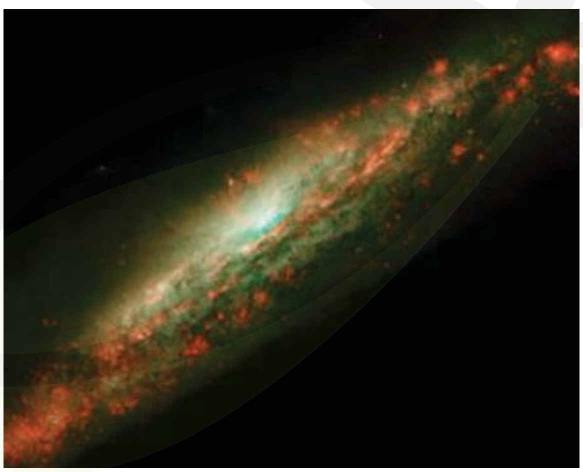
THE LIFE CYCLE OF STARS

Background Information

Galaxies

Stars are massive collections of atomic particles that create light and heat at their centers. The first atoms formed from the hot gas of subatomic particles created when the universe began. Then gravity forced the atoms to join together into ever larger clusters. Those clusters grew large enough that their gravity attracted other groups of atoms, until stars eventually formed. Those stars attracted other stars until small galaxies formed. Those galaxies attracted other galaxies, finally forming large, mature galaxies such as the Milky Way.



A distant galaxy

Galaxies continue to influence each other. Although the Milky Way as a whole is stable, small changes continue — stars continue to be born, while others either die quietly or explode as supernovas. Dying stars contribute gas and dust to the already vast amount that clogs the Milky Way. Because the Milky Way forms a **plane**, a flat, two-dimensional, plate-like shape, the dust makes it difficult to see across the Milky Way.

Did you know?

- The Milky Way galaxy contains approximately 400 billion stars.
- There are several hundred billion galaxies in the universe.
- Each year, the Milky Way creates about seven new stars.
- A supernova occurs about once every 50 years in the Milky Way galaxy. Many supernovas occur that are not visible from the earth, but since the last one observed from earth occurred in 1604, the next visible supernova is overdue.

Gas and dust clog the heart of the Milky Way

A star's life

Supernova explosions or changes in the rotation of the Milky Way can cause a **nebula**, a massive cloud of gas and dust in outer space, to contract. As the nebula contracts under its own gravity, gas and dust accumulate into ever larger bodies. The result is often the formation of **protostars**, dense bodies of gas and dust that have not yet begun to generate light. As the mass of each protostar increases, its gravity also increases, which squeezes the core of the protostar ever harder.

Finger-like protrusions hold new stars in nebula

When the hydrogen atoms at the core of a protostar are squeezed at high enough temperatures and pressures, they fuse together to create new helium atoms. This is called **stellar nucleosynthesis**, the process in which four hydrogen atoms combine together to produce a single helium atom at the center of a star. This interesting term has three parts:

- **Stellar** means star.
- Nucleo is short for nucleus or **nuclear**, having to do with the nucleus at the center of an atom.
- Synthesis refers to the process of combining.

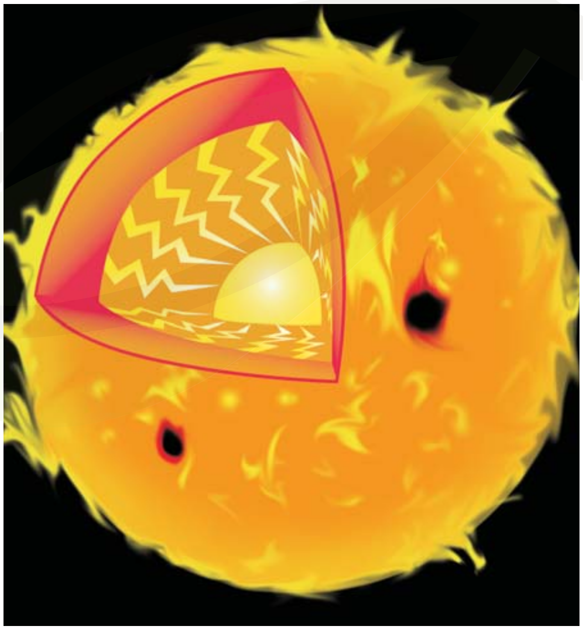
The new helium atom, however, has 0.7 percent less mass than the total mass of the four hydrogen atoms from which it was created. Most of that tiny bit of mass is converted into **nuclear energy**, the fundamental material from which mass of the universe is formed. Nuclear energy was predicted by Albert Einstein's famous equation, $E=MC^2$, which means: "energy equals mass times the speed of light squared." That little bit of mass is the fuel that the protostar burns, turning it into light and heat in the form of **photons**, particles of light energy. When nucleosynthesis begins in a protostar, it becomes a star, and photons leave the star as light and heat.

The sun was created by this process. The sun is a **yellow dwarf star**, a common type of star of average dimensions and mass. About a million years after its formation, the sun, like all yellow dwarf stars, entered the **main sequence**, the main portion of the life cycle of an average star, in which it converts hydrogen into helium steadily for billions of years. It takes an average star like the sun 10 billion years to convert the hydrogen in its core to helium. The sun is currently middle-aged, about 5 billion years old.

The light and heat radiating outward from the core of the sun and the steady gravitational pressure of the outer layers upon the core are in balance in the sun — the outward pressure equals the inward pressure. At the end of its 10 billion years as a main sequence star, however, when the hydrogen in the core has all been turned to helium, the amount of energy released decreases.

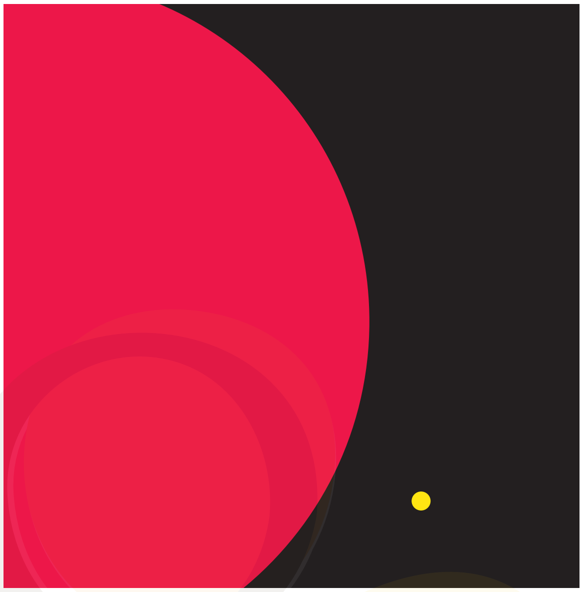
Did you know?

- The sun turns 700 million tons (635 metric tons) of hydrogen into helium every second through stellar nucleosynthesis. Of that 700 million tons (635 metric tons), 0.7 percent, or 5 million tons (4.5 metric tons), of hydrogen is converted into pure energy and released as photons every second.
- The internal temperature of the sun is 28 million degrees F (16 million degrees C).
- The sun is 432,000 mi (696,000 km) across. If the sun were to become a black hole, the entire mass of the sun would be squeezed until it was only 2 mi (3 km) across.



The interior the sun – an average star

In the absence of the steady outward pressure of light and heat, the outer layers will press in on the core, increasing the



A red giant star and the sun

temperature and pressure until the layer of hydrogen around the helium core begins to burn. The light and heat from that layer of hydrogen will inflate the sun hundreds of times its original size, making it shine up to 2,000 times brighter. At this point, the sun will become a **red giant**, a greatly expanded star whose outer layer is so distant from the burning hydrogen layer that the surface is relatively cool. Its red color shows that it is relatively cool in the same way that red-hot metal is cooler than white-hot metal.

A planetary nebula with a white dwarf star in its center.

ACTIVITY 1

Making a Model Showing the Formation of a Protostar

Purpose

To understand how an average protostar forms.

Material

2 cups (500 mL) white, yellow, or red modeling or sculpting clay.

At least 40 marble-size balls of modeling or sculpting clay prepared ahead of time, so there is a total of at least 50 balls after the students make four each from the required 2 cups (500 mL).

Illustration: Gas and dust clog the heart of the Milky Way.

Illustration: Finger-like protrusions hold new stars in nebula.

Matter and Astronomy Journal and pencils.

Presentation

- Most Montessori teachers introduce this concept in Year 2 or 3.
- Announce to the students that they will be making a model showing how an average protostar forms.

INTRODUCTION

- Review the concept of atoms (everything is made up of atoms; following the formation of the universe, hydrogen atoms, the simplest and most plentiful atoms, were the first thing to form; those atoms joined together to make protostars).
- Explain that the hydrogen gas from which protostars form is plentiful in the Milky Way galaxy. Present the illustration, Gas and dust clog the heart of the Milky Way, explaining that all the dark areas are hydrogen gas and dust from dead stars that are formed from protostars.

MODEL OF A PROTOSTAR

- Present the modeling or sculpting clay and explain that the students will use it to make pretend atoms of hydrogen. Make a marble-size ball so that the students know how large to make their own, then distribute the rest of the clay and invite the students to make four marble-size balls each.
- Ask the students to put their hydrogen atoms into a clearing at the center of the table, spread out loosely so none are touching. Add any extras that were pre-

made. Explain that following the formation of the universe, hydrogen atoms were all spread out like the marbles of clay.

- Discuss with the students what gravity does to things (pulls them toward each other and makes them stick together). Point out that gravity made the hydrogen atoms stick together. With the students, start sticking the model atoms together, but not so that they lose their shape and individual identities.
- Ask the students to continue to create an ever larger collection of atoms until all the model atoms are used up. Gently shape the final product into a ball made up of individual smaller balls. Explain that in the universe, once all the free atoms were absorbed into a single ball like this, a protostar was created.
- Present the illustration, Finger-like protrusions hold new stars in nebula. Explain that it shows a protostar forming in a cloud of gas and dust.
- Keep the ball model for use in Activity 2, Exploring How a Protostar Becomes a Star.
- Ask the students to use their journals to draw and label an illustration showing how atoms combine to create a protostar.

Extensions

- With each student playing the part of a hydrogen atom, act out the role of gravity in the creation of a protostar.