Stars, Galaxies, and the Universe

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you’ve read this lesson, reread the statements to see if you have changed your mind.

<table>
<thead>
<tr>
<th>Before</th>
<th>Statement</th>
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<td>5.</td>
<td>The Sun is more massive than 90 percent of other stars.</td>
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<td>6.</td>
<td>The solar system is at the center of the Milky Way.</td>
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Read to Learn

Stars

Do you know the song “Twinkle, Twinkle, Little Star”? Have you ever wondered what stars really are or why they twinkle? A star is a large sphere of hydrogen gas hot enough for nuclear reactions to occur in its core. A star’s core heats as gravity pulls gas inward. When the gas becomes hot enough for nuclear reactions to begin, energy starts to travel outward. When the energy reaches the star’s surface, the star shines.

A star appears to twinkle because its light passes through Earth’s atmosphere before reaching your eyes. As particles in the atmosphere move, the star’s light changes directions slightly.

Light from Stars

When astronomers measure distances to stars, they often use a unit based on the speed of light rather than astronomical units. A light-year is the distance light travels in one year. Light travels 300,000 km/s. One light-year equals 9.46 trillion km.

Because it takes time for light to travel, stars are not seen as they are now, but as they were in the past. Proxima Centauri, the star nearest the Sun, is 4.2 light-years away. The light from Proxima Centauri that we see today left the star 4.2 years ago.
Types of Stars

When you first look at them, all stars appear white. But if you look closely at the brightest stars in the night sky, you will see that some are red, some are orange, and some appear to be blue. The color of a star indicates its temperature.

Blue stars are the hottest stars, followed by blue-white, white, yellow, and orange stars. Red stars are the coolest stars. The Sun is a yellow star.

When you look at stars, they appear to be the same size. But stars vary in size. The Sun is larger and more massive than 90 percent of other stars. But the Sun is tiny compared to the giant star Aldebaran shown in the figure. Aldebaran is 44 times wider than the Sun.

The Sun is a solitary, or single, star. Many other stars are members of binary star systems or multiple-star systems. In a binary star system, two stars orbit each other’s center of mass. In a multiple-star system, two or more stars orbit the entire system’s center of mass. Stars differ in other ways, too. For example, stars called variable stars change in brightness over time.

Earth’s Star—the Sun

The Sun is the closest star to Earth. It has been shining for nearly 5 billion years. Scientists estimate that it has a lifetime of approximately 10 billion years, so it will continue to shine for 5 billion more years. When the Sun stops shining, it will become a small, dense star that emits little light. It will be a white dwarf star.

Galaxies

Stars are not randomly scattered throughout the universe. Most stars are bound by gravity into galaxies. A galaxy is a huge collection of stars, gas, and dust. Astronomers classify galaxies by their shapes. The three main types of galaxies are elliptical, irregular, and spiral.

Elliptical Galaxies Elliptical galaxies are shaped like basketballs or footballs. They contain older, redder stars and have little gas or dust. Because stars form from gas and dust, elliptical galaxies contain few young stars.
Irregular Galaxies  These oddly shaped galaxies contain large amounts of gas and dust. They show the highest rate of star formation of any galaxy type. Irregular galaxies have many young stars. These galaxies do not have bright centers.

Spiral Galaxies  These galaxies are shaped like disks. They contain dust, gas, and young stars in their bluish arms. Older, redder stars are in their central bulges. Spiral galaxies are surrounded by spherical halos containing older stars.

The universe contains hundreds of billions of galaxies. Each galaxy can contain hundreds of billions of stars. The solar system where you live is part of the Milky Way, a spiral galaxy. The Milky Way is larger than most galaxies in the universe. It contains more than 100 billion stars.

Because Earth is inside the Milky Way, scientists cannot see the Milky Way from the outside as they can see other galaxies. Even though they cannot see all of the Milky Way, scientists have determined that the Milky Way has at least two major spiral arms. The Sun is near one of the arms a little more than halfway from the Milky Way’s center.

The Universe
Most galaxies are pulled by gravity into clusters of galaxies. In the clusters, the galaxies interact and sometimes merge with one another. The Milky Way is part of a cluster called the Local Group.

The Local Group contains about 30 galaxies. The Local Group, in turn, is part of a supercluster of galaxies called the Local Supercluster.

Superclusters are some of the largest structures in the universe. Some superclusters contain thousands of galaxies. But even superclusters are parts of larger structures. Superclusters form enormous, sheetlike walls in space.

Astronomers study the rotations and the interactions of galaxies in clusters. In this way, they can determine how much mass the galaxies contain. Astronomers have discovered that only 5–10 percent of the mass in galaxies emits light. They hypothesize that the rest of the mass in galaxies—and in the universe—is invisible dark matter or dark energy.

Key Concept Check 4. Identify  In which galaxy is Earth located?

Key Concept Check 5. Summarize  How is the universe structured?
Recycled Matter

Did you know that most matter that makes up your body was originally made in stars? Hydrogen is combined into more-complex elements during nuclear reactions in stars. When a massive star explodes, it releases those elements into space. This material can then form new stars and planets. In this way, matter in the universe is recycled.

Big Bang Theory

Most scientists agree that the universe formed 13–14 billion years ago and that it had a hot and dense beginning. The Big Bang theory states that the universe began from one point and has been expanding and cooling ever since.

Will the universe expand forever, or will gravity eventually cause it to contract? These questions remain unanswered. Scientists have not yet been able to determine the fate of the universe.

Math Skills

Light-years (ly) describe distances to nearby stars. Astronomers often use parsecs (pc) to describe greater distances in space.

1 pc = 3.26 ly
1 ly = 9.46 trillion km

The star Proxima Centauri is 4.2 ly from Earth. What is that distance in parsecs?

a. Select a conversion factor with the unit you want in the numerator and the given unit in the denominator.

\[
\frac{1 \text{ pc}}{3.26 \text{ ly}}
\]

b. Multiply the starting quantity and units by the conversion factor.

\[
\frac{4.2 \text{ ly} \times 1 \text{ pc}}{3.26 \text{ ly}} = \frac{4.2 \text{ pc}}{3.26} = 1.3 \text{ pc}
\]

6. Use Dimensional Analysis

The nearest galaxy to the Milky Way is the Andromeda galaxy. It is approximately 2.5 million ly from Earth. What is that distance in parsecs?
After You Read

Mini Glossary

Big Bang theory: theory that the universe began from one point and has been expanding and cooling ever since

light-year: the distance light travels in one year

galaxy: a huge collection of stars, gas, and dust

star: a large sphere of hydrogen gas hot enough for nuclear reactions to occur in its core

1. Review the terms and their definitions in the Mini Glossary. Write a sentence explaining the Big Bang theory in your own words.

2. In the graphic organizer, list the color of stars from coolest to hottest. Then write the Sun in the correct box to show its temperature.

3. If the star Proxima Centauri exploded 4.2 years ago, why would we be able to observe the explosion today?

What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

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END OF LESSON