Coordination and Response

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Coordination and Response

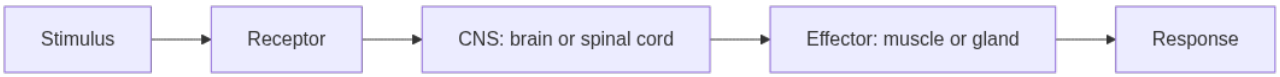
Living organisms need to detect and respond to changes in their environment to survive. Rapid changes are handled by the nervous system; slower, longer-lasting changes are managed by hormones. Both systems work by linking a stimulus (a change) to a response (an action).

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:

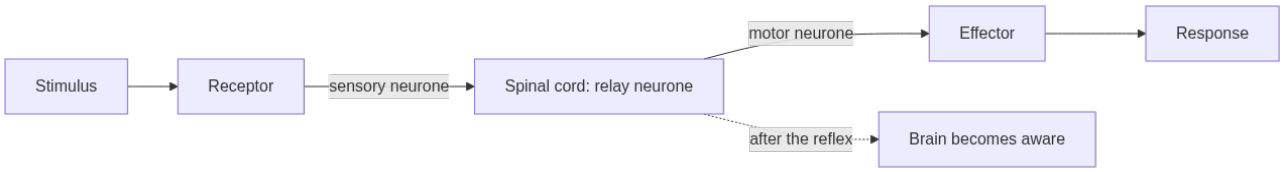
- 1. Impulse arrives at synaptic knob
- 2. Neurotransmitter molecules are released into the gap
- 3. Neurotransmitter diffuses across and binds to receptors on the next neurone
- 4. A new impulse is generated in the next neurone

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.

> **Helpful but not required: spinal cord and spinal nerves**
> The syllabus explicitly says that diagrams showing the spinal cord and spinal nerves are **not required**. Still, it may help to know the idea: nerves connected directly to the brain are called **cranial nerves**, while nerves connected to the spinal cord are called **spinal nerves**. A withdrawal reflex, such as pulling your hand away from heat, is usually a spinal reflex because the impulse is coordinated through the spinal cord before the brain becomes consciously aware.

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

Choroid	black, blood-rich layer; supplies the eye with oxygen and nutrients and absorbs stray light to prevent internal reflection
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.

> 📝 **Exam Tip**
> Invertebrate-response questions may use unfamiliar examples. For example, Daphnia move upward in darkness to feed on algae. Artificial light at night can disrupt this behaviour, so fewer may come to the surface, feeding patterns may change, and the food web may be affected. Apply the same rule: identify the stimulus, describe the response, then link it to survival or feeding.

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)
Thigmotropism	touch/contact	some climbing shoots or tendrils grow around a support

Tropisms result from unequal growth — one side of the shoot or root elongates faster than the other, causing a bend. For the syllabus, focus on the stimulus, direction of growth, and survival advantage.

> **Helpful but not required: auxins**
> The CSEC Biology syllabus explicitly mentions that the **role of auxins is not required**. The underlying idea may still be useful: auxins are plant hormones involved in growth. In shoots exposed to light from one side, auxins collect more on the shaded side. Cells on that shaded side elongate faster, so the shoot bends toward the light. This helps explain phototropism, but for the exam you mainly need the stimulus, direction of growth, and 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.

Drug abuse means using a drug improperly, for example taking an illegal drug, taking medicine without medical need, taking the wrong dose, or using a drug repeatedly in a way that harms the body or mind.

Why Young People May Abuse Drugs

Young people may abuse drugs for several reasons:

Reason	How it may lead to drug abuse
Curiosity or experimentation	trying a drug once can lead to repeated use, especially if the drug is addictive
Peer pressure	friends or social groups may make drug use seem normal or desirable
Stress, anxiety, or family problems	drugs may be used as an unhealthy way to cope with emotional pressure
Low self-esteem or body-image pressure	diet pills or stimulants may be misused by someone trying to lose weight quickly
Media and social media influence	unrealistic images of beauty, status, or lifestyle can encourage risky choices
Easy access to drugs	alcohol, cigarettes, prescription medicines, or illegal drugs may be available at home, in the community, or from peers
Addiction or dependence	after repeated use, the person may crave the drug and find it difficult to stop

The textbook emphasises that addiction makes a person want more of the drug despite harm, and that giving up alcohol or other addictive drugs is difficult because withdrawal symptoms may occur. It also treats smoking among teenagers as an early warning sign for later substance abuse.

Measures to Reduce Drug Abuse

Drug abuse can be reduced by combining prevention, support, and control:

Measure	How it helps
Education programmes in schools and communities	teach the short-term and long-term effects of drugs before habits form
Public awareness campaigns	correct misleading information, such as unsafe weight-loss claims about diet pills
Strong family and peer support	gives young people healthier ways to handle stress and resist peer pressure
Counselling and rehabilitation	help addicted persons understand triggers, change behaviour, and recover

Medical help during withdrawal	reduces danger when a person stops using an addictive substance
Enforcing laws on illegal drugs, alcohol, tobacco, and prescriptions	limits access and discourages selling or supplying harmful drugs
Healthy activities and support groups	provide belonging, confidence, and alternatives to drug-taking groups

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. If a question asks for ways to reduce drug abuse, give practical measures such as education, counselling, rehabilitation, family support, medical help, and law enforcement.

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.

Drug abuse
Improper use of a drug, such as taking an illegal drug, taking medicine without medical need, or using a drug in a harmful way.

One reason young people may abuse drugs
Peer pressure, curiosity, stress, body-image pressure, easy access, media influence, or addiction/dependence.

One measure to reduce drug abuse
Education, counselling, rehabilitation, family support, medical help during withdrawal, law enforcement, or healthy support groups.