

13 EXCRETION IN HUMANS

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[VIEW EXAM QUESTIONS](#)

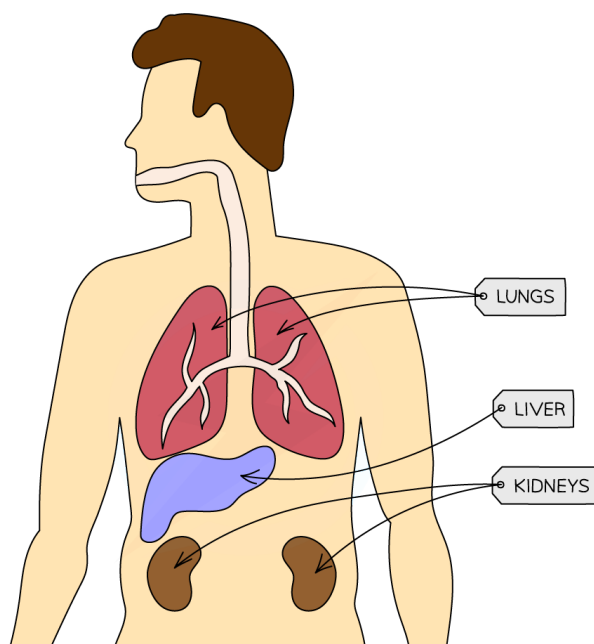
YOUR NOTES



13.1 THE EXCRETORY SYSTEM

Excretory Products

- Unlike plants, humans have organs which are specialised for the removal of certain excretory products
- They include the **lungs and kidneys**
- The **liver** also has a vital role in excretion



Organs involved in excretion

ORGAN	MAINLY EXCRETES	EXPLANATION
LUNGS	CARBON DIOXIDE	THE LUNGS EXCRETE CARBON DIOXIDE (A WASTE PRODUCT OF AEROBIC RESPIRATION) DURING EXHALATION
KIDNEYS	EXCESS WATER, SALTS AND UREA	THE KIDNEYS EXCRETE EXCESS WATER, EXCESS SALTS AND UREA (FORMED IN THE LIVER FROM EXCESS AMINO ACIDS) BY PRODUCING URINE



13 EXCRETION IN HUMANS

13.1 THE EXCRETORY SYSTEM *cont...*

YOUR NOTES



EXTENDED ONLY

The Need for Excretion

- Excretion is the **removal of the waste substances of metabolic reactions** (the chemical reactions that take place inside cells), toxic materials and **substances in excess of requirements**
- **Carbon dioxide** must be excreted as it dissolves in water easily to form an acidic solution which can **lower the pH of cells**
- This can **reduce the activity of enzymes** in the body which are essential for controlling the rate of metabolic reactions
- For this reason, too much carbon dioxide in the body is **toxic**
- **Urea** is also toxic to the body in higher concentrations and so must be excreted

The Role of the Liver

- Many digested food molecules absorbed into the blood in the small intestine are carried to the liver for **assimilation** (when food molecules are converted to other molecules that the body needs)
- These include amino acids, which are used to build proteins such as **fibrinogen**, a protein found in blood plasma that is important in blood clotting
- **Excess amino acids** absorbed in the blood that are not needed to make proteins **cannot be stored**, so they are broken down in a process called **deamination**
- Enzymes in the liver split up the amino acid molecules
- The part of the molecule which contains **carbon** is turned into **glycogen** and stored
- The other part, which contains **nitrogen**, is turned into **ammonia**, which is highly toxic, and so is immediately converted into urea, which is less toxic
- The urea dissolves in the blood and is taken to the kidney to be excreted
- A small amount is also excreted in **sweat**

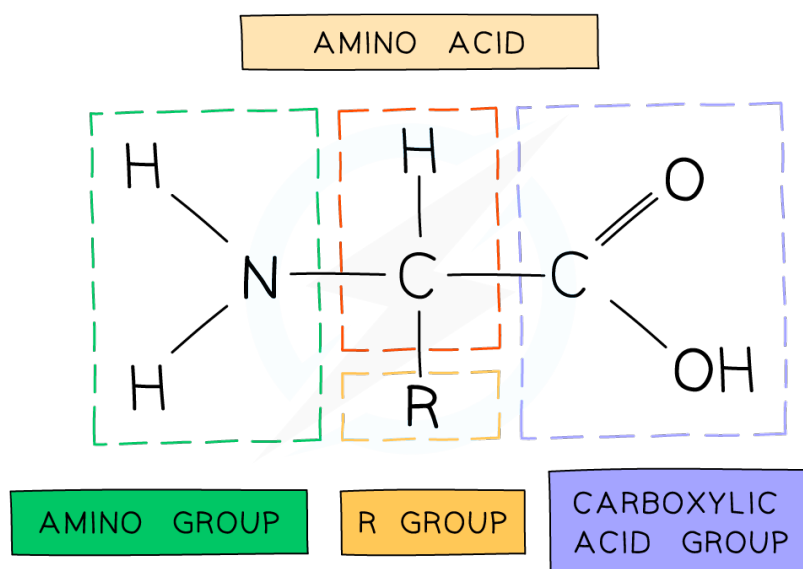
13 EXCRETION IN HUMANS

13.1 THE EXCRETORY SYSTEM cont...

YOUR NOTES



EXTENDED ONLY cont...



Amino acid groups

- In deamination, the nitrogen-containing amino group is removed and converted into ammonia and then urea to be excreted



EXAM TIP

Excretion and **egestion** are two terms that often get confused:

- **Excretion** is the removal from the body of waste products of metabolic reactions, toxic substances and substances in excess of requirements
- **Egestion** is the expulsion of undigested food waste from the anus

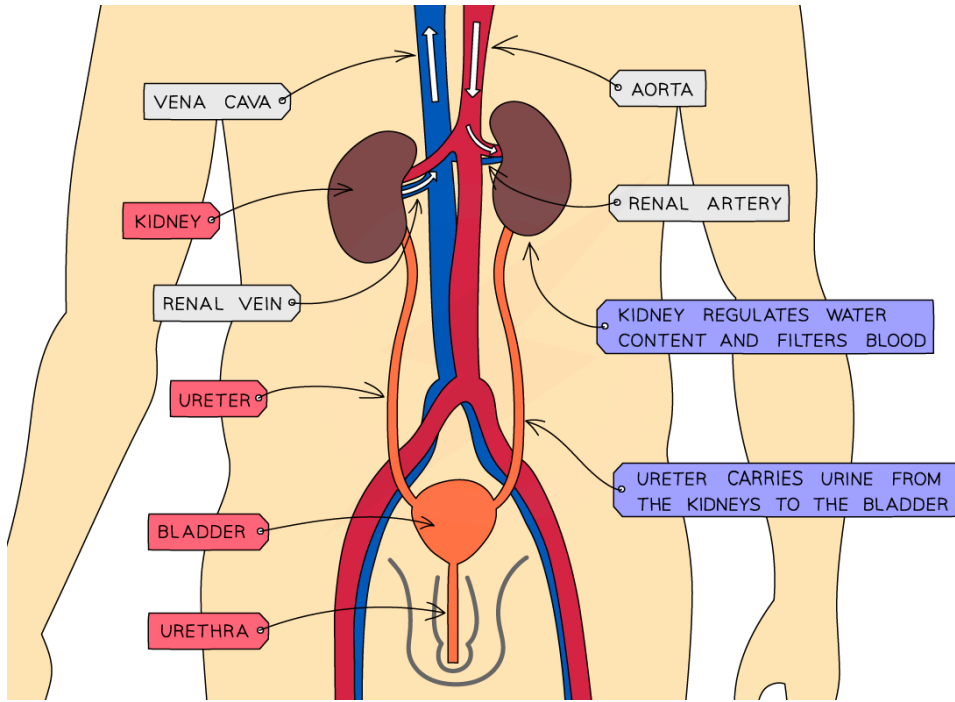
13 EXCRETION IN HUMANS

13.2 THE URINARY SYSTEM

YOUR NOTES



Structure



The urinary system in humans

Main structures involved:

STRUCTURE	EXPLANATION
KIDNEY	TWO BEAN-SHAPED ORGANS THAT FILTER THE BLOOD
URETER	TUBE CONNECTING THE KIDNEY TO THE BLADDER
BLADDER	ORGAN THAT STORES URINE (EXCESS WATER, SALTS AND UREA) AS IT IS PRODUCED BY THE KIDNEY
URETHRA	TUBE THAT CONNECTS THE BLADDER TO THE EXTERIOR; WHERE URINE IS RELEASED



13 EXCRETION IN HUMANS

13.2 THE URINARY SYSTEM cont...



EXAM TIP

Note the difference between the '**ureter**' and the '**urethra**'.

These two names are commonly confused by students so take care to learn them and know which tube is which – they are NOT interchangeable!

YOUR NOTES



Changes in Urine

- The **colour** and **quantity** of urine produced in the body can change quickly
- **Large quantities** of urine are usually **pale yellow** in colour because it contains a lot of water and so the urea is **less concentrated**
- **Small quantities** of urine are usually **darker yellow / orange** in colour because it contains little water and so the urea is **more concentrated**
- There are various reasons why the concentration of urine will change, including:
 - **Water intake** – the more fluids drunk, the more water will be removed from the body and so a **large quantity of pale yellow, dilute urine** will be produced
 - **Temperature** – the higher the temperature the more water is lost in sweat and so less will appear in urine, meaning a **smaller quantity of dark yellow, concentrated urine** will be produced
 - **Exercise** – the more exercise done, the more water is lost in sweat and so less will appear in urine, meaning a **smaller quantity of dark yellow, concentrated urine** will be produced

13.3 THE KIDNEY



EXTENDED ONLY

The Kidney

- The kidneys are located in the back of the abdomen and have two important functions in the body:
 - they regulate the water content in the blood
 - they excrete the toxic waste products of metabolism (such as urea) and substances in excess of requirements (such as salts)

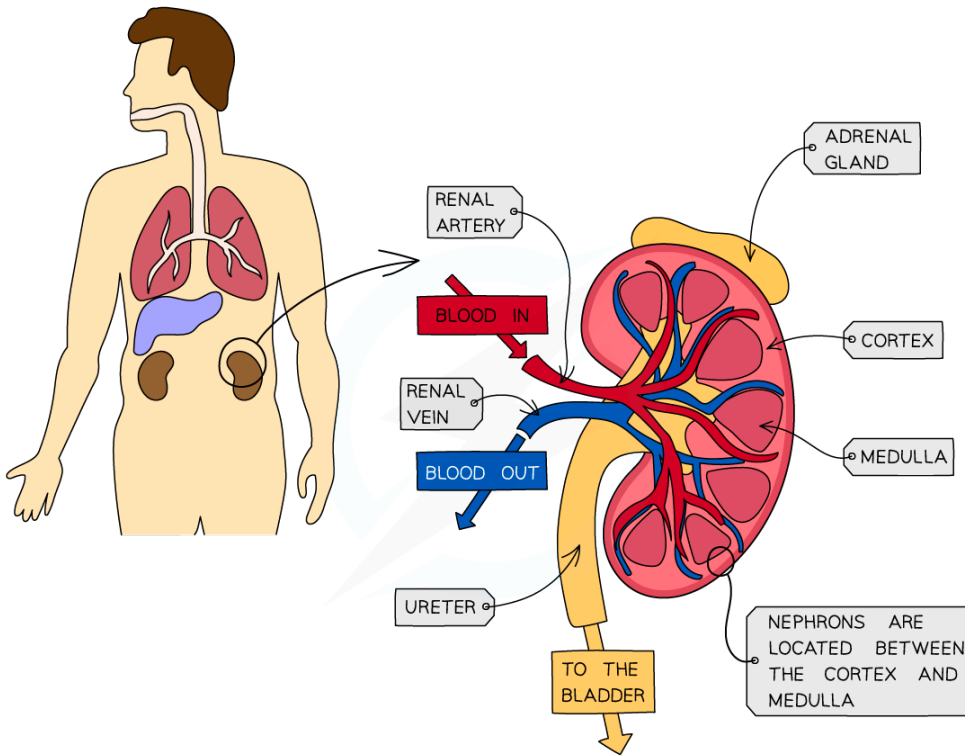
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13.3 THE KIDNEY

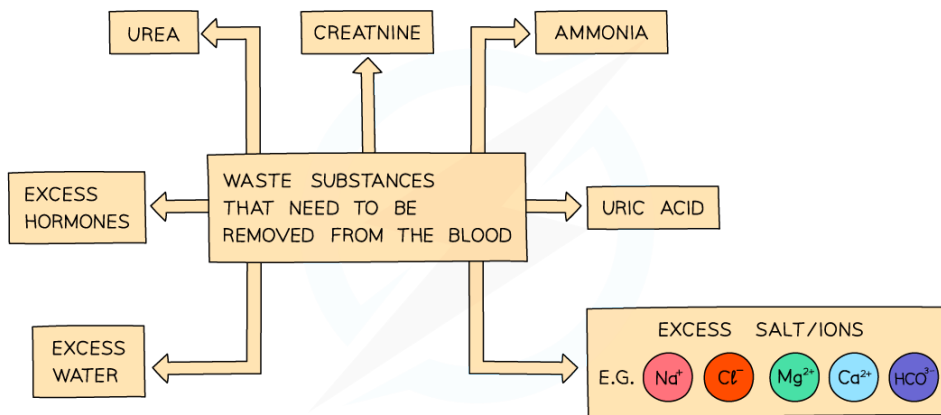
YOUR NOTES



EXTENDED ONLY cont...



The structure of a human kidney



Waste substances

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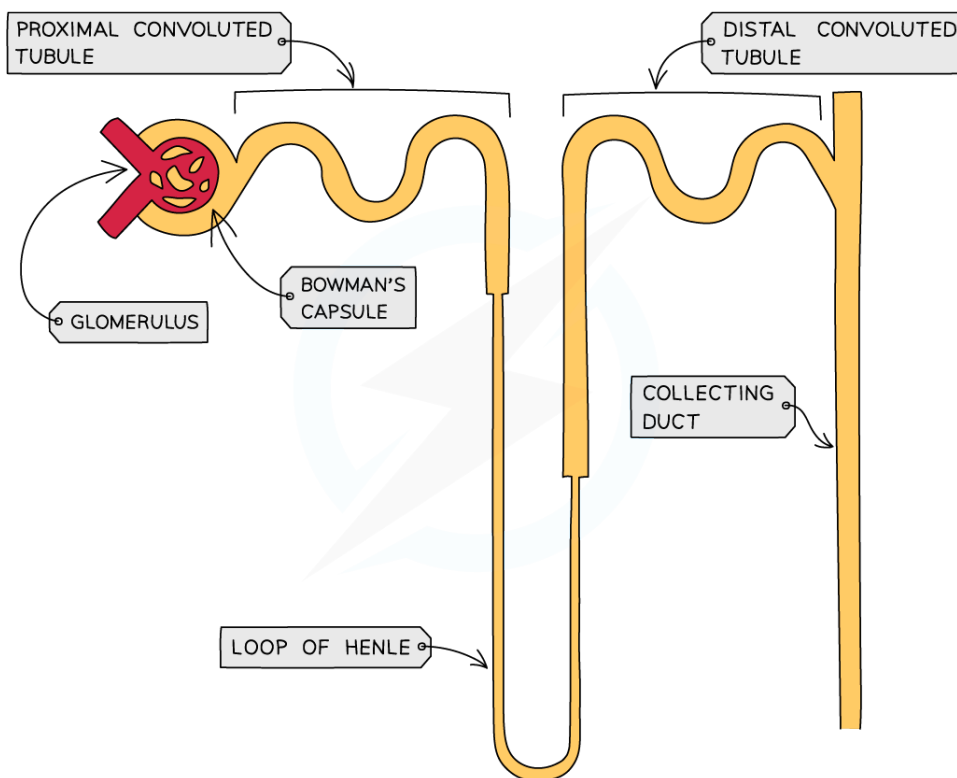
13.3 THE KIDNEY cont...

YOUR NOTES



EXTENDED ONLY cont...

- Each kidney contains around a million tiny structures called **nephrons**, also known as **kidney tubules** or **renal tubules**
- The nephrons start in the **cortex** of the kidney, loop down into the **medulla** and back up to the cortex
- The contents of the nephrons drain into the innermost part of the kidney and the **urine collects** there before it flows into the **ureter** to be carried to the **bladder** for storage



Structure of a nephron

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13.3 THE KIDNEY

YOUR NOTES



EXTENDED ONLY cont...

The Nephron

1. Ultrafiltration

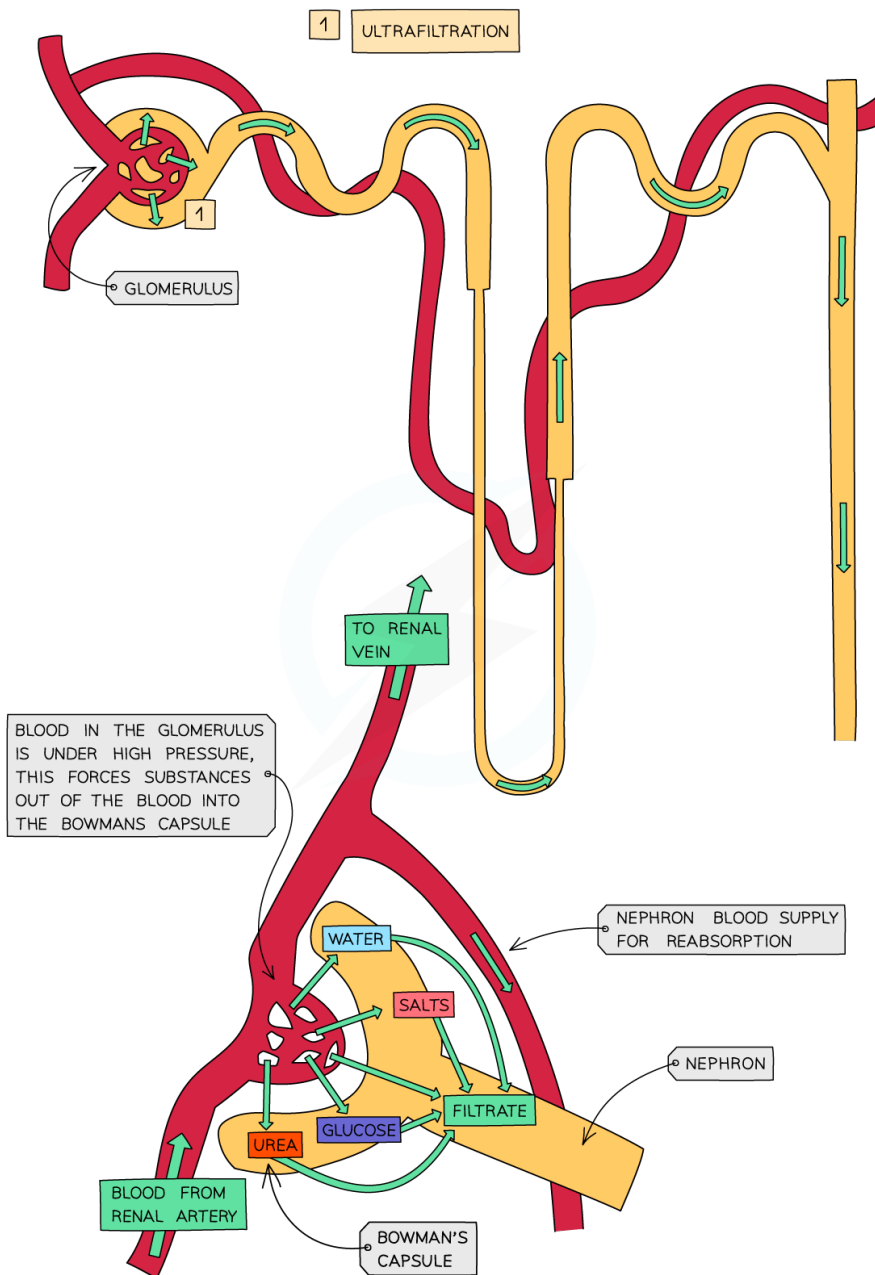


Diagram showing the process of ultrafiltration



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13.3 THE KIDNEY cont...

YOUR NOTES



EXTENDED ONLY cont...

- Arterioles branch off the **renal artery** and lead to each nephron, where they form a knot of capillaries (the **glomerulus**) sitting inside the cup-shaped **Bowman's capsule**
- The capillaries get **narrower** as they get further into the glomerulus which **increases the pressure** on the blood moving through them (which is already at high pressure because it is coming directly from the renal artery which is connected to the **aorta**)
- This eventually causes the smaller molecules being carried in the blood to be **forced out of the capillaries and into the Bowman's capsule**, where they form what is known as the filtrate
- This process is known as **ultrafiltration**
- The substances forced out of the capillaries are: **glucose, water, urea, salts**
- Some of these are useful and will be **reabsorbed back into the blood** further down the nephron

COMPONENT	REABSORBED AT
WATER	LOOP OF HENLE AND COLLECTING DUCT
SALTS	LOOP OF HENLE
GLUCOSE	PROXIMAL (FIRST) CONVOLUTED
UREA	NOT REABSORBED

Components of filtrate

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13.3 THE KIDNEY

YOUR NOTES



EXTENDED ONLY cont...

2. Selective Reabsorption

Reabsorption of Glucose

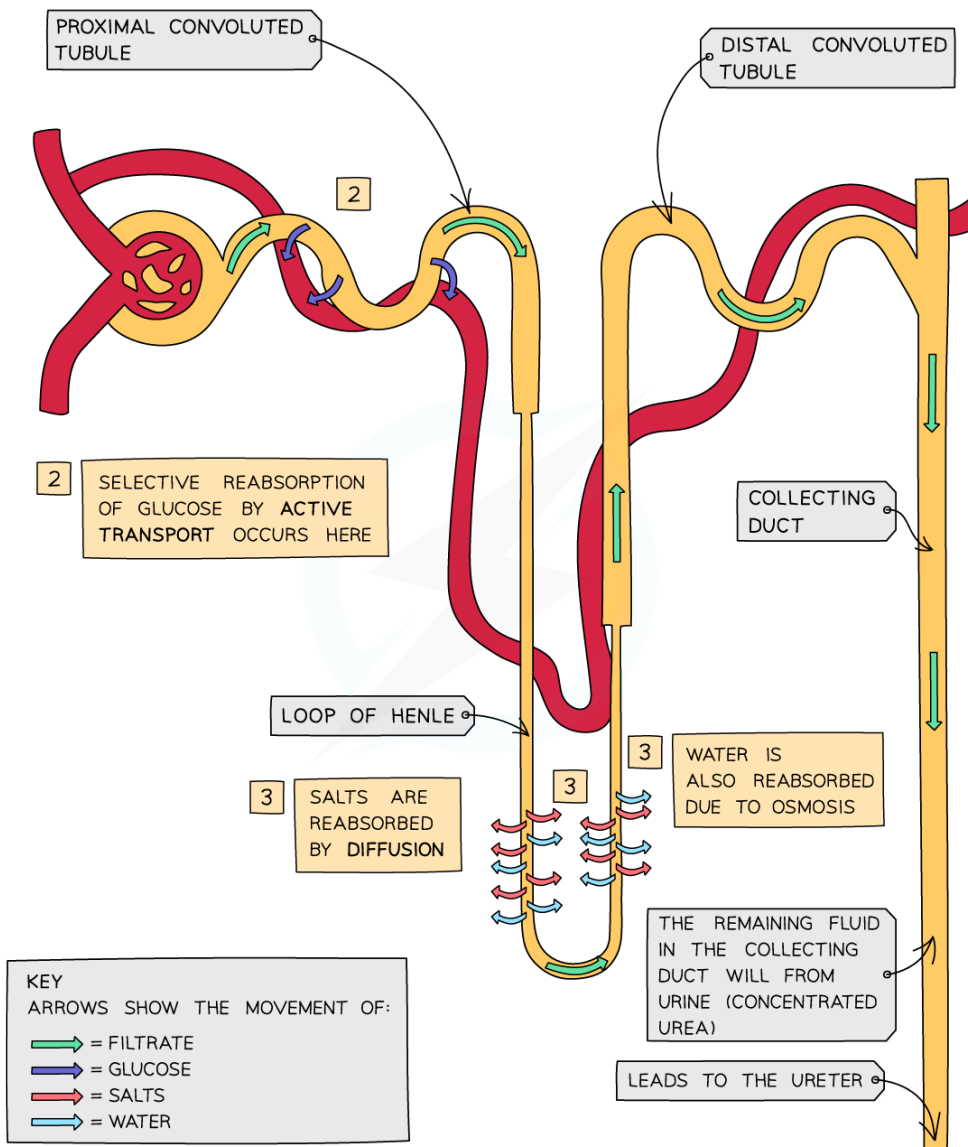


Diagram showing the reabsorption of glucose



13 EXCRETION IN HUMANS

13.3 THE KIDNEY cont...

YOUR NOTES



EXTENDED ONLY cont...

- After the glomerular filtrate enters the Bowman's Capsule, **glucose** is the first substance to be reabsorbed at the **proximal (first) convoluted tubule**
- This takes place by **active transport**
- The nephron is adapted for this by having **many mitochondria** to provide energy for the active transport of glucose molecules
- Reabsorption of glucose **cannot take place anywhere else in the nephron** as the gates that facilitate the active transport of glucose are only found in the proximal convoluted tubule
- In a person with a normal blood glucose level, there are enough gates present to remove all of the glucose from the filtrate back into the blood
- People with **diabetes** cannot control their blood glucose levels and they are often very high, meaning that not all of the glucose filtered out can be reabsorbed into the blood in the proximal convoluted tubule
- As there is nowhere else for the glucose to be reabsorbed, it continues in the filtrate and **ends up in urine**
- This is why one of the first tests a doctor may do to check if someone is diabetic is to test their urine for the presence of glucose

Reabsorption of Water & Salts

- As the filtrate drips through the **Loop of Henle** necessary salts are reabsorbed back into the blood by **diffusion**
- As salts are reabsorbed back into the blood, **water** follows by **osmosis**
- Water is also reabsorbed from the collecting duct in different amounts depending on how much water the body needs at that time

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13.4 KIDNEY FAILURE

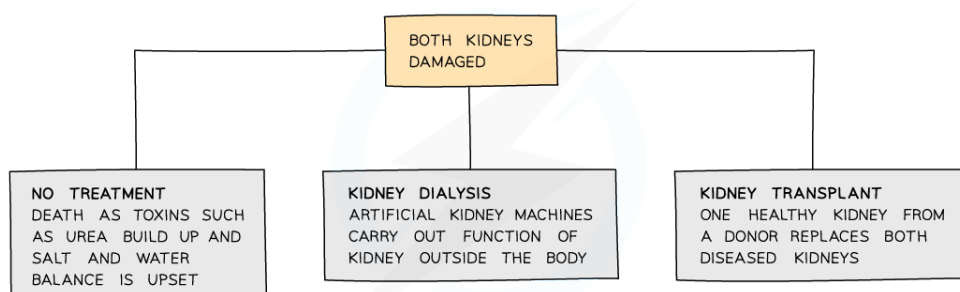
YOUR NOTES



EXTENDED ONLY cont...

Causes, Consequences, Treatments

- The kidneys might not work properly for several reasons, including **accidents or disease**
- Humans can survive with one functioning kidney, but if both are damaged then there will quickly be a **build-up of toxic wastes** in the body which will be **fatal** if not removed



Treatment options for total kidney failure

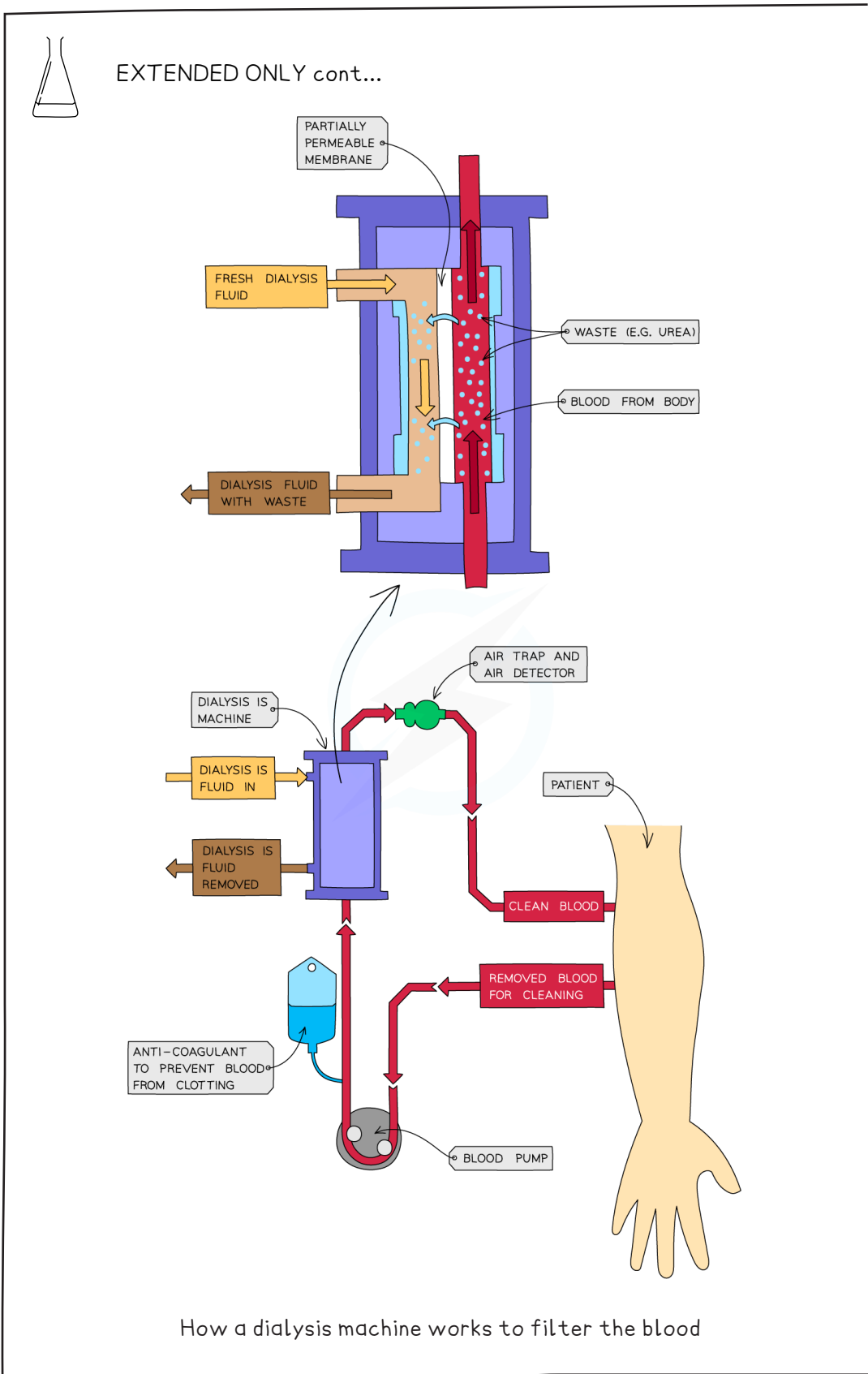
Kidney Dialysis

- The usual treatment for someone with kidney failure is **dialysis**
- This is an artificial method of filtering the blood to **remove toxins and excess substances**
- Patients are connected to a dialysis machine which acts as an **artificial kidney** to remove most of the urea and restore/maintain the water and salt balance of the blood
- **Unfiltered blood** is taken from an artery in the arm, pumped into the dialysis machine and then returned to a vein in the arm
- Inside the machine the blood and dialysis fluid are separated by a **partially permeable membrane** – the blood flows in the **opposite direction** to dialysis fluid, allowing **exchange** to occur between the two where a **concentration gradient** exists
- Dialysis fluid contains:
 - a **glucose** concentration similar to a normal level in blood
 - a concentration of **salts** similar to a normal level in blood
 - no **urea**

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13.4 KIDNEY FAILURE cont...

YOUR NOTES





13 EXCRETION IN HUMANS

13.4 KIDNEY FAILURE cont...

YOUR NOTES



EXTENDED ONLY cont...

- As the dialysis fluid has **no urea** in it, there is a **large concentration gradient** – meaning that urea **diffuses** across the partially permeable membrane, **from the blood to the dialysis fluid**
- As the dialysis fluid contains a **glucose** concentration **equal** to a normal blood sugar level, this prevents the net movement of glucose across the membrane as **no concentration gradient** exists
- As the dialysis fluid contains a **salt** concentration **similar to the ideal blood concentration**, movement of salts across the membrane only occurs where there is an **imbalance** (if the blood is too low in salts, they will diffuse into the blood; if the blood is too high in salts, they will diffuse out of the blood)
- The fluid in the machine is **continually refreshed** so that **concentration gradients are maintained** between the dialysis fluids and the blood
- Dialysis may take **3-4 hours to complete** and needs to be done **several times a week** to prevent damage to the body from the buildup of toxic substances in the blood
- An anticoagulant is added to blood before it runs through the machine to **prevent the blood from clotting** and slowing the flow

Kidney Transplants vs Dialysis

- **Kidney transplants** are a better long term solution to kidney failure than dialysis; however, there are several disadvantages to kidney transplants, including:
 - Donors won't have the same antigens on cell surfaces so there will be some **immune response** to the new kidney (risk of rejection is reduced – but not removed – by 'tissue typing' the donor and the recipient first)
 - This has to be suppressed by taking **immunosuppressant drugs** for the rest of their lives – these can have long term side effects and leave the patient vulnerable to infections
 - There are **not enough donors** to cope with demand



13 EXCRETION IN HUMANS

13.4 KIDNEY FAILURE cont...

YOUR NOTES



EXTENDED ONLY cont...

- However, if a healthy, close matched kidney is available, then the **benefits** of a transplant over dialysis include:
 - the patient has **much more freedom** as they are not tied to having dialysis several times a week in one place
 - their **diets** can be **much less restrictive** than they are when on dialysis
 - use of dialysis machines is **very expensive** and so this cost is removed
 - a kidney transplant is a long term solution whereas **dialysis will only work for a limited time**



EXAM TIP

When answering questions about dialysis, the best answers will:

- refer to differences in concentration gradients between the dialysis fluid and the blood and
- use this to explain why substances move in certain directions

> NOW TRY SOME EXAM QUESTIONS

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EXAM QUESTIONS

YOUR NOTES

**? QUESTION 1**

What is urea produced from?

- A Fatty acids
- B Glucose
- C Amino acids
- D Glycerol

? QUESTION 2

Which row of the table below correctly displays the correct roles of the following organs in processing waste in the human body?

	kidneys	liver	lungs
A	excretes urea	excretes amino acids	removes carbon dioxide
B	removes carbon dioxide	deamination of amino acids	excretes urea
C	removes urea from blood	deamination of amino acids	removes carbon dioxide
D	excretes urine	deamination of urea	removes carbon dioxide

? QUESTION 3

To remain healthy, a person must be able to excrete a number of waste products produced as a result of metabolism. A list of excretory products is given below.

Which of the following would be lost from both the kidneys and lungs?

- A Water
- B Carbon dioxide
- C Glucose
- D Urea



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EXAM QUESTIONS cont...

YOUR NOTES

**? QUESTION 4**

Which of the following is a correct example of excretion in mammals?

- A The production of carbon dioxide from aerobic respiration.
- B The removal of excess salts from the blood.
- C The removal of undigested food from the anus.
- D The release of hormones from glands.

? QUESTION 5

Which of the following is not a main function of the kidneys in a healthy person?

- A To reabsorb all glucose
- B To regulate blood pressure
- C To breakdown toxins
- D To eliminate excess sodium and potassium ions

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