

Animal coordination, control and homeostasis revision notes

Hormones are chemical messengers that coordinate what happens in the body. This topic looks at the glands that make them, how they control the menstrual cycle and blood glucose, and how the body keeps its internal environment constant. Triple Biology also covers temperature control and the kidneys.

For Edexcel GCSE Biology 1BIO and Combined Science 1SC0. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

1 Hormones and the endocrine system Spec 7.1-7.3

The endocrine system Spec 7.1

Hormones are chemical messengers. They are made in **endocrine glands** and released straight into the blood. The blood plasma carries them around the whole body, but each hormone only affects its **target organs**.

1. An endocrine gland secretes a hormone into the blood.
2. The blood carries the hormone around the body.
3. The hormone reaches its target organ and causes a response.

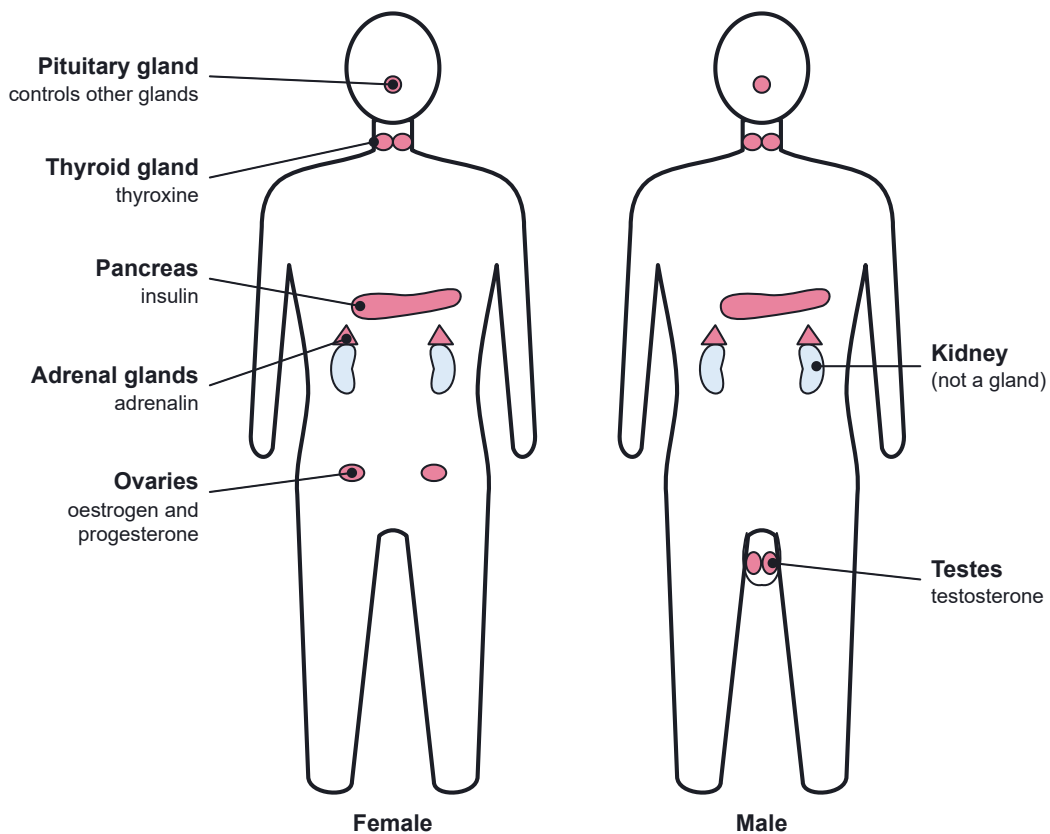
Endocrine glands you need to know

Gland	Where it is	Hormone made
Pituitary gland	At the base of the brain	Releases hormones that control other glands and organs
Thyroid gland	In the neck	Thyroxine
Pancreas	In the abdomen, below the stomach	Insulin
Adrenal glands	One on top of each kidney	Adrenalin
Ovaries	In the lower abdomen of a female	Oestrogen and progesterone
Testes	In the scrotum of a male	Testosterone

Higher tier

- The pituitary gland releases FSH and LH, which act on the ovaries, and TSH, which acts on the thyroid gland.
- The pancreas also makes a second hormone, glucagon.

Common mistake: Hormones travel in the blood, not along nerves. Write 'carried in the blood' or 'in the blood plasma' to get the mark.



The **endocrine glands** and the main hormone each one makes.

Adrenalin and fight or flight Spec 7.2 Higher tier

Adrenalin is produced by the adrenal glands. It prepares the body for **fight or flight**, for example when you are frightened or in danger. It makes the body ready to use a lot of energy quickly.

The effects of adrenalin	
Effect	Why it helps
Increased heart rate	Blood is pumped around the body faster
Increased blood pressure	Blood is pushed to the organs more quickly
Increased blood flow to the muscles	Muscles get more oxygen and glucose for respiration, so they can release more energy
Raised blood sugar level	Adrenalin stimulates the liver to change glycogen into glucose , which is released into the blood

Exam tip: Name the liver and say glycogen is changed into glucose. 'Sugar is released' on its own is too vague for the mark.

Thyroxine and negative feedback Spec 7.3 Higher tier

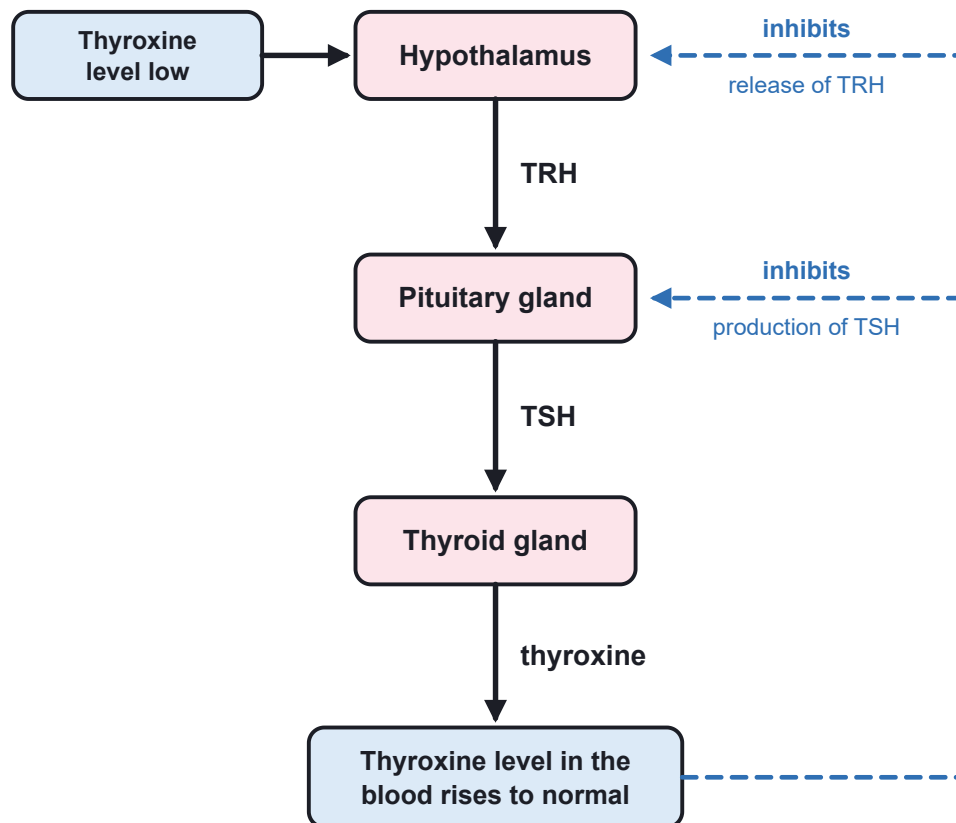
Thyroxine is made by the thyroid gland. It controls **metabolic rate**, which is the rate of the chemical reactions in the body. Its level is kept steady by **negative feedback**.

Negative feedback	A change in a level causes a response that reverses the change and brings the level back to normal.
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1. A low level of thyroxine stimulates the hypothalamus to produce TRH.

2. TRH causes the pituitary gland to release TSH.
3. TSH acts on the thyroid gland to produce thyroxine.
4. The thyroxine level rises back to normal.
5. When the thyroxine level is normal, thyroxine inhibits the release of TRH and the production of TSH.
This stops the level rising too far.

Common mistake: TRH is made in the hypothalamus and TSH is released from the pituitary gland. Mixing up the two organs loses marks.



Thyroxine is controlled by **negative feedback**: when its level is back to normal it inhibits TRH and TSH.

Quick check

1. How are hormones transported from endocrine glands to target organs?
2. Which gland produces insulin?
3. Name the four effects of adrenalin. (Higher)
4. Which hormone does the pituitary release to make the thyroid produce thyroxine? (Higher)

2 The menstrual cycle and fertility control Spec 7.4-7.8

The menstrual cycle Spec 7.4

The **menstrual cycle** is a series of changes in a woman that repeats about every 28 days. Each cycle, an egg is released from an ovary and the lining of the uterus is prepared in case the egg is fertilised.

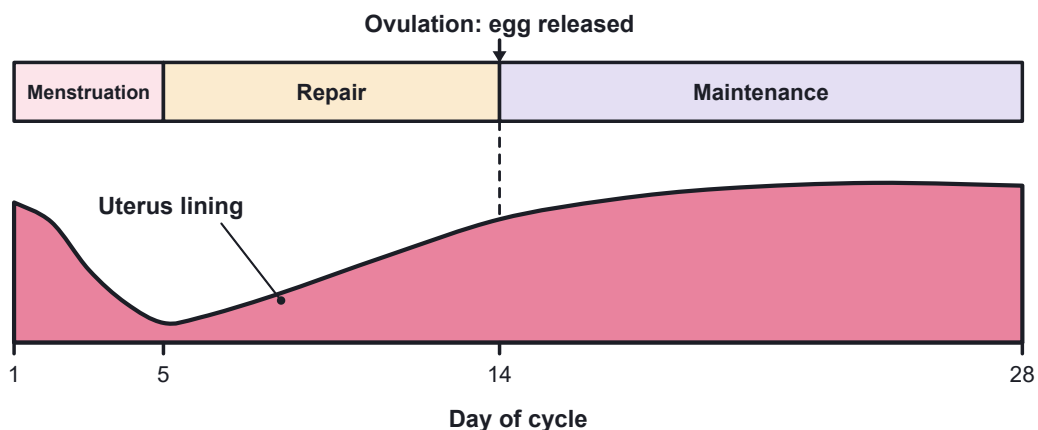
Stages of the menstrual cycle (days are approximate)

Stage	Days	What happens
Menstruation	1 to 5	The lining of the uterus breaks down and is lost through the vagina with blood
Repair	5 to 14	The uterus lining is repaired and thickens again
Ovulation	Around 14	An egg is released from an ovary
Maintenance	14 to 28	The lining stays thick, ready for a fertilised egg. If there is no pregnancy it breaks down and the cycle starts again

The roles of two hormones

- Oestrogen** is made in the ovaries. It causes the **repair and growth** of the uterus lining.
- Progesterone** is made in the ovaries. It **maintains** the uterus lining.

Maths skill: When you read a hormone graph, say which day the change happens on and whether the level rises, falls or peaks. Use figures from the axes.



The stages of the menstrual cycle and how the thickness of the **uterus lining** changes.

How four hormones control the cycle Spec 7.5 Higher tier

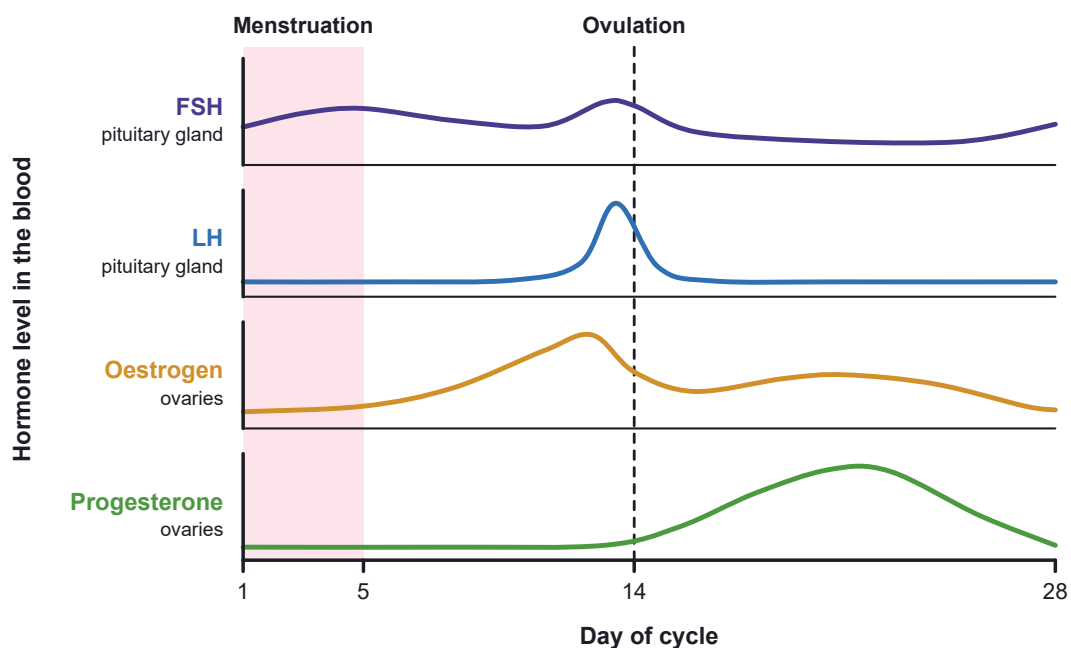
Four hormones interact to control the cycle. **FSH** and **LH** are released by the pituitary gland. **Oestrogen** and **progesterone** are made by the ovaries.

Hormones of the menstrual cycle

Hormone	Made in	What it does
FSH	Pituitary gland	Causes an egg to mature in an ovary. Stimulates the ovaries to produce oestrogen
Oestrogen	Ovaries	Repairs and builds up the uterus lining. Inhibits FSH. Stimulates the release of LH
LH	Pituitary gland	Causes ovulation
Progesterone	Ovaries	Maintains the uterus lining. Inhibits FSH and LH

1. FSH makes an egg mature and stimulates the ovaries to make oestrogen.
2. Oestrogen repairs the uterus lining. When oestrogen is high it inhibits FSH and stimulates the release of LH.
3. LH causes ovulation, around day 14.
4. After ovulation the ovary produces progesterone, which maintains the lining and inhibits FSH and LH, so no more eggs mature.
5. If there is no pregnancy, progesterone falls. The lining is no longer maintained and breaks down. This is menstruation.

Exam tip: Always say what each hormone does to the next one: stimulates or inhibits. Just writing 'oestrogen affects LH' will not score.



Levels of FSH, LH, oestrogen and progesterone. The **LH surge** triggers ovulation around day 14.

Hormonal contraception Spec 7.6

Hormonal contraceptives contain oestrogen, progesterone or both. They can be taken as a pill, or given as a patch, an injection or an implant under the skin.

The hormones keep levels in the body high. This stops the normal changes in hormone levels that cause eggs to mature and be released. The effects on the cycle and on pregnancy are:

- Eggs do not mature, so **ovulation does not happen**. There is no egg to be fertilised.

- Progesterone makes the **mucus at the cervix thicker**, so sperm cannot get through to reach an egg.

Higher tier

The oestrogen in the pill inhibits the release of FSH from the pituitary gland. With FSH kept low, eggs do not mature in the ovaries.

Common mistake: The pill does not kill sperm or stop sperm being made. It works by stopping ovulation and thickening cervical mucus.

Evaluating hormonal and barrier methods Spec 7.7

Barrier methods such as condoms and diaphragms stop sperm reaching an egg. **Hormonal methods** change the menstrual cycle. To evaluate them, give advantages and disadvantages of each.

Comparing methods		
Method	Advantages	Disadvantages
Hormonal (pill, patch, injection, implant)	Very effective when used correctly. Implants and injections last a long time, so there is nothing to remember each day	Do not protect against sexually transmitted infections. Can cause side effects. The pill must be taken at the right time every day
Barrier (condom, diaphragm)	Condoms also protect against sexually transmitted infections. No hormone side effects. Only used when needed	Less effective if not used correctly, for example a condom can split or slip. A diaphragm has to be fitted correctly

Exam tip: An evaluate answer needs both sides and a conclusion. Finish with a judgement, such as which method suits a couple who also want protection from infection.

Assisted reproductive technology Spec 7.8 Higher tier

Assisted Reproductive Technology (ART) helps people who find it hard to have a baby. Hormones are used in two types of treatment.

IVF (in vitro fertilisation)

1. The woman is given FSH and LH. These make several eggs mature in her ovaries.
2. The eggs are collected from the ovaries.
3. The eggs are mixed with sperm in a dish in the laboratory, where they are fertilised.
4. The fertilised eggs develop into embryos.
5. One or two embryos are placed into the woman's uterus.

Clomifene therapy

Clomifene is a drug taken by women who do not ovulate. It stimulates the release of FSH and LH, so eggs mature and ovulation happens.

Exam tip: In IVF the hormones are given to make eggs mature. The fertilisation then happens outside the body. Keep these two ideas separate.

Quick check

- 1 . Which hormone repairs the uterus lining and which maintains it?
- 2 . Around which day does ovulation happen in a 28-day cycle?
- 3 . State one way the contraceptive pill prevents pregnancy.
- 4 . Give one advantage of condoms over the pill.
- 5 . What does clomifene do? (Higher)

3 Homeostasis and temperature control Spec 7.9-7.12B

Maintaining a constant internal environment Spec 7.9

Homeostasis Maintaining a constant internal environment in response to internal and external change.

Conditions inside the body change. Eating a meal changes blood glucose. Exercise raises body temperature. A hot or cold day changes the temperature outside. The body responds to keep the conditions inside **constant**.

Conditions the body keeps constant	
Condition	Example of a change
Blood glucose concentration	A meal raises it, exercise lowers it
Body temperature	Hot or cold surroundings, or exercise
Water content of the blood	Sweating, or drinking a lot

This matters because **enzymes and cells work best in a narrow range of conditions**. If conditions drift too far, reactions in cells slow down or stop. Many of these controls use negative feedback.

Exam tip: Constant does not mean the level never changes. It means the body brings it back to a set level, so say 'kept within narrow limits'.

Thermoregulation and osmoregulation Spec 7.10B Triple only

Thermoregulation: the effect on enzyme activity

Thermoregulation is the control of body temperature. Core body temperature is kept at about 37°C, which is the **optimum temperature** for most enzymes in the body.

- If the temperature rises too far, enzymes are **denatured**. The shape of the active site changes, so the substrate no longer fits and the reaction stops.
- If the temperature falls too far, enzymes work more slowly, so reactions in cells are too slow.

Osmoregulation: the effect on animal cells

Osmoregulation is the control of the water content of the blood. Animal cells have no cell wall, so water moving by **osmosis** changes them.

Blood water content	Effect on animal cells
Too high (blood too dilute)	Water enters the cells by osmosis. The cells swell and may burst
Too low (blood too concentrated)	Water leaves the cells by osmosis. The cells shrink

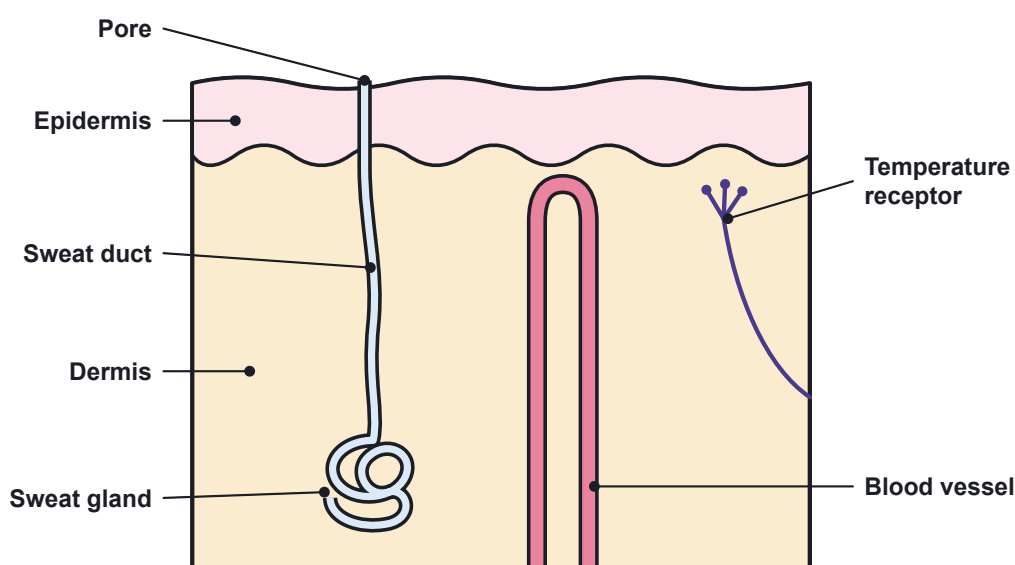
Common mistake: Say enzymes are denatured, not 'killed'. Enzymes are proteins, not living things.

The skin and the hypothalamus Spec 7.11B Triple only

The skin has two main layers, the **epidermis** and the **dermis**. The **hypothalamus** in the brain is the control centre for temperature.

Part	Role in thermoregulation
Epidermis	The thin outer layer of the skin. Sweat reaches the skin surface through pores in the epidermis, and heat is lost from the surface
Dermis	The layer below the epidermis. It contains the sweat glands, blood vessels that supply the skin, and temperature receptors that detect changes in skin temperature
Hypothalamus	Monitors the temperature of the blood and receives impulses from temperature receptors in the skin. It coordinates the response by sending nerve impulses to the effectors, such as the sweat glands, muscles and blood vessels

Exam tip: Link each part to a job. Say what the hypothalamus detects and what it then triggers, not just that it 'controls' temperature.



The structures in the skin involved in **thermoregulation**.

Responses to heat and cold Spec 7.12B Triple only

When the body is too hot

- Sweat glands release **sweat** onto the skin. Sweat evaporates and takes heat from the skin, which cools the body.

Higher tier

- Vasodilation**: the blood vessels supplying the skin surface widen. More blood flows near the surface, so more heat is lost to the surroundings.

When the body is too cold

- Shivering**: muscles contract rapidly. This needs more respiration in the muscle cells, which transfers energy as heat and warms the body.

Higher tier

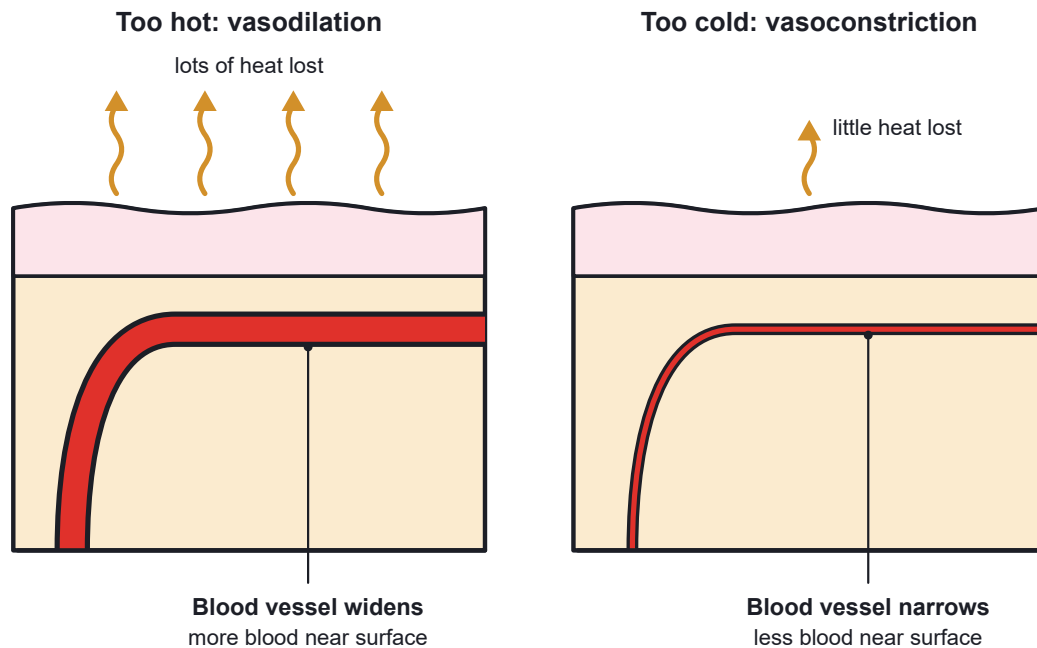
- Vasoconstriction**: the blood vessels supplying the skin surface narrow. Less blood flows near the surface, so less heat is lost.

- Sweating is reduced when the body is cold.

Higher tier

Common mistake: Blood vessels do not move up or down in the skin. They get wider (vasodilation) or narrower (vasoconstriction).

Higher tier



Vasodilation brings more blood near the surface to lose heat; **vasoconstriction** reduces heat loss.

Quick check

1. Define homeostasis.
2. Why does a high body temperature stop reactions in cells? (Triple only)
3. What happens to animal cells if the blood is too dilute? (Triple only)
4. Which part of the brain coordinates temperature control? (Triple only)
5. How does shivering warm the body? (Triple only)

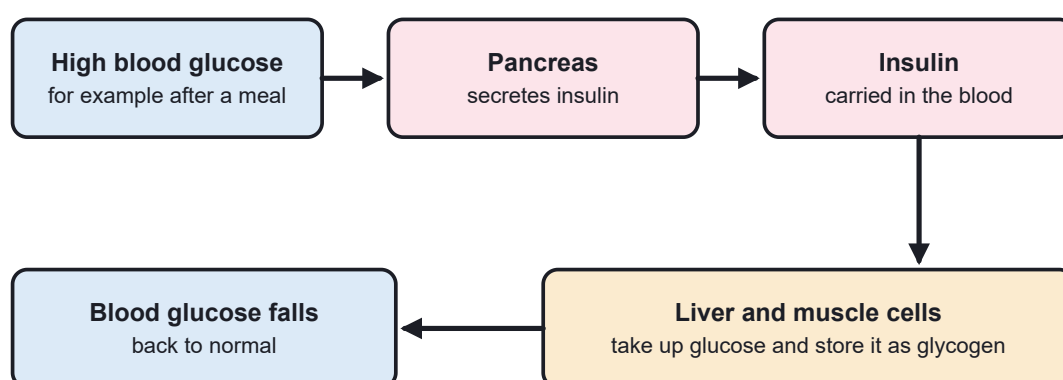
4 Blood glucose and diabetes Spec 7.13-7.17

Insulin and blood glucose Spec 7.13

Blood glucose concentration must stay steady. It rises after a meal. The **pancreas** detects this and secretes the hormone **insulin** into the blood.

1. Blood glucose concentration rises after a meal.
2. The pancreas secretes insulin into the blood.
3. Insulin makes cells take up glucose from the blood. In the liver and muscles, glucose is converted into **glycogen** for storage.
4. Blood glucose concentration falls back to normal.

Common mistake: The pancreas makes insulin. The liver stores glycogen. Do not write that the pancreas stores glucose.



How **insulin** brings a high blood glucose concentration back to normal.

Glucagon Spec 7.14 Higher tier

If blood glucose concentration falls too low, for example between meals or during exercise, the pancreas secretes **glucagon** instead.

1. Blood glucose concentration falls.
2. The pancreas secretes glucagon into the blood.
3. Glucagon acts on the liver. The liver changes **glycogen into glucose**.
4. Glucose is released into the blood, so blood glucose concentration rises back to normal.

Insulin and glucagon compared		
	Insulin	Glucagon
Released when	Blood glucose is too high	Blood glucose is too low
Acts on	Liver and other cells	Liver
Effect	Glucose into cells, glucose to glycogen	Glycogen to glucose
Result	Blood glucose falls	Blood glucose rises

Insulin and glucagon work against each other. This is negative feedback, and it keeps blood glucose concentration close to normal.

Type 1 diabetes Spec 7.15

In **type 1 diabetes**, the pancreas does not produce enough insulin. Without insulin, body cells do not take up enough glucose from the blood. After a meal, blood glucose concentration rises and stays too high.

It is controlled by:

- **injections of insulin**, usually around meals
- monitoring blood glucose concentration
- controlling the amount of carbohydrate in the diet

Exam tip: Type 1 cannot be controlled by diet alone, because the body is missing the insulin. Injections are needed.

Suggested practical: sugar in simulated urine

Urine from a healthy person contains no glucose. Glucose in urine suggests that blood glucose concentration is too high, as in untreated diabetes.

1. Put a sample of simulated urine in a test tube.
2. Add Benedict's solution.
3. Heat the tube in a hot water bath for a few minutes.
4. Record the colour. Blue means no sugar. Green, yellow, orange and brick red mean more and more sugar.

Exam tip: Wear eye protection and take care with the hot water bath. Benedict's solution must be heated, or there is no colour change.

Type 2 diabetes Spec 7.16

In **type 2 diabetes**, the body cells no longer respond properly to insulin. Blood glucose concentration stays too high. It is linked to being overweight or obese.

It is controlled by:

- a carefully controlled diet, for example less sugar and refined carbohydrate
- regular exercise
- losing weight if overweight
- some people also need medication or insulin

Type 1 and type 2 compared

	Type 1	Type 2
Cause	Pancreas does not produce enough insulin	Cells no longer respond to insulin
Control	Insulin injections, diet and monitoring	Diet, exercise and weight loss, sometimes medication

Body mass, BMI and type 2 diabetes Spec 7.17

There is a **correlation** between body mass and type 2 diabetes. In general, the higher the body mass, the greater the chance of developing it. You need to be able to calculate and interpret two measurements.

$$\text{BMI} = \text{mass (kg)} \div \text{height (m)}^2$$

$$\text{waist:hip ratio} = \text{waist circumference} \div \text{hip circumference}$$

A higher waist:hip ratio means more fat is stored around the waist, which is linked to a higher risk of type 2 diabetes.

Calculating BMI and waist:hip ratio

A man has a mass of 85 kg and a height of 1.70 m. His waist is 102 cm and his hips are 96 cm. Calculate his BMI to 1 decimal place and his waist:hip ratio to 2 decimal places.

1. Square the height: $1.70 \times 1.70 = 2.89$
2. $\text{BMI} = 85 \div 2.89 = 29.41$
3. $\text{Waist:hip ratio} = 102 \div 96 = 1.0625$

Answer: BMI = 29.4 and waist:hip ratio = 1.06

Maths skill: Square the height before you divide. Use metres for height and kilograms for mass. Waist and hip must be in the same units, and the ratio has no unit.

Evaluating the correlation

- A correlation shows that two things change together. It does **not prove one causes the other**.
- Other factors, such as diet, exercise and age, may also affect the risk.
- BMI does not show whether mass is fat or muscle, so a very muscular person can have a high BMI. The waist:hip ratio gives extra information about where fat is stored.

Quick check

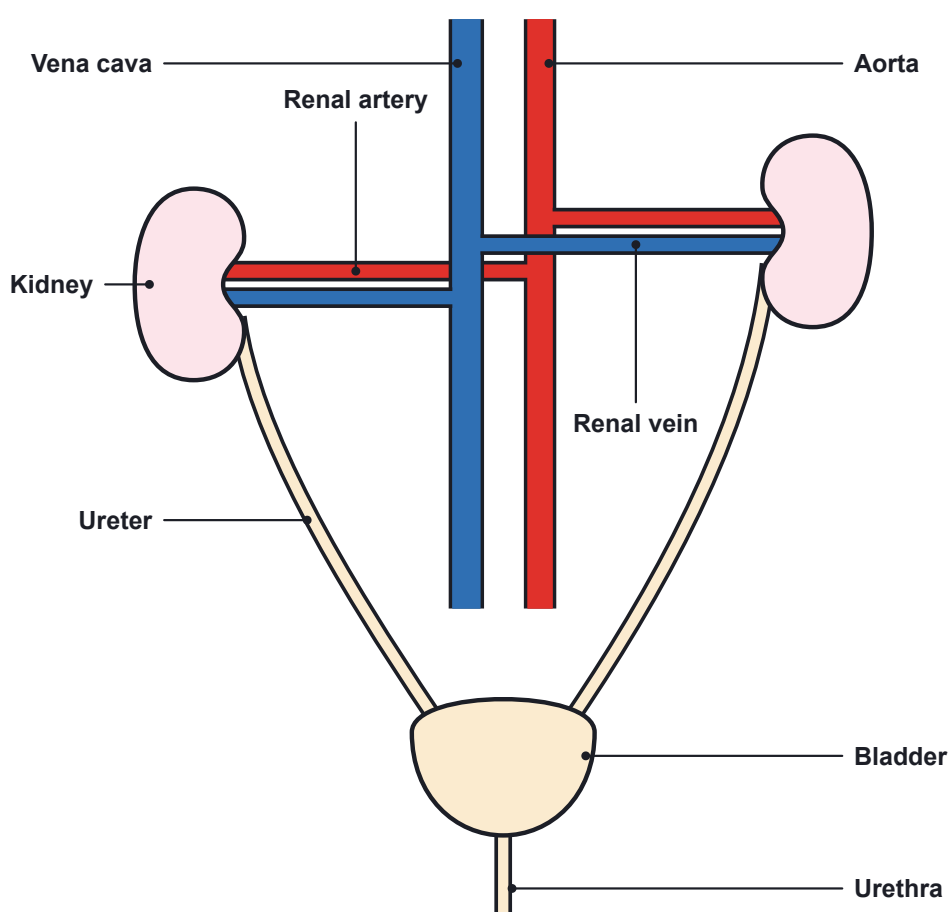
1. Which organ makes insulin and which organ stores glycogen?
2. What does glucagon do? (Higher)
3. State the cause of type 1 diabetes.
4. State the cause of type 2 diabetes.
5. Write the BMI equation.

5 The urinary system and the kidneys Spec 7.18B-7.22B Triple only

The urinary system Spec 7.18B

The **urinary system** removes waste from the blood and gets rid of it as **urine**.

Part	Function
Kidneys	Filter the blood and make urine
Renal artery	Brings blood to the kidney
Renal vein	Takes blood away from the kidney
Ureters	Tubes that carry urine from the kidneys to the bladder
Bladder	Stores urine
Urethra	Tube that carries urine out of the body



The **urinary system**. The renal artery brings blood to each kidney and the renal vein takes it away.

Urea Spec 7.22B

The body cannot store excess amino acids. They are broken down in the **liver**, and **urea** is produced. Urea is a waste substance. It is carried in the blood to the kidneys and removed in the urine.

Exam tip: Write 'urea is made in the liver from excess amino acids'. It is made from amino acids, not from glucose or fat.

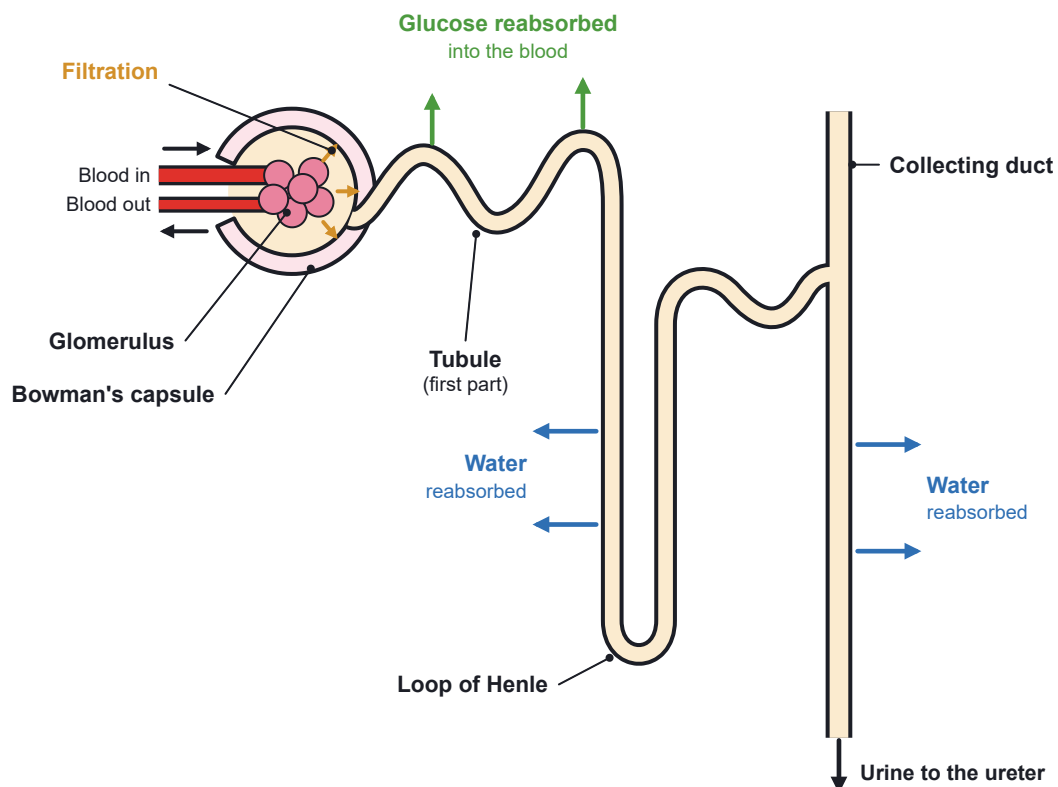
The nephron: filtering and reabsorption Spec 7.19B

Each kidney contains many tiny tubes called **nephrons**. The nephron filters the blood and forms urine. Blood enters a knot of capillaries, the **glomerulus**, which sits inside a cup-shaped **Bowman's capsule**.

1. **Filtration**: blood in the glomerulus is at high pressure. Small molecules such as water, glucose, urea and ions are forced out into the Bowman's capsule. Large molecules such as proteins, and blood cells, stay in the blood.
2. **Selective reabsorption of glucose**: in the first part of the tubule, all the glucose is reabsorbed back into the blood by active transport, which uses energy from respiration.
3. **Reabsorption of water**: as the filtrate passes along the loop of Henle and the collecting duct, water is reabsorbed back into the blood. How much depends on the body's needs.
4. What is left, which is urea, excess ions and water, is urine. It passes to the ureter.

Substance	Filtered at the glomerulus?	In urine?
Water	Yes	Yes, the amount that is not reabsorbed
Glucose	Yes	No, all reabsorbed
Urea	Yes	Yes
Proteins and blood cells	No	No

Exam tip: Link each part to its job: the glomerulus and Bowman's capsule filter, the tubule reabsorbs glucose, and the loop of Henle and collecting duct reabsorb water.



A **nephron**: filtration in the Bowman's capsule, **selective reabsorption** of glucose, then reabsorption of water.

ADH and the collecting duct Spec 7.20B

ADH is released by the pituitary gland. It controls how much water is reabsorbed in the kidney, which keeps the water content of the blood steady (osmoregulation). ADH changes the **permeability of the collecting duct**.

	Blood water content too low	Blood water content too high
ADH released	More	Less
Collecting duct	More permeable to water	Less permeable to water
Water reabsorbed into blood	More	Less
Urine	Small volume, concentrated	Large volume, dilute
Blood water content	Rises back to normal	Falls back to normal

Common mistake: ADH changes how permeable the collecting duct is to water. It does not change the amount of water the person drinks.

Treating kidney failure Spec 7.21B

If the kidneys fail, waste substances such as urea build up in the blood. There are two treatments: **kidney dialysis** and **organ donation** (a kidney transplant).

Kidney dialysis

1. The patient's blood flows through a dialysis machine, separated from dialysis fluid by a partially permeable membrane.
2. Urea and excess ions and water pass out of the blood into the dialysis fluid, which is changed to keep the concentration gradient.
3. The dialysis fluid has the same concentration of glucose and ions as healthy blood, so useful substances are not lost.
4. The cleaned blood is returned to the patient.

Kidney transplant

A healthy kidney from a donor is placed in the patient. The donor kidney must be a good tissue match, and the patient takes drugs so the immune system does not reject it.

	Dialysis	Transplant
Advantage	Available straight away	No regular treatment needed once it works
Disadvantage	Takes several hours, several times a week	Few donors, and the kidney may be rejected

Quick check

1. Which tube carries urine from the bladder out of the body?
2. Where is urea produced and from what?
3. What happens to glucose in the nephron?
4. What does ADH do to the collecting duct? (Higher)
5. Give one treatment for kidney failure.

Quick check answers

Hormones and the endocrine system

1. In the blood (plasma).
2. The pancreas.
3. Increased heart rate, increased blood pressure, increased blood flow to the muscles, and raised blood sugar level.
4. TSH.

The menstrual cycle and fertility control

1. Oestrogen repairs it. Progesterone maintains it.
2. Around day 14.
3. It stops ovulation, or thickens the mucus at the cervix so sperm cannot get through.
4. They protect against sexually transmitted infections.
5. It stimulates the release of FSH and LH so that ovulation happens.

Homeostasis and temperature control

1. Maintaining a constant internal environment in response to internal and external change.
2. Enzymes are denatured, so substrates no longer fit the active site.
3. Water enters by osmosis. The cells swell and may burst.
4. The hypothalamus.
5. Muscles contract rapidly. Respiration in the muscle cells transfers energy as heat.

Blood glucose and diabetes

1. The pancreas makes insulin. The liver stores glycogen.
2. It makes the liver change glycogen into glucose, so blood glucose concentration rises.
3. The pancreas does not produce enough insulin.
4. Body cells no longer respond to insulin.
5. $BMI = \text{mass (kg)} \div \text{height (m)}^2$

The urinary system and the kidneys

1. The urethra.
2. In the liver, from the breakdown of excess amino acids.
3. It is all reabsorbed into the blood.
4. It makes it more permeable to water, so more water is reabsorbed.
5. Kidney dialysis or a kidney transplant from a donor.