Worksheet answers

Part 1: Star clusters

1. Why do star clusters contain different coloured stars even though they were formed from the same gas cloud?

   More massive stars burn up quicker than low-mass stars, so they have shorter life spans. They reach different stages in their life cycle sooner than low mass stars and emit different colours of light.

2. Why are some stars in a cluster brighter than others?

   Stars in a star cluster vary in brightness because of differences in their mass. More massive stars appear brighter.

3. Why are star clusters of particular interest to astronomers?

   Star clusters are important to astronomers because they contain a group of stars that formed from the same gas cloud, at about the same time, at similar distance from Earth. Because of these properties several variables that affect stars' brightness can be eliminated and astronomers can focus on what causes observed differences between stars in a cluster.

Part 2: Star colours

4. The Sun and Alpha Centauri A are yellow dwarf stars. They will eventually become red giant stars. What does this tell us about their surface temperature now and in the future?

   As yellow dwarf stars, their surface temperature is 5200 – 6000 K. When they become red giants, their surface temperatures will fall to below 3700 K.

5. Use the information in Table 1 to compare the surface temperatures and colours of Betelgeuse and Rigel.

   Betelgeuse is an orange-red star with a surface temperature of 3000 – 5200 K. Rigel is blue-white star with surface temperature above 7500 K.

Part 3: Star life cycles

6. What property of a star mainly determines the future stages in its life cycle?

   A star's future is mainly determined by its mass. While all stars evolve to become red giants, only higher-mass stars explode in supernovae to form a neutron star or black hole.

7. For a star whose mass is ten times that of our Sun, arrange the following into the correct sequence for its future life cycle and briefly describe each stage:

STAGE OF A STAR'S LIFE CYCLE	Stage 1: **red supergiant**	Stage 2: **supernova**	Stage 3: **black hole**
DESCRIPTION	*This is a giant star with low surface temperature.*	*This is an exploding star that flings gas and dust into space, creating new elements.*	*This is the collapsed core of a giant star that has disappeared from sight into a region of intense gravity from which nothing, not even light, can escape.*

8. What is likely to happen to our Sun after it finishes the current stage of its life cycle?

   In the next stage of our Sun's evolution it will become a red giant, during which time it will grow to enormous size and its surface temperature will fall. After this its core will collapse and it will expel its outer layers to form a planetary nebula. The Sun's core will form a white dwarf and eventually cool to form a black dwarf.

9. 'Main sequence' stars fuse hydrogen atoms together to make helium. What causes a main sequence star to change and become a red giant star?

   When a star uses up all of hydrogen in its core, and is no longer generating heat, its core becomes unstable and collapses. The star's outer shell expands, cools and glows red. The star grows to become a red giant star when it starts 'burning' helium.

10. What are supernovae? What causes them?

    Supernovae are exploding stars that shoot materials and radiation into space. Supernovae are extremely luminous objects whose emissions can sometimes outshine a whole galaxy before fading from view after a few weeks or months.

    Supernovae are caused when stars release huge amounts of energy by burning helium to make heavier elements.

11. What is a neutron star?

    A neutron star is formed when a large star collapses into a very small volume following a supernova explosion. Gravity in the central region of the star is so great that protons and electrons can no longer exist separately, but are forced together to form neutrons.

    Information for teachers

    Neutron stars typically have a mass about 1.5 to 3 solar masses packed into a 10–20 kilometre diameter sphere. Their gravity is about 2×10^{11} times as strong as Earth's. Neutron stars are so dense that one-teaspoonful of their matter would weigh a billion tonnes on Earth.

12. What do astronomers mean by the term 'black hole'?

    A black hole is a region of space where gravity is so strong that nothing, not even light itself, can escape. Black holes can't be observed directly. Their existence is inferred from observations of interactions with objects in nearby space.

Research questions

1. What will happen to Mercury, Venus and Earth when the Sun starts to develop into a red giant star?

   When the Sun starts to become a red giant star, it will grow in size to such an extent that it will swallow up the inner planets. As it grows, Mercury, Venus and Earth will be engulfed. But long before Earth is swallowed up its surface temperature will increase, its liquid water will vaporise and all life forms will be killed off. The good news is that this won't happen for at least a few billion years!

   Information for teachers

   In approximately 5 billion years the Sun will become a red giant with a radius at least 200 times its current size, engulfing the orbits of Mercury and Venus. It is likely that Earth will also be engulfed before the Sun reaches its greatest size.

Before this happens, Earth's biosphere will be destroyed by the Sun's increased energy output. In about 3 billion years, the Sun's radiation will vaporise Earth's oceans. Our atmosphere[1] and lithosphere[2] will become like that of Venus. After a further billion years, most of our atmosphere will have gone, leaving Earth as a dry, dead planet with a surface of molten rock.

2. Astronomers and astrophysicists believe that there is a supermassive black hole at the centre of every galaxy. How can they know this when they can't actually see black holes?

   The only way to detect a black hole is to see how it affects space around it. Astronomers usually infer the presence of black holes from gravitational effects on companion stars or from bursts of energy released when matter is drawn into a black hole.

   Information for teachers

   Astronomers have convincing evidence for a supermassive black hole in the centre of the giant elliptical galaxy M87, as well as several other galaxies. These discoveries are based on velocity measurements of streams of hot gas orbiting a black hole. In 1994, Hubble Space Telescope data enabled astrophysicists to measure the mass of an invisible object at M87's centre. Based on the kinetic energy of material whirling around it, the object is about 3 billion times the mass of our Sun and appears to be concentrated into a space smaller than the Solar System. They concluded the object must be a supermassive black hole.

   Source:
   http://amazing-space.stsci.edu/resources/explorations/blackholes/teacher/sciencebackground.html#9

3. Hydrogen, helium and small amounts of lithium were formed during the Big Bang. Where did elements like gold and uranium come from and how did they reach Earth?

   All of the heavier elements were created in the cores of stars through nuclear fusion reactions. When high-mass stars explode in supernovae, heavier elements like gold and uranium are blasted out through the Universe.

4. Six elements (oxygen, carbon, hydrogen, nitrogen, calcium and phosphorous) make up 99% of the human body. To what extent can we say 'we are made of stardust'?

   We are made of the same elements as stars. Elements other than hydrogen (O, C, N, Ca and P) were synthesized in stars and ejected in supernovae. They were subsequently incorporated into new generations of stars, planets and life forms that originate on them.

   Because of this, it is true to say that we are made of stardust.

[1] The atmosphere on Venus is extremely dense. Greenhouse effects raise its surface temperatures to more than 740 K with atmospheric pressure up to 90 times that of Earth.

[2] Venus has a relatively flat surface with some evidence of volcanic activity. There are no small craters because small meteoroids burn up in Venus' atmosphere before reaching the surface.