Name: _____ Date: _____

Life Cycle of Stars

Science Literacy Article

Stars are huge burning spheres of gases, most commonly hydrogen and helium, that are held together by gravity. They are able to give off light and heat through the process of nuclear fusion. During **nuclear fusion**, hydrogen atoms are fused (combined) together to form helium atoms. This fusion of atoms releases an *extremely large amount of energy* which powers the stars and keeps them from collapsing under their own weight. Stars continue to fuse lighter elements together which form heavier elements. By identifying the elements formed within a star, astronomers can then determine the **star's age**.

Stars are born, they age, and then eventually die, much like the human life cycle. The *life cycle of a star depends on the star's mass*. The *more massive* a star is, the *shorter* its life cycle is. This is because high mass stars *burn through their nuclear fuel much more quickly* than smaller mass stars do. The mass of a star will also determine the path it takes through the different life cycle stages. However, the first three stages in the life cycle of stars are exactly the same for both low and high mass stars.

First Three Stages of All Stars

1. All stars in the universe are first formed in a nebula. A **nebula** is a huge cloud of gas and dust that is held together by gravity. A nebula is considered a star "nursery" or birthplace for a star. The amount of matter within the nebula is what determines the mass of the star created. Over time, gravity pulls the gas and dust together and causes it to spin. As the material heats up, a protostar is formed.
2. A **protostar** is considered a *"baby" star* and is the stage when a star gives off light and heat for the first time. As the protostar continues nuclear fusion, it then enters the main sequence stage.
3. A star will spend the majority of its life in the **main sequence stage** which is considered a range from "teenager" to "adult" stars. Approximately 90% of all known stars are currently in this stage of their life cycle. Our Sun is a main sequence star and will remain so for billions of years. Once a star leaves the main sequence stage, the remainder of its life cycle path will be determined by its mass.

Next Stages for a Small to Medium Star

4. After the main sequence stage, small to medium (average) mass stars, such as our Sun, will become giant stars. The **red giant stage** occurs when the nuclear fuel in a star begins to run out which causes the star's core to become unstable. As the core rises in temperature, the outer layers of the star begin to expand and cool off.

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5. Next, the outer shell of gas around the aging star expands even more and a ring-shaped nebula forms. This stage is referred to as a **planetary nebula**.
6. When the nuclear fuel has been completely exhausted and the outer shell of gas around the star is gone, the remaining materials are compacted together to form a white dwarf. A **white dwarf** is the remaining core of the star and is only about the size of a small planet.
7. Once a white dwarf completely cools, it then becomes a **black dwarf**. This is the final stage in the life cycle of a small to medium mass star. A black dwarf is considered a *dead star that no longer gives off any light or heat*. All small to medium mass stars, including our Sun, will end their life cycles this way.

Next Stages for a High Mass to Extremely High Mass Star

1. After the main sequence stage, stars with a high to extremely high mass will instead become supergiant stars. **Supergiant stars** are among the most massive and brightest of all known stars in the universe. As the core of a supergiant rises in temperature, nuclear fusion continues forming heavier elements. However, once *iron is formed*, these atoms begin to *absorb energy and nuclear fusion stops*.
2. The built up energy is then released in a powerful and bright explosion which is referred to as a **supernova**. The extreme energy release of a supernova is what produces elements heavier than iron. Therefore, supernovas are often referred to as *"element factories"*. After a supernova, the remaining core material compacts together and *its mass determines the next and final stage* in the life cycle.

Final Stage for a High Mass Star

For a high mass star, the final stage after a supernova is known as a neutron star. **Neutron stars** spin very rapidly and are among the most dense celestial (space) objects in the universe. In fact, a sugar cube sized piece of neutron star matter would weigh approximately *one hundred million tons* here on Earth!

Final Stage for an Extremely High Mass Star

For an extremely high mass star, the final stage after a supernova is known as a black hole. A **black hole** forms when the core of an extremely high mass star collapses and contracts in upon itself. This collapse creates a gravitational field so strong that *no type of matter or energy near it can escape*, not even light!

Summary

As you have read, all stars have a life cycle and that life cycle is based on the star's mass. A star's mass not only determines *how long a star will live but also the path of the specific stages* it will follow throughout its life span. Stars are the primary sources for making and distributing heavier elements throughout the universe. Therefore, astronomers consider stars to be the building blocks of galaxies as well as the planetary systems within them. In fact, everything on Earth, including ourselves, is made from elements formed by stars!

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