WJEC Biology A-level

Topic 3.7: Homeostasis and the kidney

Notes

Homeostasis serves to ensure that a **constant internal environment** consisting of factors such as temperature, water potential, pH and blood glucose level is maintained, despite changes in the external environment of the organism.

This is achieved with the help of **negative feedback** which counteracts any change in internal conditions. This means that all changes are reversed to restore the optimum conditions. In order for the negative feedback pathway to work, the following elements need to be present: **sensory receptors** such as temperature receptors to detect changes in internal conditions, in a case where a change is detected, the receptors pass the message either via the **nervous or hormonal system** to the **effectors** such as liver or muscles which bring about a response to restore the optimum conditions.

Another example of a control pathway is **positive feedback** which doesn't occur as often as negative and has an opposing effect, that is it increases the original change in the conditions. An example of positive feedback is **dilation of the cervix during childbirth.**

Kidneys

The main role of the kidneys is **excretion of waste products**, such as urea in the form of urine.
Summary of kidney function:

- Blood enters the kidney through the **renal artery** and subsequently passes through the **capillaries in the cortex** of the kidneys.
- The waste products are **filtered out of the blood** as it passes through the capillaries and into the **long tubules called nephrons** which surround the capillaries in a process known as **ultrafiltration**.
- **Selective reabsorption** is the name of a process where useful substances such as **amino acids, glucose, vitamins** are reabsorbed back through the tubules in the medulla.
- The substances to be excreted pass along the **tubules and ureter** and finally reach the bladder where they're disposed of as urine.
- The filtered blood then passes out of the kidneys through the **renal vein**.

Control of water potential of the blood

In the case of **dehydration**, where the water content of blood is too low, not as much water is **reabsorbed into the blood by osmosis from the loop of Henle, the distal convulated tubule and collecting duct** thus leading to production of more concentrated urine and vice versa in the case of water content of blood being too high. **Hormones** also play an important role in controlling the reabsorption of water.

Osmoreceptors in the **hypothalamus** control the water potential and content. In the case where the osmoreceptors detect the occurrence of low water content in the blood, the hypothalamus sends nerve impulses **to the posterior pituitary gland** to release **antidiuretic hormone (ADH)** into the blood which makes walls of **DCT and collecting duct** more

permeable to water therefore increasing the reabsorption of water from the tubules into the blood. At the same time, some **concentrated urine** is also produced to ensure that no water is lost from the body. The opposite occurs in the case where the body is well hydrated.

Kidney failure

Kidney failure can be triggered by various **kidney infections** which cause **inflammation**. The resulting damage causes the kidneys to perform processes such as **filtration and reabsorption** less efficiently. High blood pressure can also cause damage to the kidney by damaging the **capillaries of glomeruli** thus meaning that larger molecules can find their way into urine.

The consequences of kidney failure include the **buildup of toxic waste** products such as urea which causes symptoms such as vomiting. In cases where excess water cannot be removed from the blood by the kidneys, **fluid accumulation** occurs which leads to swelling. Apart from this, kidney failure can **disrupt the balance of ions**, in result making the bones **more brittle** or causing water to be retained.

If not treated, kidney failure may cause death.

Kidney failure can be treated with a **renal dialysis** which is filters the blood with the help of a machine containing **dialysis fluid** which serves as a means of removing the waste products as well as excess water and ions. Dialysis is only a temporary solution while the patient awaits a transplant. Dialysis needs to be performed several times a week and causes the patient to feel unwell between sessions as the toxic waste builds up.

Kidney transplant is required to replace the damaged kidney and to reverse kidney failure symptoms, it is believed to be the better solution as it is a more convenient and long term solution. Sometimes patients need to wait a long time for a **suitable donor** which needs to be of the **same blood type and tissue type** to minimise the risk of rejection. However, **immunosuppressants** still need to be taken by the patient to prevent rejection. In most cases a donor is a family member due to the degree of similarity, this is possible as only one kidney is required for survival.