Tastes Like Burning

Karl Steffin
Astronomy
8/9/2024

Stars

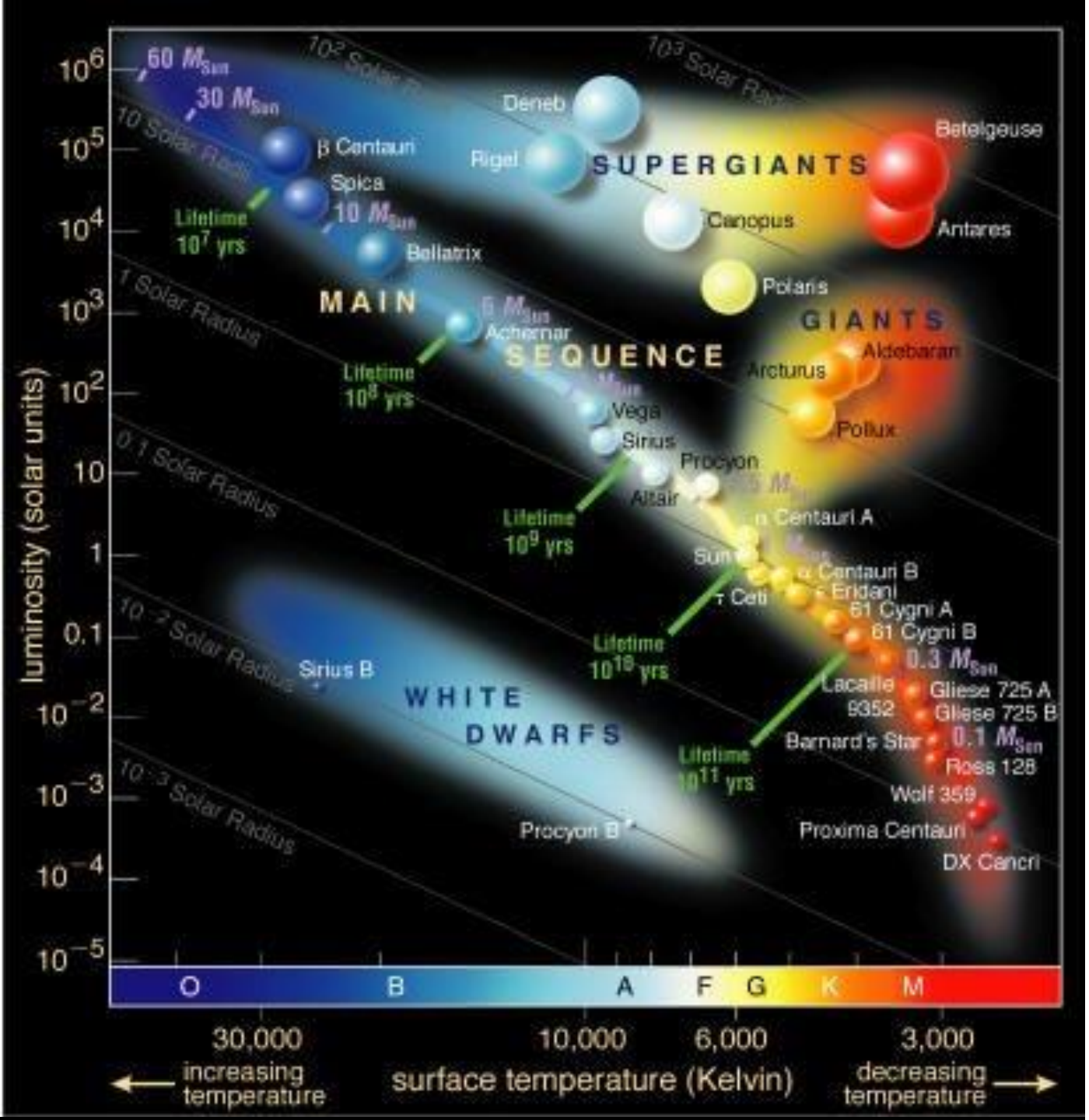
- Stars are generally bigger than planets.
- Stars are formed from the dust and gas in space (nebulas are great places).
- Size is determined by how much stuff it can ‘grab’ (gravity).
- Life is determined by two things: Size, Rate of Burn.
  - While they can have rebirths, all stars will burn out!!!

Life of Stars (Main Phase)

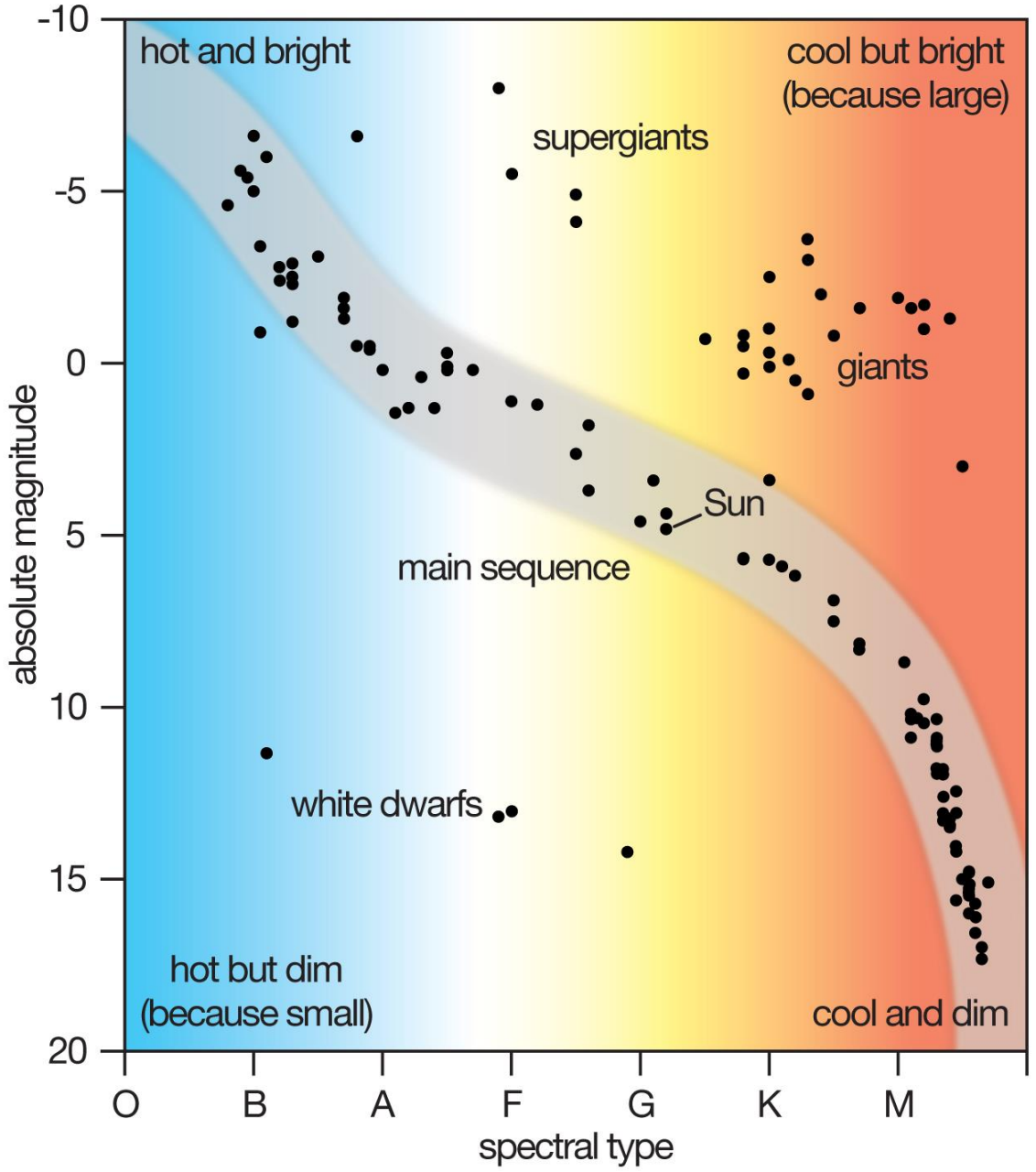
Mass (Solar Masses)	Time (years)	Spectral Type/Color
60	3 million	O3 (Blue)
30	11 million	O7 (Blue)
10	32 million	B (Blue)
3	370 million	A (White)
1.5	3 billion	F (White)
1	10 billion	G (Yellow)
.5	100’s billion	K (Orange)
0.1	1000's billions	M (Red)

Star Classification

- Stars can be classified four ways.
  - Absolute Magnitude: How bright an object would appear if it were a set distance away.
  - Luminosity: The amount of energy an object radiates per unit time.
  - Classification: The spectral characteristics of a star.
  - Surface Temperature
- In 1910 Henry Norris Russell along with Ejnar Hertzsprung, developed a diagram to describe this. (Called an H-R diagram)

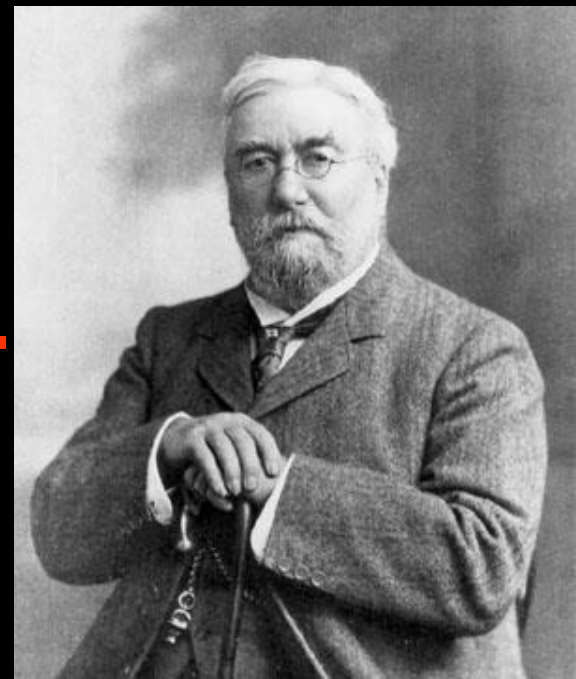


Hertzsprung-Russell diagram



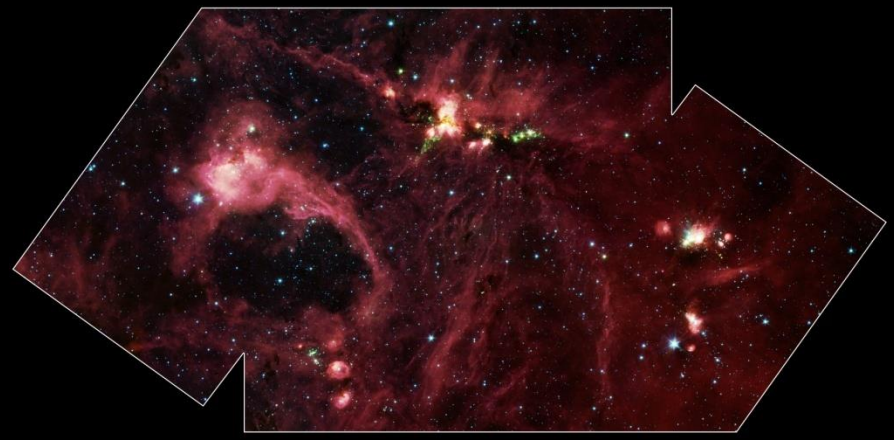
Stellar Evolution

- In 1888 British astronomer Joseph Norman Lockyer created a system to describe the evolution of a star from birth to extinction.
- Two key considerations:
  - »Gravity pulls all matter together.
  - »Fusion pushes stellar matter apart.



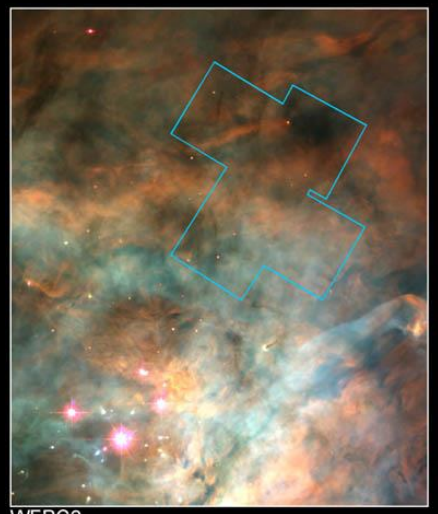
LoS: Giant Gas Cloud (1/7)

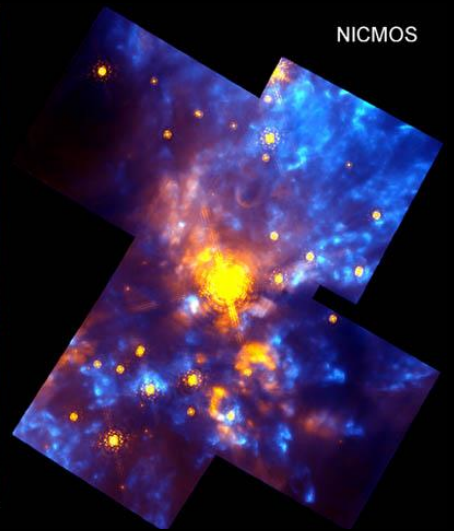
- Large, dense gas cloud that is cold enough for molecules to form. (1000's in just the disk of Milky Way)
- A cloud can form up to a million stars.
- Gravity starts to bring the dust together.
  - Small clumps form larger clumps of material… speeds up the process (The bigger the mass, the more gravity).

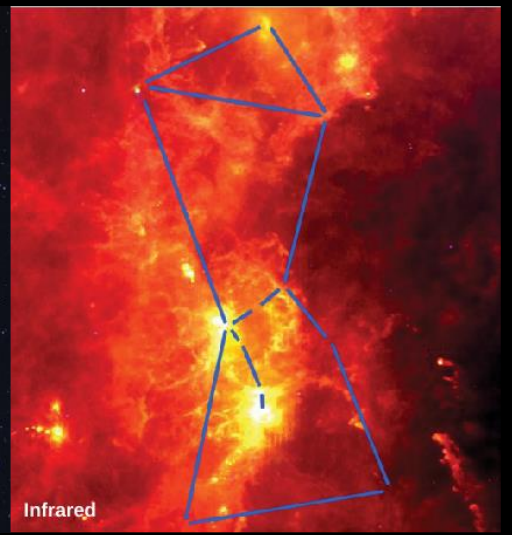


LoS: Protostar (2/7)

- Clumping together create friction/heat.
  - Infrared (heat) is detected.
- A central disk is formed that can be up to 3000-K.
- Colder Gas and dust still surround the disk and make it hard to see.

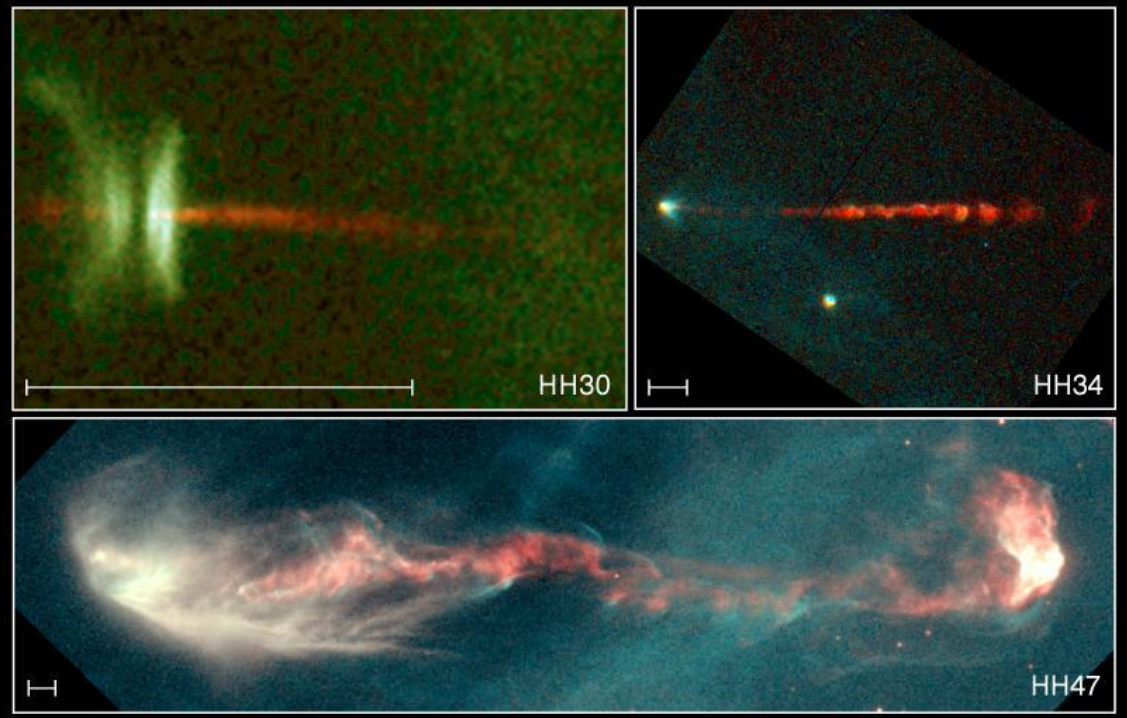






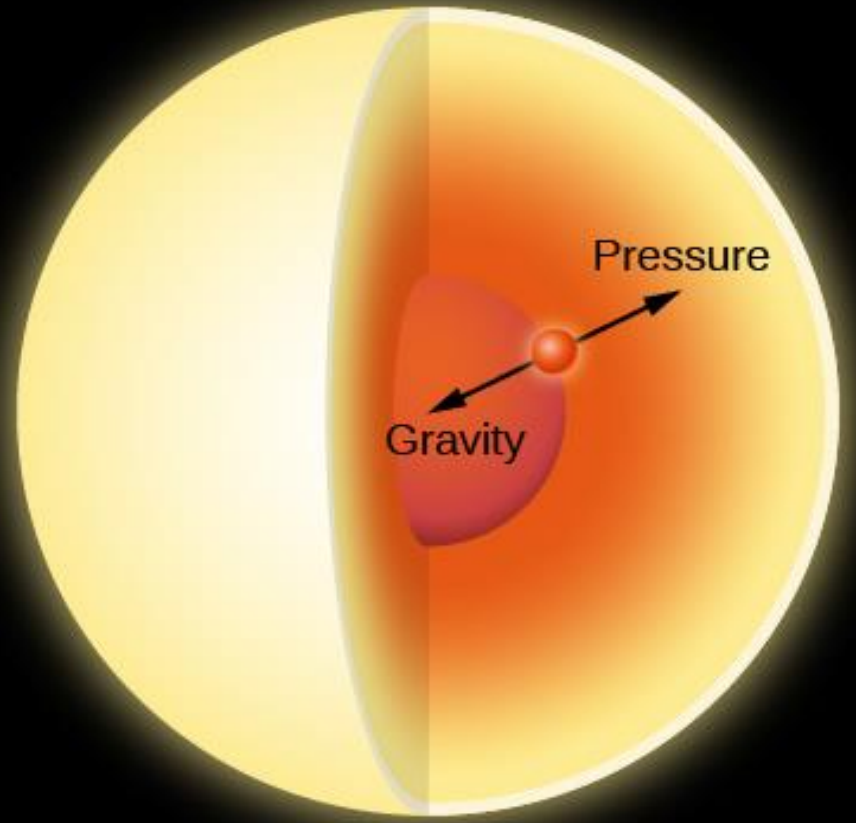
LoS: T-Tauri (3/7)

- A young star creates winds.
- This causes the surrounding dust shell to be ejected.
- The star becomes visible!

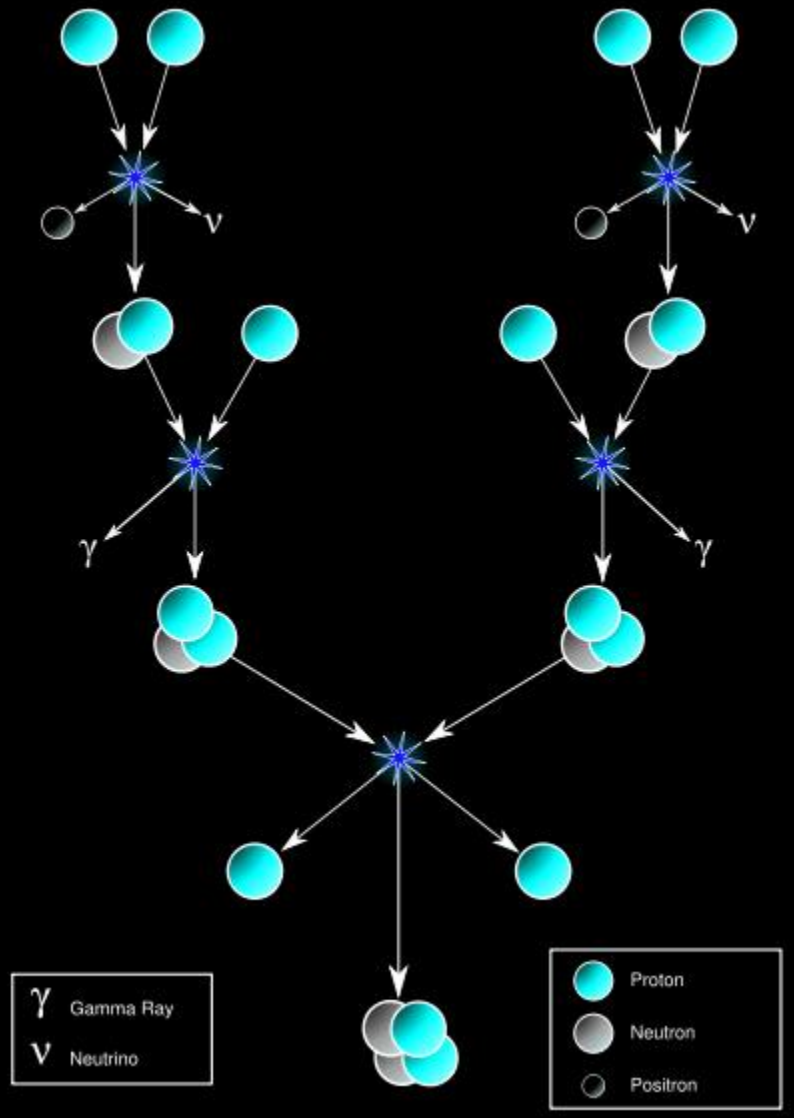


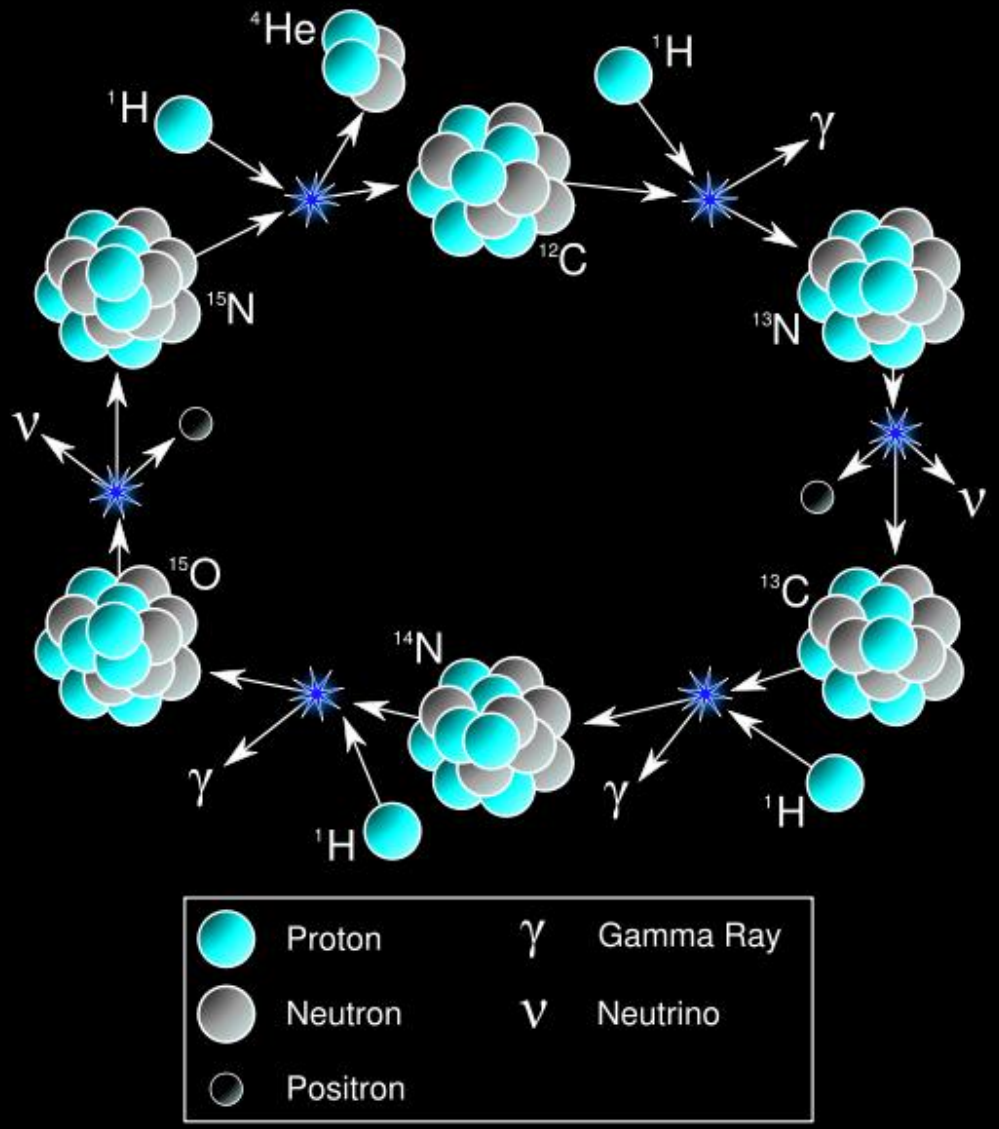
LoS: Main Sequence (4/7)

- Gravity's 'pull' in equals the fusion's 'push' out
  - Equilibrium is met.
- 90% of life is spent this way.
- Fuses H and converting to He.
  - Energy (heat) produced.
  - Photons (light) produced.



Fusion Types



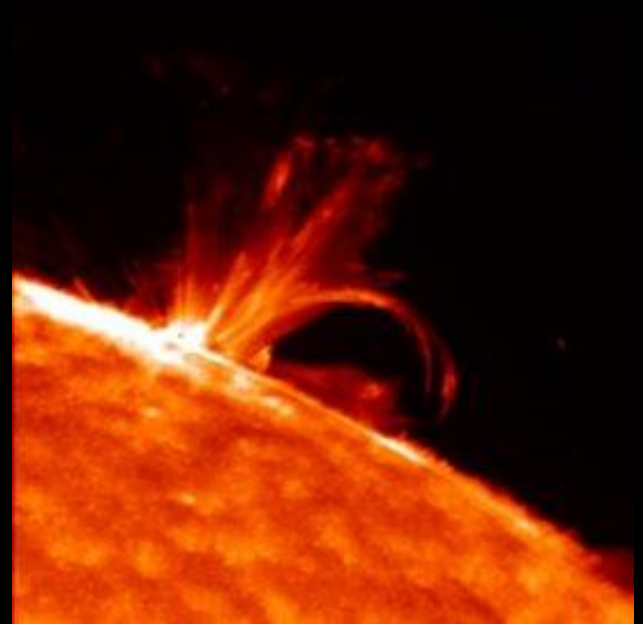


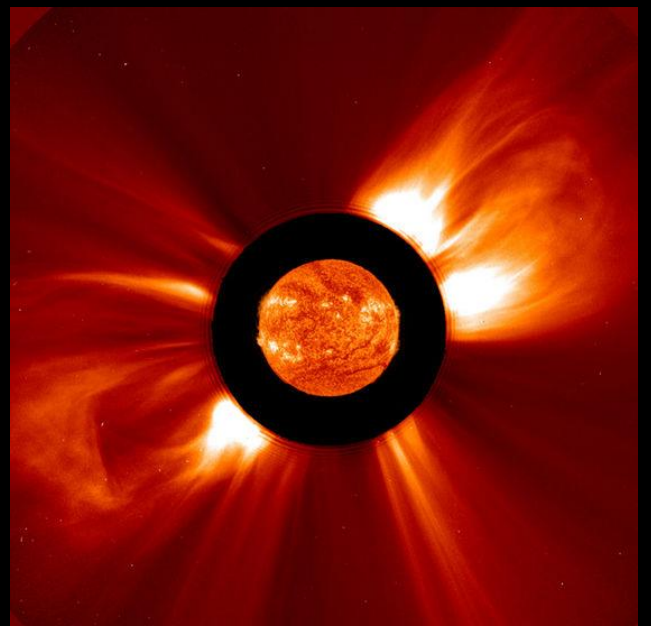
Solar Cross Section

- **Core**: Atomic nuclei are fused in the core and emit energy. (15,000,000 K)
  - It may take light up to 100,000 years to be emitted.
- **Radiative Zone**: The stable region where core energy is emitted. (400,000 K)
- **Convective Zone**: Unstable region where energy is transferred. (14,000 K)
- **Photosphere**: The visual surface of the Sun. Light is emitted. (6,000 K)
- **Chromosphere**: Thin atmosphere that is washed out by the Photosphere (10,000 K)

Solar Cross Section

- **Corona**: The luminous plasma atmosphere of the Sun extending millions of km into space. (2,000,000,000 K)
- **Solar Flare**: A explosion in the solar corona and chromosphere with an energy equivalent to a 1 billion megaton nuclear bomb, traveling at about 1 million km per hour.





A Turning Point

- Depending on a star's size three things can happen after the main phase.
  - Low Mass (<.5 Solar Masses) = Brown Dwarf
  - Medium Mass (.5-3.4) = Red Giant.
  - Large mass (>3.4) = Super Giant
- After running out of fuel, the fusion reaction slows, and gravity takes over.
  - This causes the star to collapse.

LoS: Low Mass (5/7)

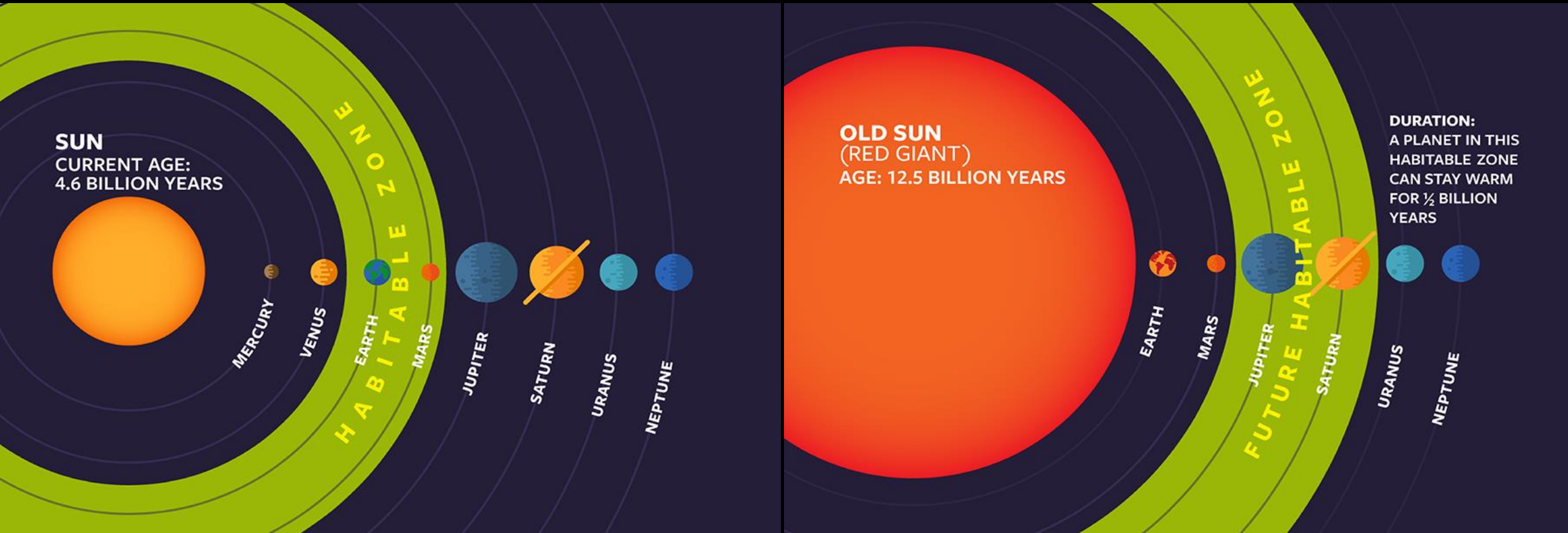
- Low mass stars have not been observed but computers have modeled what may happen.
  - Not enough fuel to keep fusion going.
  - Hot spots may form causing He to fuse forming solar winds.

LoS: Medium Mass (5/7)

- When a medium star collapses the friction creates more heat.
- This heat starts another fusion reaction outside of the core (shell burning).
  - This star is called a Sub Giant.
- The fusion reaction is more rapid than before (brighter).
- This pushes the star outward again.

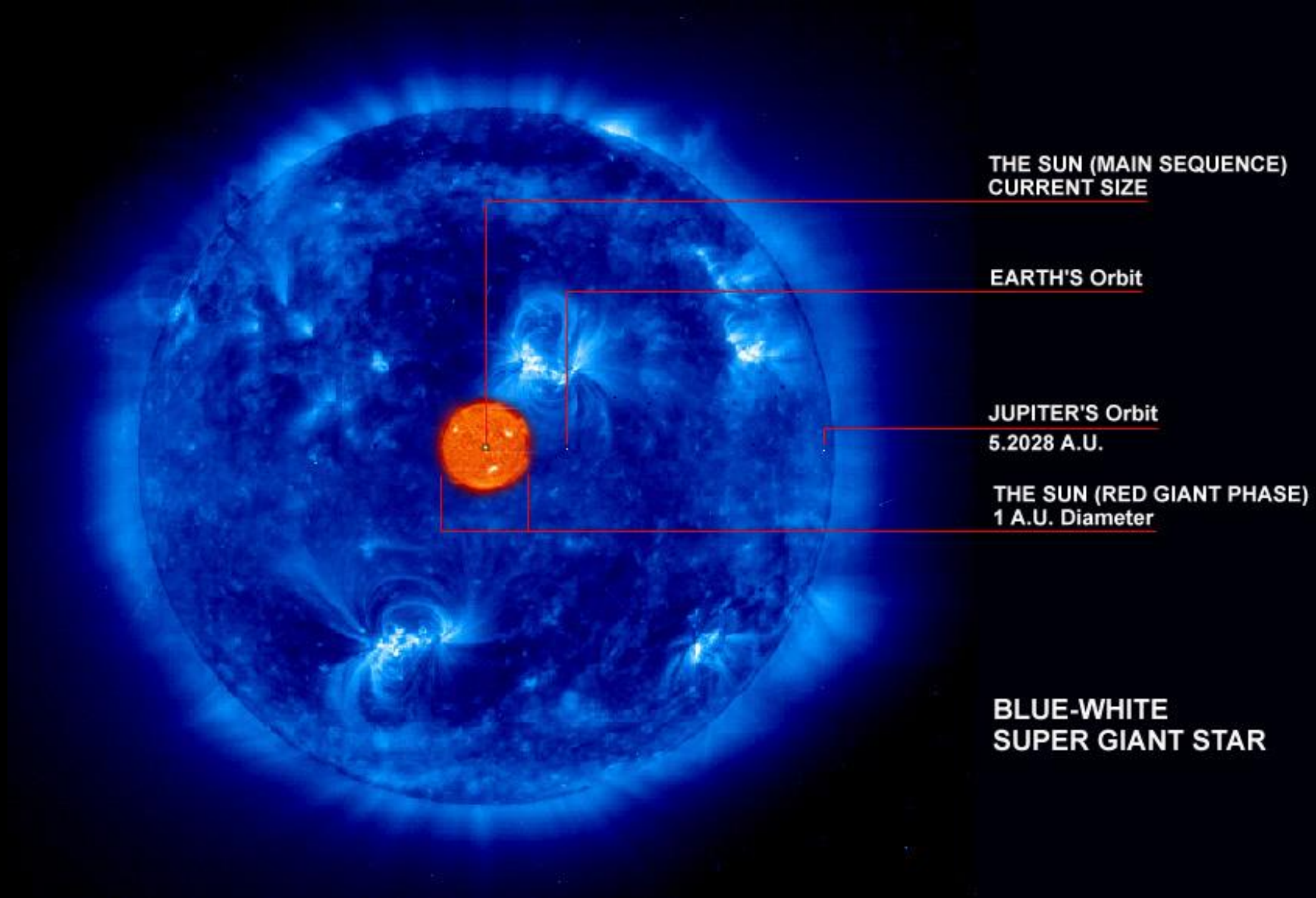
LoS: Medium Mass (5/9)

- The new size of the star (Red Giant) may envelop close planets.



LoS: Large Mass (5/7)

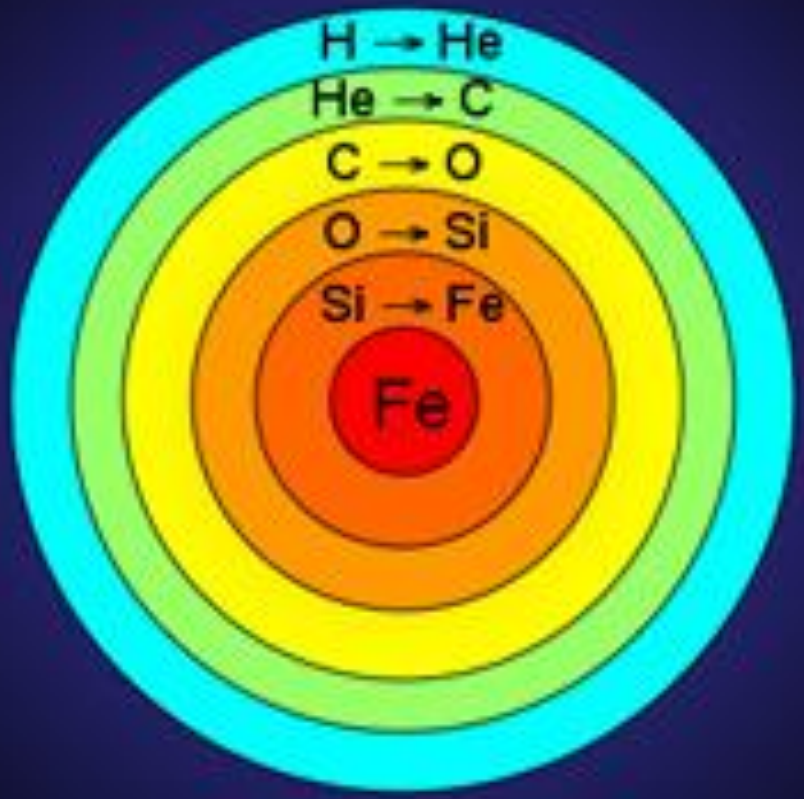
- When a large star collapses the friction creates more heat.
- This heat starts another fusion reaction outside of the core (shell burning).
  - This star is called a Super Giant.
- The fusion reaction is more rapid than before (brighter).
- This pushes the star outward again.


THE SUN (MAIN SEQUENCE)
CURRENT SIZE
EARTH'S Orbit
JUPITER'S Orbit
5.2028 A.U.
THE SUN (RED GIANT PHASE)
1 A.U. Diameter
BLUE-WHITE
SUPER GIANT STAR

LoS: Core Fusion (6/7)

- If the core runs out of H fuel and is big enough, it can fuse He.
- This creates an extreme burst of energy called a helium flash.
- Fusing He is faster and hotter.
- Bigger Stars can continue even more cycle.

Fusion Burn Times



For a 25 solar mass star:

Stage	Duration
H → He	7×10^6 years
He → C	7×10^5 years
C → O	600 years
O → Si	6 months
Si → Fe	1 day
Core Collapse	1/4 second

The End Game

- Depending on the size of the star… the more cycles and the heavier the element.
  - The biggest stars produce Fe.
- Eventually Gravity will collapse the star and there will not be enough fuel to create any new ‘gasps’.
  - Gravity will collapse the star to its smallest state.
  - The collapse give off a great amount of energy.
  - This energy pushes off the outer layer exposing the core.

LoS: Planetary Nebula or Supernova (7/7)

- The outer layer (mostly C and Si) will form a planetary nebula.
- The remaining core will emit UV light that will make the planetary nebula glow.

LoS: Planetary Nebula or Supernova (7/7)

- The rare high mass stars (5-50 solar masses) death call is more impressive.
- The core (roughly the size of the Earth) internally reacts and shrinks to the size of a town in a matter of seconds.
  - The outer layer hits the core and heats up to a billion degrees from impact.
  - This results in an explosion and the fusion of rare elements like Au, Pt, U.

LoS: Planetary Nebula or Supernova (7/7)

- This explosion is called a supernova (novae-new).
- Matter moves at thousands of km per second.
- The remaining material remains with the core
  - Core can be as bright as 1 trillion times the sun!
- This is rare though (one every century per galaxy).

Supernova

Chinese astronomers recorded the explosion of the crab nebula July 4, 1054 and the Anasazi Indians painted at least one picture of it.

The Vela supernova occurred long before the Crab Nebula so it is much more spread out.

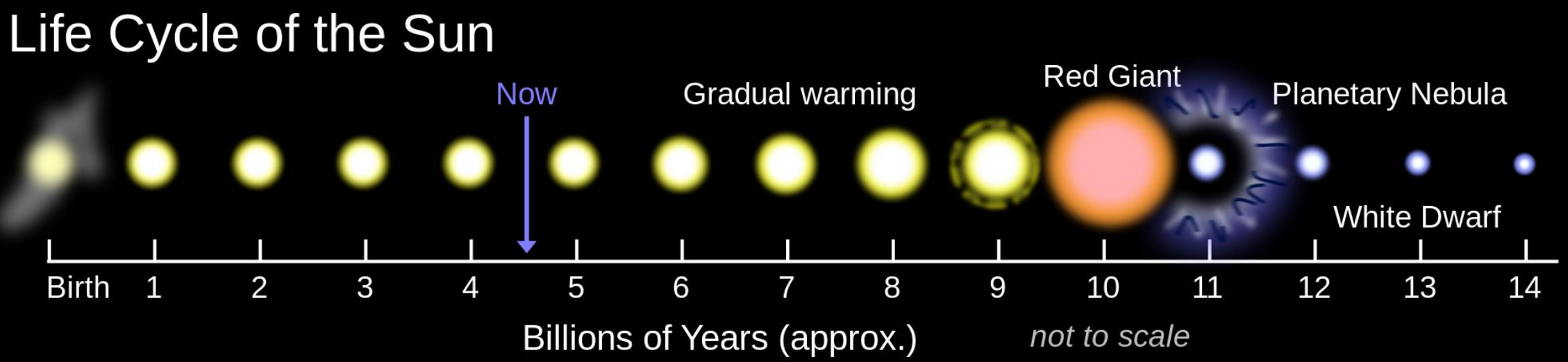
Core Remnant

- Three types of cores remain.
  - Smaller than 1.4 solar masses: A white dwarf.
  - Between 1.4 and 3 solar masses: A neutron star.
  - Bigger than 3 solar masses: Collapses further and becomes a new black hole (imagine smashing three earths into the size of a pea!)

Black Hole

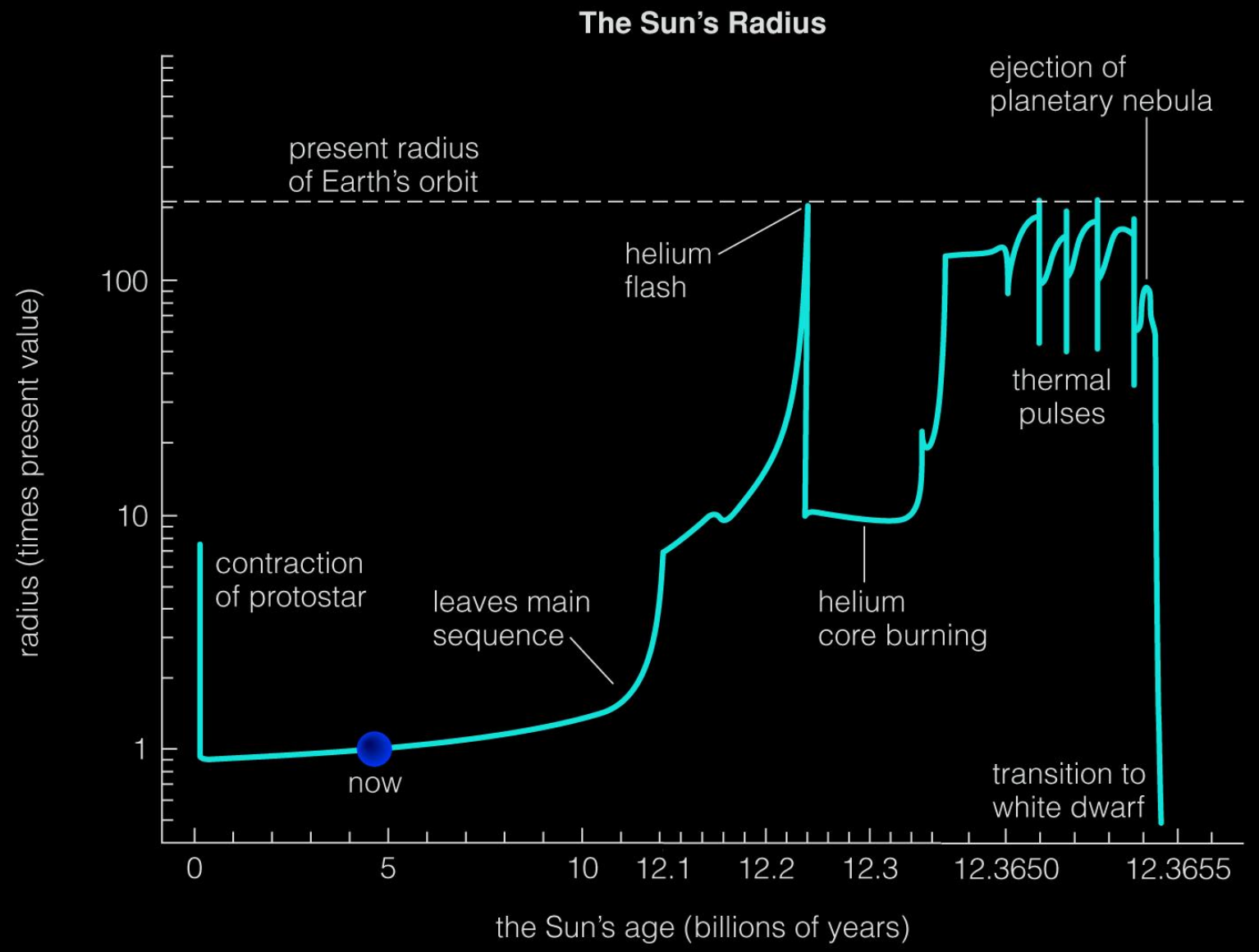
- Black holes are greedy and use gravity to constantly grab more and more stuff even trapping light.
  - The point at which it can trap light is called the Event Horizon.
- Even time becomes distorted in a Black Hole!

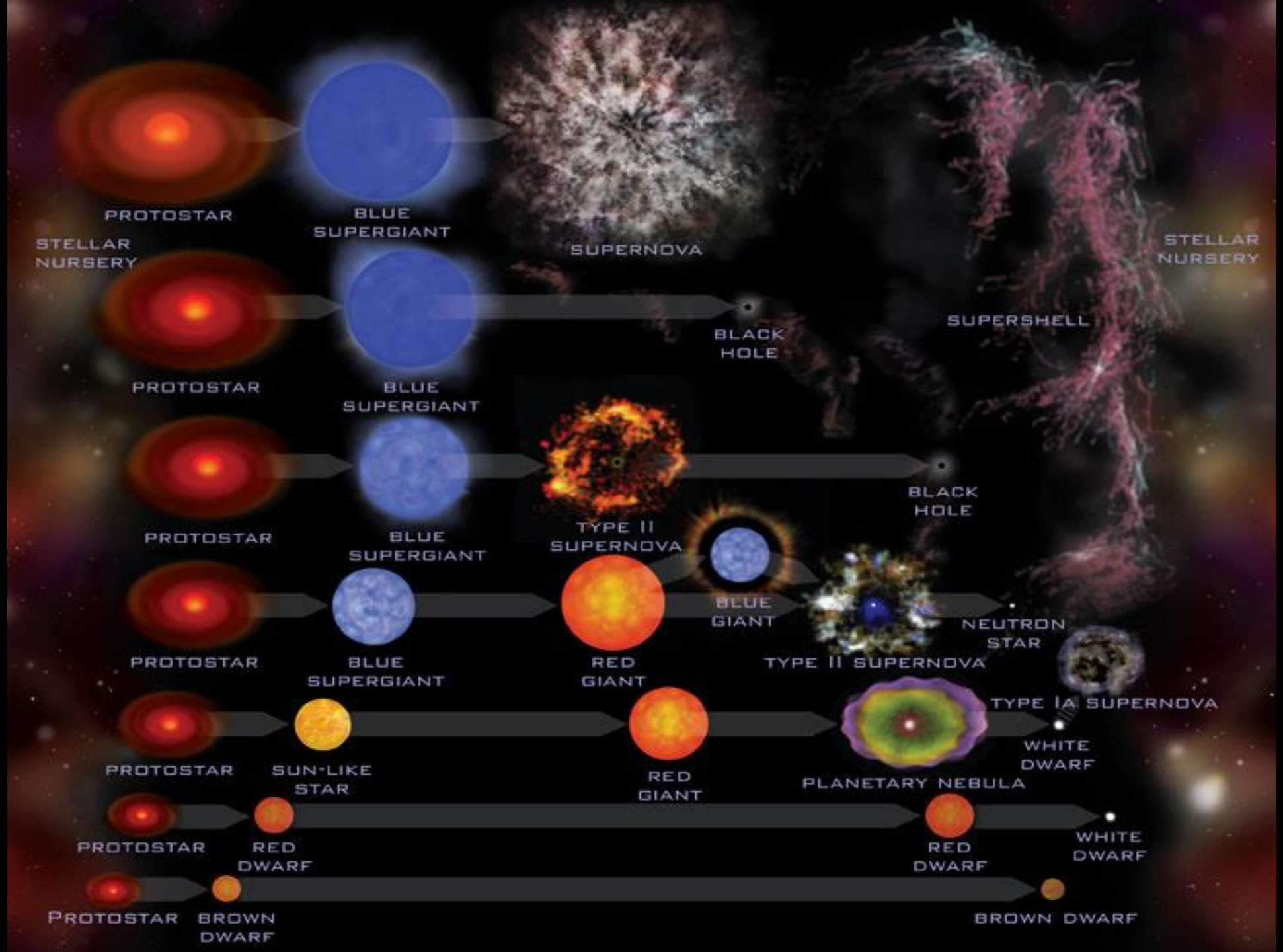
The life of the Sun



- **The diameter of the Sun is increasing roughly two inches per year.**

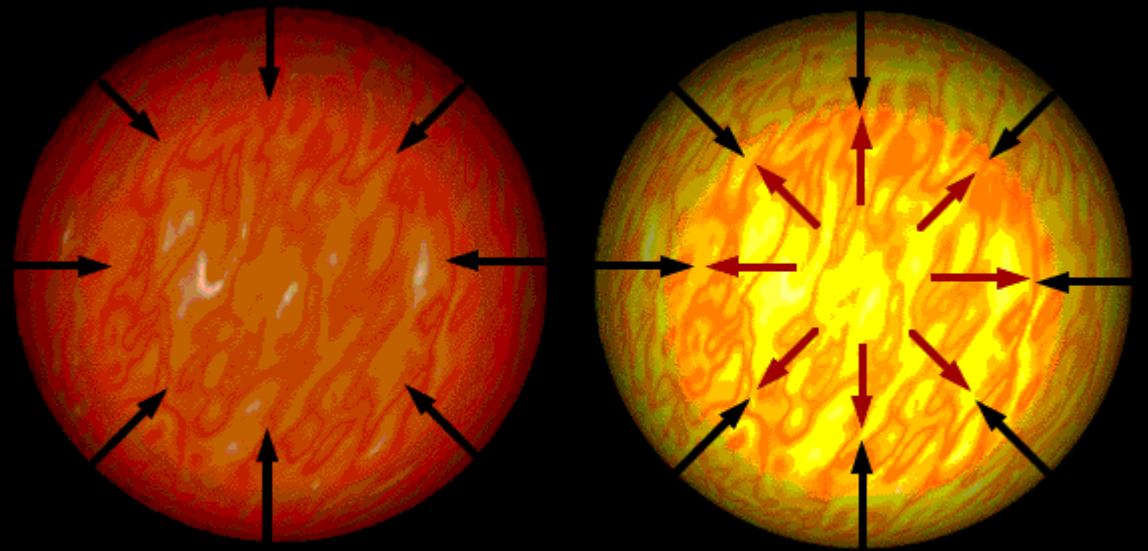
A Look at the Sun




STELLAR NURSERY
PROTOSTAR
BLUE SUPERGIANT
SUPERNOVA
STELLAR NURSERY
PROTOSTAR
BLUE SUPERGIANT
BLACK HOLE
SUPERSHELL
PROTOSTAR
BLUE SUPERGIANT
TYPE II SUPERNOVA
BLACK HOLE
PROTOSTAR
BLUE SUPERGIANT
RED GIANT
BLUE GIANT
TYPE II SUPERNOVA
NEUTRON STAR
PROTOSTAR
SUN-LIKE STAR
RED GIANT
PLANETARY NEBULA
TYPE Ia SUPERNOVA
WHITE DWARF
PROTOSTAR
RED DWARF
RED DWARF
WHITE DWARF
PROTOSTAR
BROWN DWARF
BROWN DWARF

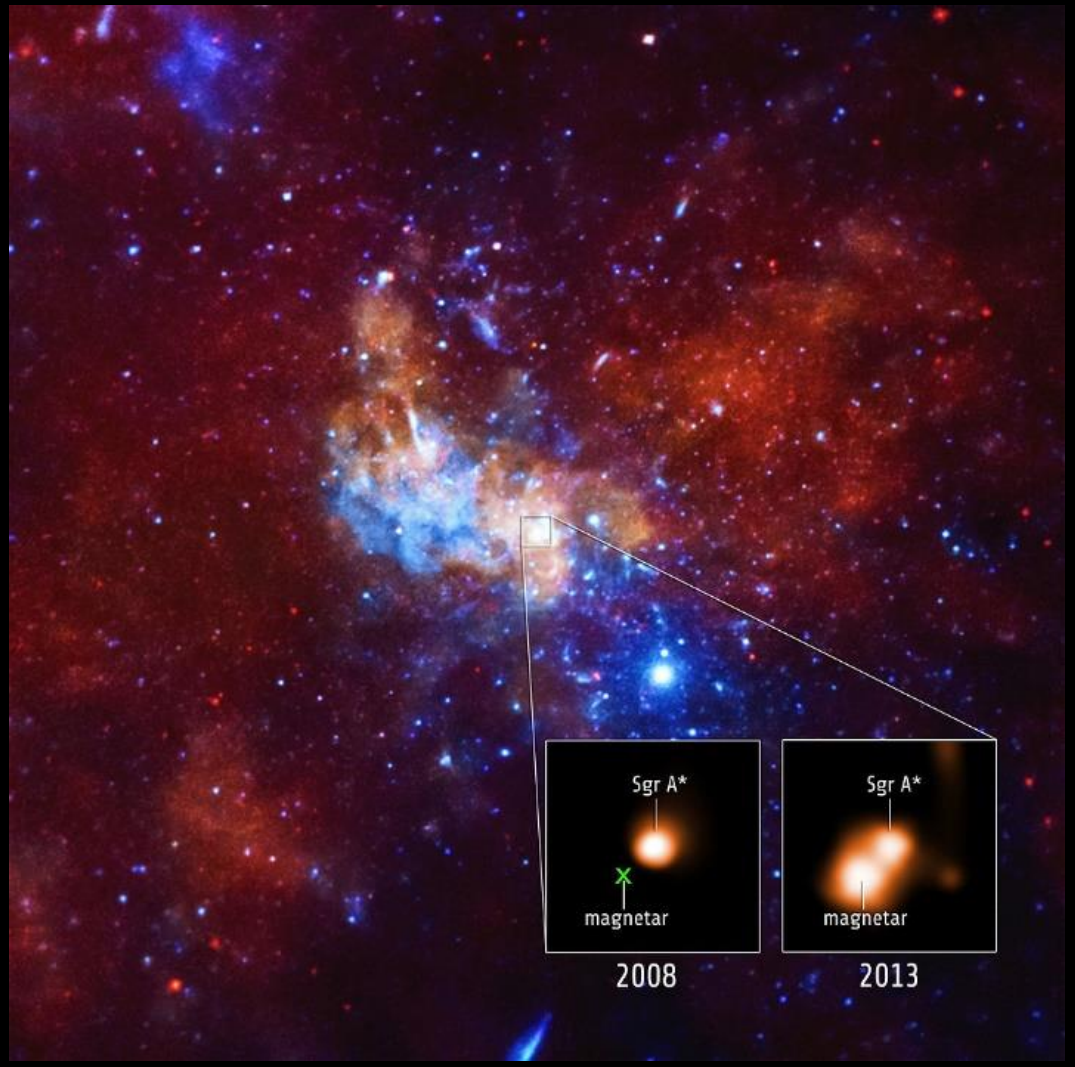
Star Types

- Cepheid Variables: Supergiant stars that regularly pulsate in size and change in brightness. As the star increases in size, its brightness decreases; then, the reverse occurs. Examples include Polaris and Delta Cephei.



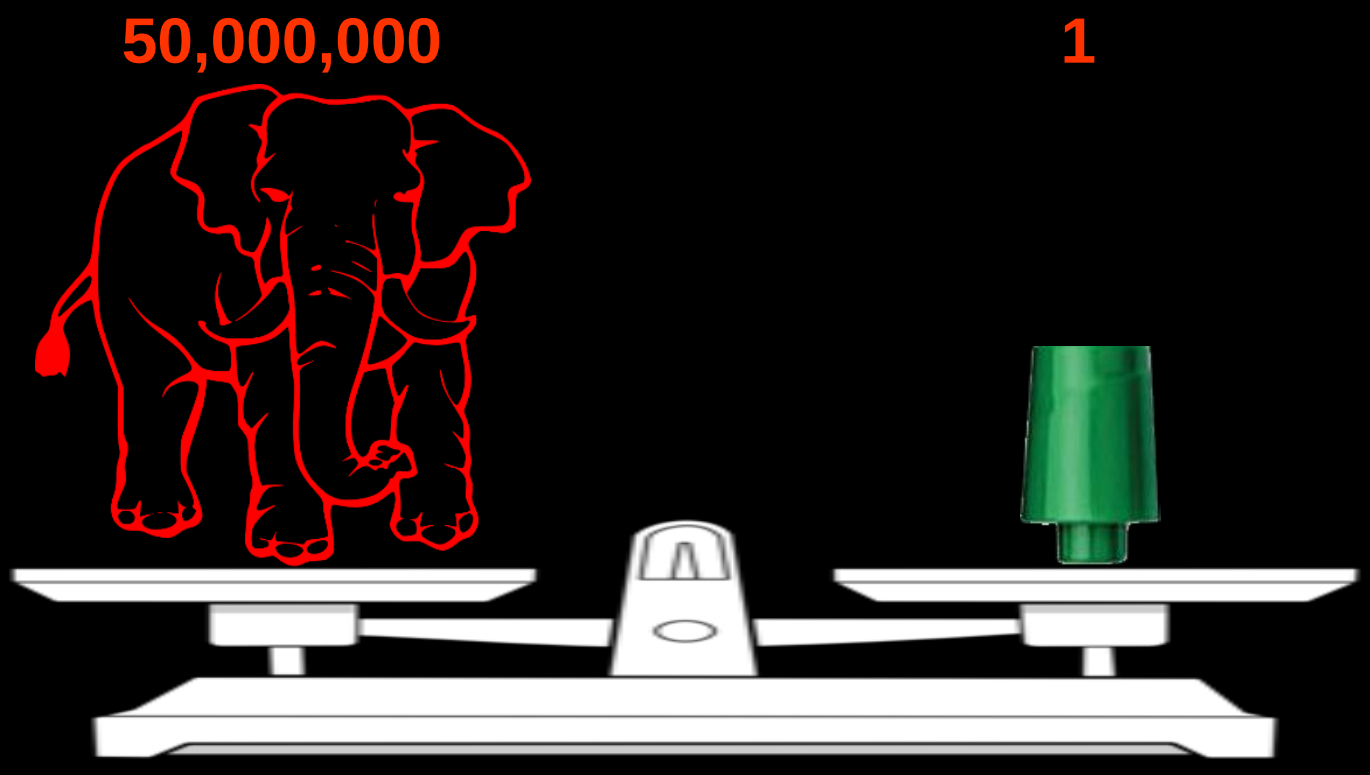
Star Types

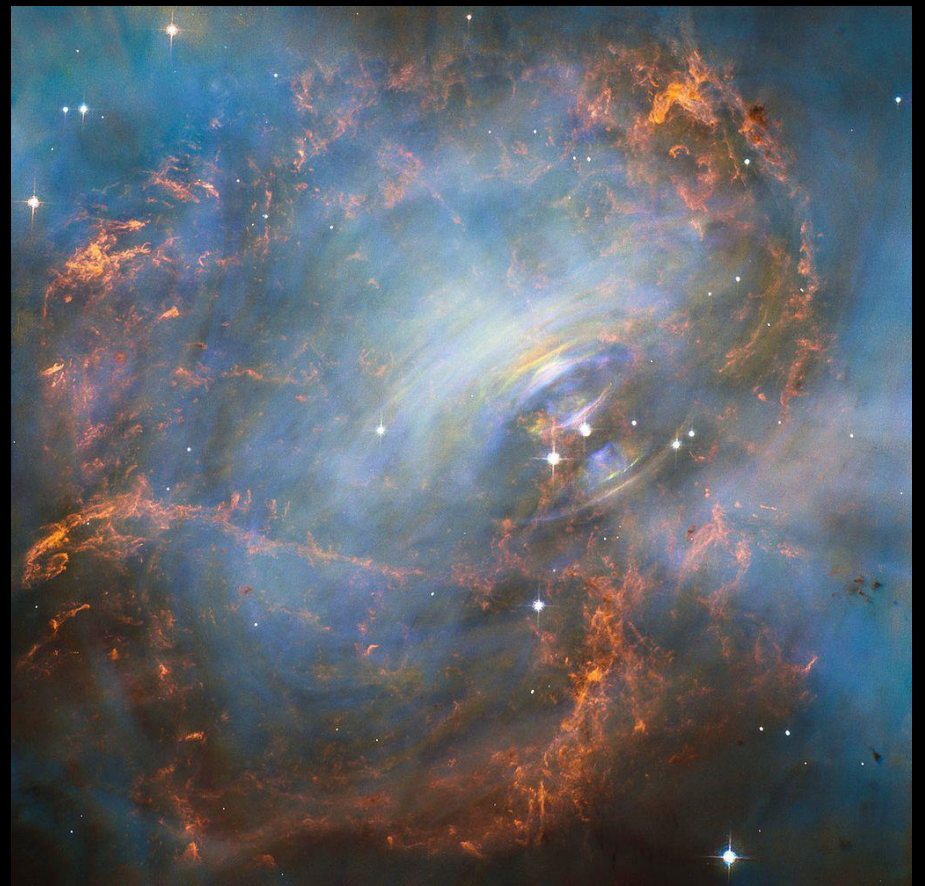
- Magnetar: A highly magnetic star. Magnetar's have magnetic fields about a thousand trillion times stronger than the Earth's field. "Starquakes" may occur from this stress.



Star Types

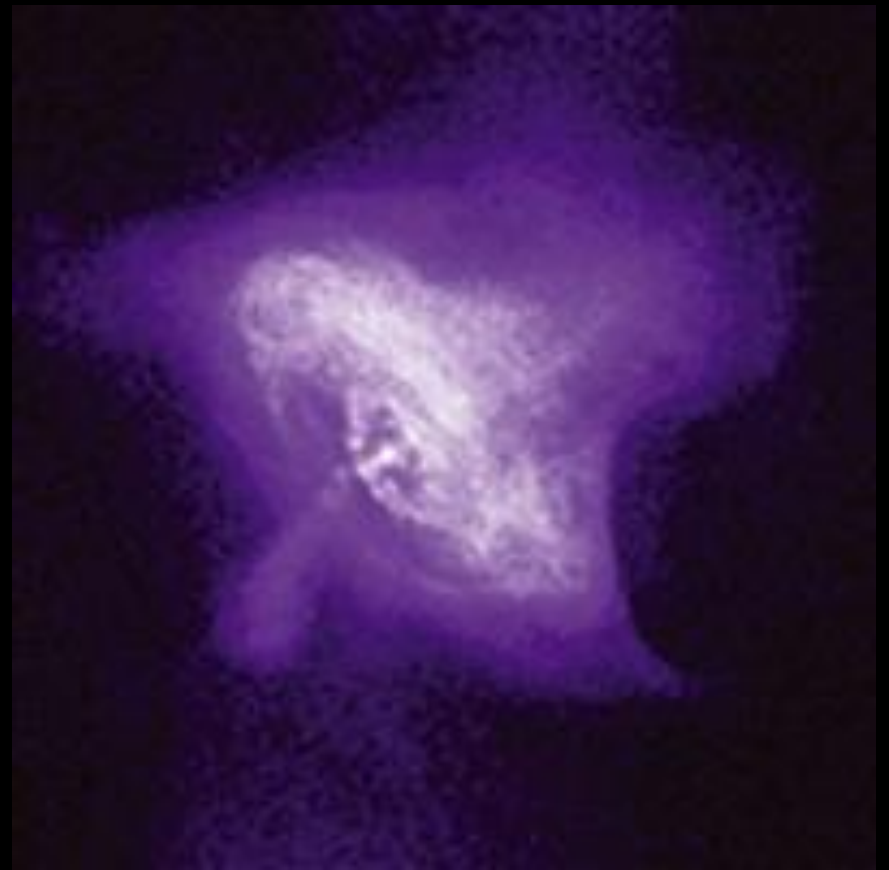
- **Neutron Star: Collapsed star with 1.4-2.2 solar masses yet a hundred-thousandth the size (6.2 miles) of the sun. (Heart of Crab)**





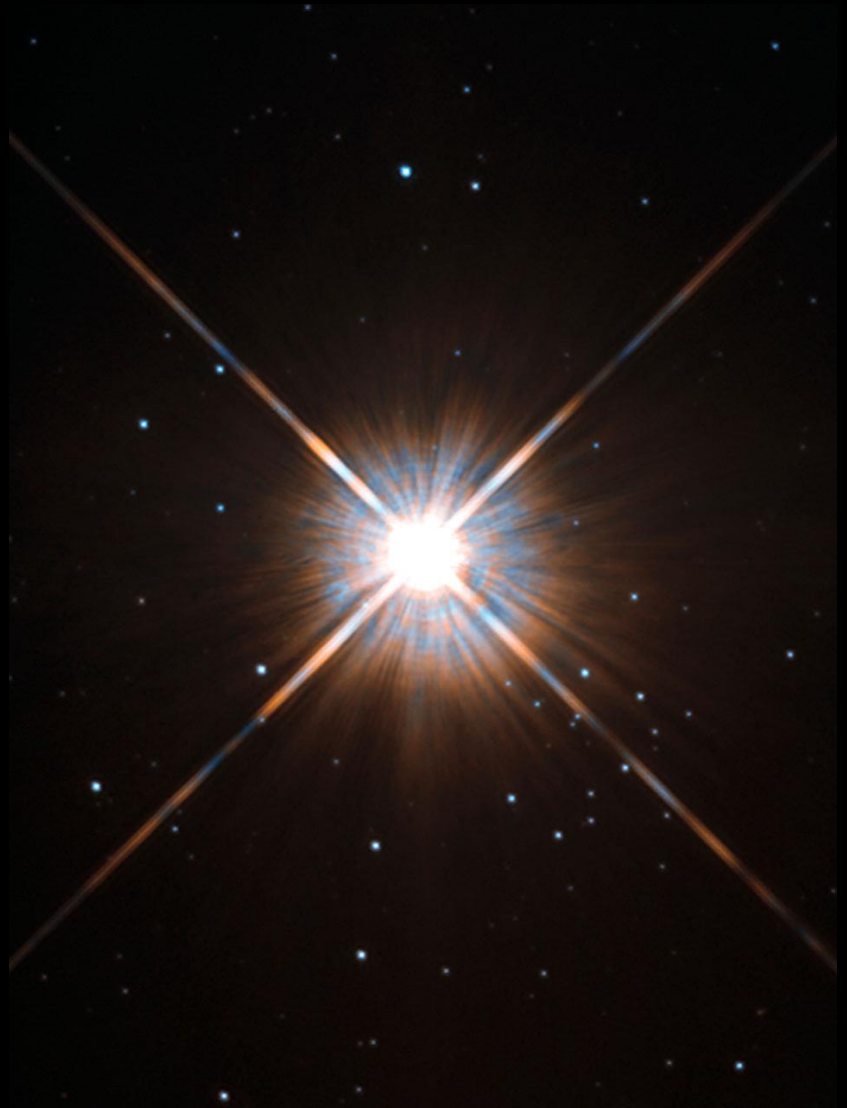
Star Types

- **Pulsar: A rapidly spinning neutron star that emits energy in pulses. May serve as lighthouses in the sky. (Crab Nebula Pulsar)**



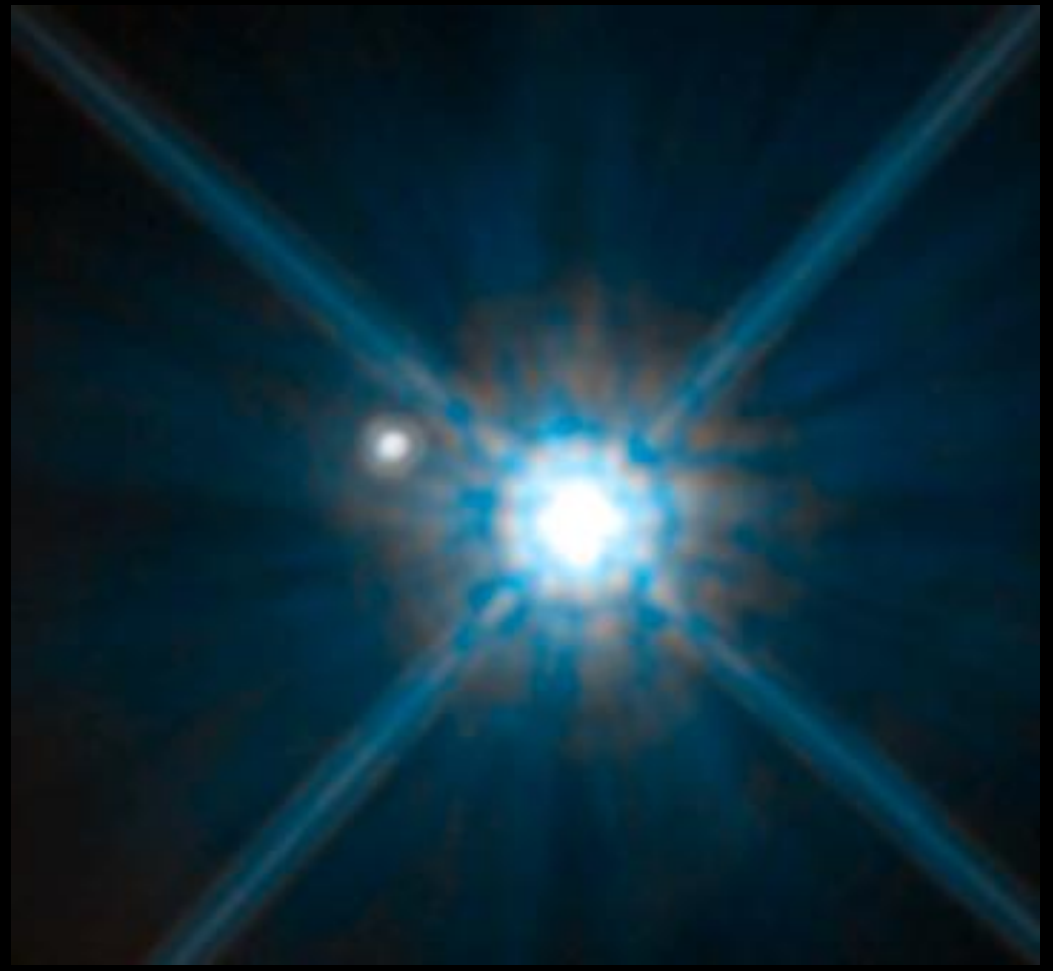
Star Types

- **Red Dwarf: A small, cool, very faint, main sequence star whose surface temperature is under about 4,000 K. Red dwarfs are the most common type of star. Proxima Centauri is a red dwarf.**



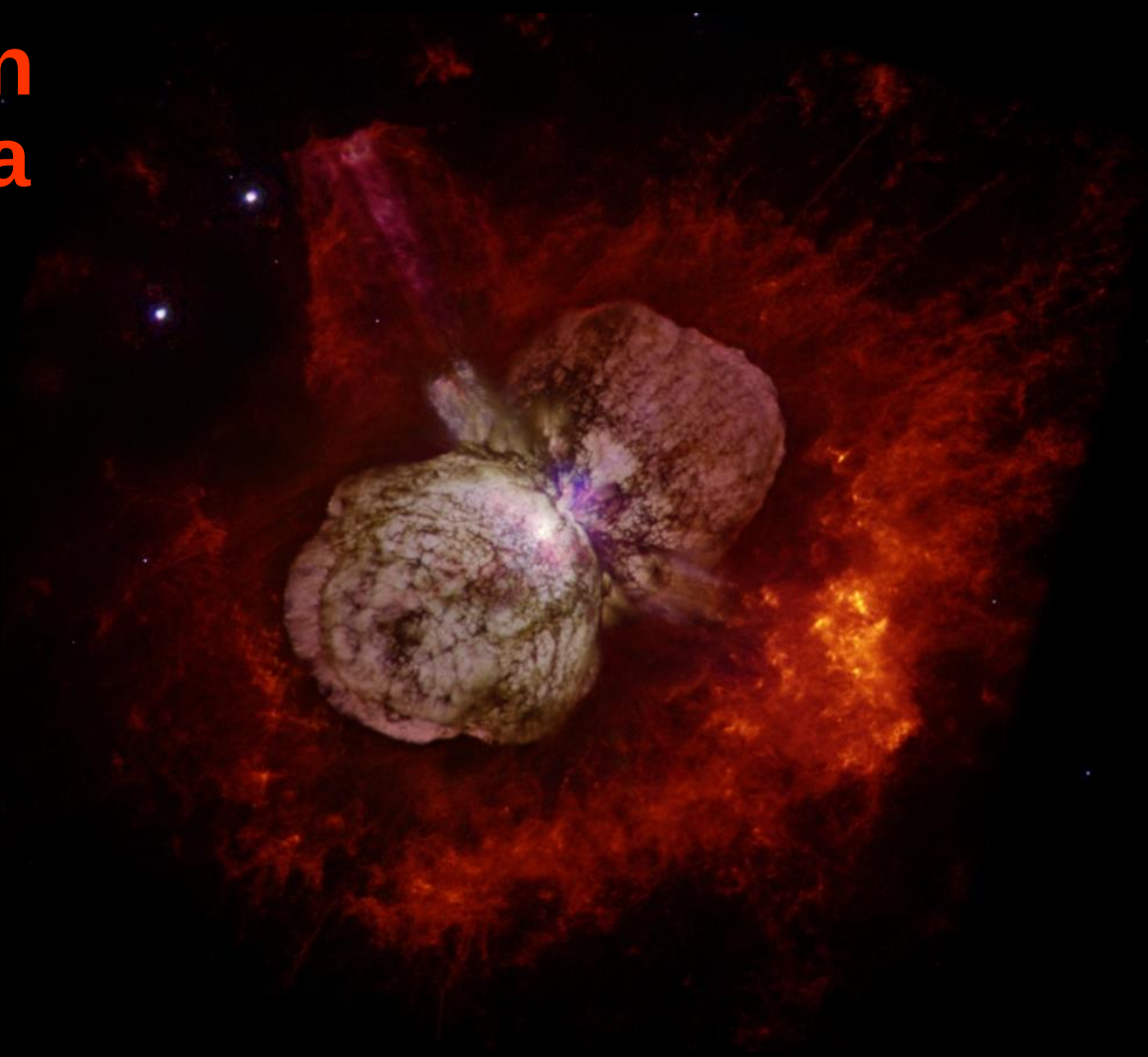
Star Types

- White Dwarf: A small (Earth size), very dense, hot star near the end of its life. It is made mostly of carbon. Our Sun will someday turn into a white dwarf. The companion of Sirius is a white dwarf.



Special Types

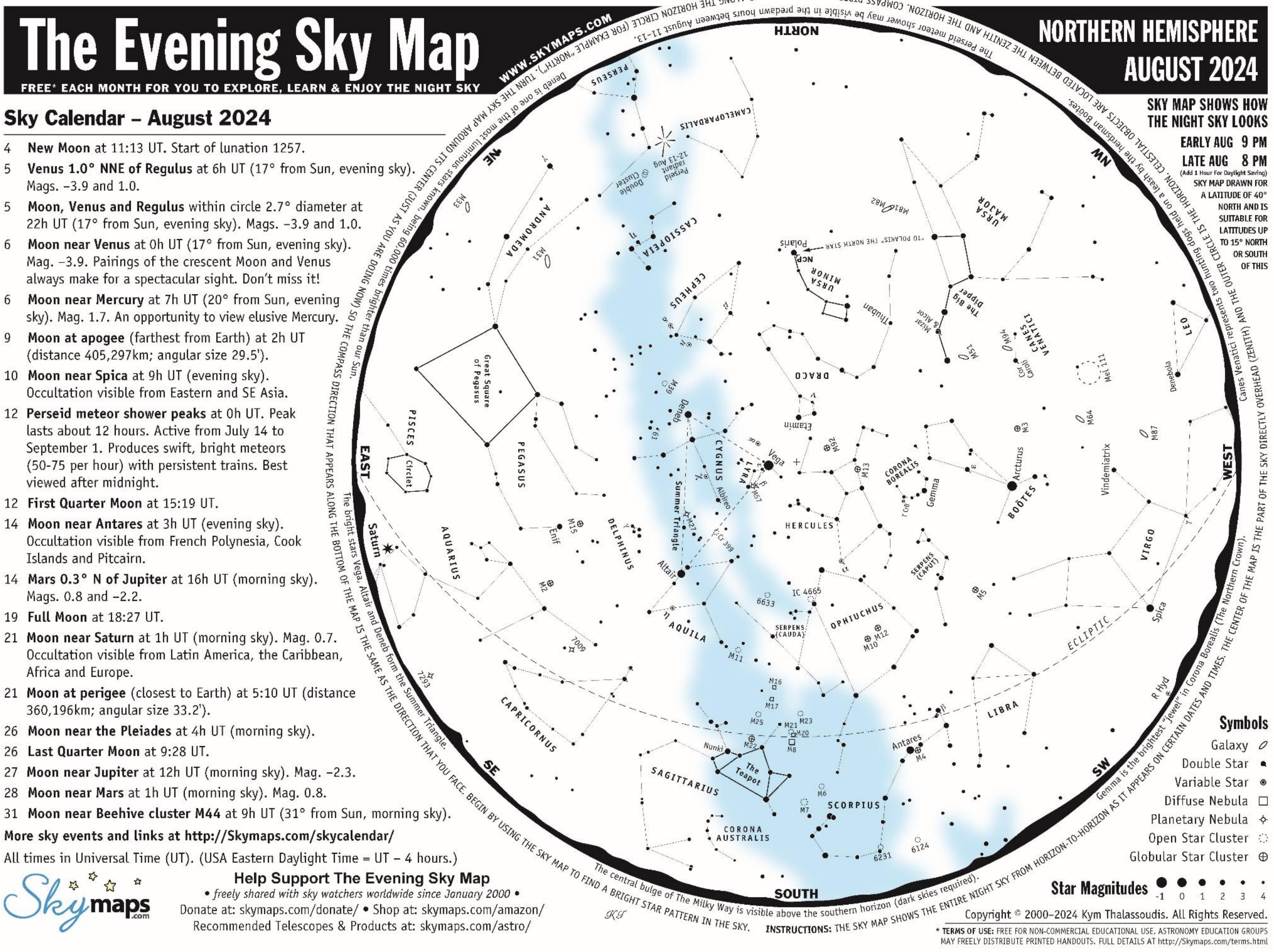
- **Hypernova: This explosion is bigger than a supernova and is accompanied by a gamma-ray burst. (Eta Carinae).**



Navigating the Night

- Constellations: A group of stars that, when seen from Earth, form a pattern. There are 88 constellations.
- Used as a traveling aid.
- Different cultures made bright groups of stars into patterns with stories to aid in memories.
- Three major groups: North, South, Zodiac.

North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LATE AUG 8 PM
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SKY MAP DRAWN FOR A LATITUDE OF 40° NORTH AND IS SUITABLE FOR LATITUDES UP TO 15° NORTH OR SOUTH OF THIS
Sky Calendar – August 2024
4 New Moon at 11:13 UT. Start of lunation 1257.
5 Venus 1.0° NNE of Regulus at 6h UT (17° from Sun, evening sky). Mags. −3.9 and 1.0.
5 Moon, Venus and Regulus within circle 2.7° diameter at 22h UT (17° from Sun, evening sky). Mags. −3.9 and 1.0.
6 Moon near Venus at 0h UT (17° from Sun, evening sky). Mag. −3.9. Pairings of the crescent Moon and Venus always make for a spectacular sight. Don't miss it!
6 Moon near Mercury at 7h UT (20° from Sun, evening sky). Mag. 1.7. An opportunity to view elusive Mercury.
9 Moon at apogee (farthest from Earth) at 2h UT (distance 405,297km; angular size 29.5').
10 Moon near Spica at 9h UT (evening sky). Occultation visible from Eastern and SE Asia.
12 Perseid meteor shower peaks at 0h UT. Peak lasts about 12 hours. Active from July 14 to September 1. Produces swift, bright meteors (50-75 per hour) with persistent trains. Best viewed after midnight.
12 First Quarter Moon at 15:19 UT.
14 Moon near Antares at 3h UT (evening sky). Occultation visible from French Polynesia, Cook Islands and Pitcairn.
14 Mars 0.3° N of Jupiter at 16h UT (morning sky). Mags. 0.8 and −2.2.
19 Full Moon at 18:27 UT.
21 Moon near Saturn at 1h UT (morning sky). Mag. 0.7. Occultation visible from Latin America, the Caribbean, Africa and Europe.
21 Moon at perigee (closest to Earth) at 5:10 UT (distance 360,196km; angular size 33.2').
26 Moon near the Pleiades at 4h UT (morning sky).
26 Last Quarter Moon at 9:28 UT.
27 Moon near Jupiter at 12h UT (morning sky). Mag. −2.3.
28 Moon near Mars at 1h UT (morning sky). Mag. 0.8.
31 Moon near Beehive cluster M44 at 9h UT (31° from Sun, morning sky).
More sky events and links at http://Skymaps.com/skycalendar/
All times in Universal Time (UT). (USA Eastern Daylight Time = UT – 4 hours.)
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SE
SW
Symbols
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Planetary Nebula
Open Star Cluster
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Star Magnitudes
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Equator

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EQUATORIAL EDITION
AUGUST 2024

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More sky events and links at http://Skymaps.com/skycalendar/

All times in Universal Time (UT). (Singapore Standard Time = UT + 8 hours.)

The Northern Cross is a prominent feature of the constellation Cygnus (The Swan).

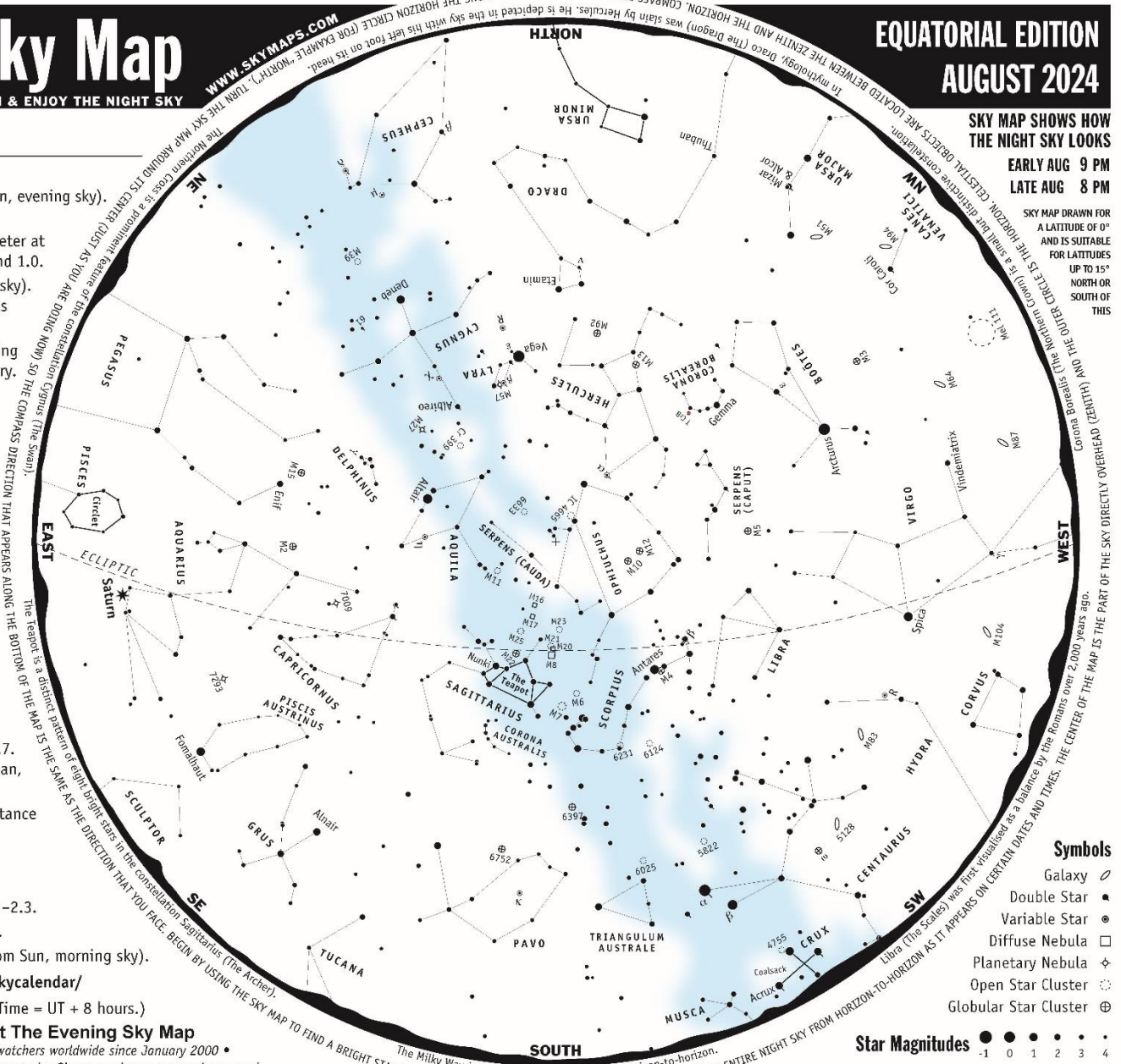
The Teapot is a distinct pattern of eight bright stars in the constellation Sagittarius (The Archer).

The Milky Way is our galaxy. It stretches from horizon-to-horizon.

In mythology, Draco (The Dragon) was slain by Hercules. He is depicted in the sky with his left foot on its head.

Libra (The Scales) was first visualised as a balance by the Romans over 2,000 years ago.

Corona Borealis (The Northern Crown) is a small but distinctive constellation.



SKY MAP SHOWS HOW THE NIGHT SKY LOOKS
EARLY AUG 9 PM
LATE AUG 8 PM

SKY MAP DRAWN FOR A LATITUDE OF 0° AND IS SUITABLE FOR LATITUDES UP TO 15° NORTH OR SOUTH OF THIS

In mythology, Draco (The Dragon) was slain by Hercules. He is depicted in the sky with his left foot on its head.

The Northern Cross is a prominent feature of the constellation Cygnus (The Swan).

The Teapot is a distinct pattern of eight bright stars in the constellation Sagittarius (The Archer).

The Milky Way is our galaxy. It stretches from horizon-to-horizon.

Libra (The Scales) was first visualised as a balance by the Romans over 2,000 years ago.

Corona Borealis (The Northern Crown) is a small but distinctive constellation.

INSTRUCTIONS: THE SKY MAP SHOWS THE ENTIRE NIGHT SKY FROM HORIZON-TO-HORIZON AS IT APPEARS ON CERTAIN DATES AND TIMES. THE CENTER OF THE MAP IS THE PART OF THE SKY DIRECTLY OVERHEAD (ZENITH) AND THE OUTER CIRCLE IS THE HORIZON. CELESTIAL OBJECTS ARE LOCATED BETWEEN THE ZENITH AND THE HORIZON. COMPASS DIRECTIONS ARE INDICATED ALONG THE HORIZON CIRCLE (FOR EXAMPLE, "NORTH"). TURN THE SKY MAP AROUND ITS CENTER (JUST AS YOU ARE DOING NOW) SO THE COMPASS DIRECTION THAT APPEARS ALONG THE BOTTOM OF THE MAP IS THE SAME AS THE DIRECTION THAT YOU FACE. BEGIN BY USING THE SKY MAP TO FIND A BRIGHT STAR PATTERN IN THE SKY.

Symbols
Galaxy
Double Star
Variable Star
Diffuse Nebula
Planetary Nebula
Open Star Cluster
Globular Star Cluster

Star Magnitudes -1 0 1 2 3 4

Skymaps.com

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South

The Evening Sky Map

FREE* EACH MONTH FOR YOU TO EXPLORE, LEARN & ENJOY THE NIGHT SKY

SOUTHERN HEMISPHERE AUGUST 2024

Sky Calendar – August 2024

4 **New Moon** at 11:13 UT. Start of lunation 1257.

5 **Venus 1.0° NNE of Regulus** at 6h UT (17° from Sun, evening sky). Mags. –3.9 and 1.0.

5 **Moon, Venus and Regulus** within circle 2.7° diameter at 22h UT (17° from Sun, evening sky). Mags. –3.9 and 1.0.

6 **Moon near Venus** at 0h UT (17° from Sun, evening sky). Mag. –3.9. Pairings of the crescent Moon and Venus always make for a spectacular sight. Don't miss it!

6 **Moon near Mercury** at 7h UT (20° from Sun, evening sky). Mag. 1.7. An opportunity to view elusive Mercury.

9 **Moon at apogee** (farthest from Earth) at 2h UT (distance 405,297km; angular size 29.5').

10 **Moon near Spica** at 9h UT (evening sky). Occultation visible from Eastern and SE Asia.

12 **Perseid meteor shower peaks** at 0h UT. Peak lasts about 12 hours. Active from July 14 to September 1. Produces swift, bright meteors (50-75 per hour) with persistent trains. Best viewed after midnight.

12 **First Quarter Moon** at 15:19 UT.

14 **Moon near Antares** at 3h UT (evening sky). Occultation visible from French Polynesia, Cook Islands and Pitcairn.

14 **Mars 0.3° N of Jupiter** at 16h UT (morning sky). Mags. 0.8 and –2.2.

19 **Full Moon** at 18:27 UT.

21 **Moon near Saturn** at 1h UT (morning sky). Mag. 0.7. Occultation visible from Latin America, the Caribbean, Africa and Europe.

21 **Moon at perigee** (closest to Earth) at 5:10 UT (distance 360,196km; angular size 33.2').

26 **Moon near the Pleiades** at 4h UT (morning sky).

26 **Last Quarter Moon** at 9:28 UT.

27 **Moon near Jupiter** at 12h UT (morning sky). Mag. –2.3.

28 **Moon near Mars** at 1h UT (morning sky). Mag. 0.8.

31 **Moon near Beehive cluster M44** at 9h UT (31° from Sun, morning sky).

More sky events and links at http://Skymaps.com/skycalendar/

All times in Universal Time (UT). (Australian Central Standard Time = UT + 9.5 hours.)

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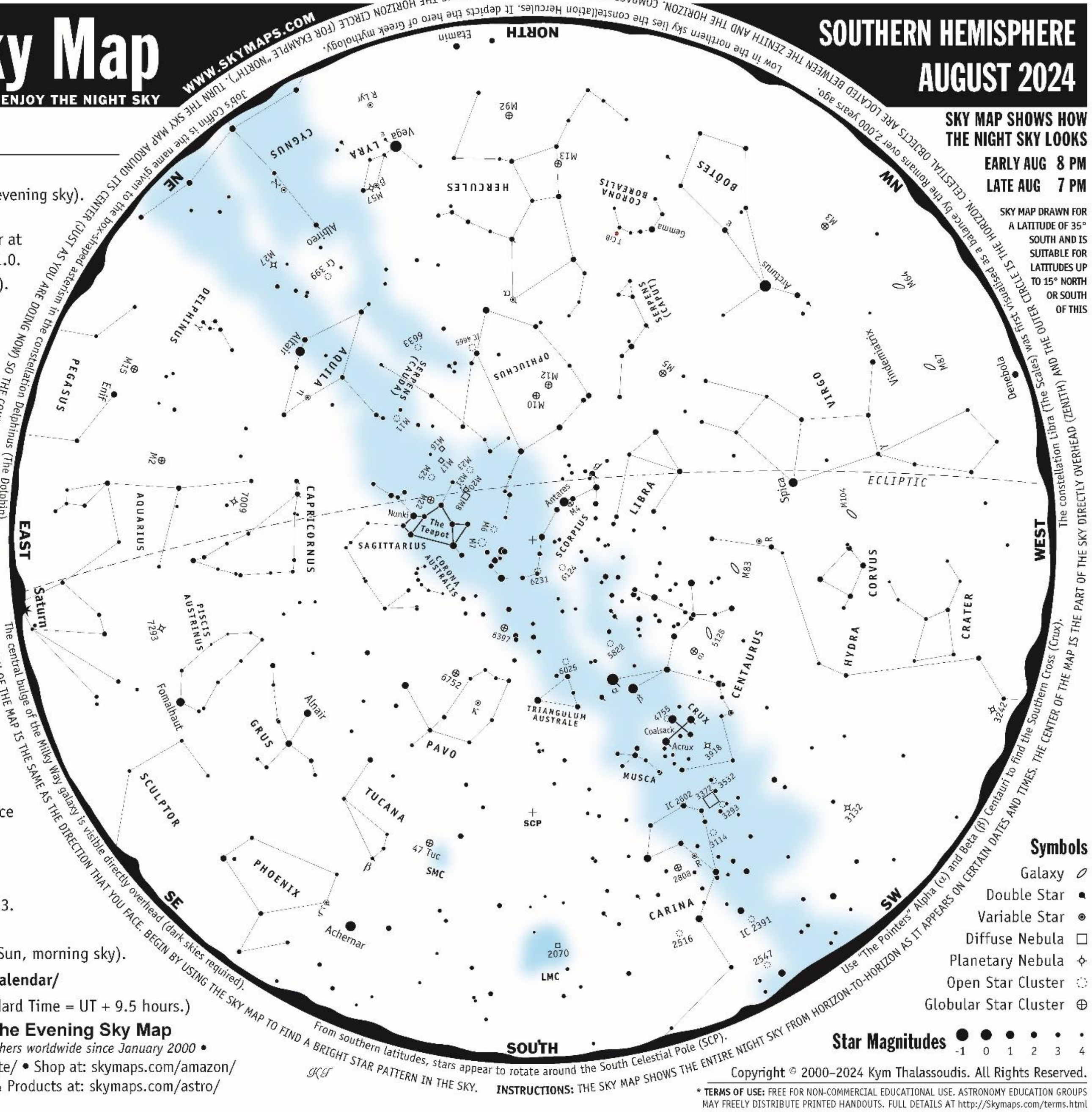

SKY MAP SHOWS HOW THE NIGHT SKY LOOKS

EARLY AUG 8 PM

LATE AUG 7 PM

SKY MAP DRAWN FOR A LATITUDE OF 35° SOUTH AND IS SUITABLE FOR LATITUDES UP TO 15° NORTH OR SOUTH OF THIS

Symbols

Galaxy

Double Star

Variable Star

Diffuse Nebula

Planetary Nebula

Open Star Cluster

Globular Star Cluster

Star Magnitudes

-1 0 1 2 3 4

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Cultural Differences

Ursa Major's back portion (The Big Dipper) aka…	
Seven Oxen – Latin	Otava (Salmon Net), Finnish
Bear – Siberian, Dutch, Native American	Wain (Wagon) – UK, German, Italian, Romanian,
Plough – Ireland, UK	Cleaver – UK
Amenominakanushi – Shinto	The Seven Sons- South Korea
Shrimp - Burma	The Seven Sages – Hindu
Coffin with Followers – Arabian	Forbidden Enclosure- China

Zodiac: Band of ‘12’ constellations along the ecliptic: