

Hormonal coordination in humans

Revision notes • The endocrine system, blood glucose and diabetes, water balance, reproductive hormones, contraception, fertility treatment and feedback.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

Hormonal coordination in humans Spec 4.5.3

The human endocrine system Spec 4.5.3.1

The **endocrine system** is made of **glands** which secrete chemicals called **hormones** directly into the **bloodstream**. The blood carries the hormone to a **target organ** where it produces an effect.

Nervous system and endocrine system compared

	Nervous system	Endocrine system
Message carried by	Electrical impulses along neurones	Hormones (chemicals) in the blood
Speed of effect	Fast	Slower
How long the effect lasts	Short	Acts for longer

The **pituitary gland** in the brain is a '**master gland**'. It secretes several hormones into the blood in response to body conditions. These hormones in turn act on other glands to stimulate other hormones to be released to bring about effects.

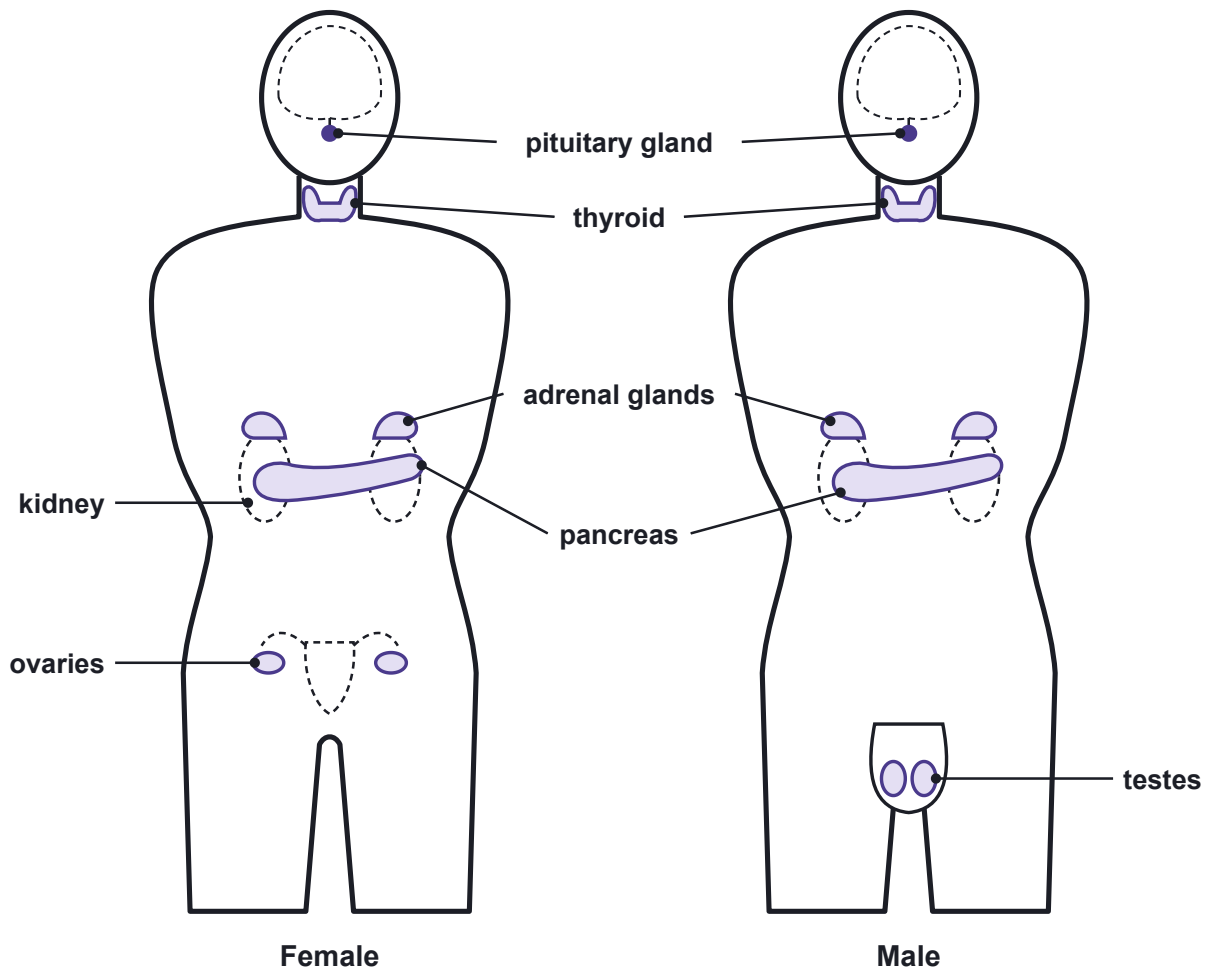
Positions of the endocrine glands

Gland	Position in the body
Pituitary gland	At the base of the brain
Thyroid	In the neck
Adrenal glands	One on top of each kidney
Pancreas	In the abdomen, just below the stomach
Ovary	In the female pelvis, one on each side of the uterus
Testes	In the male scrotum

Hormones from these glands that you need in this topic: the pituitary gland releases FSH and LH, the pancreas releases insulin, the ovaries release oestrogen and the testes release testosterone.

Higher tier

The thyroid gland releases **thyroxine** and the adrenal glands release **adrenaline**.



Positions of the main **endocrine glands**. Ovaries are found in females and testes in males.

Exam tip: Compare with the nervous system in three words: slower, longer, chemical. Hormones are carried in the blood, so they reach every part of the body but only affect their target organ.

Control of blood glucose concentration Spec 4.5.3.2

Blood glucose concentration is monitored and controlled by the **pancreas**.

If the blood glucose concentration is **too high**, the pancreas produces the hormone **insulin**. Insulin causes **glucose to move from the blood into the cells**. In **liver and muscle cells** excess glucose is converted to **glycogen** for storage.

1. Blood glucose concentration rises (for example after a meal).
2. The pancreas detects this and produces insulin.
3. Insulin causes glucose to move from the blood into the cells.
4. In the liver and muscle cells, excess glucose is converted to glycogen.
5. Blood glucose concentration falls back to the normal level.

Higher tier

Glucagon and negative feedback

Higher tier

If the blood glucose concentration is **too low**, the pancreas produces the hormone **glucagon**. Glucagon causes **glycogen to be converted into glucose** and released into the blood.

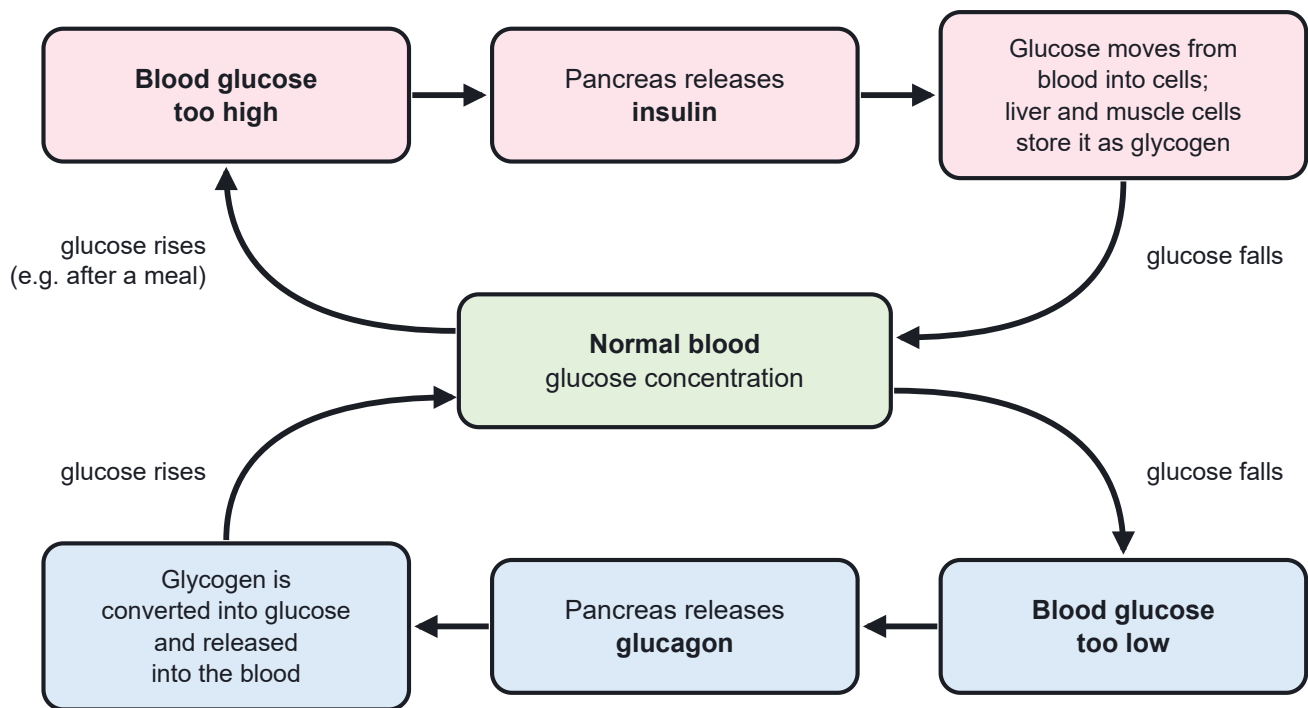
Higher tier

Insulin and glucagon work against each other in a **negative feedback cycle**. When one hormone brings the glucose level back to normal, the pancreas stops releasing it. This keeps blood glucose near the normal level.

Higher tier

Insulin and glucagon

	Insulin	Glucagon
Released when blood glucose is	Too high	Too low
Effect on glucose	Glucose moves from blood into cells	Glycogen is converted into glucose and released into the blood
Effect on blood glucose	Falls	Rises



Insulin and glucagon keep blood glucose near normal by **negative feedback**.

Common mistake: Do not mix up glucose, glycogen and glucagon. Glucose is the sugar, glycogen is the storage carbohydrate, and glucagon is the hormone.

Type 1 and Type 2 diabetes Spec 4.5.3.2

Type 1 diabetes is a disorder in which the pancreas fails to produce **sufficient insulin**. It is characterised by **uncontrolled high blood glucose levels** and is normally treated with **insulin injections**.

In **Type 2 diabetes** the body cells **no longer respond to insulin** produced by the pancreas. A **carbohydrate controlled diet** and an **exercise regime** are common treatments. **Obesity is a risk factor** for Type 2 diabetes.

Comparing Type 1 and Type 2 diabetes

	Type 1	Type 2
Cause	Pancreas fails to produce sufficient insulin	Body cells no longer respond to the insulin produced by the pancreas
Blood glucose	Uncontrolled high levels	High levels
Treatment	Insulin injections	Carbohydrate controlled diet and an exercise regime
Link to obesity	-	Obesity is a risk factor

Interpreting graphs

You may be given graphs showing blood glucose over time for a person with diabetes and a person without. In a person without diabetes, blood glucose rises after a meal and then falls back to the normal level as insulin is released. In a person with Type 1 diabetes who has not taken insulin, the glucose rises higher and stays high or falls much more slowly. If insulin is injected, the glucose falls.

Reading a glucose graph

One hour after a meal, blood glucose was 9 units in a person without diabetes and 15 units in a person with untreated Type 1 diabetes. Two hours after the meal the values were 5 units and 13 units. Compare how the two people's blood glucose changed.

1. Find the change for each person: without diabetes $9 \rightarrow 5$, a fall of 4 units; Type 1 $15 \rightarrow 13$, a fall of 2 units.
2. The person without diabetes ends back at the normal level; the person with diabetes remains high.
3. Explain: the person without diabetes makes enough insulin, so glucose moves into cells and is stored as glycogen. The person with Type 1 diabetes does not make enough insulin.

Answer: Both fell, but the person without diabetes fell more and returned to a lower level because their pancreas produces insulin. The person with Type 1 diabetes stayed high.

Exam tip: When comparing, name both types in each sentence. 'Type 1: pancreas fails to produce enough insulin. Type 2: cells no longer respond to insulin.' Quote figures from the graph to support what you say.

Obesity increases the risk of Type 2 diabetes, so questions may ask you to evaluate information on obesity and diabetes and make recommendations. Think about social and ethical issues as well as the science, for example the cost to health services and whether people should be encouraged to change their diet.

Water balance and the effect of osmosis on cells Spec 4.5.3.3 Triple only

The body loses water in several ways.

- Water leaves the body via the **lungs** during exhalation.
- **Water, ions and urea** are lost from the **skin in sweat**.
- Excess water, ions and urea are removed via the **kidneys in the urine**.

There is **no control over water, ion or urea loss by the lungs or skin**. Only the kidneys can adjust the amounts lost, which is why they are central to controlling the water level.

Effect of osmotic changes on cells

Water moves into and out of cells by **osmosis**. If body cells lose or gain too much water by osmosis they **do not function efficiently**. If the fluid around the cells is too dilute, water moves into the cells; if it is too concentrated, water moves out of the cells.

Exam tip: Name osmosis and say which way the water moves, for example: 'water moves out of the cells by osmosis, so they shrink and cannot work properly'.

The kidneys and urea Spec 4.5.3.3 Triple only

The kidneys produce urine by **filtration of the blood** and **selective reabsorption** of useful substances such as **glucose, some ions and water**. The waste urea and the excess water and ions leave in the urine.

1. Blood is filtered in the kidney. Water, glucose, ions and urea pass out of the blood.
2. Useful substances are selectively reabsorbed back into the blood: all of the glucose, some ions and some water.
3. The rest, including urea, excess ions and excess water, passes out as urine.

You do not need to know the other parts of the urinary system, the structure of the kidney or the structure of a nephron.

Example concentrations (arbitrary units, for practice)

Substance	Blood before filtration	Fluid after filtration	Urine
Glucose	5	5	0
Ions	9	9	12
Urea	2	2	60

This kind of table can be shown as a bar chart. The glucose bar drops to zero in urine because all of it is reabsorbed. The urea bar is much higher in urine because water is reabsorbed while urea is not.

Higher tier

Excess amino acids and urea

Higher tier

The digestion of proteins from the diet results in **excess amino acids** which need to be excreted safely. In the **liver**, these amino acids are **deaminated** to form **ammonia**. Ammonia is **toxic** and so it is immediately converted to **urea** for safe excretion.

Higher tier

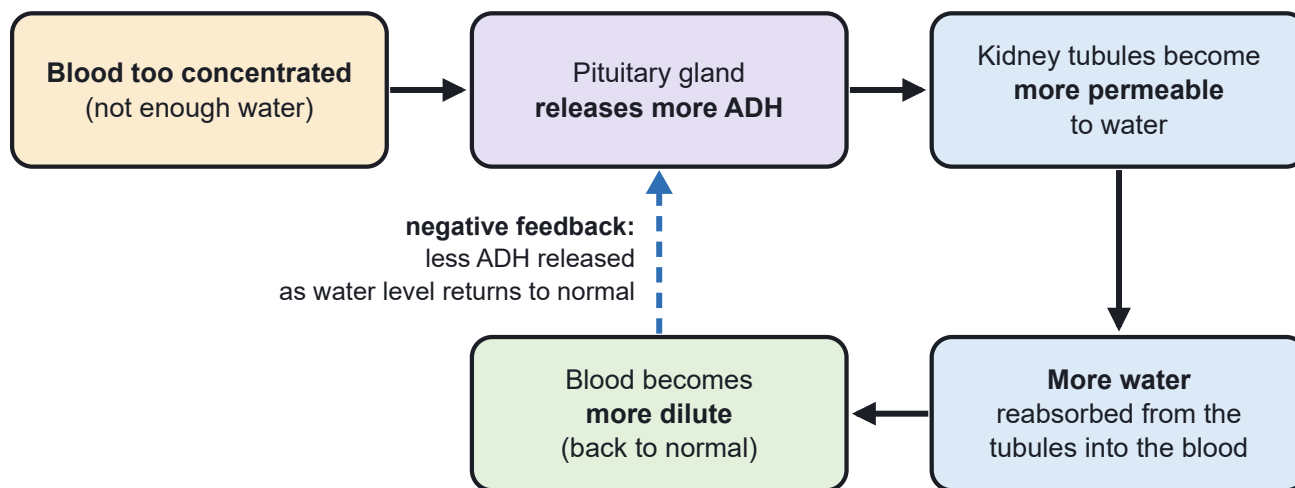
Common mistake: The kidney does not make urea. Urea is made in the liver, carried in the blood to the kidneys, and removed in the urine.

ADH and water level Spec 4.5.3.3 Triple only Higher tier

The water level in the body is controlled by the hormone **ADH**, which acts on the **kidney tubules**. ADH is released by the **pituitary gland** when the blood is **too concentrated**. It causes more water to be reabsorbed back into the blood from the kidney tubules. It does this by making the kidney tubules **more permeable to water**.

	Blood too concentrated (not enough water)	Blood too dilute (too much water)
ADH released by pituitary	More	Less
Permeability of kidney tubules to water	Increases	Decreases
Water reabsorbed into the blood	More	Less
Urine	Small volume, concentrated	Large volume, dilute

This is controlled by **negative feedback**: when the water level returns to normal, less ADH is released.



ADH makes the kidney tubules **more permeable to water**. As the blood returns to normal, less ADH is released.

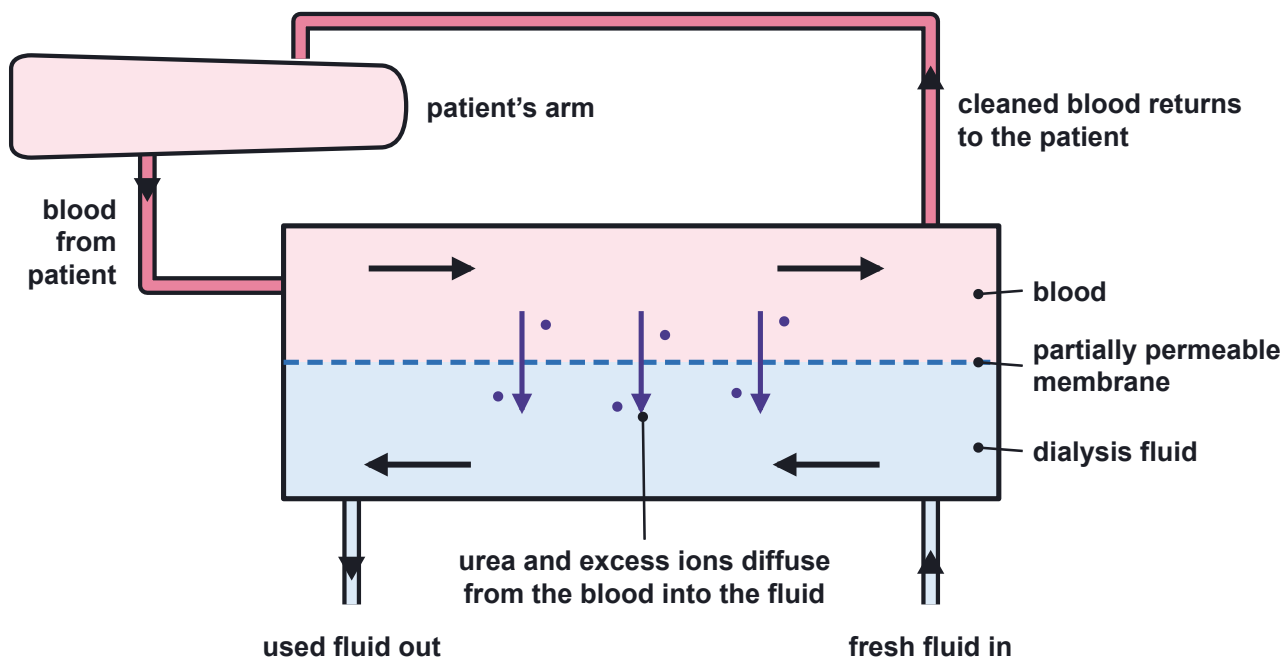
Exam tip: Always say ADH changes the permeability of the kidney tubules. Do not just say it 'makes the kidney hold on to water'.

Kidney failure: dialysis and transplant Spec 4.5.3.3 Triple only

People who suffer from kidney failure may be treated by **organ transplant** or by using **kidney dialysis**.

How dialysis works

1. Blood from the patient flows into a dialysis machine.
2. The blood flows next to a partially permeable membrane. On the other side is dialysis fluid.
3. Urea and excess ions diffuse from the blood into the dialysis fluid. Glucose and other useful substances stay in the blood, because the dialysis fluid contains these at the same concentration as normal blood.
4. The cleaned blood returns to the patient.



In dialysis, **urea and excess ions diffuse** across a partially permeable membrane into the dialysis fluid. Glucose stays in the blood.

Dialysis and transplant compared		
	Dialysis	Kidney transplant
Advantages	No need to wait for a donor; no risk of rejection	A long-term treatment; the patient is free from regular dialysis sessions and diet is less restricted
Disadvantages	Must be repeated regularly and takes several hours each time; diet and fluid intake must be controlled; expensive over a long time	Donor kidneys are in short supply; the body may reject the new kidney, so the patient must take drugs to prevent rejection; surgery has risks

Exam tip: For 'evaluate' questions, give one advantage and one disadvantage of each treatment, then finish with a short judgement.

Hormones in human reproduction Spec 4.5.3.4

During **puberty**, reproductive hormones cause **secondary sex characteristics** to develop.

Hormone	Made by	Role
Oestrogen	The ovary	The main female reproductive hormone
Testosterone	The testes	The main male reproductive hormone . It stimulates sperm production

At puberty eggs begin to mature in the ovaries, and one is released approximately every 28 days. This is called **ovulation**.

Hormones in the menstrual cycle

Hormone	Role in the menstrual cycle
Follicle stimulating hormone (FSH)	Causes maturation of an egg in the ovary
Luteinising hormone (LH)	Stimulates the release of the egg
Oestrogen and progesterone	Involved in maintaining the uterus lining

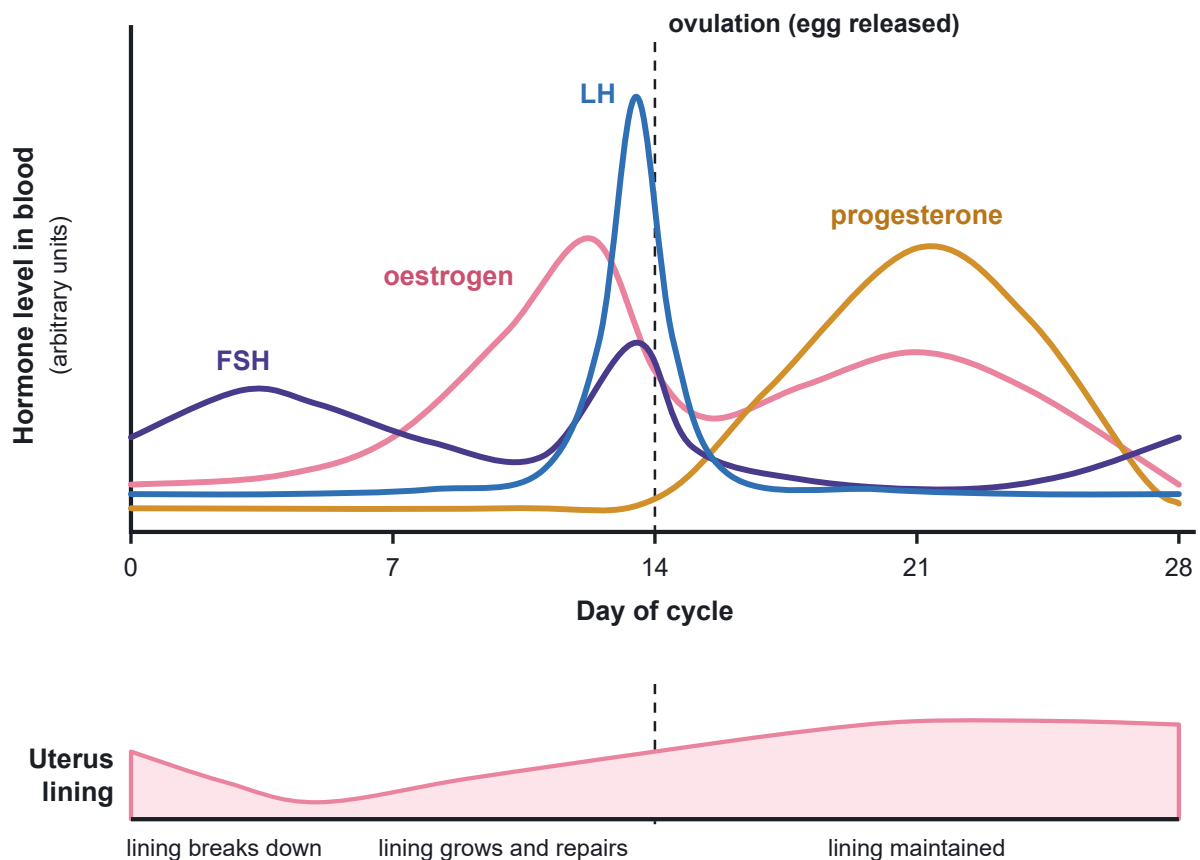
Higher tier

How the hormones interact

Higher tier

- FSH is released by the pituitary gland. It causes an egg to mature in the ovary. It also stimulates the ovary to release **oestrogen**.
- Oestrogen causes the lining of the uterus to grow and repair. It inhibits the release of FSH. When oestrogen reaches a high level it stimulates the pituitary gland to release a surge of **LH**.
- LH stimulates the release of the egg (ovulation), around the middle of the cycle.
- **Progesterone** maintains the lining of the uterus. It inhibits the release of FSH and LH.
- If progesterone falls, the uterus lining breaks down and the next cycle starts.

Higher tier



Hormone levels across a 28-day cycle. The **LH surge** triggers ovulation at about day 14; when **progesterone falls**, the lining breaks down.

Higher tier

Reading a hormone graph

A graph shows LH peaking sharply at day 14, and progesterone rising to its highest level at day 21 and falling by day 28. State what happens at day 14 and explain what the fall in progesterone at day 28 causes.

1. The LH peak at day 14 matches ovulation: LH stimulates the release of the egg.
2. Progesterone helps to maintain the uterus lining.
3. When progesterone falls, the lining can no longer be maintained.

Answer: An egg is released at day 14. The fall in progesterone at day 28 causes the uterus lining to break down.

Higher tier

Maths skill: On hormone graphs, read the day number and the line together. Say what happens (a peak, a rise, a fall), name the hormone, then link it to the event in the cycle.

Common mistake: FSH is not the hormone that releases the egg. FSH makes the egg mature; LH stimulates its release.

Contraception Spec 4.5.3.5

Fertility can be controlled by a variety of **hormonal** and **non-hormonal** methods of contraception.

Methods of contraception		
Method	Type	How it works
Oral contraceptives	Hormonal	Contain hormones which inhibit FSH production so that no eggs mature
Injection, implant or skin patch	Hormonal	Slow release of progesterone to inhibit the maturation and release of eggs for a number of months or years
Barrier methods (condoms, diaphragms)	Non-hormonal	Prevent the sperm reaching an egg
Intrauterine devices	Hormonal or non-hormonal	Prevent the implantation of an embryo, or release a hormone
Spermicidal agents	Non-hormonal	Kill or disable sperm
Abstaining from intercourse when an egg may be in the oviduct	Non-hormonal	Sperm cannot meet an egg
Surgical methods (male and female sterilisation)	Non-hormonal	A permanent operation that stops sperm or eggs from meeting

Evaluating methods

- How effective it is when used correctly.
- Whether it can have side effects (hormonal methods can).
- Whether it is reversible. Sterilisation is permanent; the others are not.
- Whether it also protects against sexually transmitted infections. Condoms do; hormonal methods do not.

- How easy it is to use correctly, and how often it must be used or replaced.

Some issues around contraception cannot be answered by science alone. Personal, social, economic and religious views also affect whether and how people use contraception.

Exam tip: A good evaluation compares two methods on the same point, for example 'The pill is hormonal and can have side effects, while condoms have no hormonal side effects and also protect against infection'.

The use of hormones to treat infertility Spec 4.5.3.6 Higher tier

Hormones are used in modern reproductive technologies to treat **infertility**. A 'fertility drug' contains **FSH and LH** given to a woman. She may then become pregnant in the normal way.

In vitro fertilisation (IVF)

1. The mother is given FSH and LH to stimulate the maturation of several eggs.
2. The eggs are collected from the mother and fertilised by sperm from the father in the laboratory.
3. The fertilised eggs develop into embryos.
4. At the stage when they are tiny balls of cells, one or two embryos are inserted into the mother's uterus (womb).

Evaluating fertility treatment

Fertility treatment gives a woman the chance to have a baby of her own. However:

- it is very **emotionally and physically stressful**
- the **success rates are not high**
- it can lead to **multiple births**, which are a risk to both the babies and the mother.

Exam tip: Give a balanced answer for IVF: the benefit is a baby of her own; the problems are stress, low success rates and the risks of multiple births. Social and ethical views also matter.

Adrenaline, thyroxine and negative feedback Spec 4.5.3.7 Higher tier

Adrenaline

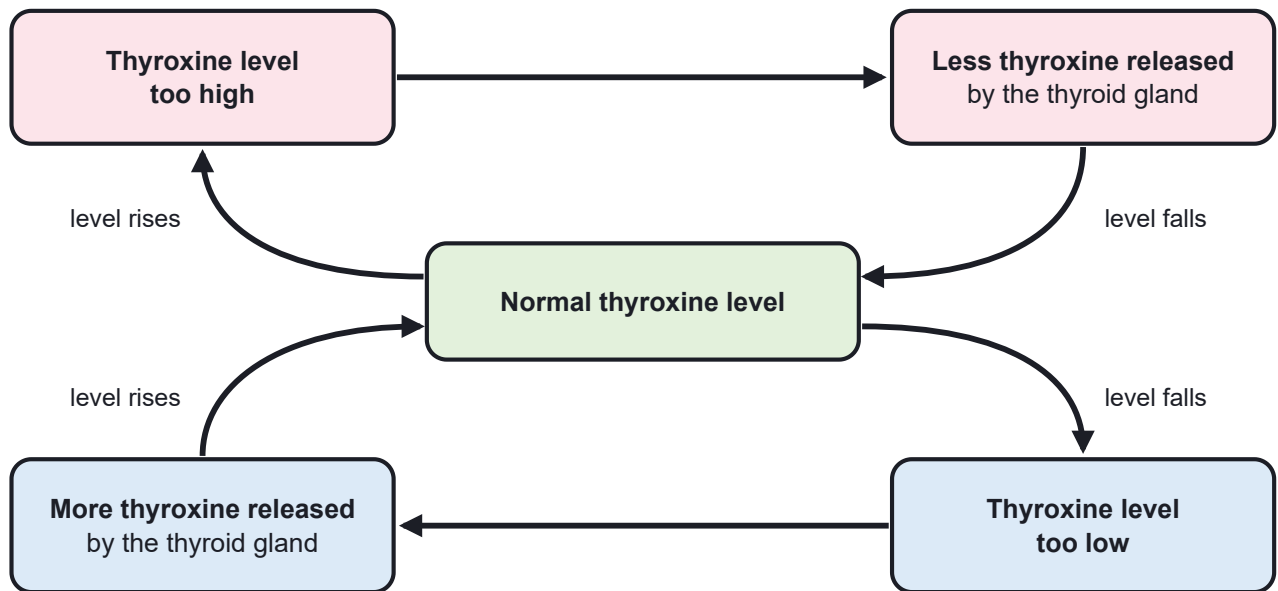
Adrenaline is produced by the **adrenal glands** in times of fear or stress. It increases the heart rate and boosts the delivery of oxygen and glucose to the brain and muscles, preparing the body for '**flight or fight**'.

Thyroxine

Thyroxine from the **thyroid gland** stimulates the **basal metabolic rate**. It plays an important role in **growth and development**.

Negative feedback

Thyroxine levels are controlled by **negative feedback**. If the thyroxine level in the blood becomes too high, less thyroxine is released, so the level falls. If it becomes too low, more is released, so the level rises. A change in the level is reversed to bring it back to normal.



Thyroxine levels are controlled by **negative feedback**: the response reverses the change.

Exam tip: Negative feedback means the response reverses the original change. Say what changed, which way the body responds, and that the level returns towards normal.

Quick check

1. What is a hormone?
2. Which hormone lowers blood glucose concentration, and where is it made?
3. Compare the cause of Type 1 and Type 2 diabetes.
4. Name the hormone that causes the release of the egg.
5. Give two non-hormonal methods of contraception.

Quick check answers

Hormonal coordination in humans

1. A chemical secreted by a gland directly into the bloodstream, which acts on a target organ.
2. Insulin, made in the pancreas.
3. Type 1: the pancreas fails to produce enough insulin. Type 2: the body cells no longer respond to insulin.
4. Luteinising hormone (LH).
5. Any two of: condoms, diaphragms, spermicidal agents, abstaining, surgical sterilisation (non-hormonal intrauterine devices also accepted).