

The human nervous system

Revision notes • How neurones, the CNS and reflex arcs give fast responses, plus the brain, the eye and control of body temperature.

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.

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**.

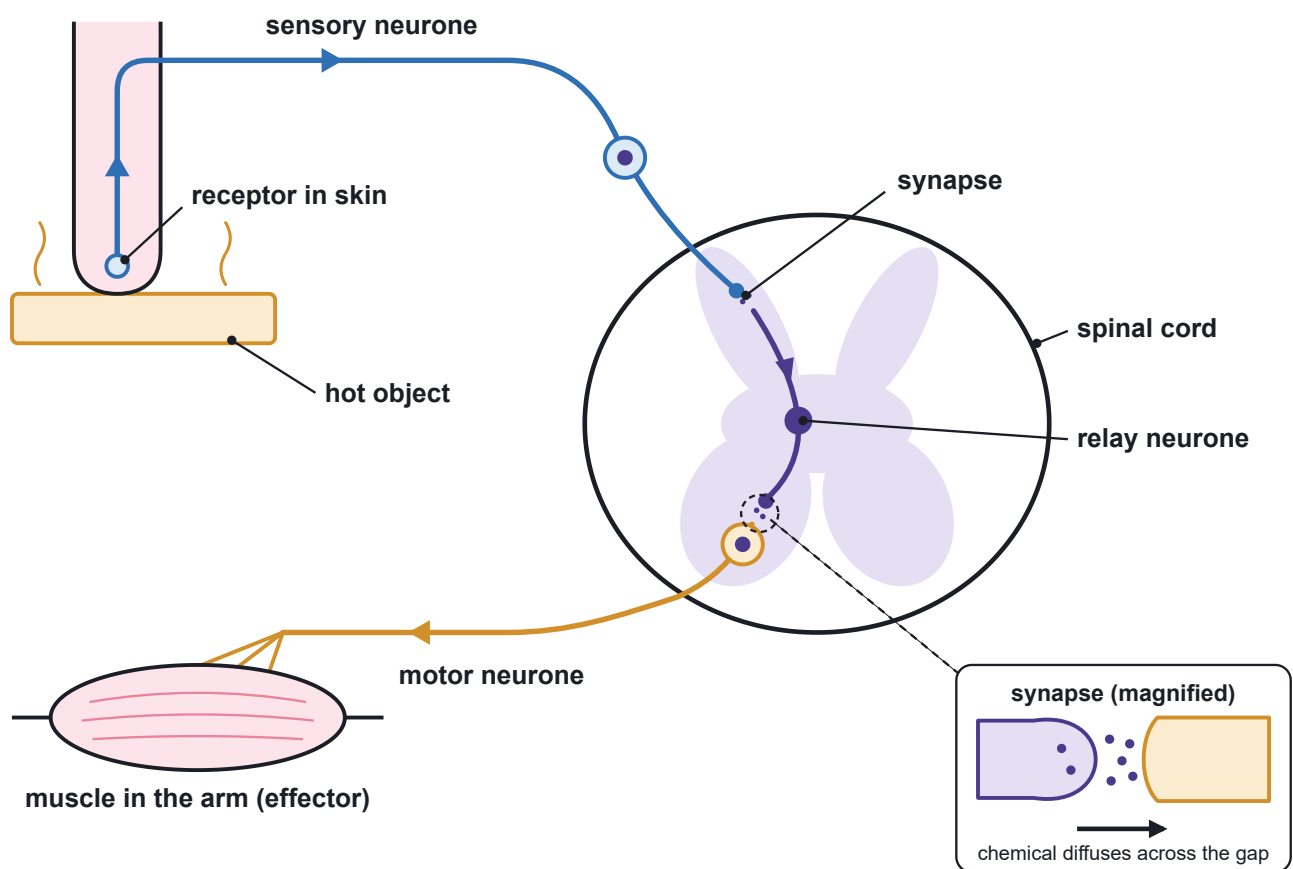
Reflex actions and the reflex arc Spec 4.5.2.1

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



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.

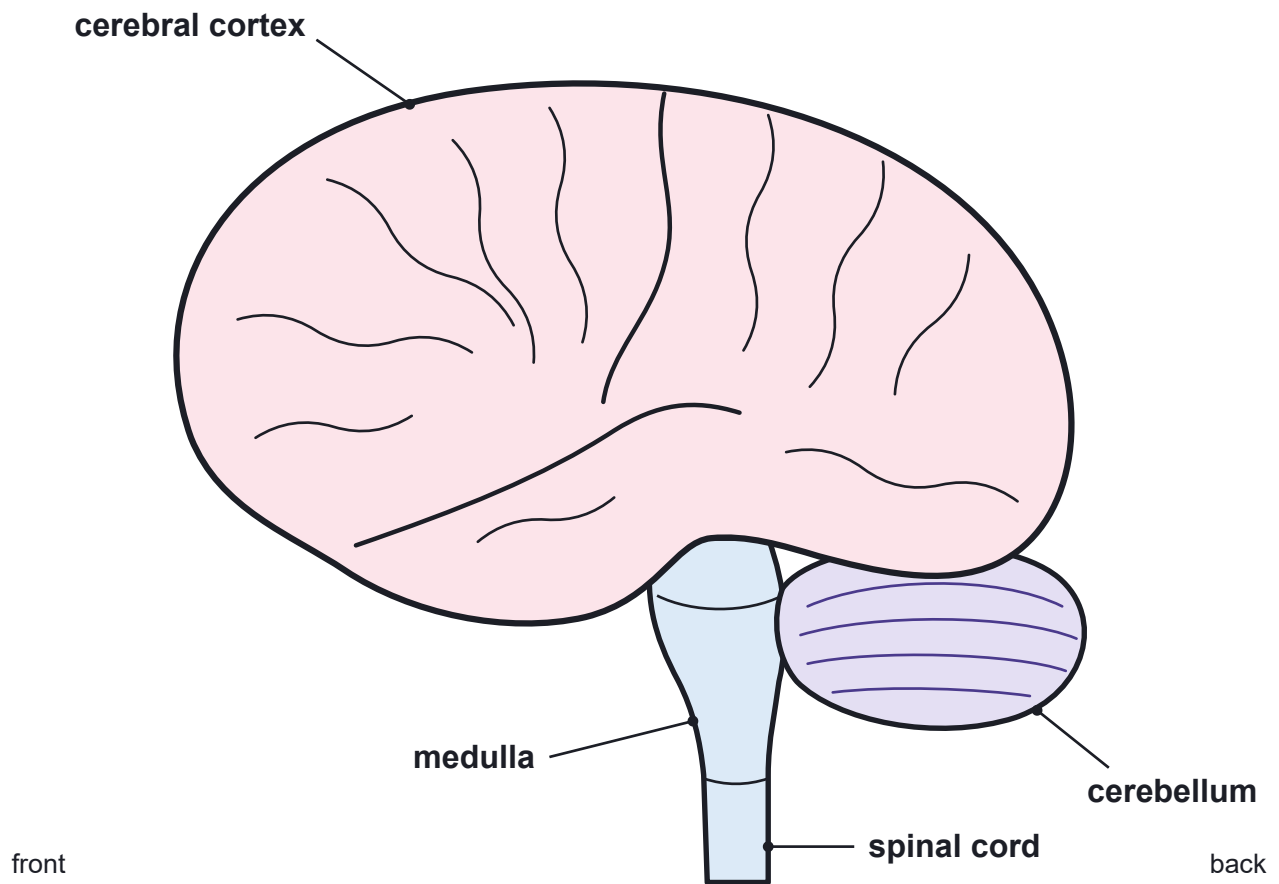
Maths skill: You may be asked to turn a table of reaction times into a graph, or read values from a graph into a table. Label axes with the quantity and unit, for example 'Reaction time (s)'. Use a bar chart when one variable is a category.

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
Cerebral cortex	Consciousness, intelligence, memory and language
Cerebellum	Coordinates muscular activity and balance
Medulla	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.

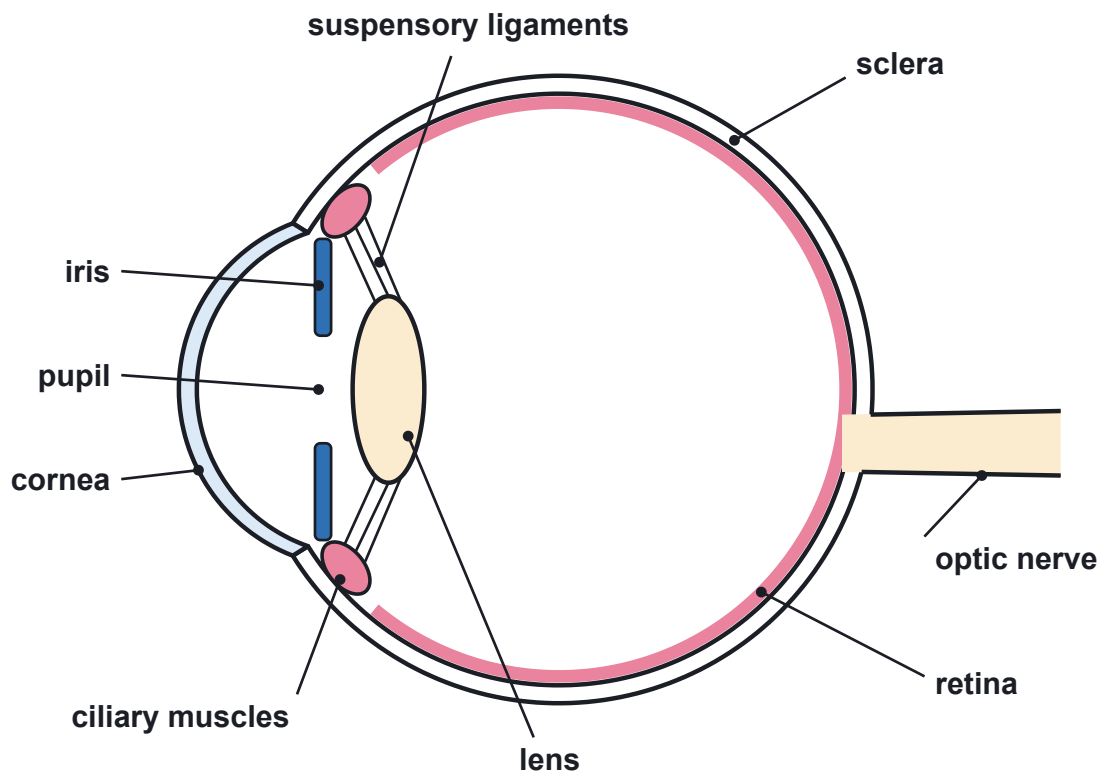
Higher tier

*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
Retina	Contains the light receptors. It is where the image is focused and it detects light intensity and colour
Optic nerve	Carries impulses from the receptors in the retina to the brain
Sclera	The tough white outer layer. It protects the eye and keeps its shape
Cornea	Transparent front surface. It lets light in and refracts (bends) the light rays
Iris	Muscles that control the size of the pupil and so how much light enters the eye
Ciliary muscles	A ring of muscle around the lens that contracts or relaxes to change the lens shape
Suspensory ligaments	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'.

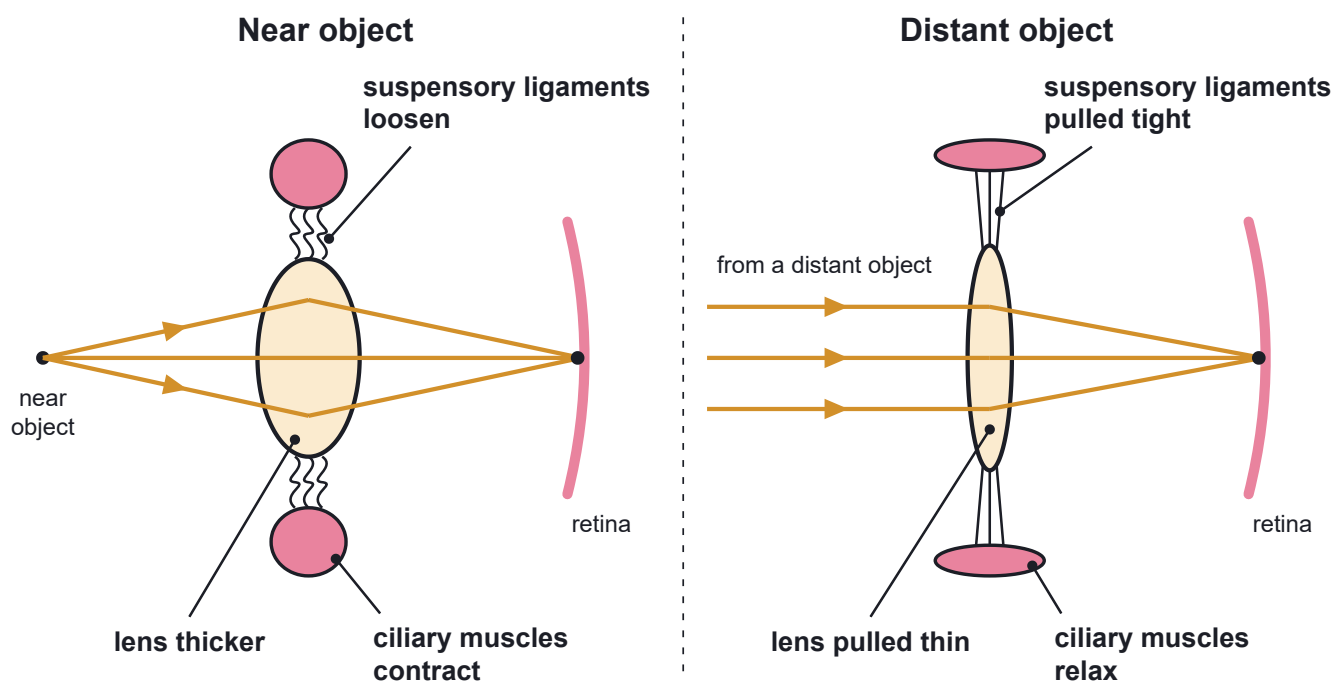
Accommodation Spec 4.5.2.3 Triple only

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
Ciliary muscles	Contract	Relax
Suspensory ligaments	Loosen	Pulled tight
Lens shape	Thicker	Pulled thin
Refraction of light rays	Strongly	Only slightly



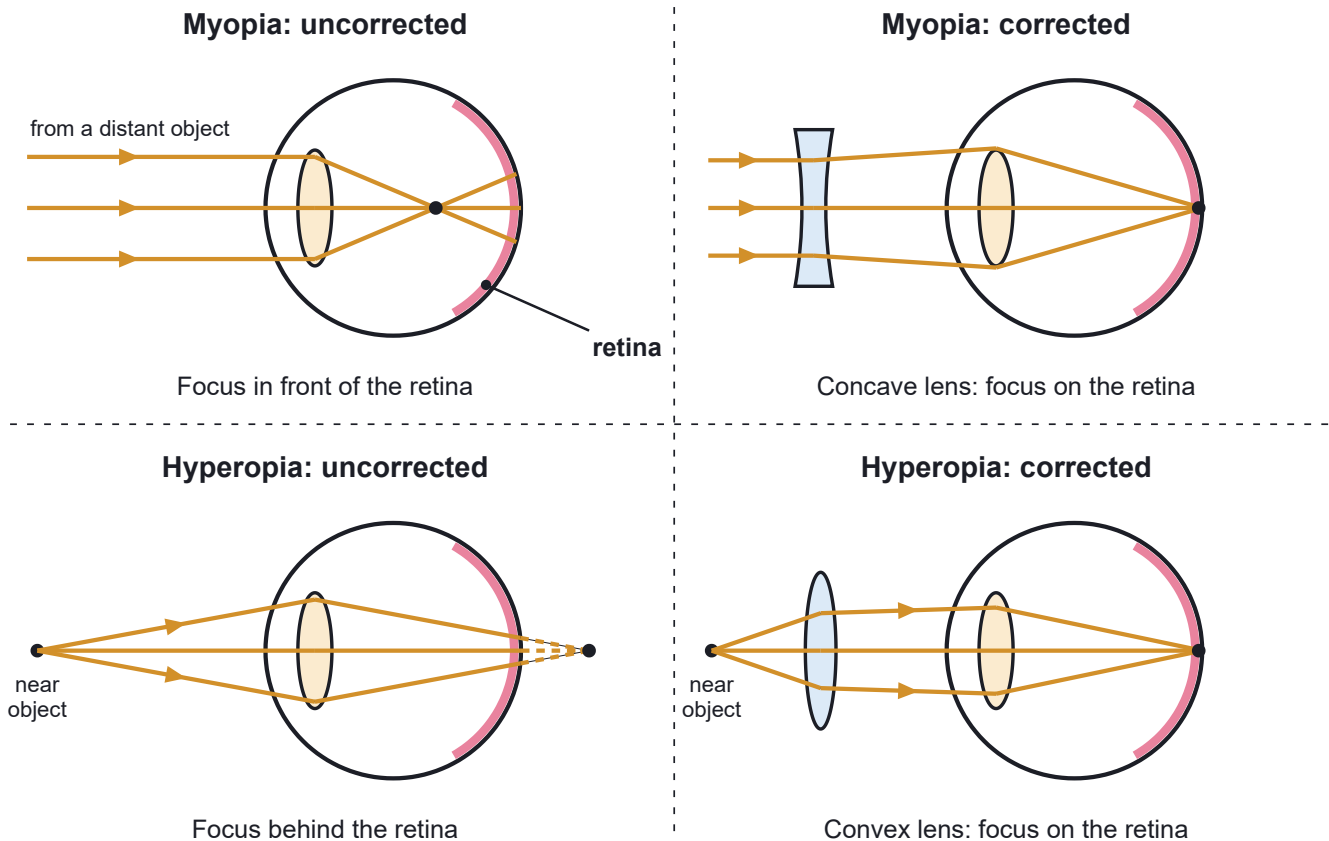
Accommodation. Near object: **muscles contract, ligaments loosen, lens thicker**. Distant object: muscles relax, ligaments tight, lens thin.

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)
Effect	Distant objects look blurred	Near objects look blurred
Where light rays focus	In front of the retina	Behind the retina
Correction with spectacle lenses	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
Too high	Blood vessels dilate (vasodilation) and sweat is produced from the sweat glands. Both cause a transfer of energy from the skin to the environment
Too low	Blood vessels constrict (vasoconstriction), sweating stops and skeletal muscles contract (shiver)

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.

Quick check answers

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.