



National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TĀEA

Exemplar for Internal Achievement Standard

Earth and Space Science Level 3

This exemplar supports assessment against:

Achievement Standard 91415

Investigating an aspect of astronomy.

An annotated exemplar is an extract of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at the grade boundaries.

New Zealand Qualifications Authority

To support internal assessment

	Grade Boundary: Low Excellence
1.	<p>For Excellence, the student needs to investigate comprehensively an aspect of astronomy.</p> <p>This involves explaining the key links between the astronomy aspect and the key science.</p> <p>This student has conducted a comprehensive investigation by explaining how Red Dwarfs occur (1), explaining the science behind Red Dwarfs (2), and showing how the process within a Red Dwarf leads to star stability and possible intelligent life on planets around it (3).</p> <p>For a more secure Excellence, the student could explain comprehensively how convection currents within a Red Dwarf lead to mixing of the hydrogen and helium and therefore maintain a stable environment and that excess heat is not locked into the core as around bigger stars.</p>

Please note – This is an extract from one student's response

Red Dwarfs and Barnard's star.

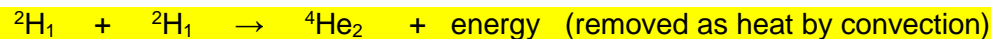
Their origin and significance to astronomy.

What is a Red Dwarf?

A red dwarf is a small and relatively cool star on the main sequence, being a M spectral type. Red dwarfs range in mass from a low of 0.075 solar masses (M_{\odot}) to about 0.50 M_{\odot} and have a surface temperature of less than 4000 K. Our sun has 1 solar mass (M_{\odot}) and a surface temperature of 6000 K.

Red dwarfs are by far the most common type of star in our galaxy but because they are dull, individual red dwarfs cannot easily be observed. From Earth, not one is visible to the naked eye. Proxima Centauri, the nearest star to the Sun, is a red dwarf, as are twenty of the next thirty nearest. Red dwarfs make up three-quarters of the stars in the Milky Way.

Models indicate that red dwarfs less than 0.35 M_{\odot} are fully convective. This means heat from the core is carried to the surface by convection currents. Our sun gets heat from the core to the surface by conduction and radiation. In a Red dwarf the helium produced by the thermonuclear fusion of hydrogen is constantly remixed throughout the star, avoiding a buildup at the core. The temperature in the core is several million degrees and at this temperature two atoms of deuterium combine to form helium and release energy.



Red dwarfs therefore develop very slowly, having a constant brightness and spectral type for, in theory, some trillions of years, until their fuel is depleted. Because of the comparatively short age of the universe, no red dwarfs of advanced evolutionary stages exist.

What processes are taking place in a Red Dwarf?

Red dwarfs are very-low-mass stars. Consequently they have relatively low temperatures in their cores and energy is generated at a slow rate through nuclear fusion of hydrogen into helium. These stars emit little light. In general, Red dwarfs less than 0.35 M_{\odot} transport energy from the core to the surface by convection. Convection occurs because of opacity of the interior, which has a high density compared to the temperature. As a result, energy transfer by radiation is decreased, and instead convection is the main form of energy transport to the surface of the star. Above this mass, the red dwarfs will have a region around their core where convection does not occur.

Because late-type red dwarfs are fully convective, helium does not accumulate at the core and, compared to larger stars such as the Sun, they can burn a larger proportion of their hydrogen before leaving the main sequence. As a result, red dwarfs have estimated lifespans far longer than the present age of the universe, and stars less than 0.8 M_{\odot} have not

had time to leave the main sequence. The lower the mass of a red dwarf, the longer the lifespan. It is believed that the lifespan of these stars exceeds the expected 10 billion year lifespan of our Sun. As the proportion of hydrogen in a red dwarf is consumed, the rate of fusion declines and the core starts to contract. The gravitational energy released by this size reduction is converted into heat, which is carried throughout the star by convection. ②

Barnard's star. An ancient Red Dwarf.

Barnard's Star is a very low-mass red dwarf star about six light-years away from Earth in the constellation of Ophiuchus. Barnard's Star is the fourth-closest known individual star to the Sun, after the three components of the Alpha Centauri system. Despite its proximity, Barnard's Star, at a dim apparent magnitude of about nine, is not visible with the unaided eye; however, it is much brighter in the infrared than it is in visible light. Barnard's star is thought to be 10 billion years old and older than our galaxy. It must have been captured from elsewhere. Barnard's star is travelling towards us at a very high speed. It will become closer to us than Proxima Centauri. ①

Barnard's star emits most of its radiation as infrared light and emits almost no ultraviolet light. Red dwarfs are often covered by starspots, reducing stellar output by as much as 40% for months at a time. At other times, some red dwarfs, called flare stars, can emit gigantic flares, doubling their brightness in minutes. These are the result of the convection currents. Barnard's star was thought to have no flares, due to its age, but one was observed in 2011. ②

The significance of Red Dwarfs to astronomy.

Although intelligent life formed around a "G" star for us astronomers think that life will most likely be found around a Red Dwarf. Primarily because their energy loss is consistent over time and the long age they can exist too. Many red dwarfs are orbited by extrasolar planets. Planetary habitability of red dwarf systems is subject to some debate. In spite of their great numbers and long lifespans, there are several factors which may make life difficult on planets around a red dwarf. First, planets in the habitable zone of a red dwarf would be so close to the parent star that they would likely be tidally locked. This would mean that one side would be in perpetual daylight and the other in eternal night. This could create enormous temperature variations from one side of the planet to the other. Such conditions would appear to make it difficult for forms of life similar to those on Earth to evolve and it appears there is a great problem with the atmosphere of such tidally locked planets. The perpetual night zone would be cold enough to freeze the main gases of their atmospheres, leaving the daylight zone dry and uninhabitable. On the other hand, recent theories propose that either a thick atmosphere or planetary ocean could potentially circulate heat around such a planet. Alternatively, a moon in orbit around a gas giant planet may be habitable. It would circumvent the tidal lock problem by becoming tidally locked to its planet, not the star. This way there would be a day/night cycle as the moon orbited its planet, and there would be distribution of heat. Intelligent life can therefore evolve and last for a long period of time. Who knows they may be watching us. Red Dwarfs are the most common star type in our galaxy. They emit energy as heat and can be long lasting. They can potentially survive trillions of years. They tend to be stable because they convect heat from the core. Intelligent life could be found on planets or moons around a Red Dwarf. ① ③

	Grade Boundary: High Merit
2.	<p>For Merit, the student needs to investigate in depth an aspect of astronomy.</p> <p>This involves explaining the key science relevant to the astronomical aspect.</p> <p>This student has conducted an in depth investigation by explaining what Red Dwarfs are (1) and the science behind the formation of Red Dwarfs (2).</p> <p>For Excellence, the student could comprehensively explain how Red Dwarfs are able to convert hydrogen to helium and maintain a constant atmosphere due to convective mixing.</p>

Please note – This is an extract from one student’s response

Red Dwarfs and Barnard’s star.

Their origin and significance to astronomy.

What is a Red Dwarf?

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Red dwarfs are by far the most common type of star in our galaxy but because they are dull, individual red dwarfs cannot easily be observed. From Earth, not one is visible to the naked eye. Proxima Centauri, the nearest star to the Sun, is a red dwarf, as are twenty of the next thirty nearest. Red dwarfs make up three-quarters of the stars in the Milky Way.

Models indicate that red dwarfs less than 0.35 M_{\odot} are fully convective. This means heat from the core is carried to the surface by convection currents. Our sun gets heat from the core to the surface by conduction and radiation. In a Red dwarf the helium produced by the thermonuclear fusion of hydrogen is constantly remixed throughout the star, avoiding a buildup at the core. Red dwarfs therefore develop very slowly, having a constant brightness and spectral type for, in theory, some trillions of years, until their fuel is depleted. Because of the comparatively short age of the universe, no red dwarfs of advanced evolutionary stages exist. ①

What processes are taking place in a Red Dwarf?

Red dwarfs are very-low-mass stars. Consequently they have relatively low temperatures in their cores and energy is generated at a slow rate through nuclear fusion of hydrogen into helium. These stars emit little light. In general, Red dwarfs less than 0.35 M_{\odot} transport energy from the core to the surface by convection. Convection occurs because of opacity of the interior, which has a high density compared to the temperature. As a result, energy transfer by radiation is decreased, and instead convection is the main form of energy transport to the surface of the star. Above this mass, the red dwarfs will have a region around their core where convection does not occur. ②

Because late-type red dwarfs are fully convective, helium does not accumulate at the core and, compared to larger stars such as the Sun, they can burn a larger proportion of their hydrogen before leaving the main sequence. ①

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Barnard's star emits most of its radiation as infrared light and emits almost no ultraviolet light. Red dwarfs are often covered by starspots, reducing stellar output by as much as 40% for months at a time. At other times, some red dwarfs, called flare stars, can emit gigantic flares, doubling their brightness in minutes. These are the result of the convection currents. Barnard's star was thought to have no flares, due to its age, but one was observed in 2011. ②

The significance of Red Dwarfs to astronomy.

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	Grade Boundary: Low Merit
3.	<p>For Merit, the student needs to investigate in depth the key science relevant to an astronomical event.</p> <p>This involves explaining the key science relevant to the astronomical aspect.</p> <p>This student has conducted an in depth investigation by explaining how Red Dwarfs occur (1), and explaining some of the science behind a Red Dwarf (2).</p> <p>For a more secure Merit, the student could explain in depth how convection currents within a Red Dwarf help maintain a stable environment within the star, and how this lasts a very long time without destroying the star.</p>

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Models indicate that red dwarfs less than 0.35 M_{\odot} are fully convective. Our sun gets heat from the core to the surface by conduction and radiation. In a Red Dwarf the helium produced by the thermonuclear fusion of hydrogen. (2)

What processes are taking place in a Red Dwarf?

Red dwarfs are very-low-mass stars. Consequently they have relatively low temperatures in their cores and energy is generated at a slow rate through nuclear fusion of hydrogen into helium. These stars emit little light. In Red Dwarfs energy transfer by radiation is decreased, and instead convection is the main form of energy transport to the surface of the star. Because Red dwarfs have estimated lifespans far longer than the present age of the universe, and (2) stars less than 0.8 M_{\odot} have not had time to leave the main sequence. The lower the mass of a red dwarf, the longer the lifespan. It is believed that the lifespan of these stars exceeds the expected 10 billion year lifespan of our Sun.

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	Grade Boundary: High Achieved
4.	<p>For Achieved, the student needs to investigate an aspect of astronomy.</p> <p>This involves:</p> <ul style="list-style-type: none">• selecting and processing a wide range of reliable information related to the astronomical aspect and the relevant science.• explaining the astronomical aspect. <p>This student has conducted an investigation by explaining Red Dwarfs (1) and the key science of these stars burning hydrogen to helium (2).</p> <p>For Merit, the student could explain the science behind the Red Dwarfs and comment on how this hydrogen-helium mixture generates heat within a Red Dwarf, and how it get to the surface by convection currents.</p>

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What processes are taking place in a Red Dwarf?

Red dwarfs are very-low-mass stars. Consequently they have relatively low temperatures in their cores and energy is generated at a slow rate through nuclear fusion of hydrogen into helium. These stars emit lots of heat instead of light. ②

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They can potentially survive trillions of years. They tend to be stable because they convect heat from the core. Intelligent life could be found on planets or moons around a Red Dwarf.

	Grade Boundary: Low Achieved
5.	<p>For Achieved, the student needs to investigate an aspect of astronomy.</p> <p>This involves:</p> <ul style="list-style-type: none">• selecting and processing a wide range of reliable information related to the astronomical aspect and the relevant science.• explaining the astronomical aspect. <p>This student has conducted an investigation into an astronomical aspect by explaining what Red Dwarfs are (1).</p> <p>For a more secure Achieved, the student could explain how Red Dwarfs operate, for example how Red Dwarfs fuse hydrogen into helium and the heat produced warms the star.</p>

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	Grade Boundary: High Not Achieved
6.	<p>For Achieved, the student needs to investigate an aspect of astronomy.</p> <p>This involves:</p> <ul style="list-style-type: none">• selecting and processing a wide range of reliable information related to the astronomical aspect and the relevant science• explaining the astronomical aspect. <p>This student has conducted an investigation into an astronomical aspect by describing what Red Dwarfs are (1).</p> <p>To reach Achieved, the student could explain the processes occurring within the star to fully explain the astronomical aspect.</p>

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