"Ah, but a man's reach should exceed his grasp, or what's a heaven for?" Robert Browning

Group Project 1 is due. I will collect them at the beginning of class.

Test 2 on Wednesday in class.

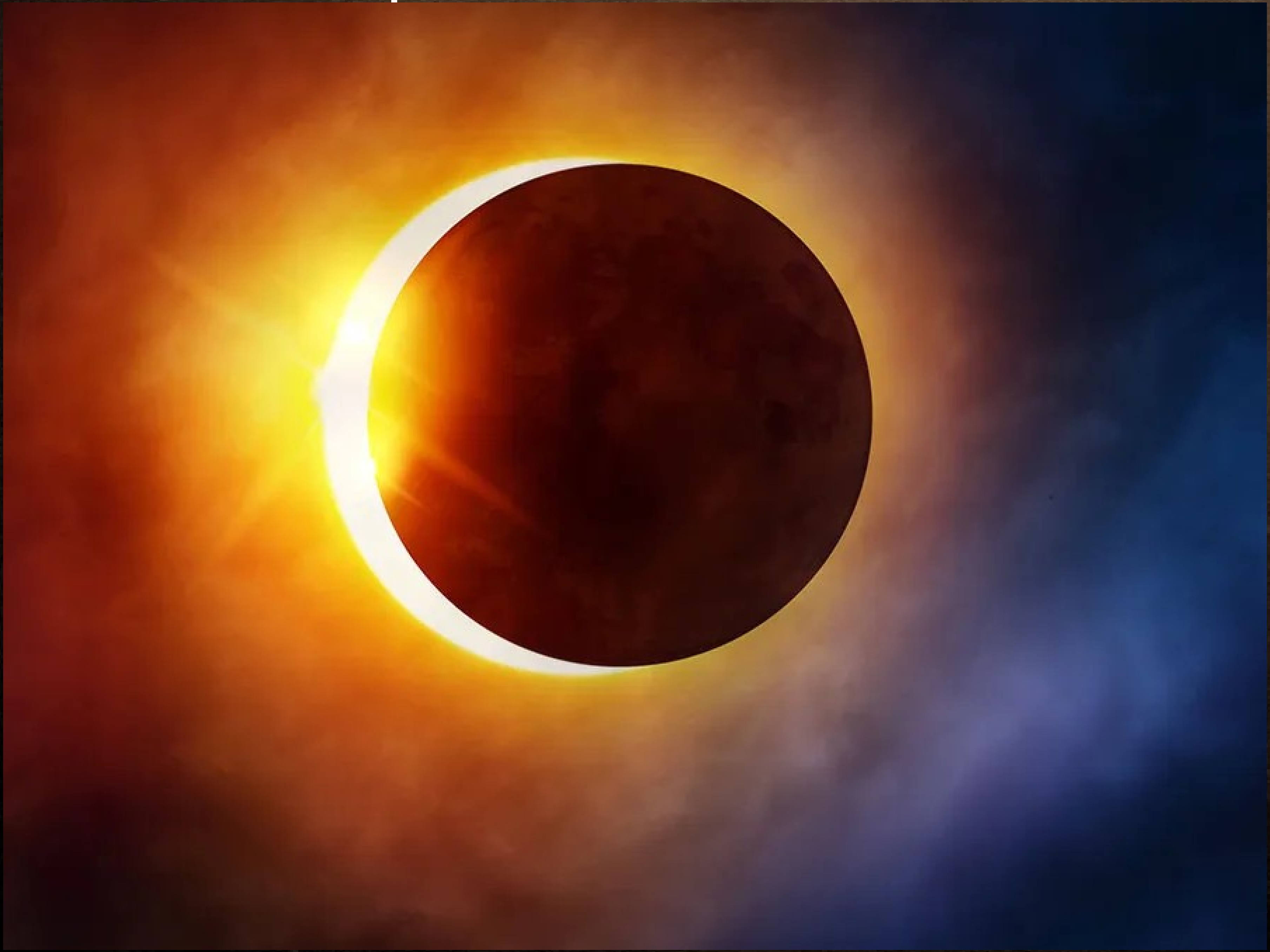
Sample Tests and study guide on the course web page now.

I will be gone April 4-11. 3 classes will be put on the course web page as videos with powerpoints.

I will also put a quiz or 2 on blackboard and a discussion page (for points) on blackboard.

Eclipse 1 week from today!

Partial: be sure to always wear eye protection



“The clouds I can handle, but I can’t fight with an eclipse” Stephanie Meyer, Eclipse

Protostars: gravity

Main Sequence:
fusion H → He in their cores

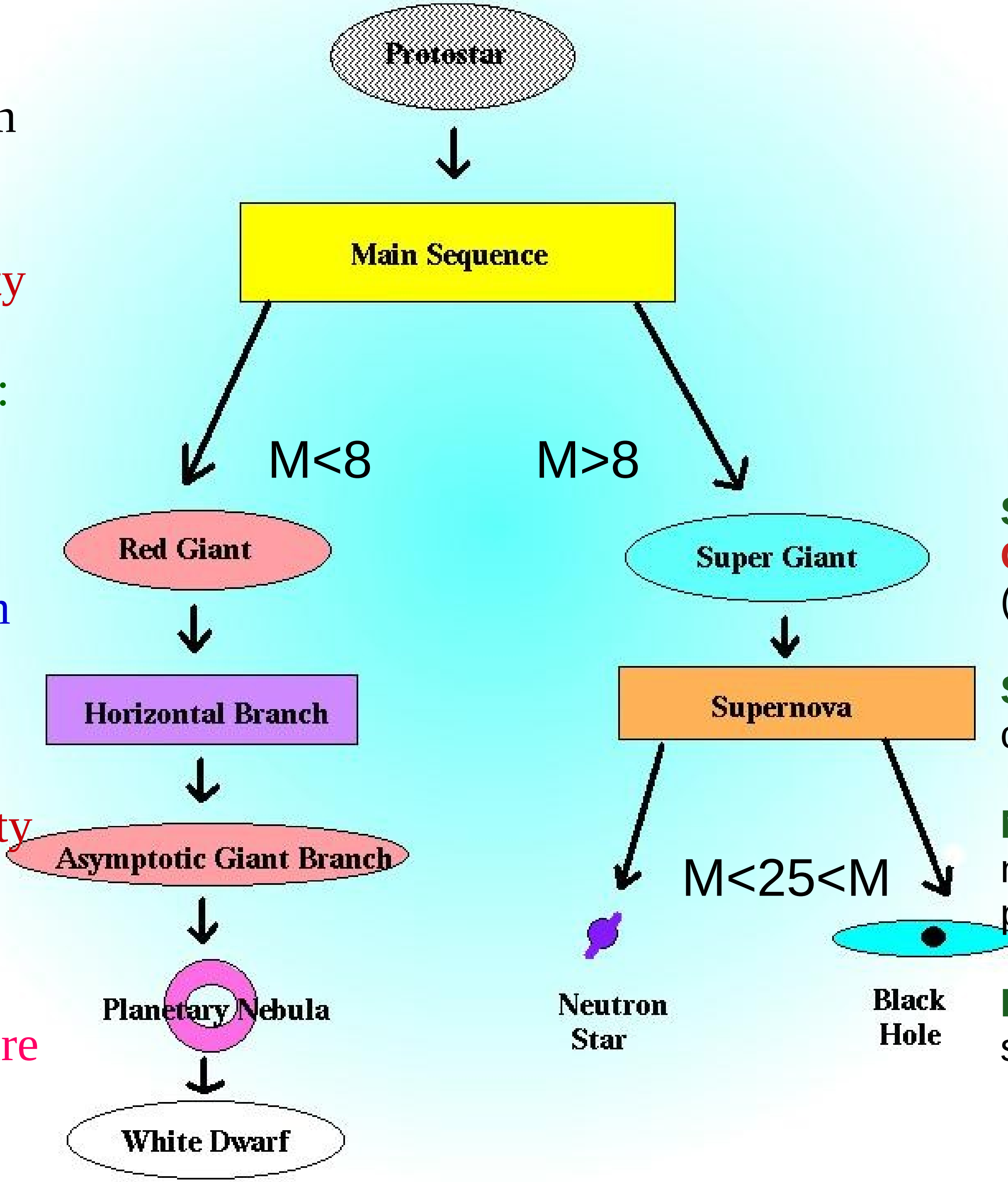
Red giants: gravity

Horizontal branch:
fusion of He → C

AGB: energy from gravity

Planetary nebula:
energy from gravity

White dwarf:
electron degeneracy pressure



Supergiant:
Gravity + fusion
(He, C, N, O, Si)

Supernova: colapse, no support.

Neutron Star: neutron degeneracy pressure.

Black hole: no support.

End States of Stars

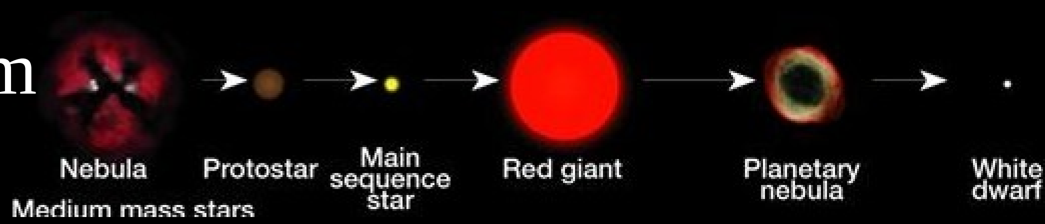
White dwarfs: electron degeneracy pressure. Earth-sized, $0.6M_{sun}$

Neutron Stars: neutron degeneracy pressure. City-sized, $1.4M_{Sun}$

Black holes: no support. Size is a point, but $R_{Sch}=3M$ (mass in M_{Sun}, R in km). Eventually black holes evaporate.

If we just keep going back to previous generations of stars, what happens to the ‘metals’?

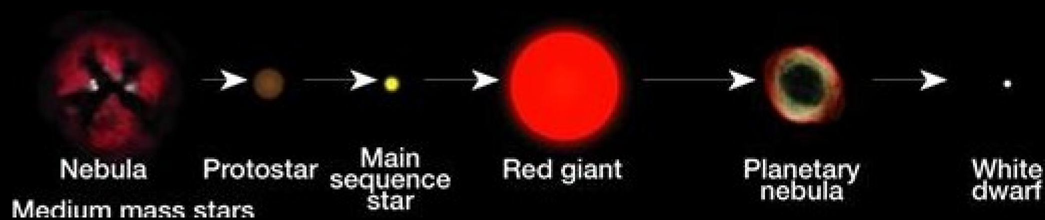
Our solar system
2% metals



Planetary nebula returns 3% metals

Before our Sun?

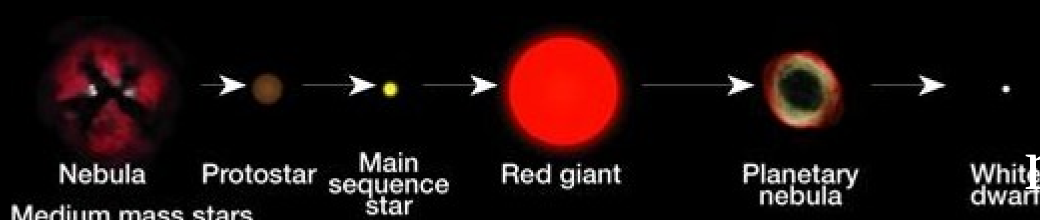
Previous star:
1% metals



Planetary nebula returns 2% metals

And before that?

Previous star:
0.5% metals



Planetary nebula returns 1% metals

Stellar Populations

As stars recycle heavier material back into space, newly formed stars incorporate this material. Thus newer stars have more "metals" then old stars. This gives us populations:

I: Stars like our Sun- they have the most metals (2%)

II: Metal-poor stars- formed in the galaxy before our Sun: have some, but little metals (<0.1%)

III: No metals at all: made only of H and He. The first stars.

Stars form in groups or clusters

<u>OB Associations</u> are 10-100s of stars, <u>not</u> gravitationally bound that formed at the same time (within a few million years).

They contain O and B type (Pop I) stars (plus all other types too).

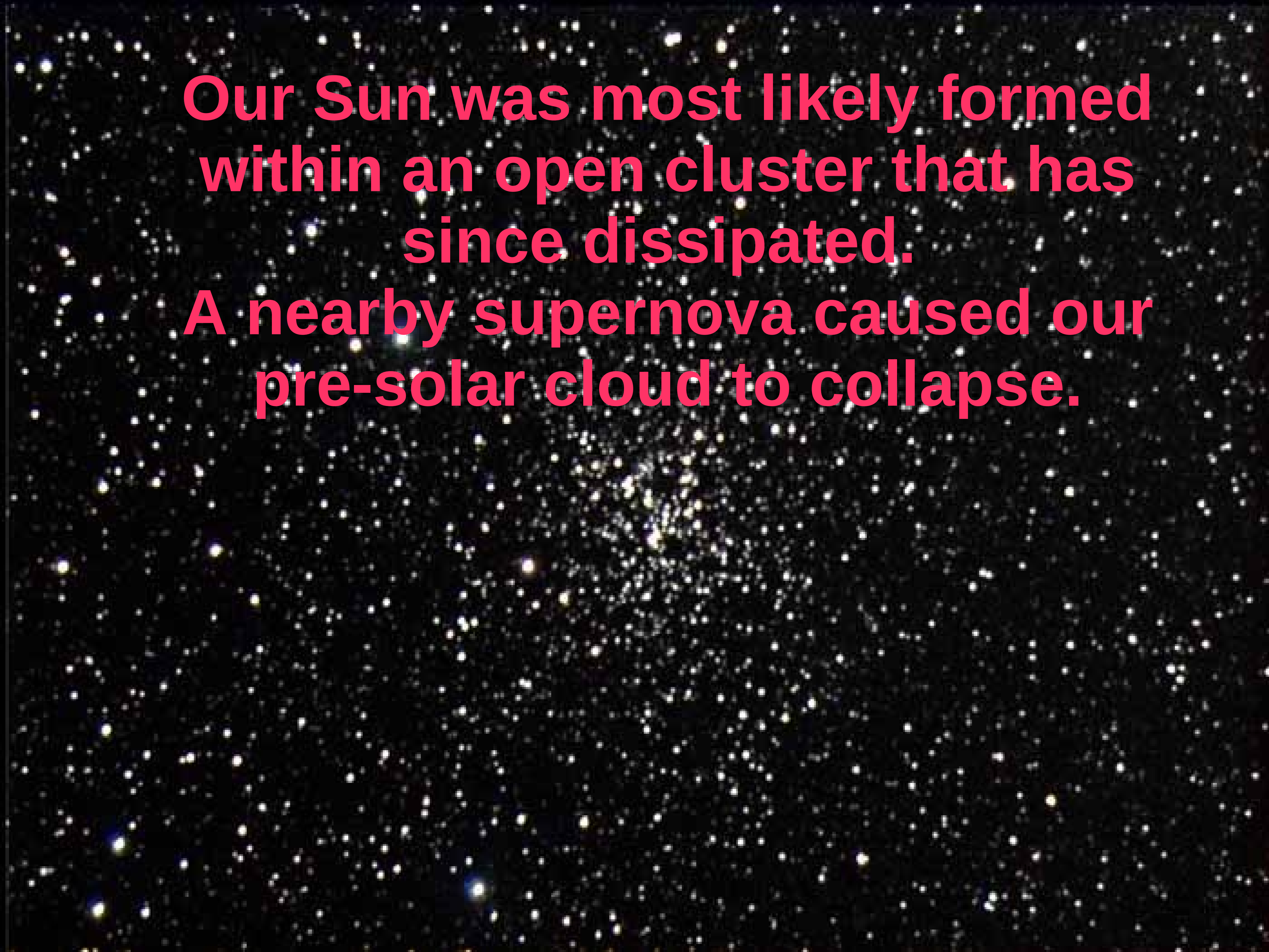
Open clusters are also a group of unbound stars, but without O and B stars. They can appear richer as stars have had more time to form. They have Pop I stars.

Globular clusters contain up to millions of stars. They are gravitationally bound together and are very old, with only low mass stars remaining.

They have Population II stars

Our Sun was most likely formed within an open cluster that has since dissipated.

A nearby supernova caused our pre-solar cloud to collapse.



Take aways

Stars form in groups.

Most groups are not gravitationally bound, but the rich ones (globular clusters) are.

Supernova come in two types:
Type I: Exploding white dwarfs
Type II: Exploding massive stars.

Why is this distinction important? A Type Ia always has the same amount of mass in the explosion, a Type II can vary widely.

How can you tell them apart? Type II have H and He, Type I do not.

Take aways

Supernova have 2 types.

Type Ia are exploding white dwarfs and are always the same brightness. Great for determining distances!

Quiz 10:
Our Sun...

A) is unusual as it is not in a binary or multiple star system.
B) will eventually use up its fuel.
C) will not explode.
D) A, B, and C are all true.
E) None of the above are true.

Q&A Time! What provides the support for white dwarf stars?

A) Fusion H → He

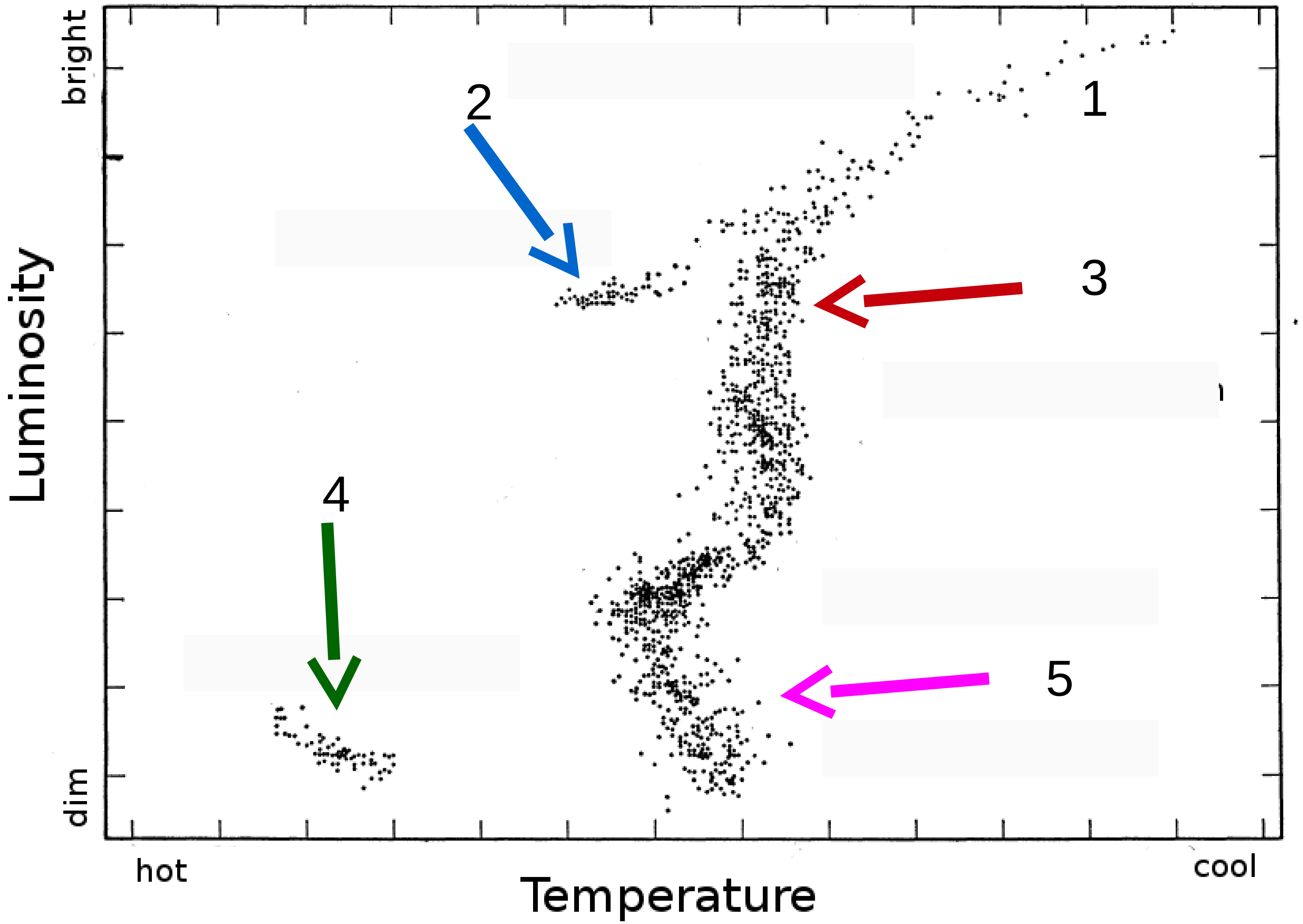
B) Fusion He → C

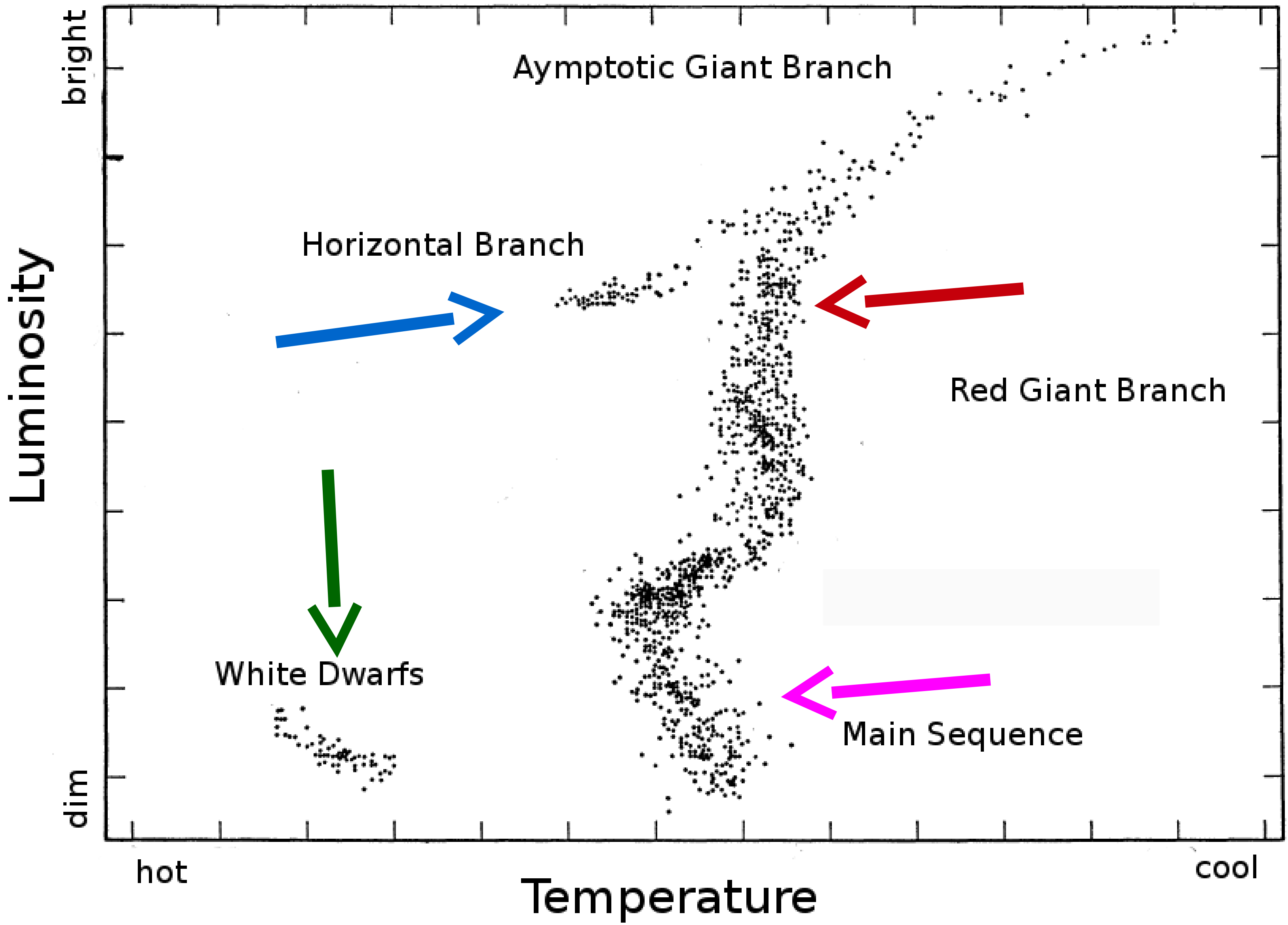
C) Gravity

D) Electron degeneracy pressure

E) Neutron degeneracy pressure

Q&A Time! What stages of evolution are the arrows pointing to?





bright
Aymptotic Giant Branch
Horizontal Branch
Luminosity
Red Giant Branch
White Dwarfs
Main Sequence
dim
hot
Temperature
cool

Q&A Time! If at the same distance, which star should be brightest?

A) Sun-like star

B) White dwarf

C) Supergiant

D) Neutron star

E) There is no way to tell

On to Galaxies....

What is a galaxy? What are galaxies made of? How big are galaxies?

Galaxies

Galaxies are collections of stars and gas (and dust) that are gravitationally bound together.

Galaxies

We will start with the easiest galaxy to study: Our own Milky Way.

Our Milky Way galaxy contains over 200 billion stars (that's 2×10^{11}!)