WJEC (Wales) Biology A-level

Unit 3.7 - Homeostasis and the kidney

Flashcards

What is homeostasis?

What is homeostasis?

The maintenance of a state of dynamic equilibrium in the body despite fluctuations in internal and external conditions.

Why is homeostasis important?

Why is homeostasis important?

To ensure optimum conditions for enzymes and cellular processes in the body.

Define negative feedback.

Define negative feedback.

Self-regulatory mechanisms return the internal environment to the optimum when there is a fluctuation.

Define positive feedback.

Define positive feedback.

A fluctuation which triggers changes that result in an even greater deviation from the normal level.

What is the set point?

What is the set point?

A desired value or range of values determined by a coordinator.

Describe receptors and effectors.

Describe receptors and effectors.

- **Receptors** - specialised cells located in sense organs that detect a specific stimulus
- **Effectors** - muscles or glands which enable a physical response to a stimulus

Describe the role of the coordinator.

Describe the role of the coordinator.

Coordinates information from the receptors and sends instructions to the effectors.

State the components of a negative feedback system.

State the components of a negative feedback system.

- Set point
- Receptors
- Coordinator
- Effectors

What is the mammalian kidney?

What is the mammalian kidney?

One of a pair of organs in the abdomen that has a role in osmoregulation and nitrogenous excretion.

What is osmoregulation?

What is osmoregulation?

The regulation of the water potential of body fluids (e.g. blood, tissue fluid, lymph) by the kidney.

Why is osmoregulation important?

Why is osmoregulation important?

- Prevents cells bursting or shrinking when water enters or leaves by osmosis
- Cellular reactions occur in aqueous solution ∴ water levels affect concentrations and the rate of reactions in cells

Define excretion.

Define excretion.

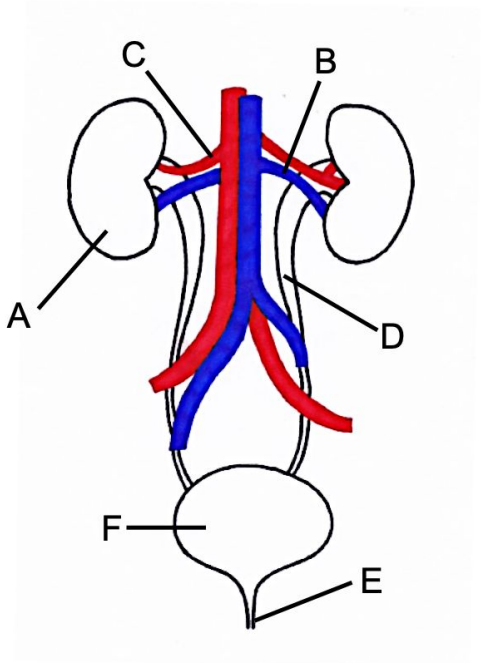
The process of removing metabolic waste from an organism.

Describe how excess amino acids are excreted.

Describe how excess amino acids are excreted.

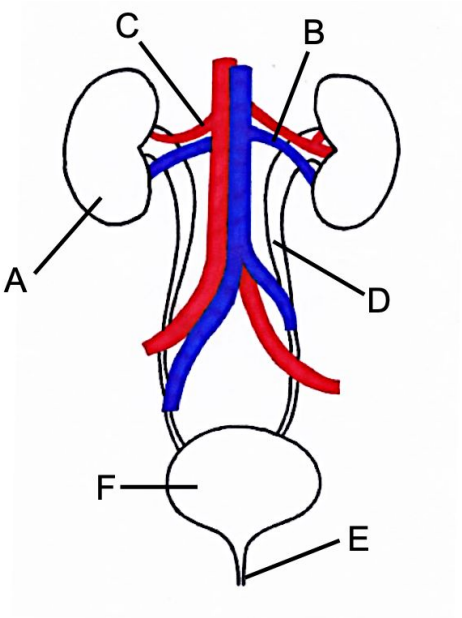
- Amino acids deaminated in the liver (removal of amino group) to form ammonia
- Ammonia converted to urea (less toxic)
- Urea transported into the blood plasma and eliminated by the kidneys

Identify the structures of the excretory system labelled in the diagram.



Identify the structures of the excretory system labelled in the diagram.

A	kidney	**D**	ureter
B	renal vein	**E**	urethra
C	renal artery	**F**	bladder



What is the function of the renal artery?

What is the function of the renal artery?

Supplies blood to the kidneys.

What is the function of the renal vein?

What is the function of the renal vein?

Drains blood from the kidneys.

What is the function of the ureter?

What is the function of the ureter?

Takes urine to the bladder from the kidneys.

What is the function of the urethra?

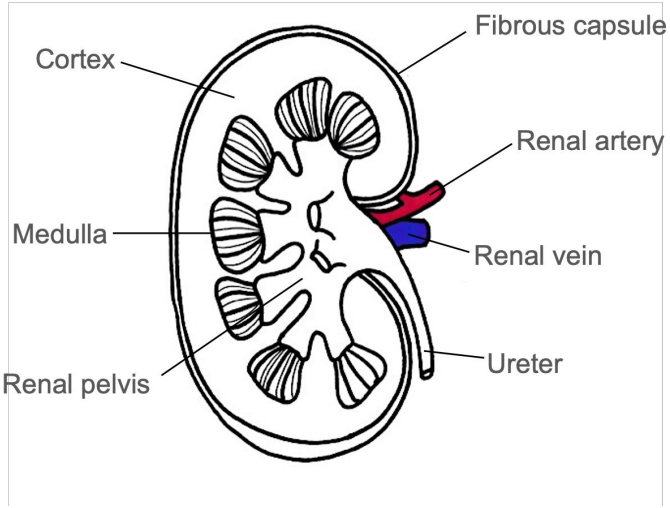
What is the function of the urethra?

Releases urine from the bladder, out of the body.

Describe the gross structure of a mammalian kidney.

Describe the gross structure of a mammalian kidney.

- **Fibrous capsule** - protects kidney
- **Cortex** - outer region consists of Bowman's capsules, convoluted tubules, blood vessels
- **Renal pyramids** - cone-shaped subdivisions
- **Renal pelvis** - funnel-shaped dilated section of ureter
- **Medulla** - inner region consists of collecting ducts, loops of Henle, blood vessels



What is a nephron?

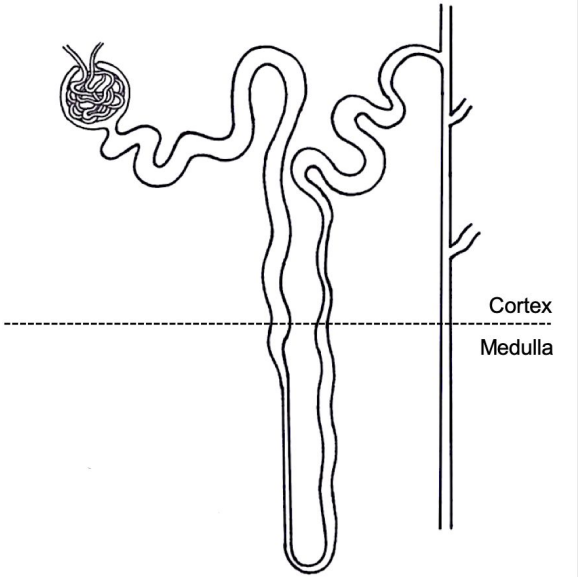
What is a nephron?

The functional unit of the mammalian kidney.

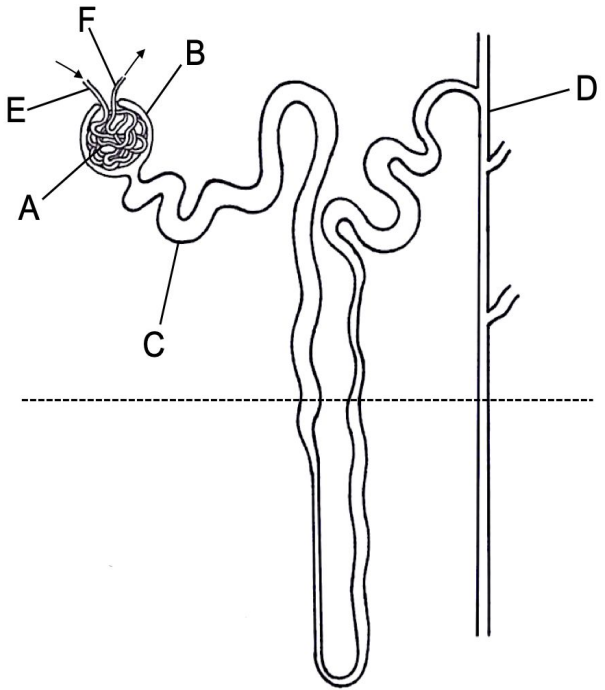
Where are nephrons found within the kidneys?

Where are nephrons found within the kidneys?

Part of the nephron is located in the medulla and part in the cortex.

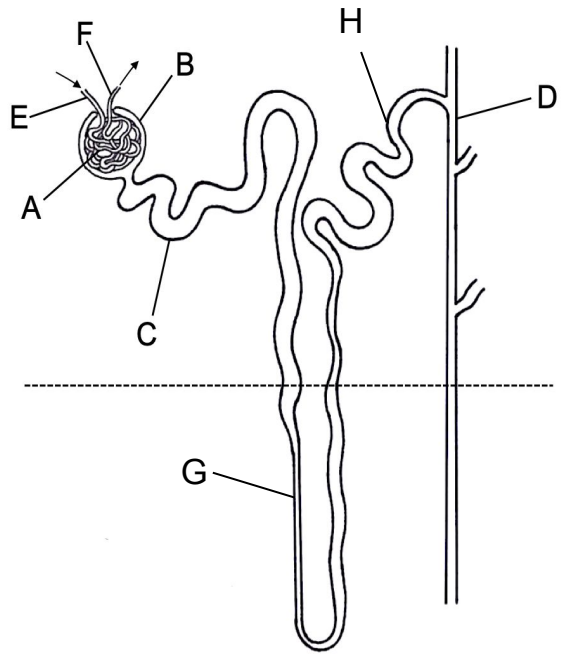


Identify the structures of the nephron labelled in the diagram.



Identify the structures of the nephron labelled in the diagram.

A - glomerulus
B - Bowman's capsule
C - proximal convoluted tubule
D - collecting duct
E - afferent arteriole
F - efferent arteriole
G - loop of Henlé
H - distal convoluted tubule



Describe the blood vessels associated with a nephron.

Describe the blood vessels associated with a nephron.

Wide afferent arteriole from **renal artery** enters renal capsule and forms the **glomerulus**, a branched knot of capillaries which combine to form **narrow efferent arteriole**.

Efferent arteriole branches to form **capillary network** that surrounds tubules.

Identify the structures of the nephron labelled in the micrograph.

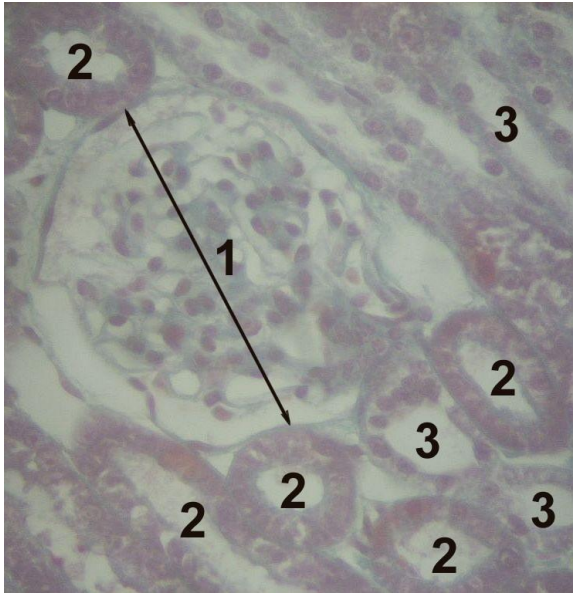


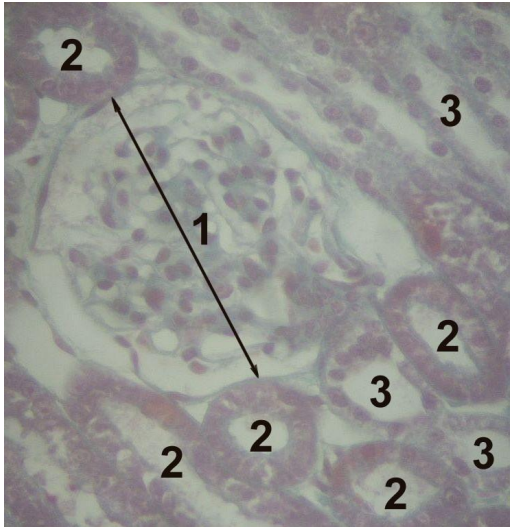
Image source: Uwe Gille, CC BY-SA 3.0

Identify the structures of the nephron labelled in the micrograph.

1 - Glomerulus

2 - Proximal convoluted tubule

3 - Distal convoluted tubule



Define ultrafiltration.

Define ultrafiltration.

The removal of small molecules, water and ions from the blood in the glomerulus of the kidney at high pressure.

Describe the process of ultrafiltration.

Describe the process of ultrafiltration.

- Occurs in **Bowman's capsule**
- High **hydrostatic pressure** in glomerulus forces small molecules (e.g. urea, water, glucose, ions) out of capillary fenestrations against osmotic gradient
- **Basement membrane** acts as filter. Blood cells and large molecules (e.g. proteins) remain in capillary

Why is there a build-up of pressure in the glomerulus?

Why is there a build-up of pressure in the glomerulus?

Afferent arteriole leading into the glomerulus is **wider** than the efferent arteriole taking blood from the glomerulus.

How are cells of the Bowman's capsule adapted for ultrafiltration?

How are cells of the Bowman's capsule adapted for ultrafiltration?

- Fenestrations between epithelial cells of capillaries
- Fluid can pass between and under folded membrane of podocytes

What happens during selective reabsorption?

What happens during selective reabsorption?

- Useful molecules from glomerular filtrate (glucose, some water, some ions) are reabsorbed into the blood
- Involves membrane transport proteins

Where does selective reabsorption occur?

Where does selective reabsorption occur?

Proximal convoluted tubule

How are cells in the proximal convoluted tubule adapted for selective reabsorption?

How are cells in the proximal convoluted tubule adapted for selective reabsorption?

- **Microvilli** provide a large surface area for co-transporter proteins
- Many **mitochondria** produce ATP for active transport of glucose into intercellular spaces
- **Folded basal membrane** provides a large surface area
- **Tight junctions** stop reabsorbed materials leaking back into the filtrate
- **Peritubular capillaries** extend into the medulla enabling reabsorption of materials

By what mechanism are amino acids and filtered glucose selectively reabsorbed into the blood?

By what mechanism are amino acids and glucose selectively reabsorbed into the blood?

- Secondary active transport
- Uses a co-transport mechanism involving Na^+

By what mechanism are mineral ions selectively reabsorbed into the blood?

By what mechanism are mineral ions selectively reabsorbed into the blood?

Active transport

By what mechanism is water selectively reabsorbed into the blood?

By what mechanism is water selectively reabsorbed into the blood?

Osmosis

How are filtered proteins (and some urea) selectively reabsorbed into the blood?

How are filtered proteins (and some urea) selectively reabsorbed into the blood?

Via diffusion

Describe the loop of Henlé.

Describe the loop of Henlé.

A loop consisting of a descending limb (dips into the medulla) and ascending limb (rises into the cortex) surrounded by blood capillaries.

What is the function of the loop of Henlé?

What is the function of the loop of Henlé?

It creates a low water potential in the medulla, enabling the reabsorption of water.

Describe what happens in the loop of Henlé.

Describe what happens in the loop of Henlé.

- Active transport of Na^+ and Cl^- out of **ascending limb**
- Water potential of **interstitial fluid** decreases
- Movement of water out of **descending limb** via osmosis (ascending limb is impermeable to water)
- Water potential of **filtrate** decreases going down descending limb - lowest in **medullary region**, highest at top of ascending limb
- Hair-pin counter-current multiplier

What is an endocrine gland?

What is an endocrine gland?

A gland of the endocrine system that secrete hormones directly into the bloodstream.

How is the concentration and volume of urine controlled?

How is the concentration and volume of urine controlled?

Controlled by the secretion of anti-diuretic hormone (ADH).

Explain the role of the hypothalamus in osmoregulation.

Explain the role of the hypothalamus in osmoregulation.

- **Osmoreceptors** in hypothalamus detect the concentration of the blood plasma
- Hypothalamus secretes **ADH**

Explain the role of the posterior pituitary gland in osmoregulation.

Explain the role of the posterior pituitary gland in osmoregulation.

Stores and secretes the ADH produced by the hypothalamus.

Describe how ADH affects the reabsorption of water from the kidney tubules.

Describe how ADH affects the reabsorption of water from the kidney tubules.

- ADH causes insertion of **aquaporins** into the plasma membranes of cells of the DCT and collecting duct
- Increases permeability of the DCT and collecting duct
- More water reabsorbed
- More concentrated urine produced

Describe the effects of kidney failure.

Describe the effects of kidney failure.

- Build-up of **toxic waste products** (e.g. urea) causes symptoms such as vomiting
- **Fluid accumulation** leads to swelling
- Disruption to electrolyte balance can make bones more **brittle**
- High concentrations of **renin** may lead to **hypertension**
- Low concentrations of **EPO** can lead to **anaemia**

Outline the potential treatments for kidney failure.

Outline the potential treatments for kidney failure.

- Low protein diet
- Control of blood calcium and potassium levels using medication
- Drugs to lower blood pressure
- Renal dialysis
- Kidney transplant

Describe renal dialysis.

Describe renal dialysis.

- Medical procedure that artificially filters the blood
- Relies on a **partially permeable membrane** between the patient's blood and dialysis fluid
- Two types: haemodialysis and peritoneal dialysis.

What is a transplant?

What is a transplant?

A medical procedure in which an organ or tissue in an individual is replaced.

Describe how animal excretory products can differ.

Describe how animal excretory products can differ.

- Freshwater animal species excrete **ammonia**
- Reptiles, birds and insects produce **uric acid**
- Mammals excrete **urea**

How does the length of the loop of Henlé differ between mammals?

How does the length of the loop of Henlé differ between mammals?

- Length of the loop varies depending on the availability of water in the mammal's environment
- Longer loop in desert animals (e.g. kangaroo rat) to allow greater time for reabsorption of water and salts