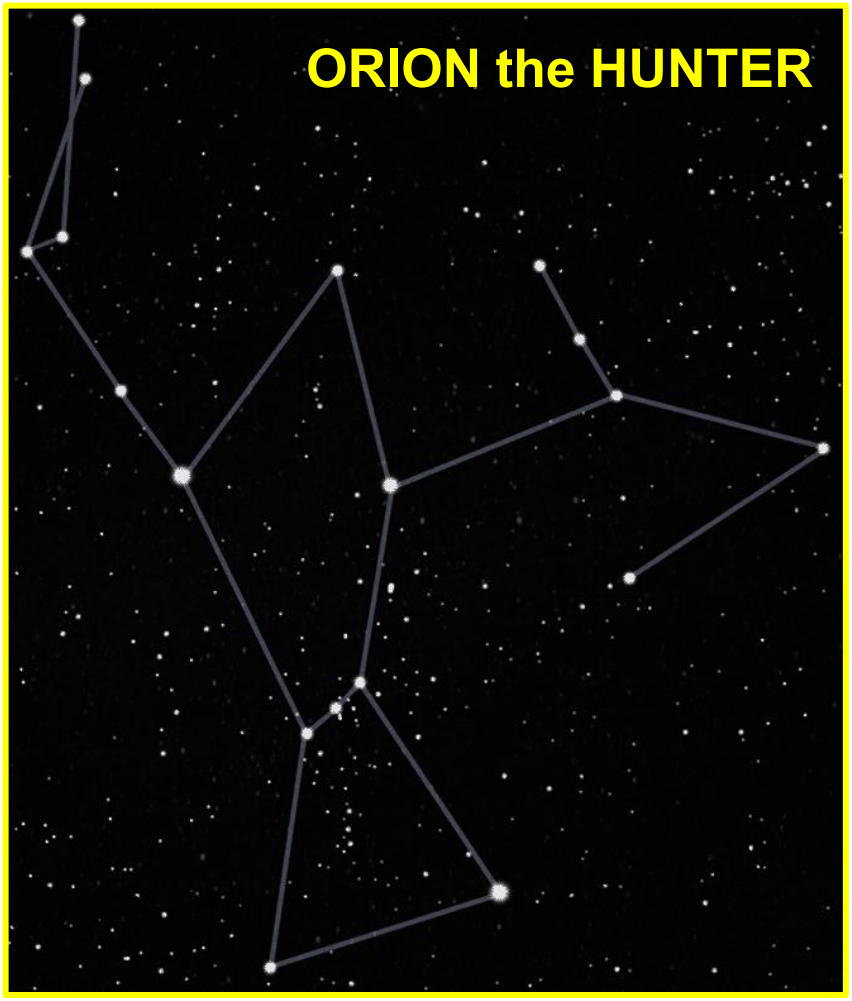
- **The *Ecliptic* - the apparent path of the Sun on the celestial sphere.**

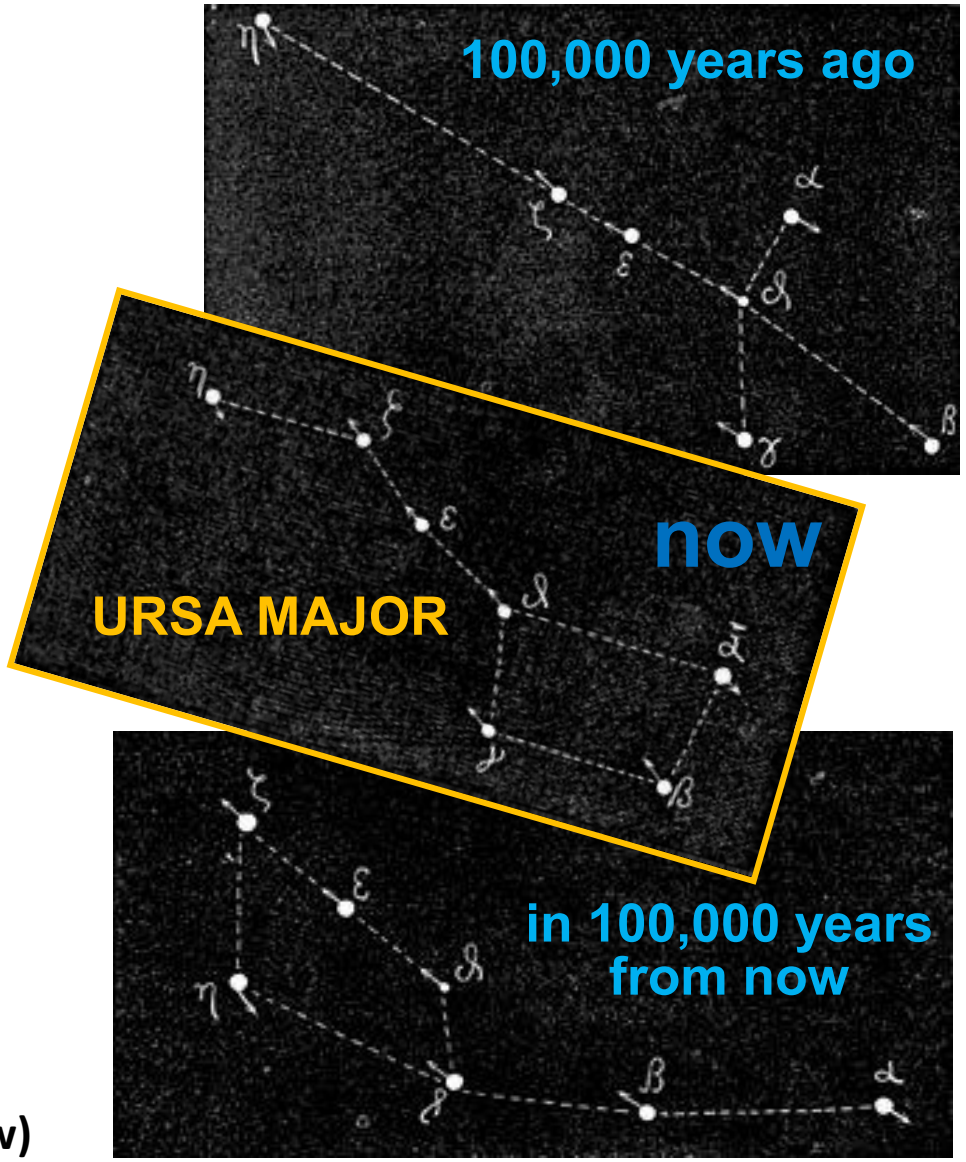
Constellations

- **Constellation is a group of stars that form a pattern in the sky.**
- **The shapes you see all depend on your point of view!**
- **Stars in a constellation are NOT close to each other, but when viewed from Earth they *seem to be grouped* together.**



Constellations change over (very long) time





Watch Orion's head and bow!

(from 50,000 years ago to 100,000 from now)

Galaxy

A galaxy is a large, massive system consisting of stars, an interstellar medium of gas and dust, stellar remnants, and dark matter, all bound together by gravity.

- **There are probably about 2 trillion galaxies in the observable Universe!**
- **Tens of thousands of galaxies have now been catalogued, but only a few given a well-established name (example: Andromeda Galaxy, Magellanic Clouds, etc.)**
- **Sizes of galaxies range from dwarfs with as few as ten million stars to giants with one hundred trillion stars; most galaxies in the Universe appear to contain only a few billion stars.**

(Hubble) Galaxy Types

Have *black holes* at their centers!

May have "wandering" black holes...

EVOLUTION?

Elliptical

Elliptical galaxies have smooth, featureless light distributions and appear as ***ellipses*** in images; they consist mostly of old stars.

Spiral

Spiral galaxies consist of a flat, rotating disc of two or more ***spiral arms*** containing mostly young stars, gas and dust, and a central ***bulge*** of older stars.

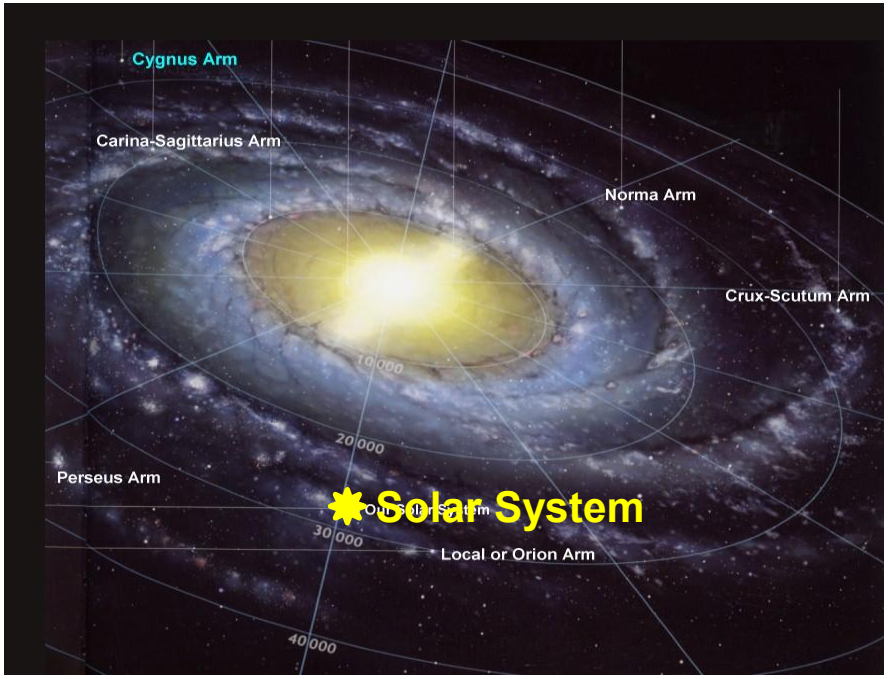
Irregular

Irregular galaxies do not have any distinct regular shape.

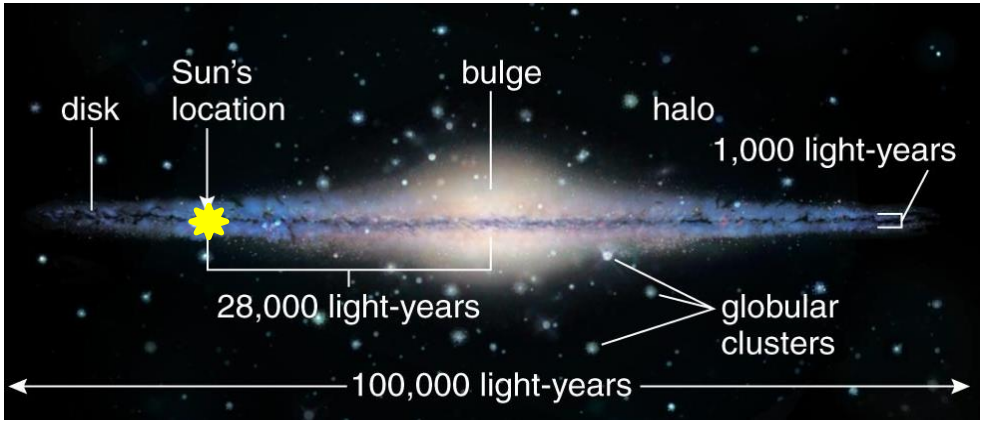
Together they make ~60% of all galaxies in the observable Universe.

Our Galaxy: the Milky Way

The Milky Way is a large barred spiral galaxy (we think!) some ~100,000 light-years in diameter, which contains 100–400 billion stars. It may contain at least as many planets as well.



Every star we see in the night sky is in our own galaxy. We cannot see stars in other galaxies because they are too far away.



Our Local Group of Galaxies