AP Biology
2000 Student Samples

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2. Feedback mechanisms are used by organisms to maintain the steady-state physiological condition known as homeostasis. Choose **three** of the following and for each, explain how feedback mechanisms maintain homeostasis.

a) Blood glucose concentration.

b) Calcium ion concentration in blood.

c) Body temperatures in mammals.

d) Osmolarity of the blood.

e) Pulse rate in mammals.

Feedback mechanisms are very important in maintaing the ~~steady-state~~ homeostasis in the body. Three key examples are blood glucose concentration, body temperature in mammals, and osmolarity of the blood. In each case, homeostasis is maintained by a negative feedback mechanism.

Blood Glucose concentration is monitored by the medulla of the Brain. when Glucose levels increase above the set point the pancreas is stimulated to release insulin into the blood stream from β-cells in islets of Langerhaens. Insulin increases the permeability of all cells in the body to glucose, espcecially muscle cells. The liver, meanwhile, begins storing glucose in the form of glycogen. when blood glucose levels are low, the pancreas releases glucagon from α-cells in islets of Langerhaans into the blood stream. Glucagon causes the liver to begin breaking glycogen into glucose and performing gluconeogenesis as well. Meanwhile, the cells of the body release glucose into the bloodstream. This hormonal stimulus is translated into a behavioral response; hunger. As blood

(ie skip lunch)

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glucose levels return to normal production of insulin and glucagon respectively is inhibited.

Body temp is controlled in a similar fashion. When temperature receptors register a decrease in body temperature, the body activates its warming mechanisms. Body hair is raised to trap moving air and keep it from taking heat away from the body. Skeletal muscles also contract and create heat from friction (shivering). Blood is directed from the capillaries near the skin to reduce (vasoconstriction) heat lost from blood. Shunt vessels may even be used to divert blood from appendages such as the hands and feet. Furthermore, the hypothalamus secretes TSH-releasing hormone, which targets the pituitary gland. The pituitary then releases Thyroid-Stimulating Hormone (TSH), which stimulates the Thyroid to release Thyroxine. Thyroxine increases metabolism and thus warmth. As the body temp returns to normal these processes are inhibited (neg. feedback). When the body temperature is too high, blood is pumped through capillaries near the skin (vasodilation), the body perspires. Evaporation of sweat takes a lot of energy.

Blood osmolarity is also maintained at a relatively constant point via negative feedback mechanisms. When blood osmolarity rises above the set point of 300 mosmol/L the body acts to conserve water. The osmoreceptor cells

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in the medulla register this increase and trigger the pituitary gland to release Anti-diuretic Hormone (ADH). ADH targets the distal tubules and collecting duct of a nephron and makes their membranes more permeable to water so more water can be retained. This results in darker, more hypertonic urine. As blood osmolarity levels off ADH is inhibited. However osmolarity can not return all the way back to normal unless fluids are ingested. In the opposite scenario, no ADH is secreted and very little water is reabsorbed in the collecting duct. This results in a lot of clear hypotonic urine.

Thus, negative feedback mechanisms are very important in maintaining the homeostasis of the body.

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Body temperatures in mammals are regulated with the help of the hypothalamus to maintain homeostasis. When the temperature inside the body increases above the set point, the hypothalamus sends a signal that dilates the blood vessels. The mammal will also begin to sweat when the sweat glands are activated. Sweating is a type of evaporative cooling because in order for the water to leave the skin, energy and heat is taken off of it. Once the temperature goes back to normal, the hypothalamus stops sending the appropriate signals.

In contrast, when the homeostatic temperature is below the norm, the hypothalamus sends the message to constrict the blood vessel to increase the blood flow. In addition, shivering occurs. Shivering produces heat for the mammals. The constriction of the blood vessels help bring the heat to the upper regions of the underlying tissues under the skin. Once the temperature is at normal, hypothalamus ceases to signals.

The osmolarity of the blood is also maintained by the hypothalamus.

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Once the osmolarity dips below normal, the thirst glands are activated by the hypothalamus. The ~~the~~ increase in uptake of the water will aid in bringing the blood osmolarity back to normal. ~~In~~ In addition, the pituitary gland will secrete ADH ~~and aldosterone~~, which helps the reabsorption of water. ~~The~~ If the kidney does not reabsorb enough water, diarrhea is a sign of the lack of water. ~~The thirst The~~ A combination of the diarrhea-warning sign is an indicator in the unbalanced blood osmolarity. Meanwhile, the thirst gland and hormones are already working feverishly to maintain a homeostatic condition.

If calcium ions are too concentrated in the blood, calcitonin is in charge of lowering it. This occurs when the bones increase their uptake of Ca^{2+}, along with the pancreas. ~~On~~ On the other hand, the liver does not increase its uptake. The increased storage of Ca^{2+} ~~come Retreat~~ in the bones and pancreas lower the Ca^{2+} concentration in blood.

On contrast, PTH is ~~throw~~ activated when Ca^{2+} dips below normal. The bone and pancreas release the excess-stored Ca^{2+} into the bloodstream. The liver does the opposite. The combination of the pancreas and bone Ca^{2+} release enables the Ca^{2+} concentration to be brought up to normal again.

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a) As glucose levels in your blood increase, ~~the~~ insulin (β cells) is released from your pancreas. This causes the breakdown of glucogen to stop, thereby decreasing glucose levels in blood. If your glucose level is too low, your pancreas will release glucogen (α cells). This is broken down to glucose which will increase ~~d~~glucose blood level. This is feed back regulation because the problems automatically trigger reactions which will prevent them, i.e., increased glucose level in ~~the~~ blood triggers release of insulin. thereby keeping the organism at homeostasis

b) When ~~a~~ Ca^{+2} concentration becomes to high, the thyroid is triggered into action. It releases calcitonin which does some things to decrease Ca^{+2} levels. First, it will make your bones absorb calcium. Then it will prevent your intestine from absorbing calcium and make your kidneys ~~excrete~~ lose calcium through urine. All of this will ~~bring~~ bring Ca^{+2} levels down. If the levels are too low, the parathyroid will release PTH (parathyroid hormone) which will also take action. It will cause ~~the~~ the bones to release calcium,

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the intestines to absorb it, and the kidneys to stop releasing it through urine. therefore, extreme Ca^{+2} levels trigger the release of hormones that keep the organism at homeostasis.

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2a. Let us say that we have [redacted] just consumed a bar of chocolate which is high in sugar. The sugar is digested and is absorbed in to the blood. This increased level of glucose stimulates receptors in the pancreas to produce more [redacted] insulin (a hormone that helps [redacted] stimulate the breakdown or excretion of [redacted] excess glucose). The insulin circulates throughout the body and starts the breakdown of glucose wherever it goes until levels of glucose go down again to the "proper" homeostatic level.

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c. Say it is December, on a cold we go out to observe the wonderfull processes of life that are going on. When we go out the cold begins to chill our body and blood. As this colder blood circulates through the body it passes through the part of the brain called the hypothalamus which monitors body temperature. Once the hypothalamus is stimulated it sends out instructions to the pituitary gland which in turn send out hormones to all of the body. One such hormone might be sent to muscle cells instructing them to contract and use ATP, one of the by-products of this use of ATP is the release of heat which brings the body back to its proper homeostatic temperature.