

Stars, Galaxies, and the Universe ▪ Section Summary

The Expanding Universe

Key Concepts

- What is the big bang theory?
- How did the solar system form?
- What do astronomers predict about the future of the universe?

Astronomers theorize that billions of years ago, the universe was no larger than the period at the end of this sentence. This tiny universe was incredibly hot and dense. The universe then exploded in what astronomers call the **big bang**. **According to the big bang theory, the universe formed in an instant, billions of years ago, in an enormous explosion.**

Edwin Hubble discovered that most of the galaxies are moving away from us and away from each other. Hubble also discovered that there is a relationship between the distance to a galaxy and its speed. **Hubble's law** states that the farther away a galaxy is, the faster it is moving away from us. Hubble's law provides strong support for the big bang theory.

In 1965, two physicists accidentally detected faint radiation on their radio telescope. This mysterious glow was coming from all directions in space. Scientists later concluded that this glow, now known as **cosmic background radiation**, is radiation left over from the big bang. Astronomers estimate that the universe is about 13.7 billion years old.

After the big bang, there was only cold, dark gas and dust where the solar system is now. **About five billion years ago, a giant cloud of gas and dust collapsed to form our solar system.** A large cloud of gas and dust such as the one that formed our solar system is called a **solar nebula**. Slowly, gravity began to pull the solar nebula together. As the solar nebula shrank, it spun faster and faster and eventually flattened into a rotating disk. Gravity pulled most of the gas into the center of the disk, where the gas eventually became hot and dense enough for nuclear fusion to begin. The sun was born.

Meanwhile, in the outer parts of the disk, gas and dust formed small asteroid-like bodies called **planetesimals**. These formed the building blocks of the planets. Planetesimals collided and grew larger by sticking together and eventually combining to form the planets.

New observations have led many astronomers to conclude that the universe will likely expand forever. Astronomers have discovered that the matter that astronomers can see, such as stars and nebulae, makes up as little as ten percent of the mass of galaxies. The remaining mass in galaxies exists in the form of dark matter. **Dark matter** is matter that does not give off electromagnetic radiation. Astronomers have observed that the expansion of the universe appears to be accelerating. They infer that a mysterious new force, which they call **dark energy**, is causing the expansion of the universe to accelerate. Most of the universe is thought to be made of dark matter and dark energy.

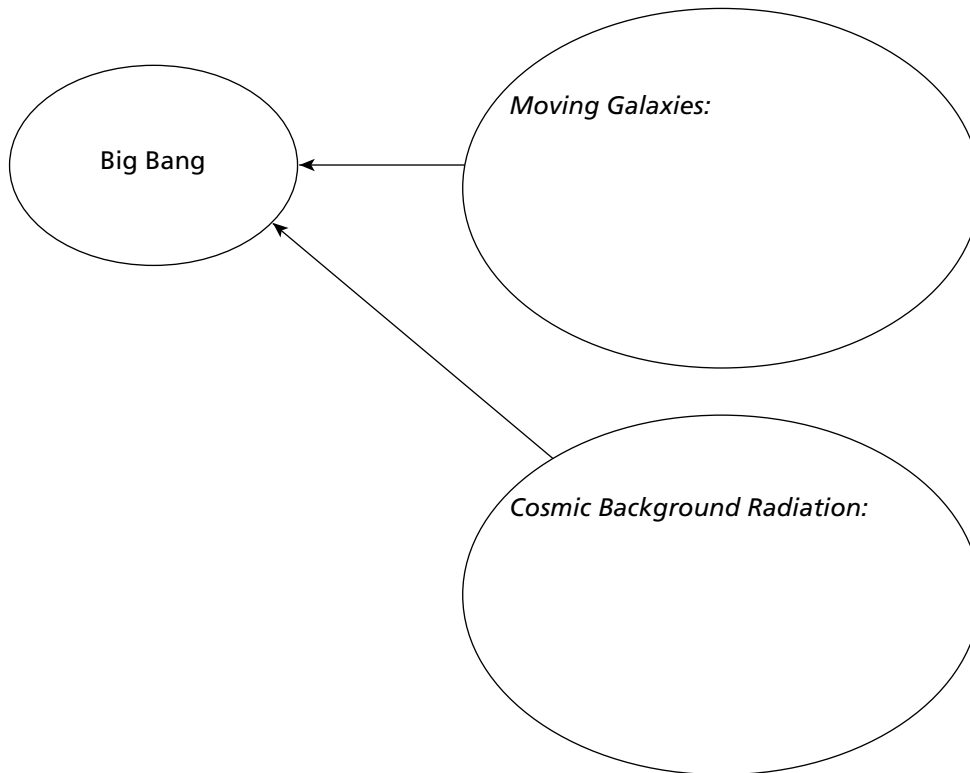
Stars, Galaxies, and the Universe ▪ *Guided Reading and Study*

The Expanding Universe

This section explains how astronomers think the universe and the solar system formed.

Use Target Reading Skills

As you read about the evidence that supports the big bang theory, complete the graphic organizer.



How the Universe Formed

1. The initial explosion that resulted in the formation and expansion of the universe is called the _____.
2. When did the big bang occur?

3. Is the following sentence true or false? The farther away a galaxy is from us, the faster it is moving away from us. _____
4. How is the universe like rising raisin bread dough?

Stars, Galaxies, and the Universe ▪ *Guided Reading and Study*

- 5. Radiation left over from the big bang is called _____.
- 6. How can astronomers infer approximately how long the universe has been expanding?

Formation of the Solar System

- 7. About how long ago did our solar system form? _____
- 8. What events led to the birth of the sun?

- 9. How did planetesimals form planets?

The Future of the Universe

- 10. Describe two possibilities of what will happen to the universe in the future.

a. _____

b. _____

- 11. Which possibility in #10 is more likely? Explain why.



Stars, Galaxies, and the Universe ▪ *Review and Reinforce*

The Expanding Universe

Understanding Main Ideas

Write an answer for each of the following questions in the spaces provided.

1. In which direction are nearly all galaxies moving?

2. What is Hubble's law?

3. Explain how the sun was formed.

Building Vocabulary

Match each term with its definition by writing the letter of the correct definition in the right column on the line beside the term in the left column.

- | | |
|--------------------------------------|--|
| _____ 4. big bang | a. a force that is causing the expansion of the universe to accelerate |
| _____ 5. cosmic background radiation | b. the asteroid-like bodies that formed the building blocks of planets |
| _____ 6. dark energy | c. leftover thermal energy from the big bang |
| _____ 7. planetesimal | d. matter that does not give off electromagnetic radiation |
| _____ 8. dark matter | e. a large cloud of gas and dust, such as the one that formed our solar system |
| _____ 9. solar nebula | f. a theory that the universe formed in a huge explosion |

Stars, Galaxies, and the Universe ▪ *Enrich*

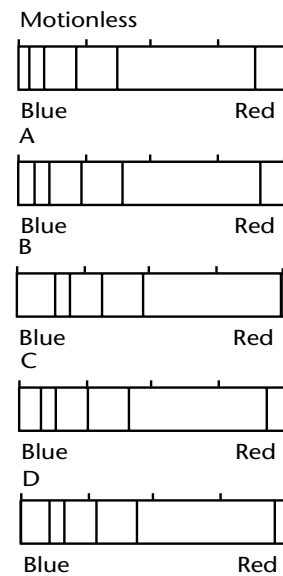
How Far and How Fast?

You know that electromagnetic radiation is energy in the form of waves. Planets, stars, and galaxies emit electromagnetic radiation. As one of these objects moves through space toward an observer, the waves of electromagnetic radiation between the object and the observer move closer together. That is, the distance between the crests of the waves decreases, causing the wavelength to shorten. If that same object moved away from an observer, the waves between the object and the observer would move farther apart from each other. The distance between the crests of the waves would increase, and the wavelength would lengthen.

When a star is moving toward Earth very fast, the wavelength of its light shortens, causing it to appear slightly more blue than usual. If a star is moving away from Earth very fast, the wavelength of its light lengthens, causing it to appear slightly more red. By measuring this *blue shift* or *red shift* of light, astronomers can determine whether the star is moving toward or away from Earth, and how fast. To do this, astronomers use the shift of spectral lines produced by chemicals in the star's atmosphere. Astronomers can also use the spectrum of a galaxy to tell how fast the galaxy is moving toward or away from Earth.

Using the principle of red shift, Edwin Hubble studied the relationship between a galaxy's distance and the speed at which it moves away from Earth. He found that the farther away a galaxy is, the faster it moves away from Earth. This relationship is called *Hubble's Law*.

Based on the spectrums in the figure, rank the four galaxies in order of the speed with which they are moving away from Earth, from slowest (1) to fastest (4).



	Rank (1 = slowest, 4 = fastest)
Galaxy A	
Galaxy B	
Galaxy C	
Galaxy D	

- Based on Hubble's Law, which of the galaxies is farthest from Earth?

- Are any of the galaxies moving toward Earth? Explain.
