

SECTION 4 **The Big Bang Theory**

**KEY IDEAS**

As you read this section, keep these questions in mind:

- How did Hubble’s discoveries lead to an understanding that the universe is expanding?
- What is the big bang theory?
- What evidence supports the big bang theory?

**What Is Cosmology?**

The study of the origin, structure, and future of the universe is called **cosmology**. Scientists who study cosmology are *cosmologists*. Cosmologists study the universe as a whole. Astronomers study the parts of the universe, such as planets, stars, and galaxies.

Cosmologists have theories about how the universe began and how it is changing. They test these theories against new observations. Many of these theories began with observations made less than 100 years ago.

**How Do We Know That Galaxies Move?**

Scientists use light to study the movement of objects in space. As an object moves, its light seems to shift on the spectrum toward red or blue, as shown below.

- blue shift = object moving toward Earth
- red shift = object moving away from Earth ✓

In the early 1900s, the astronomer Edwin Hubble studied spectra from galaxies. His research uncovered new information about the universe.

**MEASURING RED SHIFTS**

In the 1920s, Hubble found that the spectra of distant galaxies are all red-shifted. Hubble used this red shift to determine how fast the galaxies are moving away from Earth. Hubble found that the most distant galaxies show the greatest red shift. Thus, these distant galaxies are moving away from Earth the fastest. ✓

Modern telescopes with cameras can take images of spectra. These spectra all confirm Hubble’s original observations.

**READING TOOLBOX**

**Summarize** As you read this section, underline sentences that give evidence to support the big bang theory. After you read the section, use the underlined ideas to write a summary of the evidence for the big bang.

**READING CHECK**

**1. Describe** If an object’s spectrum is blue-shifted, what can you conclude about the object’s motion?

\_\_\_\_\_

\_\_\_\_\_

**READING CHECK**

**2. Identify** What did Hubble discover in the 1920s?

\_\_\_\_\_

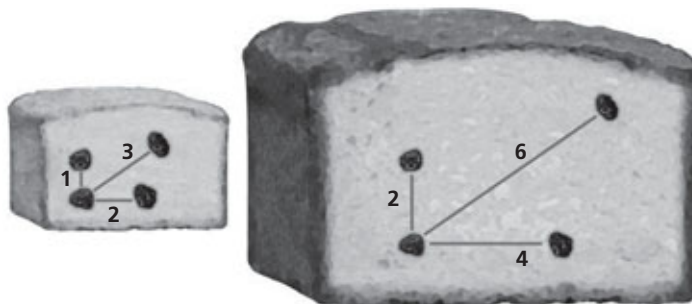
\_\_\_\_\_

\_\_\_\_\_

**SECTION 4 The Big Bang Theory** *continued*

**THE EXPANDING UNIVERSE**

Imagine a raisin cake rising in an oven. If you could sit on one raisin, you would see the other raisins moving away from you. Raisins that are farther away would move away faster. This is because more cake is between you and these distant raisins, and the whole cake is expanding. The situation is similar with galaxies and the universe, as shown below.



Just like these raisins, distant galaxies move away from the observer faster.

**Critical Thinking**

**3. Apply Analogies** Why are distant galaxies moving away from our galaxy more quickly than nearby galaxies are?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**What Is the Big Bang Theory?**

Cosmologists have offered different theories to explain why the universe is expanding. The current and most accepted theory is the **big bang theory**. This theory states that all matter and energy in the universe was once compressed into a very small space. About 14 billion years ago, a sudden event called the *big bang* happened. The big bang sent all of the matter and energy outward in all directions.

As a result, the universe expanded. Some of the matter came together in clumps, which evolved into galaxies. Today, the universe is still expanding. The galaxies continue to move apart from each other. This expansion explains the red shift of distant galaxies. ✓

**READING CHECK**

**4. Describe** How does the red shift of distant galaxies support the big bang theory?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**COSMIC BACKGROUND RADIATION**

A discovery made in the 1960s supports the big bang theory. In 1965, scientists detected **cosmic background radiation**, or low levels of energy, from all directions in space. Astronomers think that this background radiation formed just after the big bang.

The universe has cooled since the big bang. The energy of background radiation has a temperature of about  $-270^{\circ}\text{C}$ . This temperature is only  $3^{\circ}\text{C}$  above absolute zero, which is the lowest temperature possible.

**SECTION 4 The Big Bang Theory** *continued*

**RIPPLES IN SPACE**

Satellite maps of cosmic background radiation show “ripples” in temperature. These ripples show that cosmic background radiation is uneven in some places. This is because matter was not spread evenly in the early universe. The ripples show the early stages of the universe’s first galaxies. ✓

**What Materials Make Up the Universe?**

Astronomers are continuing to research ripples in cosmic background radiation. They are also studying distances to supernovas in ancient galaxies. This research has helped astronomers learn more about the structure of the universe. Astronomers now think that the universe is made of more mass and energy than they can detect.

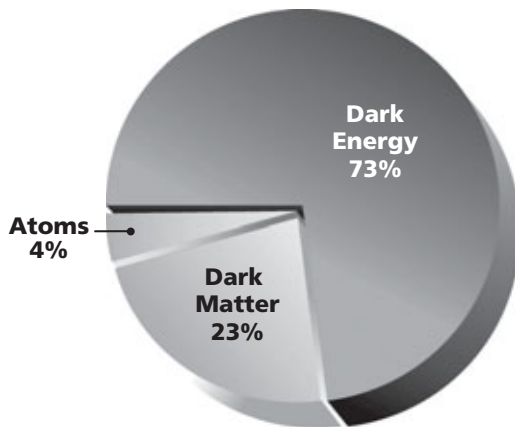
**DARK MATTER**

The ripples in cosmic background radiation show that the universe may contain different types of matter. Regular, visible matter makes up only 4% of the universe. Another 23% of the universe is made of *dark matter*. Dark matter does not emit or reflect light, but scientists can detect its gravity. ✓

**DARK ENERGY**

Research also shows that most of the universe is made of an unknown material called *dark energy*. Dark energy acts as a force against gravity. Scientists think that some form of dark energy is pushing galaxies apart. Dark energy is causing the universe to expand faster and faster.

**Composition of the Universe**



✓ **READING CHECK**

**5. Explain** Why is the cosmic background radiation uneven in some places?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

✓ **READING CHECK**

**6. Explain** How do scientists detect dark matter?

\_\_\_\_\_

\_\_\_\_\_

# Section 4 Review

## SECTION VOCABULARY

**big bang theory** the theory that all matter and energy in the universe was compressed into an extremely small volume that 13 to 15 billion years ago exploded and began expanding in all directions

**cosmic background radiation** radiation uniformly detected from every direction in space; considered a remnant of the big bang  
**cosmology** the study of the origin, properties, processes, and evolution of the universe

**1. Compare** How is cosmology different from astronomy?

---

---

**2. Explain** Describe Edwin Hubble’s observations, and explain how they show that the universe is expanding.

---

---

---

---

**3. Summarize** In your own words, describe the big bang theory for the origin of the universe.

---

---

---

---

**4. Explain** How does the big bang theory explain the existence of cosmic background radiation?

---

---

---

---

**5. Compare** How is dark matter different from regular matter? How are they similar?

---

---