

What is homeostasis?

Homeostasis is the maintenance of a constant internal environment.

Automatic control systems throughout the body maintain temperature and water at steady levels, which are required for cells to function properly.

Strenuous exercise and survival in hot or cold climates affect homeostasis. They affect temperature, **blood oxygen levels**, hydration and **salt levels**.

Two examples are **scuba diving** and **mountain climbing**.

Artificial systems, such as the temperature control system in an incubator, are similar to body control systems.

Artificial and body systems have receptors to detect stimuli, processing centres to receive information and coordinate responses and effectors which produce the response automatically.

Negative feedback between the effector and the receptor of a control system reverses any changes to the systems steady state.

Some effectors work antagonistically, which allows a more sensitive response.

Why is homeostasis important?

Diffusion is the passive overall movement of molecules from a region of their high concentration to a region of their low concentration.

Osmosis (a specific case of diffusion) is the overall movement of water from a dilute to a more concentrated solution through a partially permeable membrane.

Some examples of chemicals that move in or out of cells by diffusion are O₂, CO₂ and dissolved food.

Some chemicals (for example, glucose) are also moved by active transport.

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.

Enzymes

Enzymes are proteins that speed up chemical reactions in cells.

Enzymes need a specific constant temperature to work at their optimum.

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.

At higher temperatures enzymes stop working (denature).

Only molecules with the correct shape can fit into the enzyme. This is known as the 'lock and key' model.

Enzymes have a small part called the active site where certain molecules bind to the enzyme and the reaction occurs.

The shape of the active site is can be changed by heating above a certain temperature and altering the pH, so that the molecules can no longer fit and the reaction cannot happen.

Keeping body temperature constant

Energy gain and loss must be balanced in order to maintain a constant body temperature.

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.

Temperature receptors in the skin detect external temperature.

Temperature receptors in the brain (**hypothalamus**) detect the temperature of the blood.

The brain (**hypothalamus**) acts as a processing centre, receiving information from the temperature receptors, and triggering the effectors automatically.

Effectors include sweat glands and muscles.

At high body temperatures, more sweat is produced by sweat glands which cools the body when it evaporates and **blood vessels supplying the capillaries of the skin dilate (vasodilation) allowing more blood to flow through skin capillaries which increases energy loss.**

Heat stroke is an uncontrolled increase in body temperature.

A common cause of heat stroke is strenuous exercise when it is warm. Symptoms include headache, dizziness and an inability to concentrate. Initial treatment of heat stroke is to cool the body e.g. by spraying the skin with water.

Exposure to very hot temperatures produces increased sweating, and can produce dehydration, which may lead to reduced sweating and further increase of core body temperature.

When core body temperature becomes too high the normal mechanisms for controlling body temperature break down.

At low body temperatures the increased rate of respiration stimulated when muscles contract rapidly (shivering) results in some of the energy transferred in respiration warming the surrounding tissues.

Blood vessels supplying the capillaries of the skin constrict (vasoconstriction) restricting blood flow through skin capillaries which reduces energy loss.

Hypothermia is when core body temperature falls below 35°C.

Symptoms of hypothermia are drowsiness, poor coordination and poor judgment.

In hypothermia body heat cannot be replaced as fast as it is being lost.

How the body controls water balance

Water is gained from drinks, food and respiration and is lost through sweating, breathing, faeces and the excretion of urine.

A balanced water level is important for maintaining the concentration of cell contents at the correct level for cell activity.

The kidneys play a vital role in removing waste urea from the blood and in balancing levels of other chemicals 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;

The kidneys balance water levels by producing dilute or concentrated urine as a response to concentration of blood plasma, which varies with external temperature, exercise level, intake of fluids and salt.

Concentration of urine is controlled by a hormone called ADH, which is released into the bloodstream by the pituitary gland.

ADH secretion is controlled by negative feedback.

Alcohol results in a greater volume of more dilute urine, **due to ADH suppression**, which can lead to dehydration.

The drug Ecstasy results in a smaller volume of less dilute urine, **due to increased ADH production.**