# Coordination and Response

Matthew Williams • Biology • May 9, 2026

## Coordination and Response

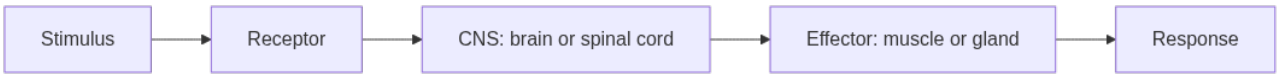
Living organisms need to detect and respond to changes in their environment to survive. Rapid changes are handled by the nervous system; slower, longer-lasting changes are managed by hormones. Both systems work by linking a stimulus (a change) to a response (an action).

### Stimulus and Response

A **stimulus** is any change in the environment, internal or external, that can be detected by an organism. A **response** is the reaction to that stimulus. The pathway from stimulus to response follows a consistent pattern:

**stimulus ’receptor ’coordinator ’effector ’response**

- **Receptor** — detects the stimulus (e.g. light receptor in the eye, temperature receptor in skin)
- **Coordinator** — processes the signal and decides on a response (brain or spinal cord)
- **Effector** — carries out the response (muscle or gland)




Stimulus-response pathway

Responding to stimuli is important for survival: finding food, avoiding predators, maintaining body temperature, and escaping harmful conditions.

### The Nervous System

The nervous system is divided into:

- **Central nervous system (CNS)** — brain and spinal cord; processes information and coordinates responses
- **Peripheral nervous system (PNS)** — all nerves that connect the CNS to the rest of the body

### Neurones

Neurones are specialised cells that carry electrical impulses. There are three types:

| Type | Function | Location |
|---|---|---|
| Sensory | carries impulses from receptor to CNS | sense organs to brain/spinal cord |
| Relay (interneurone) | connects sensory and motor neurones within the CNS | brain and spinal cord |
| Motor | carries impulses from CNS to effector | brain/spinal cord to muscles or glands |

A typical neurone has:

- **dendrites** — short extensions that receive impulses from other neurones
- **cell body** — contains nucleus and cytoplasm
- **axon** — long fibre that carries the impulse away from the cell body
- **myelin sheath** — fatty insulation that speeds up impulse transmission
- **synaptic knob** — tip of the axon where neurotransmitters are released

### Synapses

A synapse is the gap between two neurones. Electrical impulses cannot jump the gap directly. Instead:

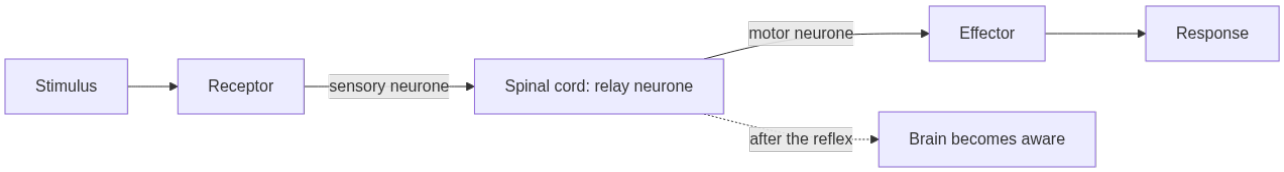
- 1. Impulse arrives at synaptic knob
- 2. Neurotransmitter molecules are released into the gap
- 3. Neurotransmitter diffuses across and binds to receptors on the next neurone
- 4. A new impulse is generated in the next neurone

Synapses ensure impulses travel in one direction only.

## Reflex Actions

A **reflex** is a rapid, automatic, involuntary response to a stimulus. Reflexes are important because they protect the body before the brain has time to process the situation consciously.

**Reflex arc:** receptor ’sensory neurone ’relay neurone (in spinal cord) ’motor neurone ’effector




The reflex arc

Example: touching something hot ’hand pulls away before conscious thought. The signal detours through the spinal cord without waiting for the brain, then the brain receives the signal afterwards.

## The Brain

The brain is the main coordinator of the nervous system. Three key regions to know:

| Region | Main functions |
|---|---|
| Cerebrum | conscious thought, memory, learning, language, voluntary movement, interpreting sensory information |
| Cerebellum | coordination of movement, balance, posture, fine motor control |
| Medulla oblongata | automatic (involuntary) functions: heart rate, breathing rate, peristalsis, swallowing |

## The Eye

The eye is the sense organ for light. Each part has a specific function:

| Structure | Function |
|---|---|
| Cornea | transparent covering; refracts (bends) most of the incoming light |
| Iris | controls pupil size; adjusts amount of light entering |
| Pupil | opening in the iris through which light passes |
| Lens | adjusts focus by changing shape (accommodation) |
| Retina | contains light-sensitive cells (rods and cones) |
| Rods | detect light and dark; work in dim light; no colour |
| Cones | detect colour; require bright light; concentrated at fovea |

| | |
|---|---|
| Optic nerve | carries impulses from retina to brain |

Labelled cross-section of the human eye showing cornea, iris, pupil, lens, retina, and optic nerve

### Accommodation

**Accommodation** is the process of changing the shape of the lens to focus on objects at different distances.

| Viewing | Ciliary muscles | Suspensory ligaments | Lens shape | Focal length |
|---|---|---|---|---|
| Near object | contract | relax (slack) | fat (more curved) | short |
| Distant object | relax | taut (pull lens) | thin (less curved) | long |

### Eye Defects

| Defect | Cause | Correction |
|---|---|---|
| Myopia (short-sightedness) | eyeball too long; image forms in front of retina | concave (diverging) lens |
| Hyperopia (long-sightedness) | eyeball too short; image would form behind retina | convex (converging) lens |
| Glaucoma | fluid pressure builds up inside the eye, damaging the optic nerve | eye drops, laser treatment, or surgery to reduce pressure |

> 📝 **Exam Tip**
> Glaucoma is caused by increased fluid pressure inside the eye — it damages the optic nerve and can cause blindness if untreated. It is different from myopia/hyperopia, which involve the shape of the eyeball.

## Skin as a Sense Organ

The skin contains several types of receptor that respond to different stimuli:

- **touch and pressure receptors** — detect contact and weight
- **temperature receptors** — separate receptors for heat and cold
- **pain receptors** — respond to damaging stimuli; trigger protective reflexes

# Hormones and the Endocrine System

Hormones are chemical messengers produced by endocrine glands, released into the blood, and carried to target organs. Their effects are slower but longer-lasting than nerve impulses.

| Gland | Hormone(s) | Target | Effect |
|---|---|---|---|
| Pancreas (islets of Langerhans) | insulin | liver, muscle, fat cells | lowers blood glucose: promotes glucose uptake and glycogen storage |
| Pancreas | glucagon | liver | raises blood glucose: breaks down glycogen to glucose |
| Adrenal glands | adrenaline | heart, muscles, liver | prepares body for "fight or flight": raises heart rate, dilates pupils, releases glucose |
| Pituitary gland | ADH | kidney collecting duct | increases water reabsorption |
| Pituitary gland | FSH, LH | ovaries | control menstrual cycle and ovulation |
| Ovaries | oestrogen, progesterone | uterus and elsewhere | control female reproductive cycle |
| Testes | testosterone | body | male secondary sexual characteristics; sperm production |
| Thyroid | thyroxine | whole body | regulates metabolic rate |

## Nervous vs Hormonal Control

| Feature | Nervous | Hormonal |
|---|---|---|
| Speed | very fast (milliseconds) | slow (seconds to minutes) |
| Duration | short-lived | longer-lasting |
| Transmission | electrical impulse along neurones | chemicals in blood |
| Specificity | precise: specific target | widespread: reaches all cells but only target cells respond |
| Example | reflex action | insulin controlling blood sugar |

## Responses of Invertebrates

Invertebrates such as woodlice, earthworms, and millipedes show clear behavioural responses to environmental stimuli. These responses improve survival:

| Stimulus | Typical response | Survival advantage |
|---|---|---|
| Light intensity | move away from bright light (negative phototaxis) | avoid desiccation and predators; remain under leaf litter |
| Temperature | move toward moderate warmth; avoid extremes | prevent overheating or freezing |
| Moisture | move toward humid areas (positive hydrotropism) | prevent desiccation; maintain cell function |

These responses can be investigated in a choice chamber — a container divided into two regions with different conditions. The number of animals in each region after a set time indicates their preference.

## Plant Tropisms

Plants respond to environmental stimuli by growing toward or away from them. These growth movements are called **tropisms**.

| Tropism | Stimulus | Response |
|---|---|---|
| Phototropism | light | shoot grows toward light (positive); root grows away (negative) |
| Geotropism | gravity | root grows downward (positive); shoot grows upward (negative) |

Tropisms result from unequal growth — one side of the shoot or root elongates faster than the other, causing a bend. The detailed hormonal mechanism is beyond the CSEC syllabus; focus on the direction of growth and its survival advantage.

# Drug Abuse

Drugs are substances that alter the way the body or mind functions. They include **legal drugs** (alcohol, caffeine, prescription medicines) and **illegal drugs** (heroin, cocaine). Misuse of any drug — including the misuse of prescription drugs such as diet pills, tranquilisers, steroids, and analgesics — has physiological, social, and economic consequences.

## Alcohol

Alcohol (ethanol) is a legal depressant — it slows the nervous system:

- **Short term:** slowed reactions, impaired judgement, loss of coordination, lowered inhibitions
- **Long term:** liver cirrhosis (scarring that prevents normal liver function), brain damage, addiction, heart disease

## Heroin (an illegal depressant)

Heroin is a highly addictive opiate that mimics natural pain-relief chemicals in the brain:

- **Physiological:** severe dependence; withdrawal is painful; sharing needles spreads HIV and hepatitis
- **Social:** crime to fund habit; breakdown of family relationships
- **Economic:** costly treatment; lost productivity; law enforcement burden

## General Effects of Drug Abuse

| Effect type | Examples |
|---|---|
| Physiological | addiction and dependence; organ damage (liver from alcohol, lungs from tobacco); brain chemistry changes; withdrawal symptoms |
| Social | strained family relationships; crime; poor decision-making; loss of employment; neglect of responsibilities |
| Economic | cost of healthcare; reduced productivity; law enforcement costs; burden on families |

> **📝 Exam Tip**
> Exam questions on drug abuse often ask for effects under multiple headings. Make sure you can give distinct answers for physiological, social, and economic effects — the same point will not score in two categories.

## PRACTICE — COORDINATION AND RESPONSE

**Stimulus**
A change in the environment that can be detected by a receptor.

**Receptor**
A cell or organ that detects a stimulus and converts it to a nerve impulse.

**Effector**
A muscle or gland that produces a response.

**Reflex**
A rapid, automatic, involuntary response to a stimulus that protects the body.

**Synapse**
The gap between two neurones; signals cross it via neurotransmitters.

**Sensory neurone**
A nerve cell that carries impulses from a receptor to the CNS.

**Motor neurone**
A nerve cell that carries impulses from the CNS to an effector.

**Cerebrum**
The largest part of the brain; controls conscious thought, memory, and voluntary movement.

**Cerebellum**
Controls coordination, balance, and fine motor movements.

**Medulla oblongata**
Controls automatic functions such as heart rate and breathing.

**Accommodation**
The adjustment of lens shape to focus on objects at different distances.

**Myopia**
Short-sightedness; corrected by a concave lens.Insulin === A hormone from the pancreas that lowers blood glucose by promoting uptake and glycogen storage.

**Glaucoma**
An eye condition caused by increased fluid pressure that damages the optic nerve; can lead to blindness if untreated.

**Negative phototaxis**
Movement away from light; shown by invertebrates such as woodlice to avoid desiccation.