# Earth Science: Chapter 4: Stellar Evolution: Fall 2017: Student Notes

**LT1: I CAN explain how stars form from Nebulae.**

* After the Big Bang the universe was filled with hydrogen and helium in huge clouds. These are called **Nebulae.**
* **Nebulae** are huge; larger than our solar system.
* A nebula spins slowly in space gathering more gas(hydrogen) and cosmic dust (leftover from long dead stars and bits of other space matter).
* As the Nebula gains more and more Hydrogen (matter) it begins to contract due to its own gravity.
* Gravity accelerates matter toward the center of the nebula. The increasing density causes great pressure and temperature increases.
* When the force of gravity creates enough pressure and temperature (about 10 million K) the H nuclei fuse into He nuclei and **fusion** begins, and the star began to glow. A star is born.
* This process is slow, taking hundreds of thousands of years.

Target summary: Please respond to the following question below: How and from what does a nebula form, and how does it give “birth” to stars? Be sure to provide forces at work and required characteristics.

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**LT2: I CAN trace the phases of Stellar Life Cycle.**

* We know that stars are “born” in Nebulae (sometimes called stellar nurseries). In nebulae the inward force of the collapsing gas is much greater than any force of energy output.
* Before fusion actually initiates, there is a stage called the **protostar** stage. In this stage the inward force of gravity is still greater than the outward energy production force.
* **Main sequence stage:** The stage in which stars spend most of their “lives”. The star is fusing hydrogen into helium. The inward pull of gravity is equal to the outward force of fusion. The star is said to be in **hydrostatic equilibrium.** Main sequence lasts for a few million to hundreds of billion years. Our sun’s main sequence stage is estimated to be 10 billion years.
* When you look into the night sky, about 90% of the stars you see are main sequence stars.
* As a star the size of our sun begins to run low on H (decreasing mass) the outward thermal force begins to be overtaken by gravity. The increasing gravity causes an increase in pressure in the core which in turn causes an increase in temperature. The star is now hot enough to fuse the helium into carbon.
* What happens next is determined by the star’s initial mass and will be in the next section.

Target summary: Summarize the steps required to go from a nebula to a main sequence star.

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**LT3: I CAN describe the characteristics of Main Sequence Stars like our Sun.**

Main sequence (MS) stars:

* Are converting Hydrogen to helium with the process of fusion
* stable; with the principle of **hydrostatic equilibrium** at work. This is a balance between the inward compression of gravity and the outward force caused by fusion.
* Range in size from as small as one-tenth the mass of our sun to 100X the mass of our sun. Most MS stars are about the mass of our sun or smaller.
* Main sequence star that are *more massive* than our sun:
	+ Are more **luminous-** a measure of the total energy output of the star. Can also be thought of as the star’s brightness.
	+ Have hotter photospheres
	+ Are physically larger (diameter)
	+ “Burn” through their Hydrogen very quickly (as quick as 10 million years)
	+ Main sequence stars are classified by their **color or spectral class.** The system is found in the table below.



Target summary: Describe a main sequence star including its characteristics and varieties.

**LT4: I CAN predict a star’s ultimate fate to its initial mass**

All stars Proceed through the nebula-protostar- main sequence stages. What happens next is totally controlled by the mass of the star.

We measure the mass of a star by comparing it to the mass of our Sun. We express the mass in **Solar Masses.**

|  |  |  |
| --- | --- | --- |
| **mass** | **Length of main sequence stage** | **What occurs after main sequence ends** |
| <1 solar masses | Greater than 10 billion years | **RED GIANT** forms. Star not massive enough to fuse Helium into anything heavier. Forms a **WHITE DWARF** star (small very dense “dead star”) with a Helium core at its center. |
| 1-3 solar masses | About 10 billion years | **RED GIANT** forms. Star has enough mass to fuse helium into carbon. **PLANETARY NEBULA** (see below) forms that has a white dwarf (with a carbon core) at its center.  |
| 3 solar masses | Much less than 10 billion years | Goes through several **RED GIANT** phases each fusing heavier elements. Eventually becomes a **SUPER GIANT.** |
| 8-20 solar masses | 10’s of million years | Same as 3 solar masses except the super-giant may **SUPERNOVA** (see below)and form a **NEUTRON STAR (**see below) |
| Greater than 20 solar masses | Less than 10 million years | Same as above except the mass is great enough to form a **BLACK HOLE** (see below) |

**Planetary nebula**: after a red giant forms material from the star is ejected and forms what looks like a nebula. The name planetary is actually misnamed by an early astronomer in the 1700’s who thought it resembled a planet.

## White dwarf star: A very dense stellar remnant with faint luminosity. It has no source of energy and is considered a dying or dead star.

**Supergiant:**  can range over the whole spectrum of star colors. Most luminous stars in the universe. Very massive.

**Supernova:** a massive explosion that causes an extremely bright event in the sky. When massive star runs out of fuel gravity causes an inward collapse toward the core and the rebound causes a massive explosion. Last supernova witnessed was in the 1600’s.

## Neutron star: has about 500,000 times Earth's mass, but is the size of Brooklyn, New York. These objects have an immense amount of gravity. Extremely dense. A pea size piece of it would weigh 100’s of millions of tons.

**Black hole:** denser than neutron stars. Gravity is so great that not even light can escape it. Located by finding an area where matter is being pulled in. Black holes emit powerful x-rays as well.

**LT5: I CAN analyze and interpret the Hertzsprung - Russell diagram.**

* 2 scientists working independently in the early 20th century developed a graph showing the relationship of a stars luminosity and its temperature.
* On the X axis is temperature (Kelvin) and its associated spectral class( color) and on the Y axis is luminosity (brightness)
* This is called a Hertzprung Russell diagram or H-R diagram.
* The H-R diagram show that hotter stars are more luminous, and that the star’s mass(size) also can influence its brightness.
* 90% of all stars fall in a curved band that runs from the upper left to the lower right of the diagram.
* Red giant stars occupy the upper right corner of the H-R diagram with the super giants just above that.
* White dwarfs occupy the lower middle part of the graph.

### Hertzsprung Russell Diagram



