CIE Biology GCSE

14: Coordination and Response

Notes

(Content in **bold** is for Extended students only)

The nervous system

Both **controlled movement and autonomic reflexes** are carried out by the body's **nervous system**. The nervous system controls movement by sending **electrical signals** known as **nerve impulses** along a network of **specialised** nerve cells called **neurons**. This allows **coordinated movement** and a **constant internal environment** to be maintained (homeostasis).

The nervous system consists of two main sections: the **central nervous system** (CNS) and the **peripheral nervous system**. The CNS is made up of the **brain and spinal cord,** whereas the peripheral nervous system contains **motor and sensory neurons,** which carry impulses to and from the CNS.

Types of neuron:

- **Sensory** - carries impulses from a receptor to the spinal cord and brain
- **Relay (connector)** - carries impulses between different parts of the central nervous system
- **Motor (effector)** - carries nervous impulses from the central nervous system to the effector, e.g. a muscle

Synapses:

Where two neurons meet is called a **synapse**. **The synapse forms a gap called a synaptic cleft between the presynaptic neuron and the postsynaptic neuron. When an impulse arrives at the presynaptic neuron, vesicles in the neuron fuse with the membrane, releasing a neurotransmitter into the synaptic cleft. The neurotransmitter diffuses across the synapse, binding to receptors on the postsynaptic neuron. This triggers a nervous impulse in the postsynaptic neuron, thus the impulse can continue.**

Synapses ensure unidirectionality of nervous impulses, as the vesicles containing the neurotransmitter are only present in the presynaptic neuron, whilst the receptors are only present in the postsynaptic neuron, thus the impulse cannot travel backwards.

Many drugs act upon synapses. Stimulants, such as caffeine, can cause the release of neurotransmitters like dopamine and serotonin into the synapse, whereas depressants, such as heroin and alcohol, inhibit synapses by blocking the receptors on the postsynaptic neuron so that impulses cannot be sent.

Reflexes:

Some movement is involuntary; organisms have adapted to carry out automatic reflexes when in danger in order to quickly remove themselves from a hazard such as fire or sharp objects. As these reactions must occur almost instantly to protect the organism, the nervous impulse does not travel to the brain. Voluntary impulses are controlled by the brain.

Reflex arc:

1. A **stimulus**, such as heat from a flame, is detected by **receptors**.
2. The receptor sends an impulse down the **sensory neuron** to the **spinal cord**.
3. The **relay neuron** in the CNS passes the impulse to the **motor neuron**.
4. The impulse travels along the motor neuron to an **effector** (e.g. a muscle), which reacts to remove the organism from the danger.

The eye

Sense organs are groups of receptor cells which **respond to a specific stimulus**. The eye is a sense organ which responds to **light**. Other sense organs may respond to **temperature, touch, sound and chemicals**.

Eye structure:

- **Cornea** - A clear layer which coats the iris. The cornea refracts light into the eye.
- **Iris** - The coloured section of the eye. This controls the amount of light that enters the eye by contracting and dilating the pupil.
- **Pupil** - Allows light into the eye
- **Lens** - Positioned behind the iris. The lens changes shape in order to focus the image on the retina.
- **Retina** - Contains rod and cone cells which are sensitive to light, these are also called photoreceptors. There are also many blood vessels which supply nutrients to these cells.
- **Fovea - a section in the middle of the retina which contains a large amount of cone cells; this section provides the clearest image.**
- **Optic nerve** - Each photoreceptor cell is attached to a neuron. These neurons group together to form the optic nerve, which carries the impulse to the brain.

Rods and cones:

Rods and cones are the two types of photoreceptor cells found in the eye:

	Rods	Cones
Shape	**Rod-shaped**	**Cone-shaped**
Function	**Used for monochromatic night vision as they are more sensitive to low levels of light**	**Used for colour vision in bright light. There are three types of cone cells, each sensitive to a different colour (red, green and blue)**
Distribution	**Evenly distributed at the periphery of the retina; absent at the fovea**	**Concentrated at the fovea**

Pupil reflex:

The pupil of the eye can expand and contract to control the amount of light that enters the eye. **This action is carried out by two sets of muscles, circular muscles and radial muscles, which work antagonistically.** At low light intensities, the pupil dilates to allow more light to enter the eye **by relaxing the circular muscles and contracting the radial muscles.** At high light intensities, the pupil constricts to limit the amount of light entering the eye **by relaxation of the radial muscles and contraction of the circular muscles.** This is to prevent the eye being damaged by the bright light.

Accommodation:

The eye can focus on both near and far objects. This is achieved by changing the shape of the lens, which is controlled by ciliary muscles and suspensory ligaments. These work antagonistically. The shape of the lens, as well as its curvature, is altered to change the way light is refracted onto the retina, focusing the image.

To focus on near objects, the ciliary muscles contract whilst the suspensory ligaments relax, making the lens fatter and curved. To focus on distant objects, the ciliary muscles relax whilst the suspensory ligaments contract, making the lens thinner and less curved.

The endocrine system

The endocrine system **produces and secretes hormones**. Hormones are molecules that travel in the blood and are used for **signalling** in the body. They are **produced in glands** such as the pituitary and adrenal glands, before being **excreted into the blood**, where they travel to **target organs** and cause a change in the cells.

Endocrine glands:
A network of hormone-secreting glands make-up the endocrine system. This system helps to **control growth, metabolism and homeostasis**, among other functions.

Example glands and functions:

Gland	Hormone	Function
Adrenal gland (located at the top of the kidneys)	Adrenaline	Secreted during the 'fight or flight' response, and when stressed or excited. It leads to an **increase in pulse rate** and **widened pupils**. **It also causes glycogen to be converted to glucose in cells so that it can be used in respiration for energy. Heart rate increases to provide more oxygen for this.**
Pancreas	Insulin	Maintains **blood-glucose concentration.**
Testes	Testosterone	Maintains **muscle and bone strength** and plays a role in **reproduction**.
Ovaries	Oestrogen	Regulates female **reproductive system**.

Endocrine system vs nervous system:

- Nervous impulses travel along **neurons** whereas hormones travel in the **blood**.
- **Nervous impulses are much quicker than hormones, as hormones must be transported in the blood whereas nervous impulses can travel along specialised nerve cells.**
- **Nervous impulses are instantaneous and short-lived, whereas a hormonal response can be long-lasting.**
- The endocrine system uses **chemicals (hormones)** whereas the nervous system uses **electrical signals**.

Homeostasis

Homeostasis is the maintenance of a **constant internal environment** in organisms, despite external changes. This allows the environment to be at an **optimum for cells** to function. **Internal conditions must be maintained between set limits and if these limits are exceeded, negative feedback mechanisms work to correct the change and restore the internal environment to the optimum.**

Regulating blood-glucose concentration:
The level of glucose in the blood must be maintained as part of homeostasis:

- **If the level of glucose in the blood is too high, the water potential of the blood becomes very low, thus water moves out of cells into the blood by osmosis. This leads to cells shrinking and eventually dying.**

- **If the level is too low, water potential is high and thus water moves from the blood into the cells, causing them to burst. Maintaining a constant blood-glucose level therefore maintains a constant water potential so no unwanted osmosis occurs. In addition, it means that there is a reliable source of energy for cells.**

There are two hormones that are used to regulate blood-sugar levels: glucagon and insulin. Both of these are synthesised in cells in the pancreas and are released into the blood from here when the levels of blood-glucose are too high or too low:

- **Insulin is released when blood-glucose concentration is too high. This is detected in the pancreas. Insulin causes glucose to be converted to glycogen in the liver. This lowers the concentration of glucose in cells, thus glucose diffuses into cells from the blood, lowering the amount of glucose in the blood.**

- **Glucagon is released when blood-glucose concentration is too low. Glucagon inhibits glucose being converted to glycogen in the liver and activates an enzyme that converts glycogen to glucose, making more glucose available to cells. It also decreases the respiratory rate in cells so that less glucose is used in respiration.**

People with diabetes cannot produce insulin. Type 1 diabetes is caused by an autoimmune response in which antibodies attack cells in the pancreas which usually make insulin. This means that no insulin can be produced. In type 2 diabetes, either not enough insulin is produced by the pancreas, or the cells do not respond correctly to the insulin. Type 1 diabetes

is usually treated by patients injecting insulin themselves. There are several new treatments being developed, including the use of stem cells and artificial pancreases, although these treatments will be very expensive.

Regulating temperature:

It is important to maintain a constant temperature of 37°C in humans as this is the **optimum temperature for enzyme reactions**. If the temperature was lower, the **rate of reaction would decrease** so reactions would take too long to occur. If it was too high, the enzymes may **denature** and prevent reactions from occurring. The temperature is regulated by the **hypothalamus** in the brain, which contains **thermoreceptors**. If the temperature moves away from the optimum, a response is triggered to return the temperature to the optimum.

Reactions to a **low** internal temperature:

- **Shivering** - muscles contract to produce heat.
- **Vasoconstriction - blood vessels constrict to reduce surface area and move away from the surface of the skin to reduce heat loss.**

Reactions to a **high** internal temperature:

- **Sweating**- sweat evaporates from the skin, reducing the surface temperature.
- **Vasodilation - blood vessels dilate, causing more heat loss to the environment**.

Tropic Responses

Tropisms are **growth movements** in plants that occur in reaction to **external stimuli**. Plants can show a **positive** or **negative** response, and different parts of the plants can show different responses. **These responses are controlled by plant hormones called auxins which cause cell elongation. Auxins are made in shoot tips and move through the plant by diffusion and active transport (short distances), or via the phloem (longer distances).**

Gravitropism:

Gravitropism (also known as geotropism) is a response to **gravity**. **Shoots are negatively gravitropic**, as they grow upwards against gravity, whereas **roots are positively gravitropic**.

Phototropism

Phototropism is a response to **light**. Plant **shoots are positively phototropic**, as they **move towards light** in order to allow the plant to absorb more light to photosynthesise. Plant **roots are negatively phototropic** as they move away from light.

Phototropic response:

1. **Auxins are produced in the shoot tips, which are then transported down the shoot.**
2. **Light causes the auxin to move to the shady side of the shoot.**
3. **The auxin causes cell elongation on the shady side.**
4. **The cells grow faster on the shaded side, thus the shoot bends towards the light.**

Weed killers:

Weed killers are used to selectively kill plants. One of the main herbicides contains an organic compound known as 2,4-D, which is a synthetic plant hormone. When a plant is exposed to 2,4-D, it results in uncontrolled growth, leading to the plant's death.