BACKGROUND

The Big Bang and Expansion

Throughout much of astronomical history, the universe was thought to be in a steady state—that is, it was thought to have always existed, and that it would always exist pretty much as it is today. However, the steady-state theory had some problems that could not be explained away.

Objects moving away seem to shift to the red end of the spectrum of light, while objects moving toward us seem to shift more to the blue end.

Redshift, Blueshift

As astronomers at the turn of the twentieth century watched the sky, they noted that the color of certain objects was different when that object was moving toward us or away from us. Objects moving away seemed to shift to the red end of the spectrum of light, while objects moving toward us seemed to shift more to the blue end.

To give you an idea what they were observing, imagine that you are sitting on your front porch as an ambulance comes past your house. As the ambulance approaches, the sound from its siren gets shorter, and higher in frequency, which you hear as a change in pitch. As it passes and goes down the street away from you, the time it takes for one cycle of the siren gets longer, and the pitch decreases as the frequency gets lower. This is called the **Doppler effect**, and scientists use it for all kinds of things having to do with waves, which is what your ears were really experiencing—a difference in sound wave patterns based on whether the ambulance was approaching or receding. The early twentieth-century astronomers, however, weren't hearing the effect, they were seeing it. Light, which behaves as a wave, shortens and increases in frequency as it approaches, causing it to appear more blue. As it recedes, the light wave lengthens and decreases in frequency, making it appear more red.

Except for a few objects, almost everything appeared to be receding from our vantage point on Earth. This was quite a surprise, since it was believed the universe was a pretty static place. By the 1930s, it was quite clear that the universe itself was expanding. The question soon became: If the universe is expanding, didn't it have to all originate at one point in the distant past? The answer was yes, the universe did have a beginning—between 12 and 15 billion years ago, in an explosion called the Big Bang.

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The Early Universe

In the first few minutes after the Big Bang, subatomic particles of extremely high energy rushed outward. As they did, the space between them expanded. The first few minutes is sometimes called the Inflationary Universe, when expansion happened at an accelerated rate. However, the initial rush slowed down, and though the universe is still expanding, it is expanding more slowly now. As the subatomic particles cooled, they were able to form atoms—mostly hydrogen and a little helium—and eventually form larger structures—molecules, clouds of hydrogen gas, stars, planets, and galaxies.

The universe will probably expand for the foreseeable future, slowing down, as stars and galaxies burn themselves out and everything reaches a more or less uniform temperature—absolute zero.

Spacetime

As space was created, time also began, as well as the arrow of time—the idea that time moves forward only. Today, we consider time part of the dimensionality of spacetime. There are three simple spatial dimensions and one time coordinate, which is sometimes called the fourth dimension. Imagine a box. It has height, width, and length—three dimensions. But knowing that gives one an incomplete picture of the box, because it also has a moment when it was created, a moment when it was left in the rain and got soggy, and a moment when it was thrown on the fireplace and burned. It exists in time as well, so time is an important part of our understanding of the nature of the box. All of us, and everything in the universe, exist in spacetime.

If the universe is expanding, will it ever contract? Scientists currently don't think so. There doesn't seem to be enough mass in the universe to force a gravitational contraction. The universe will probably expand for the foreseeable future, slowing down, as stars and galaxies burn themselves out and everything reaches a more or less uniform temperature—and a pretty cold temperature at that. Currently, the average temperature of the universe is only a couple of degrees above absolute zero. When all the stars cool off, the average temperature will be absolute zero.

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Science 8

Name: _____

The Big Bang and Expansion

Answer the following questions in complete sentences.

1. What color light is seen from objects moving away from us?

2. What color light is seen from objects moving toward us?

3. Explain the Doppler effect as it relates to the color of light.

4. Based on the fact that the universe is expanding, what question did scientists answer?

5. In the first few minutes after the Big Bang, the universe expanded at an accelerated rate. What happened as this initial rush of particles and energy slowed down?

6. What is spacetime?

7. What do scientists think will happen to the universe in the future?