“Nuclear Forces”
Newcomer Academy
High School
Visualization Three

<table>
<tr><th>Chapter</th><th>Subtopic/ Media</th><th>Key Points of Discussion</th><th>Notes/ Vocabulary</th></tr>
<tr><td>1</td><td>A Star is Born</td><td>

Birth of a Star

How and where is a star born?

- Our **galaxy**, along with many others, contains many large clouds of gas and dust, mostly made up of hydrogen. These clouds are called **nebulae**.
- If the cloud becomes large enough, then its own gravity begins to overcome the gas pressure, and the cloud can begin to **collapse**. As the cloud collapses, gravity, temperature, and pressure increase, until the cloud has collapsed enough to raise the temperature to that required to **fuse** (burn) the hydrogen.
- Once that **fusion** begins, the energy released halts the contraction, and the outer layers of gas are blown away. What's left is an incandescent ball of mostly hydrogen, set aglow by the fusion reactions in its core: a **star**.

Star Classification

What are the different types of stars?

- Stars **illuminate** and nourish solar systems with energy, generating the heavy elements **essential** to creating life. From Earth, the stars in the night sky appear as a parcel of sparkly little diamonds of different sizes, yet otherwise, all the same. *
- These "diamonds" are quite varied in fact, having different colors--black, brown, yellow, white, red. Diverse gas make-up, brightness and size also help **classify** the separate star types.

- **Astronomers** categorize stars by their **temperature** and the elements they absorb.
- The star temperature range includes:

<table>
<tr><th>Temperature</th><th>Class</th><th>Spectra</th></tr>
<tr><td>Hot/Bright</td><td>O and B</td><td>Dark Blue – O
Medium Blue – B</td></tr>
<tr><td>Medium Brightness</td><td>A, F and G</td><td>Pale Blue – A
White – F
Yellow – G</td></tr>
<tr><td>Cool/Dim</td><td>K and M</td><td>Orange – K
Red – M</td></tr>
</table>

</td><td>

Galaxy

Nebulae

Collapse

Fusion/Fuse

Star

Illuminate

Essential

Classify

Astronomer

Temperature

Spectra

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</table>

The Different Types of Stars

- The Sun is an average sized yellow star. It is about 1 million km wide and is about 4.5 billion years old. However, when the Sun gets older (in about 5 billion years), it will no longer be an average-sized yellow star. Instead, it will increase in size and become a Giant star, before using up almost all its energy and collapsing into a Dwarf Star.

Dwarf Stars

- The nearest star to the Sun, Proxima Centauri, is a Red Dwarf star. It is a star with a diameter (width) less than half the diameter of the Sun, a surface temperature about 2000 °C to 3000 °C cooler. The Sun is also about 10,000 times brighter than Proxima Centauri.

- White Dwarfs are similar to Red Dwarfs, except that their surface temperatures are much higher, and shine white instead of red. When the Sun comes to the end of its life, it will become a White Dwarf. It will be much smaller than it is now, not quite as bright but twice as hot. Its **matter** (**particles**) will be more **dense**ly-packed together.

- There are also Black Dwarfs. These are stars that we cannot see, having used up their energy for producing light, but are still closely-packed but still have a strong gravitational pull.

Neutron Stars (Pulsars) and Black Holes

- A **neutron** star is a very small star, perhaps only 20 km across, which is just as heavy as the Sun is now. Its matter is extremely densely-packed together.
- When a Giant star collapses as it dies, it causes a huge explosion called a **Supernova**. This explosion, producing vast amounts of cosmic dust and appearing like another nebula in space, ends with the star shrinking or totally disappearing.
- A neutron star, which spins very fast, gives out huge pulses of radiation. This is why it is known as a **Pulsar**.
- If it does completely disappear it becomes a **Black Hole**, appearing to suck in objects orbiting or approaching close to it.

Average-sized Stars

- Most average-sized stars, like the Sun, are about half-way through their life. They have surface temperatures about 6000°C and glow a bright yellow, almost white, color.
- They will swell up to become Giant stars, and then shrink to become White Dwarfs.

Dwarf Stars

Matter

Particles

Dense

Neutron

Supernova

Pulsar

Black Hole

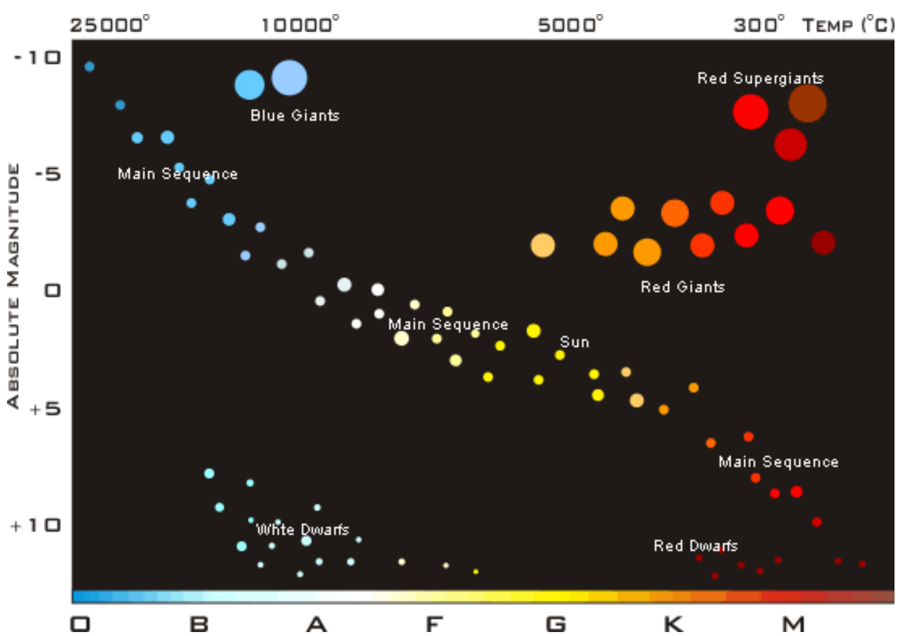
Blue-White Stars

- Some stars use up their hydrogen quicker than other stars. (The Sun uses up its hydrogen steadily, and will have a life of about 10 billion years.)

- Stars which burn up their hydrogen supplies quickly are much hotter than Sun-like stars. This heat causes them to glow bright blue, or blue-white.
- Sirius is the brightest star in the sky after the Sun, and has a surface temperature of about 10,000°C and is two and a half times bigger than the Sun.
- These hot stars are not necessarily always bigger than the Sun. They are just hotter and shine brighter.

Giants and Supergiants

- An old Blue-white star becomes a Supergiant. They expand, just like average-sized stars expand to become **Giant stars**. Because they are beginning to run out of hydrogen, they cool down and glow a more orangey color.
- A star called Betelguese is extremely old, but also extremely big. In fact, it is 500 times wider than the Sun and would, if it was at the center of the Sun's Solar System, be big enough to stretch nearly to Jupiter. This giant star will collapse in a huge explosion called a supernova and will become a neutron star or maybe even a Black Hole.



Extra Information:

Binary Stars

- *Many stars are **binary,** or double stars, either revolve around each other or simply appear close together from the viewpoint of Earth.*
- ***Eclipsing binaries** are so close together, they look like one star*

of variable luminosity.

- ***X-ray binaries*** *contain one collapsed star (i.e. white dwarfs, black holes) linked to another star by gravity. The regular star's energy radiating onto the collapsed star generates X-rays.*

Dwarfs

- ***Brown Dwarfs****: stars that failed to erupt into regular stars.*
- ***White Dwarfs****: small, dense and failing stars that are running out of fuel*
- ***Black Dwarfs****: dead stars that don't glow*
- ***Yellow Dwarfs****: small, main sequence stars (The* ***Sun*** *is one of the smaller stars that will develop into a white dwarf, exhaust its nuclear fuels and then turn into a black dwarf)*
- ***Red Dwarfs****: cool, faint and nearly dead*

Giants and Supergiants

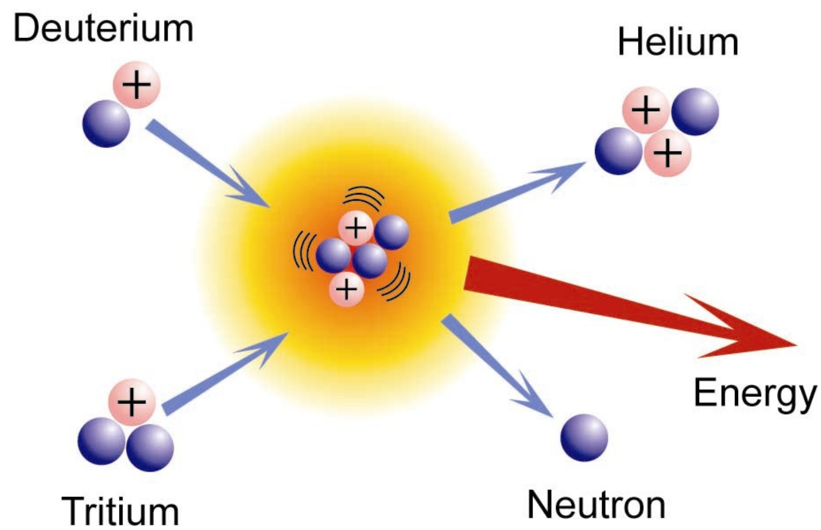
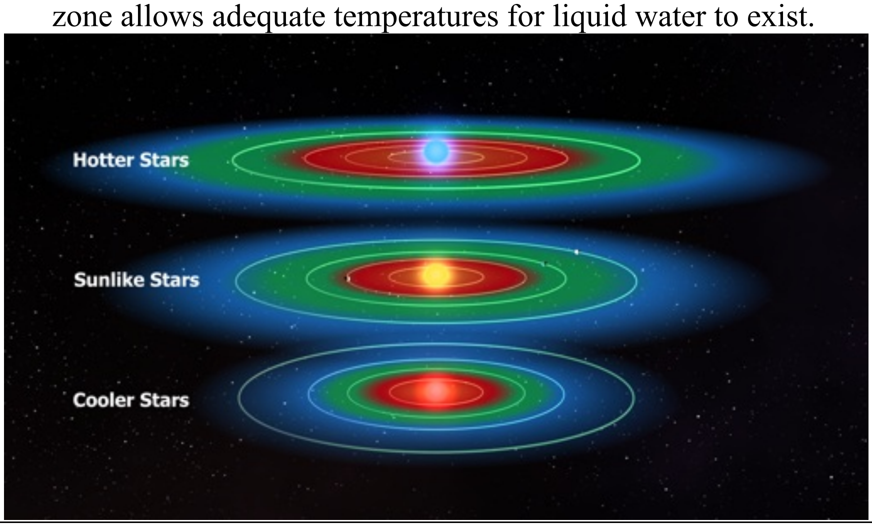
- ***Giant star*** ***luminosity*** *is 1,000 times greater than the Sun's*
- ***Supergiants*** *glow 10 million times brighter. However, due to* ***diminishing*** *fuel supplies, they begin dying and eventually blow-up.*
- *Types of Giants and Supergiants:*
- ***Red Giants****: fairly old, reddish-orange, increases to 100 times larger than original size*
- ***Blue Giants****: enormous, hot, helium burning, on its way out.*
- ***Supergiant****: largest known star-type (e.g. Rigel, Betelgeuse), become supernovas and turn into black holes.*

Neutron Stars

- ***Supernovas*** *turn into* ***neutron stars*** *- - stars that have collapsed, crushing their atoms until only the neutrons remain.*
- *One teaspoon of a supernova/neutron star weighs as much as a mountain.*
- *They revolve extremely fast--100s of times/second.*
- ***Pulsars****, a type of neutron star, release radio wave pulses, like a light house beam.*

Variable Stars

- ***Variable stars*** *waver in brightness, with* ***fluctuations*** *lasting from seconds to years.*
- *Fluctuations occur at the beginning and end of star life, according to intrinsic or extrinsic variables.*
- ***Intrinsic variable****: conditions inside the star change the brightness.*
- ***Extrinsic variable****: external circumstances (i.e. orbiting companion stars) create the fluctuations.*
- ***Cepheid variables****: a star's pulsating growth and shrinkage creates the variable brightness.*

Visualization: Birth of a star and solar system… Life Cycle of a Human			
1	What is occurring inside of a star?	**Process of Making Energy** **How are the heavy elements formed within stars?** • In the nuclear fusion process lighter **nuclei** combine to form heavier nuclei [as large as iron] in the interior of stars. **Where does the energy from the Sun come from?** • In **fusion** reactions in the core of the Sun small amounts of matter are converted to large amounts of energy. The conversion ratio is $E= mc^2$.  **How does life on Earth benefit from the fusion reactions occurring in our star, the Sun?** • The Sun provides warmth, light (photon energy for **photosynthesis**), and stars create all of the matter in the Universe beyond Hydrogen and Helium. Everything is made from stars. • **A habitable zone** is established by different types of stars. This zone allows adequate temperatures for liquid water to exist.  	*Activity 4D* **Nuclei** **Fusion** **Photosynthesis** **Habitable Zone**

Visualization: Fusion

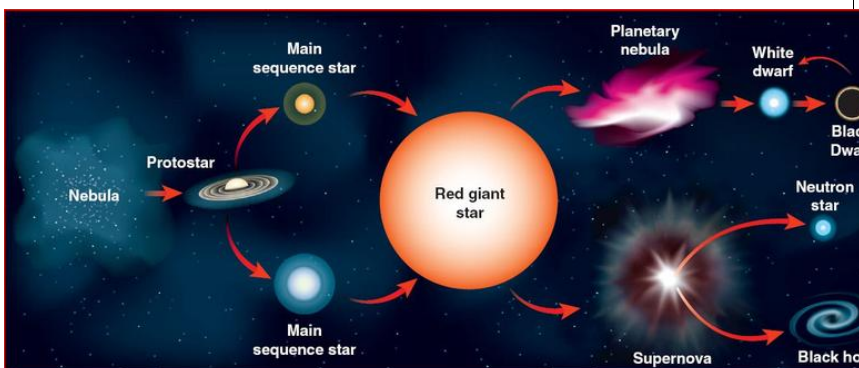
2	The Life of 2 Stars		

Life of Stars

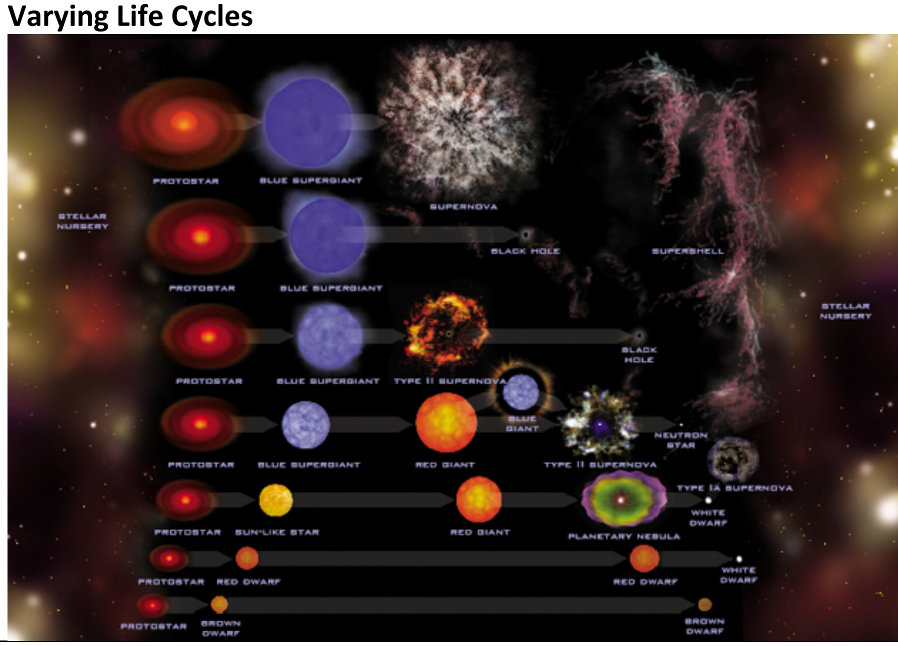
What makes one star different from another?

- Low to medium mass stars become **red giants** when their fuel is exhausted, after millions of years, they release a planetary nebula-not massive enough to **coalesce** into a new celestial body. They may also become a **white dwarf**. Since energy is no longer being generated by fusion, the white dwarf will cool and become a **black dwarf**.

- High mass stars burn brighter and faster, have much shorter lives and die an explosive death in a **supernova** explosion. Supernova remnants coalesce to form new stars and solar systems. Depending on their mass, they end as **neutron stars** or **black holes** (larger).



Varying Life Cycles



Activity 4C

Red Giant

Coalesce

White/Black Dwarf

Supernova

Neutron Star

Black Hole

Activity 5

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<td>3</td>
<td>Production of Heavier Elements

& the Death of a Star</td>
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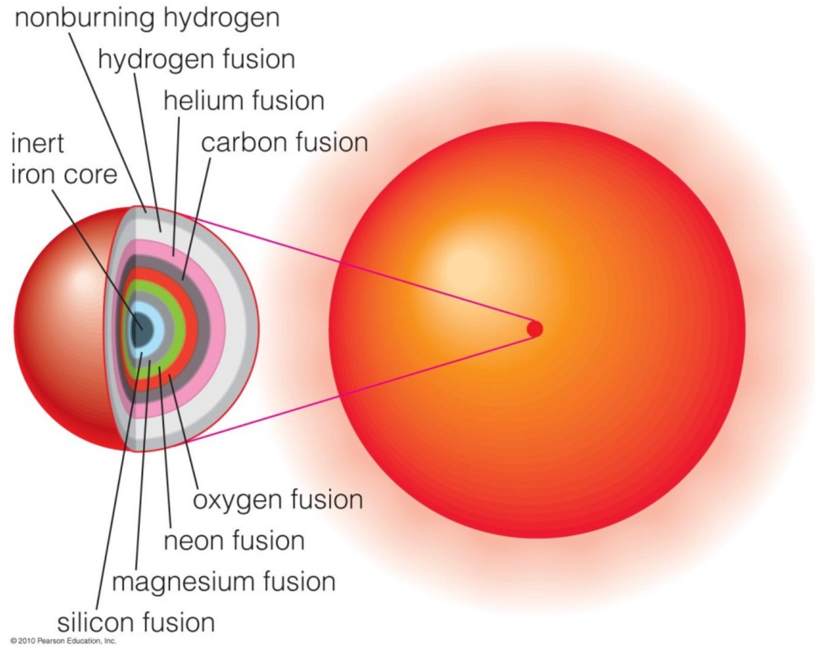
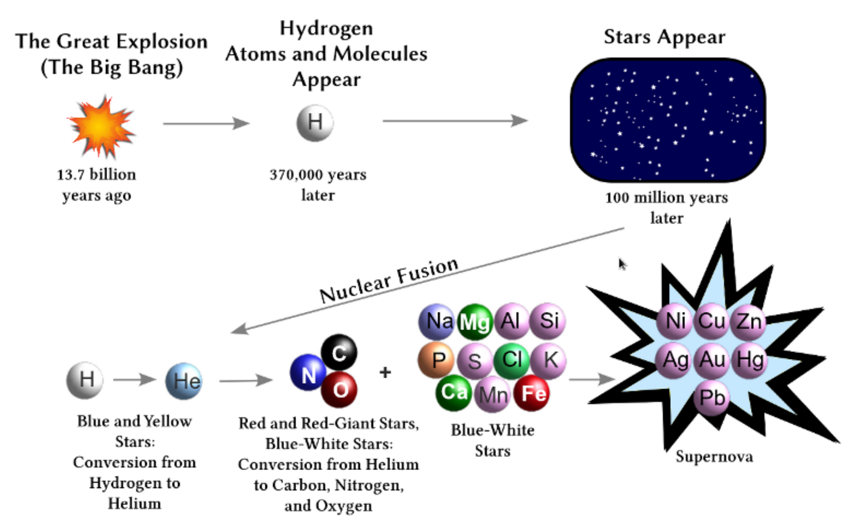
Making Elements

- **Helium to Iron is produced within a star by the process of fusion.**



Where then do you think the remaining 90 naturally occurring elements come from? (From where did the elements in the Earth system such as gold and uranium originate?)

- <u>**Nucleosynthesis**</u> : Supernovae produce the heaviest elements due to the incredible temperatures and pressures produced in these explosions. The <u>**remnants**</u> of supernovae explosions are the raw materials from which our solar system was formed.



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<td>Nucleosynthesis

Remnant</td>
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<tr><td colspan="4">Visualization: Life Cycle of Stars</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Review</td><td>Identify the various stages of a star</td><td></td></tr>
<tr><td>Describe the process and benefits provided by fusion</td><td></td></tr>
<tr><td colspan="4">Questions and Answer Session</td></tr>
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