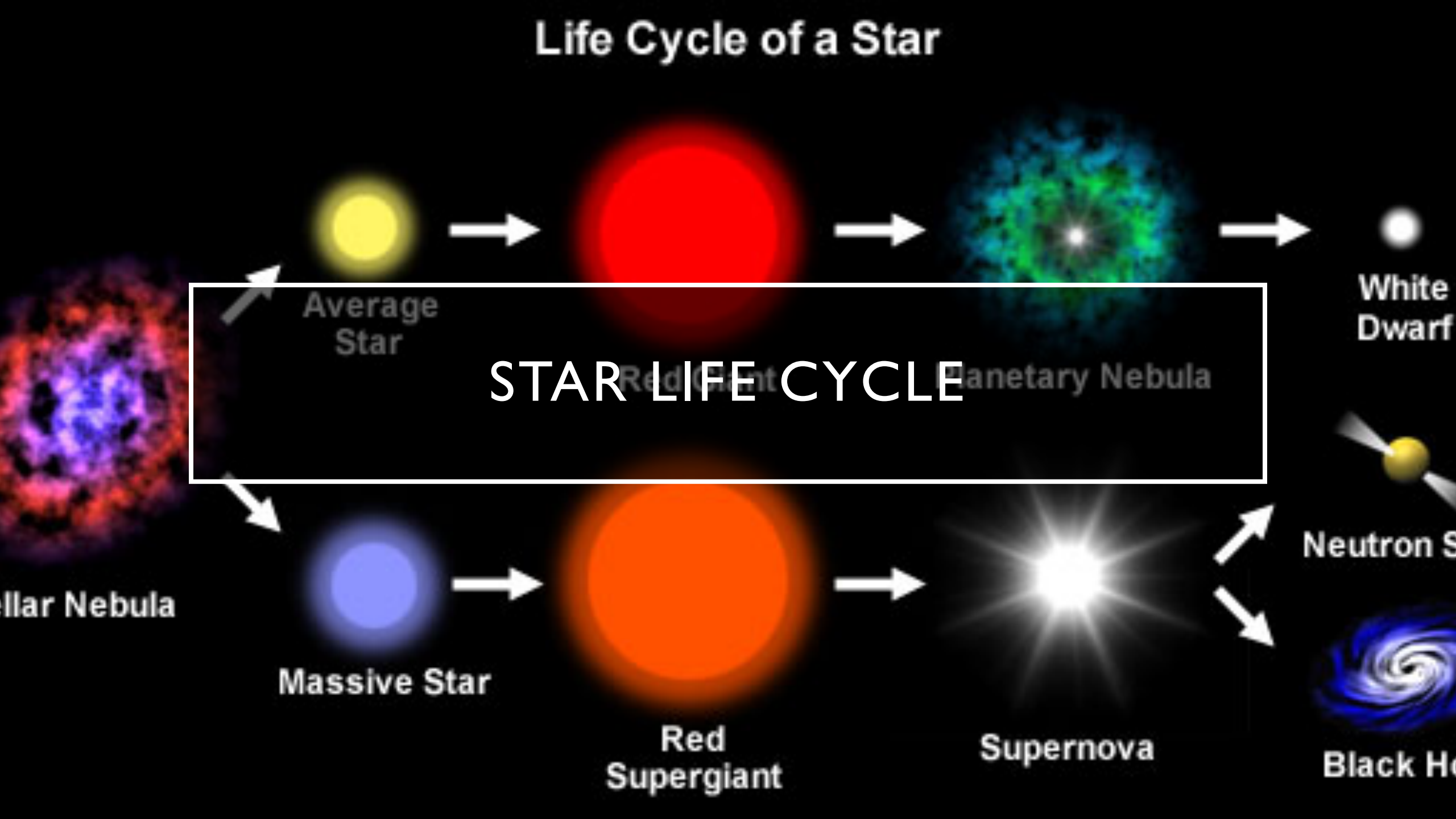
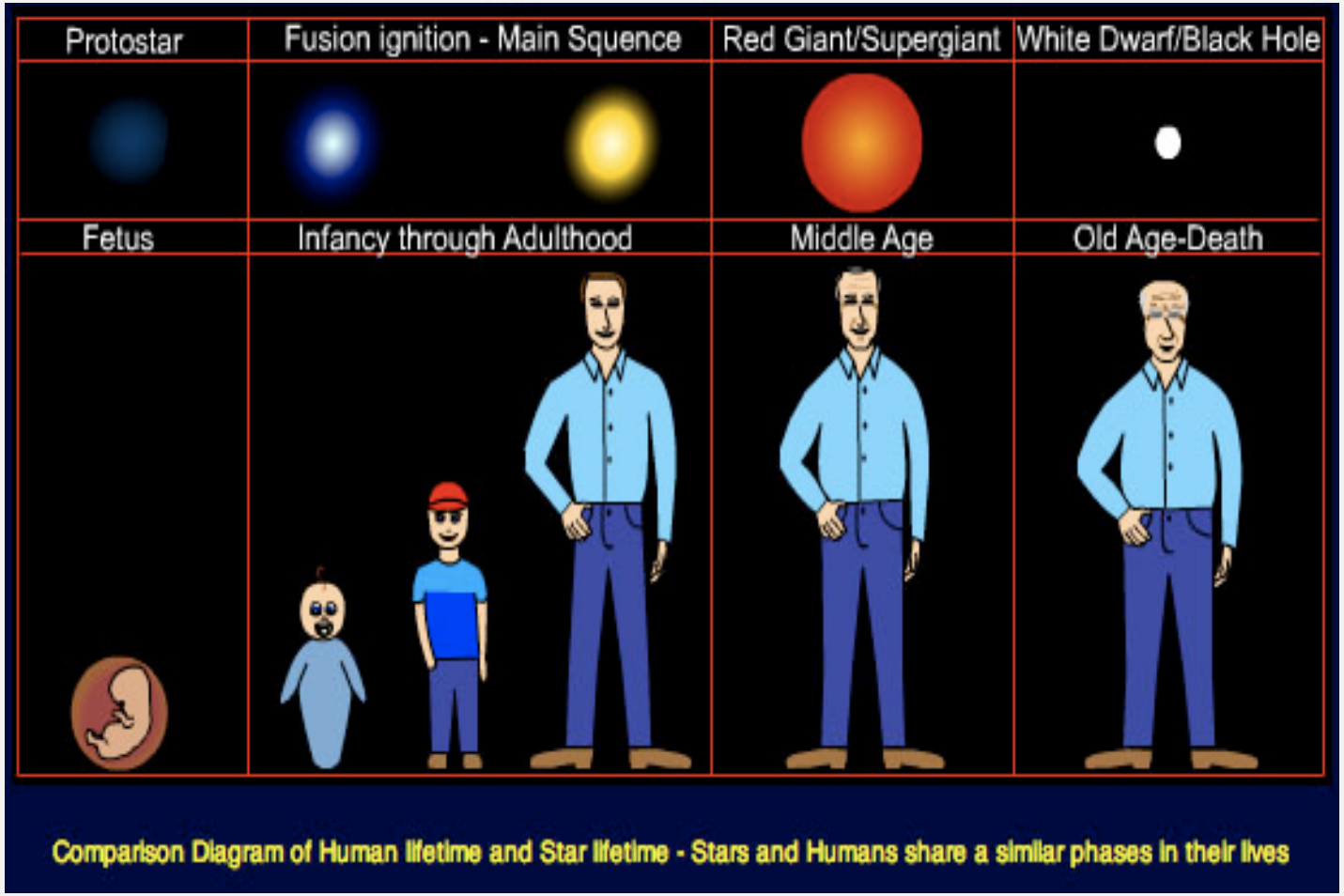
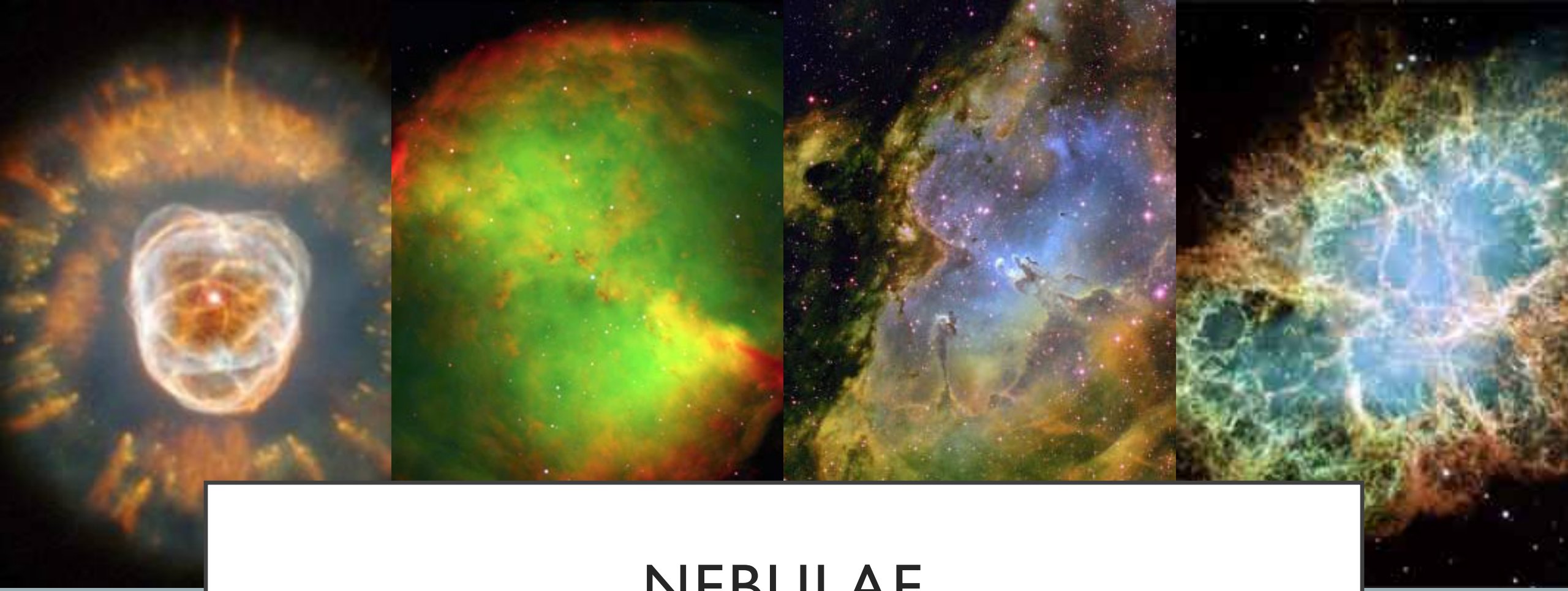

Life Cycle of a Star
Average Star
White Dwarf
Planetary Nebula
STAR LIFE CYCLE
Massive Star
Red Supergiant
Supernova
Neutron S
Black H

STELLAR EVOLUTION: LIFE OF THE STAR

- **Stars are like humans: they are born, live, and die.**

- The most massive stars have the shortest lives - a few million years.
- Stars like our Sun live for about 10 billion years.
- Stars less massive than the Sun have even longer life spans





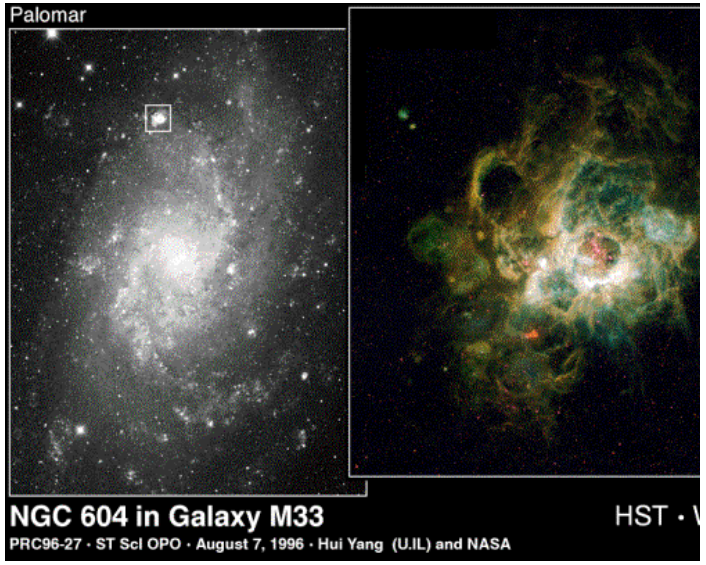
NEBULAE

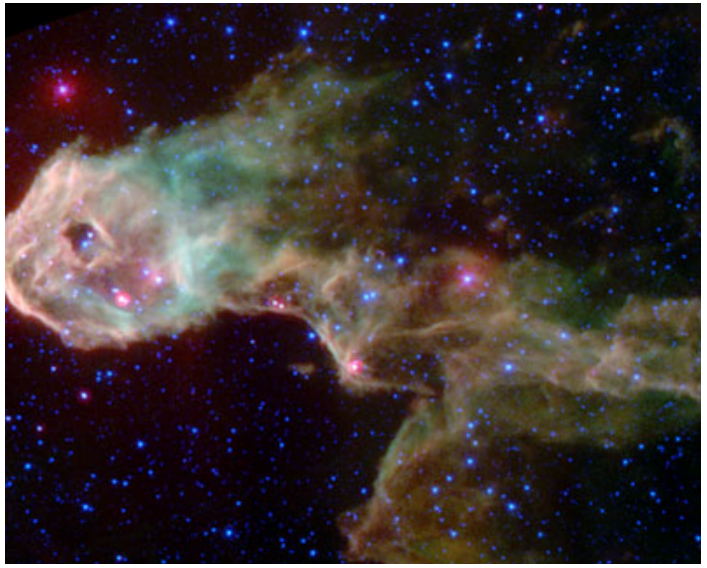
A STAR IS BORN

Stars are formed in **Nebulae,** huge clouds of dust and gas (mostly Hydrogen).

Many **nebulae** are in the arms of spiral galaxies.

Dense parts of nebulae collapse and compress to form a rotating gas globule called a **protostar**


Palomar
NGC 604 in Galaxy M33
PRC96-27 · ST ScI OPO · August 7, 1996 · Hui Yang (U.IL) and NASA
HST ·



PROTOSTARS

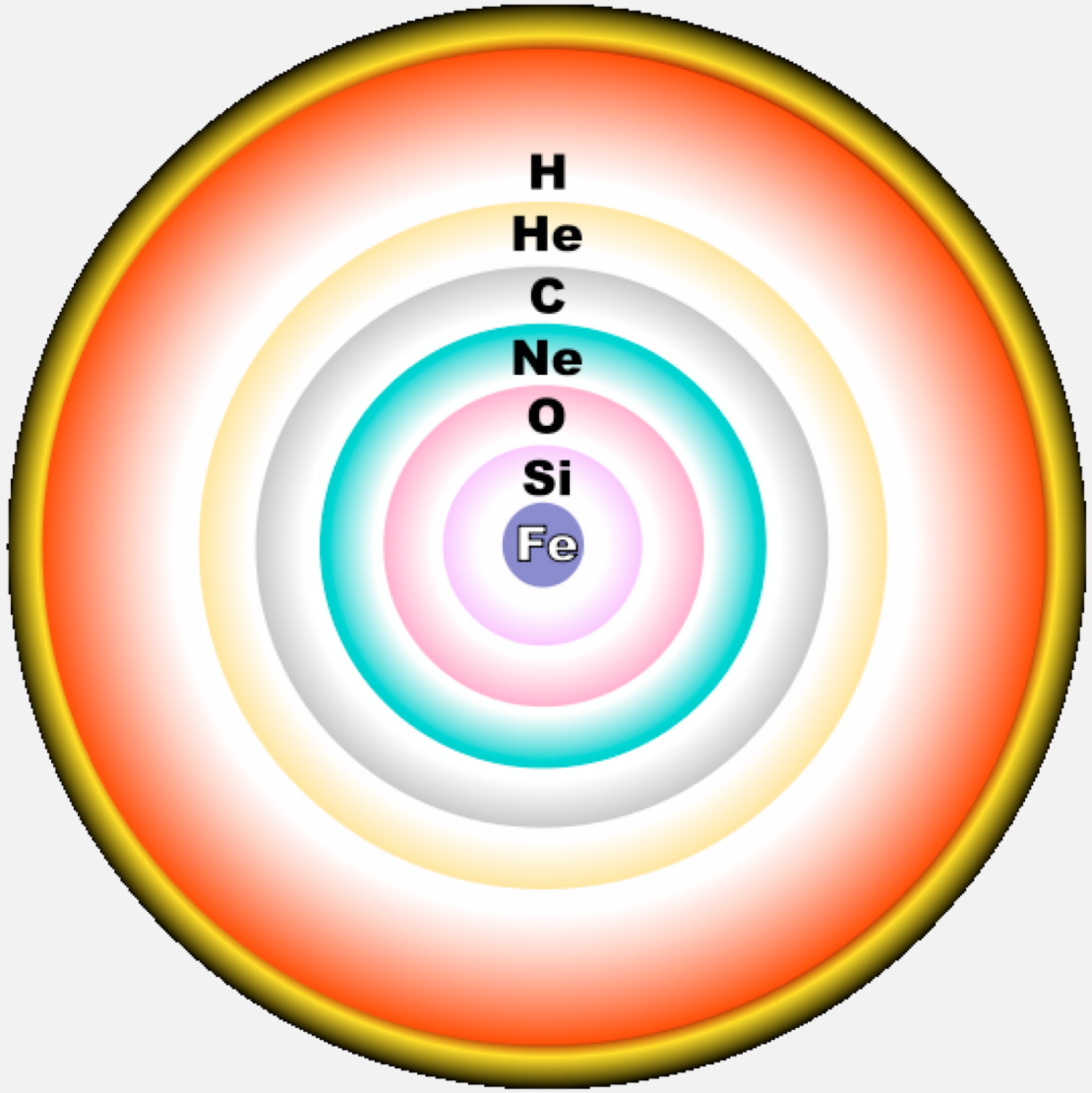
PROTOSTAR STAGE

As the nebula condenses, it gets hotter.

Colliding gas molecules create friction and heat. When temperatures reach 10 million K, **Nuclear Fusion** begins.

Hydrogen atoms **fuse** to form Helium atoms. This releases energy.

Fusion continues throughout the star's life, creating new elements at every stage.



The Birth of a Star - Part 1

Stellar Nursery

A star begins to form in a nebula, a cloud of interstellar hydrogen gas and dust.

Globule

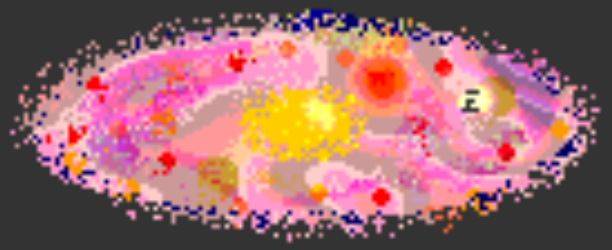
The gas and dust compress due to gravitational forces, forming a slowly rotating globule.

Globule Collapses

IR and radio waves emitted

Gravitational forces overcome gas pressure; the globule collapses. Cooling occurs and the spin increases.

Protoplanetary Disk and Core



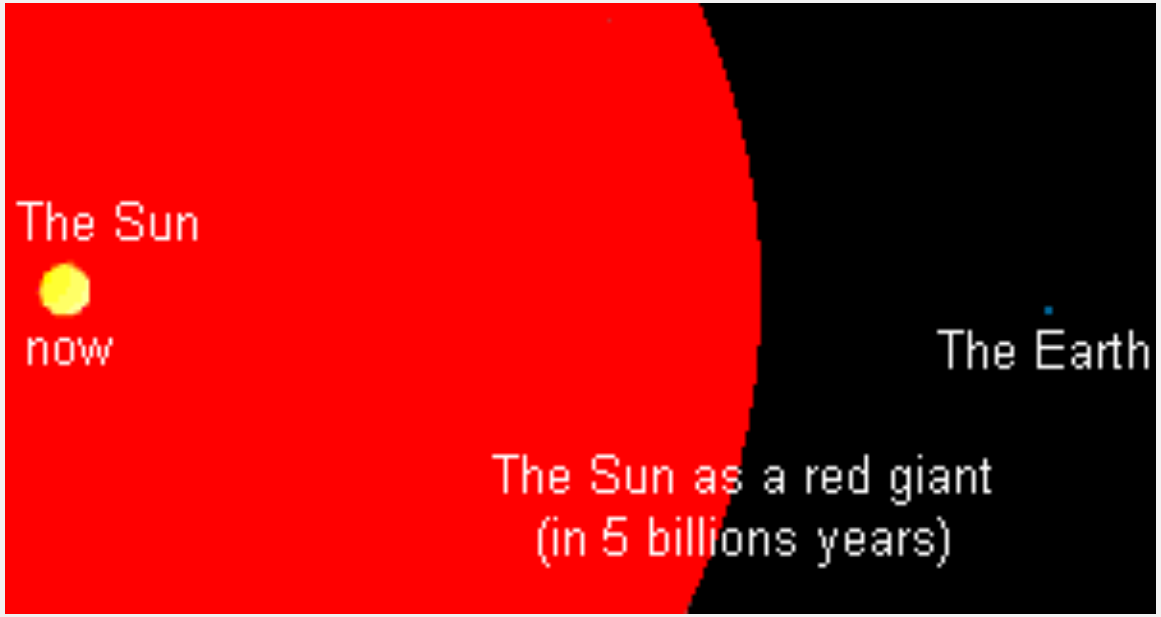
The spin, pressure and temperature increase. The globule differentiates into a protoplanetary disk (which may become planets) and a central core (which will become a star).

MAIN SEQUENCE STAGE

A **main sequence star** remains stable for about 10 million years.

Fusion continues. As all Hydrogen is used up, the star begins to die.

As this happens, the star expands and cools. This is called a **Red Giant Star.**



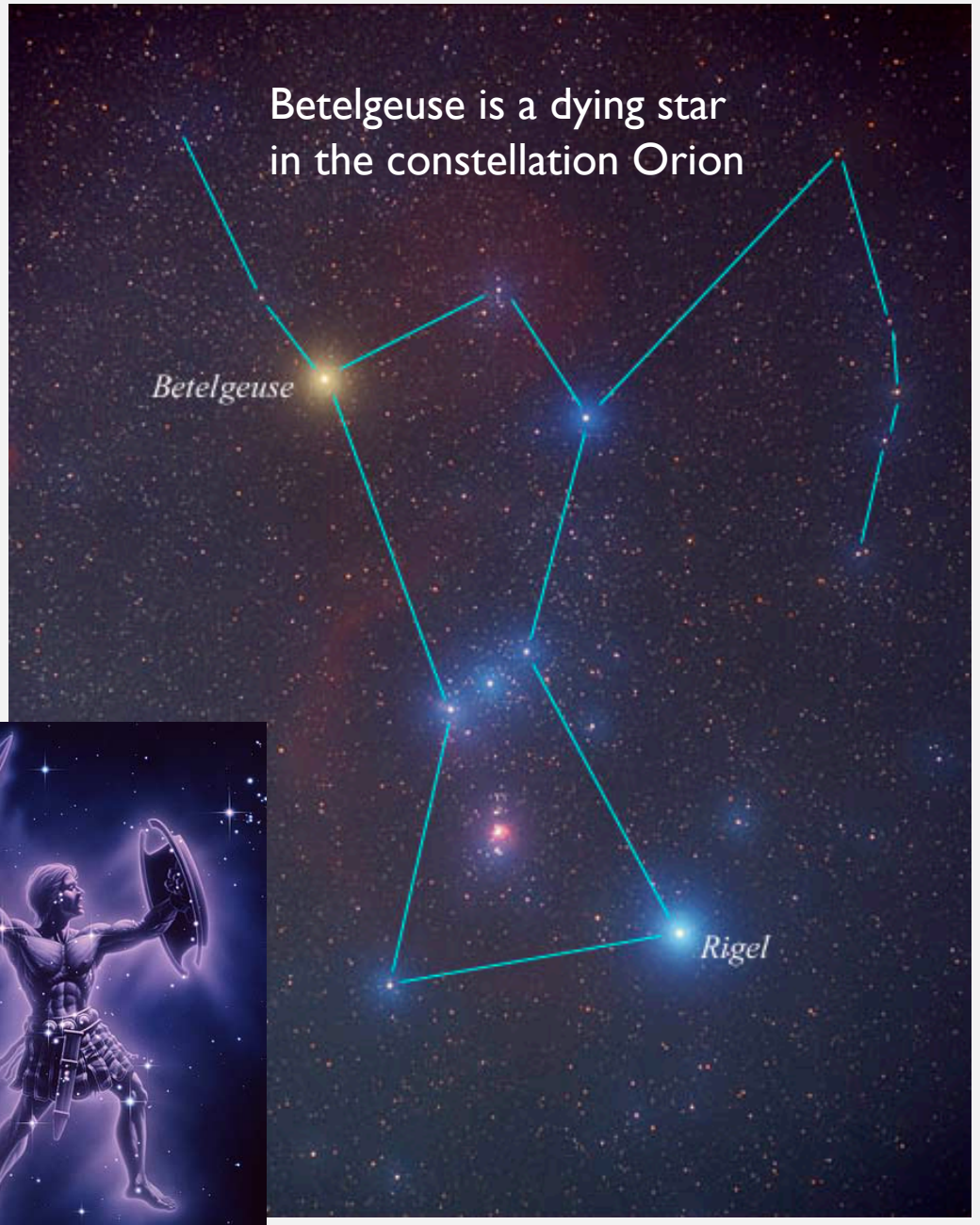
BECOMING A RED GIANT

Our Sun has used only about **5%** of its Hydrogen.

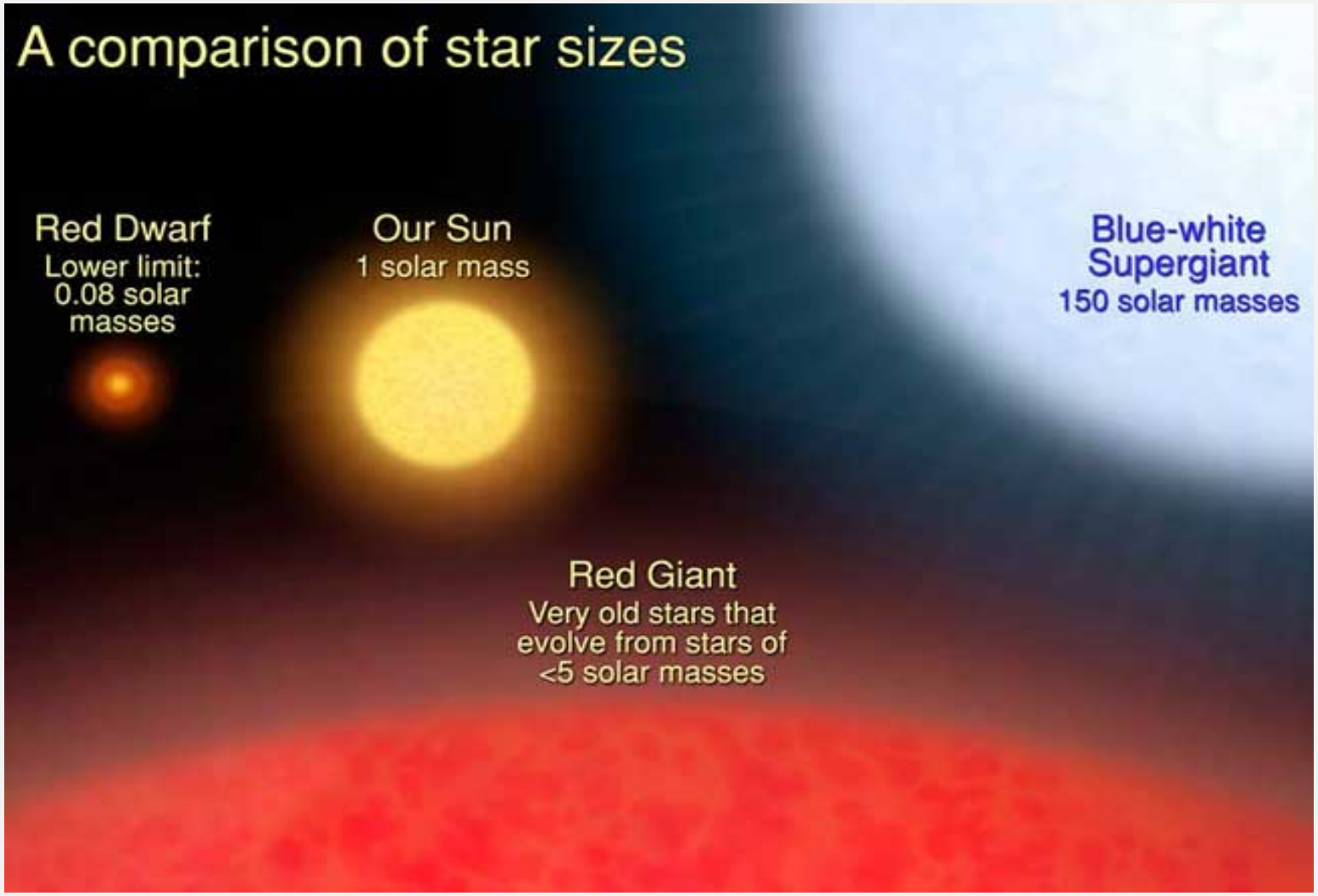
It is a G2V star, or **Yellow Dwarf**.

As a star ages:

- luminosity **increases**
- temperature **decreases**
- core **shrinks**
- core eventually becomes **Iron**.



COMPARISON OF STAR SIZES



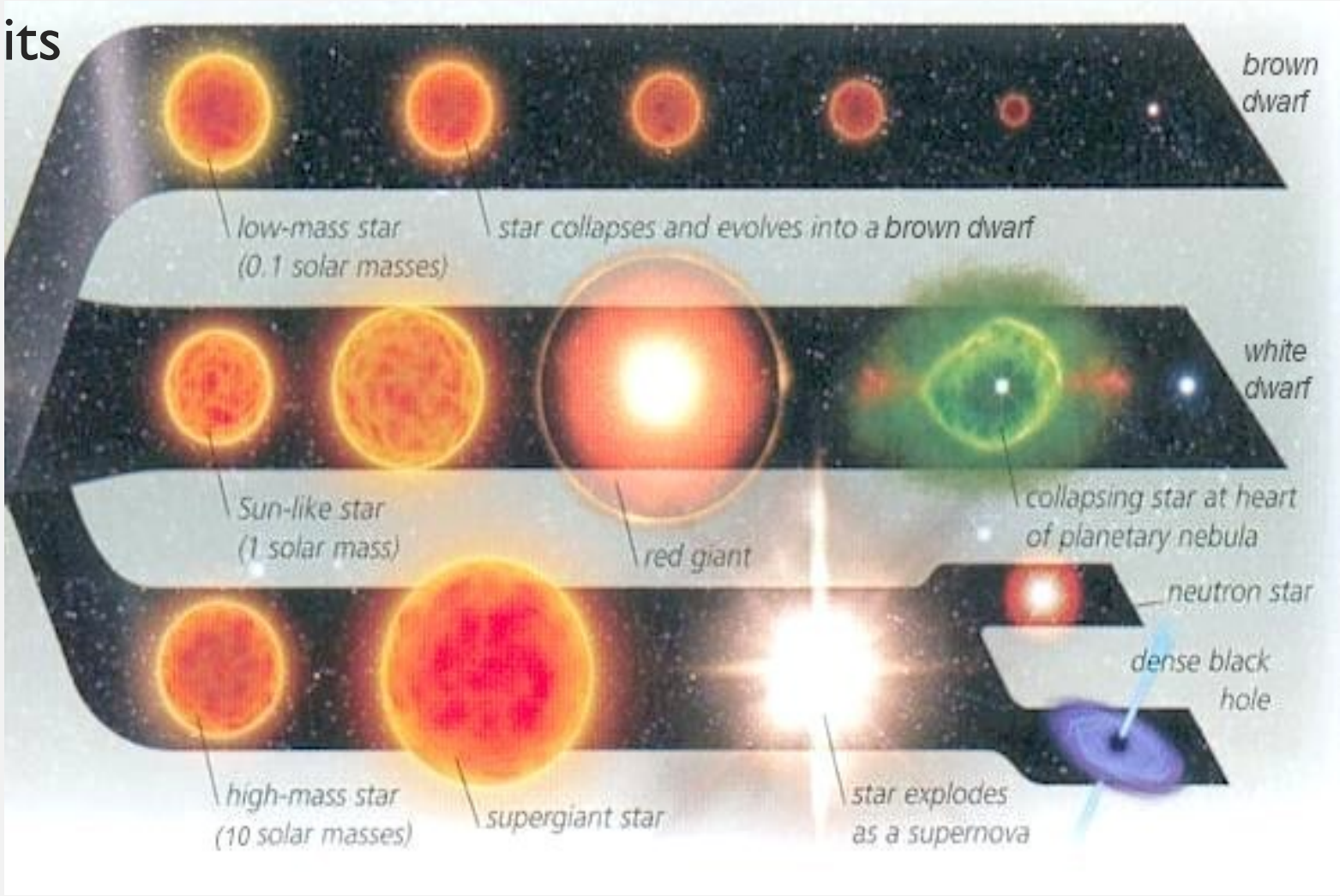
BURNOUT AND DEATH

The fate of a Star depends on its mass

All stars run out of fuel and collapse due to gravity.

They will become either a:

- **brown dwarf**
- **white dwarf**
- **neutron star**
- **black hole**



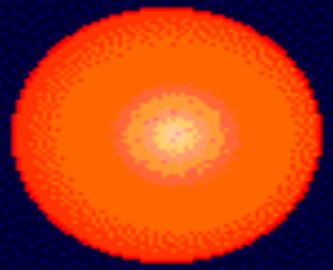
The Lifecycle of Stars

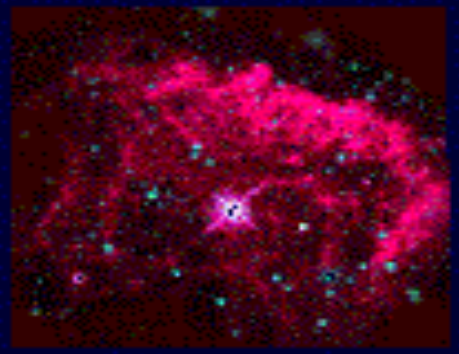
Stellar Nursery

Stars form in a nebula, from collapsing clouds of interstellar gas and dust.

Sun-Like Stars (up to 1.5 times the mass of the Sun)

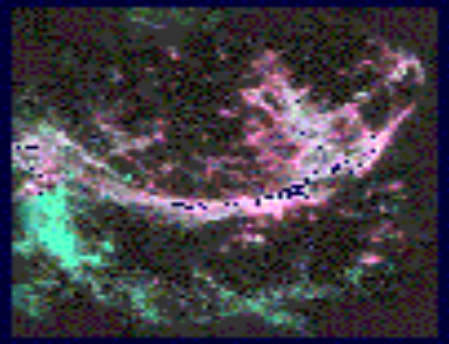
→ Red Giant → Planetary Nebula → White Dwarf → Black Dwarf





Huge Stars (from 1.5 to 3 times the mass of the Sun)

→ Red Supergiant → Supernova → Neutron Star



Giant Stars (over 3 times the mass of the Sun)

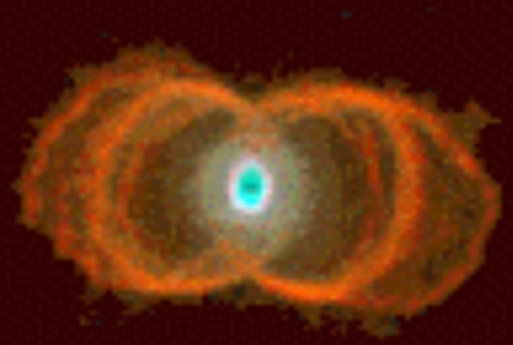
→ Red Supergiant → Supernova → Black Hole

Death of a Sun-Like Star

Sun-Like Star → **Red Giant** → **Planetary Nebula** → **White Dwarf** → **Black Dwarf**

This is the longest, most stable period of a star's life. It converts hydrogen to helium in its core, generating heat and light.

As the nuclear fuel becomes depleted, the core contracts and the outer layers expand.



Now the outer layers of the star start to drift off into space. The star loses most of its mass to the nebula.

The star cools and shrinks; it will eventually be only a few thousand miles in diameter! No nuclear reactions take place and the faint star radiates its heat into space.

Eventually the star has lost all its heat to space and is now cold and dark.

Death of a Huge Star

(from 1.5 to 3 times the mass of the Sun)

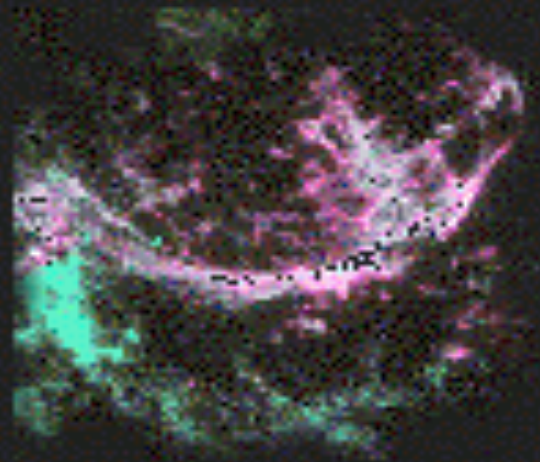
Huge Star

This is the longest, most stable period of a star's life. It converts hydrogen to helium in its core, generating heat and light.

Red Supergiant

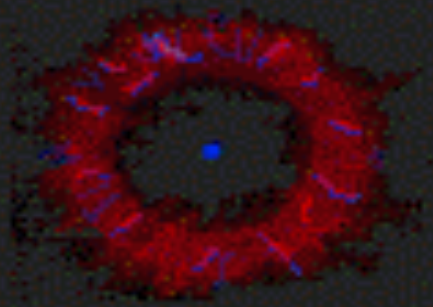
As the nuclear fuel becomes depleted, the core contracts and the outer layers expand.

Supernova



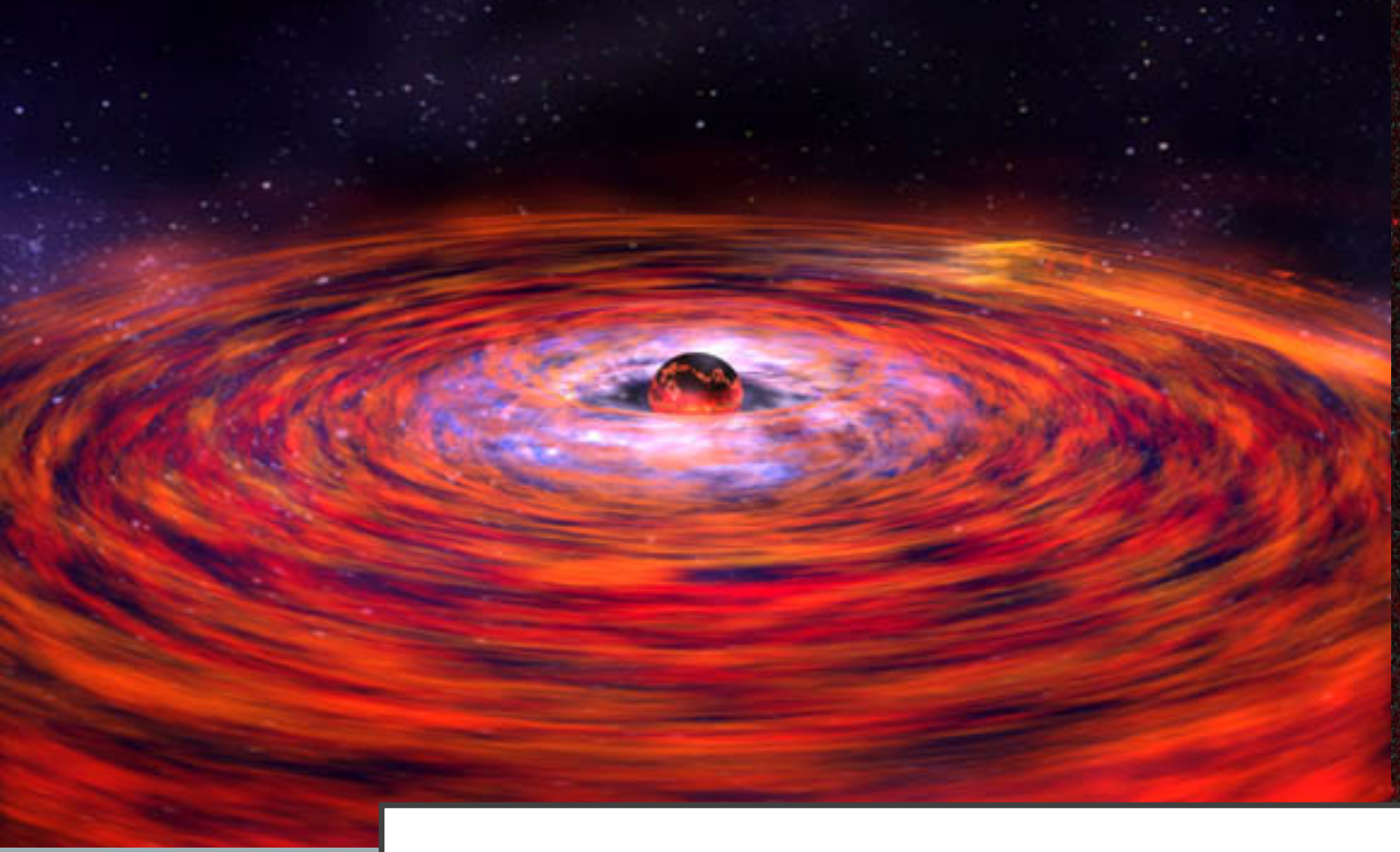
The core collapses in an instant. The repulsive electrical forces between in the core overcome the gravitational forces, causing a massive, short-lived explosion which blows away the star's outer layers.

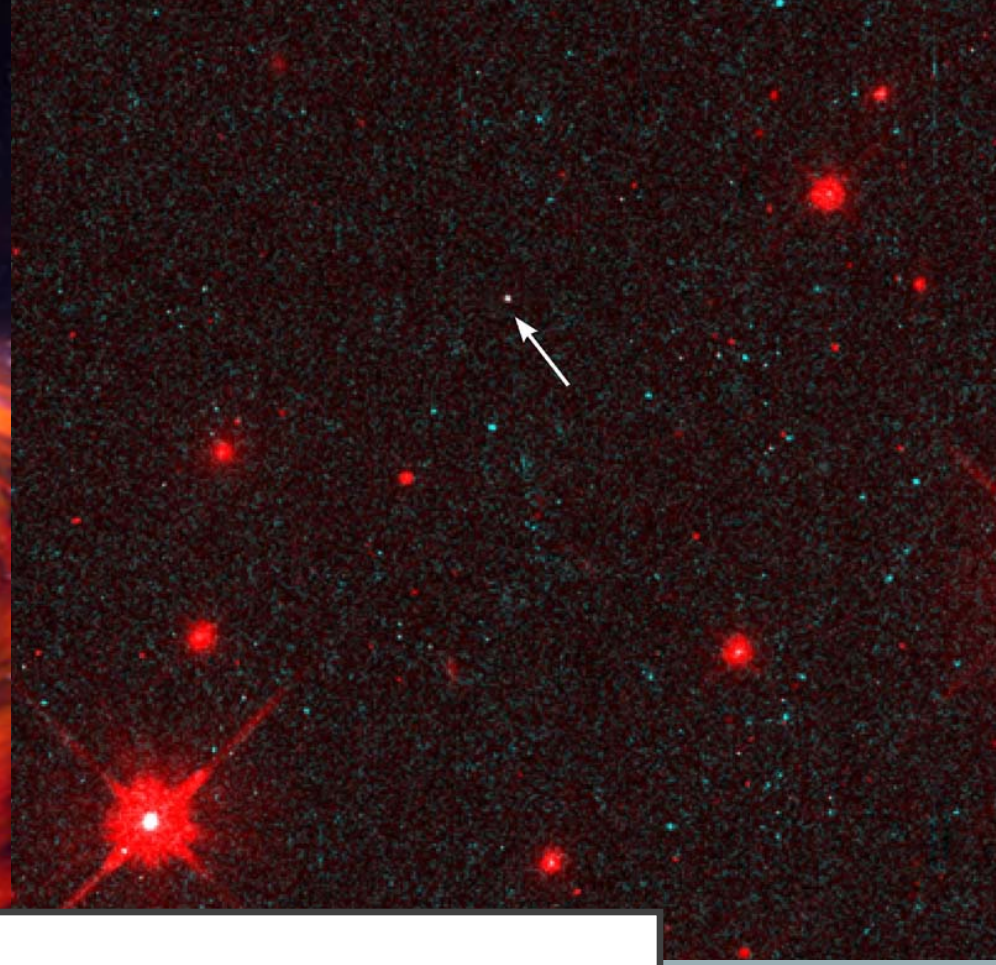
Neutron Star



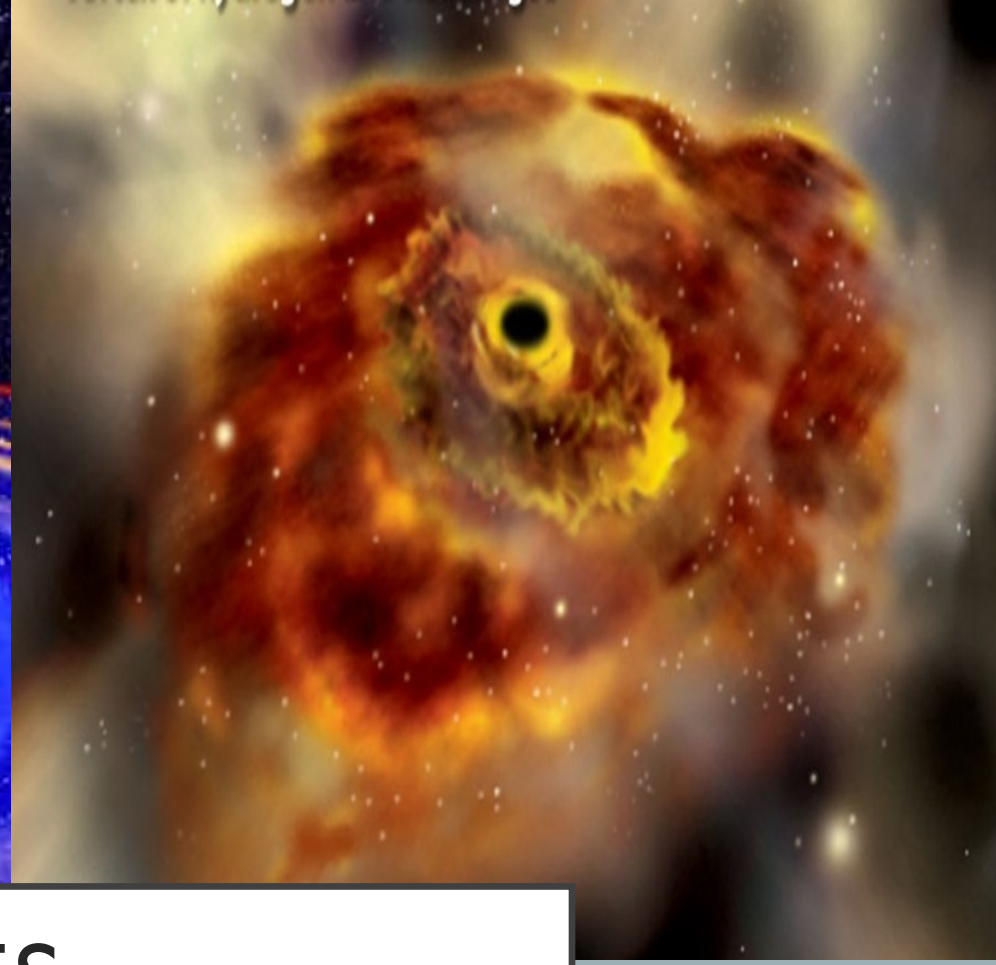
It contracts tremendously into a small, dense about ten miles in diameter, 1.4 times the mass of the Sun, with an extraordinarily strong magnetic field, and a rapid spin.

PLANETARY NEBULAE

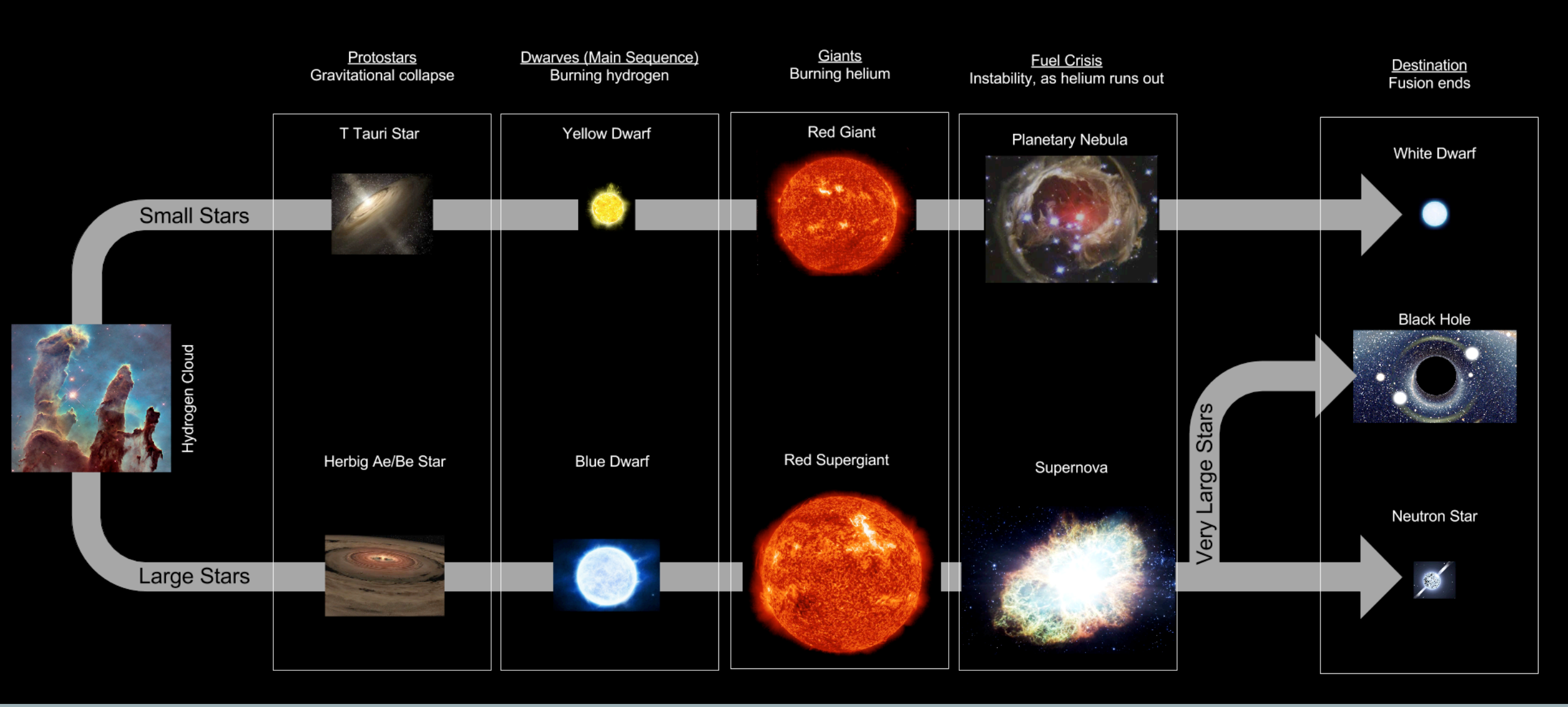




NEUTRON STARS



BLACK HOLES


Protostars
Gravitational collapse
Dwarves (Main Sequence)
Burning hydrogen
Giants
Burning helium
Fuel Crisis
Instability, as helium runs out
Destination
Fusion ends
T Tauri Star
Yellow Dwarf
Red Giant
Planetary Nebula
White Dwarf
Small Stars
Hydrogen Cloud
Black Hole
Very Large Stars
Herbig Ae/Be Star
Blue Dwarf
Red Supergiant
Supernova
Neutron Star
Large Stars

SUMMARY