OUTSIDE THE SOLAR SYSTEM

A Science A–Z Earth Series

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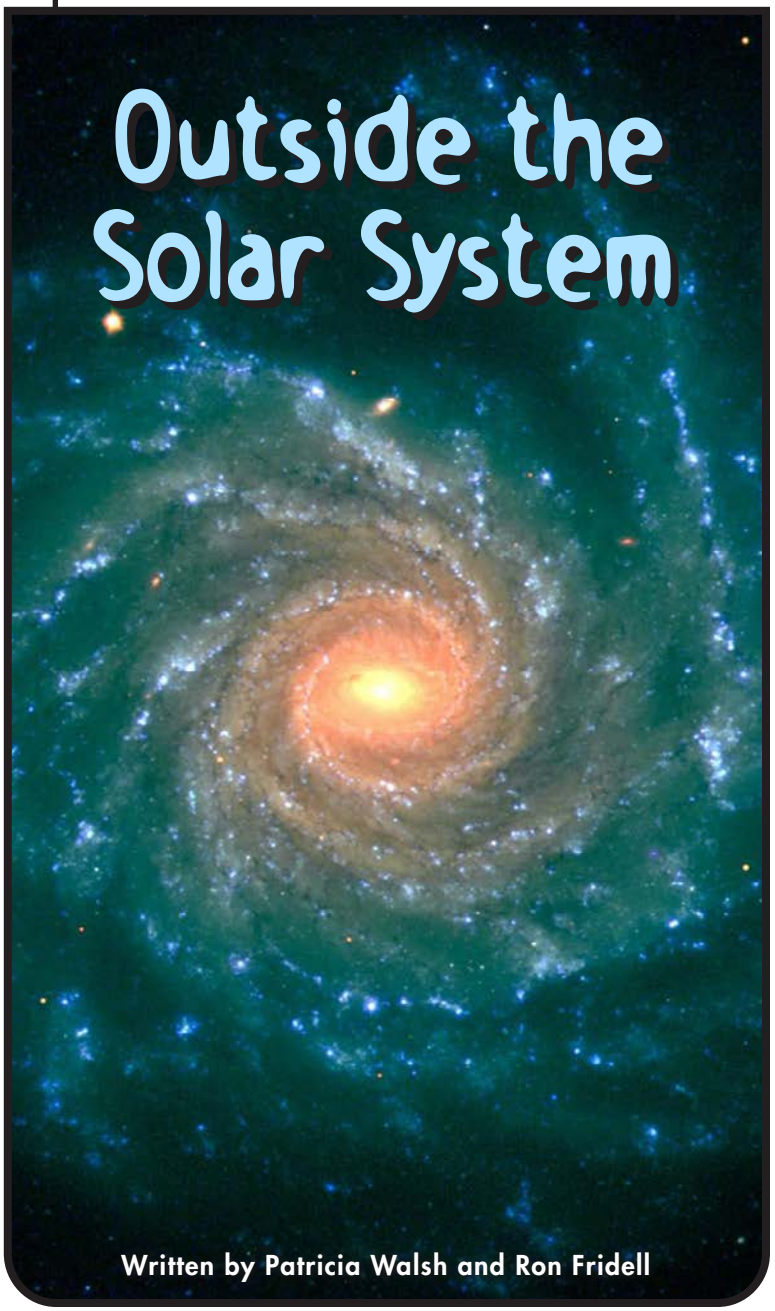
Outside the Solar System



Written by Patricia Walsh and Ron Fridell

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KEY ELEMENTS USED IN THIS BOOK
The Big Idea: As long as humans have existed, we have looked into the night sky with curiosity and wonder. At this point in history, we are fortunate to benefit from technology that allows us to see and study parts of the universe that earlier cultures never could have. However, we are also limited by our current knowledge and technology. As time marches on, humankind will continue to pursue an understanding of the universe and its many amazing features. Someday—perhaps even in students' lifetimes—we may get answers to some key questions, including how the universe began and whether life exists anywhere besides on Earth.
Key words: astronomer, big bang theory, black hole, cluster, constellation, cosmologist, deep space, dwarf, Earth, elliptical galaxy, exoplanet, galaxy, gas, gravity, irregular galaxy, life cycle, light-year, luminosity, mass, matter, Milky Way Galaxy, Moon, nebula, orbit, planet, solar system, space, spacecraft, spiral galaxy, star, Sun, supergiant, supernova, telescope, universe
Key comprehension skills: Classify information *Other suitable comprehension skills:* Cause and effect; compare and contrast; main idea and details; identify facts; elements of a genre; interpret graphs, charts, and diagrams
Key reading strategy: Ask and answer questions *Other suitable reading strategies:* Connect to prior knowledge; summarize; visualize; using a table of contents and headings; using a glossary and bold terms

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The Milky Way, our galaxy, appears as a bright stripe of stars across the sky.

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Winter nights tend to yield the clearest skies.

Introducing Deep Space

Look up on a dark, clear night away from city lights. Do you see the points of light overhead? Most of the points of light you see are **stars**. Some points of light are really double stars that **orbit**, or go around, each other. Some points of light are groups of stars called **galaxies**. What you see and what you cannot see is all part of **deep space**.

Deep space is everything beyond our **solar system**. It is space that is beyond our star—the Sun—and the planets, asteroids, and comets that orbit the Sun.

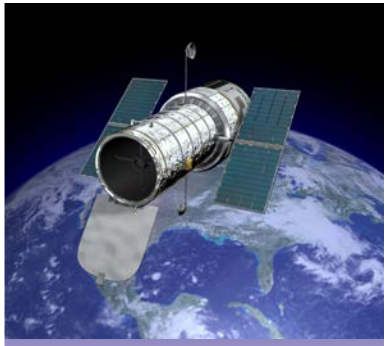
Exploring Space

For thousands of years, people used the stars to navigate their way across Earth's land and seas. About 500 years ago, people developed the first **telescopes**. Telescopes let them get a closer look at the objects in the night sky.

Galileo's telescope

Over time, telescopes have been improved in many ways. Today, huge telescopes sit on top of mountains. Space telescopes orbit Earth. Scientists also use another kind of telescope. The radio telescope detects radio waves given off by objects in space, which allows us to detect things that cannot be seen with optical telescopes.

The Very Large Array in New Mexico has twenty-seven radio telescopes working together.



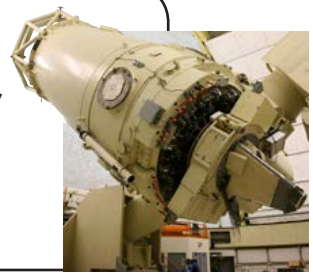
The Hubble Space Telescope was launched into orbit around Earth in 1990. It is about the size of a school bus.

Humans have gone into space. We have even landed on the Moon. But no one from Earth has ever traveled farther than our Moon. No one has traveled outside our solar system into deep space.

Pack your imagination. You're about to journey among the billions and billions of stars, planets, and galaxies in the universe.

Word Wise

The word *telescope* comes from the Greek word *teleskopos*. The word part *tele-* means "far" and *-skopos* means "seeing." Our modern-day telescopes let us see far into space.

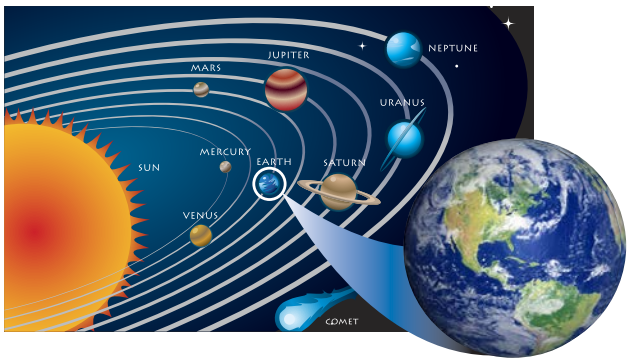


Out of This World

You already know your space neighbors—the Moon, the other planets, and our Sun. These are in our solar system. But it is only a very tiny part of a gigantic universe. Outside the solar system is vast space and billions and billions of other objects.

It's time to leave Earth, and head toward deep space. Take a moment to look back over your shoulder as you zip past the outer planets of Uranus and Neptune. Earth looked like a blue dot for a while, but now it has disappeared.

You are leaving our solar system. Did you feel a bump? It was caused by solar wind where the solar system ends and deep space begins. The bump should not have surprised you. *Voyager 2*, an unmanned spacecraft launched in 1977, let scientists know about the bumpy solar winds. You're traveling much faster than *Voyager 2*, so you might pass it as you cross into interstellar space.

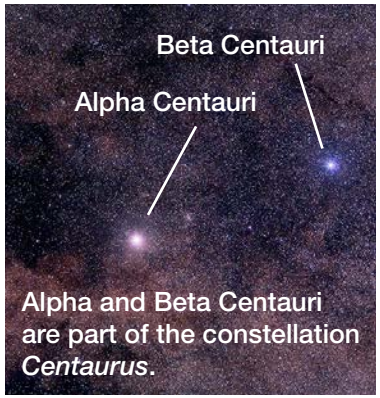


Among the Stars

You've traveled a very long distance now. You have come 4.2 **light-years** from Earth. You're arriving at Earth's nearest star neighbor. It's the dim and cool Proxima Centauri.

Next you'll see Alpha Centauri. It is much brighter than dim Proxima. Up close, you can see that Alpha Centauri has two stars that are very much like our Sun.

Standing on Earth, you saw constellations made of stars arranged in interesting shapes, like a lion and a centaur. But now you'll notice that these constellations aren't groups of dots on a flat surface. They're actually stars that are very far from one another.



Alpha and Beta Centauri are part of the constellation *Centaurus*.

Math Moment

The distance between stars is vast. Scientists use a measurement called a *light-year* to measure it. A light-year is the distance that light travels in one year. One light-year is about 9.5 trillion kilometers (5.9 trillion mi.). About how many kilometers (or mi.) from Earth is our closest star neighbor?

WOWSER!

The Sun is only eight light-minutes away from Earth. This means that if you could travel very fast—at the same speed that light travels—the trip from Earth to the Sun would take only eight minutes. The sunlight you see now left the Sun eight minutes ago!

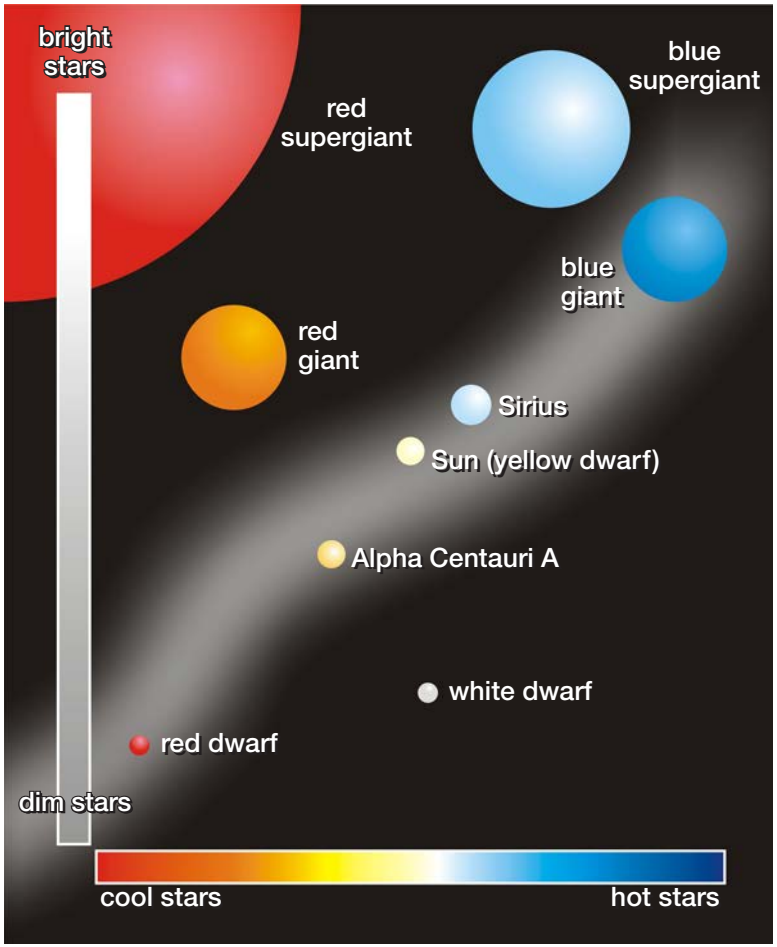
Way out here in space, you can also see that not all stars are alike. Stars are different from one another in:

- size
- **luminosity** (brightness)
- temperature
- color
- life span

Our Sun is a star. It looks very large and bright from Earth. That is because it is the closest star to Earth. But other stars are much bigger and brighter. As you fly through deep space, you'll see that stars are different in size. The sizes range from small dwarf stars to huge supergiants many times larger than our Sun.

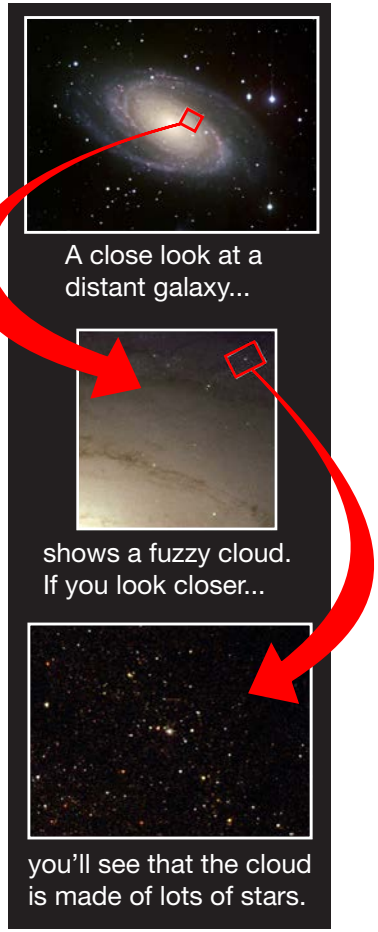
From Earth, most stars look white because they are so far away. As you get a closer look, you'll see that stars have different colors. Some stars are hot and blue, and others are cool and red. The color of a star depends on the temperature at its surface. (Think of a fire: The hottest flames are blue, while cooler flames are red.)

Star Types



Did you notice that the stars are in **clusters**? A group might be just two or three stars together. But some groups have many, many stars clustered together. A star cluster may look like one fuzzy star when you're far away. But as you zip in closer, you'll see that the group has thousands and thousands of stars.

You don't have time to stop and count them. You still have a very long way to travel.



Do You Know?

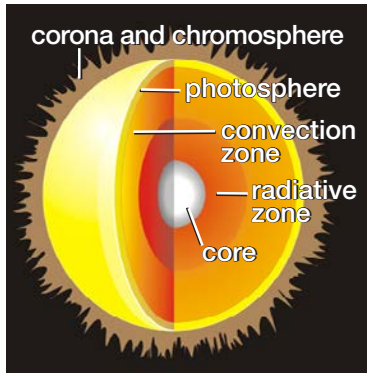
As seen from Earth, stars seem to twinkle. But stars really have a steady light. The moving air in Earth's atmosphere causes the twinkling. The moving air changes the path of the star's light. Twinkle, twinkle, little star.

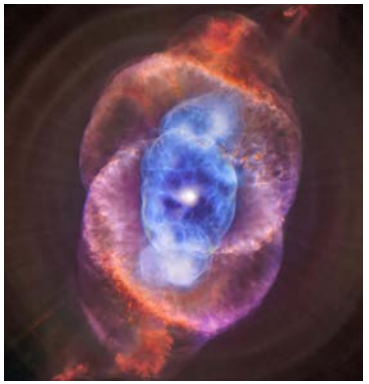
Star Life Cycles

Stars are not living creatures. But we still say that they have life cycles. This is because stars form, exist for a long time, and then die. The life cycle of a star can last for billions of years. As a star goes through its life cycle, it changes. Sometimes it can look beautiful and unique.

All stars, including our Sun, are balls of hot gas. They have layers of gas, including a dense core and lighter outer layers. The more gas the star has, the bigger it is. Bigger stars also have more mass. Mass is the amount of material, or matter, an object has. Generally, the bigger the star, the brighter it is. The brighter the star burns, the shorter its life cycle.

Inside a Star





Cat's Eye Nebula

Here's an expanding **nebula**. If you think it looks like a fuzzy cloud of gas and dust, you are correct. A nebula forms

when the outer layers of a star fly outward. A nebula can be found where an old, giant star has exploded. New stars are being born in a nebula. Now speed over to a **supernova** (below). Don't get too close. You've found the biggest fireworks celebration you've ever seen.


Crab Nebula

When an old star collapses, it crushes its core. The crushing is like squeezing a rubber ball tighter and tighter. When you let go of a rubber ball, it suddenly springs back to shape. But in a supernova, when the crushed star springs back, it keeps expanding. It hurls matter into space in a brilliant explosion. This is how a supernova forms. One day, gravity will pull the cloud of gas and dust from the supernova back together. The cloud will heat up as it spins faster and faster. Nuclear fusion will fire up the core at the center. The cloud of gas will glow. Then the universe will have another star to shine for millions or billions of years.


supernova

Watch Out for Black Holes

Are you getting too close to a **black hole**? Steer away quickly or you could be sucked into it and never return. Black holes make traveling into deep space dangerous because they are mysterious. They cannot be seen, and we don't know all that much about them.

A black hole is the core of a massive star that has exploded. After the explosion, the star collapsed back into itself. The collapsing center of the star has strong gravity. It pulls in all surrounding matter and energy. It is called a black hole because even light cannot escape it.


Artist's rendering of gas being sucked into a black hole

Artist's rendering of a planet orbiting two stars

The Search for Planets

Did you see any planets orbiting the stars? Every star, whether or not you can see it, could have planets orbiting it.

Astronomers use ground-based and space-based tools to find faraway planets. They look for a wobble in a star's movement. They look for a change in a star's brightness. Wobbling and dimming give astronomers clues that a planet is circling a star.

Fly closer to the star called Upsilon Andromedae. Scientists think this star might have three giant planets circling it.

An **exoplanet** is a planet that orbits any star other than our Sun. Most exoplanets found so far are giant gas planets. They are as big as or bigger than Saturn and Jupiter. But astronomers have also found smaller exoplanets that are almost the same size as Earth. Scientists keep finding more and more exoplanets in deep space.

At this observatory in Chile, astronomers hope to discover new planets. They observe how stars wobble as they're pulled by the gravity of the planets that orbit them.

Don't land on an exoplanet. None of the exoplanets we know about are friendly to human life. They all orbit very close to their star. This makes them much too hot for human beings to visit.

Word Wise

A *planetary system* has a star and the planets, moons, asteroids, comets, and dust that orbit the star.

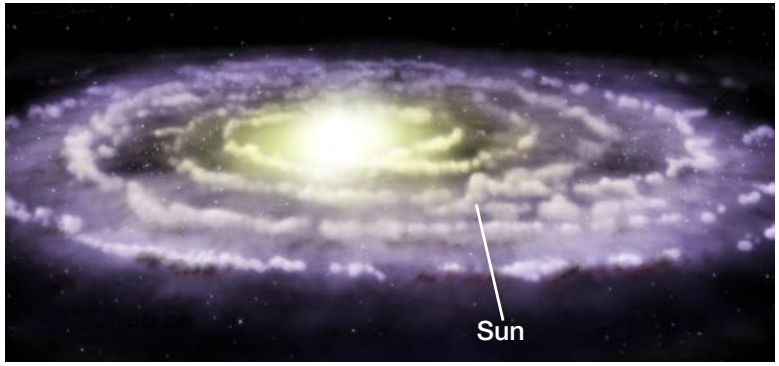
Swirling with the Galaxies

You could spend a long time looking at the stars in deep space. But stop. Take a look at where you have been.

You've been looking at some of the stars in the Milky Way Galaxy. A galaxy is a large system of stars. Between the stars is interstellar gas and dust. All of it is held together by gravity.

The Milky Way Galaxy is just one of more than 125 billion galaxies in the universe. Some of those galaxies have a few million stars. Others have billions or even trillions of stars. The Milky Way has more than 100 billion stars.

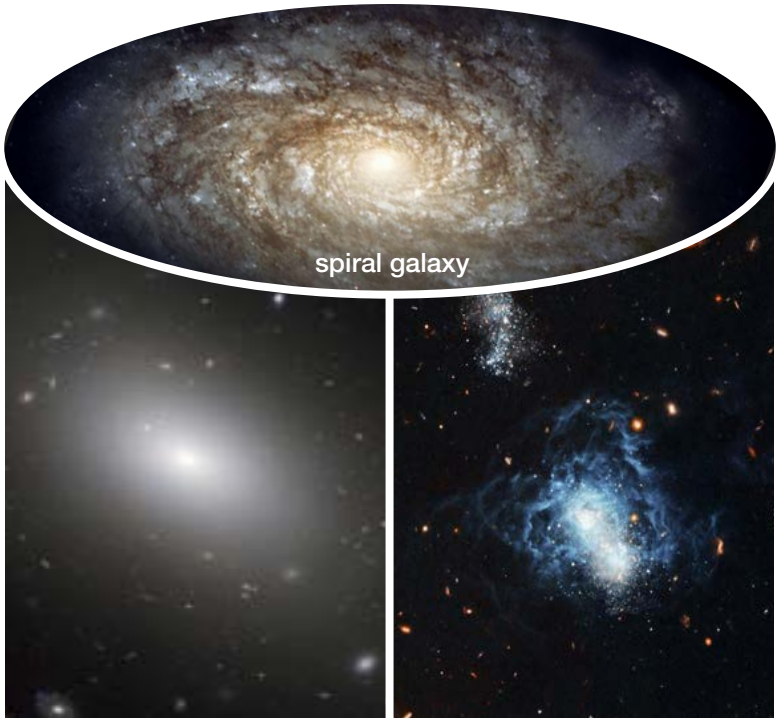
Rev up your engines. You're going to cross the Milky Way Galaxy. You have a long way to go. Even at the speed of light, it will take 100,000 years to cross the Milky Way from edge to edge.



Artist's rendering of the Milky Way Galaxy

Do you see how the Milky Way is shaped like a disk? Do you see the bulge in the middle? Look at the arms of stars that spiral out from the bulge. The Milky Way is a spiral galaxy. Galaxies come in three shapes—spiral, elliptical, and irregular. Elliptical galaxies look like flattened circles. Irregular galaxies have stars scattered around.

Now set your sights on another spiral galaxy, Andromeda. It's the nearest galaxy to the Milky Way, but it's still far away. It is two million light-years from your home on Earth. The Andromeda Galaxy is more than twice the size of the Milky Way.

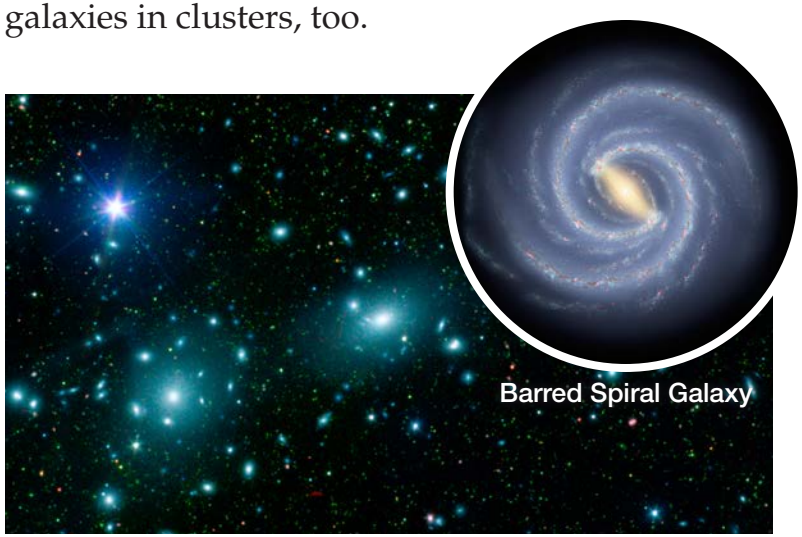


elliptical galaxy

irregular galaxy

Andromeda Galaxy

After you visit the Andromeda Galaxy, keep on going. You'll pass billions of other galaxies. Just as you saw clusters of stars, you'll see galaxies in clusters, too.



A galaxy cluster has hundreds or even thousands of galaxies.

An Expanding Universe

Scientists who study the origins, or beginnings, of the universe are called **cosmologists**. They study deep space to gather scientific information. They use the information to develop theories, or big ideas. Their primary theory about the origin of the universe is called the **big bang theory**.

This theory states that the entire universe began in a single instant 14 or 15 billion years ago. It began with a very powerful explosion. The explosion created all time and space. It created all matter and energy. The big bang theory also states that the universe is still expanding.

Artist's rendering of the big bang

Rainbow image of the Egg Nebula

Conclusion

It's time to return to your home on Earth. In your imaginary journey, you traveled out of our solar system. You visited stars. You zoomed across the Milky Way Galaxy. You continued on to the next galaxy. You gazed farther outward, looking at billions of galaxies. You even tried to understand our universe.

You can return to the universe every night. Just look up into the starry night sky. The light from distant stars will guide you. Your imagination will take you out into deep, deep space.

Glossary

astronomers scientists who study planets, stars, galaxies, and other objects in space (p. 15)

big bang theory the theory that suggests that the universe began from a single, enormous explosion and is still expanding (p. 20)

black hole a region of space with a gravitational field so intense that nothing can escape it (p. 14)

clusters close groups of similar objects (p. 11)

cosmologists scientists who study the origin and structure of the universe (p. 20)

deep space the open areas between solid bodies in the universe beyond the solar system (p. 4)

exoplanet any planet that exists outside the solar system (p. 16)

galaxies large collections of planets, gas, dust, and millions or billions of stars, bound together by gravity (p. 4)

light-years units of distance in astronomy equal to the distance that light travels in one year (p. 8)

luminosity a measure of the amount of radiating or reflected light coming off a star or other celestial object; brightness (p. 9)

nebula a region or cloud of interstellar dust and gas appearing as a bright or dark patch (p. 12)

orbit to revolve around another object (p. 4)

solar system a star and the celestial bodies that revolve around it; a planetary system (p. 4)

stars bodies in outer space, made of hot gases, that shine in the night sky (p. 4)

supernova the death explosion of a massive star, resulting in a sharp increase in brightness followed by a gradual fading (p. 13)

telescopes instruments used to make distant objects look closer (p. 5)

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