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. (1) 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.

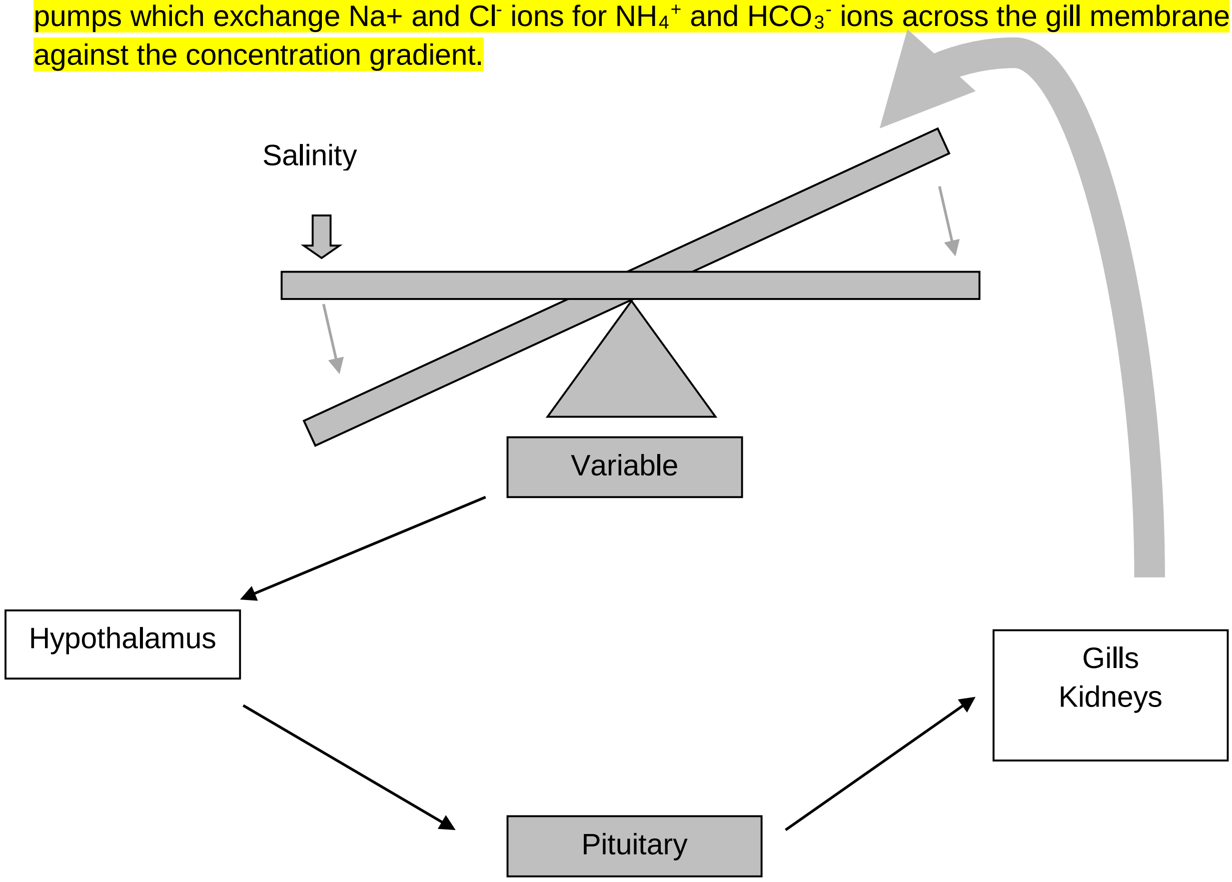
Fishes like salmon live in a habitat surrounded by water and their body contains a high percentage of water. They live in both fresh water and salt water during their lives. They are born in in fresh water and migrate out to marine waters for most of their life. They return to the place they were born in fresh water to spawn. Changing between fresh water and salt (1) 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.

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 (3) 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. (2) 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.

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 (3) 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.