

Homeostasis and response

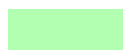
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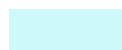
Revision notes for one topic, free to download.

These are the summary notes only. The full edition of this booklet also carries the worked examples, the required practicals and the formula sheets, with every topic in one place.

Colour Codes



Definitions



Diagrams



Notes and warnings



Mnemonics



Analogies



Common confusions



Check yourself



Sub-topic headings

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Define Homeostasis

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

Define Effector

- a muscle or gland that brings about a response to restore optimum levels.

Define Synapse

- the junction between two neurones, crossed by a chemical that starts a new impulse in the next neurone.

Define Hormone

- a chemical secreted by a gland into the blood and carried to a target organ, where it has an effect.

HIGHER TIER

Define Glucagon

- **HT ONLY** pancreatic hormone that causes glycogen to be converted into glucose and released into the blood.

Define Ovulation

- the release of a mature egg from the ovary, approximately every 28 days.

HIGHER TIER

Define Thyroxine

- **HT ONLY** hormone from the thyroid gland that stimulates the basal metabolic rate.

Define Receptor

- a cell that detects a stimulus (a change in the environment).

Define Coordination centre

- the brain, spinal cord or pancreas: receives and processes information from receptors.

Define Reflex action

- an automatic, rapid response not involving the conscious part of the brain.

Define Endocrine system

- the glands that secrete hormones directly into the bloodstream.

Define Insulin

- pancreatic hormone that causes glucose to move from the blood into the cells.

HIGHER TIER

Define Negative feedback

- **HT ONLY** control in which a change from the normal level triggers a response that reverses it.

HIGHER TIER

Define Adrenaline

- **HT ONLY** hormone from the adrenal glands, released in fear or stress, preparing the body for 'flight or fight'.

5.1 Homeostasis

Homeostasis maintains optimum conditions for enzyme action and all cell functions. In the human body it includes control of **blood glucose concentration, body temperature and water levels**, by **nervous or chemical (hormonal) responses**.

All control systems include **receptors** (cells that detect stimuli — changes in the environment), **coordination centres** such as the brain, spinal cord and pancreas (which receive and process information from receptors) and **effectors** — muscles or glands, which bring about responses that restore optimum levels.

DON'T MIX UP receptor vs effector

A **receptor detects** the change. An **effector** — a muscle or a gland — **does something about it**. Both are cells, and students regularly name the wrong one.

ANALOGY

Homeostasis works like a **central-heating thermostat**: it detects the room getting cold, switches on the boiler (the effector), then switches it off once the room is warm. The temperature is never perfectly constant — it wobbles just above and below the set point, exactly as body conditions do.

SAY IT

Receptor, Coordinator, Effector

Every control system has the same three parts, in that order — and every exam answer about homeostasis should name all three.

CHECK YOURSELF

Cover the grey line before you answer.

1. What is homeostasis for?

Maintaining optimum conditions for enzyme action and all cell functions.

2. Name the three conditions controlled in the human body that you must know.

Blood glucose concentration, body temperature and water levels.

3. Name the three components of a control system.

Receptors, a coordination centre such as the brain, spinal cord or pancreas, and effectors.

5.2 The human nervous system

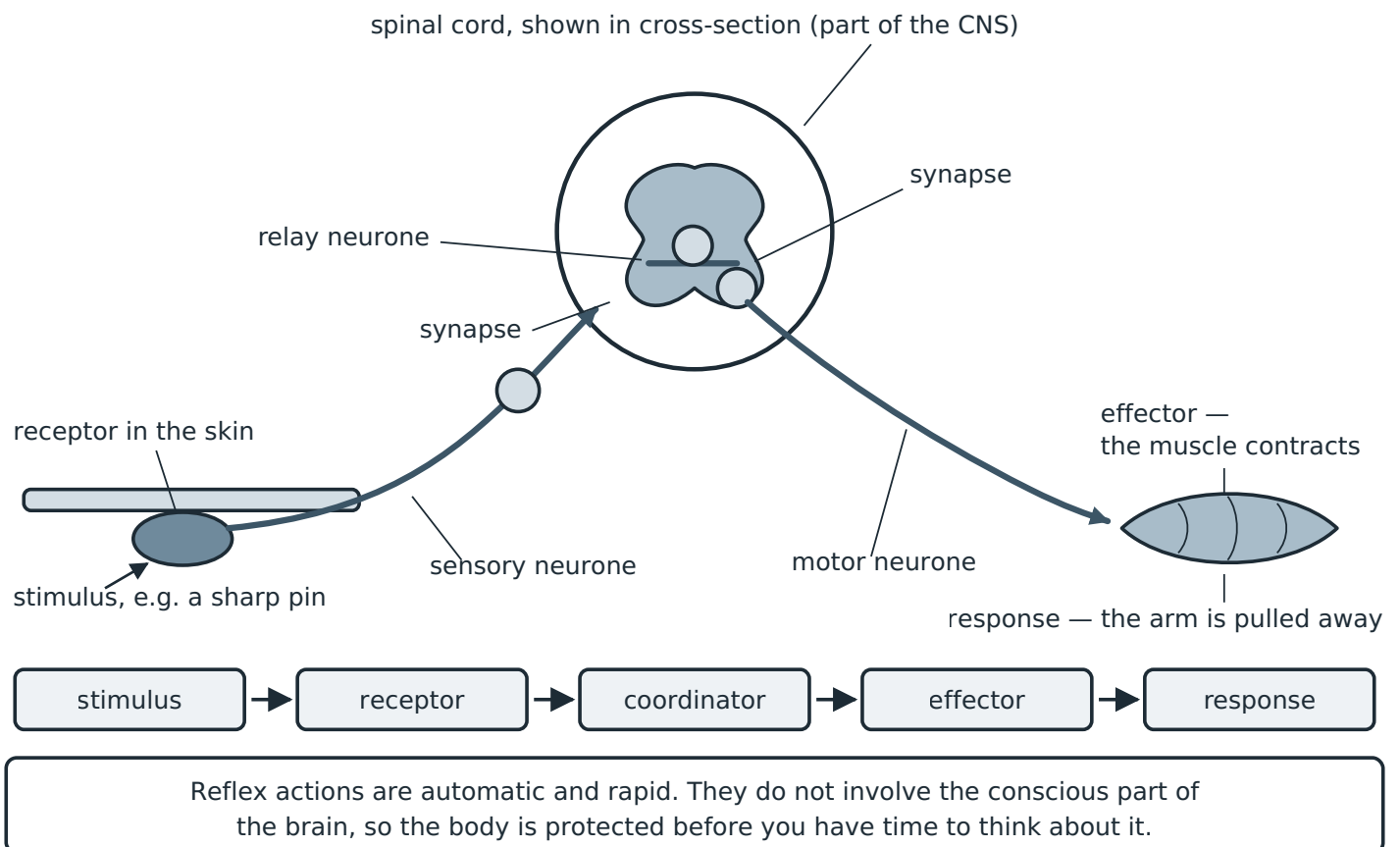
The nervous system enables humans to **react to their surroundings** and to **coordinate their behaviour**.

- Information from receptors passes along **neurones** as **electrical impulses** to the **central nervous system (CNS)** — the **brain and spinal cord**.
- The CNS coordinates the response of **effectors: muscles contracting or glands secreting hormones**.
- General pathway: stimulus → receptor → coordinator → effector → response.

The reflex arc. Reflex actions are **automatic and rapid**; they do not involve the conscious part of the brain (though the impulse does still pass through the CNS). This makes them protective — pulling a hand off a hot object, or the pupil narrowing in bright light — reducing the chance of injury.

stimulus → receptor → sensory neurone → synapse → relay neurone → motor neurone → effector → response

The reflex arc

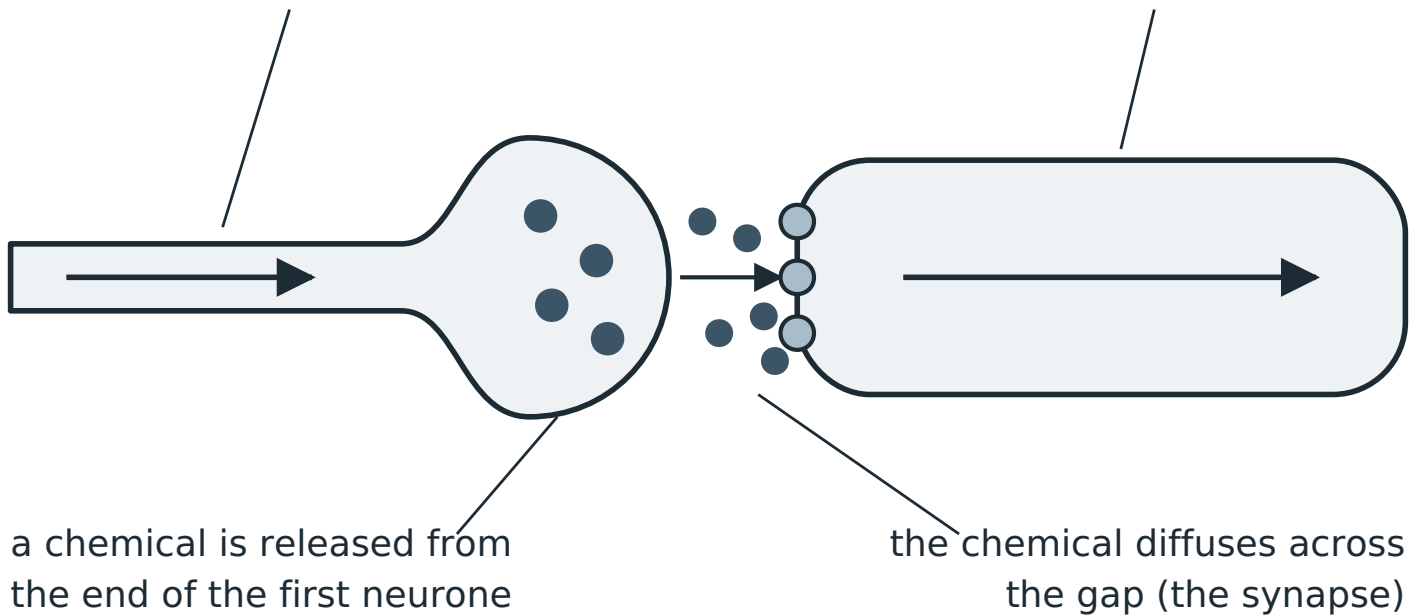


- **Receptor** — detects the stimulus, starting an electrical impulse.
- **Sensory neurone** — carries the impulse to the CNS.
- **Synapse** — a chemical is released, diffuses across the gap and starts a new impulse in the next neurone.
- **Relay neurone** — passes the impulse across the spinal cord, bypassing the conscious brain.
- **Motor neurone** — carries the impulse to the effector.
- **Effector** — a muscle contracts or a gland secretes: the response.

Transmission across a synapse

electrical impulse arrives along the first neurone

the chemical sets off a new electrical impulse in the second neurone



ANALOGY

A reflex arc is a fire alarm wired straight to the sprinklers: the smoke detector (receptor) sets off the sprinklers (effector) via the panel in the corridor (spinal cord), without phoning the manager upstairs (the conscious brain) for permission.

DON'T MIX UP

"it does not involve the brain" — what actually happens

A reflex does not involve the **conscious** part of the brain — but the impulse still travels through the **CNS**. Writing "it does not go to the brain at all" is wrong and is marked as wrong.

SAY IT

Some Really Mad Elephants

The reflex arc in order: **Stimulus** → receptor → **sensory neurone** → **relay neurone** → **motor neurone** → **effector** → response.
Sensory in, relay across, motor out.

CHECK YOURSELF

Cover the grey line before you answer.

1. What makes reflex actions protective?

They are automatic and rapid, and do not involve the conscious part of the brain, so they reduce the chance of injury.

2. What happens at a synapse?

A chemical is released, diffuses across the gap and sets off a new electrical impulse in the next neurone.

3. Give the general pathway of a nervous response.

stimulus → receptor → coordinator → effector → response.

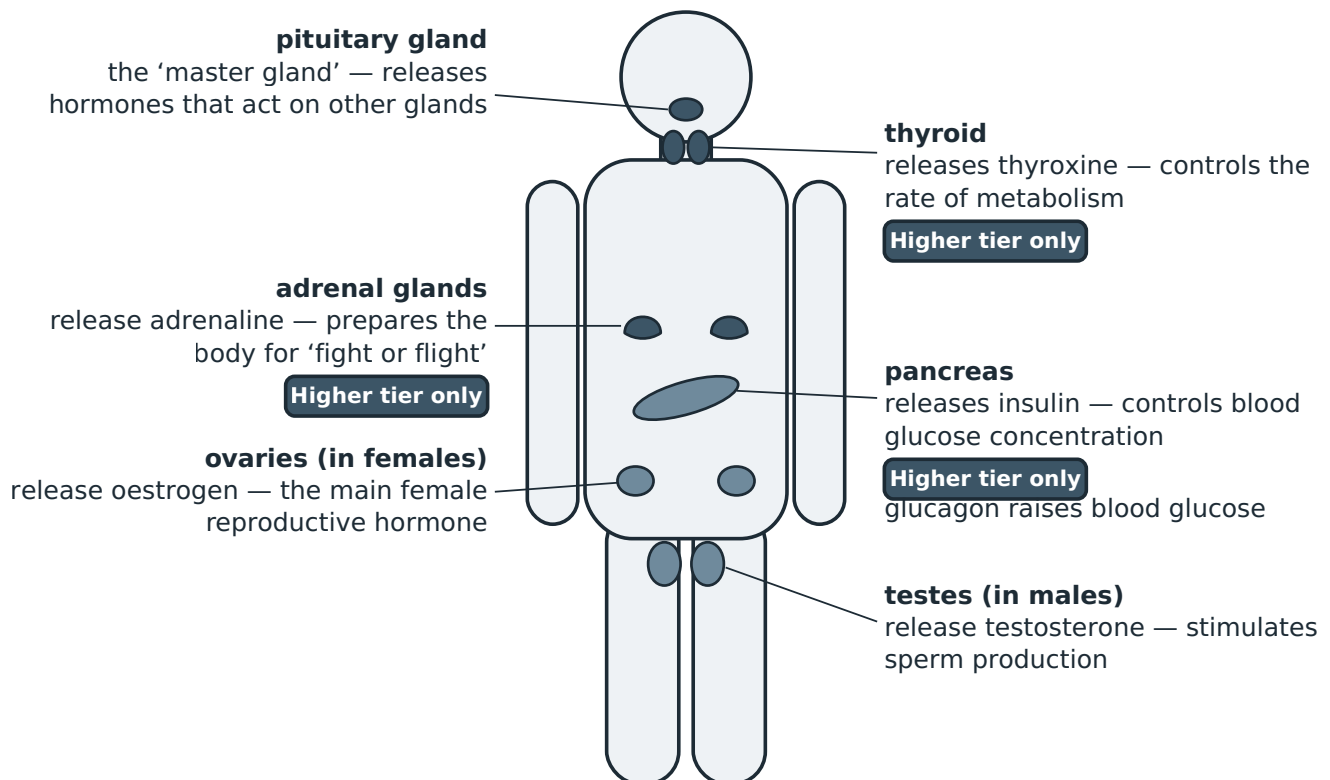
5.3 Hormonal coordination in humans

5.3.1 Human endocrine system

- The endocrine system is composed of **glands** which secrete **hormones** directly into the **bloodstream**; the blood carries the hormone to a **target organ**, where it produces an effect. Compared with the nervous system the effects are **slower but act for longer**.
- The **pituitary gland** in the brain is a '**master gland**': it secretes several hormones in response to body conditions, and these act on other glands to stimulate the release of other hormones.

Identify on a body diagram: pituitary gland (brain), **thyroid** (neck), **adrenal glands** (one on each kidney), **pancreas** (below the stomach), **ovaries** (lower abdomen) and **testes**.

The endocrine glands



Glands secrete hormones directly into the blood, which carries them to their target organs. The badges mark the hormone actions that are Higher Tier only; all students must know where the glands are.

	Nervous system	Endocrine system
Information carried by	Electrical impulses along neurones	Hormones dissolved in the blood
Speed	Very fast	Slower
Duration of effect	Short-lived	Longer lasting
Target	Precise — a specific muscle or gland	General — any organ with target cells

ANALOGY

Nerves are a **phone call** — instant, aimed at one person, over in seconds. Hormones are the **post** — slower, delivered to every address on the round, and the letter sits on the table having an effect for days.

DON'T MIX UP

why the pituitary is the master gland

The **pituitary** is the 'master gland' named by the specification. It releases hormones that act on **other glands** to make them release theirs — that chain is what makes it the master.

HIGHER TIER

5.3.2 Control of blood glucose concentration

- Blood glucose concentration is monitored and controlled by the **pancreas**.
- Too high:** the pancreas produces **insulin**, which causes glucose to move from the blood into the cells. In **liver and muscle cells** excess glucose is converted to **glycogen** for storage.

HT ONLY Too low: the pancreas produces **glucagon**, which causes glycogen to be converted into glucose and released into the blood.

- HT ONLY** Insulin and glucagon act in a **negative feedback cycle**: a rise in blood glucose triggers insulin, which lowers it; the fall triggers glucagon, which raises it. Each hormone reverses the change that caused its release, holding blood glucose near normal.

SAY IT

Pituitary, Thyroid, Adrenals, Pancreas, Ovaries, Testes

Top to bottom down the body: brain, neck, one on each kidney, below the stomach, lower abdomen. The **pituitary** is the master gland — its hormones act on the other glands.

CHECK YOURSELF

Cover the grey line before you answer.

- Where are hormones secreted, and how do they travel?

Glands secrete them directly into the bloodstream, which carries them to a target organ.

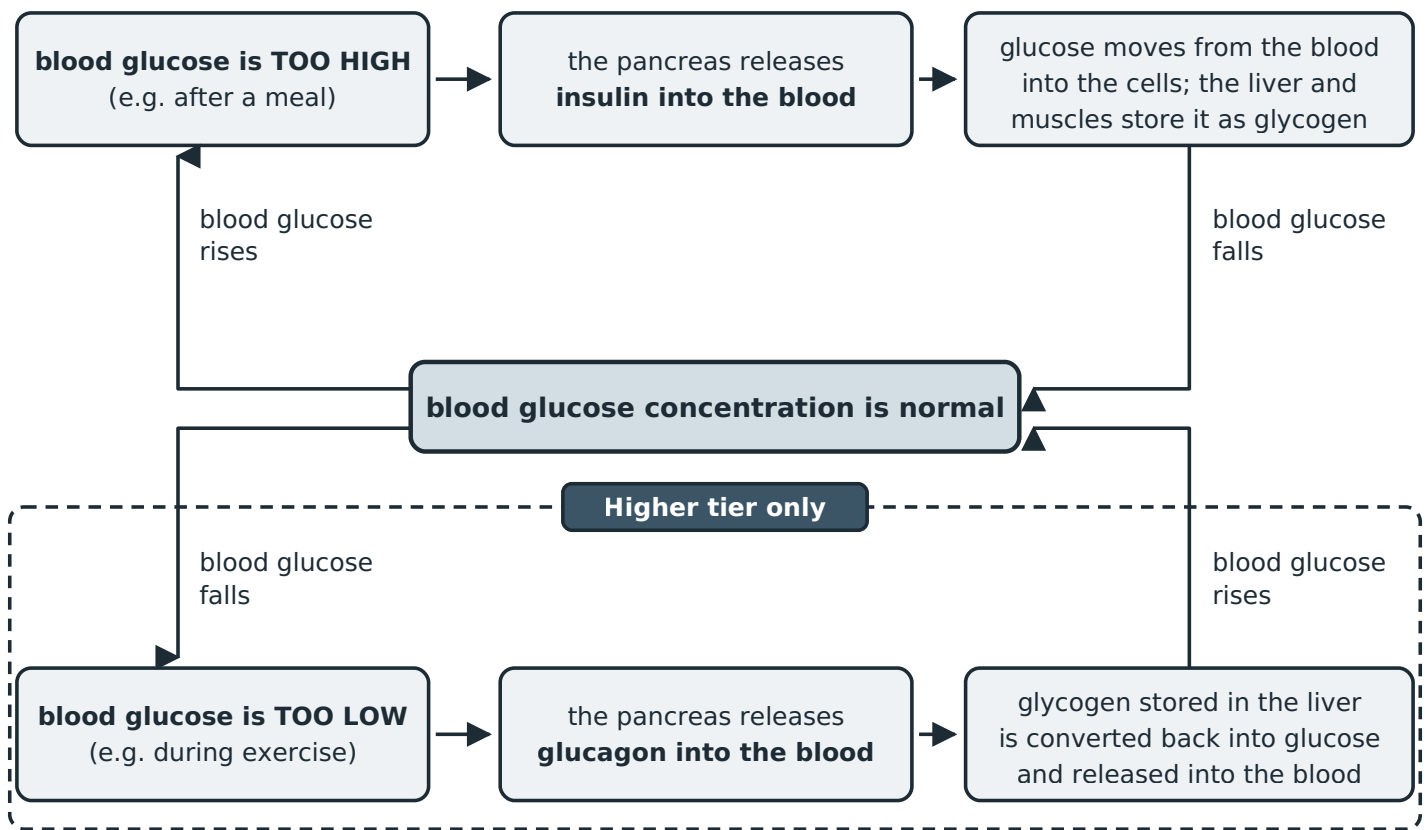
- Compare nervous and hormonal responses for speed and duration.

Nervous: very fast, short-lived, precisely targeted. Hormonal: slower, longer-lasting, more widespread.

- Why is the pituitary called the master gland?

It secretes several hormones that act on other glands to stimulate the release of further hormones.

Control of blood glucose concentration



	Type 1 diabetes	Type 2 diabetes
Cause	The pancreas fails to produce sufficient insulin	The body cells no longer respond to insulin produced by the pancreas
Effect	Uncontrolled high blood glucose levels	Uncontrolled high blood glucose levels
Treatment	Insulin injections	Carbohydrate controlled diet and an exercise regime
Risk factor	—	Obesity

SAY IT

Insulin IN, glucagon GONE

Insulin moves glucose **into** cells and stores it as glycogen, lowering blood glucose. **Glucagon** makes the store **gone**, converting glycogen back to glucose and raising blood glucose.

PICTURE IT

Blood glucose is a bank balance the pancreas watches all day. Insulin is the standing order moving money into savings when the balance runs high; glucagon is the withdrawal when it runs low. *Where it breaks down:* a bank balance can sit at any level safely. Blood glucose cannot — too high or too low and cells are damaged.

DON'T MIX UP

Type 1 diabetes vs Type 2 diabetes

Type 1: the pancreas produces **too little or no insulin**; treated with insulin injections. **Type 2:** the body **stops responding** to its own insulin; obesity is a risk factor; treated with a carbohydrate-controlled diet and exercise.

CHECK YOURSELF

Cover the grey line before you answer.

1. Which organ monitors blood glucose, and what does it release when glucose is high?

The pancreas; it releases insulin.

2. What does insulin make the liver and muscle cells do?

Convert excess glucose into glycogen for storage.

3. State the cause and the usual treatment of Type 2 diabetes.

The body no longer responds effectively to its own insulin; treated with a carbohydrate-controlled diet and an exercise regime.

You should be able to evaluate information about the relationship between obesity and diabetes, making recommendations that take social and ethical issues into account, and to **interpret graphs** of blood glucose levels in people with and without diabetes.

HIGHER TIER

5.3.3 Hormones in human reproduction

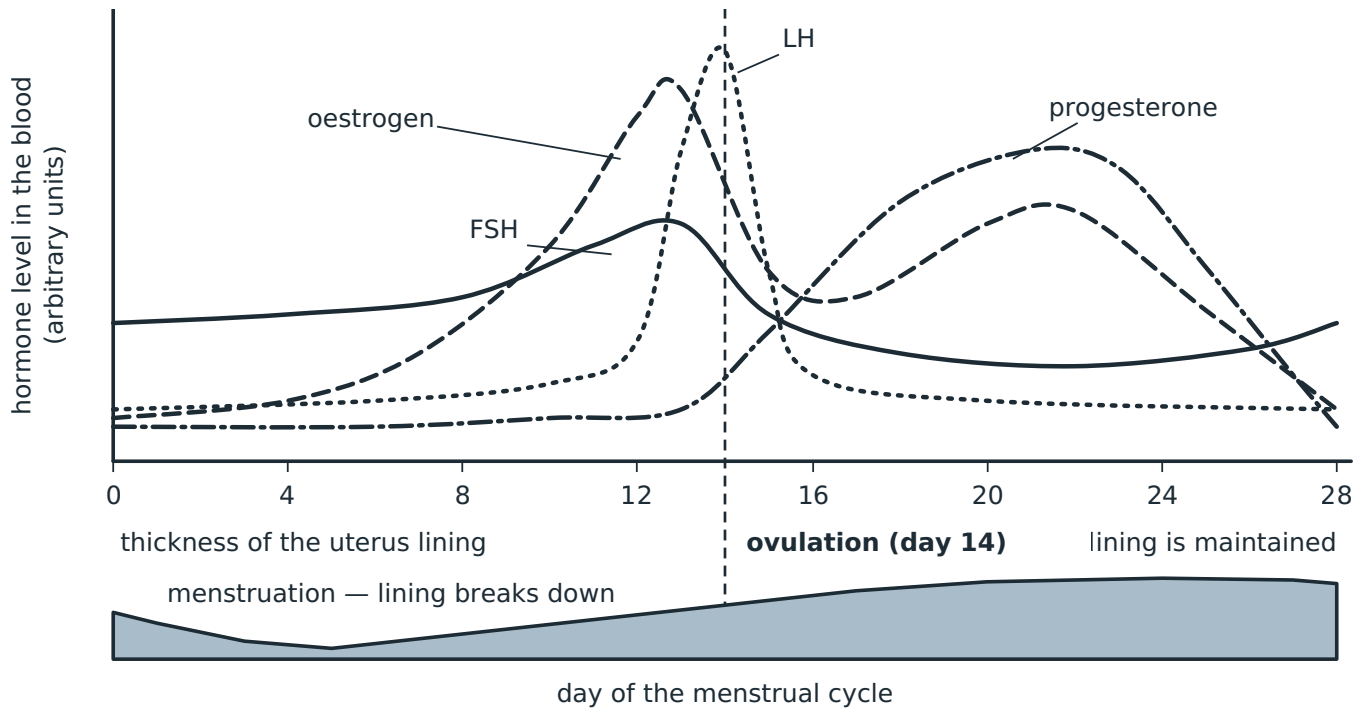
- During **puberty**, reproductive hormones cause **secondary sex characteristics** to develop.
- **Oestrogen**, the main **female** reproductive hormone, is produced in the **ovary**. At puberty eggs begin to mature and one is released approximately **every 28 days** — **ovulation**.
- **Testosterone**, the main **male** reproductive hormone, is produced by the **testes** and **stimulates sperm production**.
- **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**.

HT ONLY Interactions in the menstrual cycle:

HT ONLY FSH from the pituitary matures an egg and **stimulates the ovaries to produce oestrogen**.

- **HT ONLY** Oestrogen makes the **uterus lining grow**, **inhibits FSH** and **stimulates the release of LH**. **HT ONLY** LH from the pituitary causes ovulation at about day 14.
- **HT ONLY** Progesterone from the ovary **maintains the uterus lining** and **inhibits FSH and LH**; when it falls, the lining breaks down and the cycle restarts.

Hormonal control of the menstrual cycle



- FSH — causes an egg to mature in one of the ovaries
- - - oestrogen — causes the lining of the uterus to grow and thicken
- LH — stimulates the release of the egg (ovulation)
- . - . - progesterone — maintains the lining of the uterus

SAY IT FLOP

The four hormones of the menstrual cycle in the order they act: FSH matures the egg, LH triggers ovulation at about day 14, Oestrogen builds the uterus lining, Progesterone maintains it.

DON'T MIX UP FSH vs LH

FSH forms and matures the egg. LH lets it go — ovulation. Both come from the pituitary; they act in that order.

5.3.4 Contraception

Fertility can be controlled by **hormonal** and **non-hormonal** methods; you must be able to **evaluate** them.

PICTURE IT

The cycle is a relay race between the pituitary and the ovary. The pituitary passes the baton with FSH; the ovary runs with oestrogen; oestrogen hands back to the pituitary for LH; after ovulation progesterone carries it to the finish — and if no pregnancy begins, progesterone falls and the next race starts. *Where it breaks down:* in a relay only one runner carries the baton. Here the hormones overlap, and each one is also telling the others to speed up or stop.

CHECK YOURSELF

Cover the grey line before you answer.

- Which hormone causes an egg to mature, and where is it made?
FSH, from the pituitary gland.
- Which hormone triggers ovulation, and on roughly which day?
LH, at about day 14.
- Which two hormones maintain the uterus lining?
Oestrogen and progesterone.

Method	How it works	Hormonal?
Oral contraceptives	Contain hormones to inhibit FSH production so no eggs mature	Yes
Injection, implant or skin patch	Slow-release progesterone inhibits the maturation and release of eggs for months or years	Yes
Barrier methods (condoms, diaphragms)	Prevent the sperm reaching an egg	No
Intrauterine devices	Prevent implantation of an embryo , or release a hormone	Either
Spermicidal agents	Kill or disable sperm	No
Abstaining from intercourse	Avoiding intercourse when an egg may be in the oviduct	No
Surgical sterilisation	Male or female sterilisation; permanent	No

SAY IT

Hormonal, Barrier, Device, Chemical, Abstain, Surgery

The six families of method. Only the first is hormonal; only barriers protect against sexually transmitted infections; only surgery is permanent.

Evaluating them: hormonal methods are very effective and long lasting, but can have side effects and give no protection against sexually transmitted infections; barrier methods are cheap and do protect against STIs but are less reliable; sterilisation is most reliable but permanent. Because personal, religious and ethical views are involved, issues around contraception cannot be answered by science alone.

SAY IT

FSH and LH, then IVF

A fertility drug of **FSH and LH** may let a woman conceive normally. If not, **IVF**: FSH and LH mature several eggs, they are collected and fertilised in the laboratory, and one or two tiny balls of cells are inserted into the uterus.

CHECK YOURSELF

Cover the grey line before you answer.

- Which two hormones are given in IVF, and why?
FSH and LH, to stimulate the maturation of several eggs.
- Give two disadvantages of IVF.
It is emotionally and physically stressful, success rates are not high, and it can lead to multiple births, which are a risk to both babies and mother.
- What laboratory development made IVF possible?
Developments in microscopy.

DON'T MIX UP

effectiveness vs protection from infection

Hormonal methods are very effective at preventing pregnancy and give **no protection at all** against STIs. Barriers are less reliable at preventing pregnancy but **do** protect. An evaluation question wants both halves.

CHECK YOURSELF

Cover the grey line before you answer.

- Which methods are hormonal?
Oral contraceptives, and injections, implants or skin patches.
- Give one advantage and one disadvantage of hormonal contraception.
Very effective and long lasting; but it can have side effects and gives no protection against STIs.
- Why can science not settle questions about contraception on its own?
Personal, religious and ethical views are involved as well as the evidence.

DON'T MIX UP

a fertility drug vs IVF

A **fertility drug** is hormones alone, and conception happens normally. **IVF** is fertilisation outside the body followed by implantation. Both start with FSH and LH, which is why they get confused.

5.3.5 The use of hormones to treat infertility **HT ONLY**

- **HT ONLY** A 'fertility drug' of FSH and LH can be given to a woman; she may then become pregnant in the normal way.
- **HT ONLY** In Vitro Fertilisation (IVF): the mother is given FSH and LH to stimulate the **maturation of several eggs**; the eggs are collected and fertilised by the father's sperm in the laboratory; they develop into **embryos**; at the stage when they are **tiny balls of cells**, one or two are inserted into the mother's uterus (womb). **HT ONLY** **Evaluation**. IVF gives a woman the chance of a baby of her own, but it is **very emotionally and physically stressful, success rates are not high**, and it **can lead to multiple births**, a risk to babies and mother. Developments in **microscopy** enabled IVF; there are also social and ethical issues around unused embryos.

SAY IT

Thyroxine is steered, adrenaline is triggered

Thyroxine is held at a set level by **negative feedback** through TSH from the pituitary. **Adrenaline** is not — it responds to fear or stress, not to a deviation from a set point.

DON'T MIX UP

thyroxine vs TSH

Thyroxine comes from the **thyroid** and raises the basal metabolic rate. **TSH** comes from the **pituitary** and tells the thyroid to make more thyroxine. Low thyroxine → more TSH → more thyroxine → less TSH.

5.3.6 Feedback systems **HT ONLY**

HT ONLY **Adrenaline** is produced by the **adrenal glands** in times of **fear or stress**. It **increases the heart rate** and boosts delivery of oxygen and glucose to the brain and muscles, preparing the body for '**flight or fight**'. **HT ONLY** **Thyroxine** from the **thyroid gland stimulates the basal metabolic rate** and is important in **growth and development**. **HT ONLY** **Thyroxine is controlled by negative feedback**: if blood thyroxine falls below normal, the pituitary releases **TSH**, stimulating the thyroid to release more; if thyroxine rises above normal, TSH release is **inhibited**, so less is made and the level returns to normal.

- **HT ONLY** Adrenaline is **not** controlled this way — it responds to a stimulus (fear or stress), not to a deviation from a set level.

PICTURE IT

Negative feedback is cruise control: it does not care how fast you want to go, only whether you are above or below the set speed, and it corrects in the opposite direction every time. Adrenaline is the driver stamping on the accelerator because something ran into the road. *Where it breaks down*: cruise control acts in a fraction of a second. Hormonal feedback takes minutes to hours.

CHECK YOURSELF

Cover the grey line before you answer.

1. What does adrenaline do, and when is it released?

In times of fear or stress it increases the heart rate and boosts delivery of oxygen and glucose to the brain and muscles, preparing the body for 'flight or fight'.

2. Describe the negative feedback control of thyroxine.

If blood thyroxine falls below normal, the pituitary releases TSH, stimulating the thyroid to release more; if thyroxine rises above normal, TSH release is inhibited.

3. Why is adrenaline not controlled by negative feedback?

It responds to a stimulus — fear or stress — rather than to a deviation from a set level.