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 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. ①

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. 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. 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 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 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 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 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.