Answers to Unit 4 Review Questions

Note: If you are using the first printing of the textbook, you will see two questions labelled number 5. In subsequent printings of the textbook, this will be corrected. The answers below assume the corrected numbering sequence.

1. a) Low-mass star: nebula, dim star, white dwarf, black dwarf
   b) Intermediate-mass star: nebula, protostar, yellow main sequence, red giant, white dwarf, black dwarf c) High-mass star: nebula, main sequence yellow, white, or blue star, red or blue supergiant, supernova, neutron star or black hole (heaviest stars)
2. Accept all reasonable representations, such as the one shown on page 343 of the text. Additional information could show that as red giants shrink to a white dwarf, the outer layers produce drift away from the star producing a planetary nebula.
3. The graphic organizer with the simplest possible visual representation of the most important elements of the big bang is shown in the text on pages 360–361.
4. For example: Figure 4.20 of the Milky Way seen from Earth. The light takes thousands of years to reach us. Figure 4.42 CMB. The radiation is cold and spread out. Light is reaching us in this image from the most distant places in the universe. Figure 4.21 Galaxies. The universe must be vast to fit them all in. For the favourite image, accept all logical answers.
5. Students' answers may vary but could include
   a) Alnilam: blue supergiant; Betelgeuse: red supergiant; Rigel: blue supergiant; Bellatrix: giant; Salph: supergiant; Alpha Orionis: red giant
   b) Orion's belt stars: Alnitak, Alnilam, Mintaka; Orion's sword stars: 42 Orionis, Theta Orionis, Iota Orionis c) Some examples: ancient Babylon: heavenly shepherd; ancient Egypt: the god Dah; ancient China: Shen; Ojibwe: Wintermaker.
6. For example: Constellations are patterns of stars in the sky. They appear to be affixed to a large dome that surrounds Earth, referred to as the celestial sphere. As Earth rotates, it appears as if the celestial sphere moves. The Sun's path follows an imaginary line on the celestial sphere called the ecliptic.
7. Objects noted by students should include the Sun, Moon, stars, and the planets Mercury, Venus, Mars, Jupiter, and Saturn; some students might also include meteors and comets. Their definitions, in their own words, will likely be very similar to those provided below. Sketches will probably feature the solar system.
   Sun: the star around which Earth orbits

   Moon: natural satellite that orbits Earth
   Stars: bright points of light visible in the night sky; spheres of glowing gases Planets: celestial bodies that move in elliptical orbits around a star

8. For example: The big bang is a process of evolution of the universe from a small hot state to a large cool one full of matter in the form of dust, stars, galaxies, dark matter, ordinary matter, and dark energy. Expansion of space caused the energy of the big bang to spread out and cool off. Today this is observed as the cosmic microwave background. The expansion of space may be driven by dark energy. Because of the expansion of space, light from distant galaxies is redshifted. Nearby galaxies such as Andromeda are attracted to the Milky Way by gravity and are moving toward us; their light is blueshifted.
9. The stars and constellations appear to rotate about a central point. The point aligns to Earth's rotational axis. As Earth spins, so does the celestial sphere.

10. Students' answers could include reference to differences in brightness, size, age, and/or distance from Earth. In addition, atmospheric effects on Earth may affect the apparent brightness of stars.
11. It is a radio telescope and views space in different wavelengths than visible light. It is unaffected by atmospheric effects, or sunlight.

12. Both sound and light have wavelengths. When an observer is moving toward the source, the wavelength appears shortened. This results in a high pitch for sound and a bluer colour for light.
13. Our Sun will not become a black hole as it does not have sufficient mass to become a supernova. Instead, after going through a few billion years as a red giant, it will shrink into a white dwarf that is expected to cool over the next 100 billion years.
14. The early universe was hot but small. Due to the expansion of space and the stretching out of the wavelengths of radiation from very short to very long, low-energy waves, the radiation was in effect diluted in the vast expanse of the universe today. This manifests as a cooler universe.
15. For example: Stars and constellations appear to rise in the east and set in the west just like the Sun. Numerous constellations point to Polaris, the North Star. Stars have been used for navigation for millennia because their distances make them appear to be stationary, so they can be used for reference.
16. a) The circular pattern of star trails shows revolution around a central focus. The apparent motion of stars is due to Earth's rotation. The North Star, Polaris, aligns with Earth's axis of rotation, due north. It is an optical illusion that the celestial sphere rotates.
    b) Polaris, the North Star
17. All stars produce new elements, but only the more massive ones explode to form the nebulas that seed the universe with heavier elements.
18. White dwarfs are hot because they are the remnant cores of red giants that had core temperatures in excess of 100 million degrees. Despite being brilliantly hot at their surfaces they are also extremely small, about the size of Earth. The small surface area makes them relatively dim.
19. The spectrum of light from a distant galaxy can indicate what elements are present in the galaxy and, by its redshift, indicate how fast the galaxy is moving away from us.
20. Students' answers could include i) people needing to navigate can find the Big Dipper (Ursa Major) and use the pointer stars to locate Polaris, which will show the traveller due north; ii) the end of the Little Dipper's handle (Ursa Minor) is Polaris, the North Star.
21. Hubble's law says that the rate at which distant galaxies move away from an observer is proportional to the distance. In other words, as with dots placed on a stretching rubber sheet, doubling the distance stretched doubles the rate at which a dot is moving away.
22. a) Altitude is the distance (in degrees) an object is above the horizon. Azimuth is the distance, in degrees, away from true north.
    b) Students' answers could include i) students have different-sized hands; ii) it is difficult to keep hands motionless when adding fists one at a time; iii) eyesight may play a role in inaccuracy; iv) parallax errors can lead to inaccuracies.
23. For example the Crab Nebula, which formed in a supernova explosion. It may have resulted from the explosion of a star about 10 times more massive than the Sun. It is a beautiful nebula, roughly spherical but with many interesting details. At its centre is a neutron star, which is spinning rapidly and sending out streams of X-ray, making it a pulsar.
24. Red giants are on the top right of the H-R diagram because, though cool on the surface, making them red, they are enormous stars which makes them bright. This moves them off the main sequence. Similarly, white dwarfs are on the bottom left of the H-R diagram and though they are extremely hot on their surface, they are not bright relative to other stars because they are so small (about the size of Earth).
25. Students could consider how knowledge of the skies applied to successful gathering of food resources, and how important sky observations were for the timing of seasonal harvesting activities. Other topics to consider are navigation and ways of travelling on the land and sea, and predicting the weather.

26. No. The ecliptic is due to Earth's rotation. If Earth did not rotate, the Sun would not move through the sky, and the planets would not follow the Sun's path.
27. Blueshifted light would be heard as a higher pitch of sound and redshifted light would be heard as a lower pitch of sound. The ability to mix senses in this way is called synesthesia.
28. The galaxy is not moving relative to ours. The galaxy is spinning, and as stars move toward our galaxy, that light is blueshifted. The stars currently moving away from us have light that is redshifted. Most of the stars

have no shift at all, which shows the galaxy is not moving relative to ours. These measurements could be used to determine the rate of rotation of the galaxy.

29. You would need a clock to tell you where the stars' positions are at a particular time. Because Earth is rotating, the stars' apparent position changes throughout the night.
30. The position of Polaris does not change because it is aligned to Earth's axis of rotation. It is the point around which Earth spins.
31. Students' answers could include reference to the evolution of technology. As technology improves our ability to see fainter and fainter light, we see deeper into space. Because space is so immense, light takes a lot of time to reach observers on Earth. The farther you look into space, the farther back in time you are looking, to a time when the light originated billions of years in the past.
32. Students' answers could include i) the solar system and the Milky Way both revolve around a centre; ii) the centre of the solar system is the Sun, the centre of the Milky Way is believed to be a black hole, the motion of stars of the Milky Way simulate the motion of the planets in the solar system; iii) gravity is the force that keeps stars in a galaxy, and planets in a solar system (it should be noted that phenomena like dark matter and dark energy may also contribute to maintaining the structure of a galaxy).
33. If possible, facilitate a visit or meeting with local First Nations language teachers, Elders, or the Aboriginal Education department in your school or district to learn words that relate to ancient astronomers or sky observers.
34. a) A globular cluster is a group of thousands or millions of stars tightly bound by gravity and in close proximity to each other.
    b) Globular clusters were seen to be in a similar place in the sky as viewed from Earth. It was reasoned that they were close to the centre of the galaxy, which then meant that Earth was nowhere near the galactic centre.
35. For example, use several identical candles. In this way, the flicker of the flame can represent distortions in the light due to the atmosphere or dust in space affecting the light gathering. Using a camera, photograph two burning candles at the same distance from the camera. Note the distance. Then move one candle farther away and photograph both again in the same shot. Repeat this process. It is expected that the more distant candle will be less bright.
36. a) The stars in the band are in the Milky Way galaxy.
    b) The globular clusters are located near the centre of the Milky Way galaxy, which appears in one spot in the band referred to in part a).
37. a) Student answers may vary. For example: Bromley, A. G. (1990). "The Antikythera Mechanism." *Horological Journal 132*: 412–415. Ensure that students cite the sources of their references. The mechanism was able to pinpoint the position of the Sun and the Moon decades into the future.
    b) Accept all logical responses. For example, the above reference is in a peer-reviewed journal.
38. a) Proxima Centauri (4.2 light-years) .0014 years
    b) centre of the Milky Way (25 000 light-years) 8.3 years c) Andromeda galaxy (2.537 million light-years) 846 years
39. The TMT International Observatory project was approved in September 2017, but was challenged in Hawaii Supreme Court in June 2018. At this writing a judgment had not been delivered. Students can begin their research by finding out the current status of the project. To mediate the issue, students will need to gather background information. They can consider questions such as the following:

- What sacred features would be disturbed if the telescope is built? (There are significant prehistoric shrines that circle the top of the plateau; see http://www.mauna-a-wakea.info/maunakea/F5_ shrines.html.)

- What makes Mauna Kea a preferred site for an observatory? (high altitude and dry atmosphere)
- How would the new telescope impact the land and the sacred places? (e.g., The building could destroy

shrines in the Ring of Shrines. A large number of telescopes are already on the mountain. Native Hawaiians fear if this one is allowed, more and more telescopes will be built. The destruction of the shrines could mean a loss of knowledge that ancient Hawaiians held about the stars.)

- How do native Hawaiians connect their cultural history as oceangoing navigators with the science of astronomy and this project? (e.g., their ancestors navigated the ocean by the stars to reach Hawaii, so they support astronomical research, but not this project)

Students should be able to locate a variety of online sources to learn more about the issue. A suggested source is a PBS page including a video and transcript the covers both sides of the issue: The sacred and the scientific clash on Hawaii's Mauna Kea. PBS 2016 https://www.pbs.org/newshour/show/sacred-scientific-clash- hawaiis-mauna-kea

40. Students' answers could include references to health, education, transportation, entertainment, and technological advancement.
41. Students' answers could include the idea that what we witness in youth may affect the course of our lives later on. Inspiration can come from many sources, even entertainment. Creative minds will find any catalyst to motivate themselves. There can be little doubt that science fiction and fantasy have fuelled creativity, stimulated future scientists, and inspired astronauts for generations.