Topic 4.4 Assessment

Check Your Understanding Answers

Understanding Key Ideas

1. The redshift of distant galaxies shows that all galaxies are moving away from each other. The cosmic microwave background indicates that energy left over from the big bang is still present in the universe. Both are consistent with the big bang theory.
2. The Doppler effect is a change in the wavelength of an approaching wave due to the source and observer of the wave moving toward or away from each other. A siren on a vehicle moving toward an observer has sound waves that appear shortened to the observer. This corresponds to a higher frequency and so a higher pitch.
3. The blueshifted light from the Andromeda galaxy indicates that the Milky Way and the Andromeda galaxies are moving toward each other.
4. Spectral lines move toward the red end of the spectrum when the light is redshifted. The greater the redshift the greater the speed the galaxy is moving away.
5. The speed at which distant galaxies are moving away from Earth is proportional to their distance from Earth.
6. Hubble's law states that the speed at which distant galaxies are moving away from Earth is proportional to

   their distance from Earth. In other words, the farther the galaxies are away, the faster they are moving away.

7. The tremendous radiant energy of the universe was affected by the expansion of space. The expansion causes

   the waves of light to increase in wavelength. This changes the energy into longer-wavelength, lower-energy radiation. With the current amount of expansion present in the universe, these waves are now of a wavelength that corresponds to microwave radiation.

8. When dots are drawn on the surface of a balloon, and the balloon is then inflated, every dot moves away from every other dot due to the stretching of the surface of the balloon. Galaxies are like the dots on the balloon, and every (distant) galaxy moves away from every other distant galaxy.
9. Dark matter is inferred to be a form of matter that has mass, and therefore gravity, but is unlike ordinary matter in that it does not interact with light. This makes it invisible to observers. Its presence, however, is detected by its effects on ordinary matter. It is important to understanding the structure and evolution of the universe because of its abundance. There is about five times as much dark matter as there is ordinary matter.
10. Dark energy was hypothesized to explain the observation that distant stars of known brightness appear even dimmer than expected. This is thought to result from an acceleration in the expansion of the universe, and dark energy is thought to drive this expansion.

Connecting Ideas

11. Variations in colour of the image represent tiny variations in the amount of microwave radiation.
12. The universe started out very hot. After electrons and protons came into existence, light rays could not travel

any distance without encountering these forms of matter. At 380 000 years, cooling was sufficient that electrons and protons could combine into neutral atoms. At this point light could pass freely throughout the universe for the first time. This is the light we detect today with our telescope, and so is the first opportunity to see anything in the early universe.

13. For example: If all the students could stand on their own tile, all crowded together, and then the tiles themselves could be made to move apart from every other tile, then the students would be seen to be moving apart just by remaining motionless on their tile.

Making New Connections

14. The article should include that the big crunch theory suggested that gravity would eventually win out over expansion and that everything would eventually collapse and recombine, leading to a possible new big bang. This theory was ruled out in 1998 when the accelerating expansion of the universe was discovered. The steady state theory was promoted by astrophysicist Fred Hoyle, who coined the term big bang theory as a derogatory expression. He hypothesized that matter constantly came into the universe and also left it at a steady continuous pace. The discovery of the cosmic microwave background ruled out his hypothesis in the 1960s. The big bang theory involving an accelerating expansion is consistent with the evidence we now have.
15. For example: The universe began about 13.8 billion years ago as a small dense hot place that expanded quickly and cooled. During this time matter came into existence and over billions of years collected by gravity and combined and changed to form all the matter and energy that we see today. Evidence from the redshifted light from galaxies and the cosmic microwave background indicates that the universe is expanding and continues to cool. There appears to be no centre of the universe (alternately, every place is equally at the centre). We are simultaneously of infinite value and importance, and yet, if the entire Milky Way Galaxy suddenly disappeared, on the broadest of scales it wouldn't even be noticeable.