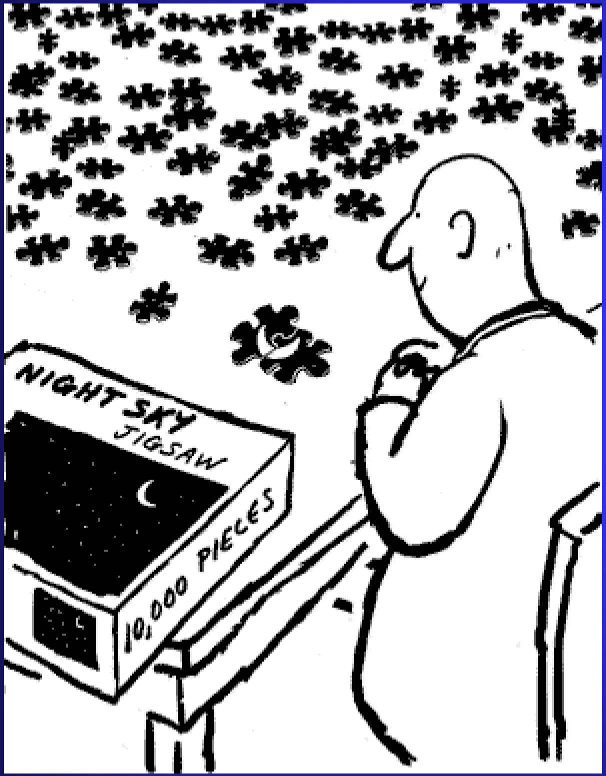
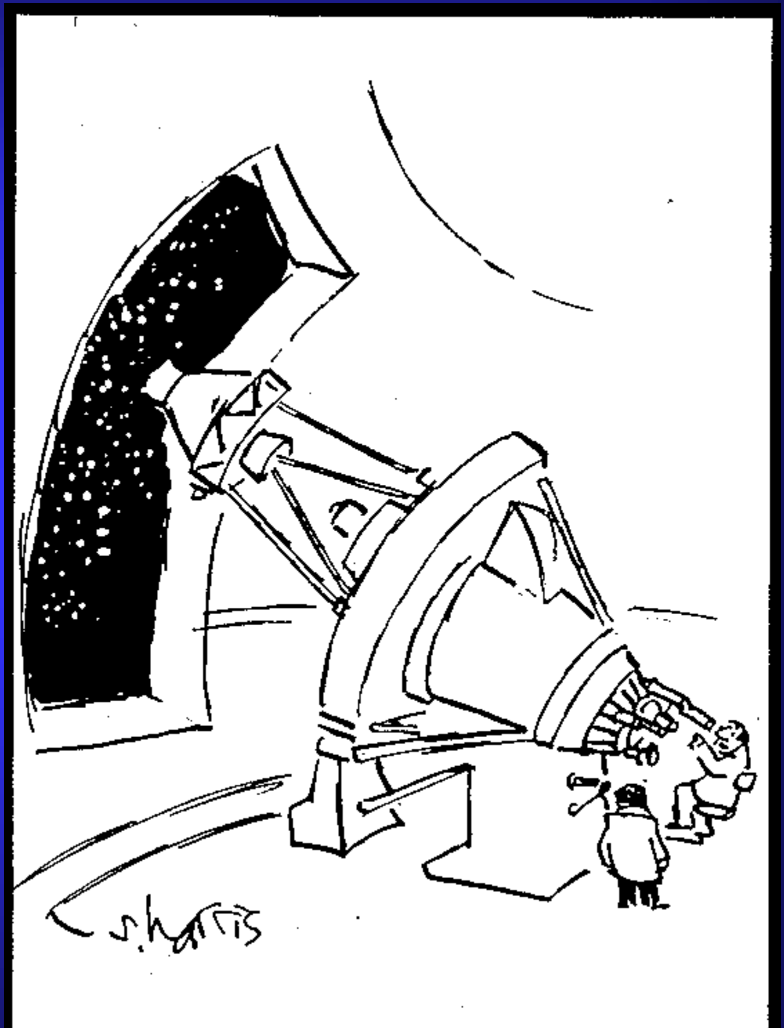
Stars





"Actually they all look alike to me."

Overview

A. Definitions
   A. Luminosity
   B. Apparent Brightness
   C. Absolute Magnitude
   D. Apparent Magnitude
   E. A.U.
   F. Parallax
   G. HR-Diagram
   H. Main Sequence
   I. Red Giant Star
   J. Horizontal Branch Star
   K. Asymptotic Giant Branch Star

Overview

B. The Distance Ladder
   A. Luminosity, Apparent Brightness, and Distance.
   B. The Distance to the Sun.
   C. Distances to nearby stars.
   D. The HR-Diagram and **Spectroscopic Parallax**

Overview

C. Stellar Evolution

A. What is the size (mass) distribution of stars?

B. What is the evolutionary sequence of a low mass star?

C. What is the evolutionary sequence of a high mass star?

D. How can get determine the AGE of a star cluster?

Apparent Brightness

Luminosity:

The total amount of light emitted by an object in space.

Apparent Brightness:

The light that reaches the Earth from an object in space.

Apparent Brightness

Star A and B are at the same distance from the Observer

Star A and B are at the same Temperature

Star A is Larger than Star B

Which has a greater **Luminosity?**

Which has a greater **Apparent Brightness?**

Apparent Brightness

Star A and B are at the same distance from the Observer

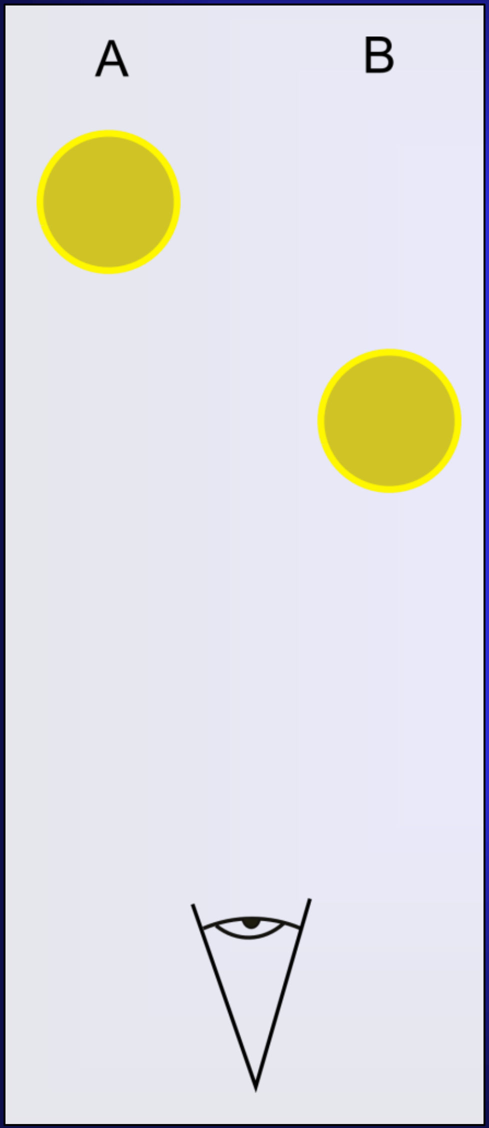
Star A is hotter than Star B

Star A and Star B are the same size

Which has a greater **Luminosity?**

Which has a greater **Apparent Brightness?**

Apparent Brightness



Star A is farther away than Star B

Star A and B are at the same Temperature

Star A and Star B are the same size

Which has a greater **Luminosity?**

Which has a greater **Apparent Brightness?**

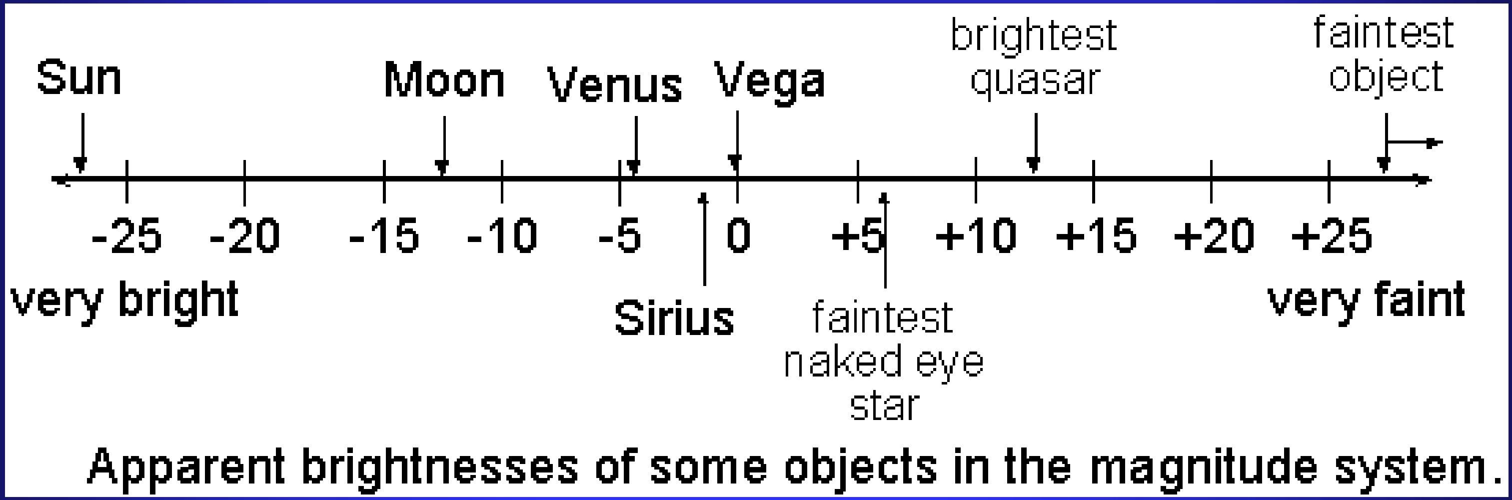
Relationships

	T	R	D
L			
B			

If I increase T,R, or D, what happens to L and B

Magnitudes

Here's something stupid that astronomers did



Absolute Magnitude:

The intrinsic brightness of a star on the magnitude system.

Apparent Magnitude:

The magnitude of the star as measured from Earth

Distances

Distance Gives us Luminosity and Size

So to study Anything we need to know:

How Far Away Is It?

Kepler's 3rd Law

$$P^2 = a^3$$

A.U. (Astronomical Unit):

The distance between the Earth and Sun

a = Semi-major axis

P = Orbital Period

We can **measure** *P* and calculate *a* (in AU)

From Kepler's 3rd Law

Planet	Period (Years)	Orbital Radius(A.U.)
Mercury	0.2	0.4
Venus	0.6	0.7
Earth	1	1
Mars	1.9	1.5
Jupiter	11.9	5.2
Saturn	29.5	9.5
Uruanus	84.3	19.2
Neptune	165	30

But how many Kilometers in an AU?

Distances in the Solar System

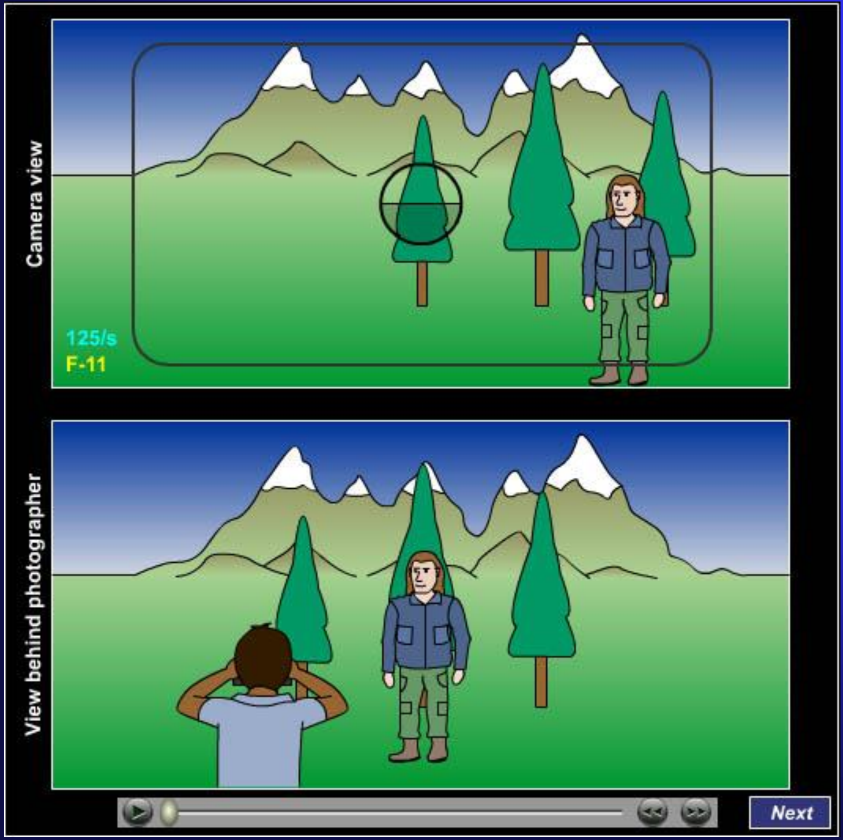
Earth to Venus = 0.3 A.U

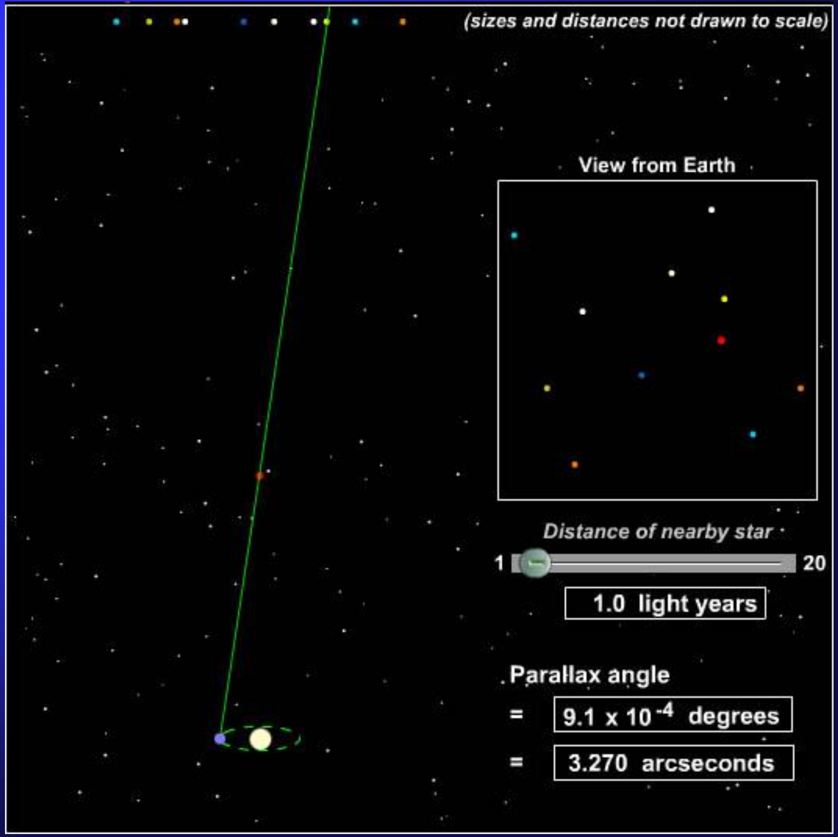
Earth to Venus = 4.47×10^7 km

1 A.U = 1.49×10^8 km

Parallax

We use parallax to get distances to stars within 100 Light Years

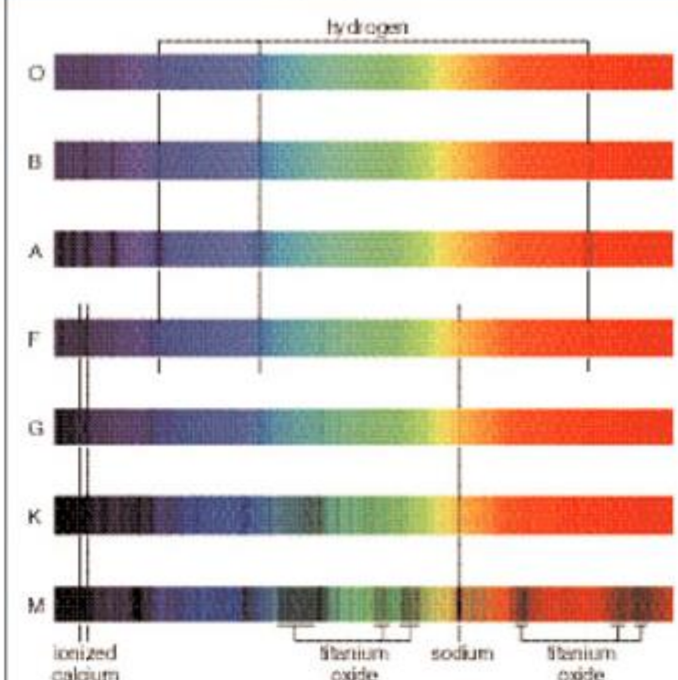




Spectroscopic Sequence

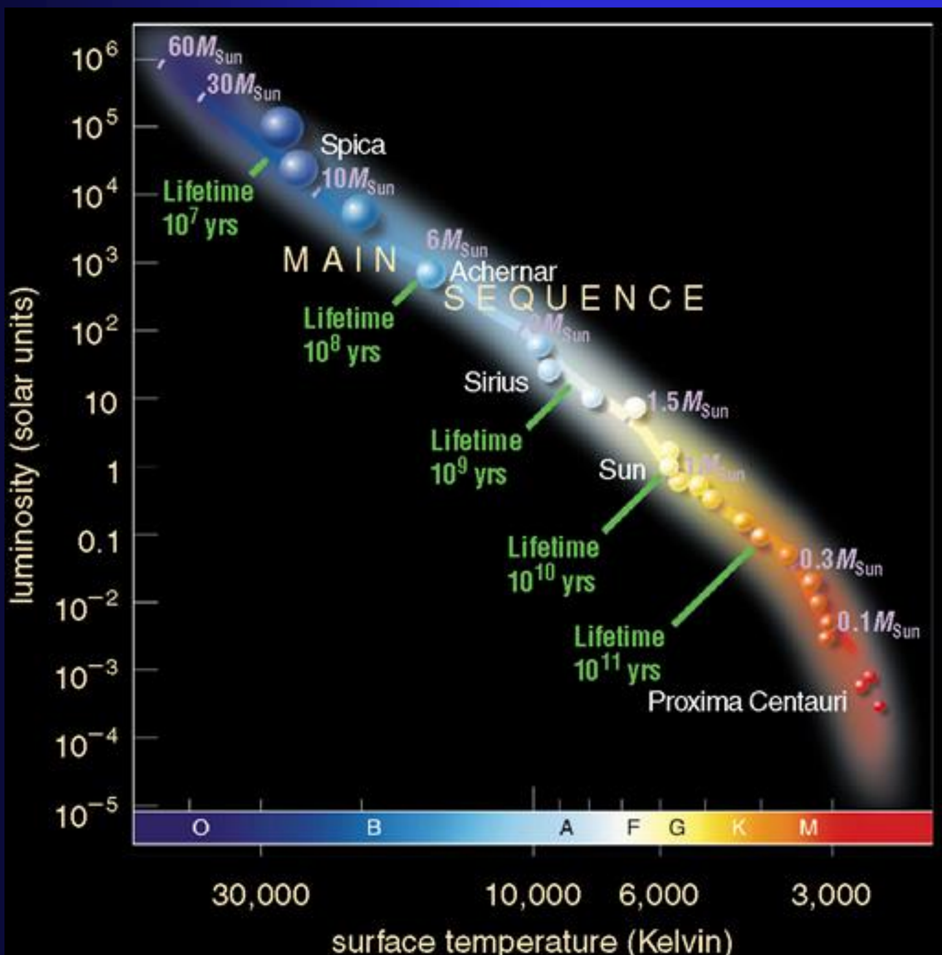
Studying stellar spectra…

		Temperature Range	Key Absorption Line Features	Brightest Wavelength (color)	Typical Spectrum
		>30,000 K	Lines of ionized helium, weak hydrogen lines	<97 nm (ultraviolet)*	
		000 K–10,000 K	Lines of neutral helium, moderate hydrogen lines	97–290 nm (ultraviolet)*	
		000 K–7,500 K	Very strong hydrogen lines	290–390 nm (violet)*	
		00 K–6,000 K	Moderate hydrogen lines, moderate lines of ionized calcium	390–480 nm (blue)*	
G	Sun, Alpha Centauri A	6,000 K–5,000 K	Weak hydrogen lines, strong lines of ionized calcium	480–580 nm (yellow)	
K	Arcturus	5,000 K–3,500 K	Lines of neutral and singly ionized metals, some molecules	580–830 nm (red)	
M	Betelgeuse, Proxima Centauri	<3,500 K	Molecular lines strong	>830 nm (infrared)	



H-R Diagram

Using Distance to get Luminosity



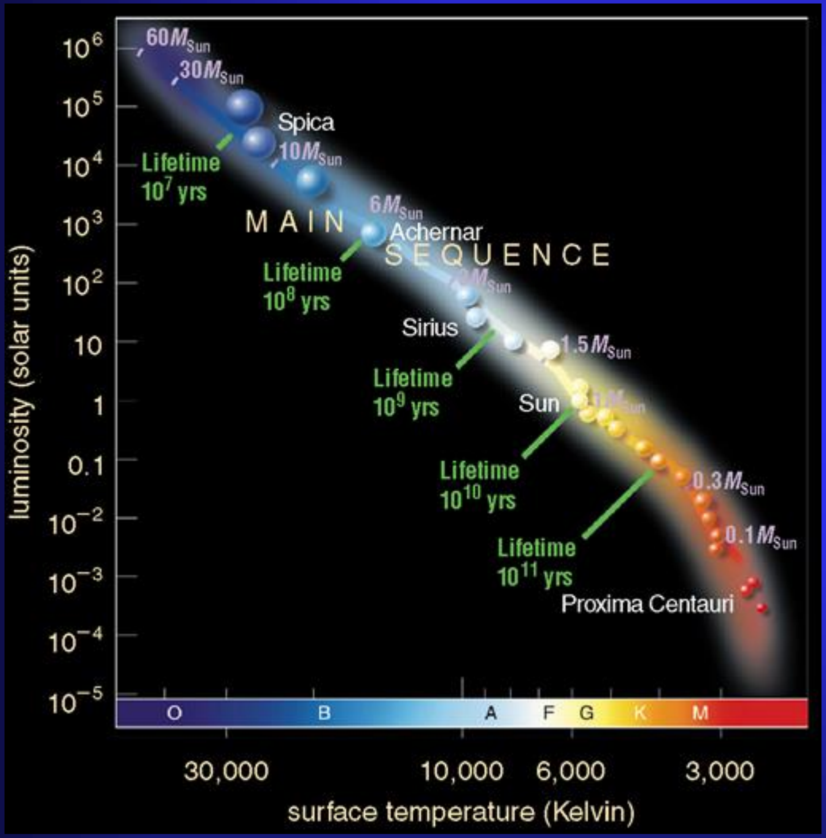
Get Luminosity from Parallax measurements

Get Temperature from the spectra

There's a correlation!

Spectroscopic Parallax

Using Luminosity to get large distances!

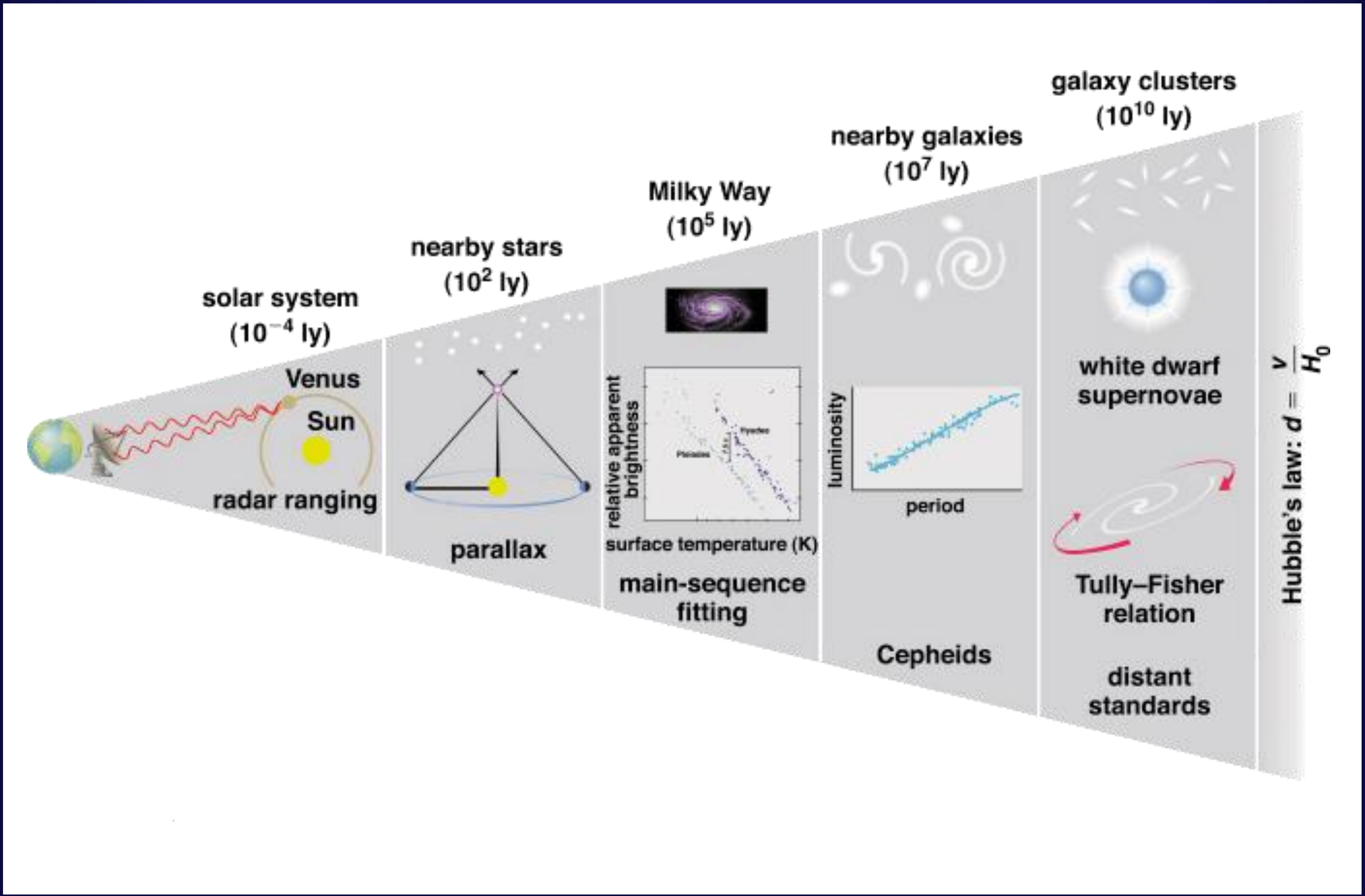


Get Temperature from the spectra

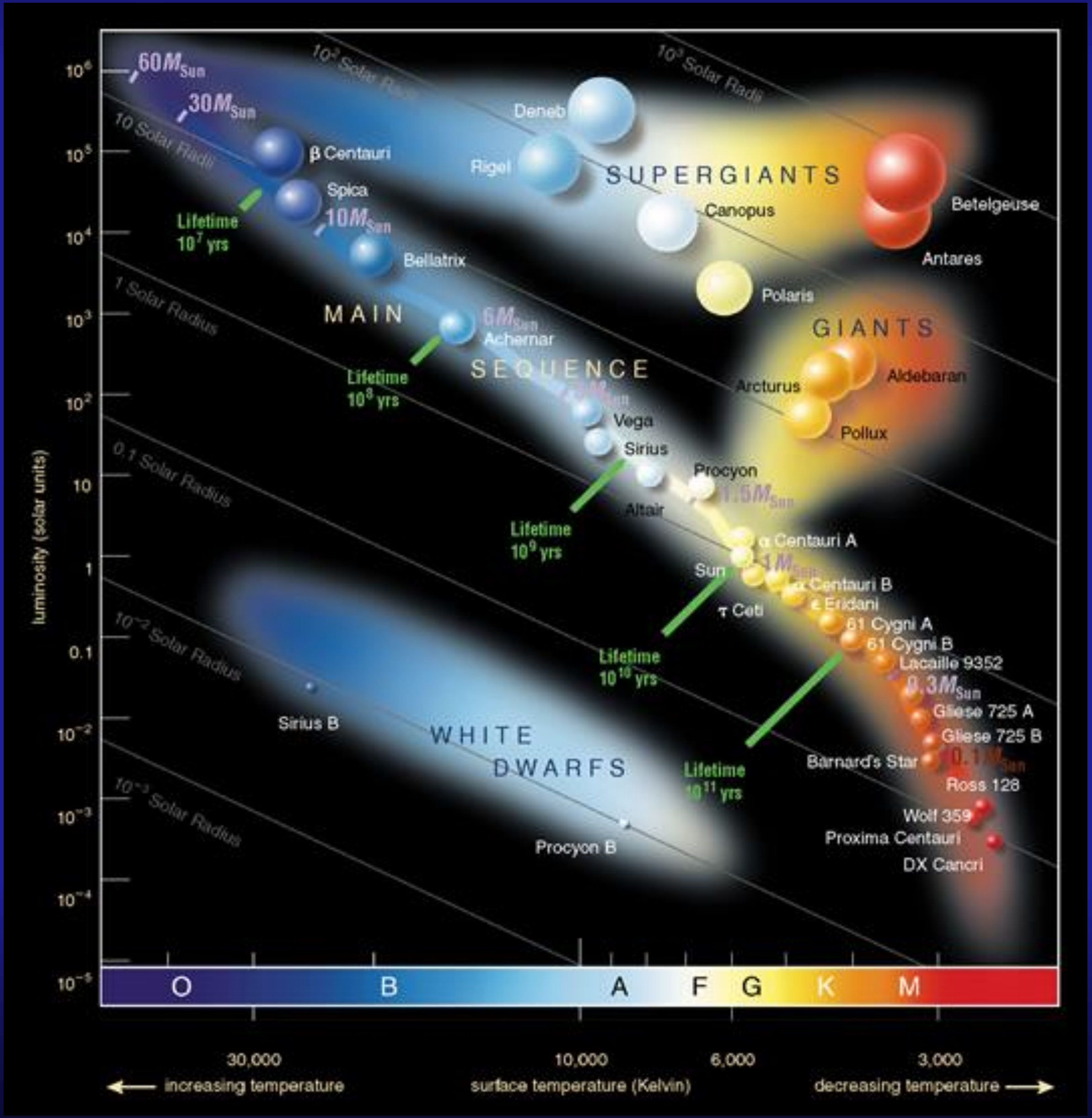
Get Luminosity from the Temperature – Luminosity Correlation.

Get Distances greater than 100 light years!

The Distance Ladder



The HR Diagram



Stellar Evolution

The single factor determining a star's life-cycle is...

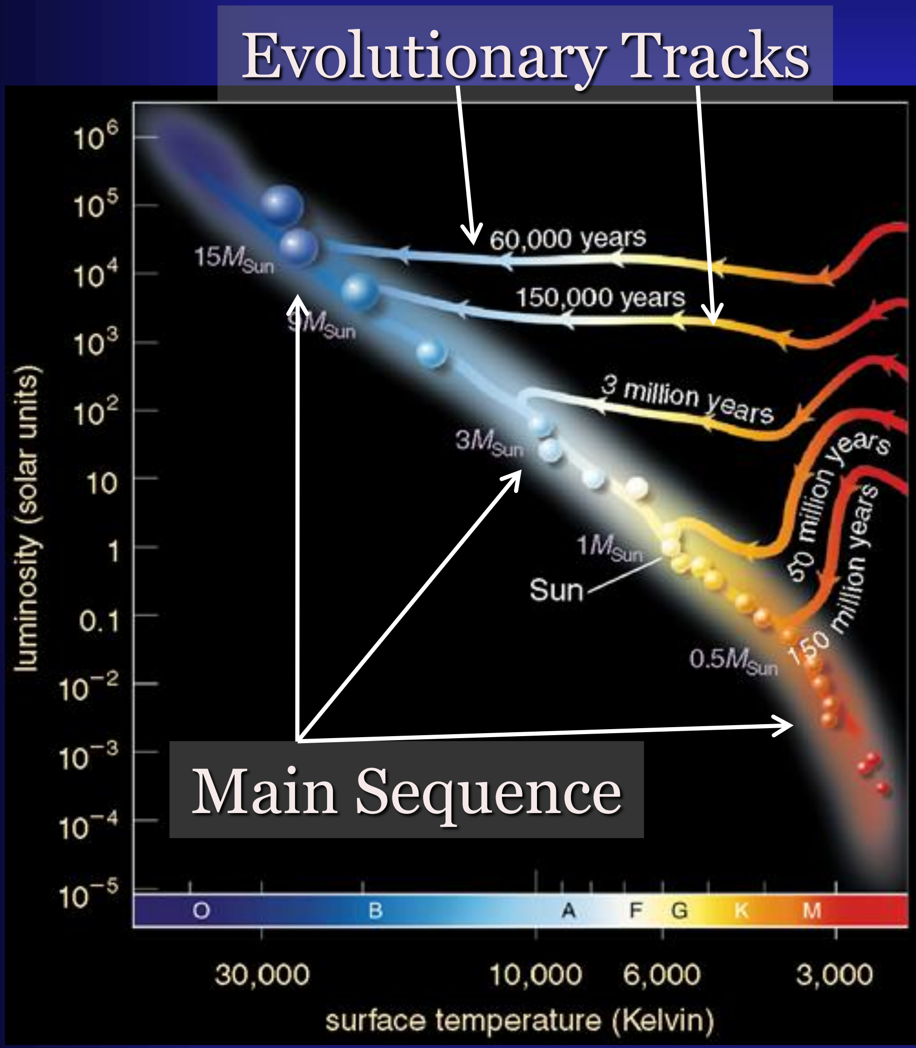
Mass

Birth

Stars are born in clusters

Clouds fragment as they collapse

Protostars



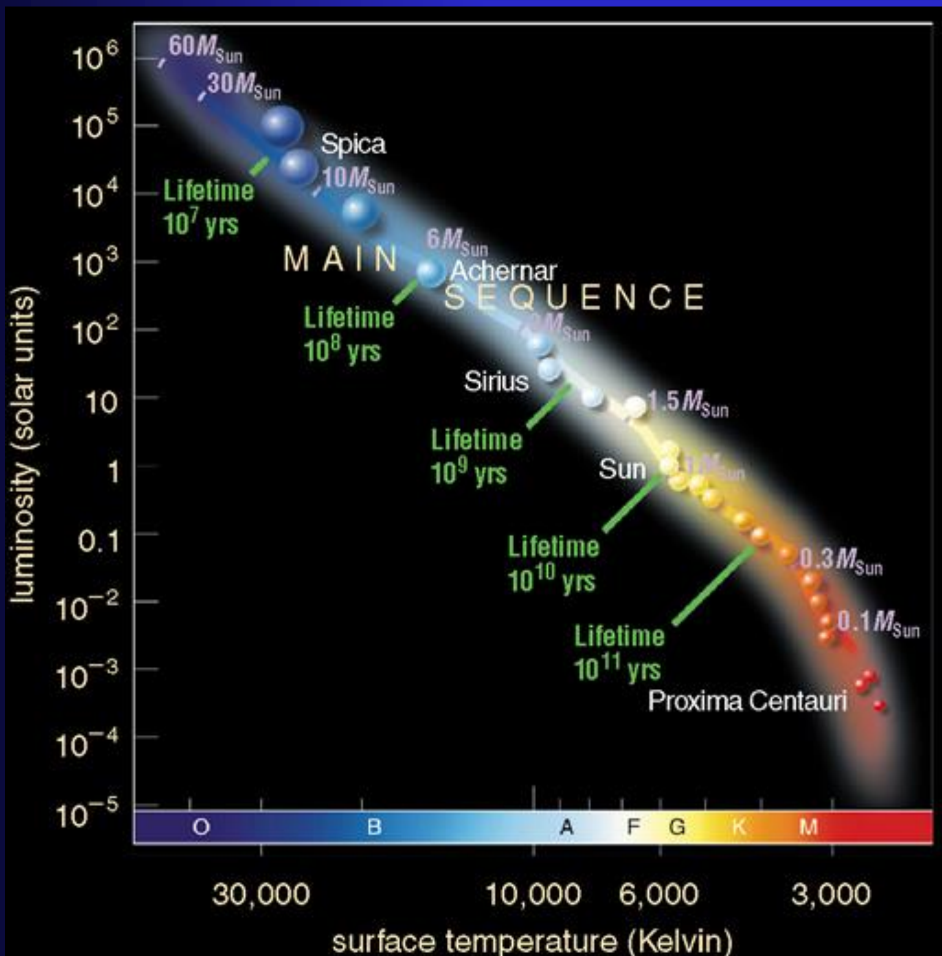
Not fusing helium yet

Energy is from gravitational potential

Fusion begins when the star hits the **Main Sequence**

The Main Sequence

Fusing Hydrogen into Helium in their Core



Brighter main sequence stars are more massive

Massive stars die more quickly

Main Sequence lifetime depends **only** on mass

Stars on the **Main Sequence:**

A) Evolve up the MS towards the hot blue corner.

B) Evolve down the MS towards the cold red corner.

C) Move in along the MS in a direction determined by their mass.

D) Stay in the same place on the MS until they run out of Hydrogen.

We observe a **Main Sequence** star that is 10 times more luminous than the Sun. Which of the following is true.

A) The star is bluer, hotter, and more massive than the Sun.
B) The star is bluer, hotter, and less massive than the Sun.
C) The star is redder, hotter, and more massive than the Sun.
D) The star is redder, colder, and less massive than the Sun.

Star A and B are the same age. They are **$10M_{sun}$** and **$5M_{sun}$** respectively.
Which of the following is true

- A) Star A will die first because it has much less fuel.
- B) Star B will die first because it has less fuel to consume
- C) Star A will die first because its ratio of fuel consumption to mass is much higher.
- D) They will live about the same amount of time.

The Main Sequence

Imagine a cluster of stars ALL with the same birthday. In the cluster are:

A few massive stars (O and B)

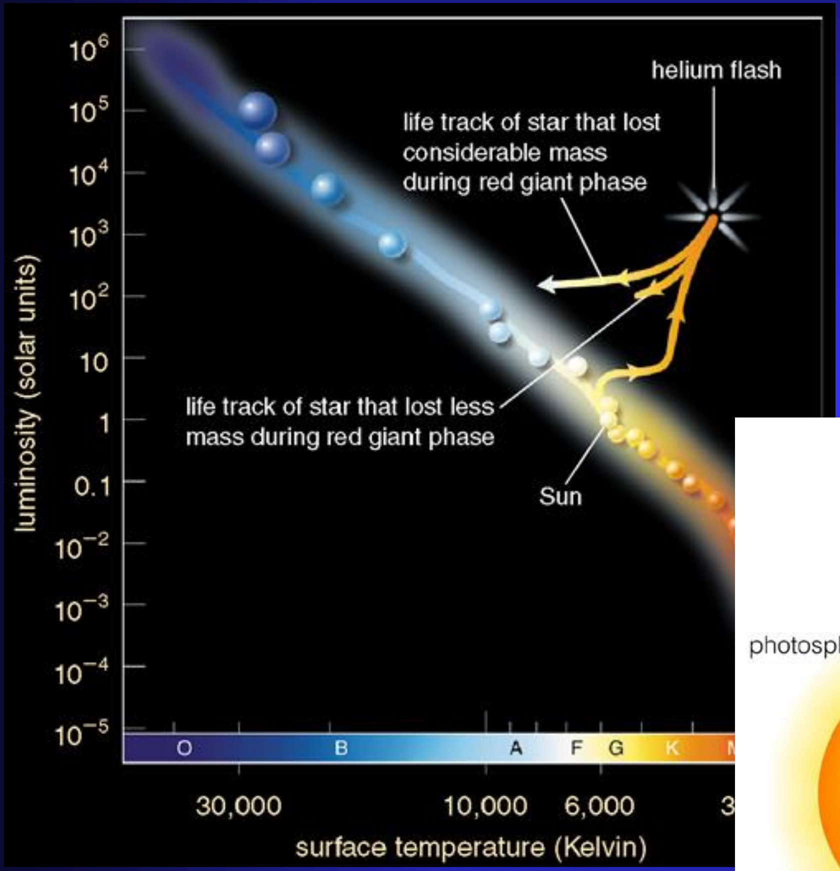
A few hundred solar like stars (G,K)

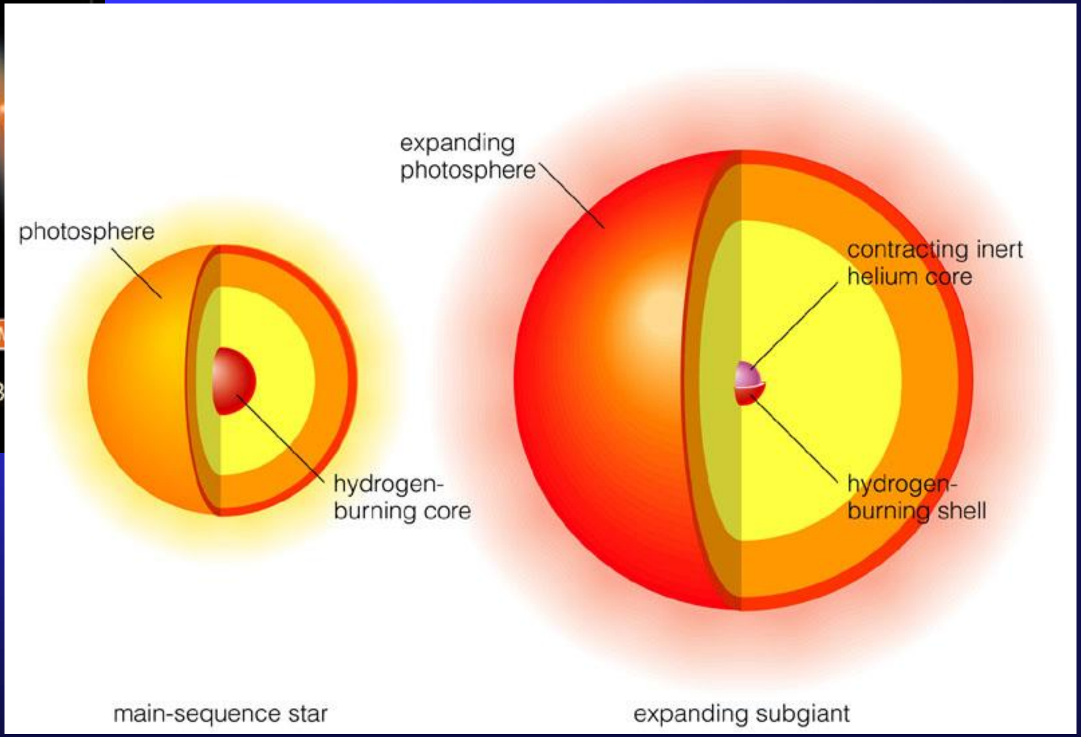
A few thousand low mass (M)

What is the dominant color of the cluster when it is new? Why?

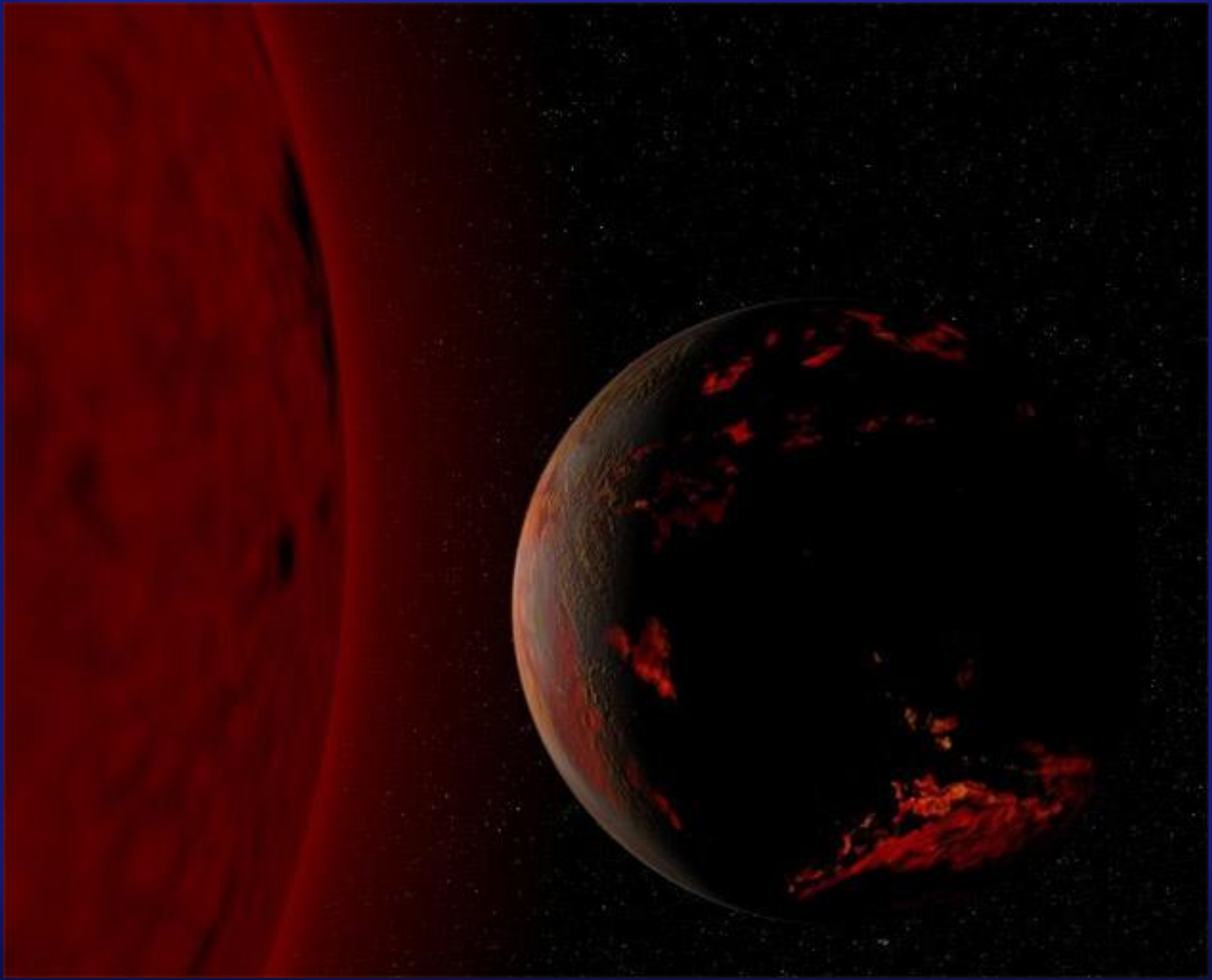
What is the dominant color is the cluster when it is old? Why?

Stellar Evolution





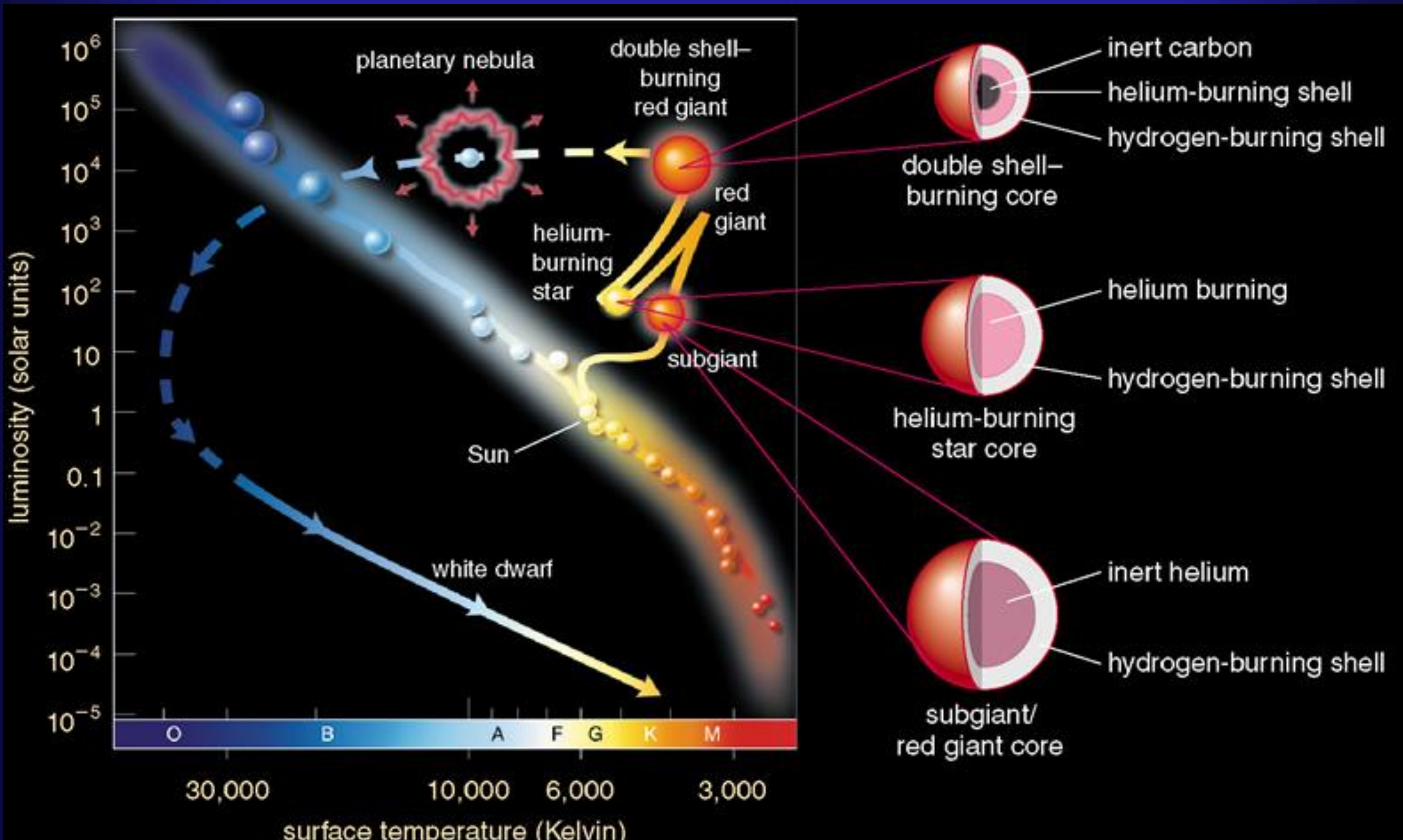
Bye Bye Terrestrial Planets



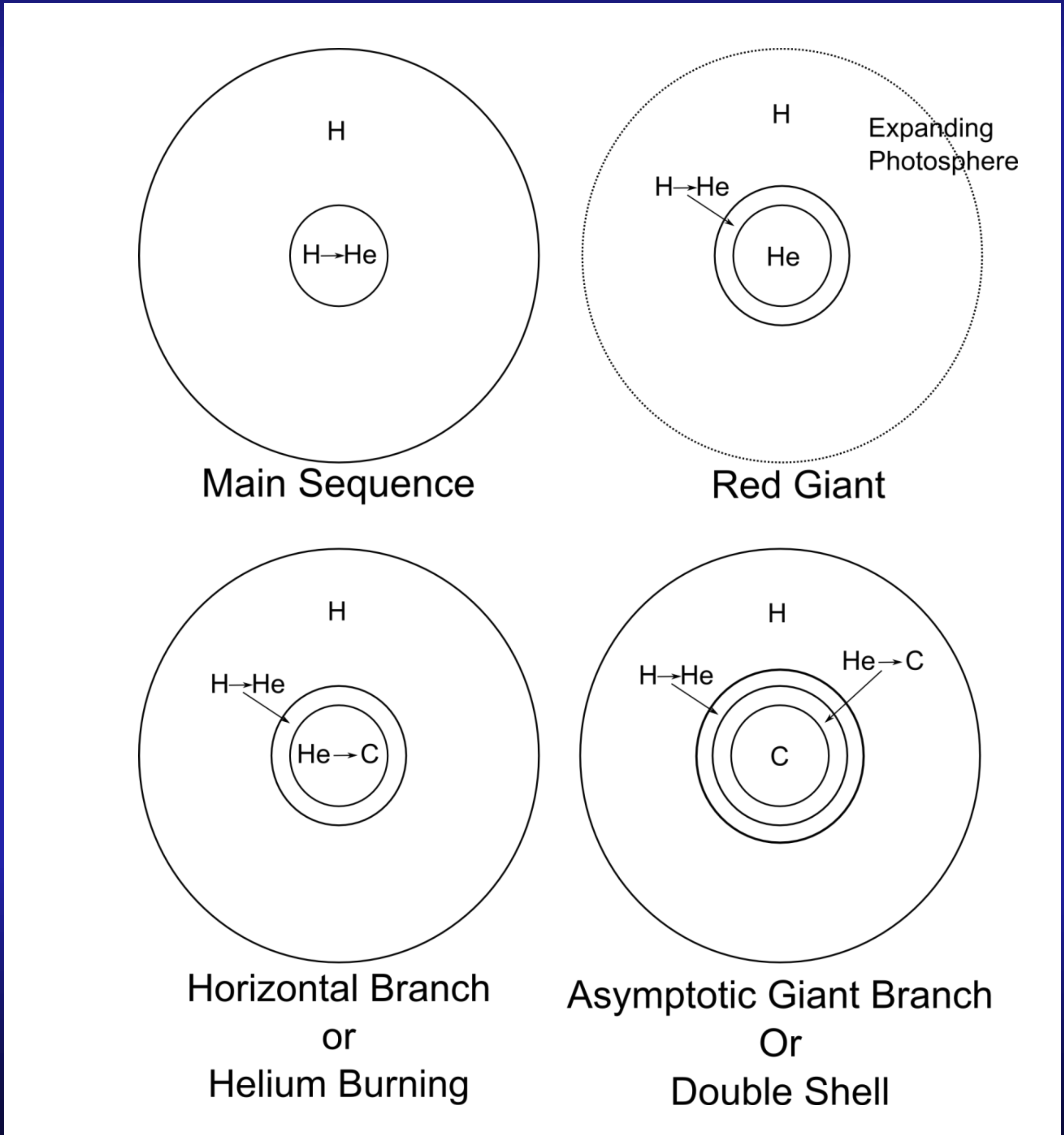
During its **Main Sequence** Lifetime, a star:

A) Evolves up the main sequence towards the upper left of the HR diagram.
B) Remains in roughly the same spot on the HR diagram.
C) Evolves down the main sequence towards the lower right of the HR diagram.
D) has a very complex motion on the HR diagram.

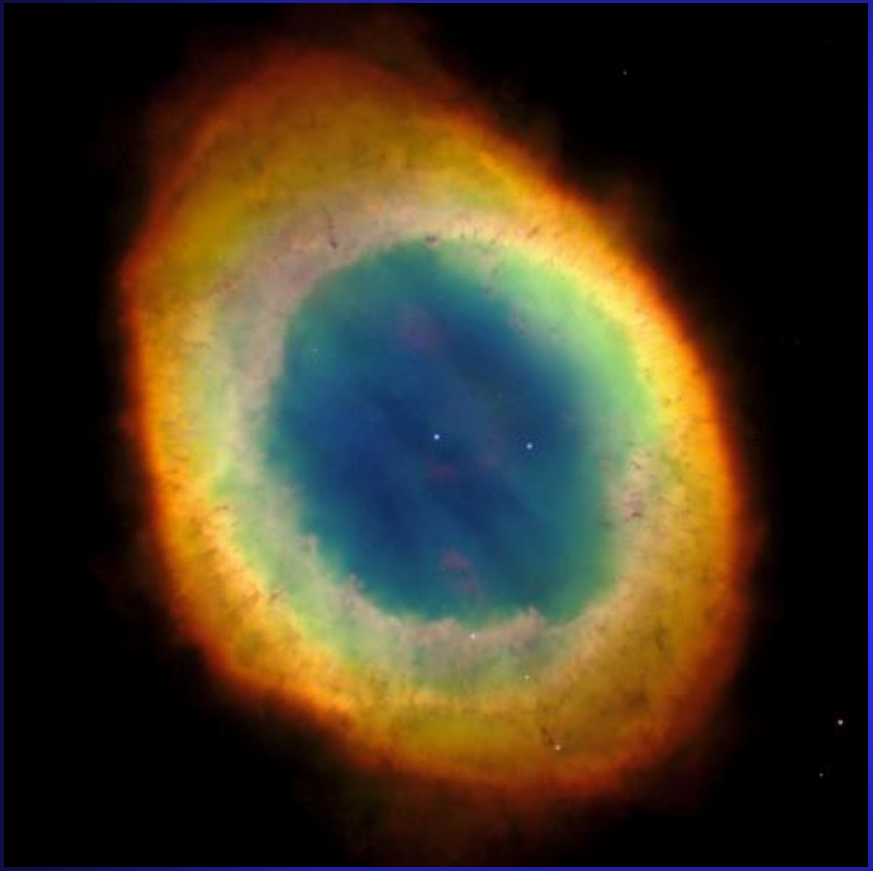
Low Mass Evolution



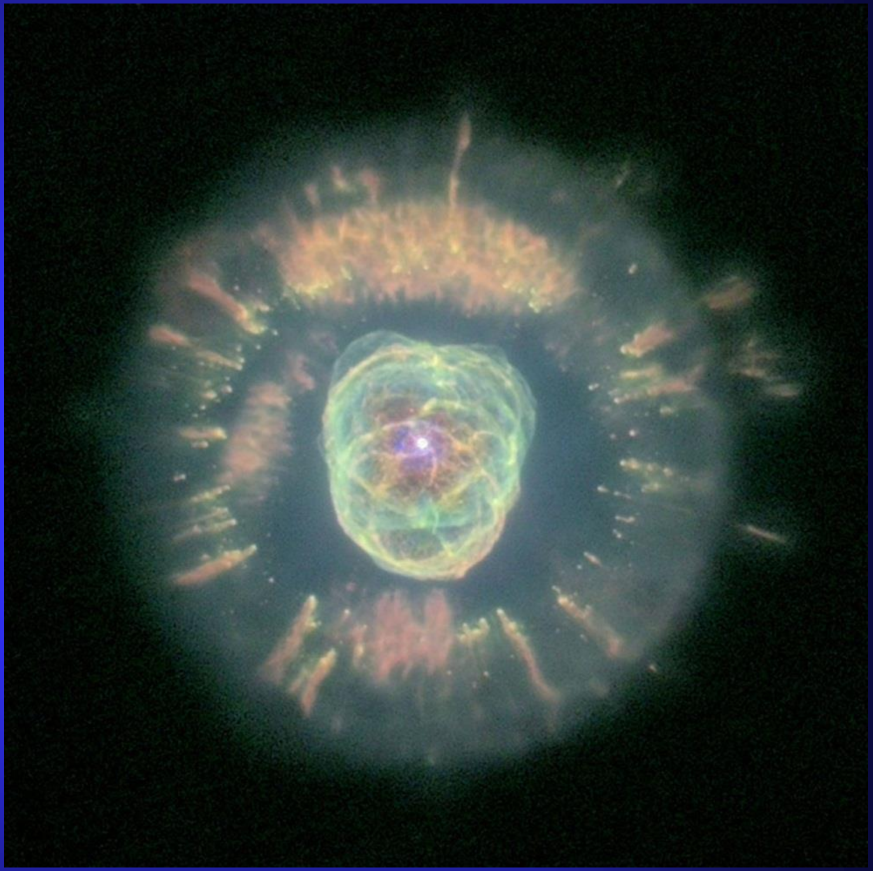
Low Mass Evolution



Planetary Nebula



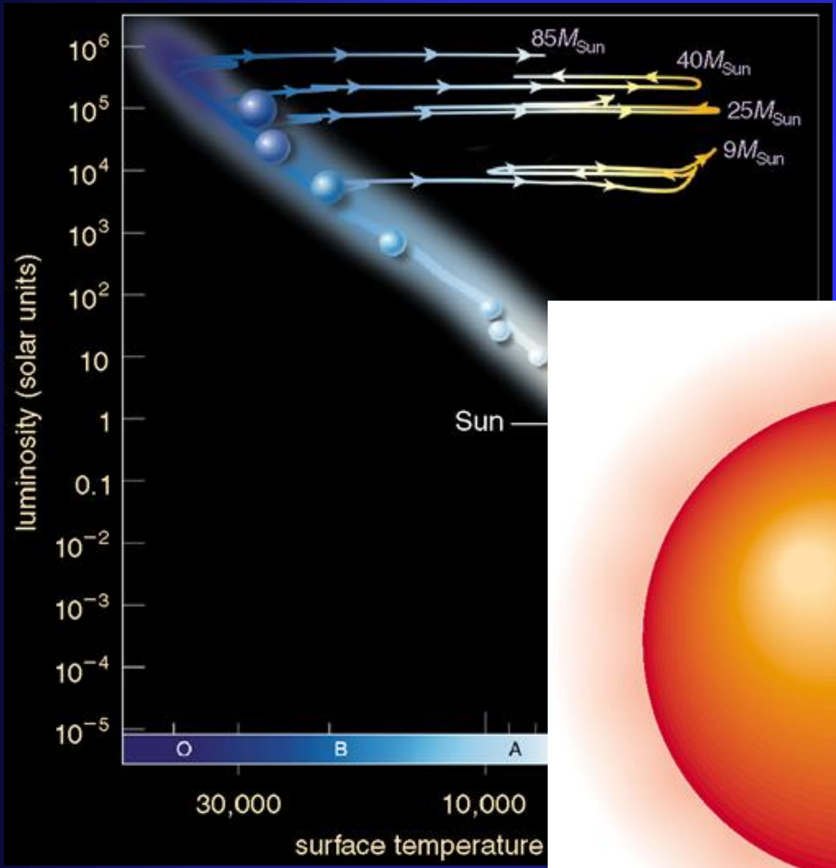
Ring Nebula

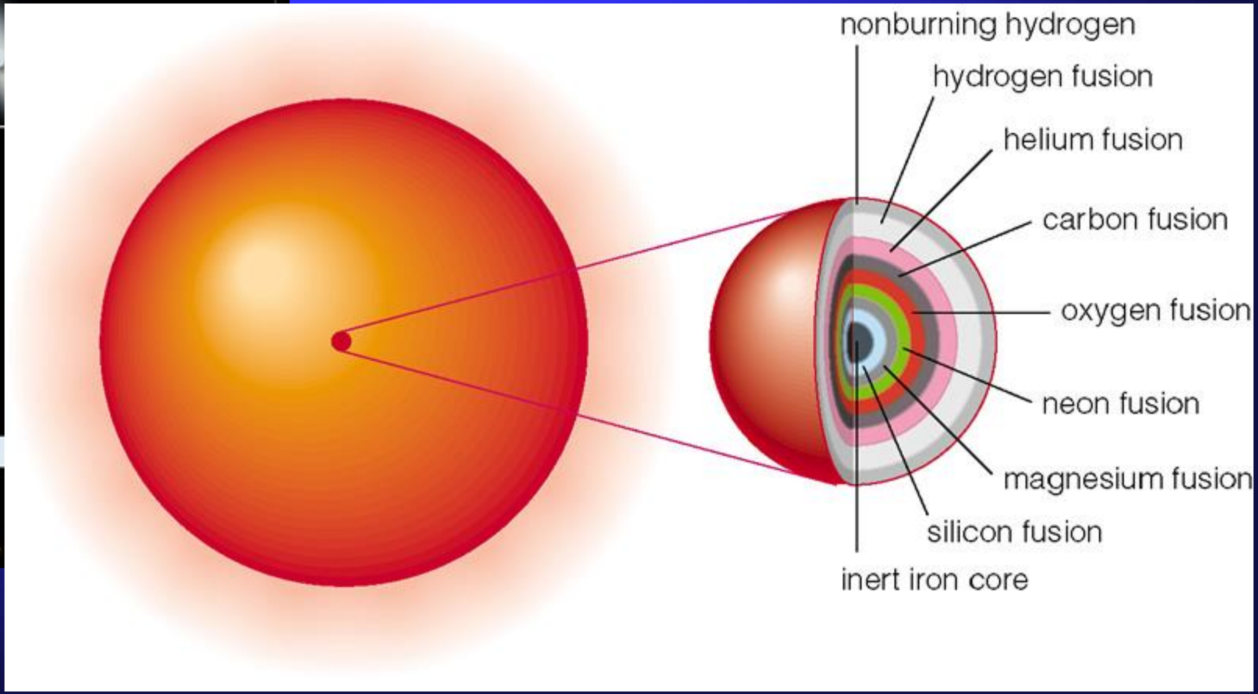


Eskimo Nebula

High Mass Evolution

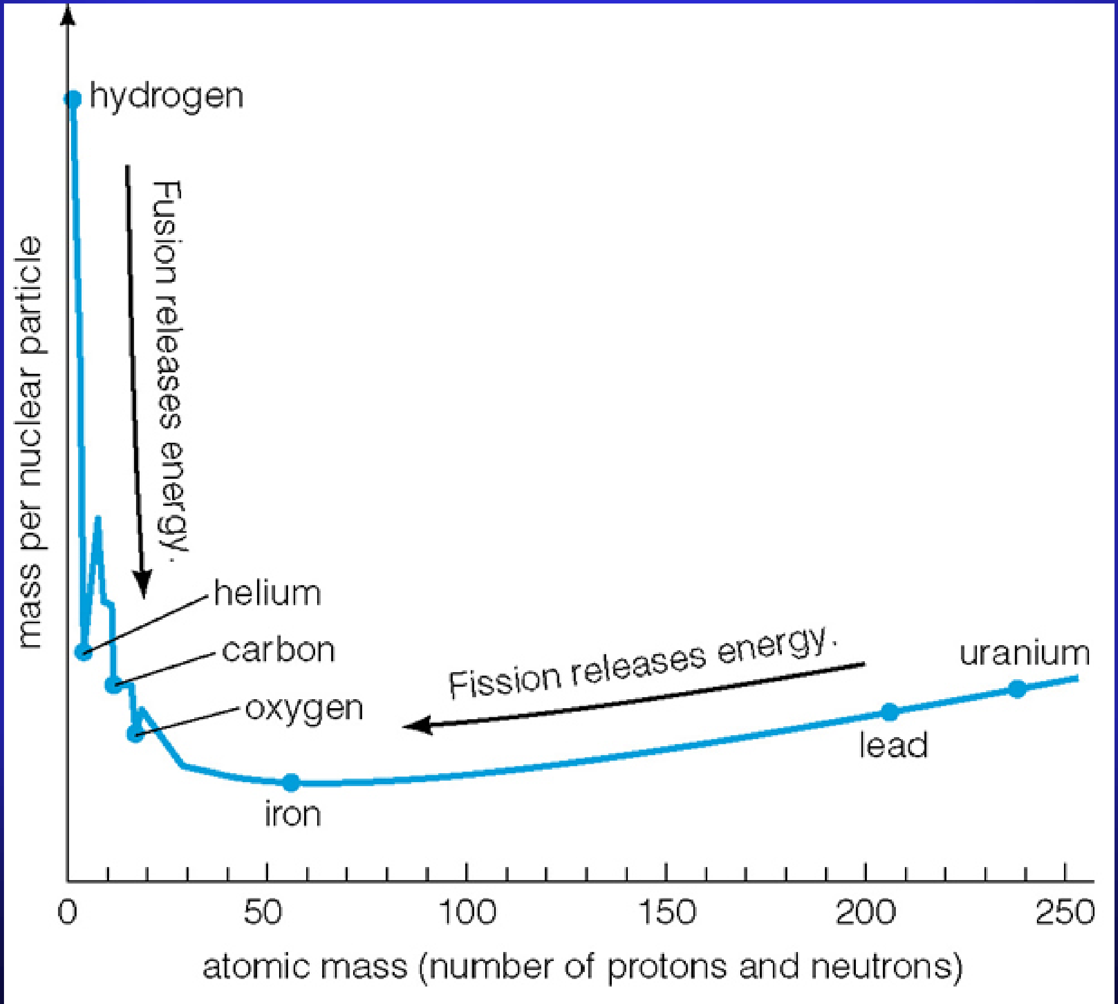
High mass stars keep on fusing





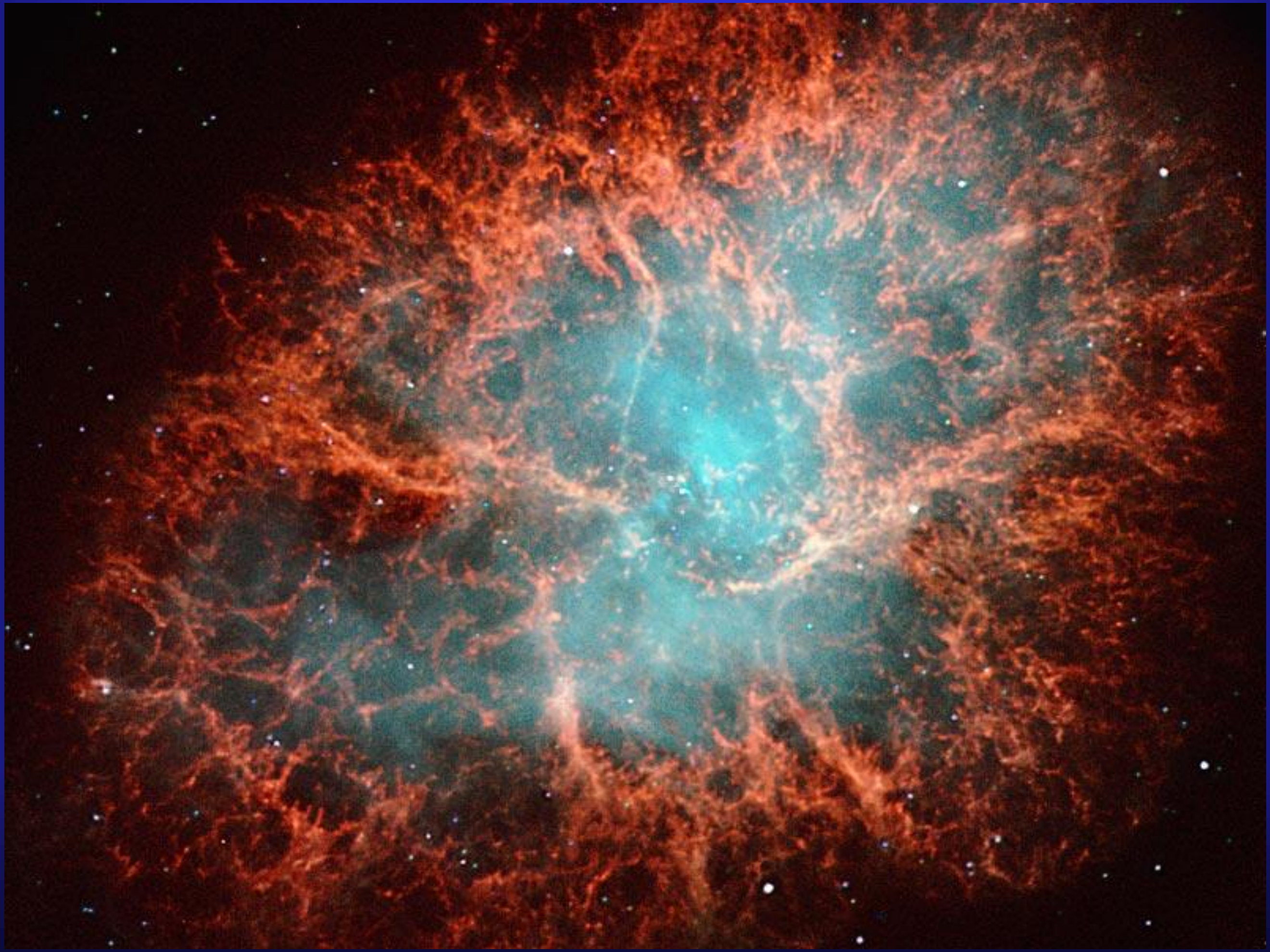
Why Stop?

We can't get energy out anymore

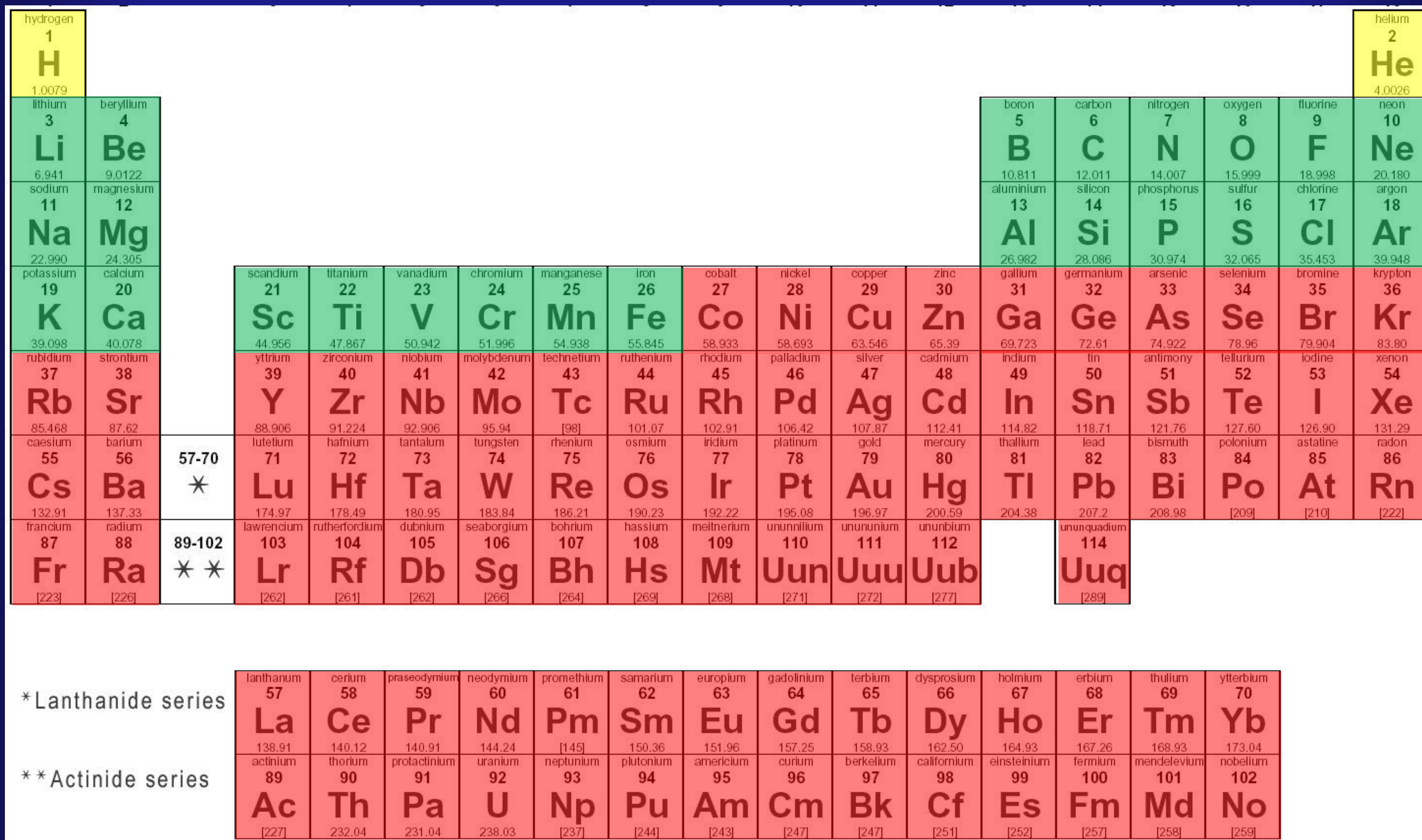


Super Nova

The Crab Super Nova Remnant



The Formation of Elements

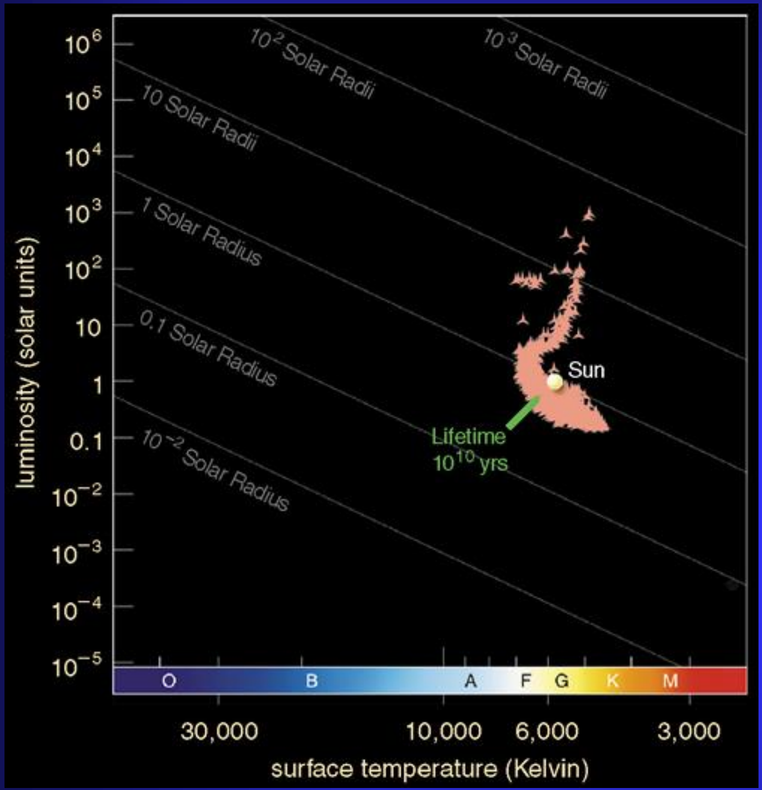


Big Bang

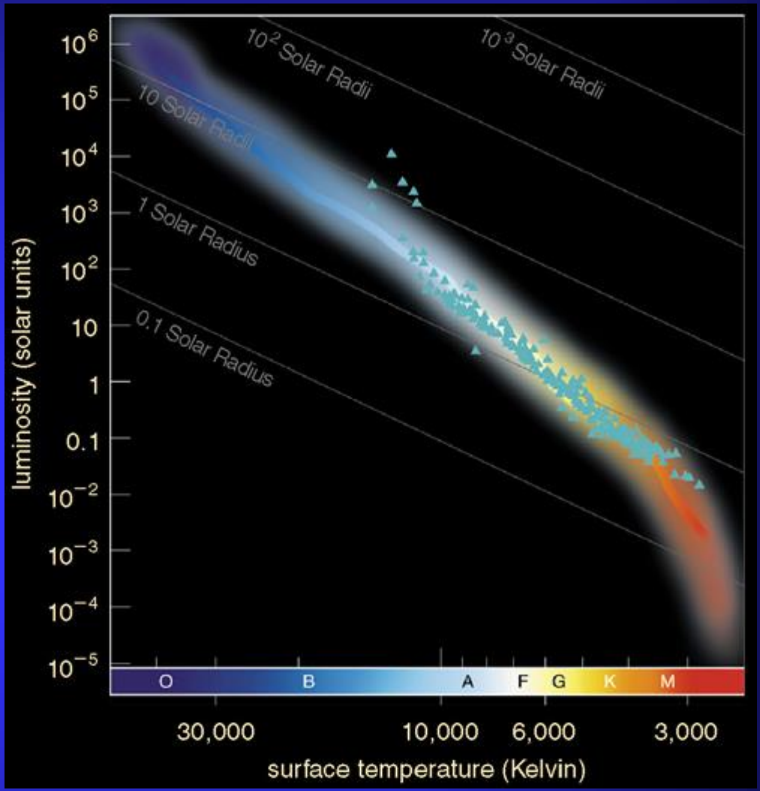
Stellar Fusion

Super Nova

Clusters



A

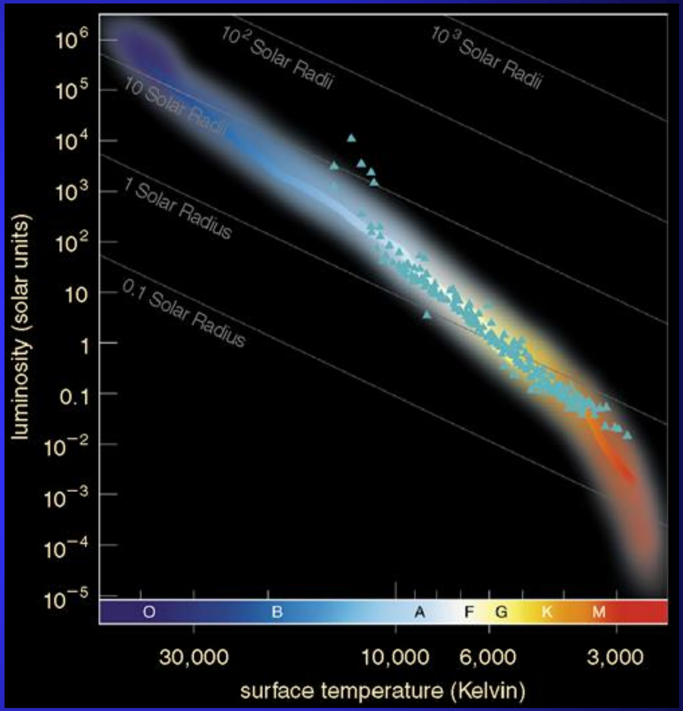


B

Which Cluster is older?

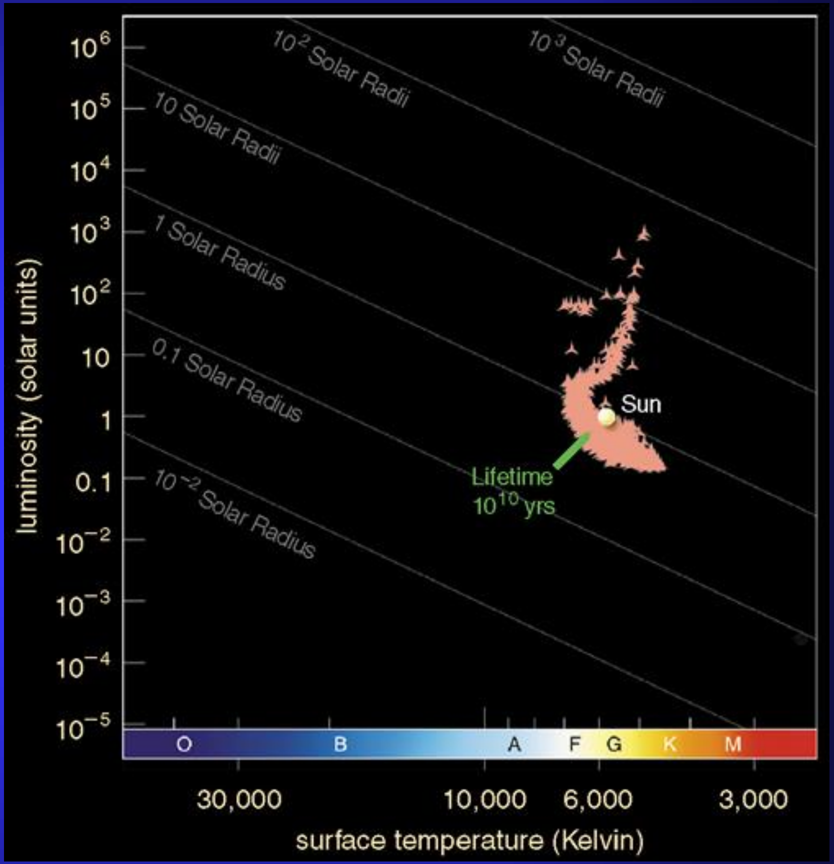
Clusters

Determining the age of a cluster



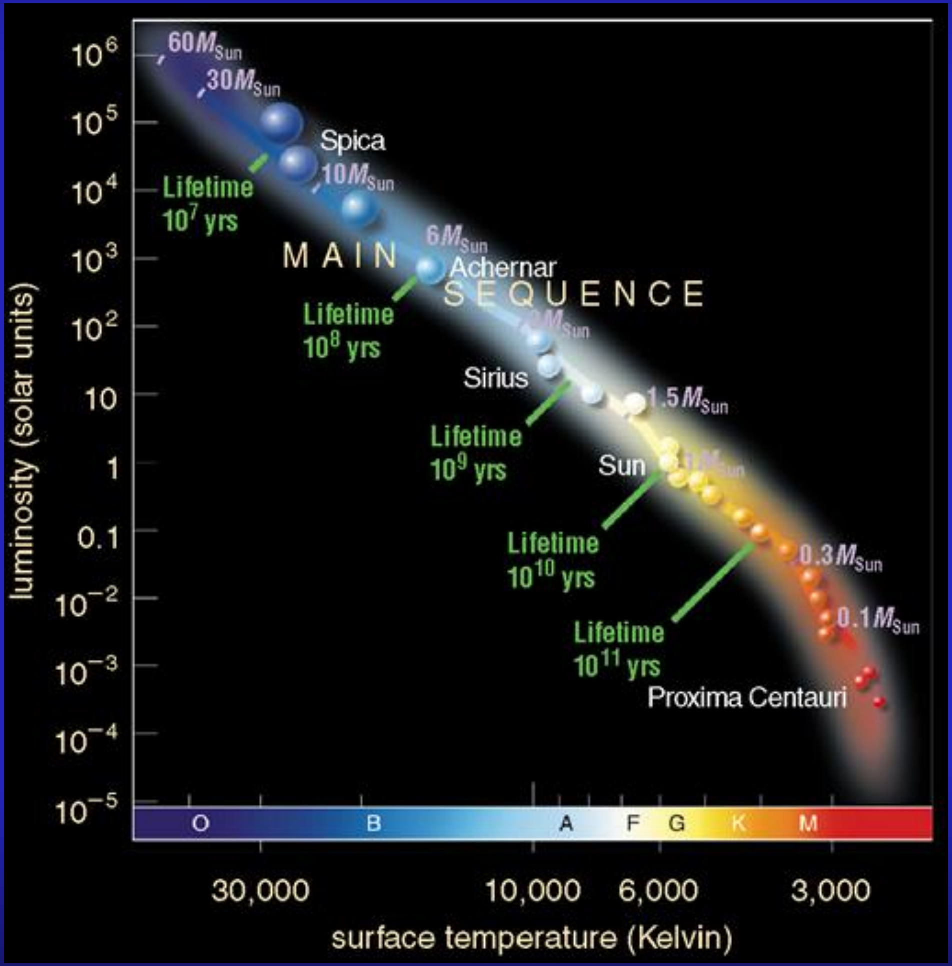
The **main sequence turnoff** tells us the age

Clusters



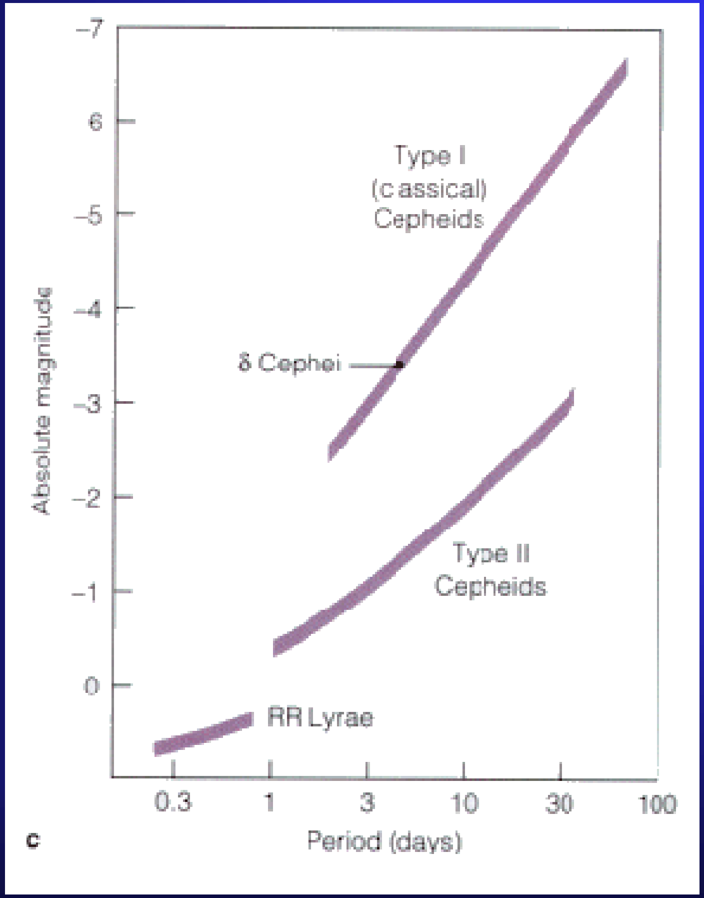
luminosity (solar units)
10^6
10^5
10^4
10^3
10^2
10
1
0.1
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^2 Solar Radii
10^3 Solar Radii
10 Solar Radii
1 Solar Radius
0.1 Solar Radius
10^{-2} Solar Radius
Sun
Lifetime
10^{10} yrs
O
B
A
F
G
K
M
30,000
10,000
6,000
3,000
surface temperature (Kelvin)

Main Sequence Distances



Cepheid Variables

Cepheids have a luminosity-period relationship



Nova

A binary system can turn into a nova