CAIE Biology A-level

Topic 14: Homeostasis

Flashcards

Define homeostasis.

Define homeostasis.

Homeostasis is the maintenance of a constant internal environment by the biological systems of the body.

Why is homeostasis necessary?

Why is homeostasis necessary?

Homeostasis ensures that the cells and tissues of the body have the correct environment to function e.g. optimum temperature and pH, enough glucose for energy.

Define negative feedback.

Define negative feedback.

Negative feedback is a response of a biological system. When a change from the optimum is detected, the system that produced the change is turned off to return the variable to its optimum level.

Which component of a biological system detects a stimulus?

Which component of a biological system detects a stimulus?

A receptor.

Describe the role of a coordination system in homeostasis.

Describe the role of a coordination system in homeostasis.

A coordination system (e.g. nervous system, endocrine system) receives information about stimuli from receptors and determines what the response should be by sending instructions to effectors.

In homeostasis, what are effectors?

In homeostasis, what are effectors?

Effectors are components of a homeostatic mechanism that produce a response to a stimulus. Muscles and glands are effectors.

Describe the ways in which the body can conserve heat in a cold environment.

Describe the ways in which the body can conserve heat in a cold environment.

- **Shivering**
- **Vasoconstriction** of blood vessels to prevent heat loss from the blood
- **Raising hairs** to trap a layer of insulating air next to the skin

Describe the ways in which the body can rapidly lose heat in a warm environment.

Describe the ways in which the body can rapidly lose heat in a warm environment.

- **Vasodilation** of blood vessels to increase heat loss from the blood
- Increase in **sweating** - as the sweat evaporates, it cools the skin.

Define osmoregulation. Why is it important?

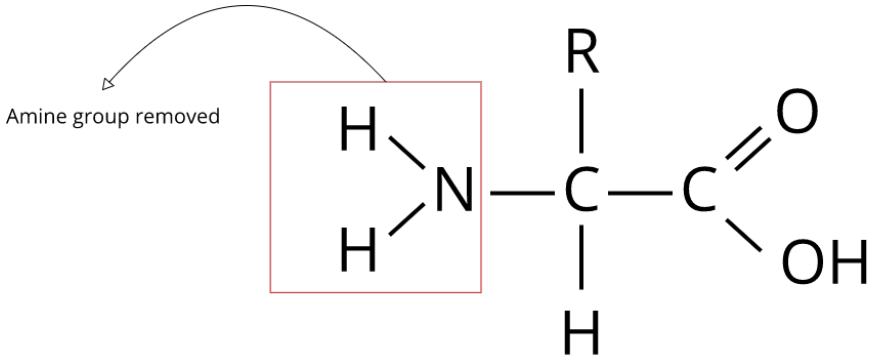
Define osmoregulation. Why is it important?

The regulation of the water potential of the blood. It is important because cells may shrink or burst if the water potential of the blood is too high or low, due to movement of water by osmosis.

Where and how is urea formed?

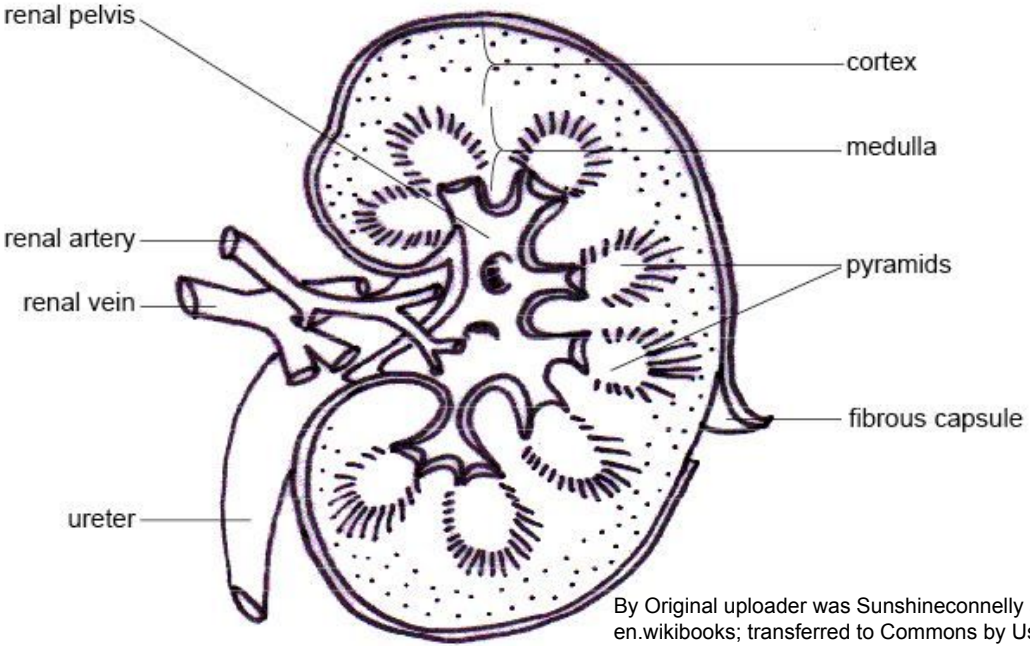
Where and how is urea formed?

Urea is produced in the liver from the **deamination** (removal of the amine group) of excess amino acids.



Outline the gross structure of the kidney.

Outline the gross structure of the kidney.

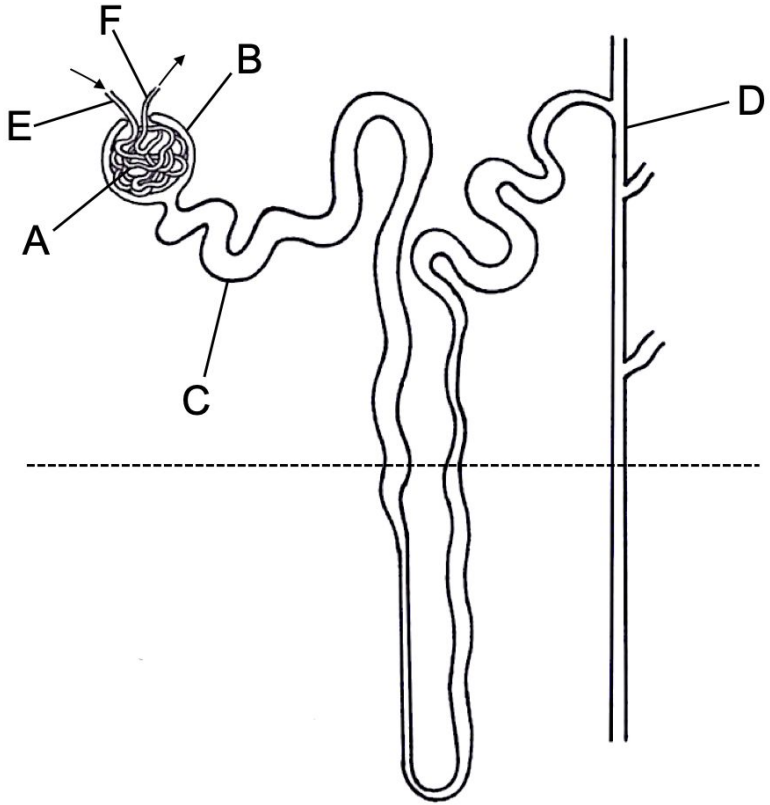


What is a nephron?

What is a nephron?

A nephron is one functional unit of the kidney.

Name the structures of the nephron.



Name the structures of the nephron.

A = glomerulus

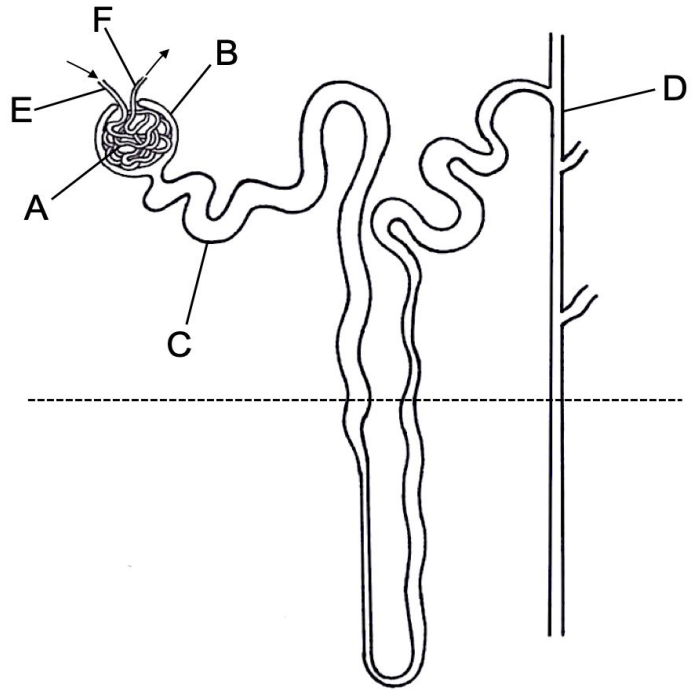
B = Bowman's capsule

C = proximal convoluted tubule

D = collecting duct

E = afferent arteriole

F = efferent arteriole



Outline the blood vessels associated with a nephron.

Outline the blood vessels associated with a nephron.

An **afferent arteriole** from the **renal artery** forms the glomerulus. The **efferent arteriole** takes blood away from the glomerulus.

The efferent arteriole branches to form the capillaries that surround the nephron tubules. These combine to form the **renal vein** which drains the kidney.

Describe the process of ultrafiltration.

Describe the process of ultrafiltration.

Within the glomerular capillaries, there is **hydrostatic pressure**. This filters the blood, forcing water, glucose, urea and ions into Bowman's capsule to form the glomerular filtrate.

Proteins and cells are too big and are not filtered into Bowman's capsule; they stay in the blood.

In which part of the nephron does selective reabsorption occur?

In which part of the nephron does selective reabsorption occur?

In the **proximal convoluted tubule**.

Water, glucose and ions are reabsorbed back into the blood.

Describe the process of selective reabsorption of glucose.

Describe the process of selective reabsorption of glucose.

Co-transport of glucose with Na^+ ions into the cells of the proximal convoluted tubule. Glucose diffuses out of the cell and into the blood.

Active transport of Na^+ ions out of the cells is required to ensure there is a low concentration. This maintains the Na^+ diffusion gradient.

The presence of glucose and Na^+ ions in the cells reduces the water potential, which draws water out of the tubule by osmosis.

What happens in the loop of Henle in the nephron?

What happens in the loop of Henle in the nephron?

In the ascending limb, Na^+ and Cl^- are actively transported into the medulla. The water potential of the medulla is very low, which draws water out of the descending limb by osmosis. The water potential of the surrounding tissue is much lower at the bottom of the loop than at the top.

Describe what happens in the distal convoluted tubule and collecting duct.

Describe what happens in the distal convoluted tubule and collecting duct.

In the collecting duct, Na^+ ions are actively transported out of the tubule, resulting in water reabsorption.

The collecting duct moves through the medulla tissue which has a lower water potential from the loop of Henle. This results in further water reabsorption.

What is the role of the hypothalamus in osmoregulation?

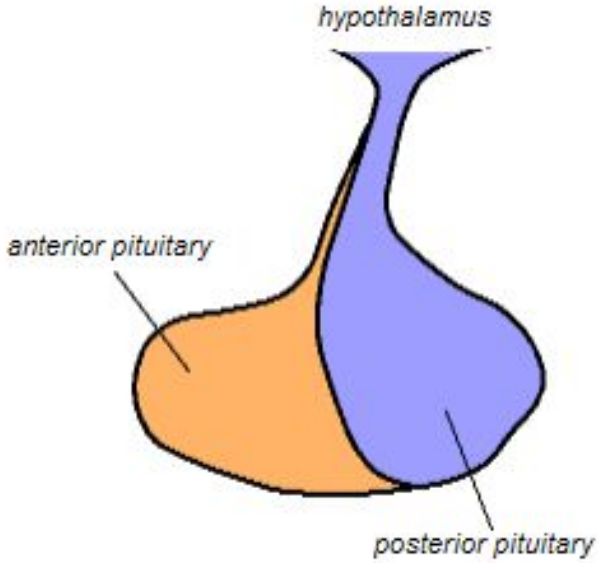
What is the role of the hypothalamus in osmoregulation?

It contains osmoreceptors which detect the water potential of the blood. If the water potential is low, the hypothalamus releases **antidiuretic hormone** (**ADH**).

Where is ADH released into the blood?

Where is ADH released into the blood?

ADH from the hypothalamus is transferred to the **posterior pituitary gland** where it is secreted into the blood.



By Original uploader was Diberri at en.wikipedia - Transferred from en.wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=7547800

Explain how ADH increases the water potential of the blood.

Explain how ADH increases the water potential of the blood.

ADH binds to receptors on the cells of the distal convoluted tubule and collecting duct. It increases the number of **aquaporins** in the membrane of the cells in this part of the nephron. This increases permeability to water, which increases absorption and therefore the water potential of the blood.

What happens to the secretion of ADH once the water potential of the blood has been restored?

What happens to the secretion of ADH once the water potential of the blood has been restored?

Secretion is reduced to prevent too much water reabsorption, which would make the water potential of the blood too high. This is an example of **negative feedback**.

What are the effects of hypoglycaemia and hyperglycaemia?

What are the effects of hypoglycaemia and hyperglycaemia?

- **Hypoglycaemia** - not enough glucose for respiration in cells. The cell cannot function normally.
- **Hyperglycaemia** - the high glucose concentration in the blood decreases the water potential. Water leaves the cells, preventing normal functioning.

How is the pancreas involved in the regulation of blood glucose?

How is the pancreas involved in the regulation of blood glucose?

- The pancreas contains **islets of Langerhans**, which consist of **α-cells** and **β-cells**
- The α-cells produce the hormone **glucagon**, whereas β-cells produce the hormone **insulin**
- The pancreas also has **receptors** to detect the blood glucose concentration

When is insulin released?

When is insulin released?

Insulin is secreted into the blood when the blood glucose concentration is high.

Describe how insulin decreases the blood glucose concentration.

Describe how insulin reduces the blood glucose concentration.

- Insulin increases uptake of glucose into cells from the blood by increasing the number of carrier proteins in the membrane
- Insulin stimulates the conversion of glucose into glycogen in muscle and liver cells

Which hormone is released from the pancreas if the blood glucose concentration is too low?

Which hormone is released from the pancreas if the blood glucose concentration is too low?

Glucagon

Describe how glucagon increases the blood glucose concentration.

Describe how glucagon increases the blood glucose concentration.

- Glucagon stimulates liver cells to convert glycogen to glucose (**glycogenolysis**)
- Glucagon stimulates liver cells to synthesise glucose from non-carbohydrate sources such as amino acids and lipids (**gluconeogenesis**)

What effect does adrenaline have on blood glucose concentration?

What effect does adrenaline have on blood glucose concentration?

Adrenaline increases the concentration of glucose in the blood by glycogenolysis, similar to glucagon.

Outline the second messenger model in the stimulation of liver cells by adrenaline.

Outline the second messenger model in the stimulation of liver cells by adrenaline.

- Adrenaline binds to a **receptor** on the membrane of a liver cell
- This results in a change in shape in the receptor protein
- The shape change activates an **adenylyl cyclase** enzyme in the cell
- Adenyl cyclase converts ATP into **cyclic AMP**
- Cyclic AMP is the second messenger; it binds to a **protein kinase** and activates it. The protein kinase phosphorylates other enzymes to amplify the signal
- Eventually, the enzyme responsible for glycogenolysis is activated

The presence of glucose and ketones in the urine is indicative of which disease?

The presence of glucose and ketones in the urine is indicative of which disease?

Diabetes mellitus

Describe how a dipstick can measure the concentration of glucose in an urine sample.

Describe how a dipstick can measure the concentration of glucose in a urine sample.

The **glucose oxidase** on the stick reacts with glucose in the urine to form **gluconolactone** and **hydrogen peroxide**.

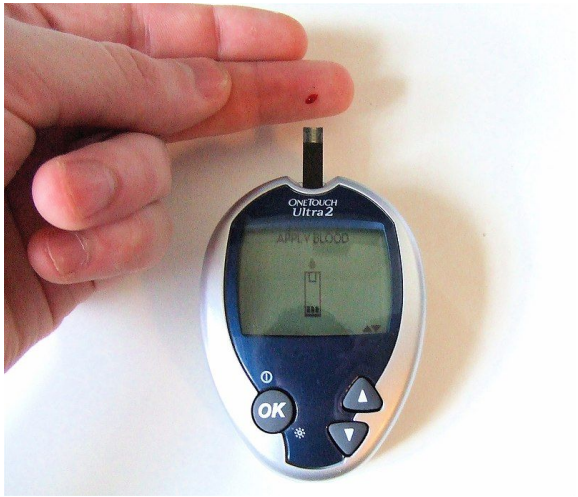
Hydrogen peroxide reacts with the **chromogen** chemical on the stick, catalysed by **peroxidase**. The colour produced is compared against a chart to obtain a measurement of glucose concentration.

Name and explain a method of measuring the blood glucose concentration.

Name a method of measuring the blood glucose concentration.

A **biosensor**.

The strip from a biosensor contains **glucose oxidase**, which reacts with the glucose in the blood to produce **gluconolactone**. An electric current is produced, which is measured by an electrode.



What may be the cause of protein in the urine?

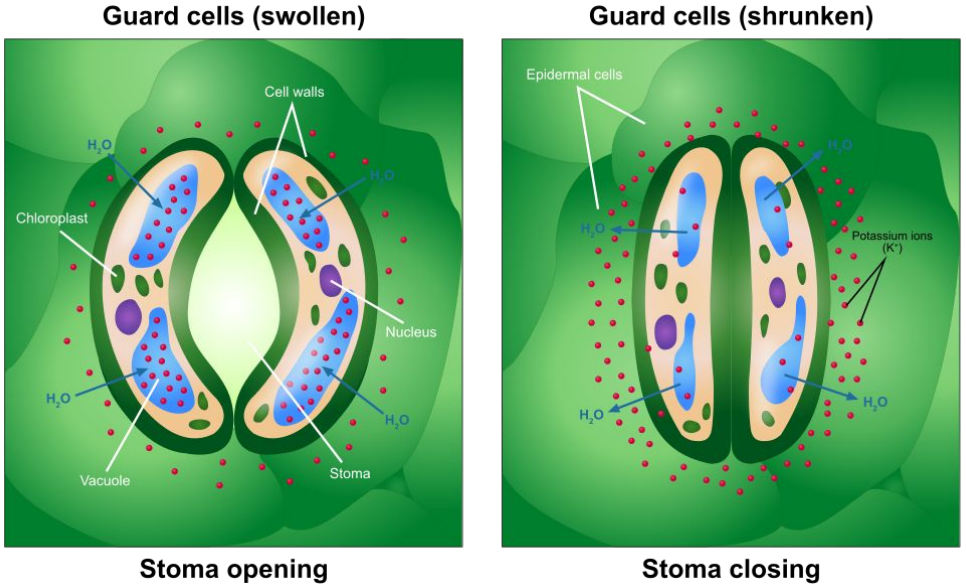
What may be the cause of protein in the urine?

- Diseases affecting the glomeruli
- An infection of the kidney or urinary tract
- Congestive heart failure

Which cells regulate the opening and closing of stomata?

Which cells regulate the opening and closing of stomata?

Guard cells



Stoma opening **Stoma closing**

In what conditions do stomata open and close?

In what conditions do stomata open and close?

Stomata are open when there is high light intensity (to allow diffusion of CO_2 for photosynthesis).

Stomata may close during the night, during low humidity, high temperature or in water stress to limit water loss by transpiration.

Explain the mechanism by which guard cells open the stomata.

Explain the mechanism by which guard cells open the stomata.

The **water potential** of the guard cells drives the opening and closing of the pore. When the cell is **turgid**, the pore **opens**; when the cell is **flaccid**, the pore **closes**.

The guard cells drive H^+ ions out of the cell via proton pumps, using ATP. This activates K^+ channels, leading to a high concentration of K^+ in the cell. This reduces water potential, leading to osmosis of water into the cell and turgidity.

Explain the mechanism by which guard cells close the stomata.

Explain the mechanism by which guard cells close the stomata.

The guard cell membrane becomes depolarised as ions (such as Cl^-) leave the cell. This causes the release of K^+ ions, which increases water potential of the cell. Water leaves by osmosis and the cell becomes flaccid, closing the pore.

What is abscisic acid?

What is abscisic acid?

A plant hormone released during water stress.

What effect does abscisic acid have on stomata?

What effect does abscisic acid have on stomata?

Abscisic acid causes the closure of stomatal pores.

Explain how abscisic acid brings about the closure of stomata.

Explain how abscisic acid brings out about the closure of stomata.

- Abscisic acid binds to receptors on the cell membrane of guard cells. This inhibits the proton pumps, causing a rise in pH. It also stimulates movement of Ca^{2+} ions into the cell
- The Ca^{2+} ions act as a second messenger, opening channels to allow anions and K^{+} ions to leave the cell
- This increases the water potential and causes water to leave the guard cells by osmosis, closing the stomata