FACTFILE: GCSE BIOLOGY: UNIT 1.6

Rewarding Learning

Homeostasis

Learning outcomes

Students should be able to:

- 1.6.9 explain the importance of maintaining a constant internal environment for the proper functioning of cells and enzymes in response to internal and external change, limited to controlling blood glucose concentration and osmoregulation.

Why is it important to maintain a constant internal environment?

The human body is made up of billions of cells working together to maintain the whole body. Although cells may perform different functions in different parts of the body they all have very similar needs to survive. Cells are very sensitive to changes in their environment so the conditions inside the body must stay within a very narrow range for cells to function as efficiently as possible.

Changes in both the internal and external environments are a constant for living things. The body responds to these changes by a process called homeostasis.

Homeostasis is the process of maintaining a stable internal environment for the proper functioning of cells, in response to internal and external changes.

Homeostasis involves the precise control of factors that can affect conditions inside the body. These factors include:

Glucose concentration

Glucose is needed for respiration to produce energy for cells, if a cell cannot produce enough energy it will not be able to carry out certain chemical reactions it needs to survive. The opposite problem, having too much glucose, can also cause damage to cells.

Water concentration

All the chemical reactions in cells take place in water. The reactants must be dissolved in water, therefore the water concentration of cells and the surrounding fluid is vital.

Dissolved substances such as salts, affect the balance of these fluids and so must also be controlled.

Temperature

All the chemical reactions in cells require enzymes and these only function within a narrow range of temperature. Outside of this range, the enzymes denature, meaning they are unable to carry out their functions.

What causes conditions in the body to change?

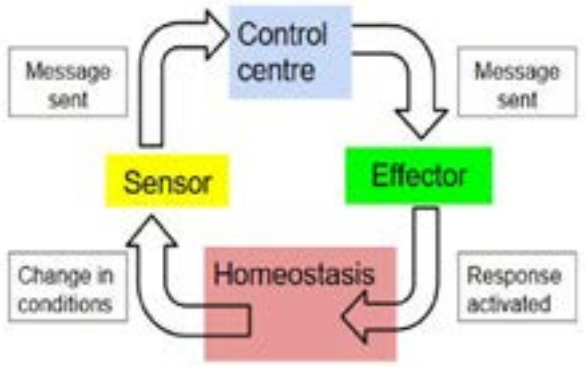
Conditions outside the body can change for many reasons. Walking in the desert on a hot day will cause an increase in body temperature, eating a sandwich will increase blood glucose levels or the stress from studying for a test might make you forget to drink water. Fortunately the body has mechanisms to counteract these changes and bring us back to normal.

How does the body maintain internal conditions?

In order to maintain a constant internal environment there are three important steps. Firstly, detect the change, secondly, coordinate a response and finally, reverse the change.

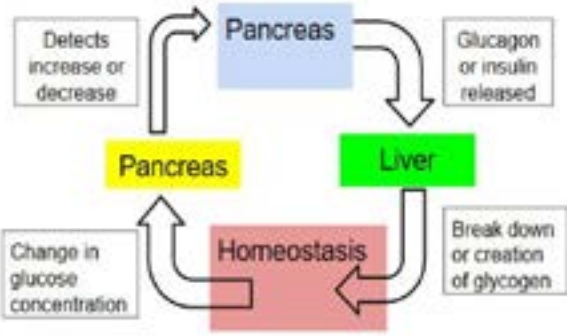
Sensory cells or receptors detect a change in the environment, this is known as a stimulus. The sensor sends a message to a control centre which then sends a message to the effector. The effector organs (which can be muscles or glands) then work to reverse or counteract the change; this is known as a response. As the response aims to cancel the stimulus that caused it this is known as a negative feedback loop.

The diagram below shows the maintenance of homeostasis using negative feedback.



How does the body control glucose levels?

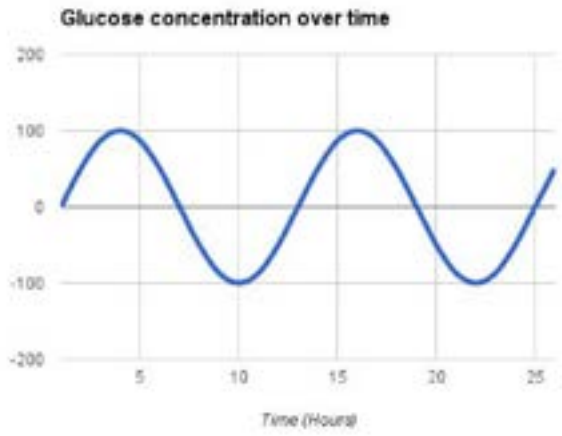
For glucose the sensor and the control centre are in the same organ: the pancreas. The pancreas monitors glucose levels and if the level of glucose is low (called hypoglycemia) the pancreas releases a hormone called glucagon. If the level of glucose is too high (called hyperglycemia) it releases the hormone insulin.



The effector for this feedback loop is the liver. Glucagon stimulates the liver to breakdown its store of glycogen into glucose, which is then released into the blood to increase the level of blood glucose.

Insulin does the opposite and stimulates the liver to start converting glucose to glycogen and storing it so the level in the blood goes down.

All organisms have a set point – which is an ideal value for a particular variable, in this case glucose level. Homeostasis does not maintain the glucose levels at a fixed set point. This means that the concentration of glucose and other conditions, fluctuates around the ideal value as illustrated in the graph below. Problems only arise if the change is larger than the normal range of values.

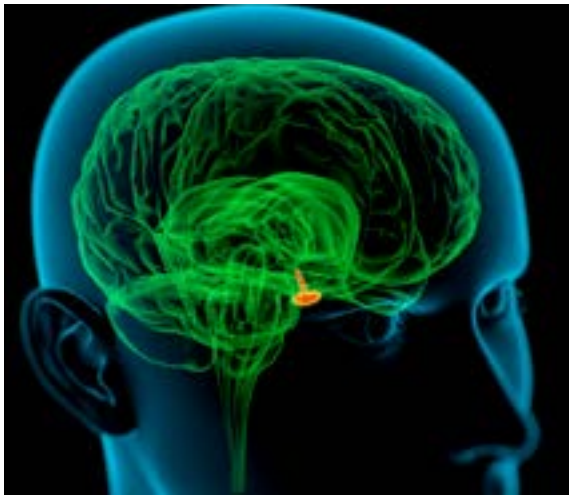


This can happen due to illnesses such diabetes, where the body cannot produce insulin or becomes resistant to the effects of insulin. People who suffer from diabetes must regularly measure their blood glucose level to ensure that it does not go beyond the normal range.

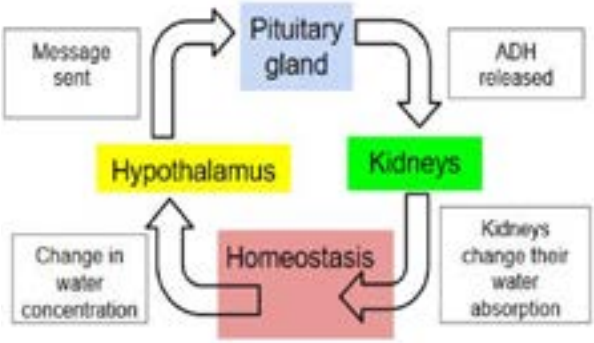
How does the body control water levels?

The control of water level in the body is called osmoregulation and also uses a negative feedback loop. For osmoregulation the sensor is a small section of the brain called the hypothalamus.

When the hypothalamus detects a change it sends a message to the pituitary gland in the brain, highlighted in the illustration below. The pituitary gland then sends a chemical message using the hormone ADH (antidiuretic hormone).



The effectors for osmoregulation are the kidneys. Depending on the level of ADH the kidneys will alter the amount of water that is reabsorbed from the blood. If the kidneys reabsorb less water, the water is able to go to the bladder and more urine is produced.



In situations where the body needs to conserve water, the kidneys increase the reabsorption of water from the blood. This results in less urine being produced. As a side effect, ADH can also trigger feelings of thirst so that you increase your water intake.

Glossary

Homeostasis: The process of maintaining a stable internal environment for the proper functioning of cells, in response to internal and external changes.

Negative feedback: A process that reverses changes and returns a system back to a set point.

Sensor: An organ that detects changes of a particular condition.

Stimulus: Any change in condition that can activate a sensor.

Effector: An organ that acts to reverse a change in conditions.

Response: The action of the effector that aims to return conditions to normal.

Glycogen: The main storage form of glucose in cells.

Osmoregulation: The control of water concentration in the body.

Learning Activities

1. Negative feedback loops are very common in nature. Investigate what other conditions are regulated by negative feedback.
2. Marta is in the middle of running a marathon, she has been running continuously without stopping to eat or drink for nearly an hour. Describe what her body is doing to maintain her levels of glucose and water.
3. Type 1 Diabetes is an illness caused by the body being unable to produce enough insulin. Why must sufferers carefully monitor their diet and level of physical activity?
4. Paul is a diabetic, he injects insulin before he is about to eat a big meal. However, he gets distracted and forgets to eat. A few hours later he faints. Explain why.
5. A pair of twins take part in an experiment. They drink the same amount of water. An hour later the experimenters measure the amount of urine they produced and find that the amounts are very different. What could have happened in the hour to produce this result?