

11.3 The Kidney & Osmoregulation

Kidneys

Define excretion

Excretion is the removal from the body of the waste products of metabolic activity

Identify the nitrogenous waste produced by the following animals:

Fish: Ammonia (which is very toxic but very water soluble)

Birds: Uric acid (which requires minimal water to flush)

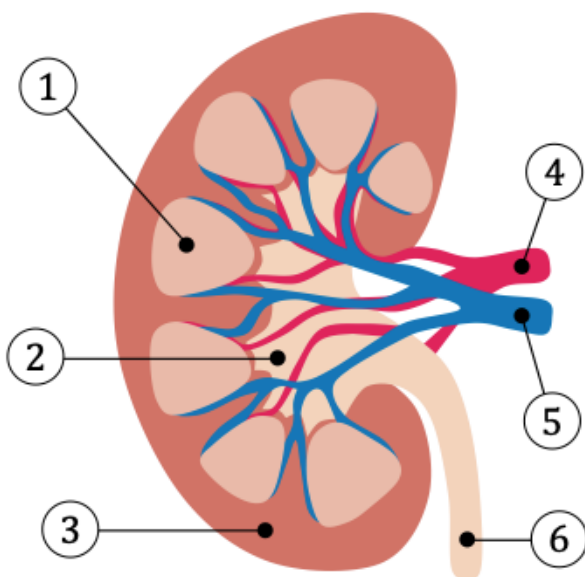
Mammals: Urea (which is non-toxic and so can be stored at higher concentrations)

Distinguish between the excretory systems of insects and mammals

Mammals possess autonomous kidneys

Insects possess Malpighian tubules that are connected to the insect's digestive system

Label the diagram of a human kidney



1. Medulla

2. Renal pelvis

3. Cortex

4. Renal artery

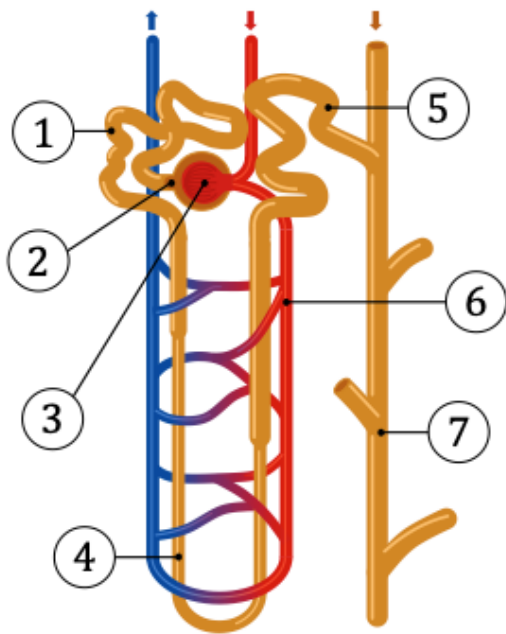
5. Renal vein

6. Ureter

State the functional unit of a kidney

Nephron

Annotate a diagram of a nephron



1. Proximal convoluted tubule
2. Bowman's capsule
3. Glomerulus
4. Loop of Henle
5. Distal convoluted tubule
6. Vasa recta
7. Collecting duct

Osmoregulation

Distinguish between osmoconformers and osmoregulators

Osmoconformers match their internal osmolarity to that of the environment

Osmoregulators maintain a constant osmolarity (independent of environment)

Identify the three stages of urine formation and where each stage occurs

	Stage	Location
1	Ultrafiltration	Glomerulus / Bowman's capsule
2	Selective reabsorption	Convoluted tubules (mainly proximal but some distal)
3	Osmoregulation	Loop of Henle / collecting duct

Explain the process of ultrafiltration

Ultrafiltration is the non-specific filtration of blood under high pressure (separates blood cells and proteins)

Glomerular capillaries are fenestrated and the capsule is lined with podocytes that have extensions (pedicels)

Blood freely enters the capsule by passing between the extensions, so the only barrier is a basement membrane

Blood enters the glomerulus via a wide afferent arteriole and exits via a narrow efferent arteriole

This makes it difficult for blood to exit the glomerulus, increasing the hydrostatic pressure in the glomerulus

Describe the selective reabsorption of glucose, salts and amino acids by the nephron

Selective reabsorption involves the reuptake of usable substances from filtrate

Substances are actively transported across apical membrane, before diffusing across basolateral membrane

Tubules are lined by microvilli (↑ surface area) and reabsorb the following materials:

Glucose & amino acids (symport with Na⁺), ions & vitamins (via protein pumps), water (follows via osmosis)

Explain, using the diagram, how the loop of Henle maintains hypertonic conditions in the medulla

The loop of Henle creates a salt gradient within the medulla

• The descending limb is permeable to water but not to salt

• The ascending limb is permeable to salts but not to water

This means that as the loop descends into the medulla, the

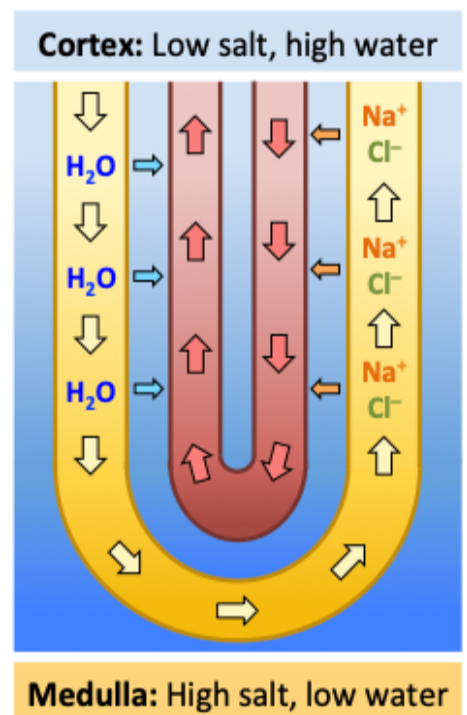
interstitial fluid becomes salty (hypertonic)

Additionally, blood in the vasa recta runs countercurrent to the

filtrate, so salts in blood move towards the medulla (and water away)

As the collecting duct passes through the medulla, the salt gradient

will draw water from the ducts (osmoregulation)



Explain the role of ADH (vasopressin) in maintaining the water balance of the blood

The level of water drawn from collecting ducts is controlled by the hormone antidiuretic hormone (ADH)

ADH is released from the pituitary gland (posterior lobe) in response to dehydration

ADH produces water channels (aquaporins) to facilitate water reabsorption via osmosis

This means less water remains in the filtrate and the urine becomes more concentrated

When an individual is suitably rehydrated, ADH levels decrease and less water is reabsorbed

Outline an adaptation to the kidneys of desert mammals that increases water conservation

Animals living in arid / dry habitats have long loops of Henle (↑ water reabsorption)

Explain the difference in the concentration of molecules within the blood plasma, filtrate and urine

Component	Blood	Filtrate	Urine	Reason
Protein	Present	Absent	Absent	Remains in blood due to ultrafiltration
Glucose	Present	Present	Absent	Selectively reabsorbed in tubules
Urea	Present	Present	Present	Eliminated (nitrogen waste product)
Water	Present	Present	Present	Variable excretion to regulate water levels in body (osmoregulation)

Identify four substances that can be detected via urinary tests, and the significance of a positive sample

1. **Glucose:** Presence in urine indicates diabetes
2. **Protein:** Certain diseases / hormonal condition
3. **Blood cells:** Infectious diseases or cancers
4. **Drugs:** For example, performance enhancers

Outline the consequences of dehydration and overhydration

Dehydration

Dehydration causes blood pressure to drop and heart rate rises to compensate

Overhydration

Overhydration can potentially lead to tissue damage (cells lyse from osmosis)

Outline two methods for the treatment of kidney failure

Kidney dialysis involves the external filtering of blood in order to remove metabolic wastes

Blood is pumped through a dialyzer, which restricts passage of certain materials and introduces fresh fluid

The best long-term treatment for kidney failure is a kidney transplant:

A transplanted kidney is grafted into the abdomen, but donors must be a close genetic match to minimise rejection