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

Exemplar for Internal Achievement Standard

Biology Level 3

This exemplar supports assessment against:

Achievement Standard 91604

Demonstrate understanding of how an animal maintains a stable internal environment

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.	For Excellence, the student needs to demonstrate comprehensive understanding of how an animal maintains a stable internal environment. This involves linking biological ideas, see Explanatory Note (EN) 4, about maintaining a stable internal environment in an animal, by at least one of: • a discussion of the significance of the control system (EN3) in terms of its adaptive advantage • an explanation of the biochemical and/or biophysical processes underpinning the mechanism • an analysis of a specific example of how external and/or internal environmental influences result in a breakdown of the control system. This student has described and explained the purpose (1), components (2) and the mechanism (3) of osmoregulation in Chinook salmon. Biological ideas are used to explain how a specific disruption results in responses to re-establish a stable internal environment (4). Some biological ideas linking the significance of osmotic balance in terms adaptive advantage are discussed (5). For a more secure Excellence, the student could: • discuss the significance of osmotic balance in terms of its adaptive advantage in more depth, or • analyse how external and/or internal influences result in a breakdown of osmoregulation in more detail.

Student 1: Low Excellence

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Homeostasis is the maintenance of the steady state of equilibrium in the internal environment of an animal. An animal needs to 1 maintain a constant internal environment despite fluctuations by internal or external influences, as it allows their body cells to function at optimal levels, ensuring the animal's survival and reproduction. Osmoregulation is an example of homeostasis. It is the mechanism by which osmosis is controlled by the animal to maintain a homeostatic water balance. Osmosis is the net movement of water molecules from an area of high concentration to an area of low concentration.
Euryhaline fishes live in a habitat surrounded by water and their body contains a high percentage of water. They live in both fresh water and salt water during their lives. They are born in in fresh water and migrate out to marine waters for most of their life. They return to the place they were born in fresh water to spawn. Changing between these two water environments can cause rapid changes in the balance of water in their body. There is a need 1 to create and maintain a stable osmotic balance of water and salts. An example of euryhaline fishes is the Chinook salmon (*Oncorhynchus tshawytscha*). They are adapted to the changes they face in their lifetime through the control system of osmoregulation.

Osmoregulation is an example of a negative feedback, homeostatic control system. This
3 system detects changes in the salinity of the water Chinook salmon live in, working to keep the body water concentration constant. The osmoregulatory feedback mechanism works differently when they are in fresh water and marine environments. Like all negative feedback systems it consists of components which detect the change, and then employs a process to negate the change. There are five components in the negative feedback system: the **stimulus** and its variability, the **receptor**, the **control centre** and the **effector**. The stimulus is basically an action or condition which accelerates the fish's physiological response. In this case it is the change in water salinity or salt level within the body of the euryhaline fish, and the response to it would be by reversing the effect. The change in the environment is detected by the receptor. In these fish, the receptor is the hypothalamus which is part of the brain. The hypothalamus detects how concentrated the blood is inside the fish, i.e. if there 2 are too many or too few water molecules. The hypothalamus also stimulates the pituitary gland next to it, which is the control centre. The role of the control centre is to determine the appropriate outcome for the stimulus, which is to reverse the change in the water salinity in the fish. The effector includes the kidneys and gills, which respond to the commands set by the pituitary gland to oppose the stimulus.

When the euryhaline fish is in salt water environments there are more water molecules inside the body cells than outside the body cells. Therefore due to osmosis, the water molecules move out of the body cells. The osmotic balance is maintained by counteracting the massive gain in salt from the water and the loss of water molecules. Osmoreceptors in the
3 hypothalamus detect that there is a high concentration of salts in the blood, and stimulate the tilapia pituitary glands to release the hormone cortisol into the bloodstream. This regulates plasma ions by binding to cellular receptors, causing the specialised transport activity of ions to take place within the gill cells - the primary site for the transport of sodium and chloride ions. The gills contain epithelial cells which are mitochondria rich. These cells are specialised to remove Na+ and Cl^- ions by one of two ways: active or facilitated transport.

Active transport is when substances move against their concentration gradient and therefore need ATP energy to move. Facilitated transport involves channels in the membrane that ions and larger molecules cannot diffuse through.
(3) The kidney removes other salts such as Mg^{2+} and $S0_4^{2-}$ by passive diffusion through their urine, which is quite concentrated due to the ion loss. The concentrated urine is also due to the increase in ADH hormone which is released by the pituitary gland, and carried to the kidney by blood. ADH causes more water to be reabsorbed by the kidneys.

When the euryhaline fish is in a fresh water environment, there are more water molecules outside their body cells than inside their body cells. Therefore due to osmosis, the water molecules move inside the body cells and the osmotic balance is maintained by
(3) counteracting the massive gain in water molecules and loss of salts. Osmoreceptors in the hypothalamus detect the high concentration of water within the blood to stimulate the tilapia pituitary glands to release the hormone Prolactin into the bloodstream. This regulates plasma ions by binding to cellular receptors. The hormone causes the transport activity of ions to take place within the epithelial gill cells while they actively absorb salts across the gill epithelium. The gills contain special ion pumps which exchange Na+ and Cl^- ions for NH_4^+ and HCO_3^- ions across the gill membrane against the concentration gradient.

There are various things that can lead to disruptions in the control system, such as water-borne toxicants which fish gills are sensitive to; for example, organic pollutants, toxicants and micro-organisms. Toxicants such as copper and other heavy metals can damage the gill membrane by competing with the Ca^{2+} ions for binding sites. This interrupts the ion transport mechanism within chloride cells, by increasing the permeability of the gill epithelium to water (4)
molecules and ions. This can increase the movement of ions across gills more than normal. This may also increase or decrease the uptake of water across gills depending on the environment the euryhaline fish are in, resulting in an increase or decrease of losses of ions in the urine. The inhibition of active ion uptake by epithelial cells in the gills may also result in the negative ion balance of the blood. It is also possible that pollutants clog the gills directly. Excessive loss of water molecules can cause dehydration within the fish which can ultimately result in death.

This osmoregulatory system is significant because of its adaptive advantage for the euryhaline fish such as the Chinook salmon. These fish can move between salt water and fresh water environments having advantages that stenohaline fish don't have. For example, if conditions in their current environment decline the fish can travel to another environment. The current environment could decline for reasons such as pollution, over population, and therefore result in competition for food, space or predation. Euryhaline fish migrate between
(5) the two different environments at specific points in their life. For example the Chinook salmon migrate from the river to the sea as adolescents. However if salinity levels were to change during other periods, euryhaline species can remain whereas the non euryhaline species will be forced to perish or migrate. If fish are able to tolerate both salt water and fresh water environments, it must mean that they have adapted to many changes, like their diet. This is because marine vegetation is similar to the needs of all living organisms - they need specific conditions in which they can survive. This means that the vegetation that the fish used to feed on, or other organisms if the fish is carnivorous, may or may not be in an environment with a different salinity.

	Grade Boundary: High Merit
2.	For Merit, the student needs to demonstrate in-depth understanding of how an animal maintains a stable internal environment. This involves using biological ideas, see Explanatory Note (EN) 4, to explain how or why an animal maintains a stable internal environment. This includes explaining how a specific disruption results in responses within a control system (EN3) to re-establish a stable internal environment. This student has described and explained the purpose (1), components (2) and the mechanism (3) of osmoregulation in Chinook salmon. Biological ideas are used to explain how a specific disruption results in responses to re-establish a stable internal environment (4). An attempt is made to link biological ideas on the significance of osmoregulation in terms of its adaptive advantage (5). To reach Excellence, the student could link biological ideas further to: • discuss the significance of osmotic balance in terms of its adaptive advantage in more detail, or • analyse how external and/or internal influences result in a breakdown of osmoregulation, or • explain the biochemical and/or biophysical processes underpinning the mechanism of osmoregulation.

Student 2: High Merit

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Homeostasis is the maintenance of the steady state of equilibrium in the internal environment of an animal. An animal needs to maintain a constant internal environment despite fluctuations by internal or external influences, as it allows their body ① cells to function at optimal levels, ensuring the animal's survival and reproduction. Osmoregulation is an example of homeostasis. It is the mechanism by which osmosis is controlled by the animal to maintain a homeostatic water balance. Osmosis is the net movement of water molecules from an area of high concentration to an area of low concentration.
Euryhaline fishes live in a habitat surrounded by water and their body contains a high percentage of water. They live in both fresh water and salt water during their lives. They are born in in fresh water and migrate out to marine waters for most of their life. They return to the place they were born in fresh water to spawn. Changing between these two water environments can cause rapid changes in the balance of water in their body. There is a need ① to create and maintain a stable osmotic balance of water and salts. An example of euryhaline fishes is the Chinook salmon (*Oncorhynchus tshawytscha*). They are adapted to the changes they face in their lifetime through the control system of osmoregulation.

Osmoregulation is an example of a negative feedback, homeostatic control system. This ③ system detects changes in the salinity of the water Chinook salmon live in, working to keep the body water concentration constant. The osmoregulatory feedback mechanism works differently when they are in fresh water and marine environments. Like all negative feedback systems it consists of components which detect the change, and then employs a process to negate the change. There are five components in the negative feedback system: the **stimulus** and its variability, the **receptor**, the **control centre** and the **effector**. The stimulus is basically an action or condition which accelerates the fish's physiological response. In this case it is the change in water salinity or salt level within the body of the euryhaline fish, and the response to it would be by reversing the effect. The change in the environment is detected by the receptor. In these fish, the receptor is the hypothalamus which is part of the brain. The hypothalamus detects how concentrated the blood is inside the fish, i.e. if there are too many or too few water molecules. The hypothalamus also stimulates the pituitary ② gland next to it, which is the control centre. The role of the control centre is to determine the appropriate outcome for the stimulus, which is to reverse the change in the water salinity in the fish. The effector includes the kidneys and gills, which respond to the commands set by the pituitary gland to oppose the stimulus.

When the euryhaline fish is in salt water environments there are more water molecules inside the body cells than outside the body cells. Therefore due to osmosis, the water molecules move out of the body cells. The osmotic balance is maintained by counteracting the massive gain in salt from the water and the loss of water molecules. Osmoreceptors in the ③ hypothalamus detect that there is a high concentration of salts in the blood, and stimulate the tilapia pituitary glands to release the hormone cortisol into the bloodstream. This regulates plasma ions by binding to cellular receptors, causing the specialised transport activity of ions to take place within the gill cells - the primary site for the transport of sodium and chloride ions. The gills contain epithelial cells which are mitochondria rich. These cells are specialised to remove Na+ and Cl^- ions by one of two ways: active or facilitated transport.

Active transport is when substances move against their concentration gradient and therefore
need ATP energy to move. Facilitated transport involves channels in the membrane that ions
and larger molecules cannot diffuse through.
3 The kidney removes other salts such as Mg^{2+} and $S0_4^{2-}$ by passive diffusion through their
urine, which is quite concentrated due to the ion loss. The concentrated urine is also due to
the increase in ADH hormone which is released by the pituitary gland, and carried to the
kidney by blood. ADH causes more water to be reabsorbed by the kidneys.

When the euryhaline fish is in a fresh water environment, there are more water molecules
outside their body cells than inside their body cells. Therefore due to osmosis, the water
molecules move inside the body cells and the osmotic balance is maintained by
3 counteracting the massive gain in water molecules and loss of salts. Osmoreceptors in the
hypothalamus detect the high concentration of water within the blood to stimulate the tilapia
pituitary glands to release the hormone Prolactin into the bloodstream. This regulates plasma
ions by binding to cellular receptors. The hormone causes the transport activity of ions to
take place within the epithelial gill cells while they actively absorb salts across the gill
epithelium. The gills contain special ion pumps which exchange Na+ and Cl^- ions for NH_4^+
and HCO_3^- ions across the gill membrane against the concentration gradient.

There are various things that can lead to disruptions in the control system, such as water-
borne toxicants which fish gills are sensitive to; for example, organic pollutants, toxicants and
micro-organisms. Toxicants such as copper and other heavy metals can damage the gill
membrane by competing with the Ca^{2+} ions for binding sites. This interrupts the ion transport
mechanism within chloride cells, by increasing the permeability of the gill epithelium to water 4
molecules and ions. This can increase the movement of ions across gills more than normal.
This may also increase or decrease the uptake of water across gills depending on the
environment the euryhaline fish are in, resulting in an increase or decrease of losses of ions
in the urine. The inhibition of active ion uptake by epithelial cells in the gills may also result in
the negative ion balance of the blood. It is also possible that pollutants clog the gills directly.
Excessive loss of water molecules can cause dehydration within the fish which can ultimately
result in death.

This osmoregulatory system is significant because of its adaptive advantage for the
euryhaline fish such as the Chinook salmon. These fish can move between salt water and
fresh water environments, so if conditions decline the fish can travel to another environment.
5 The current environment could decline for reasons such as pollution, over population, and
therefore result in competition for food, space or predation. If food ran low for young salmon
in a river they will be able to swim to the ocean where there will be more food available.
There is also camouflage in rivers such as eelgrass and other weeds for young salmon to
prevent them from being seen by predators. Salmon spawn and reproduce in fresh water,
where there is less danger to the spawn of predation by other fish, increasing the chances of
them developing into young salmon.

	Grade Boundary: Low Merit
3.	For Merit, the student needs to demonstrate in-depth understanding of how an animal maintains a stable internal environment. This involves using biological ideas, see Explanatory Note (EN) 4, to explain how or why an animal maintains a stable internal environment. This includes explaining how a specific disruption results in responses within a control system (EN3) to re-establish a stable internal environment. This student has described and explained the purpose (1), components (2) and the mechanism (3) of osmoregulation in Chinook salmon. Some biological ideas are used to describe and explain how a specific disruption results in responses to re-establish a stable internal environment (4). For a more secure Merit, the student could use biological ideas to give a more in-depth explanation of: • the mechanism of osmoregulation in Chinook salmon • how a specific disruption results in responses within a this control system to re-establish a stable internal environment.

Student 3: Low Merit
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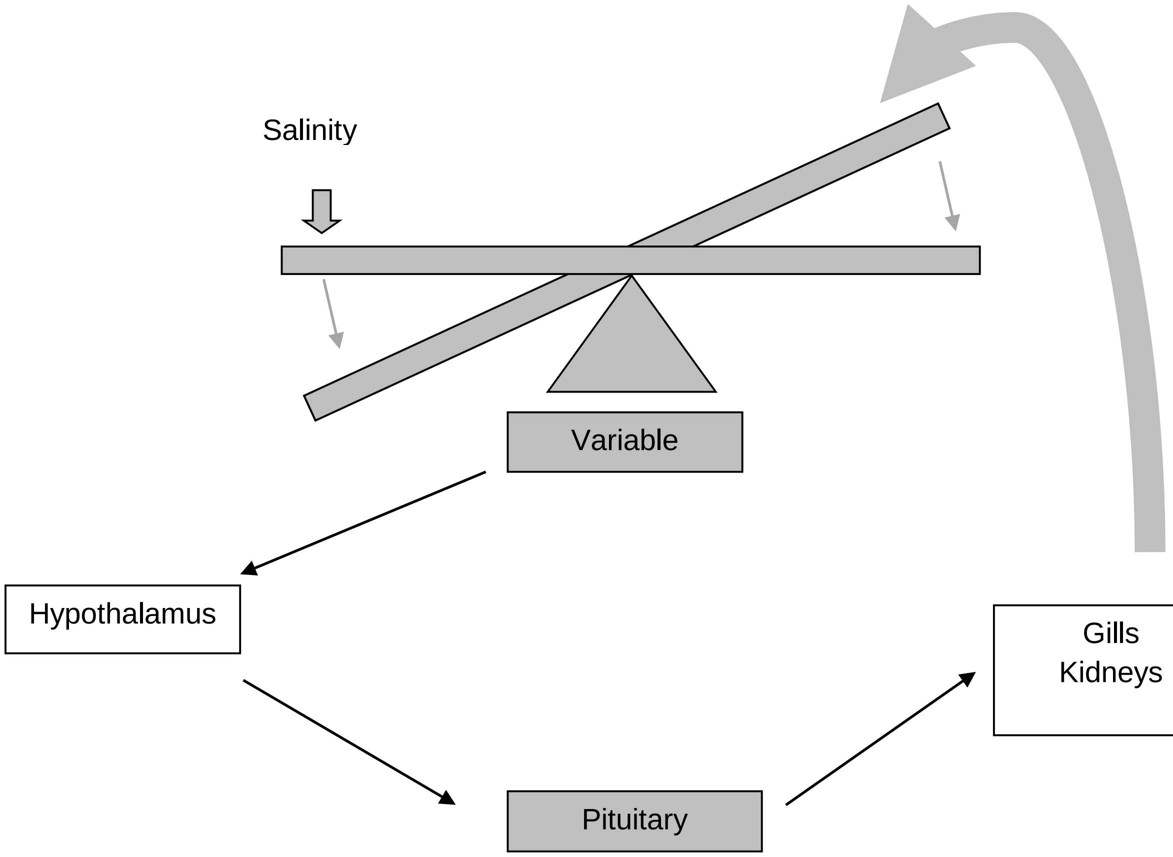
Homeostasis is the maintenance of the steady state of equilibrium in the internal environment of an animal. An animal needs to maintain a constant internal environment, despite fluctuations by internal or external influences, to ensure the animal's survival and ability to 1 reproduce. Osmoregulation is an example of homeostasis. It is way osmosis is controlled by the animal to maintain a water balance. Osmosis is the net movement of water molecules from an area of high concentration to an area of low concentration.
Euryhaline fishes live in a habitat surrounded by water and their body contains a high percentage of water. They live in both fresh water and salt water during their lives. They are born in in fresh water and migrate out to marine waters for most of their life. They return to the place they were born in fresh water to spawn. Changing between these two water environments can cause rapid changes in the balance of water in their body. There is a need to create and maintain a stable osmotic balance of water and salts. 1 An example of euryhaline fishes is the Chinook salmon (*Oncorhynchus tshawytscha*). They are adapted to the changes they face in their lifetime through the control system of osmoregulation.

Osmoregulation is an example of a negative feedback, homeostatic control system. This system detects changes in the salinity of the water Chinook salmon live in, working to keep the body water concentration constant. The osmoregulatory feedback mechanism works 3 differently when they are in fresh water and marine environments. Like all negative feedback systems it consists of components which detect the change, and then employs a process to negate the change. There are five components in the negative feedback system (see diagram below): the **stimulus** and its variability, the **receptor**, the **control centre** and the **effector**. The stimulus is basically an action or condition which accelerates the fish's physiological response. In this case it is the change in water salinity or salt level within the body of the euryhaline fish, and the response to it would be by reversing the effect. The change in the environment is detected by the receptor. In these fish, the receptor is the hypothalamus which is part of the brain. The hypothalamus detects how concentrated the blood is inside the fish, i.e. if there are too many or too few water molecules. The 2 hypothalamus also stimulates the pituitary gland next to it, which is the control centre. The role of the control centre is to determine the appropriate outcome for the stimulus, which is to reverse the change in the water salinity in the fish. The effector includes the kidneys and gills, which respond to the commands set by the pituitary gland to oppose the stimulus.

When the euryhaline fish is in salt water environments there are more water molecules inside the body cells than outside the body cells. Therefore due to osmosis, the water molecules move out of the body cells. Osmoreceptors in the hypothalamus detect that there is a high concentration of salts in the blood, and stimulate the pituitary glands to release the hormone 3 cortisol into the bloodstream. This regulates plasma ions causing the transport activity of ions to take place within the gill cells - the main site for the transport of sodium and chloride ions. The gills contain epithelial cells which are specialised to remove Na+ and Cl^- ions by one of two ways: active or facilitated transport. Active transport is when substances move against their concentration gradient. Facilitated transport involves channels in the membrane that ions and larger molecules cannot diffuse through.

3 The kidney removes other salts such as Mg^{2+} and $S0_4^{2-}$ by passive diffusion through their urine, which is quite concentrated due to the ion loss. The concentrated urine is also due to the increase in ADH hormone which is released by the pituitary gland, and carried to the kidney by blood. ADH causes more water to be reabsorbed by the kidneys.

When the euryhaline fish is in a fresh water environment, there are more water molecules outside their body cells than inside their body cells. Therefore due to osmosis, the water molecules move inside the body cells. Osmoreceptors in the hypothalamus detect the high
3 concentration of water within the blood to stimulate the pituitary glands to release the hormone Prolactin into the bloodstream. The hormone causes the transport activity of ions to take place within the epithelial gill cells while they actively absorb salts across the gill epithelium. The gills contain special ion pumps which exchange Na+ and Cl^- ions for NH_4^+ and HCO_3^- ions across the gill membrane against the concentration gradient.



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There are various things that can lead to disruptions in the control system, such as water-borne toxicants which fish gills are sensitive to; for example, organic pollutants, toxicants and micro-organisms. Toxicants such as copper and other heavy metals can damage the gill membrane by interrupting the ion transport mechanism within chloride cells, by increasing 4 the permeability of the gill epithelium to water molecules and ions. This can increase the movement of ions across gills more than normal. Excessive loss of water molecules can cause dehydration within the fish which can ultimately result in death. Reactions within the fish's body like any other living thing can only happen if the right pH, salt level and nutrients are maintained.

	Grade Boundary: High Achieved
4.	For Achieved, the student needs to demonstrate understanding of how an animal maintains a stable internal environment. This involves using biological ideas, see Explanatory Note (EN) 4, to describe a control system (EN3) by which an animal maintains a stable internal environment. Annotated diagrams or models may be used to support the description. This student has described and partly explained the purpose (1), components (2) and the mechanism (3) of osmoregulation in Chinook salmon. Some biological ideas are used to describe and partly explain how a specific disruption results in responses to re-establish osmotic balance (4). To reach Merit, the student could use biological ideas to explain in more depth: • how or why an animal maintains a stable internal environment to regulate osmotic balance • how a specific disruption results in responses within this control system to re-establish a stable internal environment.

Student 4: High Achieved

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Chinook salmon work to maintain a stable internal environment despite changes in external conditions by the process called homeostasis. Homeostasis is important because salmon, like all living organisms, depend on the proper functioning of its cells to ensure its survival and the ability to reproduce. Homeostasis is the maintenance of the steady state in the internal environment of an animal. Osmoregulation is an example of homeostasis. It is way osmosis is controlled by salmon to maintain a water balance. Osmosis is the net movement of water molecules from an area of high concentration to an area of low concentration. ①

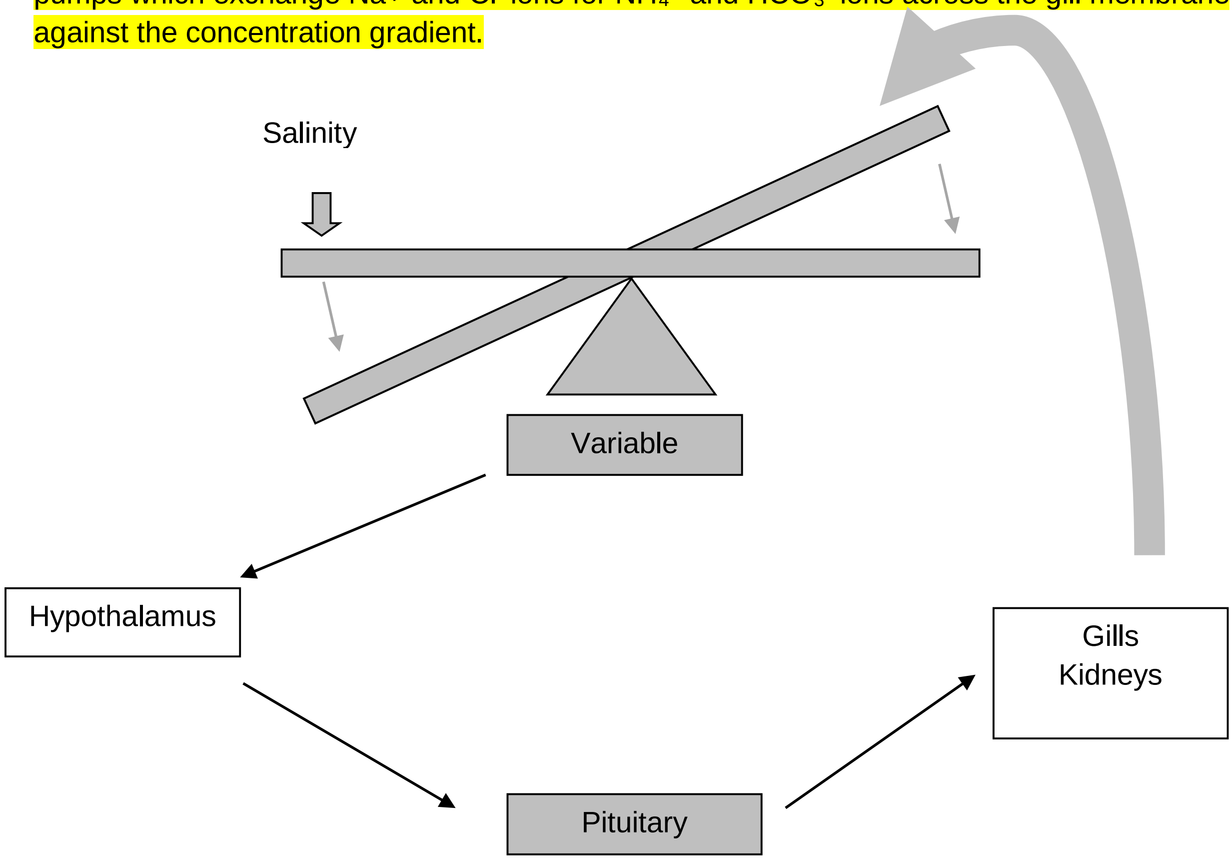
Fishes like salmon live in a habitat surrounded by water and their body contains a high percentage of water. They live in both fresh water and salt water during their lives. They are born in in fresh water and migrate out to marine waters for most of their life. They return to the place they were born in fresh water to spawn. Changing between fresh water and salt water changes the balance of water in their body. Salmon need to maintain a stable osmotic balance of water and salts. They are adapted to the changes they face in their lifetime through the control system of osmoregulation. ①

③ Osmoregulation is an example of a negative feedback, homeostatic control system. This system detects changes in the salinity of the water Chinook salmon live in, working to keep the body water concentration constant. The feedback mechanism works differently when they are in fresh water and marine environments. Like all negative feedback systems it consists of components which detect the change, followed by a process to negate the change. There are five components in the negative feedback system (see diagram below): the **stimulus** and its variability, the **receptor**, the **control centre** and the **effector**. The stimulus is basically an action or condition which accelerates the fish's physiological response. In this case it is the change in water salinity or salt level within the body of the fish, and the response to it would be by reversing the effect. The change in the environment is detected by the receptor. In these fish, the receptor is the hypothalamus which is part of the brain. The hypothalamus detects how concentrated the blood is inside the fish, i.e. if there are too many or too few water molecules. The hypothalamus also stimulates the pituitary gland next to it, which is the control centre. The role of the control centre is to determine the appropriate outcome for the stimulus, which is to reverse the change in the water salinity in the fish. The effector includes the kidneys and gills, which respond to the commands set by the pituitary gland to oppose the stimulus. ②

③ When salmon are in salt water there are more water molecules inside the body cells than outside the body cells. This means they are hypotonic to their surroundings. Water molecules move out of the body cells as a result of osmosis. Receptors in the hypothalamus detect that there is a high concentration of salts in the blood, and stimulate the pituitary glands to release a hormone into the bloodstream. This causes the transport activity of ions to take place within the gill cells - the main site for the transport of sodium and chloride ions. The gill cells are specialised to remove $Na+$ and Cl^- ions by one of two ways: active or facilitated transport. Active transport is when substances move against their concentration gradient. Facilitated transport involves channels in the membrane that ions and larger molecules cannot diffuse through. The very high NaCl concentration in the ocean means that salt will be constantly diffusing into the salmon's body. Therefore salmon suffer from dehydration and salt loading. To prevent dehydration salmon drink several litres of water a day.

3 The kidneys are used to remove excess salts, including as Mg^{2+} and $S0_4^{2-}$, by passive diffusion through their urine, which is quite concentrated due to the ion loss. The concentrated urine is also due to the increase in ADH hormone which is released by the pituitary gland, and carried to the kidney by blood. ADH causes more water to be reabsorbed by the kidneys.

When salmon are in fresh water, there are more water molecules outside their body cells than inside their body cells. This means they are hypertonic to their surroundings. Therefore due to osmosis, the water molecules move inside the body cells. In fresh water salmon suffer
3 from salt loss and water loading. Receptors in the hypothalamus detect the high concentration of water within the blood to stimulate the pituitary glands to release a hormone into the bloodstream. The hormone causes the transport activity of ions to take place within the gill cells while they actively absorb salts across the gill lining. The gills contain special ion pumps which exchange Na+ and Cl^- ions for NH_4^+ and HCO_3^- ions across the gill membrane against the concentration gradient.



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A number of environmental factors can lead to disruptions in the control system, such as water-borne toxicants which fish gills are sensitive to; for example, organic pollutants, toxicants and micro-organisms. Toxicants such as copper and other heavy metals can 4 damage the gill membrane by interrupting the ion transport mechanism. It is also possible that pollutants clog the gills directly. Excessive loss of water molecules can cause dehydration which can ultimately result in death. Reactions within the fish's body like any other living thing can only happen if the right pH, salt level and nutrients are maintained.

	Grade Boundary: Low Achieved
5.	For Achieved, the student needs to demonstrate understanding of how an animal maintains a stable internal environment. This involves using biological ideas, see Explanatory Note (EN) 4, to describe a control system (EN3) by which an animal maintains a stable internal environment. Annotated diagrams or models may be used to support the description. This student has described the purpose (1) and components (2) of osmoregulation in Chinook salmon. Some biological ideas are used to describe the mechanism of (3), and disruption to this control system (4). For a more secure Achieved, the student could use biological ideas to give a more detailed description of the: • feedback mechanism of osmoregulation in Chinook salmon. • potential effect of disruption to this control system by internal or external influences.

Student 5: Low Achieved

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Homeostasis is the way animals maintain a stable internal balance in their body. It allows animals to function in the changing external conditions surrounding their body. Homeostasis is important to Chinook salmon because they depend on the functioning of its cells to help its survival and ability to reproduce. Osmoregulation is an example of homeostasis. It is way osmosis is controlled by salmon to maintain a water balance. Osmosis is the net movement of water molecules from an area of high concentration to an area of low concentration.

Salmon live in both fresh water and salt water during their lives. They are born in in fresh water and migrate out to marine waters for most of their life. They return to the place they were born in fresh water to spawn. Changing between fresh water and salt water changes 1 the balance of water in their body. Salmon need to maintain the balance of water and salts in their bodies. They are adapted to the changes they face in their lifetime through the control system called osmoregulation.

Whenever an imbalance occurs, osmoregulation restores the balance by negative feedback. This control system detects the changes and initiates changes to maintain a constant 3 concentration of water in the body. Osmoregulation is an example of a negative feedback, control system. This system detects changes in the salt concentration of the water Chinook salmon live in. The feedback mechanism works differently when they are in fresh water and salt water environments.

Like all negative feedback systems it is made up of components which detect the change, followed by a process to reverse the change. The components in the negative feedback system include (see diagram below): the **stimulus**, the **receptor**, the **control centre** and the **effector**. The stimulus is the thing which causes the fish's response. In this case it is the 2 change in water salinity or salt level within the body. The receptor senses and detects the stimulus and sends information to the control centre. In salmon the receptor is the hypothalamus, part of the brain. The hypothalamus detects how concentrated the blood is inside the fish. The hypothalamus stimulates the pituitary gland, which is the control centre. The control centre determines the appropriate response to the stimulus. The effector includes the kidneys and gills, which respond to the commands set by the pituitary gland.

When salmon are in salt water there are more water molecules inside the body cells than outside the body cells. Water molecules move out of the body cells. Receptors in the hypothalamus detect that there is a high concentration of salts in the blood, and stimulate the pituitary glands to release a hormone into the bloodstream. This causes the transport of ions to take place in the gill membrane - the main site for the transport of sodium and chloride 3 ions. The high salt concentration in the ocean means that salt will be constantly diffusing into the salmon's body, which means that salmon suffer from dehydration and salt loading. To prevent dehydration salmon drink several litres of water a day. Water and salts can move through the gill membrane to maintain the balance.
The kidneys are used to remove excess salts through their urine, which is quite concentrated. The concentrated urine is also due to the increase in a hormone (ADH) which causes more water to be reabsorbed by the kidneys.

When salmon are in fresh water, there are more water molecules and low levels of salt outside their body cells than inside their body cells, so water molecules move inside the body cells. In fresh water salmon suffer from salt loss and water loading. Receptors in the

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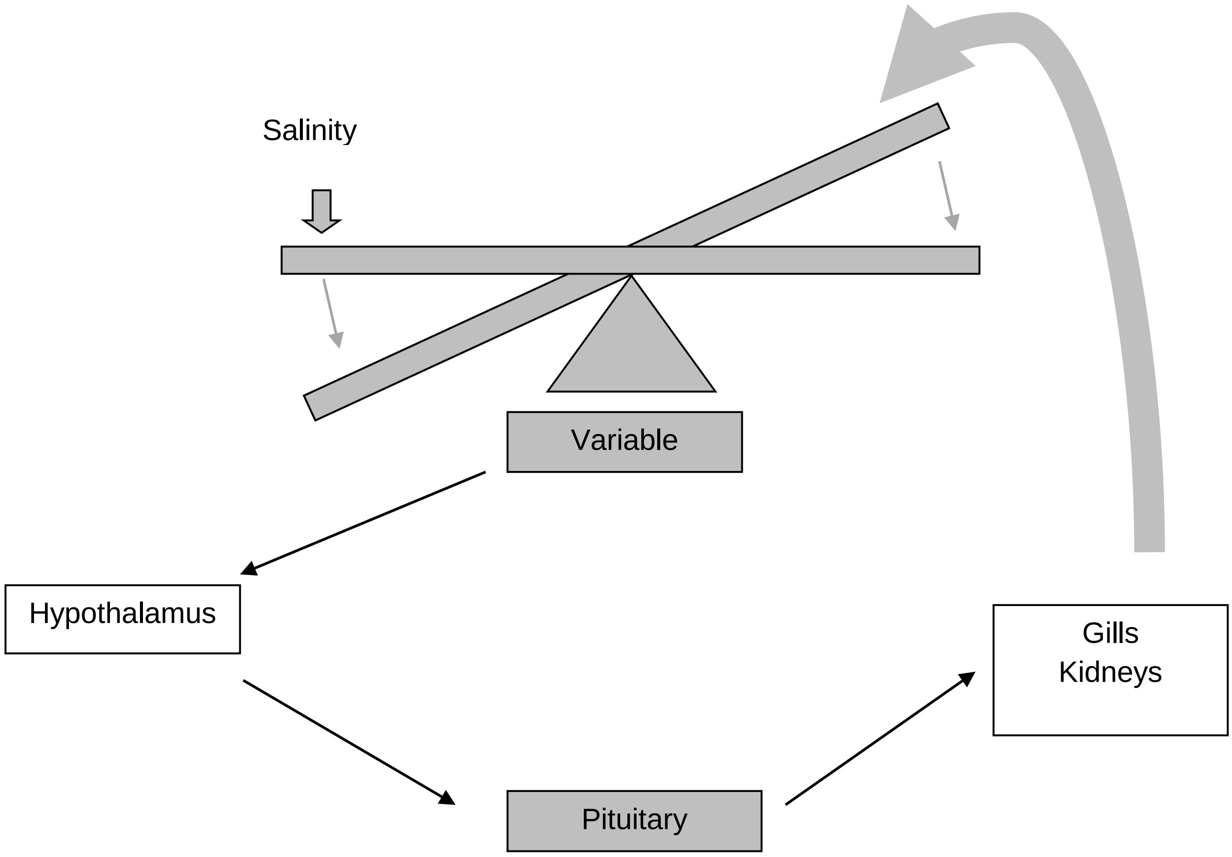
hypothalamus detect the high concentration of water within the blood to stimulate the pituitary glands to release a hormone into the bloodstream. The hormone causes the transport of ions to take place within the gill membrane. The salmon will not drink much and a large quantity of water is expelled.



②

A number of environmental factors can lead to disruptions in the control system, such as toxicants and micro-organisms which fish gills are sensitive to. It is also possible that pollutants clog the gills directly. Excessive loss of water molecules can cause dehydration which can ultimately result in death. Damage to the kidney through bacterial infection can also be lethal. When the control system breaks down, salmon are under stress and may not be able to break down food or carry out essential life processes. For example, the excretion of waste products which can then build up and cause further harm to the fish. ④

	Grade Boundary: High Not Achieved
6.	For Achieved, the student needs to demonstrate understanding of how an animal maintains a stable internal environment. This involves using biological ideas, see Explanatory Note (EN) 4, to describe a control system (EN3) by which an animal maintains a stable internal environment. Annotated diagrams or models may be used to support the description. This student has demonstrated limited understanding by describing the purpose (1) and components (2) of osmoregulation in Chinook salmon. Some biological ideas are briefly considered to describe the mechanism of (3), and disruption to this system (4). To reach Achieved, the student could use biological ideas to give a more thorough description of: • the purpose, components and mechanism of osmoregulation in Chinook salmon. • a specific disruption results in responses within this control system to re-establish a stable internal environment.

Student 6: High Not Achieved

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The word ‘homeostasis’ originates from the Greek word meaning ‘staying the same’, and involves the balance and consistency of certain conditions. An example is the control of body temperature by thermoregulation in warm blooded animals like humans. Homeostasis can 1
be an open or closed system. Homeostasis is important to fish like Chinook salmon. Osmoregulation is also an example of homeostasis and is the way by which salmon regulate their body water.

Salmon live in both fresh water and salt water during their lives. They are born in in fresh water and migrate out to marine waters for most of their life. They return to the place they were born in fresh water to reproduce. Changing between fresh water and salt water 1
changes the amount of water in their body. They are adapted to the changes by osmoregulation.

When an imbalance occurs, osmoregulation works by negative feedback. This system detects any changes and initiates changes to restore the concentration of water in the body.
3 This control system detects changes in the salt concentration of the water Chinook salmon live in. The feedback mechanism works differently when they are in fresh water and salt water environments.
Feedback systems are made up of components which detect the change, followed by a process to reverse the change. The components (see diagram below) in the system include: the **stimulus**, the **receptor**, the **control centre** and the **effector**. The stimulus causes the 2
fish’s response. In this case it is the change in salt level within the body. The receptor senses the stimulus and sends information to the control centre. In salmon the receptor is the hypothalamus - part of the brain. The hypothalamus detects how concentrated the blood is inside the fish. The hypothalamus stimulates the pituitary gland, which is the control centre. The control centre responds to the stimulus. The effector includes the kidneys and gills, which respond to the commands set by the pituitary gland.

When salmon are in salt water (hypertonic):

1. water is lost through the gills and skin
2. water and salt are gained by drinking (3)
3. salt is removed by the chloride cells, and lost via the faeces
4. salt and little water is lost via the urine

The kidneys of salmon have fewer and smaller glomeruli which reabsorb glucose in convoluted tubules. Osmosis is the process of diffusion of water molecules through a semi-permeable membrane. Water has the ability to go through a number of different membranes. The concentrations can be categorised in three different sections:
Isotonic - the concentration of water is the same as the concentration of salt
Hypotonic - less concentration of salt in comparison to a greater concentration of water
Hypertonic - more concentration of salt in comparison to a lesser concentration of water

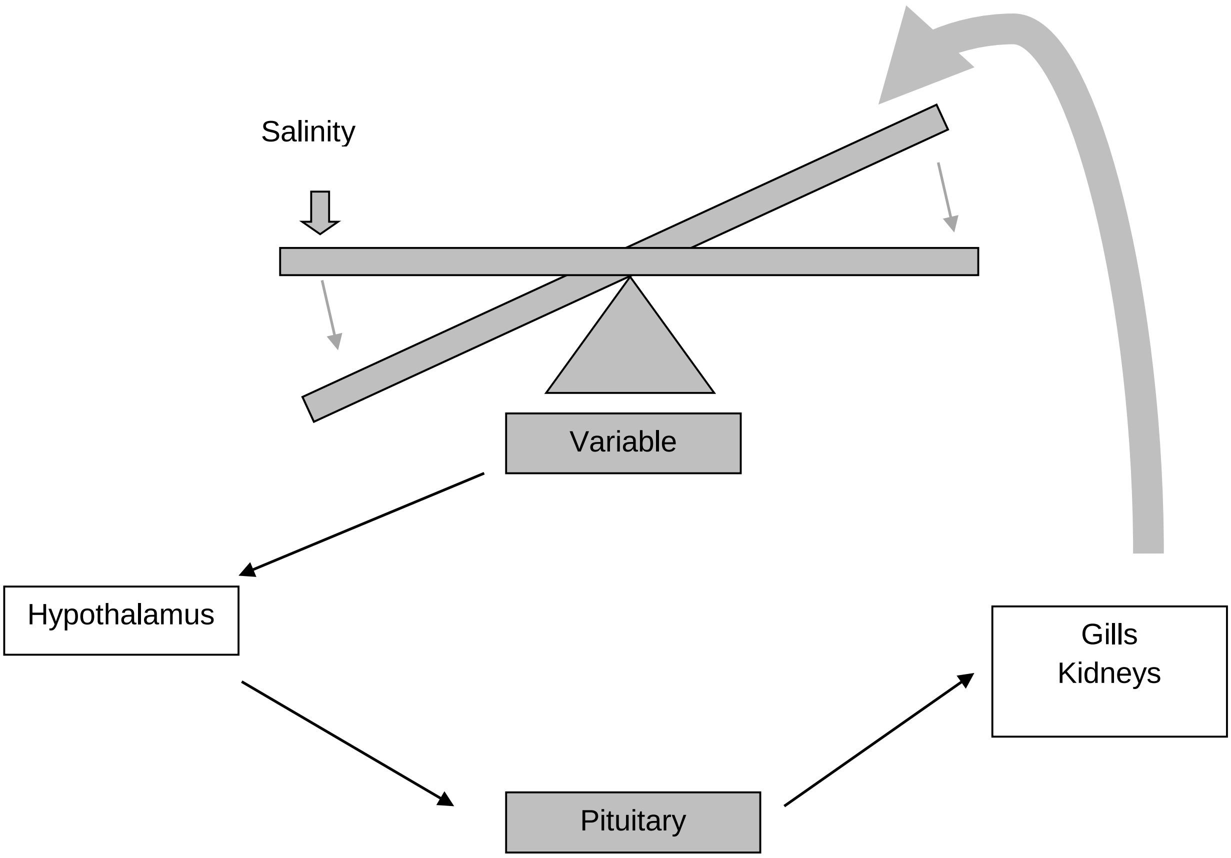
In salt water there is more water inside the body than outside the body, so water moves out of the body. Receptors in the hypothalamus detect that there is a high concentration of salts in the blood, and stimulate the pituitary glands to release a hormone that causes the transport of ions to take place in the gill membrane .The high salt concentration in the ocean

3 means that salt will also be constantly diffusing into the salmon's body, which means that salmon suffer from dehydration and salt loading.

When salmon are in fresh water (hypotonic):

1. water is absorbed through the gills and skin
2. salt is obtained through 'chloride cells' and with food
3. water is removed via copious urine

The kidneys have numerous large glomeruli which reabsorb salts along convoluted tubes.
In fresh water there is more water and lower levels of salt outside the body than inside the
3 body, so water moves inside the body. Receptors in the hypothalamus detect that there is a high concentration of water in the blood, and stimulate the pituitary glands to release a hormone that causes less water to be absorbed back into the blood in the kidneys.



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Disruptions to the system happen as the result of toxicants and micro-organisms which fish gills are sensitive to. Pollutants clog the gills directly. Damage to the kidney through bacterial infection can be serious. If the toxicity cannot be removed the organs are not able to function 4 properly. If salmon become diseased by losing their ability of osmoregulation, they may even die. When the control system breaks down, salmon are under stress and may not be able to break down food or carry out essential life processes. For example, the excretion of waste products which can then build up and cause harm to the fish.