

Homeostasis and response revision notes

Cells can only survive within narrow limits of temperature, pH, water and dissolved food, so the body constantly monitors and adjusts its internal conditions. This topic covers the nervous system and its fast responses, the hormonal system and its slower, longer-lasting effects, and how hormones control blood glucose and reproduction.

For AQA GCSE Combined Science: Trilogy 8464, **Higher tier** is only on the Higher paper.

1 Homeostasis Spec 4.5.1

What homeostasis is Spec 4.5.1

Cells in the body can only survive within narrow physical and chemical limits. They need a constant temperature and pH, and a constant supply of dissolved food and water. The body therefore has control systems that constantly monitor and adjust the composition of the blood and tissues.

Homeostasis

The regulation of the internal conditions of a cell or organism to maintain optimum conditions for function, in response to internal and external changes.

Homeostasis maintains **optimal conditions for enzyme action** and for all cell functions. If conditions drift too far from the optimum, enzymes work more slowly or stop working, and cells cannot carry out their reactions.

In the human body, homeostasis includes control of:

- **blood glucose concentration**
- **body temperature**
- **water levels**

These control systems are **automatic**. They may involve **nervous responses** or **chemical responses** (hormones).

Exam tip: Homeostasis does not keep conditions exactly the same all the time. It keeps them close to the optimum. Link your answer to enzymes working at their best.

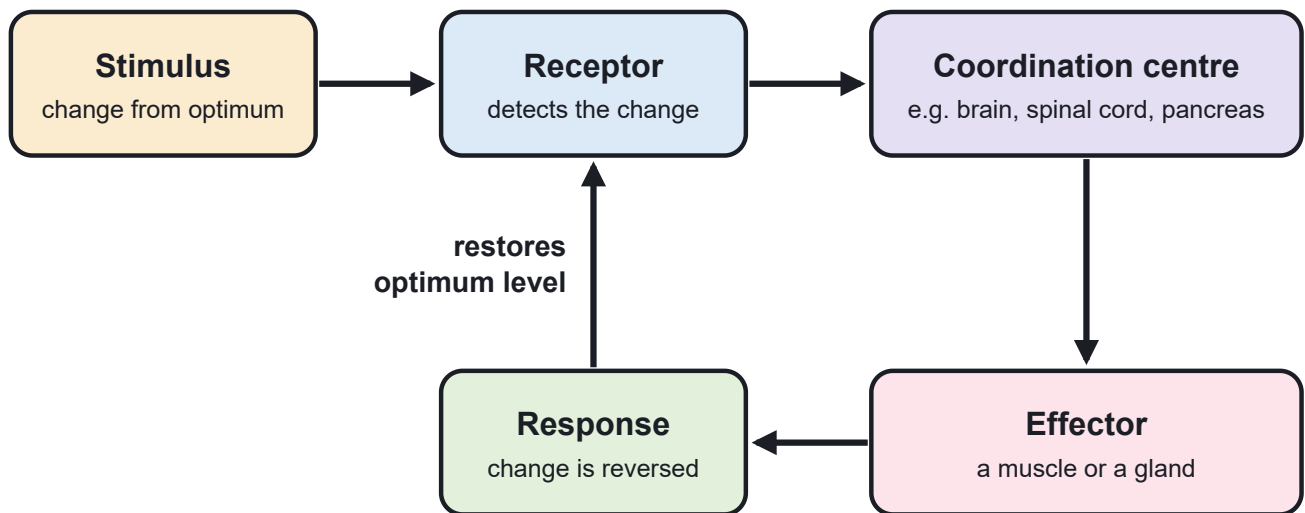
Parts of a control system Spec 4.5.1

All control systems include three types of component.

The three parts of every control system

Component	What it does	Examples
Receptors	Cells that detect stimuli (changes in the environment)	Temperature receptors in the skin
Coordination centres	Receive and process information from receptors	The brain, the spinal cord and the pancreas
Effectors	Muscles or glands that bring about responses which restore optimum levels	A muscle that contracts; a gland that secretes a hormone

The sequence is: stimulus, receptor, coordination centre, effector, response. The response restores the optimum level, which the receptors then detect again.



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Every control system: **stimulus** → **receptor** → **coordination centre** → **effector** → **response**, which restores the optimum level.

Common mistake: Effectors are muscles or glands only. Do not write that the brain or a receptor is an effector.

Quick check

1. Define homeostasis.
2. Name three things controlled by homeostasis in the human body.
3. What do receptors do?
4. Name the two types of effector.

2 The human nervous system Spec 4.5.2

Structure and function of the nervous system Spec 4.5.2.1

The nervous system enables humans to **react to their surroundings** and to **coordinate their behaviour**. Information from receptors passes along cells called **neurones** as **electrical impulses** to the **central nervous system (CNS)**. The CNS is the **brain and spinal cord**. The CNS coordinates the response of effectors, which may be **muscles contracting** or **glands secreting hormones**.

1. Stimulus (a change in the environment)
2. Receptor detects the stimulus
3. Coordinator (the CNS) processes the information
4. Effector (a muscle or a gland)
5. Response

How the structure suits the function

Part	Adaptation	Why it helps
Receptors	Each type is sensitive to one kind of stimulus	The body only picks up the changes it needs to respond to
Neurones	Long cells that carry electrical impulses	Impulses travel quickly over long distances between receptors, the CNS and effectors
CNS	The brain and spinal cord receive information and send out a coordinated response	The right effectors respond together
Effectors	Muscles contract; glands secrete hormones	They carry out the response

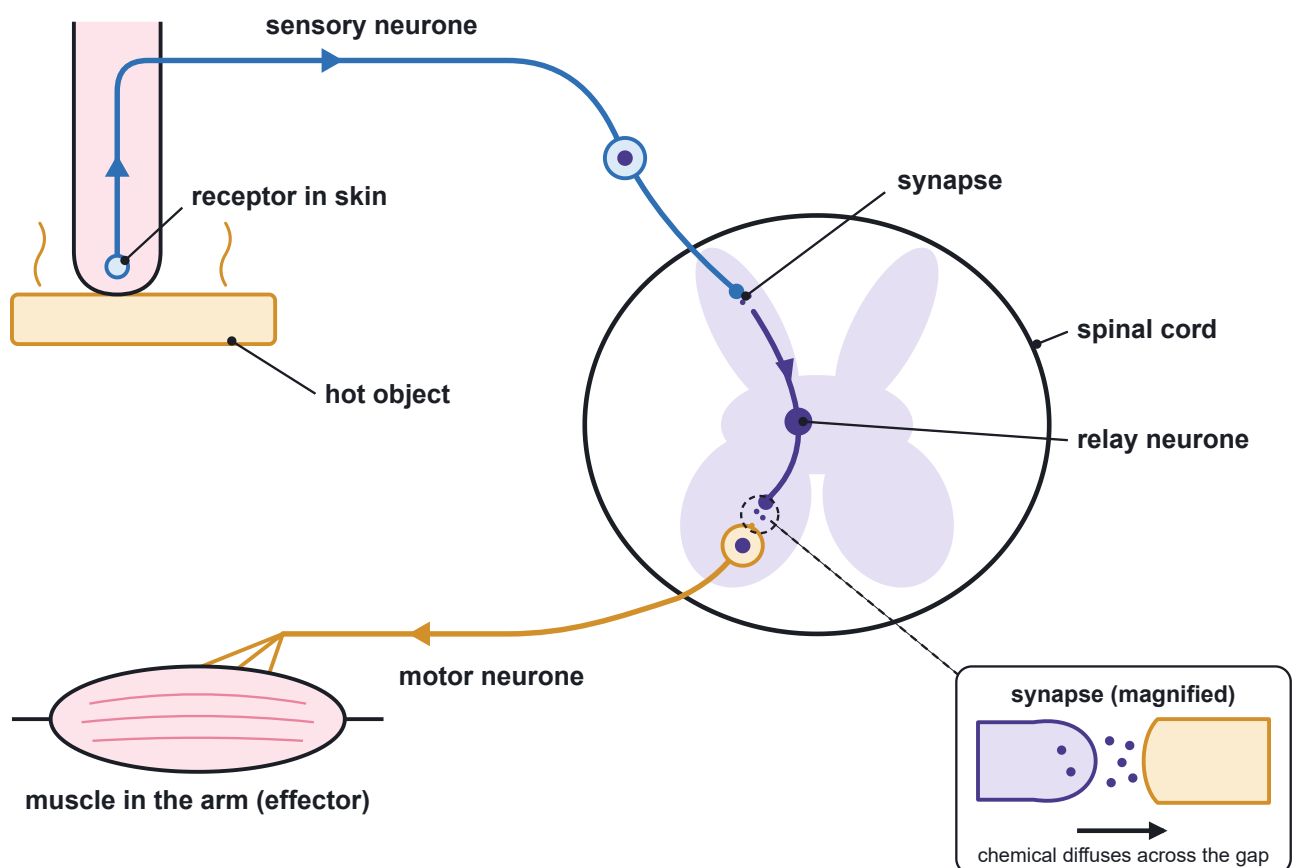
Exam tip: Say that the CNS is the brain and spinal cord. The neurones carry the impulses, but they are not the coordinator.

Reflex actions and the reflex arc Spec 4.5.2.1

Reflex actions are **automatic** and **rapid**. They do **not involve the conscious part of the brain**. Reflexes are important because they protect the body from harm, for example pulling your hand away from a hot object before you have time to think.

1. A receptor detects the stimulus and an impulse starts in the sensory neurone.
2. The sensory neurone carries the impulse to the CNS.
3. At a synapse, chemicals diffuse across the gap and start an impulse in the relay neurone.
4. The relay neurone passes the impulse on, through another synapse, to the motor neurone.
5. The motor neurone carries the impulse to the effector.
6. The effector (a muscle or gland) produces the response.

Structures in a reflex arc	
Structure	Function
Receptor	Detects the stimulus
Sensory neurone	Carries impulses from the receptor to the CNS
Relay neurone	Carries impulses within the CNS, from the sensory neurone to the motor neurone
Synapse	A gap between two neurones. A chemical diffuses across the gap and starts an impulse in the next neurone
Motor neurone	Carries impulses from the CNS to the effector
Effector	A muscle (contracts) or a gland (secretes) that produces the response



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A reflex arc. The impulse goes **receptor** → **sensory neurone** → **relay neurone** → **motor neurone** → **effector**, crossing a **synapse** by chemical diffusion at each junction.

Common mistake: The reflex arc does not go through the conscious part of the brain, which is why it is fast. Do not write that the brain is never told; just say the response happens before you are aware of it.

Required practical: reaction time Spec 4.5.2.1

Required practical: Required practical activity 7 (activity 6 in Combined Science): plan and carry out an investigation into the effect of a factor on human reaction time.

Reaction time is the time taken to respond to a stimulus. A common method uses a ruler.

1. The volunteer sits with their forearm resting on the edge of a table and their hand over the edge.

2. A partner holds a ruler vertically so that the zero mark is level with the volunteer's thumb and finger, which are about to grip it.
 3. Without warning, the partner drops the ruler.
 4. The volunteer catches it as fast as possible. Read the distance on the ruler at the top of their thumb.
 5. Repeat several times and calculate a mean for each condition.
- Independent variable: the factor you change, for example caffeine, a distraction, practice or which hand is used.
 - Dependent variable: reaction time, shown by the distance the ruler falls (a shorter distance means a faster reaction), or by a time from a computer test.
 - Control variables: the same volunteer, the same hand, the same ruler, the same drop height, and the same method of reading the result.
 - Safety: the risk is low. Make sure nobody is pressured into taking a drink or doing anything they are not comfortable with.

Repeating the test and taking a **mean** makes the results more reliable. Ignore any anomalous result when you calculate the mean.

From numbers to a graph

A student measured reaction time (in s) five times: 0.31, 0.29, 0.33, 0.30, 0.32. Calculate the mean, then say how the means for two conditions would be shown on a bar chart.

1. Add the five results: $0.31 + 0.29 + 0.33 + 0.30 + 0.32 = 1.55$
2. Divide by the number of results: $1.55 \div 5 = 0.31$
3. Draw one bar per condition, labelled on the x-axis, with bar height equal to the mean reaction time on the y-axis (in s).

Answer: Mean reaction time = 0.31 s.

Maths skill: You may be asked to turn a table of reaction times into a graph, or read values from a graph into a table. Label axes with the quantity and unit, for example 'Reaction time (s)'. Use a bar chart when one variable is a category.

Quick check

1. What is the CNS?
2. Put these in order: motor neurone, sensory neurone, relay neurone.
3. Why are reflex actions important?

3 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

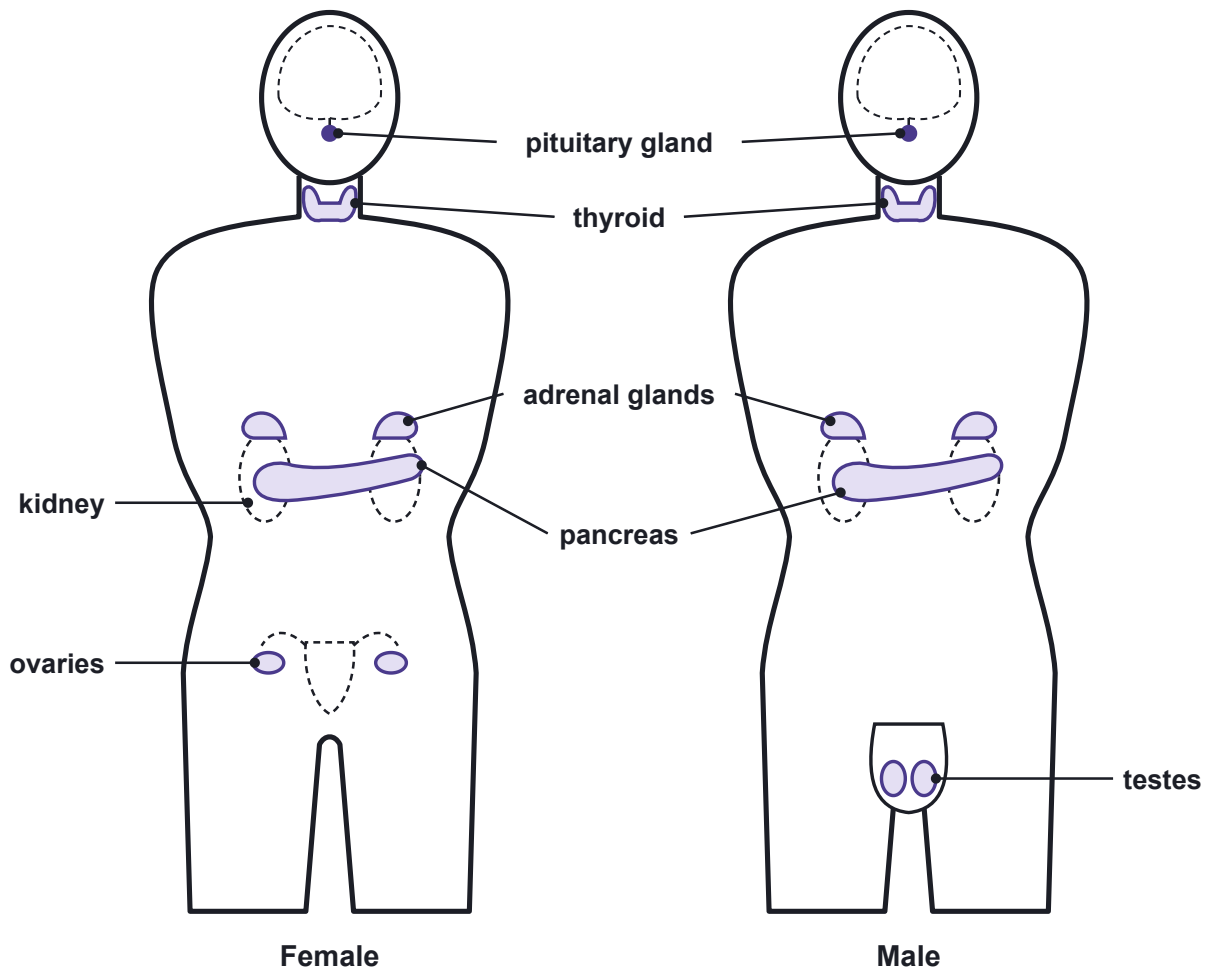
The **pituitary gland** in the brain is a '**master gland**'. It secretes several hormones into the blood in response to body conditions. These hormones in turn act on other glands to stimulate other hormones to be released to bring about effects.

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**.



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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.

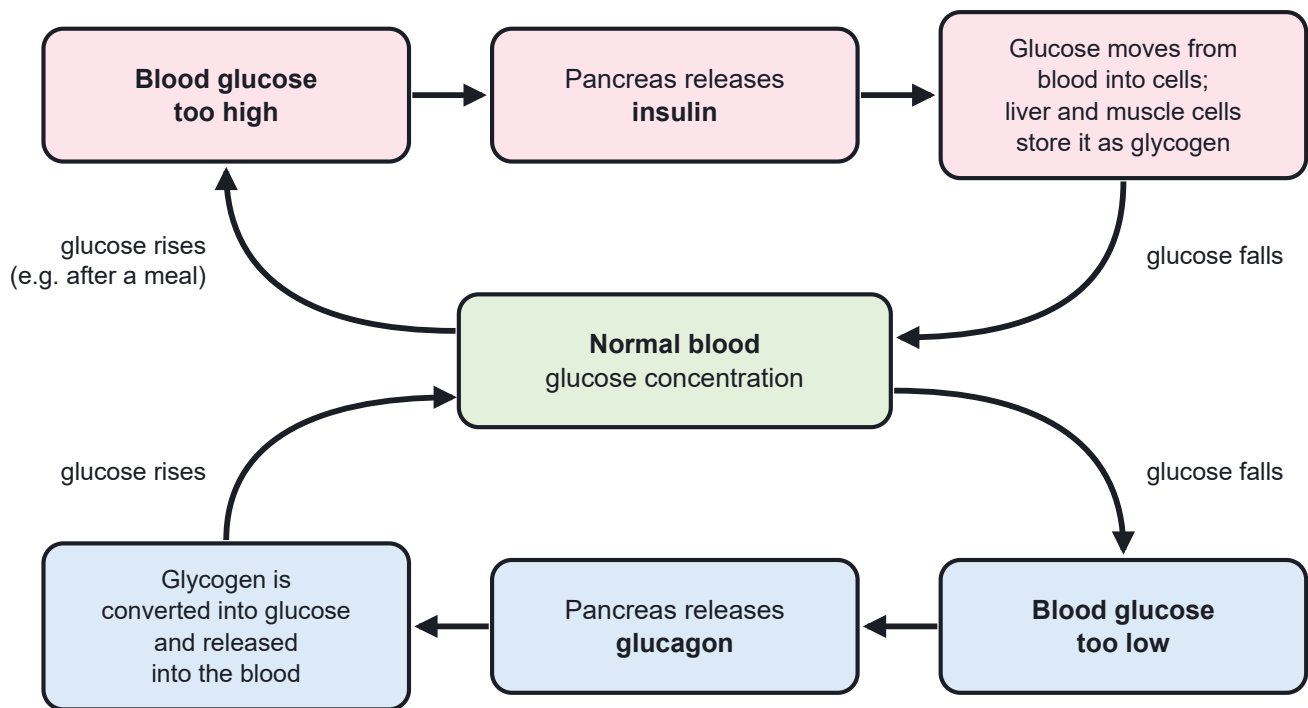
Higher tier

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



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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.

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

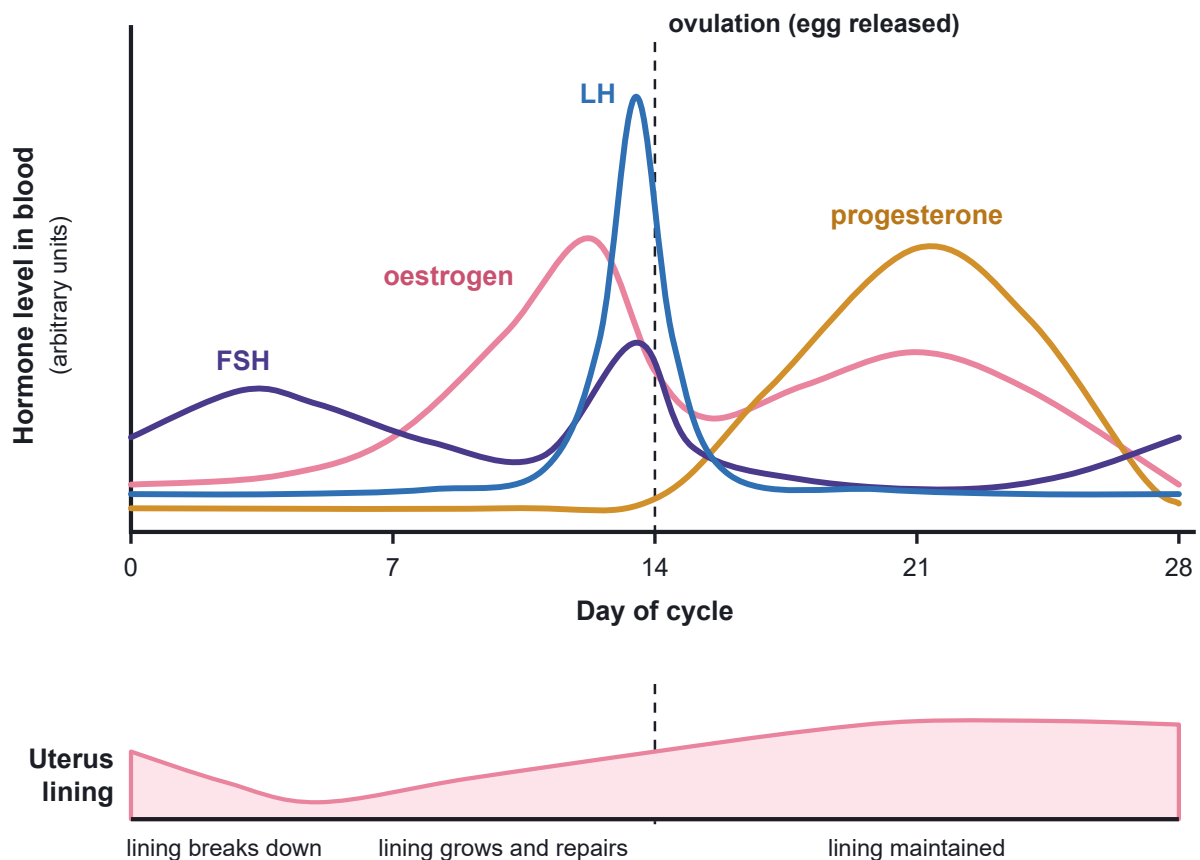
Higher tier

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



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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

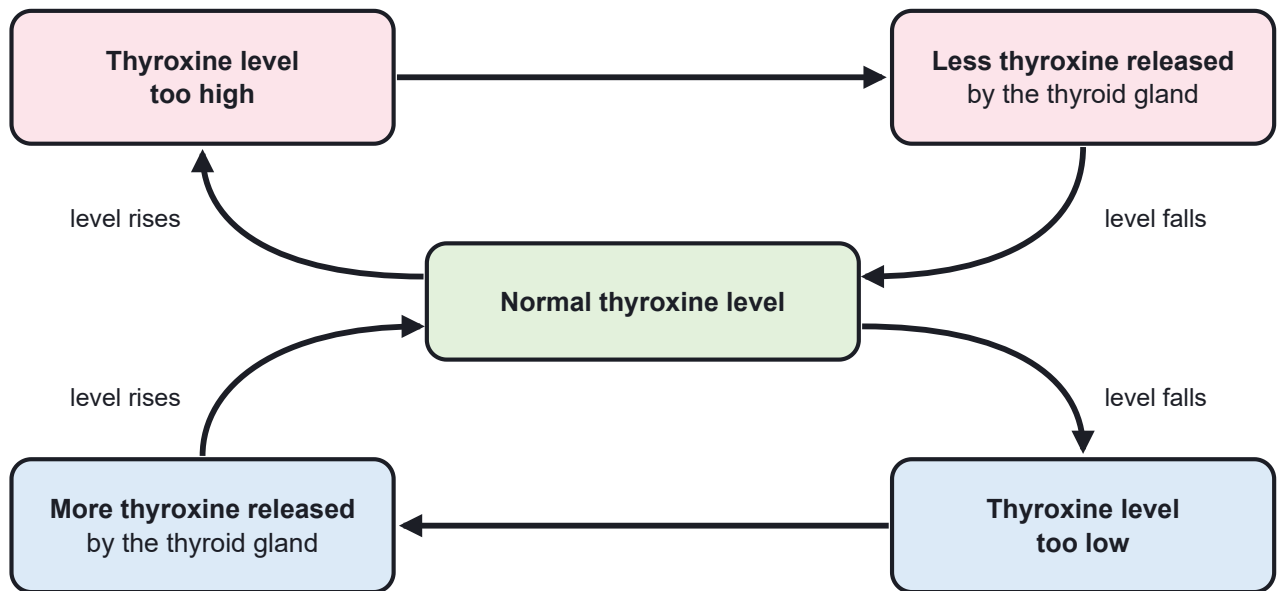
Adrenaline is produced by the **adrenal glands** in times of fear or stress. It increases the heart rate and boosts the delivery of oxygen and glucose to the brain and muscles, preparing the body for '**flight or fight**'.

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.



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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

Homeostasis

1. The regulation of the internal conditions of a cell or organism to maintain optimum conditions for function, in response to internal and external changes.
2. Blood glucose concentration, body temperature and water levels.
3. They detect stimuli (changes in the environment).
4. Muscles and glands.

The human nervous system

1. The central nervous system: the brain and spinal cord.
2. Sensory neurone, relay neurone, motor neurone.
3. They are automatic and rapid, protecting the body from harm without involving the conscious part of the brain.

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).