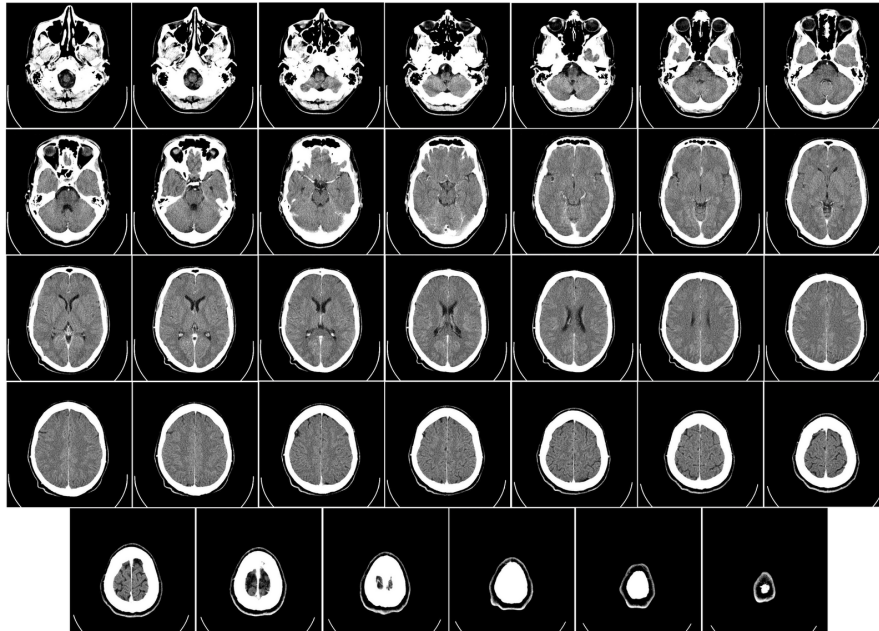


Coordination and response

IGCSE Biology

The nervous system



The brain coordinates the body through the nervous system.

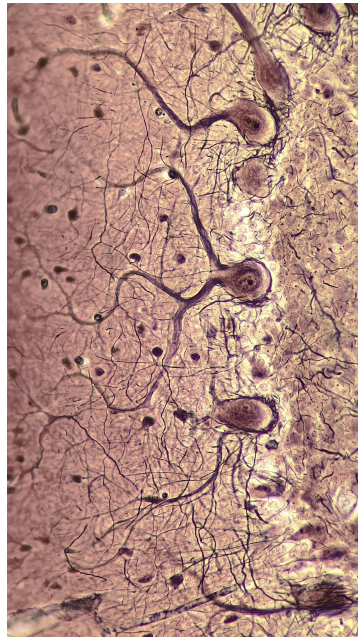
Image: Department of Radiology, Uppsala University Hospital. Uploaded by Mikael Häggström, CC0 (commons.wikimedia.org)

Your body must **coordinate** 协调 all its parts and react to changes. The **nervous system** 神经系统 does this using fast **electrical impulses** 电脉冲 that travel along **neurons** 神经元 (nerve cells). It has two parts:

- the **central nervous system** 中枢神经系统 (CNS) —the **brain** 大脑 and the **spinal cord** 脊髓.
- the **peripheral nervous system** 周围神经系统 (PNS) —all the nerves outside the brain and spinal cord.

The nervous system coordinates and **regulates** 调节 the body's functions.

Neurones and the reflex arc



A neurone (nerve cell) carries electrical impulses around the body.

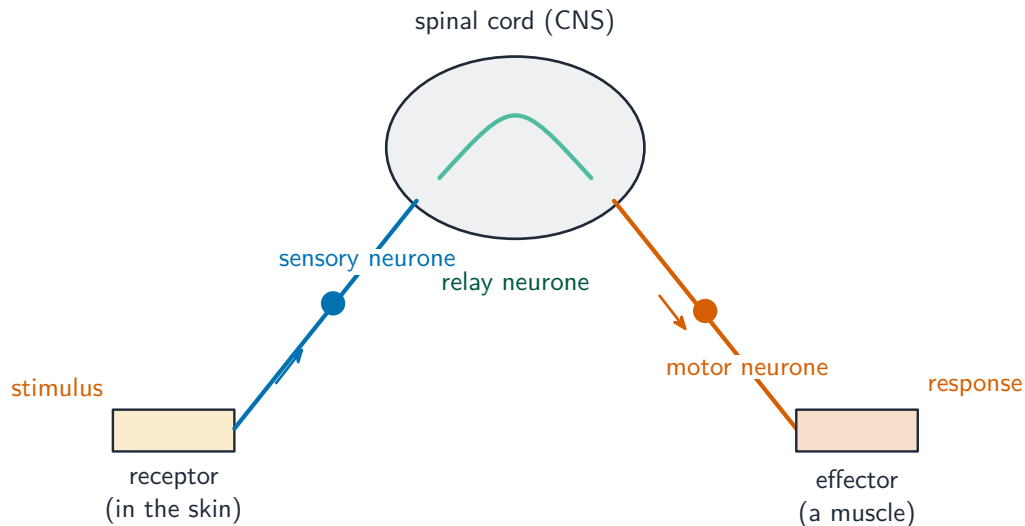
Image: Lennart Rikk, CC0 (commons.wikimedia.org)

There are three kinds of neurone:

- **sensory neurones** 感觉神经元—carry impulses from receptors to the CNS.
- **relay neurones** 中间神经元—pass impulses on inside the CNS.
- **motor neurones** 运动神经元—carry impulses from the CNS to effectors.

A **reflex** 反射 action is a fast, automatic **response** 反应 to a **stimulus** 刺激 (a change). It follows a fixed path, the **reflex arc** 反射弧:

receptor 感受器 → sensory neurone → relay neurone → motor neurone → **effector** 效应器 (a **muscle** 肌肉 or **gland** 腺体)



In a reflex arc the impulse passes from receptor → sensory → relay → motor neurone → effector

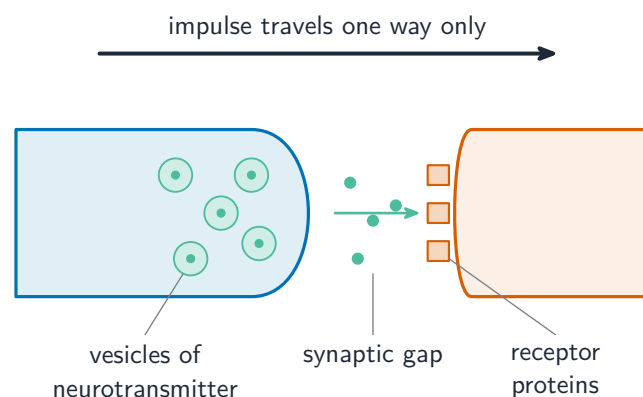
Synapses (Supplement)

A **synapse** 突触 is a junction (a tiny gap) between two neurones. At the end of one neurone are **vesicles** 囊泡 holding **neurotransmitter** 神经递质 molecules. Across the **synaptic gap** 突触间隙, the next neurone has **receptor proteins** 受体蛋白.

Events at a synapse:

1. an impulse arrives and makes the vesicles release neurotransmitter into the synaptic gap.
2. the neurotransmitter molecules **diffuse** 扩散 across the gap.
3. they bind to the receptor proteins on the next neurone.
4. this starts a new impulse in the next neurone.

Synapses make impulses travel in **one direction only**.



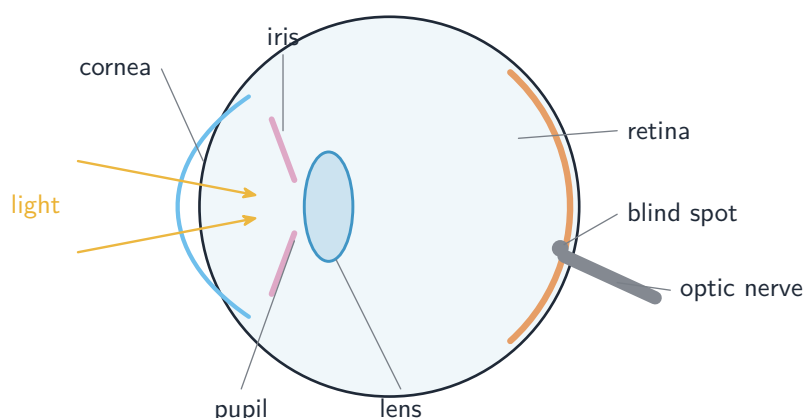
At a synapse, neurotransmitter diffuses across the gap, so impulses travel one way only

Sense organs and the eye

Sense organs 感觉器官 are groups of receptor cells that respond to one kind of stimulus —light, sound, touch, temperature or chemicals. The eye responds to light.

Parts of the eye

Part	Function
cornea 角膜	refracts 折射 (bends) the light as it enters
iris 虹膜	controls how much light enters the pupil 瞳孔
lens 晶状体	focuses the light onto the retina
retina 视网膜	contains light receptors, some sensitive to different colours
optic nerve 视神经	carries the impulses to the brain
blind spot 盲点	where the optic nerve leaves the eye; it has no receptors



Light is focused by the cornea and lens onto the retina; impulses leave by the optic nerve

The pupil reflex

In bright light the pupil gets **smaller**, to protect the retina. In dim light it gets **wider**, to let more light in. (**Supplement**) This is done by two sets of **antagonistic** 拮抗 muscles in the iris: the **circular muscles** 环肌 and the **radial muscles** 辐射肌. In bright light the circular muscles contract and the pupil narrows; in dim light the radial muscles contract and the pupil widens.

Accommodation (Supplement)

Accommodation 视觉调节 is changing the shape of the lens to focus on near or far objects, using the **ciliary muscles** 睫状肌 and the **suspensory ligaments** 悬韧带:

- near object: the ciliary muscles contract, the ligaments slacken, and the lens becomes fatter —more refraction.
- far object: the ciliary muscles relax, the ligaments pull tight, and the lens becomes thinner —less refraction.

Rods and cones (Supplement)

The retina has two kinds of light receptor:

- **rods** 视杆细胞—very sensitive, good for **vision** 视觉 in dim light (night vision); they do not detect colour.
- **cones** 视锥细胞—three kinds, each absorbing a different colour, giving colour vision; they work best in bright light.

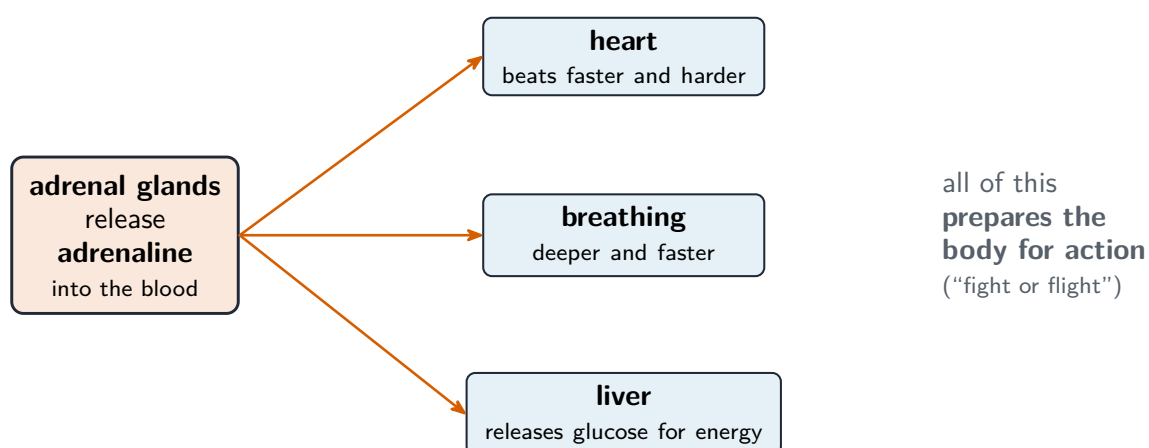
Cones are packed most densely at the **fovea** 中央凹, the part of the retina that gives the sharpest image.

Hormones

A **hormone** 激素 is a chemical, made by a gland and carried in the blood, that changes the activity of one or more **target organs** 靶器官. Hormones are made by **endocrine glands** 内分泌腺, which release them straight into the blood.

Gland	Hormone	Main effect
adrenal glands 肾上腺	adrenaline 肾上腺素	prepares the body for action
pancreas 胰腺	insulin 胰岛素 (and glucagon 胰高血糖素)	control blood glucose 葡萄糖
testes 睾丸	testosterone 睾酮	male development
ovaries 卵巢	oestrogen 雌激素	female development

Adrenaline is released in 'fight or flight' situations, such as fear or danger. It increases the breathing rate, the **heart rate** 心率, the blood glucose **concentration** 浓度 and the pupil diameter, getting the body ready to act.



Adrenaline prepares the body for action by acting on several target organs

Nervous control vs hormonal control

	Nervous control	Hormonal control
speed	very fast	slower
duration 持续时间	short-lived	longer-lasting
how it travels	electrical impulses along neurones	chemicals in the blood

	nervous control	hormonal control
how it travels	electrical impulses along neurones	chemicals in the blood
speed	very fast	slower
duration	short-lived	longer-lasting

fast but brief, versus slow but lasting

Nervous control is fast but brief; hormonal control is slower but longer-lasting

Homeostasis

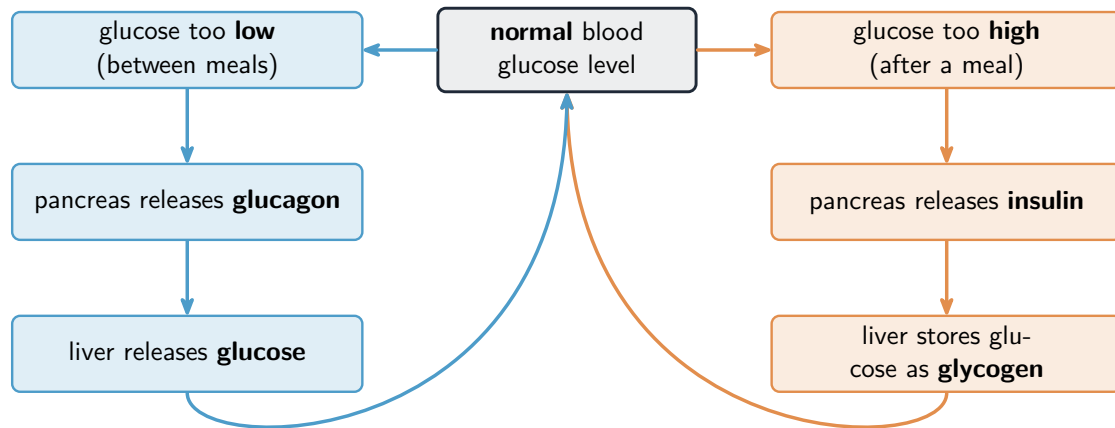
Homeostasis 稳态 is keeping a constant internal **environment** 环境 inside the body —for example a steady temperature and a steady blood glucose level.

(Supplement) Homeostasis works by **negative feedback** 负反馈: when a value moves away from its **set point** 设定点, the body acts to bring it back. The change itself triggers the correction.

Controlling blood glucose

The **liver** 肝脏 and the pancreas keep blood glucose steady:

- **insulin** lowers blood glucose after a meal —the liver stores the glucose as **glycogen** 糖原.
- (Supplement) **glucagon** raises blood glucose between meals —the liver releases glucose.



Insulin lowers blood glucose and glucagon raises it, keeping it near a normal level

In **Type 1 diabetes** 糖尿病 the pancreas cannot make insulin, so blood glucose rises too high. It is treated with insulin injections and a carefully planned diet.

Worked example. Blood glucose rises sharply after a meal, then falls back to normal over the next two hours. Name the organs and the hormone involved, and say what they do. The **pancreas** detects the rise and releases **insulin**. Insulin makes the **liver** take glucose out of the blood and store it as **glycogen**, so the level falls back to normal. Between meals the opposite loop runs: the pancreas releases glucagon and the liver releases glucose again. Keep the two words apart - insulin is the **hormone**, glycogen is the **store**. Swapping them is the classic error.

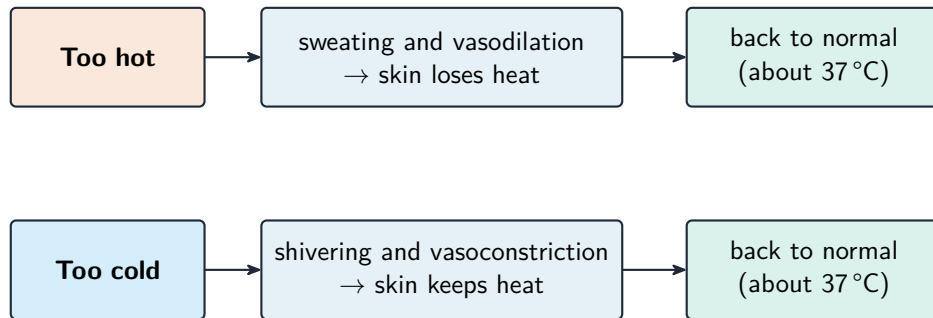
Controlling body temperature (Supplement)

The brain detects the body **temperature** 温度 and keeps it steady. The skin helps:

Structure	Role
sweat glands 汗腺	make sweat; as it evaporates it cools the skin (sweating 出汗)
hair erector muscles 立毛肌	raise the hairs to trap a layer of air
blood vessels 血管	change how much blood flows near the skin surface
fatty tissue 脂肪组织	gives insulation 隔热 to reduce heat loss

When you are **too hot**: you sweat, and the **arterioles** 小动脉 widen (**vasodilation** 血管舒张) so more blood flows to the skin **capillaries** 毛细血管 and loses heat.

When you are **too cold**: you **shiver** 颤抖 (the muscles make heat), and the arterioles narrow (**vasoconstriction** 血管收缩) so less blood reaches the surface, keeping heat in.



Negative feedback: a change away from about 37 °C triggers the response that reverses it, bringing the body back to normal.

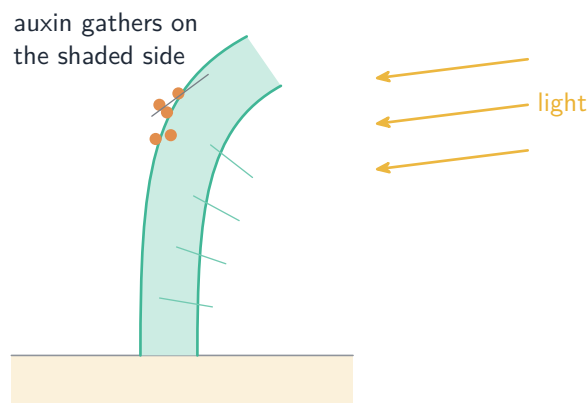
Tropisms

A **tropism** 向性 is a plant's growth response to a direction:

- **gravitropism** 向地性—growth in response to **gravity** 重力 (roots grow down, shoots grow up).
- **phototropism** 向光性—growth in response to the direction of light (shoots grow towards the light).

(Supplement) These responses are controlled by a chemical called **auxin** 生长素:

- auxin is made in the **shoot** 嫩枝 tip.
- it diffuses down through the plant.
- light or gravity makes the auxin spread unequally to one side.
- auxin makes cells **elongate** 伸长 (grow longer). The side with more auxin grows faster, so the shoot bends.



cells on the shaded side grow longer, so the shoot bends towards the light

Auxin gathers on the shaded side and makes those cells grow longer, bending the shoot to the light

Exam tips

- Nervous system: CNS (brain + spinal cord) and PNS (the nerves). Impulses travel along neurones.
- Learn the reflex arc in order: receptor → sensory → relay → motor → effector.
- At a synapse, neurotransmitter diffuses across the gap —this makes impulses go one way only.
- Eye: cornea and lens refract light; the lens changes shape (accommodation); rods for dim light, cones for colour.
- Hormones are slower but longer-lasting than nerves. Insulin lowers blood glucose; glucagon raises it.
- Too hot → sweating and vasodilation; too cold → shivering and vasoconstriction.
- Auxin from the shoot tip controls phototropism and gravitropism by making cells elongate.