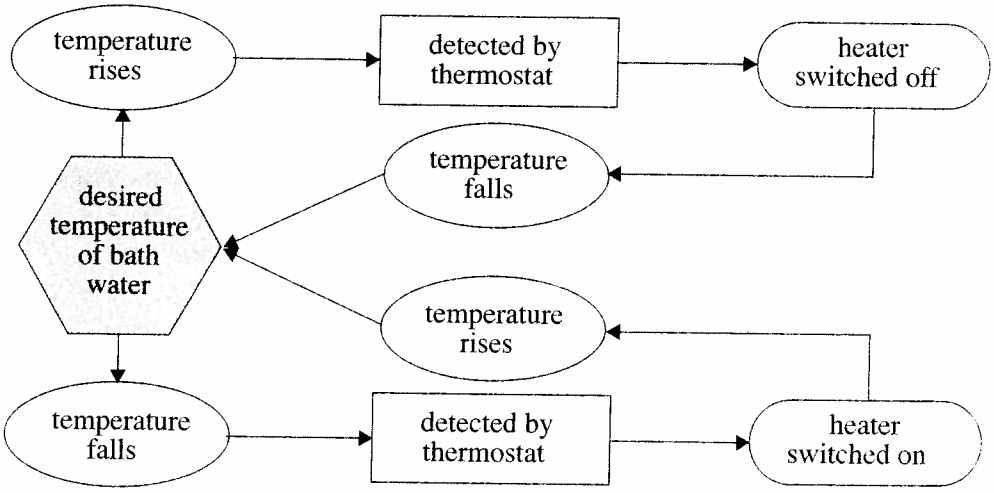
5.6 HOMEOSTASIS AND EXCRETION

5.6.1 State that homeostasis involves maintaining the internal environment at a constant level or between narrow limits, including blood pH, oxygen and carbon dioxide concentrations, blood glucose, body temperature and water balance.

Homeostasis: the maintenance of a constant internal environment despite possible fluctuations in the external environment.

AN EXAMPLE OF HOMEOSTASIS IN A NON-BIOLOGICAL SYSTEM



Examples of homeostasis are: the maintenance of

- oxygen and carbon dioxide concentrations
- blood glucose
- body temperature
- water balance

Blood pH is maintained within narrow limits, around pH 7.4. The blood plasma contains buffers to minimise the fluctuations in the pH, caused by e.g. dissolving carbon dioxide.

Oxygen and carbon dioxide concentrations are maintained with the aid of a system of chemodetectors in the walls of certain blood vessels (see section H.6)

The maintenance of the blood glucose level is described in section 5.6.7.

The maintenance of the body temperature is described in section 5.6.5.

The maintenance of the water balance is described in section 12.2

5.6.2 Explain that homeostasis involves monitoring levels of variables and correcting changes in levels by negative feedback mechanisms.

Negative feedback: the control of a process by the result or effect of the process in such a way that an increase or decrease in the results or effects is always reversed.

The process of negative feedback requires certain elements to be present. It requires sensors to measure the current situation. The sensors need to pass on the information to a centre which knows the desired value (the norm) and compares the current situation to the norm. If these two are not the same, then the centre activates a mechanism to bring the current value closer to the norm. When this has happened, the centre will turn off the mechanism. This is the key to negative feedback. The action taken aims at changing a situation so that the action is no longer required. In the diagram given in section 5.6.1, a change in temperature is detected. When the water in the bath becomes too cold, the heater is switched on. This will result in the water warming up and the heater being switched off. So the action will result in a change which will cancel the action.

5.6.3 State that the nervous and the endocrine systems are both involved in homeostasis.

Both the nervous system and the endocrine system are involved in homeostasis. Thermoregulation is done mainly via nerves (Section 5.6.5) but the maintenance of blood glucose levels is mainly carried out via hormones (see Section 5.6.7).

5.6.4 State that the nervous system consists of the central nervous system (CNS) and peripheral nerves and is composed of special cells called neurons that can carry electrical impulses rapidly.

No structural or functional division of the nervous system or details of impulse transmission or synapses are required.

The nervous system can be divided into the **Central Nervous System** (CNS) and the peripheral nerves. The CNS is the brain and spinal cord, everything else is peripheral. The peripheral nerve cells are called **neurons**. Their function is to transport messages in the form of electrical impulses to specific sites. This is done very quickly by local depolarisations of the cell membrane of the neuron.

5.6.5 Describe the control of body temperature including the transfer of heat in blood, the role of sweat glands and skin arterioles, and shivering.

Thermoregulation:
The body of a mammal/bird has thermoreceptors in the skin and in the heat centre in the brain. This way, it monitors temperature changes in the environment as well as changes in the blood temperature.

If the organism is too hot, it can cool down using one or more of the following mechanisms:

- **vasodilation:** the blood vessels in the skin become wider which increases the flow of blood to the skin; as a result the skin becomes warmer which increases heat loss to the environment. Convection and radiation are increased.
- **sweating:** evaporation of fluid from the skin; change of phase (liquid to gas) requires energy which is taken from the body. Panting has the same effect.
- **decreased metabolism:** any reaction produces heat as a by product.
- **behaviour adaptations**: for example birds - bathing, desert rodent - retreat into humid burrows, dogs - dig holes and allow cool earth to absorb heat from belly.

If the organism is too cold, it can warm up using one or more of the following mechanisms:

- **vasoconstriction:** the blood vessels in the skin contract which decreases the flow of blood to the skin; as a result the skin becomes colder reducing the heat loss to the environment. Convection and radiation are decreased.
- **shivering:** any reaction will produce heat as a by product. Muscular contractions produce a lot of heat.
- **increased metabolism:** increase production of heat.
- **'fluffing' of hair or feathers:** this increases the thickness of the insulating layer of air.
- **thick layer of brown fat or of blubber:** this is a good insulator and reduces radiation and convection and also generates heat.
- **special structure hair:** (polar bears) which absorbs UV light

Heat is not produced equally in all parts of the body, neither is it lost equally. The blood moving round all parts of the body, will carry heat around. When you are out in the cold, your nose may go red. It is losing a lot of heat and the cells are in danger of being damaged. To compensate for the rapid loss of heat, dilating the blood vessels increases the blood supply to your nose, which brings in more warm blood and turns your nose red.

5.6.6 State that the endocrine system consists of glands which release hormones that are transported in the blood.

The nature and action of hormones or direct comparisons between nerve and endocrine systems are not required.

The **endocrine system** consists of endocrine glands which produce hormones to the blood. Endocrine glands are **ductless glands**; they do not release their product into a duct, as exocrine glands, for example sweat glands do. Instead, endocrine glands secrete their product (hormones) into the blood which transports it around the body. As the

hormone passes cells, only those with special receptors will react to the presence of the hormone. These cells are called **target cells**.

5.6.7 Explain the control of blood glucose concentration, including the roles of glucagon, insulin and α and β cells in the pancreatic islets.

The pancreas is both an exocrine and an endocrine gland. The exocrine cells in the pancreas produce digestive enzymes which are released into the small intestine via the pancreatic duct (see section 5.1.4 and H.2) The endocrine cells are clustered together in groups called the Islets of Langerhans. They produce hormones, which help in regulating the blood glucose levels.

Cells in the islets of Langerhans in the pancreas have chemoreceptors which are sensitive to levels of glucose in the blood. Glucose is absorbed from the digested food and is used in cellular respiration. It can also be converted to glycogen and stored. Levels of glucose could go up after a meal and down after exercise if not carefully regulated.

If blood glucose levels are too low, the α cells in the islets of Langerhans in the pancreas will secrete glucagon. Glucagon is a protein hormone and is secreted into the blood. It will travel to all parts of the body but the liver is the main target organ. Hepatocytes (cells in the liver) will respond to the presence of glucagon by converting glycogen to glucose and releasing it to the blood. They also convert amino acids into glucose (indirectly).

If blood glucose levels are too high, the β cells in the islets of Langerhans in the pancreas will secrete insulin. Insulin is a protein hormone and is secreted into the blood. It will travel to all parts of the body. The presence of insulin will make the muscle cells absorb more glucose and the muscle cells and hepatocytes convert glucose into glycogen. In adipose tissue (fat tissue), glucose is converted to fat in the presence of the hormone insulin.

5.6.8 Define excretion.

Excretion: the removal from an organism of the toxic waste products of metabolism

5.6.9 Outline the role of the kidney in excretion and the maintainance of water.

The main functions of the kidneys are the maintenance of the water balance in the body and the removal of nitrogenous metabolic waste via excretion.

The two basic processes in the working of the kidney are (ultra)filtration and reabsorption. In the process of ultrafiltration, some components of the blood flowing