

CHAPTER 19 Stars, Galaxies, and the Universe

SECTION

4

# Formation of the Universe

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What is the big bang theory?
- How is the universe structured?
- How old is the universe?

## How Do Scientists Think the Universe Formed?

Like all scientific theories, theories about the beginning and end of the universe must be tested by observations or experiments. The study of how the universe started, what it is made of, and how it changes is called **cosmology**.

To understand how the universe formed, scientists study the movements of galaxies. Careful measurements have shown that most galaxies are moving away from each other. This indicates that the universe is expanding. Based on this observation, scientists have made inferences about how the universe may have formed. ✓

Imagine that the formation and evolution of the universe was recorded on a video tape. If you rewound the video, the universe would seem to contract. At the beginning of the universe, all matter and energy would be squeezed into one small space. Now imagine running that same video forward. All the matter and energy in the universe would explode and begin to expand in all directions.

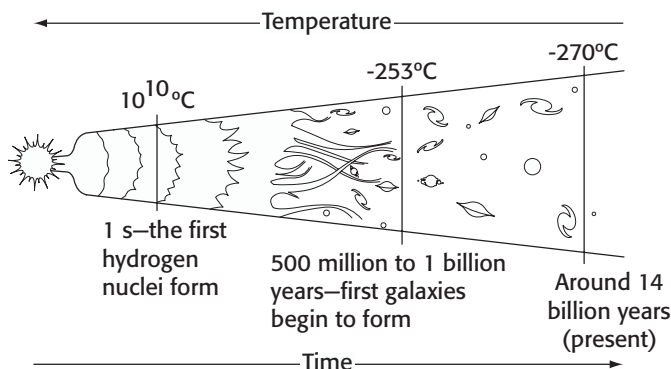
### STUDY TIP

**Predict** Before you read this section, write down your prediction of how scientists think the universe formed and what will happen to it in the future. As you read, take notes on these topics.

### READING CHECK

**1. Complete** Scientists took careful measurements of galaxies and found that the universe is \_\_\_\_\_.

### The Big Bang



Most astronomers think that the big bang caused the universe to expand in all directions.

### TAKE A LOOK

**2. Identify** After the big bang, how did the temperature of the universe change? \_\_\_\_\_

**SECTION 4** Formation of the Universe *continued*

### What Is the Big Bang Theory?

The theory that the universe began with a huge explosion is called the **big bang theory**. It is the scientific model that explains why the universe is expanding. According to this theory, all the contents of the universe were originally squeezed into a very small volume. These contents were at extremely high pressure and temperature. About 14 billion years ago, this small volume rapidly expanded and cooled. ✓

**READING CHECK**

**3. Identify** Where were the contents of the universe before the big bang?

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\_\_\_\_\_

\_\_\_\_\_

Just minutes after the big bang, the following things had already formed:

- the light elements, such as helium
- the forces of nature, such as gravity
- the beginnings of galaxies

#### EVIDENCE FOR THE BIG BANG

All scientific theories must have evidence to support them. The first piece of evidence for the big bang theory is the expansion of the universe. The second piece of evidence is called *cosmic background radiation*.

Scientists use radio telescopes to pick up radiation with long wavelengths. Several decades ago, some scientists noticed a background “noise” coming from all directions in space. They think this cosmic background radiation is energy left over from the big bang. ✓

**READING CHECK**

**4. List** Give two pieces of evidence for the big bang theory.

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### What Is the Structure of the Universe?

The universe contains many different objects. However, these objects are not just scattered around the universe. They are grouped into systems. Every object in the universe is part of a larger system:

- A planet is part of a planetary system.
- A planetary system is part of a galaxy.
- A galaxy is part of a galaxy cluster.

Earth is part of the planetary system called the solar system. Our solar system is part of the Milky Way galaxy.

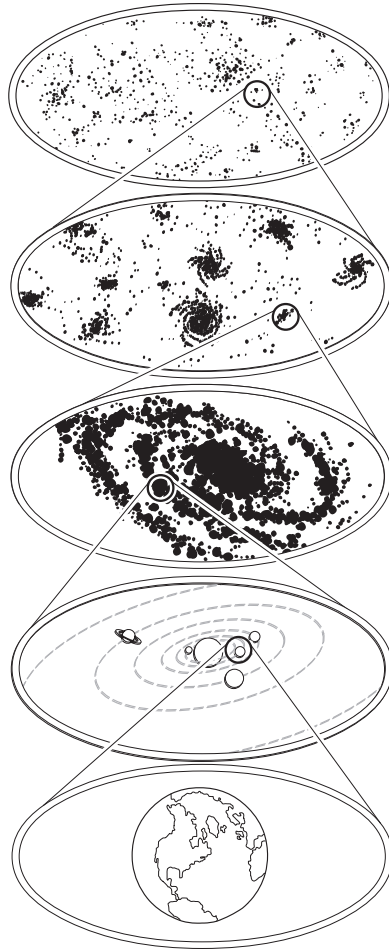
### Critical Thinking

**5. Apply Concepts** Are there probably more planets or more galaxies in the universe? Explain your answer.

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**SECTION 4** Formation of the Universe *continued***TAKE A LOOK**

**6. Label** On the figure, label the systems that make up the structure of the universe.

**How Old Is the Universe?**

Scientists can estimate the age of the universe by studying the oldest stars in the Milky Way galaxy. These stars are white dwarfs. The first stars that formed after the big bang became white dwarfs after about 1 billion years. The oldest white dwarfs are between 12 billion and 13 billion years old. Therefore, scientists think that the universe is about 14 billion years old. ✓

No one knows what will happen to the universe in the future. Some scientists think that the universe will continue to expand, faster and faster. Stars will age and die, and one day, the universe will become cold and dark. Even after the universe becomes cold and dark, it will continue to expand.

 **READING CHECK**

**7. Identify** How old do scientists think the universe is?

\_\_\_\_\_

# 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 billion to 15 billion years ago exploded and began expanding in all directions

**cosmology** the study of the origin, properties, processes, and evolution of the universe

**1. Explain** How does the expansion of the universe support the big bang theory?

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**2. Explain** How is cosmic background radiation related to the big bang theory?

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**3. Identify** List three things that had formed by a few minutes after the big bang.

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**4. Describe** Explain how every object in the universe is part of a larger system.

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**5. Explain** Imagine you are a scientist studying the formation of the universe. How could you estimate the age of the universe?

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