

# 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, water balance and reproduction. Triple students also study the brain, the eye, body temperature and plant hormones.

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.

## 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.*

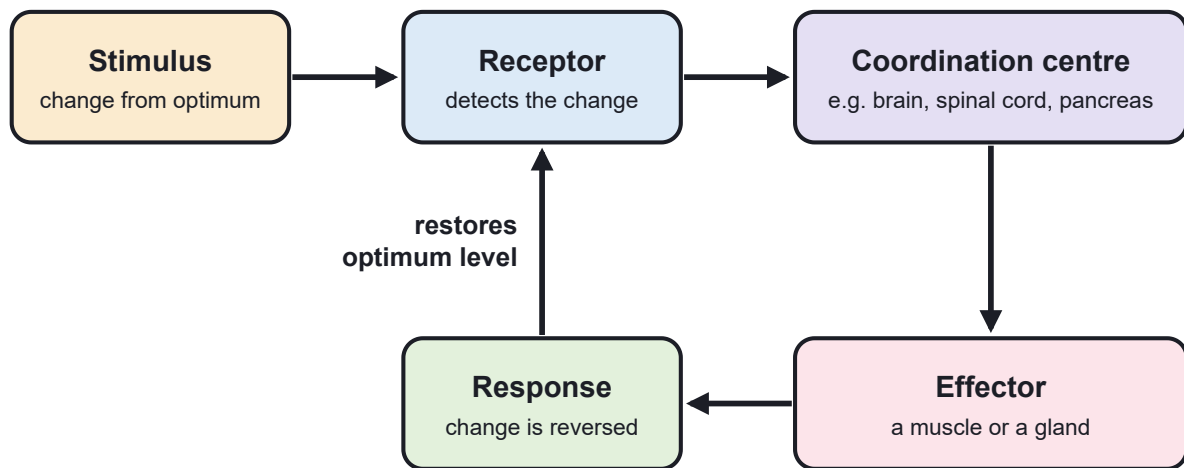
### Parts of a control system Spec 4.5.1

All control systems include three types of component.

### The three parts of every control system

| Component                   | What it does                                                                     | Examples                                                 |
|-----------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Receptors</b>            | Cells that detect <b>stimuli</b> (changes in the environment)                    | Temperature receptors in the skin                        |
| <b>Coordination centres</b> | Receive and process information from receptors                                   | The brain, the spinal cord and the pancreas              |
| <b>Effectors</b>            | <b>Muscles or glands</b> 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.



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                                                                         |
|------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Receptors</b> | Each type is sensitive to one kind of stimulus                                    | The body only picks up the changes it needs to respond to                            |
| <b>Neurones</b>  | Long cells that carry electrical impulses                                         | Impulses travel quickly over long distances between receptors, the CNS and effectors |
| <b>CNS</b>       | The brain and spinal cord receive information and send out a coordinated response | The right effectors respond together                                                 |
| <b>Effectors</b> | 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.*

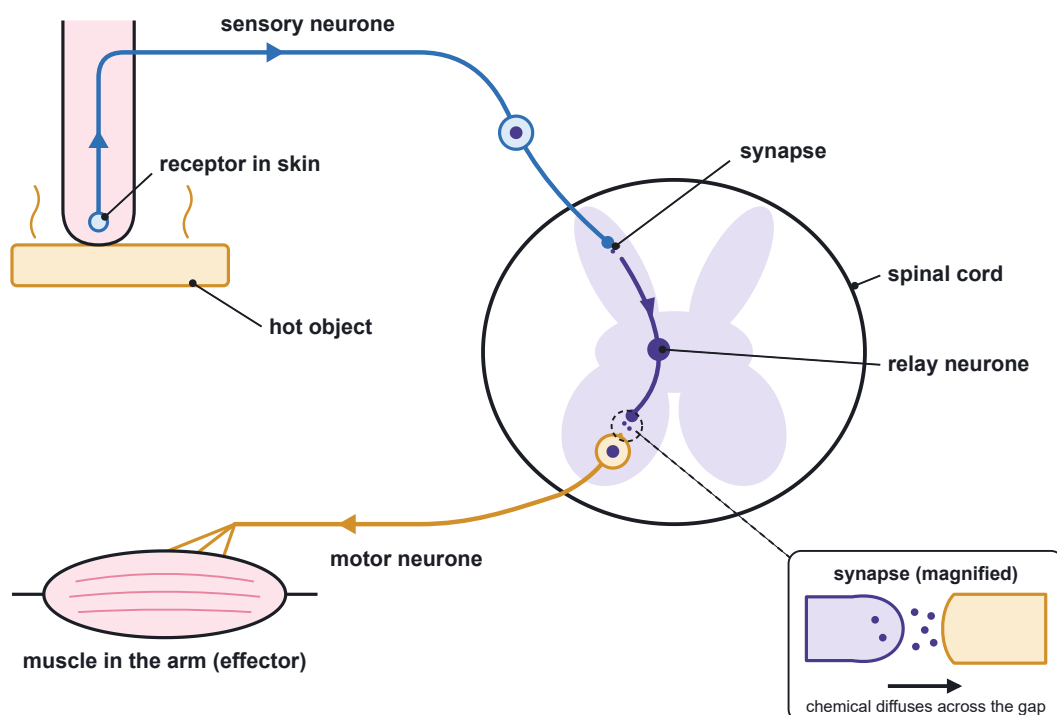
### Reflex actions and the reflex arc Spec 4.5.2.1

**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                                                                                                 |
|------------------------|----------------------------------------------------------------------------------------------------------|
| <b>Receptor</b>        | Detects the stimulus                                                                                     |
| <b>Sensory neurone</b> | Carries impulses from the receptor to the CNS                                                            |
| <b>Relay neurone</b>   | Carries impulses within the CNS, from the sensory neurone to the motor neurone                           |
| <b>Synapse</b>         | A gap between two neurones. A chemical diffuses across the gap and starts an impulse in the next neurone |
| <b>Motor neurone</b>   | Carries impulses from the CNS to the effector                                                            |
| <b>Effector</b>        | A muscle (contracts) or a gland (secretes) that produces the response                                    |



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.

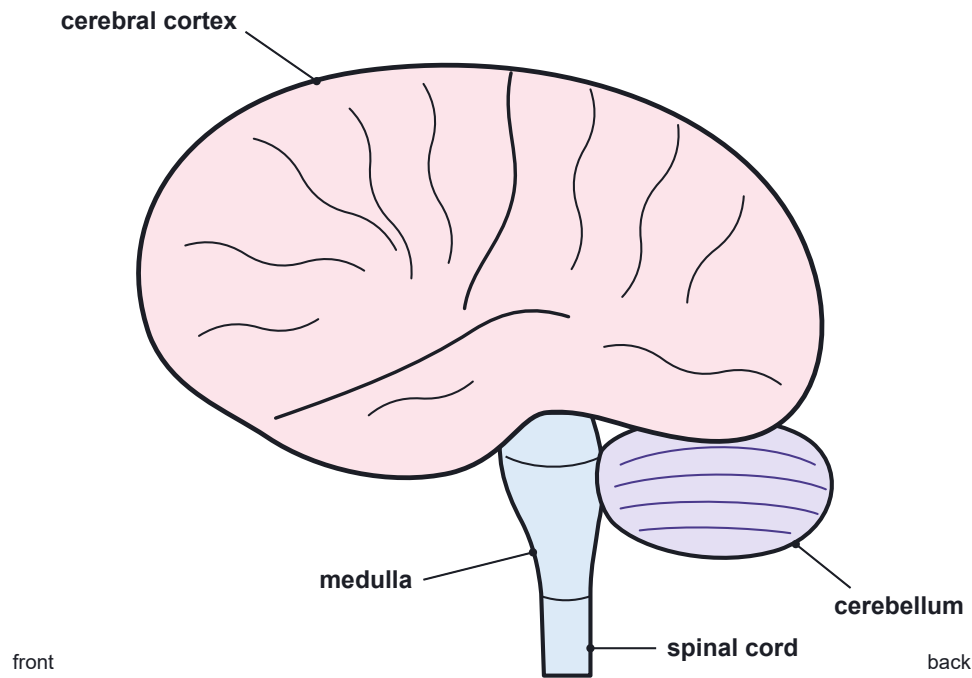
*Maths skill: You may be asked to turn a table of reaction times into a graph, or read values from a graph into a table. Label axes with the quantity and unit, for example 'Reaction time (s)'. Use a bar chart when one variable is a category.*

## The brain Spec 4.5.2.2 Triple only

The brain controls **complex behaviour**. It is made of **billions of interconnected neurones** and has **different regions that carry out different functions**.

### Regions of the brain

| Region                 | Function                                                         |
|------------------------|------------------------------------------------------------------|
| <b>Cerebral cortex</b> | Consciousness, intelligence, memory and language                 |
| <b>Cerebellum</b>      | Coordinates muscular activity and balance                        |
| <b>Medulla</b>         | Controls unconscious activities such as heart rate and breathing |



Regions of the brain: the **cerebral cortex**, the **cerebellum** and the **medulla**.

#### Higher tier

### Investigating the brain and treating brain disorders

#### Higher tier

Neuroscientists have mapped regions of the brain to particular functions in three main ways.

#### Higher tier

- Studying **patients with brain damage** and seeing which abilities are lost.
- **Electrically stimulating** different parts of the brain and seeing what happens.
- Using **MRI scanning** techniques.

#### Higher tier

The **complexity and delicacy** of the brain makes investigating and treating brain disorders very difficult. It is made of billions of interconnected neurones, and its tissue is easily damaged during investigation or treatment. Any procedure on the brain or nervous system has benefits and risks that must be weighed up.

#### Higher tier

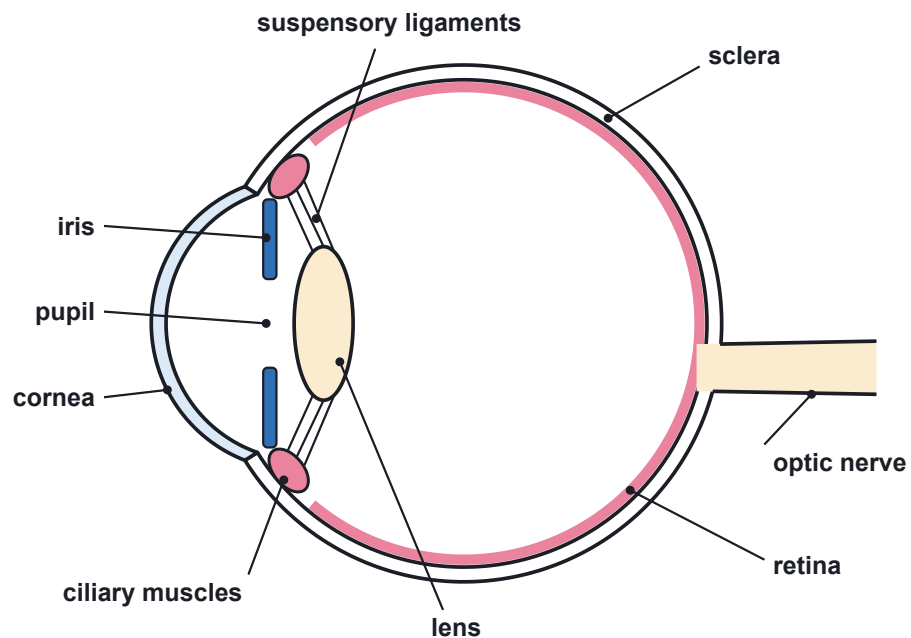
*Exam tip: For 'difficulties' questions, use the words **complex** and **delicate**, and link them to the risk of damaging the brain during investigation or treatment.*

## The eye: structures and their functions Spec 4.5.2.3 Triple only

The eye is a **sense organ** containing **receptors sensitive to light intensity and colour**.

## Structures of the eye

| Structure                   | How its structure relates to its function                                                                |
|-----------------------------|----------------------------------------------------------------------------------------------------------|
| <b>Retina</b>               | Contains the light receptors. It is where the image is focused and it detects light intensity and colour |
| <b>Optic nerve</b>          | Carries impulses from the receptors in the retina to the brain                                           |
| <b>Sclera</b>               | The tough white outer layer. It protects the eye and keeps its shape                                     |
| <b>Cornea</b>               | Transparent front surface. It lets light in and <b>refracts</b> (bends) the light rays                   |
| <b>Iris</b>                 | Muscles that control the size of the pupil and so how much light enters the eye                          |
| <b>Ciliary muscles</b>      | A ring of muscle around the lens that contracts or relaxes to change the lens shape                      |
| <b>Suspensory ligaments</b> | Hold the lens in place and connect it to the ciliary muscles. Their tension changes the lens shape       |



Structures of the eye. Light enters through the **cornea** and **pupil** and is focused by the **lens** onto the **retina**.

### Adaptation to dim light

The iris controls how much light reaches the retina. In **dim light** the pupil gets **wider** so more light enters. In bright light the pupil gets narrower so less light enters, which protects the retina.

*Exam tip: Link each structure to its job with a reason, for example 'the cornea refracts light', not just 'the cornea is at the front'.*

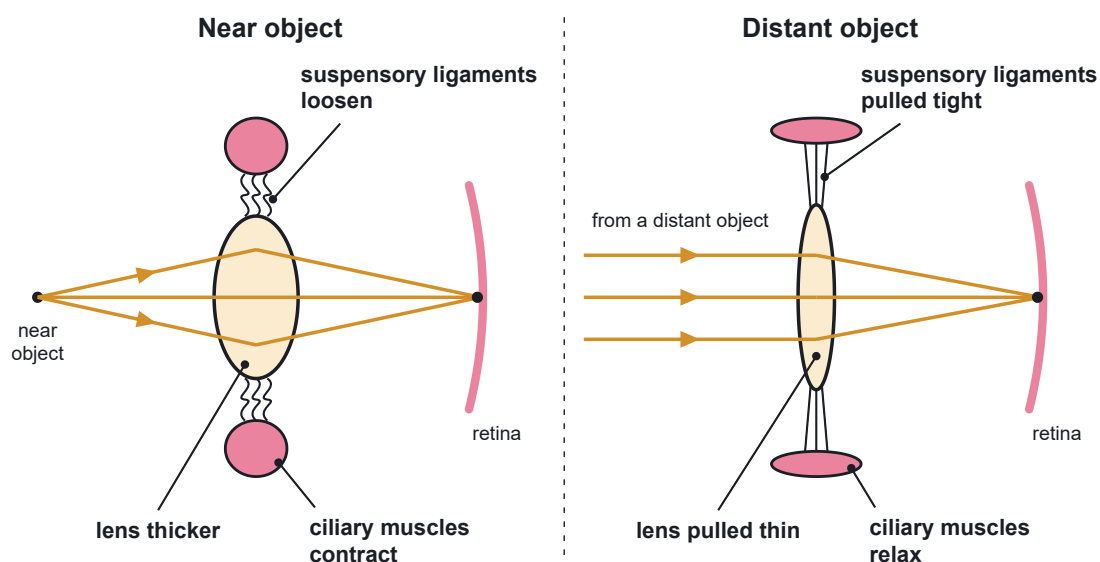
### Accommodation Spec 4.5.2.3 Triple only

#### Accommodation

The process of changing the shape of the lens to focus on near or distant objects.

## Focusing on near and distant objects

|                                 | Near object | Distant object |
|---------------------------------|-------------|----------------|
| <b>Ciliary muscles</b>          | Contract    | Relax          |
| <b>Suspensory ligaments</b>     | Loosen      | Pulled tight   |
| <b>Lens shape</b>               | Thicker     | Pulled thin    |
| <b>Refraction of light rays</b> | Strongly    | Only slightly  |



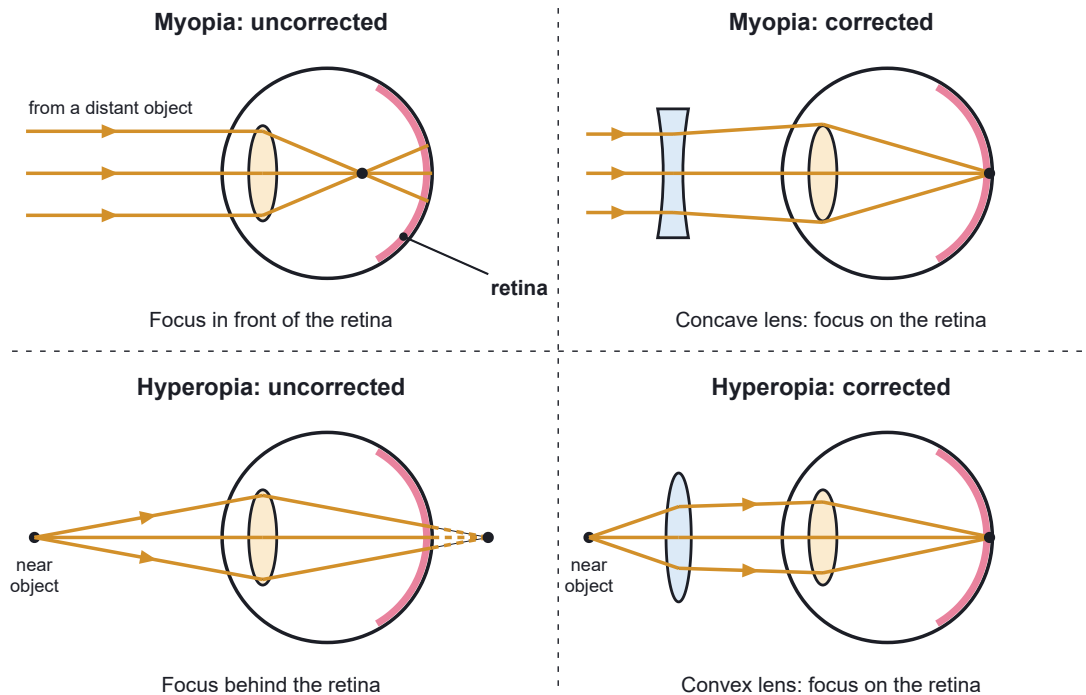
Accommodation. Near object: **muscles contract, ligaments loosen, lens thicker**. Distant object: muscles relax, ligaments tight, lens thin.

**Common mistake:** For a near object the ciliary muscles contract and the ligaments go slack. Many students reverse this. Remember: contracted muscle, loose ligaments, fat lens.

## Defects of the eye Spec 4.5.2.3 Triple only

Two common defects of the eye are **myopia** (short sightedness) and **hyperopia** (long sightedness). In both, rays of light do not focus on the retina.

|                                         | Myopia (short sightedness)                                                    | Hyperopia (long sightedness)                                              |
|-----------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| <b>Effect</b>                           | Distant objects look blurred                                                  | Near objects look blurred                                                 |
| <b>Where light rays focus</b>           | In front of the retina                                                        | Behind the retina                                                         |
| <b>Correction with spectacle lenses</b> | Concave lens, which spreads the light rays slightly before they enter the eye | Convex lens, which bends the light rays inwards before they enter the eye |



Myopia is corrected with a **concave lens**; hyperopia is corrected with a **convex lens**. Both bring the focus onto the retina.

Generally these defects are treated with **spectacle lenses** which refract the light rays so that they do focus on the retina. New technologies now include:

- hard and soft contact lenses
- laser surgery to change the shape of the cornea
- a replacement lens in the eye.

**Exam tip:** In a ray diagram question, say where the rays meet (in front of, behind or on the retina) and which lens moves that point onto the retina.

## Control of body temperature Spec 4.5.2.4 Triple only

Body temperature is monitored and controlled by the **thermoregulatory centre** in the brain. It contains **receptors sensitive to the temperature of the blood**. The skin also contains **temperature receptors** and sends nervous impulses to the thermoregulatory centre.

| Responses to a change in body temperature |                                                                                                                                                            |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| If body temperature is...                 | Responses                                                                                                                                                  |
| <b>Too high</b>                           | Blood vessels dilate ( <b>vasodilation</b> ) and sweat is produced from the sweat glands. Both cause a transfer of energy from the skin to the environment |
| <b>Too low</b>                            | Blood vessels constrict ( <b>vasoconstriction</b> ), sweating stops and skeletal muscles contract ( <b>shiver</b> )                                        |

#### Higher tier

### Explaining how the mechanisms work

#### Higher tier

- Vasodilation: more blood flows through the vessels near the skin surface, so more energy is transferred from the blood to the surroundings.
- Sweating: the sweat evaporates from the skin surface, which transfers energy from the skin to the environment and cools the body.
- Vasoconstriction: less blood flows near the skin surface, so less energy is transferred to the surroundings.
- Shivering: skeletal muscles contract rapidly, and the respiration in the muscle cells releases energy that warms the body.
- Sweating stops, so less energy is lost by evaporation.

#### Higher tier

*Exam tip: In a 'given context' question, say whether the person is too hot or too cold first, then give each response with its effect on energy transfer.*

*Common mistake: Blood vessels do not move closer to or further from the skin. They dilate or constrict, which changes how much blood flows near the surface.*

### Quick check

1. What is the CNS?
2. Put these in order: motor neurone, sensory neurone, relay neurone.
3. Why are reflex actions important?
4. **Triple only** What happens to the ciliary muscles and lens when focusing on a near object?
5. **Triple only** Name the type of lens that corrects myopia.

### 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                   |

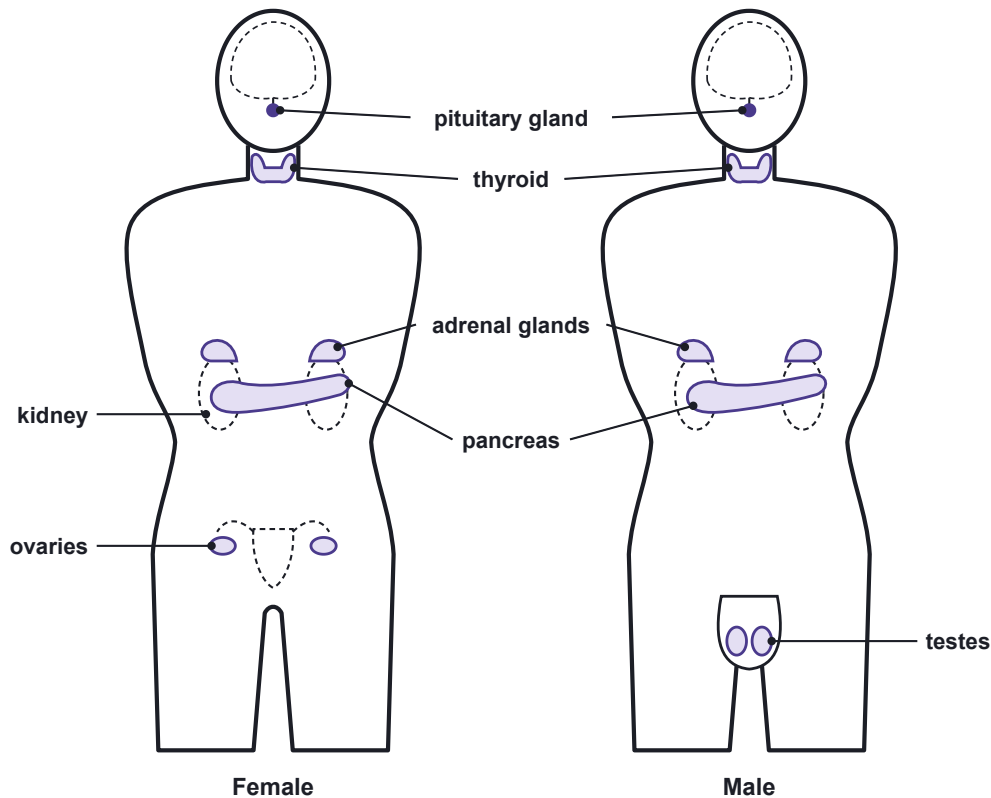
The **pituitary gland** in the brain is a ‘**master gland**’. It secretes several hormones into the blood in response to body conditions. These hormones in turn act on other glands to stimulate other hormones to be released to bring about effects.

| 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**.



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.

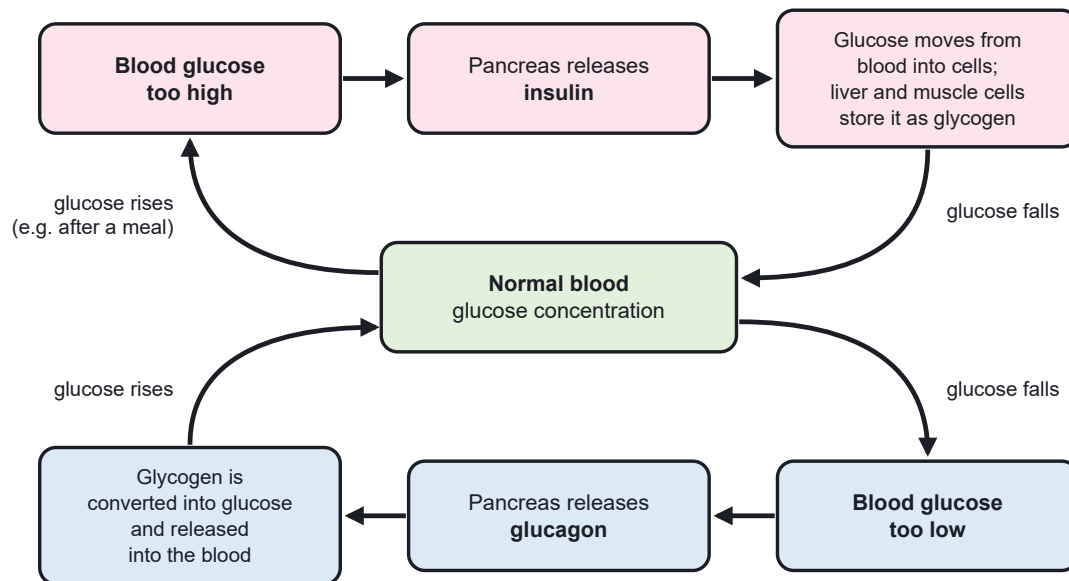
### Higher tier

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                                                       |
|---------------------------------------|-------------------------------------|----------------------------------------------------------------|
| <b>Released when blood glucose is</b> | Too high                            | Too low                                                        |
| <b>Effect on glucose</b>              | Glucose moves from blood into cells | Glycogen is converted into glucose and released into the blood |
| <b>Effect on blood glucose</b>        | 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                                                               |
|------------------------|----------------------------------------------|----------------------------------------------------------------------|
| <b>Cause</b>           | Pancreas fails to produce sufficient insulin | Body cells no longer respond to the insulin produced by the pancreas |
| <b>Blood glucose</b>   | Uncontrolled high levels                     | High levels                                                          |
| <b>Treatment</b>       | Insulin injections                           | Carbohydrate controlled diet and an exercise regime                  |
| <b>Link to obesity</b> | -                                            | 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

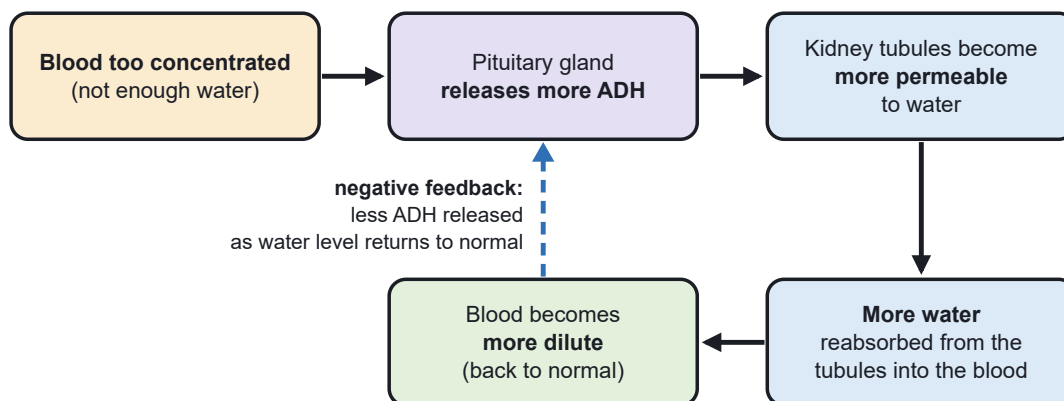
*Common mistake: The kidney does not make urea. Urea is made in the liver, carried in the blood to the kidneys, and removed in the urine.*

## 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) |
|------------------------------------------------|-------------------------------------------|-----------------------------------|
| <b>ADH released by pituitary</b>               | More                                      | Less                              |
| <b>Permeability of kidney tubules to water</b> | Increases                                 | Decreases                         |
| <b>Water reabsorbed into the blood</b>         | More                                      | Less                              |
| <b>Urine</b>                                   | 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.

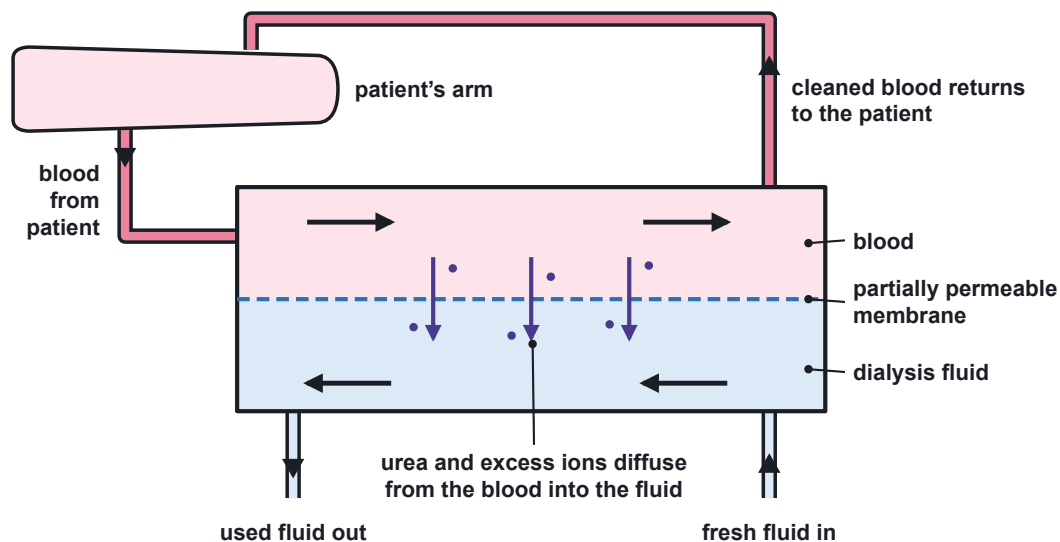
*Exam tip: Always say ADH changes the permeability of the kidney tubules. Do not just say it 'makes the kidney hold on to water'.*

## 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                                                                                                                             |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Advantages</b>    | 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                                         |
| <b>Disadvantages</b> | 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                                                                              |
|---------------------|------------|-----------------------------------------------------------------------------------|
| <b>Oestrogen</b>    | The ovary  | The <b>main female reproductive hormone</b>                                       |
| <b>Testosterone</b> | The testes | The <b>main male reproductive hormone</b> . It stimulates <b>sperm production</b> |

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               |
|-------------------------------------------|-------------------------------------------|
| <b>Follicle stimulating hormone (FSH)</b> | Causes maturation of an egg in the ovary  |
| <b>Luteinising hormone (LH)</b>           | Stimulates the release of the egg         |
| <b>Oestrogen and progesterone</b>         | Involved in maintaining the uterus lining |

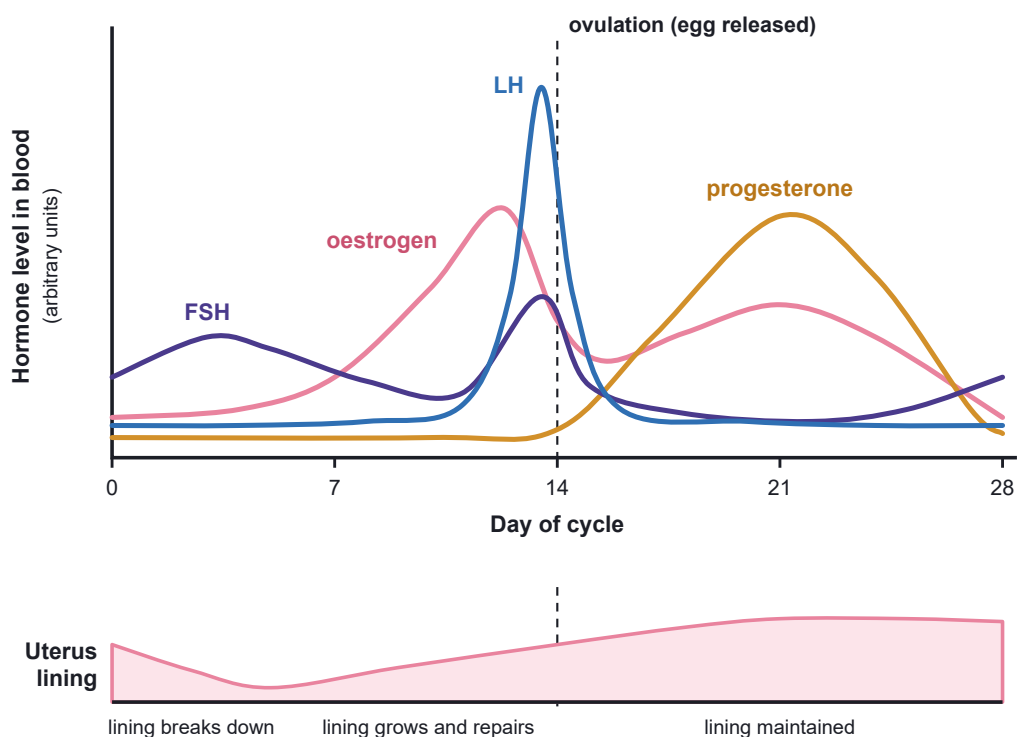
### Higher tier

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

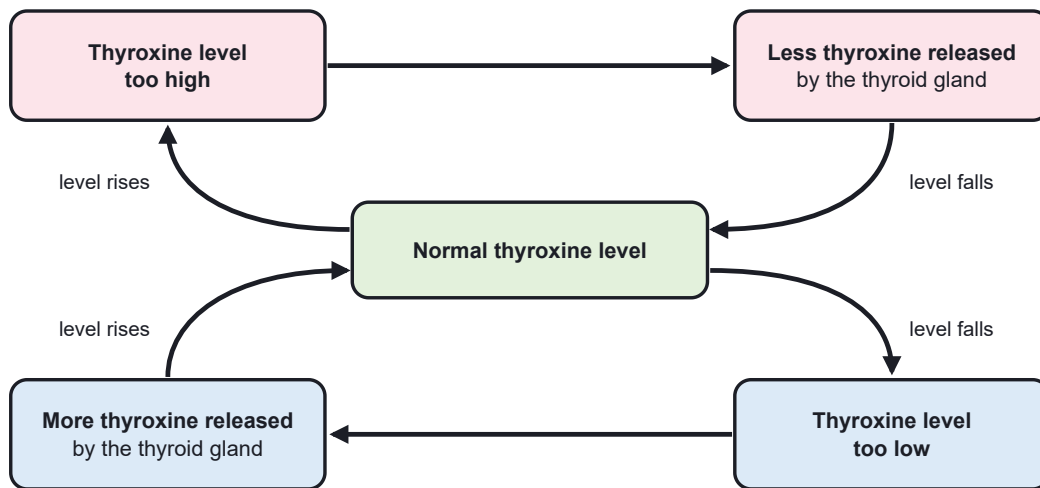
**Adrenaline** is produced by the **adrenal glands** in times of fear or stress. It increases the heart rate and boosts the delivery of oxygen and glucose to the brain and muscles, preparing the body for '**flight or fight**'.

### 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.

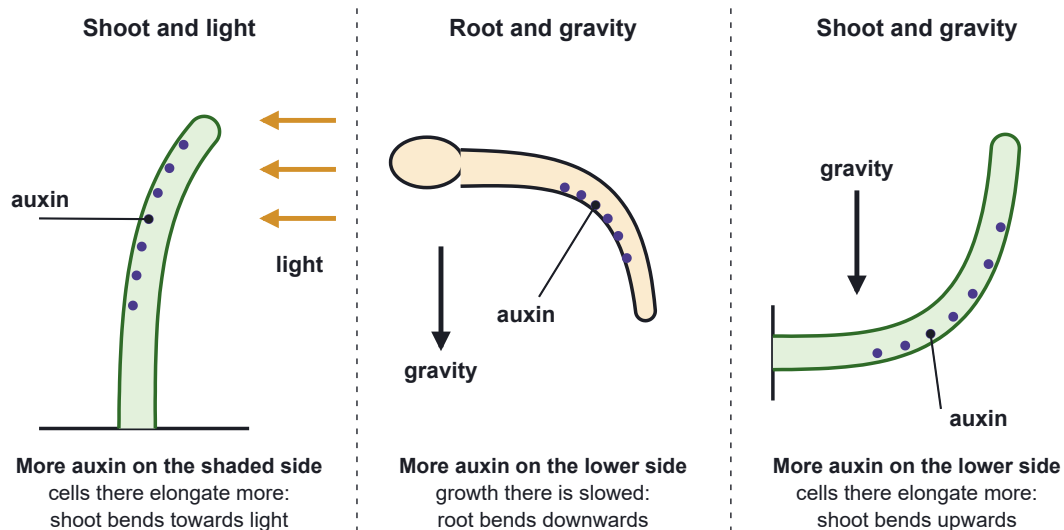
## 4 Plant hormones Spec 4.5.4 Triple only

### Plant hormones, phototropism and gravitropism Spec 4.5.4.1

Plants produce **hormones** to coordinate and control **growth** and **responses to light (phototropism)** and **gravity (gravitropism or geotropism)**.

**Unequal distributions of auxin** cause **unequal growth rates** in plant roots and shoots.

| Auxin and plant responses          |                                 |                                                  |                                                       |
|------------------------------------|---------------------------------|--------------------------------------------------|-------------------------------------------------------|
| Response                           | Where auxin builds up           | Effect on growth                                 | Result                                                |
| <b>Shoot growing towards light</b> | On the shaded side of the shoot | Cells on the shaded side elongate more           | The shoot bends towards the light                     |
| <b>Root growing downwards</b>      | On the lower side of the root   | Growth of cells on the lower side is slowed down | The root bends downwards, in the direction of gravity |
| <b>Shoot growing upwards</b>       | On the lower side of the shoot  | Cells on the lower side elongate more            | The shoot bends upwards, away from gravity            |



**Unequal distribution of auxin** causes unequal growth, so shoots bend towards light and away from gravity, and roots bend towards gravity.

#### Higher tier

### Gibberellins and ethene

#### Higher tier

- **Gibberellins** are important in **initiating seed germination**.
- **Ethene** controls **cell division and ripening of fruits**.

#### Higher tier

You do not need to know how gibberellins and ethene work.

**Exam tip:** Always say that the auxin is **unequally distributed**. Then say which side has more auxin and what that does to growth on that side.

**Required practical: Required practical activity 8: investigate the effect of light or gravity on the growth of newly germinated seedlings. Record results as both length measurements and as careful, labelled biological drawings.**

1. Germinate seeds (for example cress) on damp cotton wool or filter paper in a dish.
  2. For light: place identical seedlings in a box with a slit that lets light in from one side only. Keep a control set in even light all round.
  3. For gravity: fix seedlings in a dish, turn the dish on its side so the roots point sideways and keep it in the dark. Keep a control set upright.
  4. Measure the length of the shoot (and root) with a ruler at regular intervals, and make a labelled drawing of each seedling to show the direction of growth.
  5. Compare the treated seedlings with the control seedlings.
- Independent variable: the direction of the light, or the position of the seedling (gravity).
  - Dependent variable: the direction and length of growth.
  - Control variables: the type and age of seedling, temperature and the amount of water. Keep the gravity test in the dark so light does not affect the result.
  - Safety: wash your hands after handling seedlings and compost, and do not eat any seeds or seedlings.
  - Typical results: shoots bend towards the light; roots bend down; shoots grow upwards even in the dark.

## Uses of plant hormones Spec 4.5.4.2

Plant growth hormones are used in **agriculture and horticulture** to control plant growth.

| Uses of plant hormones |                                                                                                    |
|------------------------|----------------------------------------------------------------------------------------------------|
| Hormone                | Use                                                                                                |
| <b>Auxins</b>          | As <b>weed killers</b> ; as <b>rooting powders</b> ; for promoting growth in <b>tissue culture</b> |
| <b>Ethene</b>          | In the food industry to <b>control ripening of fruit</b> during storage and transport              |
| <b>Gibberellins</b>    | To <b>end seed dormancy</b> ; to <b>promote flowering</b> ; to <b>increase fruit size</b>          |

Using hormones as weed killers can affect biodiversity. Killing weeds helps the crop grow, but it also reduces the number of other plant species in the area, and so the animals that depend on them.

**Exam tip: Match the hormone to its use: auxin for weed killer, rooting powder and tissue culture; ethene for ripening; gibberellins for dormancy, flowering and fruit size.**

### Quick check

1. Which hormone causes unequal growth in roots and shoots?
2. Why does a shoot bend towards light?
3. What do the terms phototropism and gravitropism mean?
4. **Higher tier** Name one use of gibberellins.

# 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.
4. The ciliary muscles contract, the suspensory ligaments loosen and the lens becomes thicker.
5. A concave lens.

## 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).

## Plant hormones

1. Auxin.
2. Auxin builds up on the shaded side, so cells there grow more and the shoot bends towards the light.
3. Phototropism is a growth response to light. Gravitropism (geotropism) is a growth response to gravity.
4. Any one of: ending seed dormancy, promoting flowering, increasing fruit size.