G1: Homeostasis

Here is a checklist of knowledge and understanding needed for Homeostasis. You will be expected to apply your knowledge and understanding to familiar and unfamiliar situations.

Ge1.1 What is homeostasis?

I should be able to:

- describe homeostasis as the maintenance of a constant internal environment;
- recognise that automatic control systems throughout the body maintain a range of factors at steady levels, which are required for cells to function properly (limited to temperature and water).

Why is homeostasis so important?

Cells need a constant supply of food and oxygen for respiration and growth and repair. They also require the removal of toxic waste products such as carbon dioxide – excreted via the lungs when we breathe out.

I should be able to:

- recognise the importance of a balanced water level maintaining the concentration of the cell contents at an appropriate level for cell activity;
- appreciate that enzymes need a particular constant temperature to work at their optimum;
- appreciate that excess amino acids are broken down to urea in the liver;
- recall that urea is carried in the bloodstream to the kidneys to be excreted in the urine.

How do substances enter or leave cells?

I should be able to:

- describe the process of diffusion as the passive overall movement of molecules from a region of their high concentration to a region of their low concentration;
- identify osmosis as a special case of diffusion;

- describe osmosis as the overall movement of water from a dilute to a more concentrated solution through a partially permeable membrane;
- appreciate the importance of diffusion and osmosis in transporting molecules into and out of cells;
- *explain that if excess water moves into animal cells by osmosis the cell membrane may rupture and if too much water moves out of cells they are unable to function correctly.*

Ge1.2 Why is temperature homeostasis important for a cell?

How do enzymes work?

I should be able to:

- recall that enzymes are proteins that speed up chemical reactions in cells;
- explain how, at low temperatures, small increases in temperature increase the frequency and energy of collisions between an enzyme and other molecules, so the rate of reaction increases;
- *describe how enzymes have a small part called the active site where certain molecules can bind to the enzyme, and the chemical reaction takes place;*
- *describe how only molecules with the correct shape can fit into the active site and that this is described as the lock and key model;*
- explain how the shape of the active site is changed by heating the enzyme above a certain temperature; this means that the molecules can no longer fit and the reaction cannot happen.

Ge1.3 How can an artificial system maintain a steady state?

Scientific models and explanations

Do artificial systems work in similar ways to body control systems?

I should be able to:

- recognise that artificial systems, for example, the temperature control system in an incubator, are similar to body control systems;
- describe how artificial systems have receptors to detect stimuli (changes in the environment);
- recognise the role of a processing centre which receives information from the receptors and triggers the necessary response;
- *recognise that the necessary response is produced automatically by effectors.*

How do artificial devices keep a steady state?

I should be able to:

- describe how negative feedback between the effector and the receptor of a control system reverses any changes to the system's steady state;
- *recognise that some effectors work antagonistically, which allows a more sensitive response.*

Ge1.4 How is our body temperature kept constant and what happens when it is disrupted?

Which structures in our body help to control body temperature?

I should be able to:

- describe how energy gain and loss must be balanced in order to maintain a constant body temperature;
- recall that temperature receptors in the skin and the hypothalamus detect changes in the temperature of blood;
- describe how the hypothalamus acts as a processing centre, receiving information from the temperature receptors, and triggering the effectors automatically without the need for conscious thought;
- recall that the effectors include sweat glands, muscles, and smooth muscle in blood vessels;
- *describe how body extremities tend to be cooler than the core body temperature, and that energy is transferred from the blood to the tissues when blood reaches cooler parts.*

What does the body do if the core temperature is too high?

I should be able to:

- explain how more sweat is produced by sweat glands which cools the body when it evaporates;
- *explain how blood vessels supplying the capillaries of the skin dilate (vasodilation) allowing more blood to flow through skin capillaries which increases energy loss.*

What does the body do if the core temperature is too low?

I should be able to:

- explain how the increased rate of respiration stimulated when muscles contract rapidly (shivering) results in some of the energy transferred in respiration warming the surrounding tissues;
- *explain how blood vessels supplying the capillaries of the skin constrict (vasoconstriction) restricting blood flow through skin capillaries which reduces energy loss.*

Scientific models and explanations

What dangers do we face if our body temperature becomes too high?

I should be able to:

- recognise that heat stroke is an uncontrolled increase in body temperature;
- recognise that heat stroke can be caused by illness, over-exposure to the sun and drugs such as ecstasy;
- explain how exposure to very hot temperatures produces increased sweating, and can produce dehydration; dehydration may lead to reduced sweating which further increases core body temperature;
- *explain that when the temperature of the hypothalamus becomes too high it can no longer function properly, because the normal negative feedback mechanisms for controlling body temperature break down;*
- describe the symptoms of heat stroke to include red, hot and dry skin, a rapid pulse rate, dizziness and confusion;
- *describe the immediate treatment for heat stroke (to lower the body temperature, for example, by placing the person in a cool place, either in a bath of cold water or covered in cold, wet sheets).*

What dangers do we face if our body temperature becomes too low?

I should be able to:

- recognise that exposure to very low temperatures can result in hypothermia and this happens when the core body temperature drops below $35^{o}C$;
- *explain that, in hypothermia, even though the normal negative feedback mechanism is controlling body temperature, body heat cannot be replaced as fast as it is being lost;*
- describe the symptoms of hypothermia to include confusion, drowsiness, loss of coordination and slurred speech;
- describe the immediate treatment for hypothermia (to increase the body temperature, by placing the person in a warm place, wrapping them in layers, and by giving them warm drinks (but not alcohol).

What might happen to disrupt homeostasis?

I should be able to:

- appreciate that strenuous exercise, survival in hot or cold climates, scuba-diving and mountain climbing affect homeostasis (temperature, blood O_2 levels, hydration and salt levels);
- *appreciate that during illness or after surgery or injury, the body may need help in maintaining homeostasis;*
- *appreciate that monitoring patients in intensive care ensures that their state does not deviate from normal levels.*

(Note: You are not expected to know details of these homeostatic mechanisms other than those outlined in this module. However, when you are presented with relevant information about a control system, a simple discussion of negative feedback involved in the system is expected.)

Ge1.5 How does the body control water balance and what can disrupt it?

How does the kidney work?

I should be able to:

- recall that water is gained from drinks, food and respiration and is lost through sweating, breathing, faeces and the excretion of urine;
- describe how the kidneys play a vital role in removing the waste product urea from the blood and in balancing levels of other substances in the blood by:
- filtering small molecules from the blood to form urine (water, salt and urea);
- reabsorbing all the sugar;
- reabsorbing as much salt as the body requires;
- reabsorbing as much water as the body requires;
- excreting the remaining urine, which is stored in the bladder before being released from the body.
- *explain that reabsorption of molecules by the kidneys is achieved through a combination of diffusion and active transport;*
- appreciate that active transport requires energy to 'pump' molecules across cell membranes against a concentration gradient.

(Note: Specific details of reabsorption other than those outlined above are not required.)

How does kidney function respond to different conditions?

I should be able to:

- appreciate that the concentration of urine excreted by the kidneys varies, depending on the concentration of the blood plasma. This will vary with the external temperature, the level of exercise and the intake of fluids and salt;
- describe how the kidneys help balance water levels by producing dilute or concentrated urine;
- *explain how the concentration of the urine is controlled by a hormone called ADH which is released into the bloodstream by the pituitary gland;*
- *appreciate that ADH secretion is controlled by a negative feedback mechanism.*

(Note: Your are not expected to be able to recall detail of kidney structure.)

How do drugs alter kidney function?

I should be able to:

- *explain that alcohol acts as a diuretic by suppressing ADH secretion;*
- *appreciate that this suppression results in a decrease in the concentration of urine, which can lead to dehydration*;
- explain that ecstasy also suppresses the production of ADH, resulting in uncontrolled water levels within the body.