Edexcel GCSE Biology

Your notes

Homeostasis

Contents

Importance of Homeostasis

Your notes

Importance of Homeostasis

- Homeostasis is defined as **the maintenance of a constant internal environment**
- This means that **internal conditions** within your body (such as temperature, blood pressure, water concentration, glucose concentration etc) **need to be kept within set limits** in order to ensure that **reactions in body cells can function** and therefore the organism as a whole can live
- When one of these conditions deviates far away from the normal and is not brought back within set limits the **body will not function properly** and the eventual consequence without medical intervention will be death
- This is why **diabetics** need to control glucose intake (as their body cannot regulate it for them), why an extremely high and **prolonged fever** will kill you or why drinking **too little or too much water** can damage cells throughout the body – especially the kidneys and brain – and lead to death within days

Negative feedback and homeostasis

- Most homeostatic mechanisms in the body are controlled by a process known as **negative feedback**
- Negative feedback occurs when conditions change from the ideal or **set point** and returns conditions to this set point
- It works in the following way:
  - if the level of something **rises**, control systems are switched on to **reduce it** again
  - if the level of something **falls**, control systems are switched on to **raise it** again
- Negative feedback mechanisms are usually a continuous cycle of bringing levels down and then bringing them back up so that overall, they stay within a **narrow range** of what is considered '**normal**'

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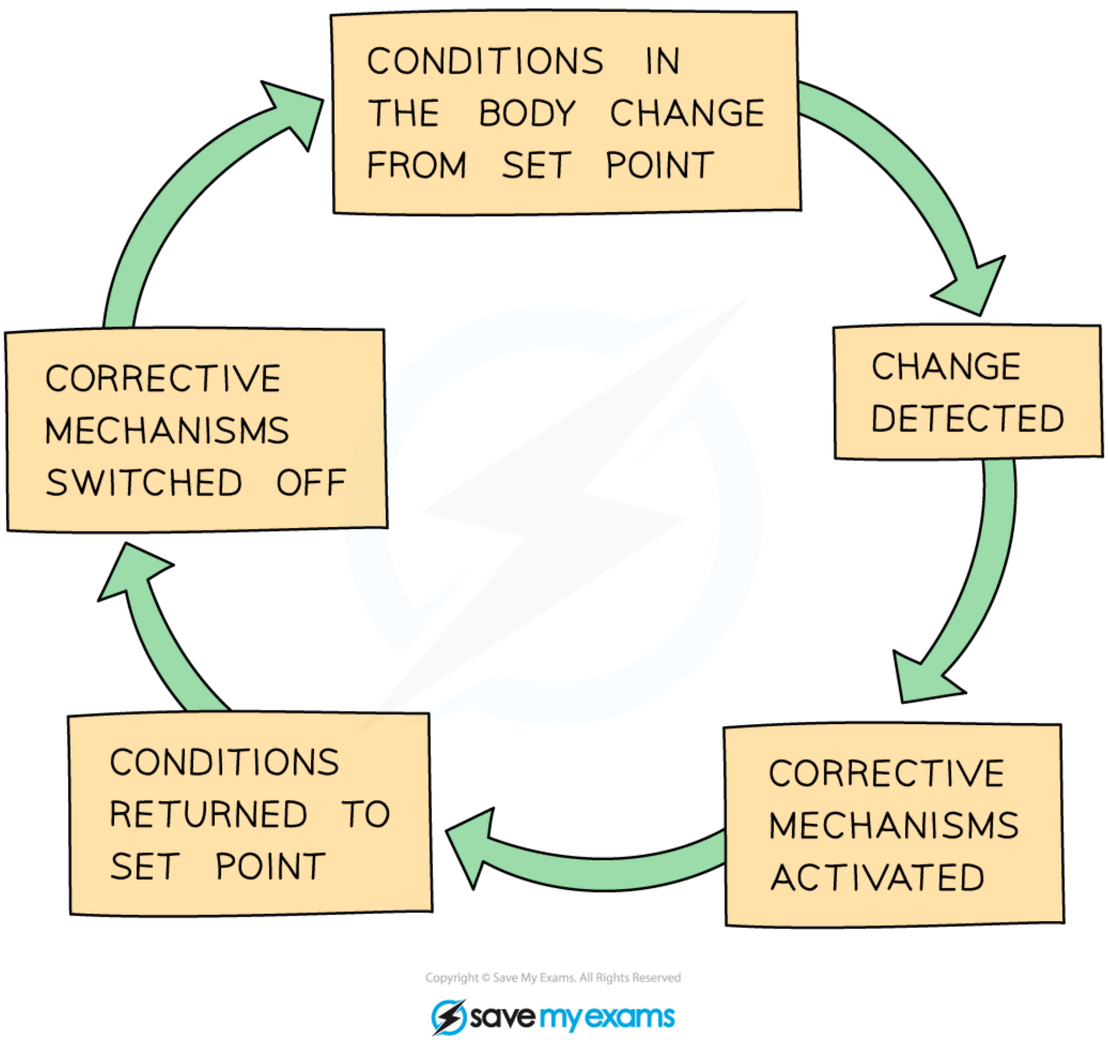


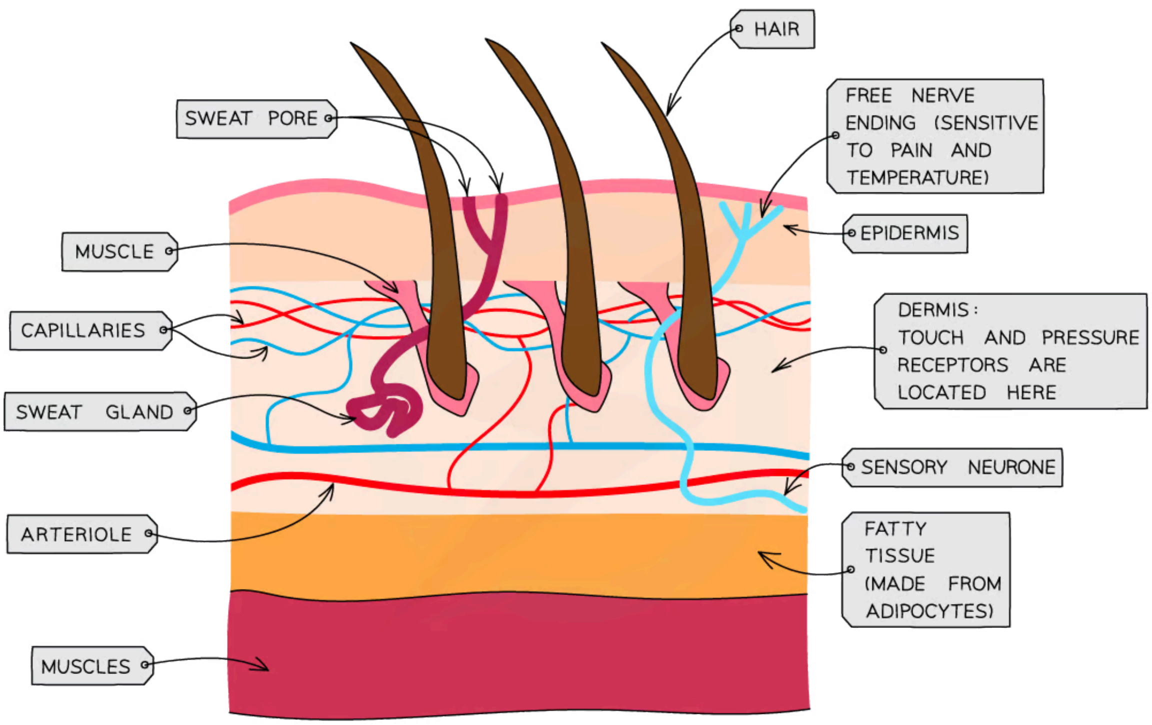
Negative feedback mechanisms

Thermoregulation

Your notes

Thermoregulation

- The human body needs to maintain a **temperature** at which enzymes work best, around 37°C
- Processes such as **respiration**, release energy as heat, while the body loses heat energy to its surroundings – the energy gained and lost must be regulated to maintain a constant core body temperature
- Body temperature is monitored and controlled by the **thermoregulatory centre** in the **hypothalamus** (structure within the brain)
- The thermoregulatory centre contains **receptors** sensitive to the temperature of the blood
- The **skin** also contains temperature receptors within the epidermal layer which send nerve impulses to the thermoregulatory centre

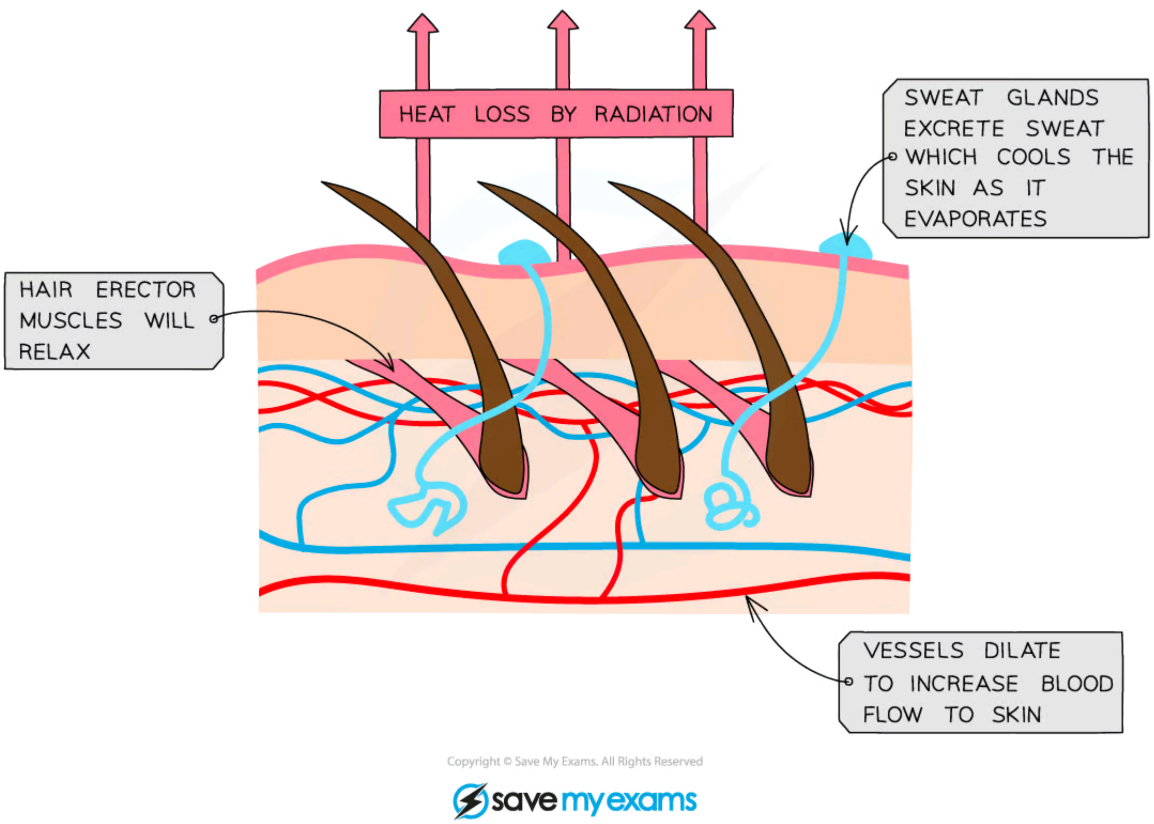


Your notes

Human skin contains structures involved in processes that can increase or reduce heat loss to the surroundings. Temperature receptors are located within the epidermis.

Controlling body temperature

- If the **body temperature is too high**, the hair erector muscles relax, blood vessels dilate (vasodilation) and sweat is produced from the sweat glands
- These mechanisms cause a transfer of energy from the skin to the environment, cooling the body down



Responses in the skin when the body temperature is too high and needs to decrease

- If the **body temperature is too low**, hair erector muscles contract, blood vessels constrict (vasoconstriction), sweating stops and skeletal muscles contract (shiver)
- These mechanisms reduce heat loss to the surroundings (with skeletal muscle contraction increasing heat released in the body)

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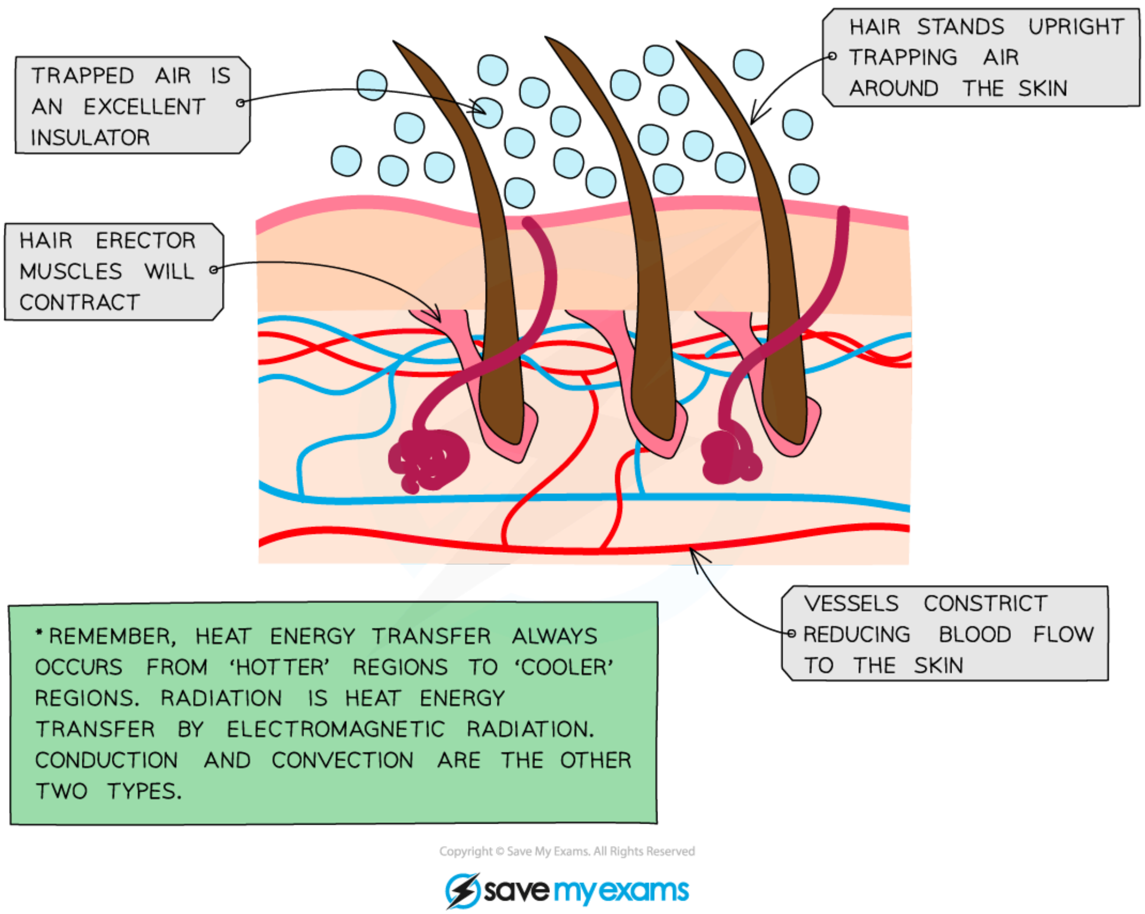

Responses in the skin when body temperature is too low and needs to increase

Body Temperature Control Table

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Body temperature too high	Body temperature too low
• Sweat is secreted by sweat glands in the skin • Sweat evaporates, cooling the skin • Heat energy from the body is lost as liquid water in sweat becomes water vapour (a state change)	• Skeletal muscles contract rapidly and shivering occurs • Skeletal muscle contraction is involuntary and requires energy from respiration (which releases heat energy)
• Hairs lie flat against the skin, allowing air to freely circulate • This reduces the insulating effect of air against the skin, increasing heat loss	• Erect hairs allow an insulating layer of air to be trapped against the skin • This reduces heat loss to the surroundings

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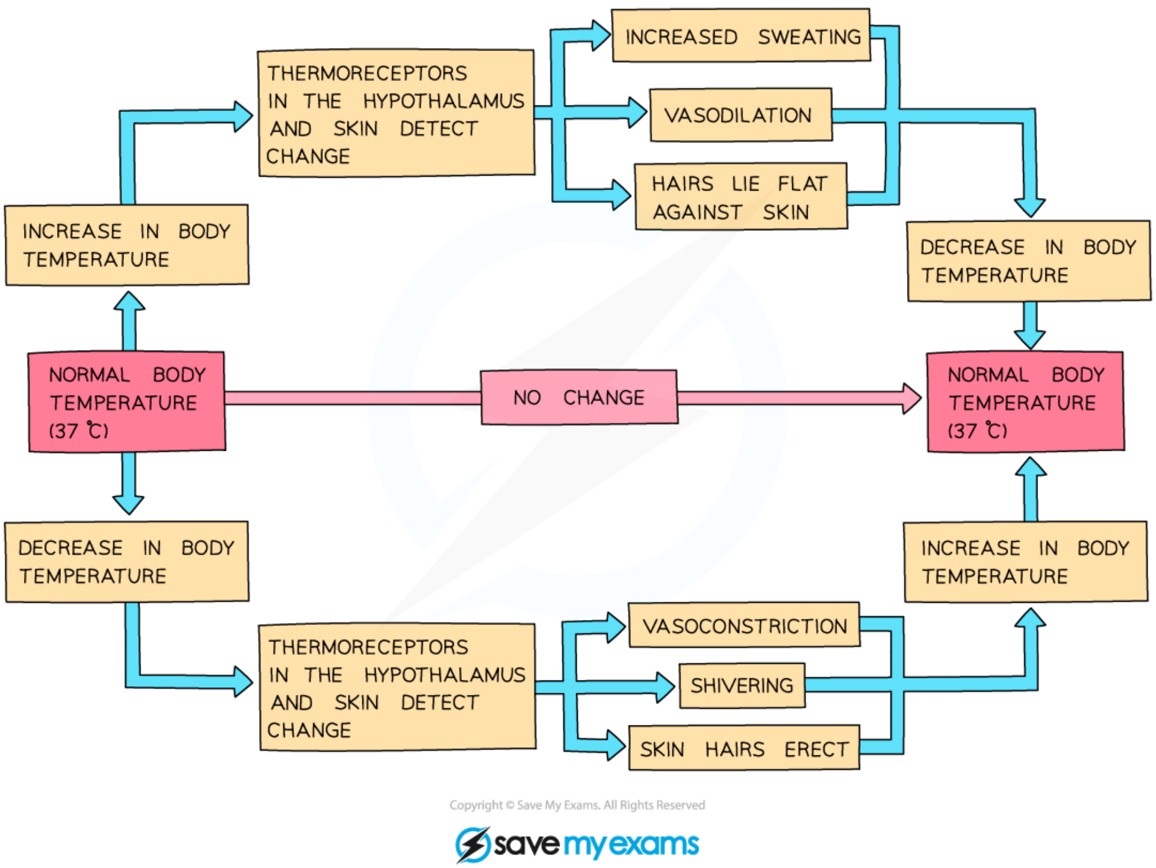

Remember homeostasis involves the maintenance of a constant internal environment; temperature control is an example of negative feedback

Examiner Tips and Tricks

You only need to know about the mechanisms of vasodilation and vasoconstriction for higher tier!

Your notes

Vasoconstriction & Vasodilation

Vasoconstriction & Vasodilation

Higher tier only

Vasodilation

- Heat exchange (both during warming and cooling) occurs at the body's surface as this is where the blood comes into closest proximity to the environment
- One way to **increase heat loss** is to supply the capillaries in the skin with a **greater volume of blood**, which then loses heat to the environment via radiation
- **Arterioles** (small vessels that connect arteries to capillaries) have muscles in their walls that can relax or contract to allow more or less blood to flow through them
- During vasodilation these **muscles relax**, causing the arterioles near the skin to **dilate** and allowing more blood to flow through capillaries
  - Note that it is the **arterioles that supply the skin capillaries** that vasodilate, and not the capillaries themselves; capillary walls are only one cell thick and contain no muscle that is capable of relaxing or contracting
- This is why pale-skinned people go red when they are hot

Vasoconstriction

- One way to **decrease heat loss** is to supply the capillaries in the skin with a **smaller volume of blood**, minimising the loss of heat to the environment via radiation
- During vasoconstriction the muscles in the arteriole walls **contract**, causing the arterioles near the skin to **constrict** and allowing less blood to flow through capillaries
  - Again, remember that it is the **arterioles that supply the skin capillaries** that vasoconstrict and not the capillaries themselves
- Instead, the blood is diverted through shunt vessels, which are further down in the skin and therefore do not lose heat to the environment
- Vasoconstriction is not, strictly speaking, a 'warming' mechanism as it does not raise the temperature of the blood but instead **reduces heat loss** from the blood as it flows through the skin

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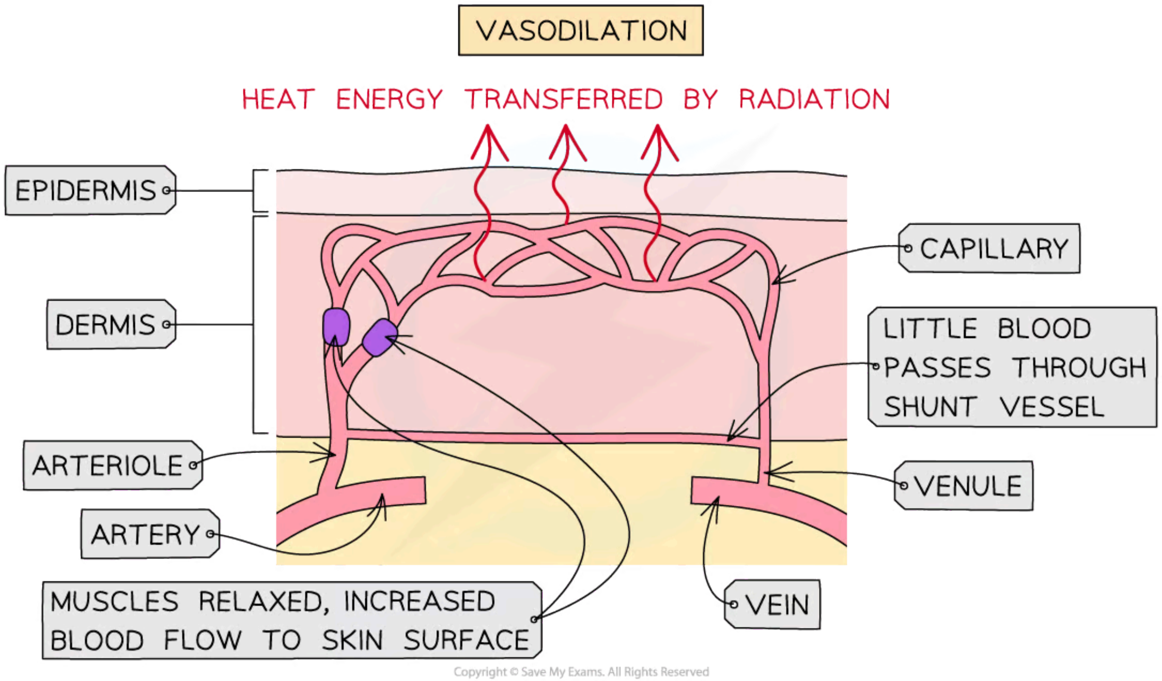

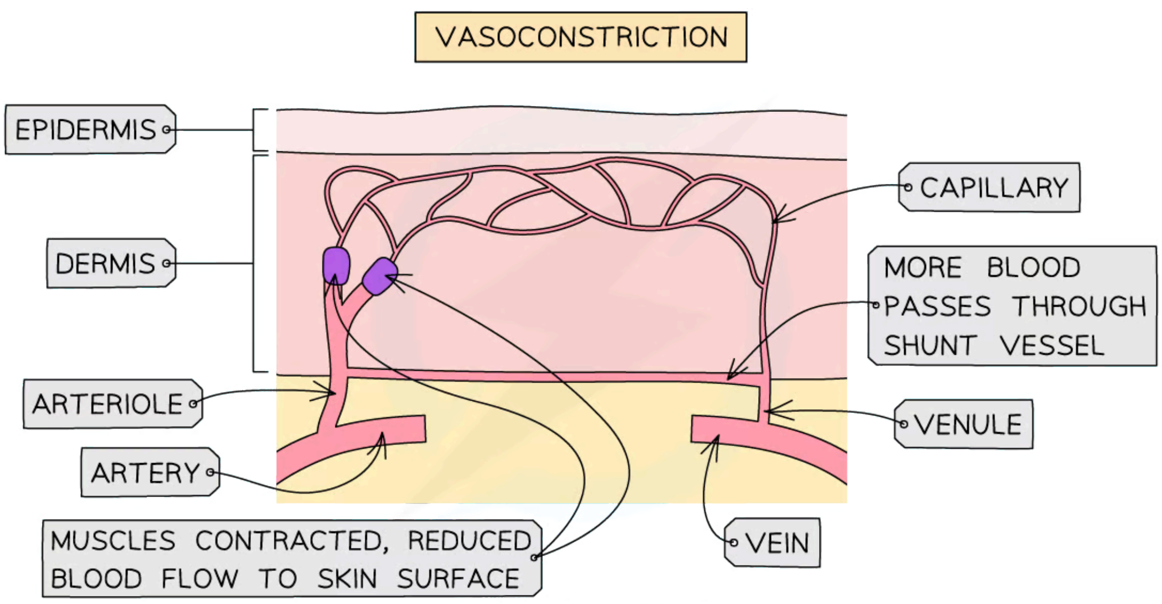

The mechanisms of vasodilation and vasoconstriction

Your notes

Examiner Tips and Tricks

There are some common areas of confusion in this topic:

- Firstly, it is the **arterioles** which control the blood flow to the skin; arterioles have a layer of **muscle** which allow them to constrict or dilate. Capillaries, on the other hand, cannot change in diameter as their walls are only **one cell thick** and do not have a layer of muscle.
- Secondly, the **blood flow to the surface of the skin** increases and decreases depending on the amount of blood being directed to the capillaries; ensure that you do not suggest that the capillaries themselves move towards or further away from the surface of the skin, as this cannot happen.

Osmoregulation

Your notes

Osmoregulation

- **Osmoregulation** is the process of maintaining water and salt concentrations (osmotic balance) across membranes within the body
- It is an example of **homeostasis** in the human body

The importance of osmoregulation

- The **cytoplasm** of all cells is largely composed of water, as is the **blood plasma**
- Maintaining water levels in the body is vital to prevent harmful changes occurring to cells of the body as a result of **osmosis**
- If body cells lose or gain too much water by osmosis they do not function efficiently:
    - **Too much water** in the blood results in cells swelling as water moves into them, this has a diluting effect and can lead to cell lysis (bursting)
    - **Too little water** in the blood (or too high an ion concentration) and the cells lose water by osmosis, this has a dehydrating effect and can lead to cell death

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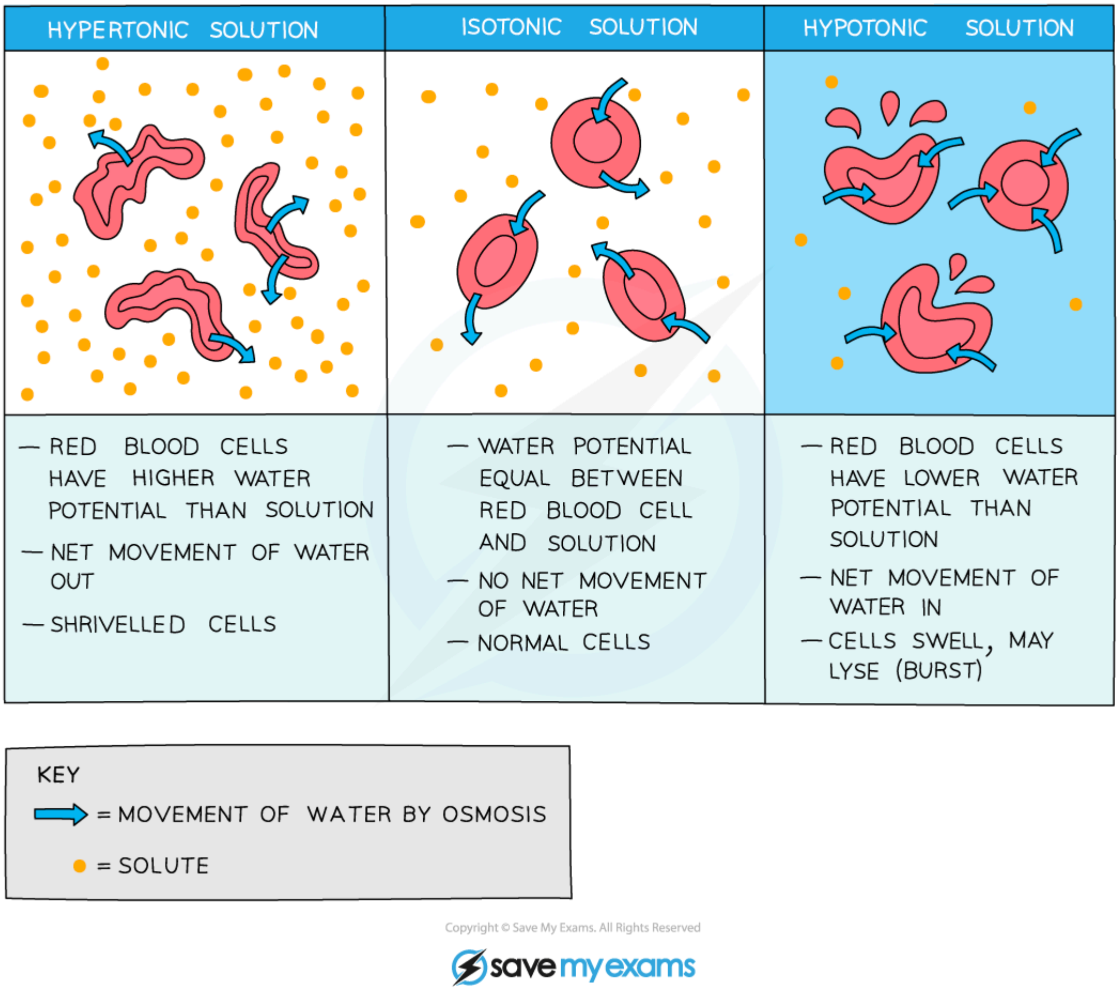

The effect of water concentration on body cells due to osmosis

Water content of the body

- There are two **sources** of water in the body:
  - Water produced as a result of **aerobic respiration**
  - Water in the **diet**
- Water is **lost** from the body in the following ways:
  - Via the lungs during exhalation (breathing out)
  - Lost from the skin as **sweat** (along side **mineral ions** and **urea)**

- Water lost through the lungs or skin **cannot be controlled**, but the volume of water lost in the production of urine can be **controlled by the kidneys**

The Urinary System

- Two key functions of the **urinary system** are:
  - To **filter waste** products from the blood and expel it from the body as **urine**
  - To control the **water levels** of the body (**osmoregulation)**
- The urinary system consists of two **kidneys** (found at the back of the abdomen) joined to the **bladder** by two tubes called the **ureters**
- Another tube, the **urethra**, carries urine from the bladder to outside the body
- Each kidney is also connected to:
  - The **renal artery** which comes from the aorta and delivers oxygenated blood to the kidney
  - The **renal vein** which delivers the deoxygenated blood from the kidney to the vena cava

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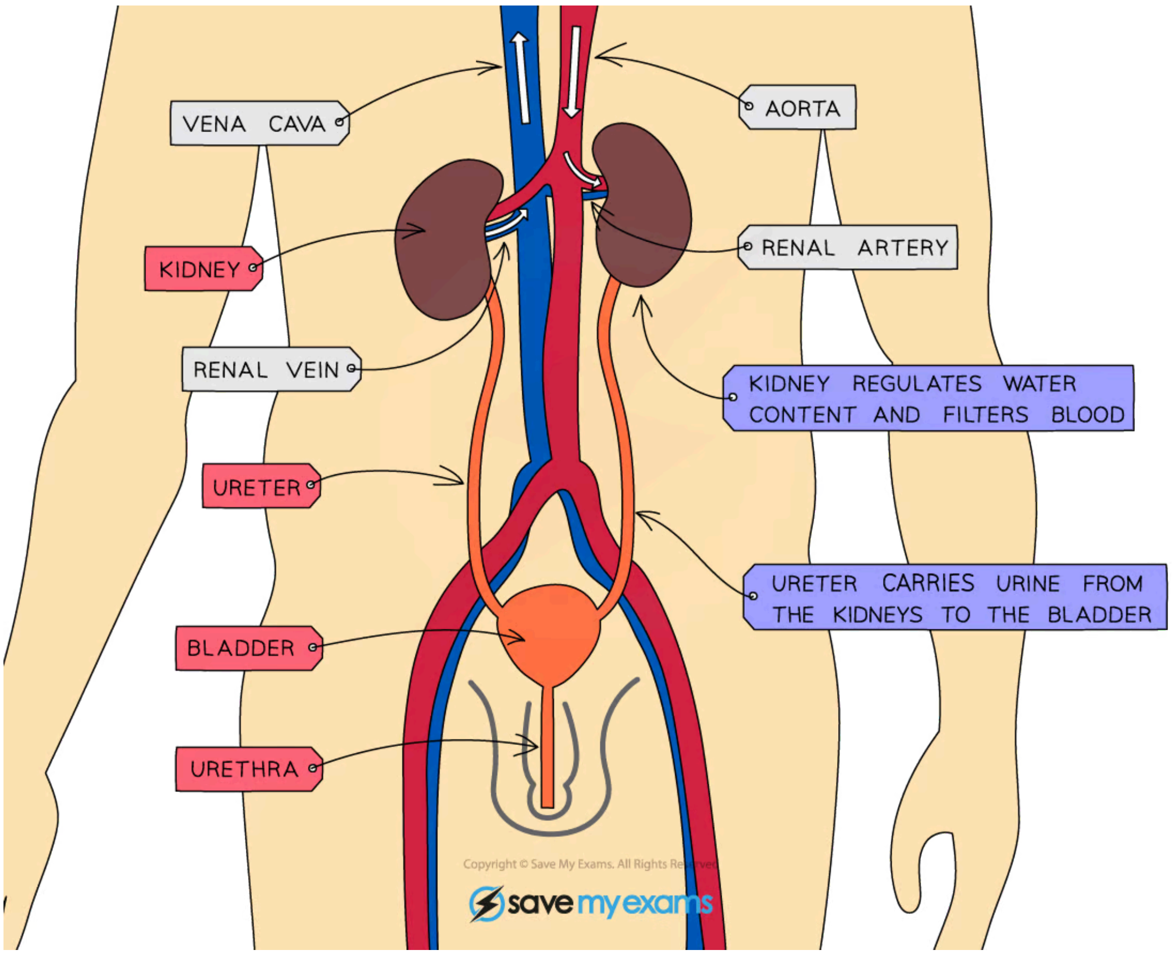

The urinary system in humans

Main Structures of the Urinary System Table

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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

Your notes

Examiner Tips and Tricks

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!

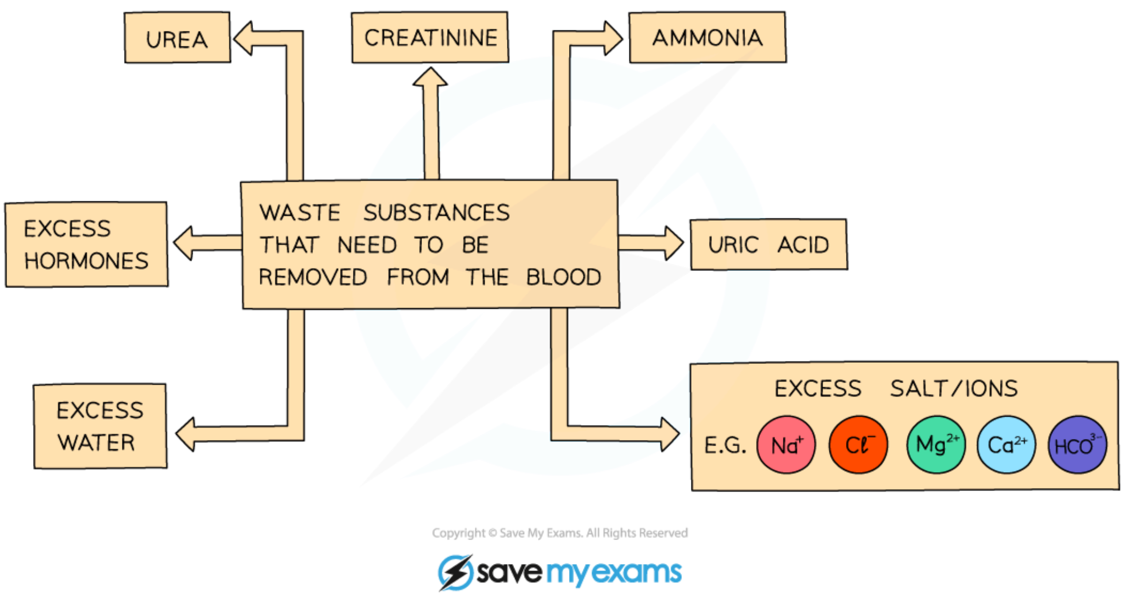
Forming Urine

Your notes

Forming Urine

The kidneys

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

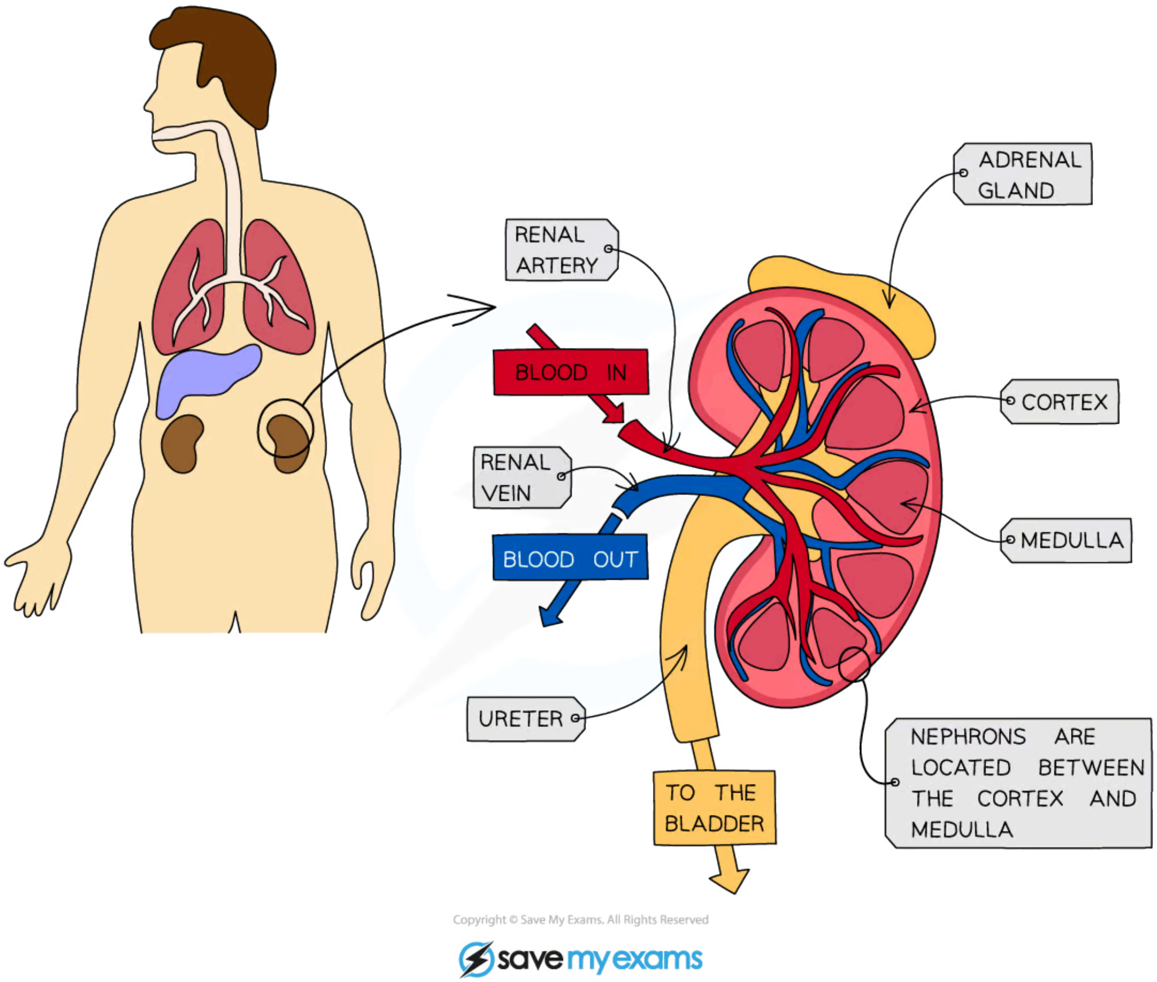


Waste substances removed by the kidney

Structure of the kidneys

- There are three regions of the kidney
  - **Cortex** - the outermost region
  - **Medulla** - the inner section of the kidney
  - **Renal pelvis** - the tube linking the kidney to the ureter

- Each kidney contains around a million tiny structures called **nephrons**, also known as **kidney tubules** or **renal tubules**
- 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 **renal pelvis** and the **urine collects** there before it flows into the **ureter** to be carried to the **bladder** for storage



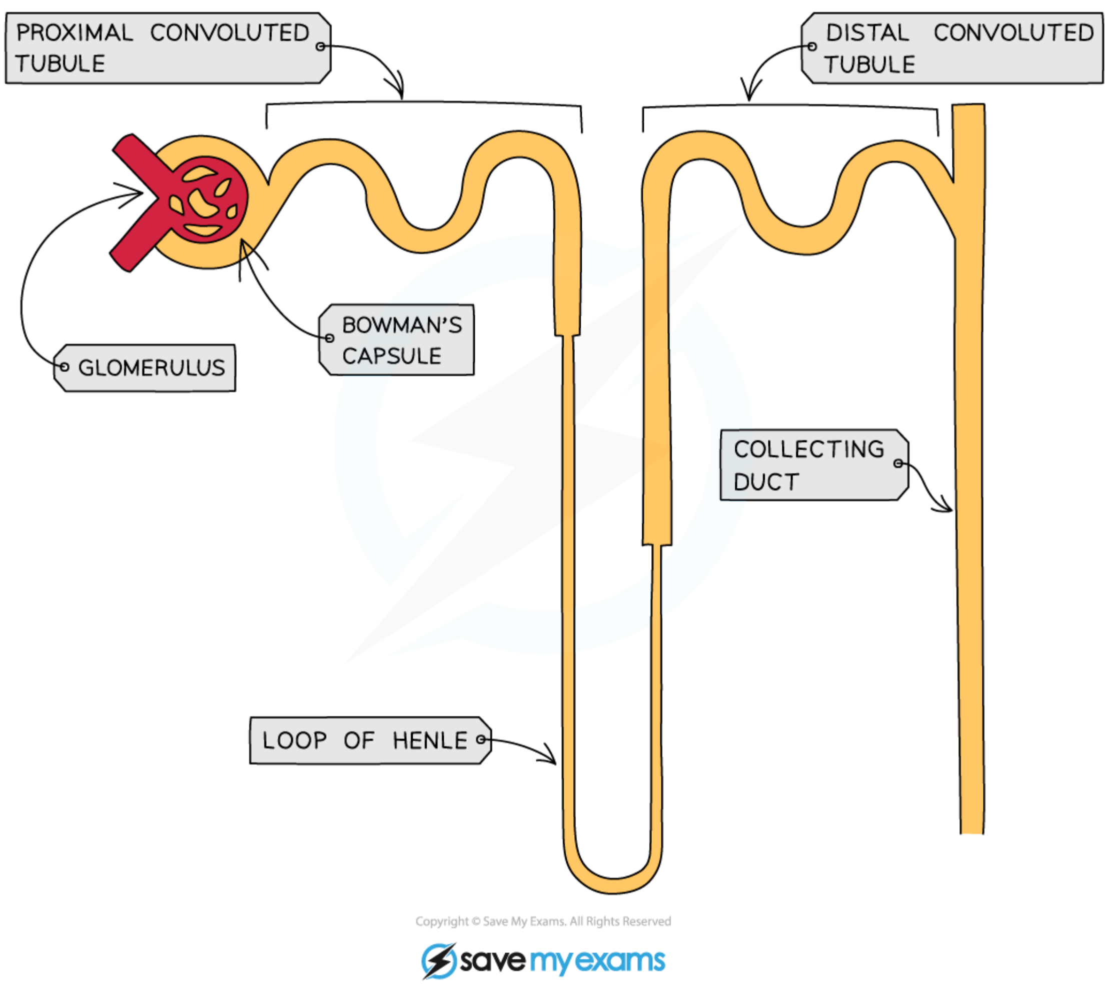
The structure and location of the kidney

The nephron

- The nephron is made up of a **kidney tubule** which has several sections:
  - **Bowman's capsule**
  - **Proximal convoluted tubule**

Your notes

    - **Loop of Henlé**
    - **Distal convoluted tubule**
    - **Collecting duct**
- Surrounding the tubule is a **network of capillaries** with a knotted section which sits inside the **Bowman's capsule**



Structure of a nephron

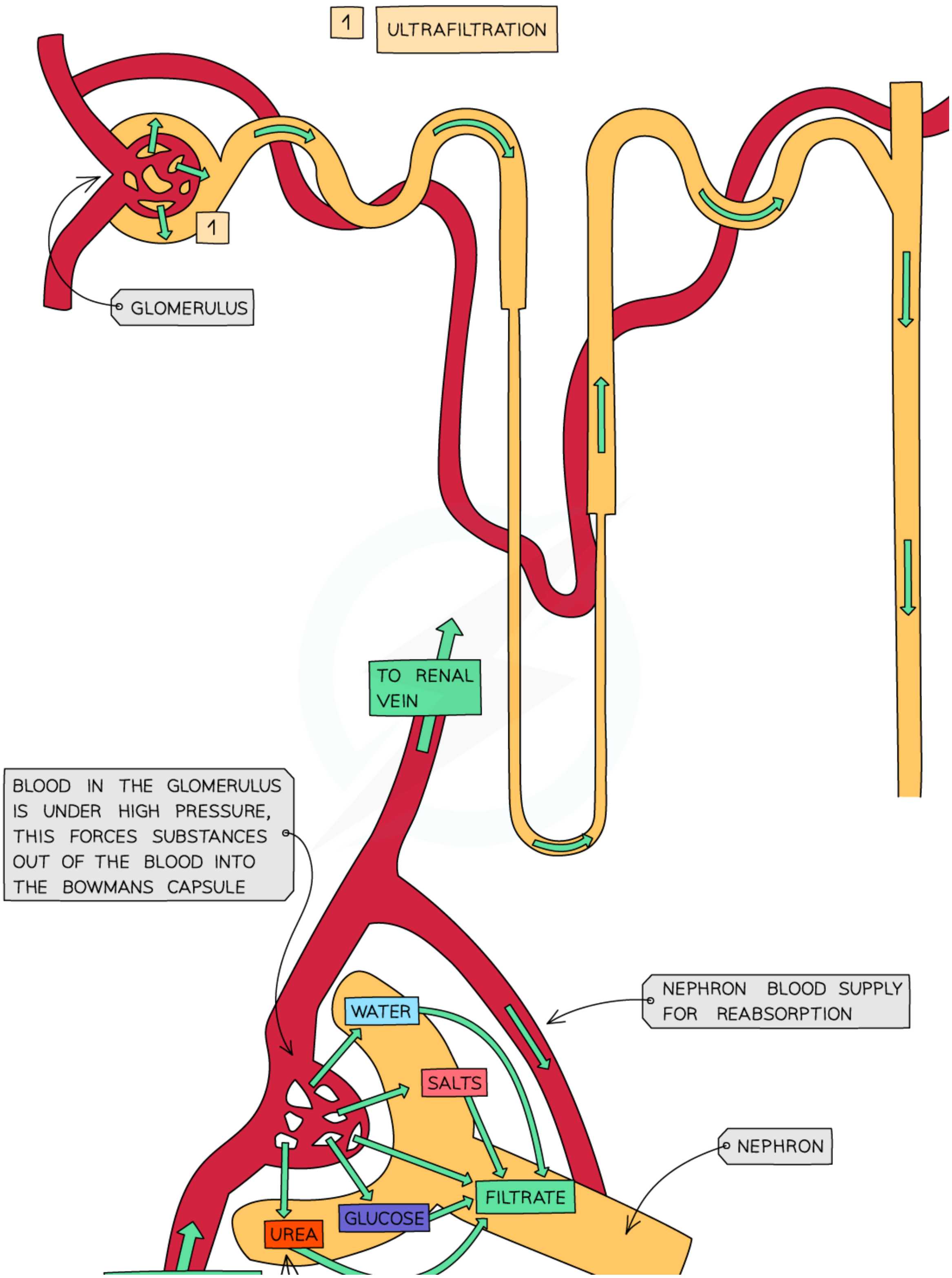
- In the kidney, blood is filtered (**ultrafiltration**) before the key substances are reabsorbed back into the blood again **(selective reabsorption)**

Ultrafiltration

- 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

Your notes

Your notes


1
ULTRAFILTRATION
1
GLOMERULUS
TO RENAL VEIN
BLOOD IN THE GLOMERULUS IS UNDER HIGH PRESSURE, THIS FORCES SUBSTANCES OUT OF THE BLOOD INTO THE BOWMANS CAPSULE
NEPHRON BLOOD SUPPLY FOR REABSORPTION
WATER
SALTS
NEPHRON
FILTRATE
GLUCOSE
UREA

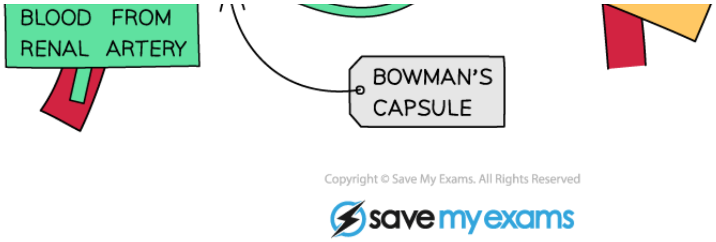


Diagram showing the process of ultrafiltration

Reabsorption of glucose

- 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 the 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

Your notes

Your notes

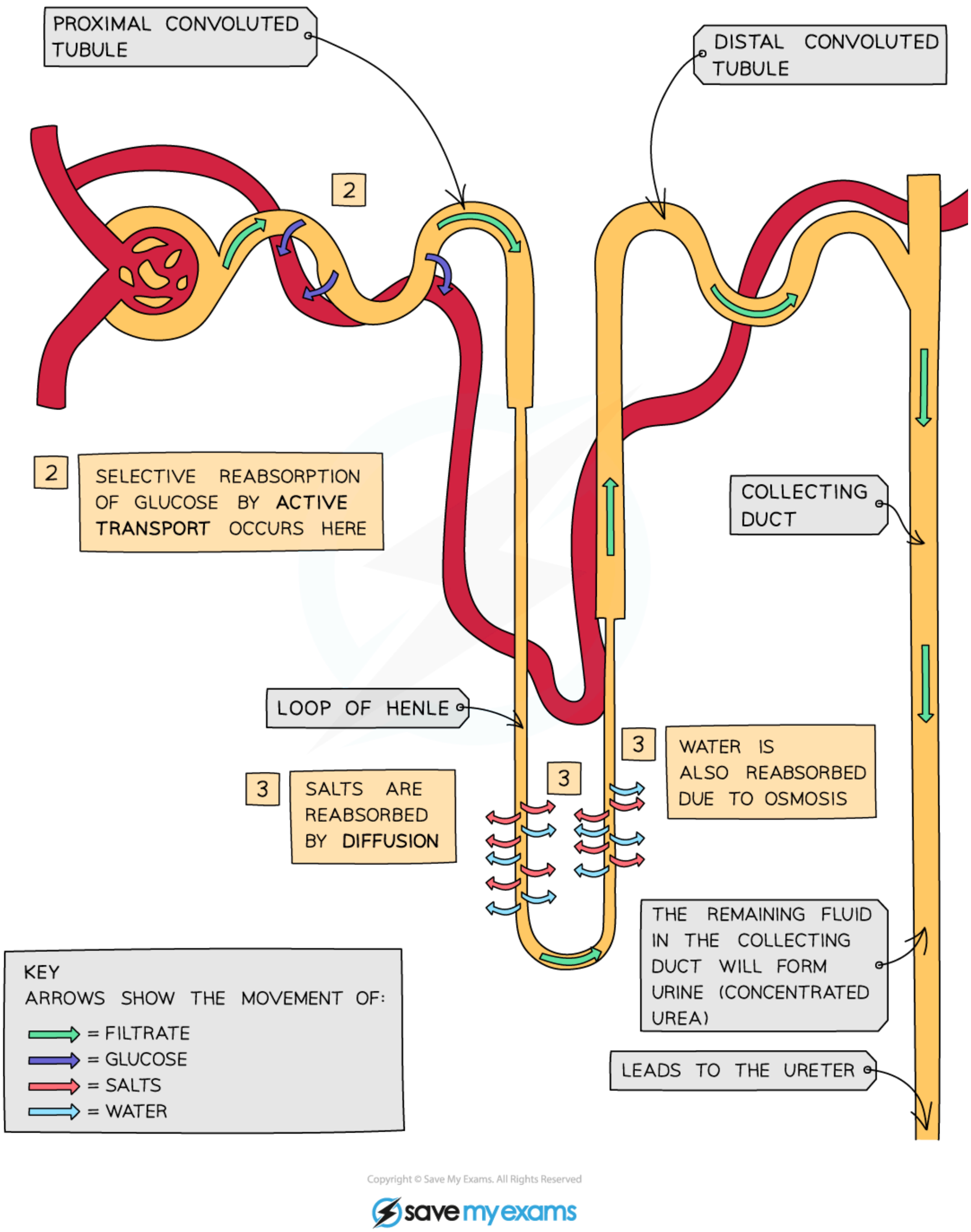

PROXIMAL CONVOLUTED TUBULE
DISTAL CONVOLUTED TUBULE
2
2
SELECTIVE REABSORPTION OF GLUCOSE BY ACTIVE TRANSPORT OCCURS HERE
COLLECTING DUCT
LOOP OF HENLE
3
WATER IS ALSO REABSORBED DUE TO OSMOSIS
3
3
SALTS ARE REABSORBED BY DIFFUSION
THE REMAINING FLUID IN THE COLLECTING DUCT WILL FORM URINE (CONCENTRATED UREA)
KEY
ARROWS SHOW THE MOVEMENT OF:
= FILTRATE
= GLUCOSE
= SALTS
= WATER
LEADS TO THE URETER
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Diagram showing reabsorption in the nephron

Components of Filtrate Table

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

Your notes

Examiner Tips and Tricks

Take care to describe clearly where substances are moving from and to in the kidneys (ie. glucose moves from the filtrate into the bloodstream when it is selectively reabsorbed. Using your technical terminology incorrectly here could lose you marks.Also – small substances such as urea are forced out of the blood during filtration as a result of high-pressure mass flow, they don't diffuse out of the blood.

Your notes

ADH

ADH

Higher tier only

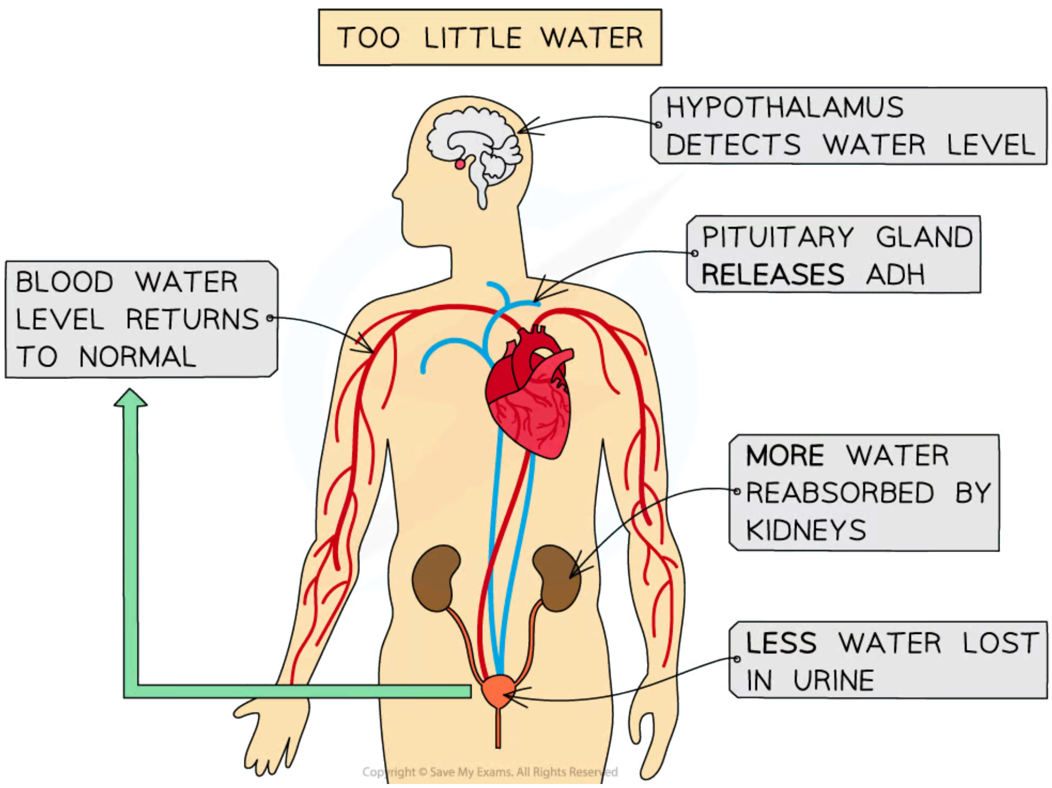
The concentration and volume of urine

- **Urine** produced by the kidneys contains a mixture of
  - **Urea**
  - **Excess mineral ions**
  - **Excess water**
- 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 the urine, meaning a **smaller quantity of dark yellow, concentrated urine** will be produced
  - **Exercise** - the greater the level of exercise, the more water is lost in sweat and so less will appear in the urine, meaning a **smaller quantity of dark yellow, concentrated urine** will be produced

The role of ADH in regulating water content of the blood

- Water reabsorption occurs along the nephron tubules in the kidneys
- The control of water reabsorption by the tubules is an example of **negative feedback**
- If the water content of the blood is too high then less water is reabsorbed, if it is too low then more water is reabsorbed
  - This is controlled by the hormone **ADH**
- The pituitary gland in the brain constantly releases **ADH**
- How much ADH is released depends on how much water the kidneys need to reabsorb from the filtrate

- ADH affects the permeability of the tubules to water
- If the **water** content of the blood is too **high:**
  - The pituitary gland releases **less ADH** which leads to **less water being reabsorbed** in the tubules of the kidney (the tubules become less permeable to water)
  - As a result, the kidneys produce a large volume of dilute urine
- If the **water** content of the blood is too **low:**
  - The pituitary gland releases **more ADH** which leads to **more water being reabsorbed** in the tubules of the kidney (the tubules become more permeable to water)
  - As a result, the kidneys produce a small volume of concentrated urine



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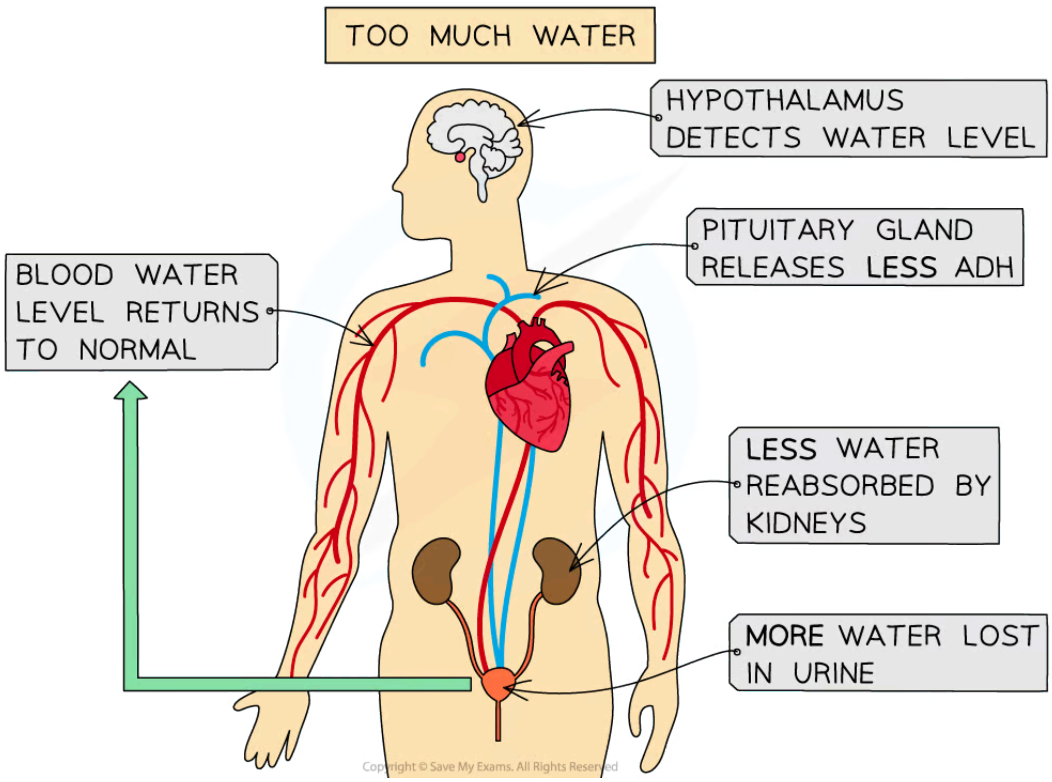
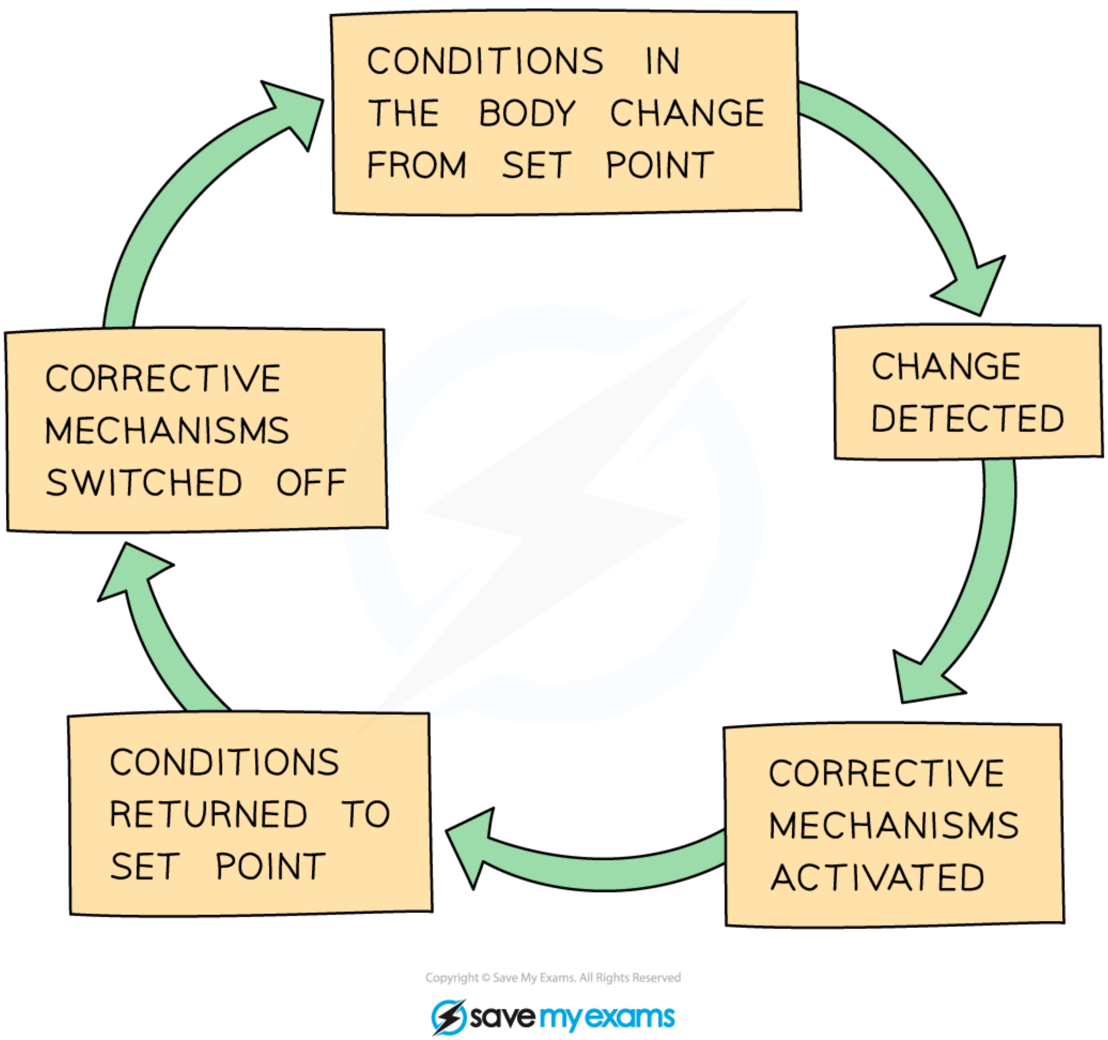


The kidney controls water levels using the hormone ADH. It is an example of a negative feedback mechanism.



Remember the negative feedback cycle covered in 7.2.1: the brain detects if the level is too high or low and modulates how much ADH the pituitary gland releases

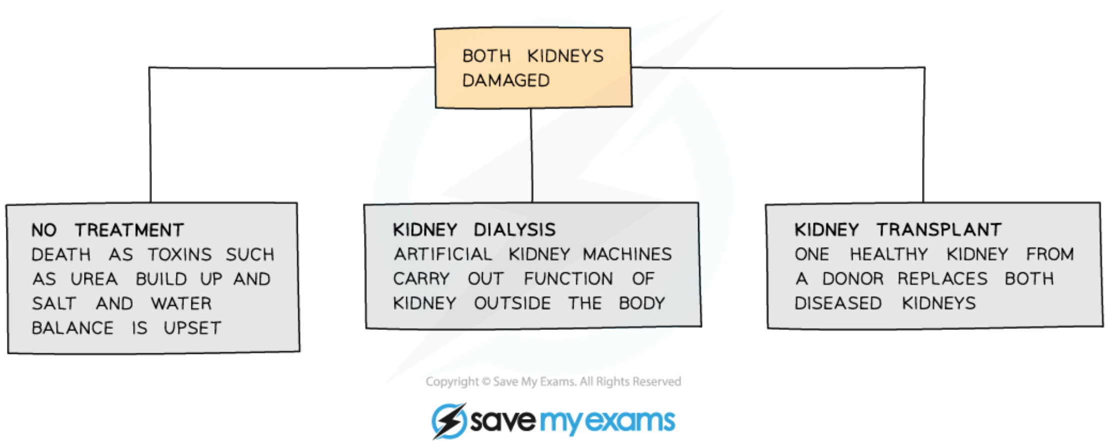
Your notes

Your notes

Kidney Failure

Kidney Failure

- 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
- There are several different **treatment options** for kidney failure



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 optimise 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 dialysis machine the blood and dialysis fluid are separated by a **partially permeable membrane** - the blood flows in the **opposite direction** to dialysis fluid, allowing **the 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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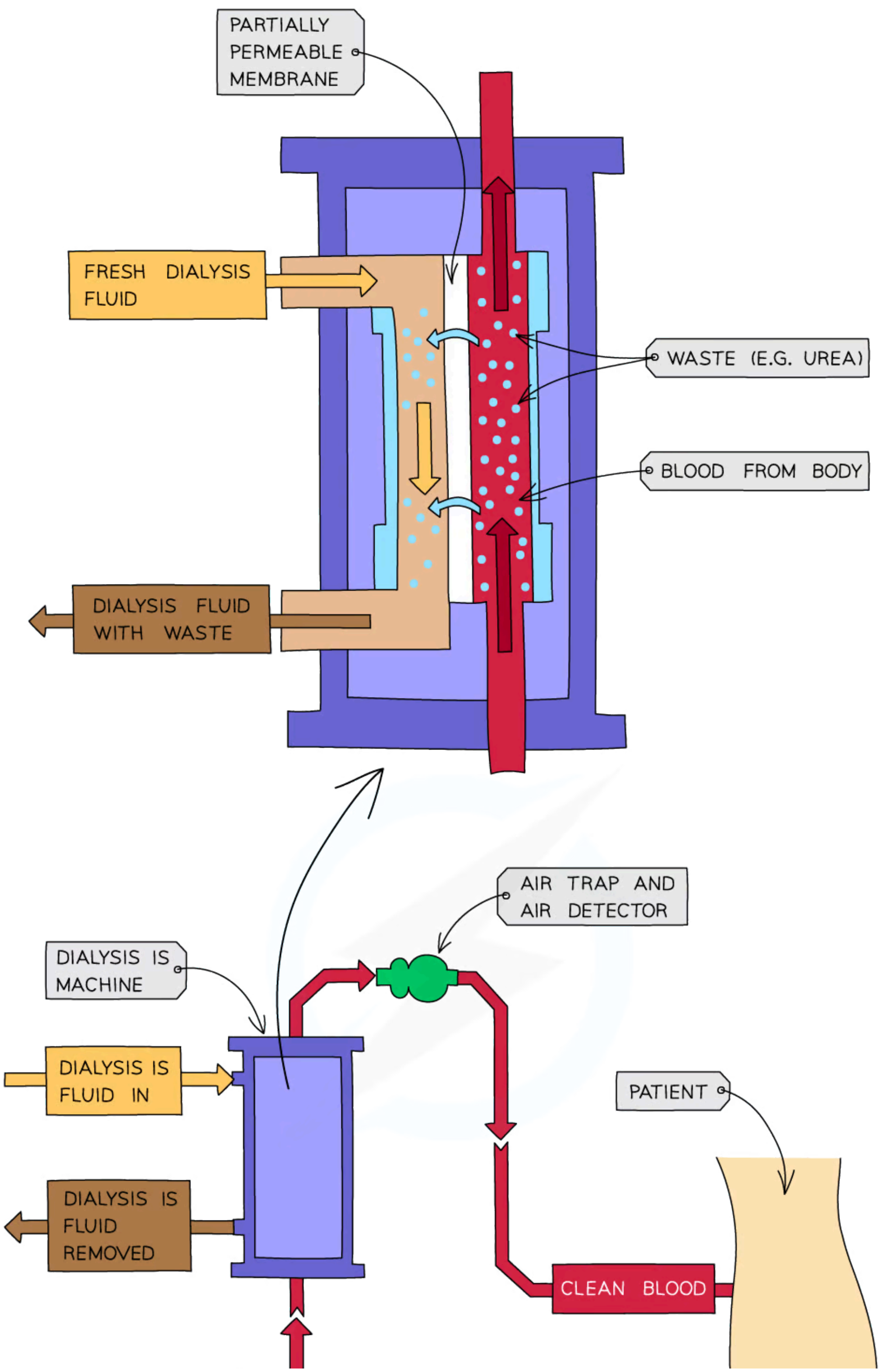
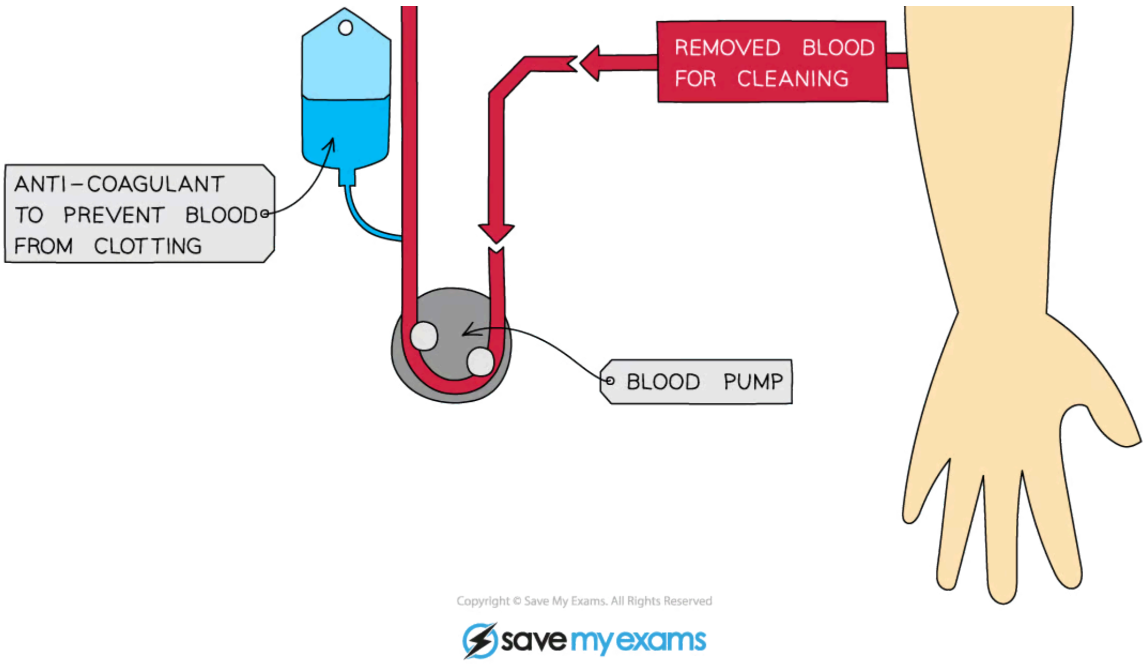
Your notes


PARTIALLY PERMEABLE MEMBRANE
FRESH DIALYSIS FLUID
WASTE (E.G. UREA)
BLOOD FROM BODY
DIALYSIS FLUID WITH WASTE
AIR TRAP AND AIR DETECTOR
DIALYSIS IS MACHINE
DIALYSIS IS FLUID IN
DIALYSIS IS FLUID REMOVED
PATIENT
CLEAN BLOOD



How dialysis works

- 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 the blood before it runs through the machine to **prevent the blood from clotting** and slowing the flow

Kidney transplant

- **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

Your notes

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 the demand

- 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**

Examiner Tips and Tricks

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.

Your notes

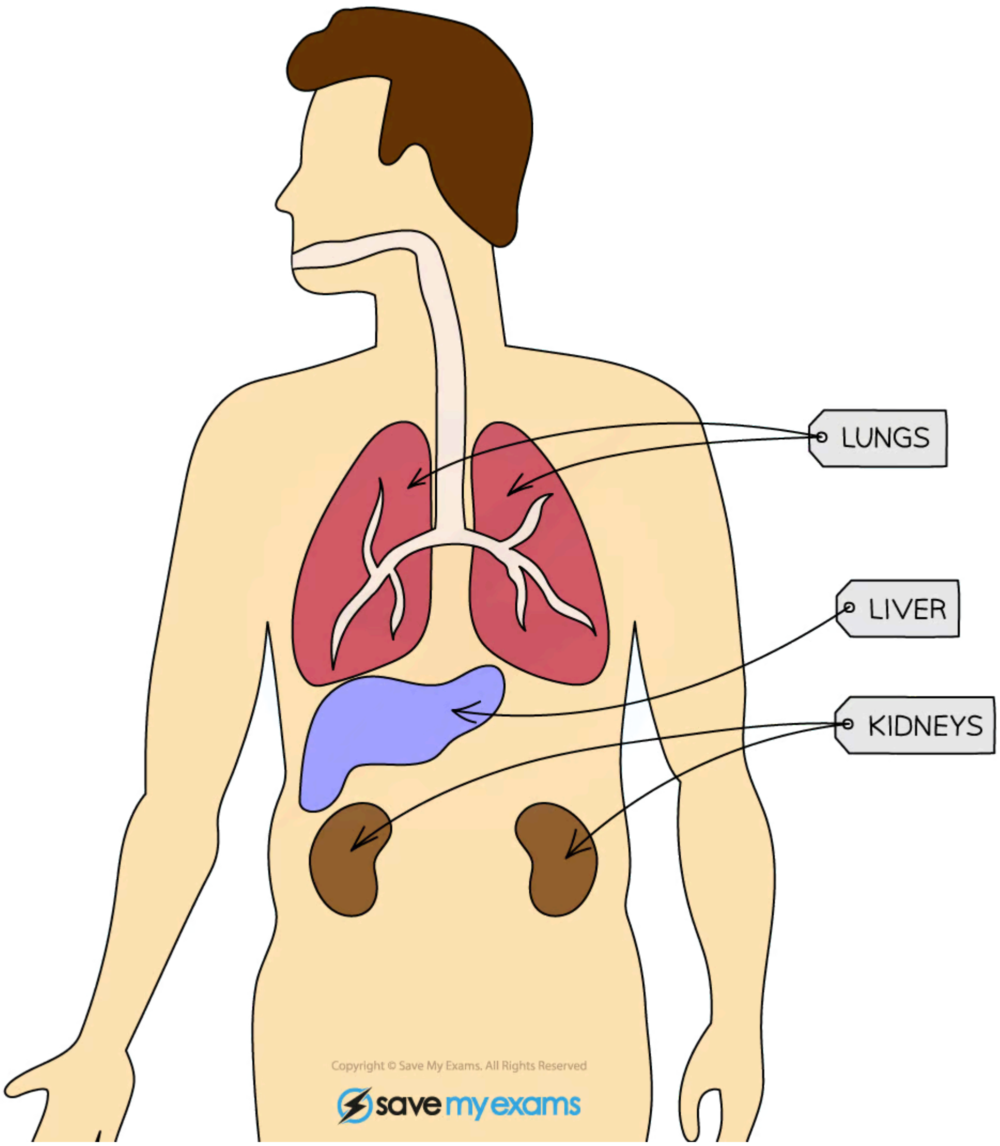
Formation of Urea

Your notes

Formation of Urea

- 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**
- Too much **carbon dioxide** in the body is **toxic** and therefore, must be excreted
  - 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
- **Urea** is also toxic to the body in higher concentrations and so must be excreted via the **liver**

Your notes



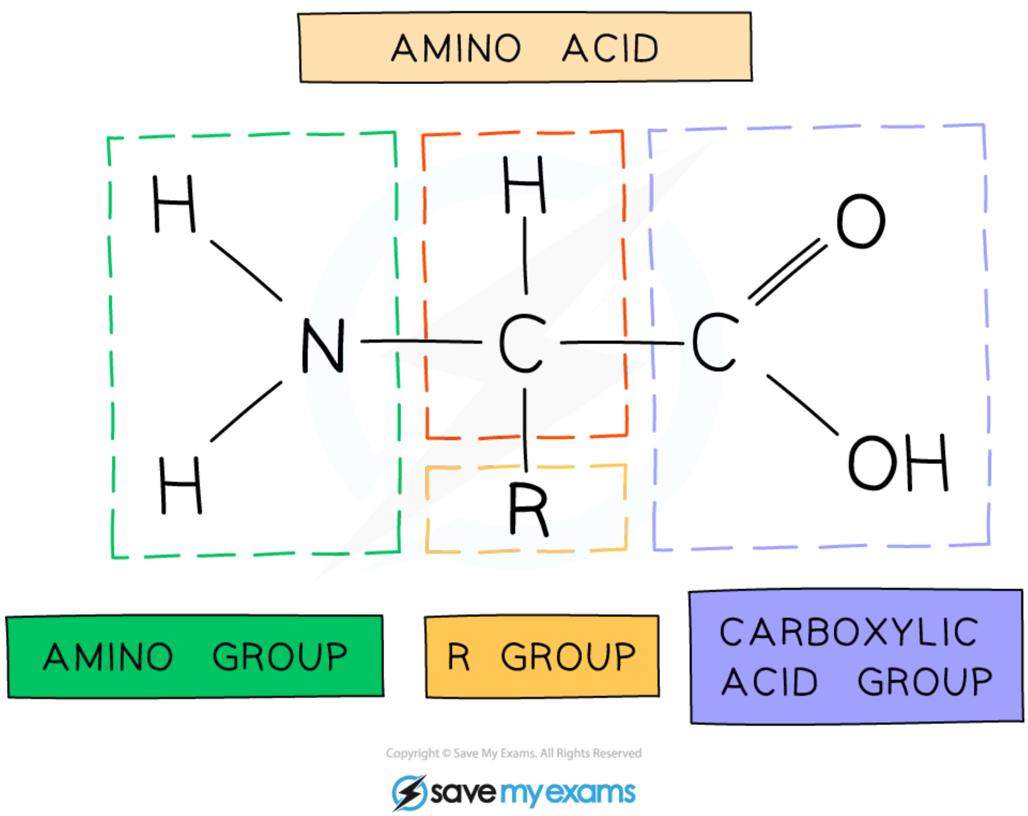
The main organs involved in excretion. The lungs excrete carbon dioxide, the liver forms urea from excess amino acids and the kidneys excrete water, excess salts and urea.

The role of the liver – forming urea

- 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

Your notes

- **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**



Amino acid groups

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

Examiner Tips and Tricks

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.

Your notes

Regulating Blood Glucose Concentration

Your notes

Insulin & Blood Glucose Concentration

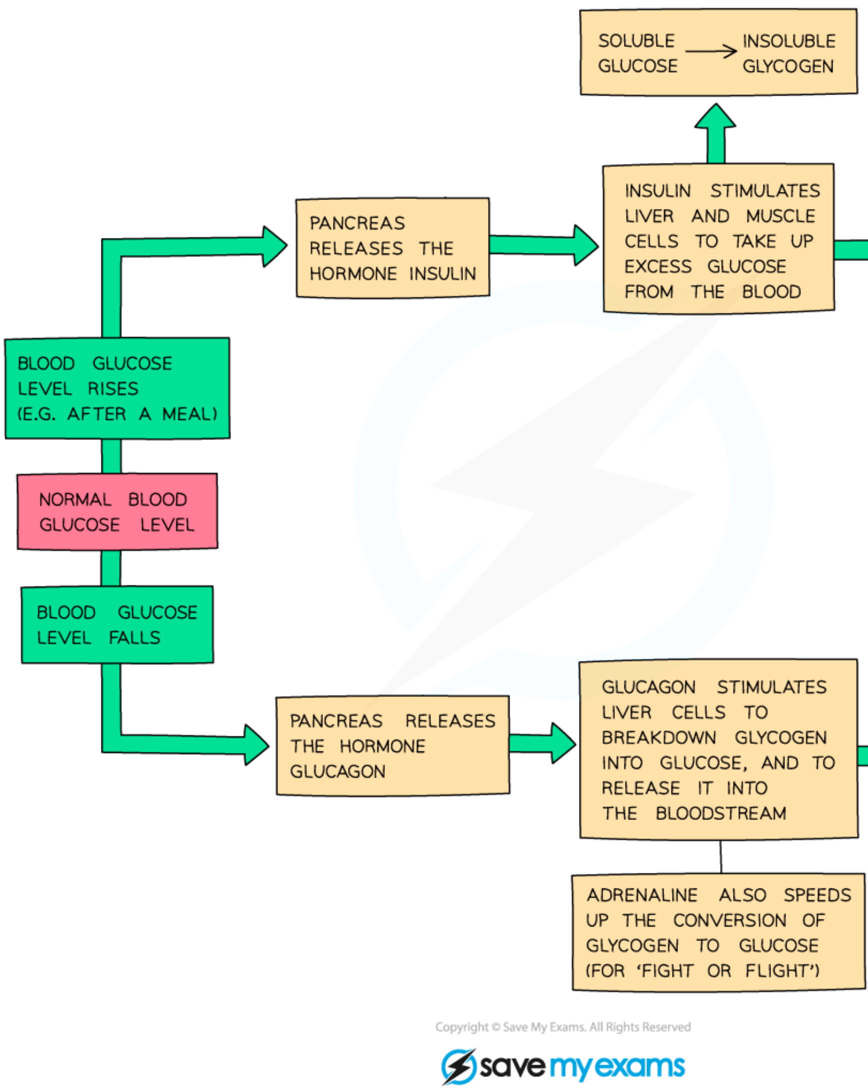
- **Blood glucose concentration** must be kept within a narrow range, so it's another example of **homeostasis** (like temperature control)
- Blood glucose concentration is monitored and controlled by the **pancreas**
- The pancreas is an **endocrine gland** (making and secreting hormones into the bloodstream) and it also plays a vital (but separate) role in **digestion** (making and secreting enzymes into the digestive system)
- Eating foods containing carbohydrate results in an increase of glucose into the bloodstream
- If the blood glucose concentration is too high, the pancreas produces the hormone **insulin** to bring it back down
  - Too high a level of glucose in the blood can lead to cells of the body losing water by osmosis, which can be dangerous
- Insulin **stimulates cells to take in glucose from the bloodstream** (particularly liver and muscle cells)
- In **liver and muscle cells** excess glucose is converted into **glycogen** (a polymer of glucose) for storage

The Action of Glucagon

Higher tier only

- If the blood glucose concentration is too low, the pancreas produces the hormone **glucagon** that causes glycogen to be converted into glucose and released into the blood.
- Glucagon and insulin interact as part of a negative feedback cycle to control blood glucose (sugar) levels in the body:
  - **Insulin** is produced when **blood glucose rises** and stimulates liver and muscle cells to convert excess **glucose** into **glycogen** to be stored – this reduces the blood glucose level
  - **Glucagon** is produced when **blood glucose falls** too low and stimulates liver and muscle cells to convert stored **glycogen** into **glucose** to be released into the bloodstream – this increases the blood glucose level

Your notes



Negative feedback regulation of blood glucose levels

Examiner Tips and Tricks

The terms glucagon and glycogen are very often mixed up by students as they sound similar. Remember:

- Glucagon is the **hormone**

- Glycogen is the polysaccharide **glucose is stored as**

Learn the differences between the spellings and what each one does so you don't get confused in the exam!

Your notes

Diabetes

Type 1 diabetes

- **Type 1 diabetes** is a disorder in which the pancreas **fails to produce sufficient** insulin to control blood glucose levels
  - Scientists think this is a result of a person's own immune system destroying the cells of the pancreas that make insulin during development
- Type 1 diabetes is characterised by uncontrolled high blood glucose levels and is normally treated with **insulin injections**

Type 2 diabetes

- In **Type 2 diabetes** the body **cells no longer respond to insulin** produced by the pancreas - the person still makes insulin but their cells are resistant to it and don't respond as well as they should
- This can also lead to uncontrolled high blood glucose levels
- A **carbohydrate-controlled diet and an exercise regime** are common treatments for Type 2 diabetes

Comparing Type 1 & Type 2 diabetes

	Type 1	Type 2
Cause	Inability of pancreas to produce insulin	Cells of the body become resistant to insulin or insufficient insulin produced by the pancreas
Treatment	Monitoring blood glucose levels and injecting human insulin throughout the day (particularly before meals consumed)	Maintain a low-carbohydrate diet and regular exercise to reduce need for insulin

Correlation between body mass and Type 2 diabetes

Your notes

- Obesity is a major **risk factor** for Type 2 diabetes - obese individuals have an increased risk of developing the condition compared to non-obese individuals
- This is probably because a person who is obese is likely to consume a diet rich in carbohydrates which causes an **over-production of insulin** resulting in the development of **insulin resistance**

The body mass index

- An individual is classified as obese if their BMI (body mass index) is greater than 30
- BMI is worked out using the following formula:

BMI = mass (kg) ÷ height (m)^2

- An individual with a BMI over 30 has an increased risk of developing Type 2 diabetes

The waist-to-hip ratio

- Where on the body excess fat is being stored also plays a role
- Individuals with a lot of **excess fat stored around the abdomen area** have an increased risk of developing Type 2 diabetes
- Calcuating a waist-to-hip ratio gives an indication of how much fat is being stored in this area
- A ratio above 1.0 for men and 0.85 for women is associated with increased risk of developing Type 2 diabetes
- The ratio can be calculated using the following formula:

Waist-to-hip ratio = waist circumference (cm) ÷ hip circumference (cm)