

Exemplar for Internal Achievement Standard Biology Level 2

This exemplar supports assessment against:

Achievement Standard 91155

**Demonstrate understanding of adaptation of plants or animals to their
way of life**

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

New Zealand Qualifications Authority

To support internal assessment from 2014

	Grade Boundary: Low Excellence
1.	<p>For Excellence, the student needs to demonstrate comprehensive understanding of adaptation of plants or animals to their way of life.</p> <p>This involves linking several biological ideas, which may include justifying, evaluating, comparing and contrasting, or analysing. In the context of understanding adaptation as it relates to one life process over three taxonomic or functional groups of multi-cellular plants or animals, links between biological ideas must consider these two points:</p> <ul style="list-style-type: none"> • comparing diversity of adaptation in response to the same demand across different taxonomic or functional groups. • considering the limitations and advantages involved in each feature within each organism. <p>This student has described (1) and provided biological reasons to explain how and why adaptations (2) enable fish to carry out gas exchange in order to survive (4) in water (3). The student has given some biological ideas about diversity of adaptation, and about limitations and advantages involved in features for gas exchange, comparing fish, humans and insects (5).</p> <p>For a more secure Excellence, the student could consider a more thorough comparison of the diversity of adaptation in response to the demand for oxygen across the three groups, and in particular, the limitations and advantages in the gas exchange system of insects.</p>

Please note – These are extracts from one student's response

4

All living organisms respire. Cells need and use the energy that is formed through this process to assist with life processes in order for organisms to survive and reproduce. Oxygen and carbon dioxide are the main gases involved in aerobic respiration. Gas exchange is a physical process by which oxygen is extracted from the air and into the bloodstream, while carbon dioxide is simultaneously released. Gas exchange is the diffusion of these gases into and out of cells, and this is essential for respiration to occur.

For diffusion and therefore gas exchange to occur quickly there must be a large surface area to volume ratio for the gas exchange to take place, a partial pressure gradient for the gases to diffuse down, a thin surface that gases can diffuse rapidly across and a moist surface that gases can dissolve and diffuse into and out of. These conditions are called gas exchange surfaces.

2

Reptiles, mammals and fish are vertebrates which all require oxygen (O_2) to survive, and all carry out gas exchange. They have different ways of carrying this out, related to their habitat in order to occupy a specific ecological niche.

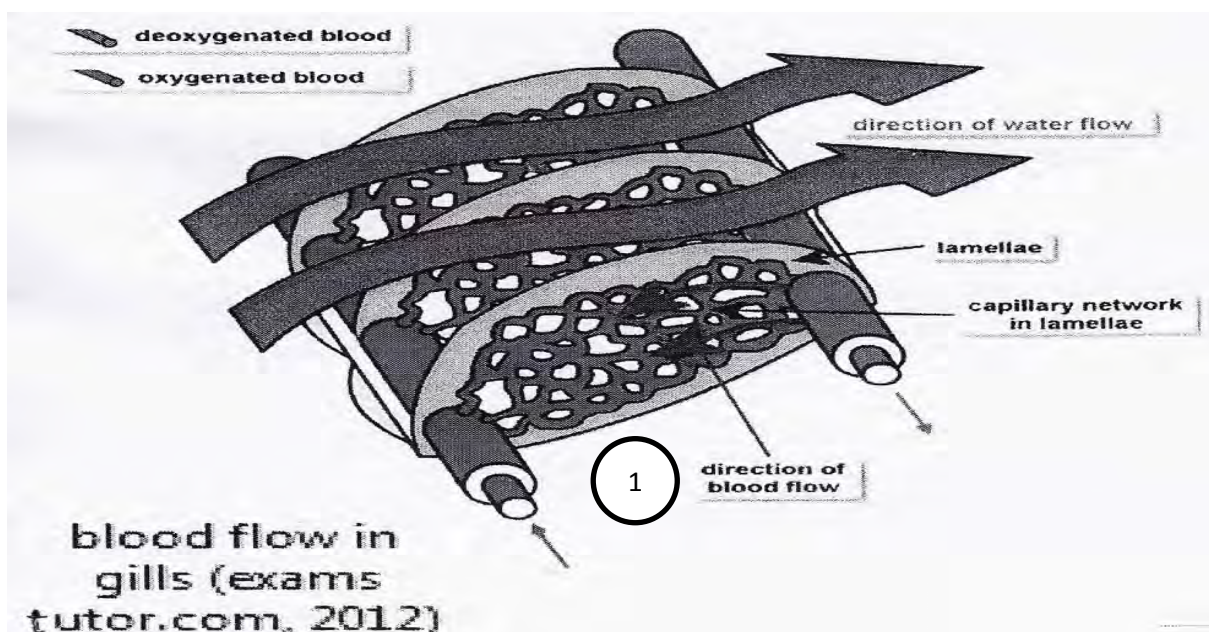
3

Fish live in water. They carry out gas exchange in a different way to mammals. They use gills and the flow of water over their gills to take O_2 and to remove CO_2 . A fish breathes as it swims by opening its mouth and allowing water to flow over the gills. When the fish opens its mouth the opercula close, meaning that water can flow over the gills and O_2 can be extracted and CO_2 can be removed. Then the fish closes the mouth and the opercula open, allowing the water to flow out of the fish.

2

1

The gills of a fish have filaments, which comb through the water. On the filaments are lamellas. The lamella are shaped like a ladder, so that the O_2 poor blood travels up one side before crossing over to the other side and travelling back down as O_2 rich blood. As the blood travels across, through the capillaries, it takes in O_2 by diffusion.



Oxygenated blood then flows through the body of the fish where mitochondria in cells carry out respiration and ATP is produced to give the fish energy for its life processes.

4

2 A counter current system ensures that the water which meets the blood in the gills always has a greater concentration of oxygen, therefore producing a relatively effective gradient for the diffusion of oxygen into the fish's circulatory system.

Water entering the mouth with high oxygen saturation meets the blood with low oxygen saturation. This allows oxygen to diffuse from the water and across the lamellae into the capillaries. As the water flows across the lamellae it gradually loses more oxygen but will still allow for diffusion as it flows across incrementally deoxygenated and unsaturated blood in the capillaries where the concentration and partial pressure of oxygen is still lower than that of the dwindling concentration in the water. This is more effective than concurrent flow, in which blood flows the same way as water.

2

5 Because there is less oxygen in water it requires fish to use more energy to carry out gas exchange i.e. 20% of its energy. This is much higher than the 1-2% used by terrestrial vertebrates. To accommodate for this, fish are able to remove 80% of the oxygen in water, compared to only the 25% of oxygen removed in air by humans. This is achieved by fish through the counter current flow system, which isn't present or needed in terrestrial animals, as their lower extraction rates provide them with sufficient oxygen due to the drastically higher abundance of oxygen in air.

Lungs in humans and gills in fish use blood capillaries to remove the oxygen they need and excrete waste carbon dioxide. Fish have adapted to absorb oxygen from the water they filter, whereas humans and insects on land diffuse air which is easier and more efficient.

5

5 All of these animals use different ways to carry out gas exchange, whether it is done through the alveoli, lamellae, or tracheoles. All are moist, thin, and have large surface area: volume ratios. All three ways provide an increase in the rate of diffusion.

All three gas exchange systems require ATP to function efficiently. The rhythmic body movements of an insect are required for ventilation, the negative pressure breathing for a human and the counter current exchange of fish. These energy costs are necessary for efficient gas exchange, and to support the metabolic rate of the animal and ultimately its survival. Therefore each animal has a gas exchange system adapted to its habitat. An external gas exchange system would not be suitable for land animals as the moisture would not be able to be maintained due to evaporation and the gill filaments would collapse without the support of water.

1, 3, 4

5

	Grade Boundary: High Merit
2.	<p>For Merit, the student needs to demonstrate in-depth understanding of adaptation of plants or animals to their way of life.</p> <p>This involves providing a biological reason that explains how or why the adaptations enable each organism to carry out its life process(es) in order to survive in its habitat.</p> <p>An adaptation:</p> <ul style="list-style-type: none"> • may include structural, behavioural, or physiological features of an organism • provides an advantage for the organism in its specific habitat and ecological niche. <p>Way of life includes:</p> <ul style="list-style-type: none"> • relationships with other organisms • reproductive strategies • adaptations to the physical habitat. <p>This student has described (1) and provided biological reasons to explain how and why adaptations (2) enable fish to carry out gas exchange in order to survive (4) in water (3). Some biological ideas describing limitations and advantages involved in features for gas exchange within fish and humans are given (5).</p> <p>To reach Excellence, the student could link more examples of biological ideas in the gas exchange systems of fish, humans and insects by:</p> <ul style="list-style-type: none"> • comparing the diversity of adaptation in response to the demand for oxygen for respiration to provide energy • considering more thoroughly the limitations and advantages in the habitats of each animal in order to survive.

Please note – These are extracts from one student's response

4

All living organisms respire. Cells need and use the energy that is formed through this process to assist with life processes in order for organisms to survive and reproduce. Oxygen and carbon dioxide are the main gases involved in aerobic respiration. Gas exchange is a physical process by which oxygen is extracted from the air and into the bloodstream, while carbon dioxide is simultaneously released. Gas exchange is the diffusion of these gases into and out of cells, and this is essential for respiration to occur.

For diffusion and therefore gas exchange to occur quickly there must be a large surface area to volume ratio for the gas exchange to take place, a partial pressure gradient for the gases to diffuse down, a thin surface that gases can diffuse rapidly across and a moist surface that gases can dissolve and diffuse into and out of. These conditions are called gas exchange surfaces.

2

Reptiles, mammals and fish are vertebrates which all require oxygen (O_2) to survive, and all carry out gas exchange. They have different ways of carrying this out, related to their habitat in order to occupy a specific ecological niche.

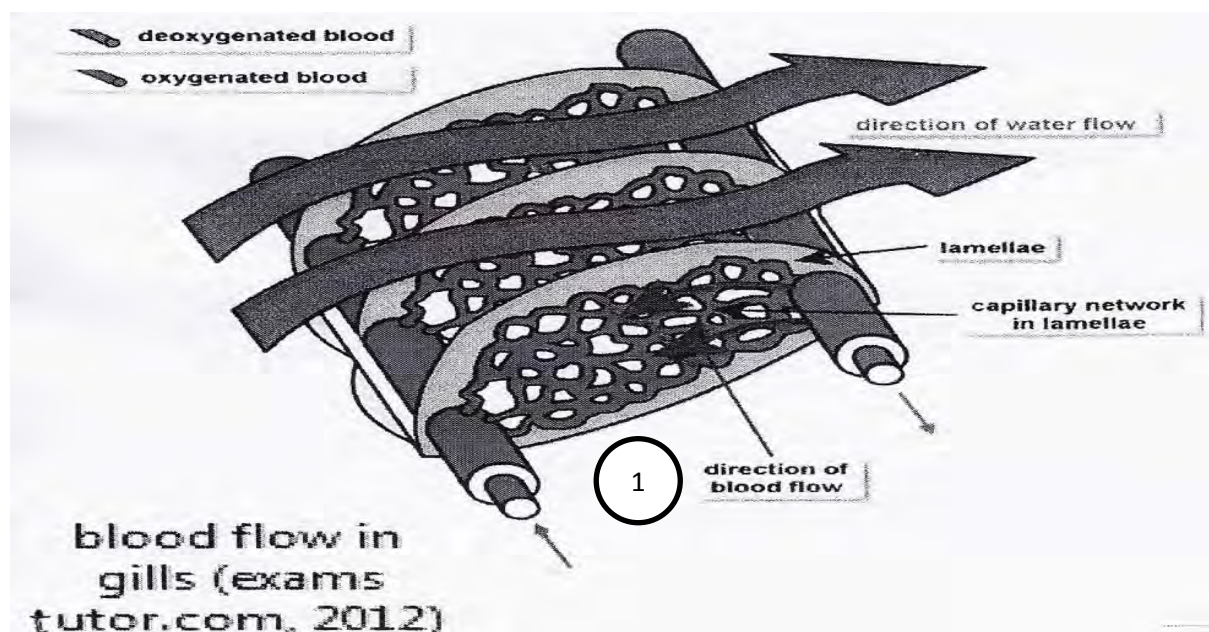
3

Fish live in water. They carry out gas exchange in a different way to mammals. They use gills and the flow of water over their gills to take O_2 and to remove CO_2 . A fish breathes as it swims by opening its mouth and allowing water to flow over the gills. When the fish opens its mouth the opercula close, meaning that water can flow over the gills and O_2 can be extracted and CO_2 can be removed. Then the fish closes the mouth and the opercula open, allowing the water to flow out of the fish.

2

1

The gills of a fish have filaments, which comb through the water. On the filaments are lamellas. The lamella are shaped like a ladder, so that the O_2 poor blood travels up one side before crossing over to the other side and travelling back down as O_2 rich blood. As the blood travels across, through the capillaries, it takes in O_2 by diffusion.

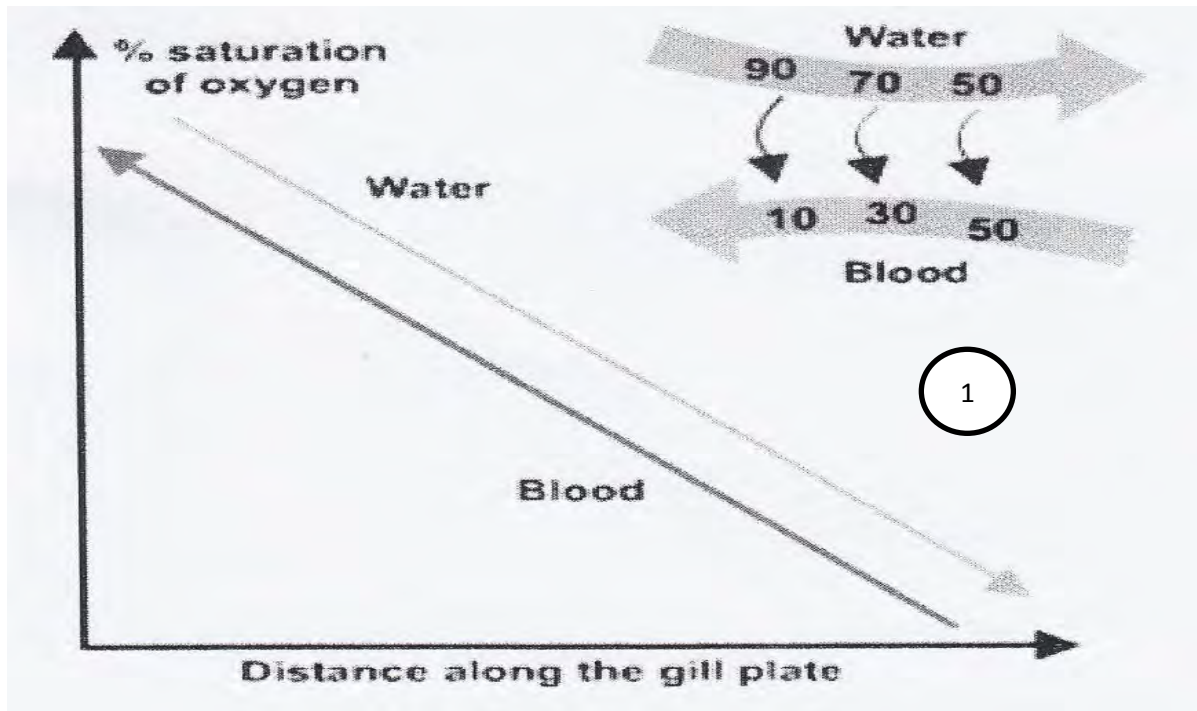


Oxygenated blood then flows through the body of the fish where mitochondria in cells carry out respiration and ATP is produced to give the fish energy for its life processes.

4

2

A counter current system ensures that the water which meets the blood in the gills always has a greater concentration of oxygen, therefore producing a relatively effective gradient for the diffusion of oxygen into the fish's circulatory system.



(Counter current flow, Google images, 2012)

The diagram shows that water entering the mouth with high oxygen saturation meets the blood with low oxygen saturation. This allows oxygen to diffuse from the water and across the lamellae into the capillaries. As the water flows across the lamellae it gradually loses more oxygen but will still allow for diffusion as it flows across incrementally deoxygenated and unsaturated blood in the capillaries where the concentration and partial pressure of oxygen is still lower than that of the dwindling concentration in the water. This is more effective than concurrent flow, in which blood flows the same way as water.

2

5

Because there is less oxygen in water it requires fish to use more energy to carry out gas exchange i.e. 20% of its energy. This is much higher than the 1-2% used by terrestrial vertebrates. To accommodate for this, fish are able to remove 80% of the oxygen in water, compared to only the 25% of oxygen removed in air by humans. This is achieved by fish through the counter current flow system, which isn't present or needed in terrestrial animals, as their lower extraction rates provide them with sufficient oxygen due to the drastically higher abundance of oxygen in air.

	Grade Boundary: Low Merit
3.	<p>For Merit, the student needs to demonstrate in-depth understanding of adaptation of plants or animals to their way of life.</p> <p>This involves providing a biological reason that explains how or why the adaptations enable each organism to carry out its life process(es) in order to survive in its habitat.</p> <p>An adaptation:</p> <ul style="list-style-type: none"> • may include structural, behavioural, or physiological features of an organism • provides an advantage for the organism in its specific habitat and ecological niche. <p>Way of life includes:</p> <ul style="list-style-type: none"> • relationships with other organisms • reproductive strategies • adaptations to the physical habitat. <p>This student has described (1) and provided biological reasons to explain how structural adaptations (2) enable fish to carry out gas exchange in order to survive (4) in water (3).</p> <p>For a more secure Merit, the student could further develop the reasons explaining the adaptations that enable fish to carry out gas exchange in order to survive in water. For example, by explaining how and why the lamellae (surface area to volume ratio) and counter current system operate to ensure efficient gas exchange in water.</p>

Please note – These are extracts from one student's response

4

Living organisms need energy from respiration to survive and reproduce. Gas exchange is when oxygen is taken from the air or water and into the bloodstream, and carbon dioxide is released.

Fish are vertebrates which all require oxygen (O_2) to survive, and they carry out gas exchange in water as this is their habitat. They are adapted to occupy a specific ecological niche in fresh and salt water.

3

3

Because the percentage of dissolved oxygen is only 1% in water compared 21% in air, getting oxygen for gas exchange is more difficult for fish than terrestrial animals. Water is also denser making it more strenuous to ventilate - it requires 15 times more energy.

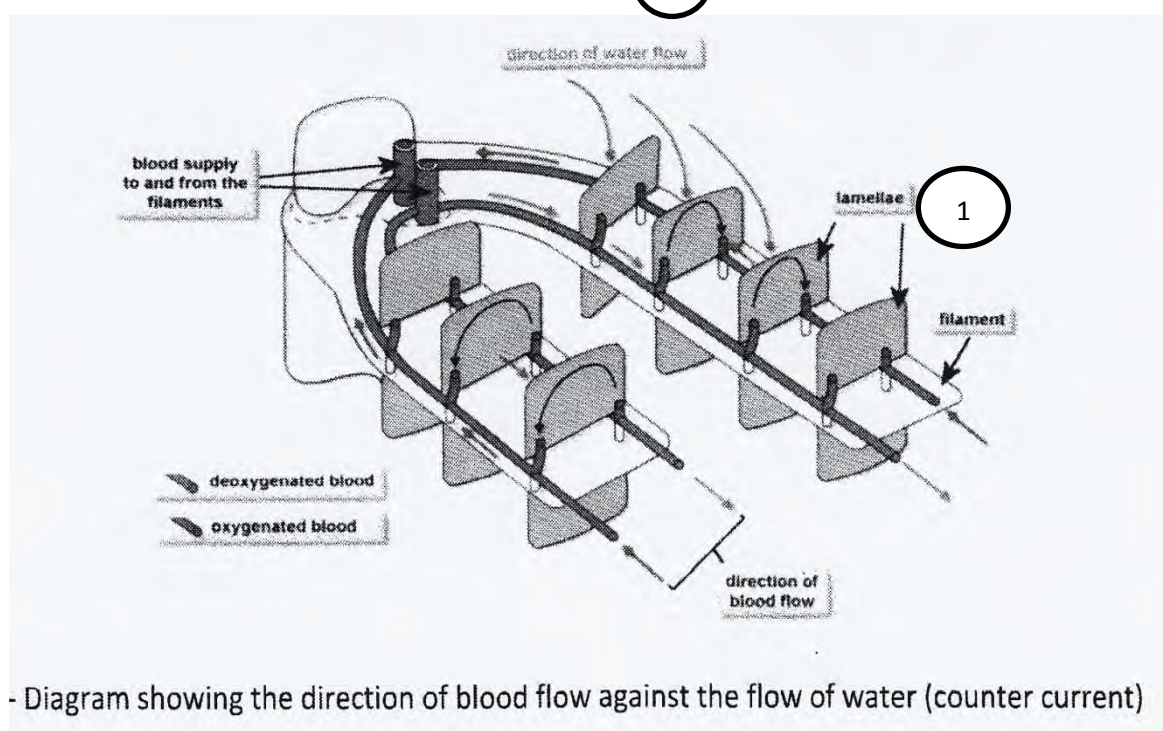
1

Fish use gills and the flow of water over their gills to take in O_2 and to remove CO_2 . A fish breathes as it swims by opening its mouth and allowing water to flow over the gills. When the fish opens its mouth opercula (flaps) close, so that water can flow over the gills, O_2 can be removed and CO_2 can be released. When the fish closes its mouth the opercula are forced open, letting the water and waste CO_2 flow out of the fish.

2

The gills of a fish have filaments, which comb through the water. On the filaments are lamellae, shaped like a ladder, so that the O_2 poor blood travels up one side before crossing over to the other side and travelling back down as O_2 rich blood. As the blood travels across, through the capillaries, it takes in O_2 by diffusion.

2

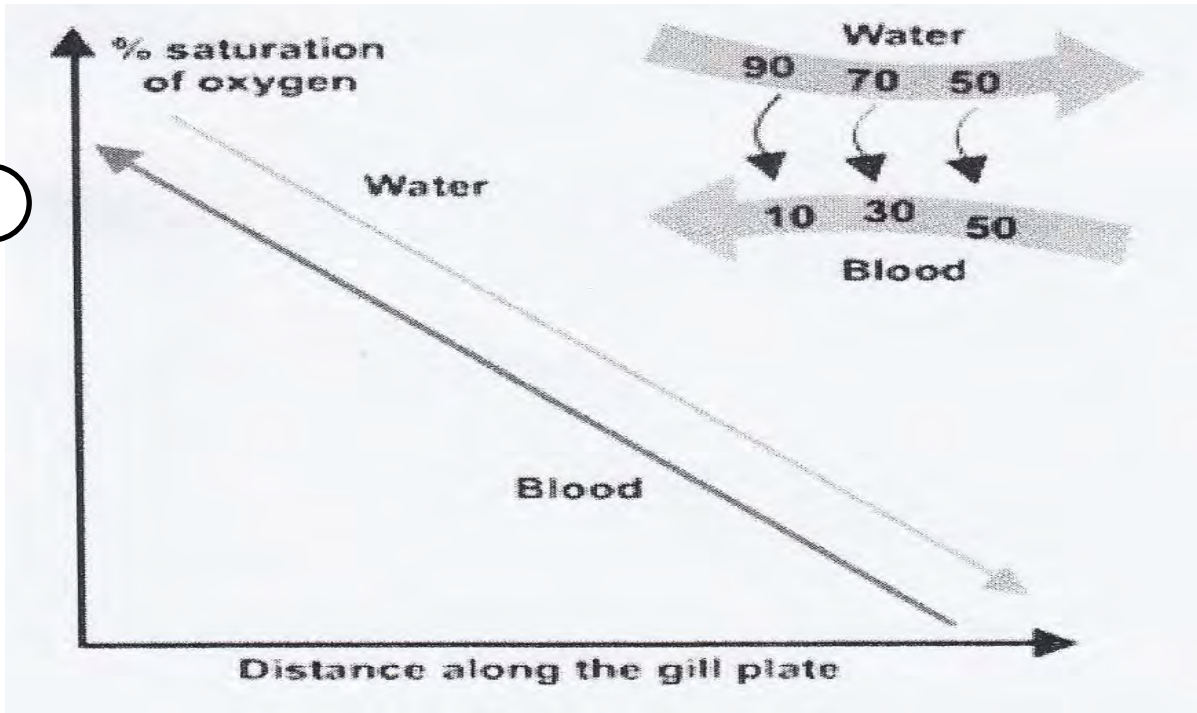


(Google images, 2012)

2

A counter current system makes sure that the water which meets the blood in the gills always has a higher concentration of oxygen, thereby producing a relatively effective gradient for the diffusion of oxygen into the fish's circulatory system.

1



(Counter current flow, Google images, 2012)

The graph shows that when water with high oxygen saturation meets the blood with low oxygen saturation, the oxygen diffuses from the water across the lamellae and into the capillaries. This is more effective than concurrent flow, in which blood flows the same way as water.

2

	Grade Boundary: High Achieved
4.	<p>For Achieved, the student needs to demonstrate understanding of adaptation of plants or animals to their way of life.</p> <p>This involves describing the adaptations and identifying the aspects of the adaptations that enable each organism to carry out its life process(es) in order to survive in its habitat.</p> <p>An adaptation:</p> <ul style="list-style-type: none"> • may include structural, behavioural, or physiological features of an organism • provides an advantage for the organism in its specific habitat and ecological niche. <p>Way of life includes:</p> <ul style="list-style-type: none"> • relationships with other organisms • reproductive strategies • adaptations to the physical habitat. <p>This student has described (1) and provided some biological reasons to explain how structural adaptations (2) enable fish to carry out gas exchange in order to survive (4) in water (3).</p> <p>To reach Merit, the student could support in-depth understanding by providing more thorough biological reasons to explain how or why the adaptations enable fish to carry out gas exchange in order to survive in water. For example, using the graph to explain the counter-current exchange system.</p>

Please note – These are extracts from one student’s response

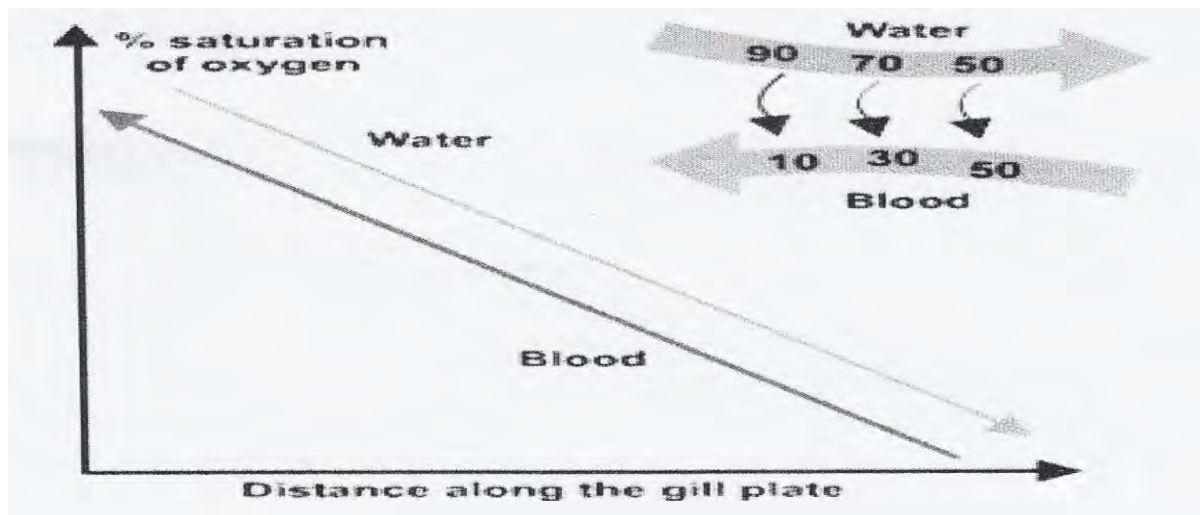
Gills - gas exchange system in fish

3 The solubility of the respiratory gases in water is very low. Gas exchange in water is more difficult for fish because the concentration of dissolved oxygen is said to be less than 1% compared to 20% that of carbon dioxide. Like humans though, fish require respiration and the process of gas exchange to survive. 4

3 Fish have adapted to live underwater. Over time they have evolved specialised organs known as gills, which are made of thousands of filaments, in turn are heavily covered in lamellae. A gill lamella is a plate structure that assists the increase of amount of oxygen intake of the blood in a fish, as it contains blood capillaries. This structure contributes to a large surface area and a short distance for gas exchange to take place, increasing the rate of diffusion. 1 2

1 Fish ventilate their gills by the action of two skeletal muscle pumps to maintain the gas concentration gradient, one in and through the mouth cavity, and the other in the operculum cavity. The water is drawn into the mouth where it remains until the mouth is closed. Once the mouth has shut, the water is pushed into the gill bars where it travels in and past the gill filaments. 2

(Counter current flow, Google images, 2012)



2 The counter current exchange system helps maximise the effectiveness and efficiency of gas exchange. Water flows over the gills so oxygen is removed and enters the blood.

The surface area of the gill filaments is an important factor in gas exchange. Water contains much less oxygen compared to air; therefore fish must have an organ (gills) with a large surface area to get enough oxygen from the water to survive. 4

	Grade Boundary: Low Achieved
5.	<p>For Achieved, the student needs to demonstrate understanding of adaptation of plants or animals to their way of life.</p> <p>This involves describing the adaptations and identifying the aspects of the adaptations that enable each organism to carry out its life process(es) in order to survive in its habitat.</p> <p>An adaptation:</p> <ul style="list-style-type: none"> • may include structural, behavioural, or physiological features of an organism • provides an advantage for the organism in its specific habitat and ecological niche. <p>Way of life includes:</p> <ul style="list-style-type: none"> • relationships with other organisms • reproductive strategies • adaptations to the physical habitat. <p>This student has described some structural adaptations (1), and aspects of these adaptations that enable fish to carry out gas exchange in order to survive (3) in water (2).</p> <p>For a more secure Achieved, the student would need to identify and describe more aspects of these adaptations that enable fish to carry out gas exchange in order to survive in water. For example, the student could identify and describe the counter-current exchange system and high concentration gradient of oxygen and carbon dioxide gases in the gill lamellae.</p>

Please note – These are extracts from one student’s response

Gases are exchanged during respiration in all living things, especially the exchange of oxygen and carbon dioxide between an organism and its environment.

Cells need energy to stay active, grow and divide. This energy comes from the oxidation of glucose in respiration. All cells must have a constant supply of oxygen to survive.

3

Gas exchange is not the same as respiration. It is the process by which oxygen gets into cells and carbon dioxide is removed. Respiration creates the constant demand for oxygen and a constant release of carbon dioxide.

Gas exchange surfaces are needed to exchange the gases. They allow the diffusion of gases into and out of cells and are the gills in fish (tracheae in insects and lungs in mammals.) These surfaces in fish gills have a large area. They are thin and kept moist as fish live in water.

1

2

Fish live underwater and have no problem in removing carbon dioxide because it dissolves very easily in water. The amount of oxygen dissolved in the water depends upon the water temperature but, in general, there is about 30 times more oxygen in the air than in water.

2

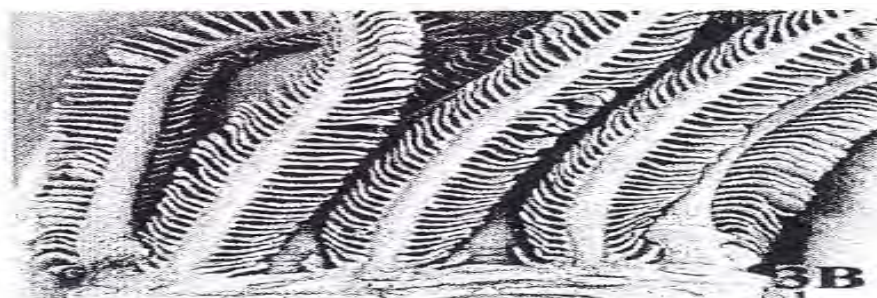
Gills in fish are internal and covered by an operculum. To get enough oxygen the fish must make water flow across its gills. The gills come in several layers. Fish carry out gas exchange in a different way to mammals. They use gills and the flow of water over their gills to take in O_2 and to remove CO_2 . A fish breathes as it swims by opening its mouth and allowing water to flow over the gills.

1

The gills of a fish have fine filaments, which comb through the water. On the filaments are lamellae. The blood flows against the flow of water, so that they are flowing in opposite directions.

1

2



Microscope image of gills (Radboud University,

When the water is forced over the gills small pointy structures called gill rakers get rid of small food particles and foreign materials from the water. This adaptation gets rid of all materials that may damage the gills. The water passes over the gill arches. The gill arch is the bony support structure for the gills.

1

	Grade Boundary: High Not Achieved
6.	<p>For Achieved, the student needs to demonstrate understanding of adaptation of plants or animals to their way of life.</p> <p>This involves describing the adaptations and identifying the aspects of the adaptations that enable each organism to carry out its life process(es) in order to survive in its habitat.</p> <p>An adaptation:</p> <ul style="list-style-type: none"> • may include structural, behavioural, or physiological features of an organism • provides an advantage for the organism in its specific habitat and ecological niche. <p>Way of life includes:</p> <ul style="list-style-type: none"> • relationships with other organisms • reproductive strategies • adaptations to the physical habitat. <p>This student has briefly described some structural adaptations (1) and identified some aspects of the adaptations that enable fish to carry out gas exchange in order to survive (3) in water (2).</p> <p>To reach Achieved, the student could identify and clearly describe more aspects of the adaptations that enable fish to carry out gas exchange in order to survive in water. For example, the student could identify that each gill filament has lamellae to increase the surface area. For gas exchange to occur, the blood flows through the lamellae in the opposite direction to that of the flow of water.</p>

Please note – These are extracts from one student’s response

In fish, gases are exchanged during respiration. The diffusion of gases happens from an area of higher concentration to an area of lower concentration, especially the exchange of oxygen and carbon dioxide between fish and its environment.

3

If cells in fish are to stay active, grow and divide they need energy. This energy comes from the oxidation of glucose in respiration. All respiration involves oxidation reactions, which means that all cells must have a constant supply of oxygen.

Gas exchange surfaces are found in the gills of fish. They have a large surface area, are thin and have a moist surface. Gases can dissolve first before they diffuse in our out. They are able to maintain the diffusion gradient down which the gases can diffuse.

1

2

Fish live underwater so have no problem in removing carbon dioxide because it dissolves very easily in water. Their problem is how to get enough oxygen. There is 30 times more oxygen in the air than in water. Animals which swim a lot need a considerable amount of oxygen to make the muscles work.

The gills are covered by a flap called the operculum. To get enough oxygen the fish must make water flow across its gills. The fish does not breathe water in and out of its mouth. The water gives oxygen to the blood in the gill filaments and receives carbon dioxide in exchange.

1

Finally, the water passes out from under the operculum. The fish's gills are feathery, made of gill filaments which give them a large surface. The gills also come in several layers.

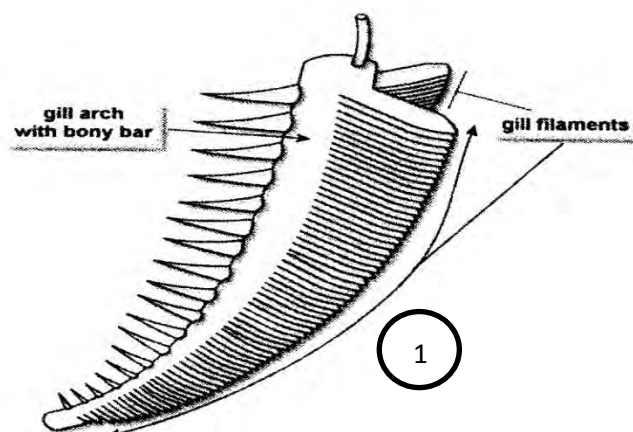


Fig 1.2- The structure of the gill filaments

(Google images, 2012)

Gill filaments are supported by gill arches. Fish suffocate when they are taken out of water. This isn't because they cannot breathe oxygen in air, but the gill arches collapse. It is also possible for a fish to suffocate in water. This may happen when the oxygen in water has been taken up by something else.

2