## Stellar Evolution

**Purpose:** To give visitors an overall view of the stages that stars go through as they age.

**What to See and Do:**

This exhibit follows the evolution of three stars from their beginnings as clouds of gas to their deaths as black holes, neutron stars, or white dwarfs. Since most people walk along the wall from right to left, that is the direction the exhibit goes. The red, yellow, and blue arrows trace the evolutions respectively of the red, yellow, and blue stars. The topic of stellar evolution is a fairly complicated one and this exhibit is only meant as an overview of the subject. Eventually other exhibits will talk more about individuals stages of a stars' life. Given below is some background information on the evolution of each of the three stars.

All stars start from huge clouds of hydrogen and helium gas. Something, perhaps the explosion of a nearby supernova, causes the cloud to break into smaller pieces. Each of these small pieces (each is much larger than the solar system) collapses under the force of gravity. As these pieces (or fragments) collapse, they heat up. As they heat up, the pressure inside the cloud increases and the battle between gravity, which would like to make the cloud smaller, and pressure, which would like to make the cloud bigger, begins. This battle between pressure and gravity will continue throughout the star's life. Eventually the temperature inside the star reaches 10 million degrees C. At this point, nuclear reactions which convert hydrogen into helium begin. These reactions release enough energy so that pressure and gravity balance one another. At this point, the star is middle-aged.

The initial color of a middle-aged star depends on how much mass it contains. A blue star will have a mass greater than five times the sun's mass, while a red star will have only one-fifth of the sun's mass. The subsequent evolution of a star also depends upon how much mass it contains. Since the blue star has more mass than the sun, the force of gravity which is trying to make it smaller is also greater. In order to balance this high gravitational force, the pressure inside the star must also be higher. In order to maintain this higher pressure, the temperature of the star must be greater. Since objects with high temperatures appear blue, this massive star has a blue color. In the case of the red star, the situation is reversed. The force of gravity is smaller, so both the pressure and temperature are smaller. Since objects that have low temperatures are red, these stars appear red.

The mass of the star also determines how the star will die. Although the blue star has a greater mass than the sun, it will live for a shorter time because it must burn its fuel faster in order to maintain a higher temperature. So this star will live for only a few tens of millions of years.

When the supply of hydrogen in the center of the star begins to run out, the core of the star will start to collapse. As the star collapses, it once again heats up. As the temperature increases, the star may find new sources of energy. As the inside of the star collapses, the outer layers of the star expand. As they expand, they cool off and become red. At this point, the star is a red supergiant. Regardless of how resourceful the star is in coming up with new energy sources, it will eventually run out of fuel.

When this star runs out of fuel, it will start to collapse and of course, as it collapses, it will heat up. In fact, it will collapse so quickly that it will not be able to get rid of this heat fast enough, so the star will explode. This is called a supernova explosion. This explosion blows the outer layers of the star out into space, where they will mix with other gas and dust and eventually, after millions of years, form another generation of stars. If the core survives, it continues to collapse and will become either a neutron star or a black hole.

A neutron star is an object that has about twice as much mass as the sun, but is only 10 miles across. Neutron stars spin very rapidly, and emit radiation in two narrow beams. When one of these beams sweeps by the Earth, we see a flash. When the beams point in any other direction, we don't. This effect is much like the beacon of a lighthouse. In these instances, the neutron stars are called pulsars.

A black hole is formed when the core of the star contains more than three times the mass of the sun. The gravity of the black hole is so strong that nothing, not even an object traveling at the speed of light, can escape from it.

The death of a yellow star is not as violent as the death of a blue star. When a yellow star runs out of hydrogen, the interior will collapse, heat up, and begin fusing helium. The interior collapses, the outer layer expands and cools off. At this point, the star is a red giant.

As the star runs out of helium in its core, it will gently puff off its outer layers to form a planetary nebula. This planetary nebula will move out into space, mix with other gas and dust and eventually form another generation of stars. At about the same time, the rest of the star (90% of the original star) begins to collapse. Since there are no longer any sources of energy inside the star, it will continue to collapse until it gets to be about the size of the Earth (8000 miles in diameter). At this point, the star is called a white dwarf. It is an Earth-sized "star" that contains as much mass as the Sun. Actually, a white dwarf is not really a star, since it is no longer generating any energy of its own. Over the course of time, it will cool of and become dark.

For all practical purposes, the red star never dies. It uses its fuel so slowly that it will take trillions of years for the star to run out. When it does run out of fuel, it will slowly shrink and become dark.

**Suggestions of What to Do:**

Since most people look at the north wall from right to left, the exhibit starts on the right and works its way to the left.

**Questions/Comments:**