Collins

Student Book

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EDEXCEL INTERNATIONAL GCSE (9-1) BIOLOGY

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Contents

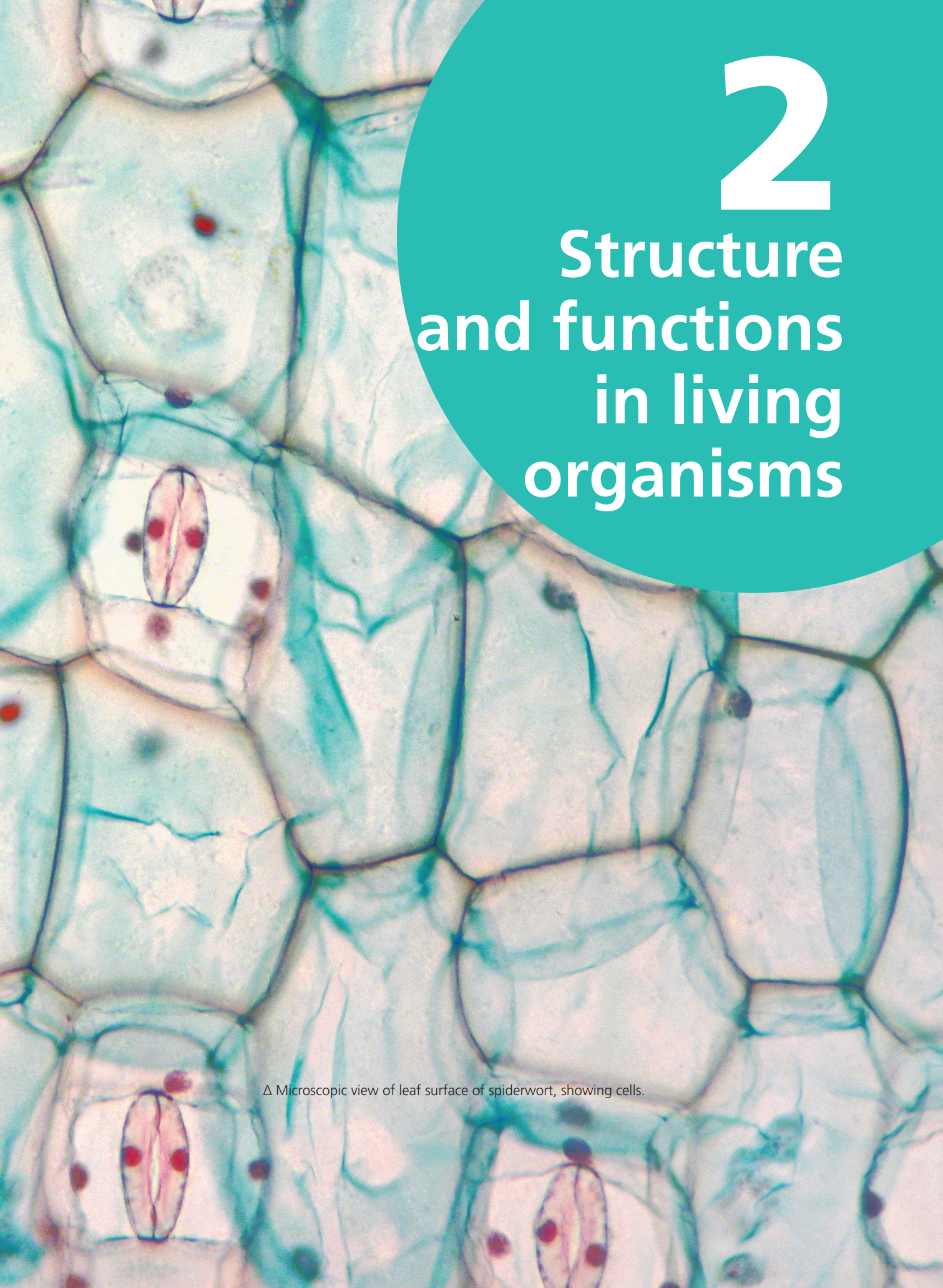
When we talk about the 'heart' of something, in a general way, we mean the centre of something – not only where it is, but also the role it plays. And for good reason: the human heart is not only positioned in the middle of the body; it also plays a central role in maintaining life.

The heart and circulatory system function to circulate blood around the body and so deliver oxygen from the lungs, and nutrients from the digestive system, to all cells so that they can respire and carry out all the processes needed for life. The blood then removes waste products from these processes, for example delivering carbon dioxide to the lungs and urea to the kidneys for excretion and removal from the body. The heart plays a central role in staying alive and staying healthy.

STARTING POINTS

1. How is the body organised so that it can carry out the life processes effectively?
2. What do all cells have in common, and how are some cells different from others?
3. What are the basic molecules of life?
4. How do cell membranes control what can get into and out of the cell?
5. How do plants and humans get the food they need for growth?
6. What is cellular respiration and how do the body systems support it?
7. How are gas exchange surfaces adapted for rapid exchange of gases into and out of the body?
8. How are materials transported around the bodies of plants and humans?
9. What are the waste materials of metabolism and how are they removed from the body?
10. How do plants and humans respond to changes in the environment around them?

SECTION CONTENTS



2 Structure and functions in living organisms

Δ Microscopic view of leaf surface of spiderwort, showing cells.

Coordination and response

INTRODUCTION

US tennis star Andy Roddick can hit a tennis ball so hard that it travels at around 250 km per hour. In order to return the ball successfully, his opponents have only a fraction of a second to work out where to stand and how best to return the ball. Their response is built on years of training, so that they can respond without consciously thinking.

Δ Fig. 2.110 Professional tennis players serve so quickly that a radar gun is used to measure the speed of the ball.

KNOWLEDGE CHECK

- ✓ Plants and animals detect the environment with specialised sense organs.
- ✓ Animals respond to changes in the environment using nervous and hormonal systems.
- ✓ Plants respond to changes in the environment using their hormonal system.
- ✓ Nerve cells are specialised cells adapted to the function of carrying electrical impulses.

LEARNING OBJECTIVES

- ✓ Understand how organisms are able to respond to changes in their environment.
- ✓ Understand that homeostasis is the maintenance of a constant internal environment, and that body water content and body temperature are both examples of homeostasis.
- ✓ Understand that a coordinated response requires a stimulus, a receptor and an effector.
- ✓ Understand that plants respond to stimuli.
- ✓ Describe the geotropic and phototropic responses of roots and stems.
- ✓ Understand the role of auxin in the phototropic response of stems.
- ✓ Describe how nervous and hormonal communication control responses and understand the differences between the two systems.
- ✓ Understand that the central nervous system consists of the brain and spinal cord and is linked to sense organs by nerves.
- ✓ Understand that stimulation of receptors in the sense organs sends electrical impulses along nerves into and out of the central nervous system, resulting in rapid responses.
- ✓ Understand the role of neurotransmitters at synapses.
- ✓ Describe the structure and functioning of a simple reflex arc illustrated by the withdrawal of a finger from a hot object.
- ✓ Describe the structure and function of the eye as a receptor.
- ✓ Understand the function of the eye in focusing on near and distant objects, and in responding to changes in light intensity.
- ✓ Describe the role of the skin in temperature regulation, with reference to sweating, vasoconstriction and vasodilation.
- ✓ Understand the sources, roles and effects of the following hormones: adrenaline, insulin, testosterone, progesterone and oestrogen.
- ✓ Understand the sources, roles and effects of the following hormones: ADH, FSH and LH.

SENSITIVITY

Sensitivity, the ability to recognise and respond to changes in external and internal conditions, is recognised as one of the characteristics of living organisms.

A change in conditions is called a **stimulus**. To produce a coordinated response to that stimulus, there must be a **receptor** that can recognise the stimulus and an **effector**, a mechanism to carry out the response. **Coordination** means detecting and responding appropriately to a particular stimulus.

Coordination and response in flowering plants

TROPISMS

Plants generally respond to changes in the environment by a change in the way they grow. For example, a shoot grows towards light, and in the opposite direction to the force of gravity, while a root grows away from light, but towards moisture and in the direction of the force of gravity. These growth responses to a stimulus in plants are called **tropisms**. These responses help the plant produce leaves where there is the most light, and roots that can supply the water that the plant needs.

◁ Fig. 2.111 The response of growing towards light helps a plant get more light for photosynthesis.

Growth in response to the direction of light is called **phototropism**. If the growth is *towards* light, it is called *positive* phototropism, as in shoots. Roots grow *away* from light so they are *negatively* phototropic. Growth in response to gravity is called **geotropism**. Roots show *positive* geotropism, but shoots are *negatively* geotropic.

Tropisms are controlled by plant hormones called **auxins**. These hormones are made in the tips of shoots (and roots) and diffuse away from the tips. Further back along a shoot, the hormones *stimulate* cells to elongate (grow longer) so that the shoot grows longer.

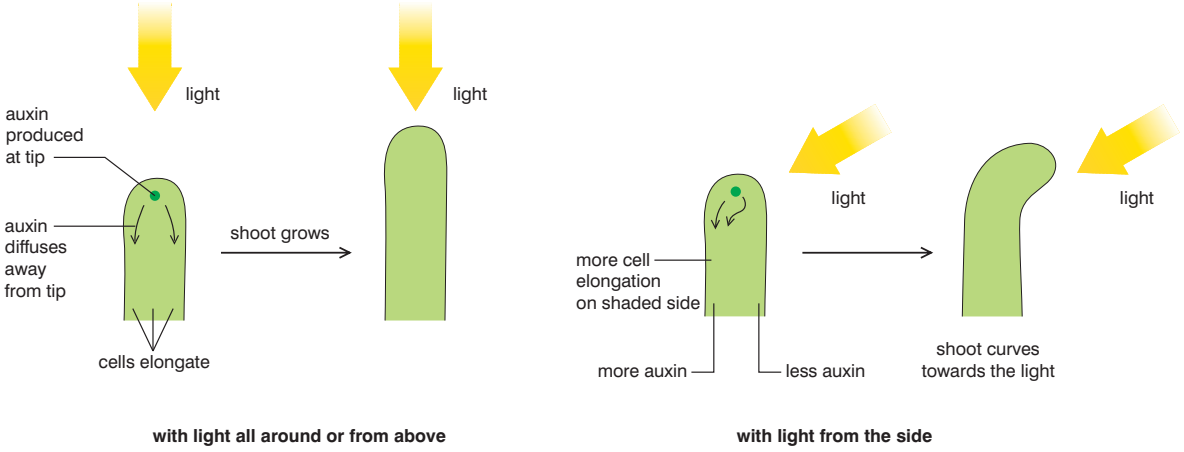
SCIENCE IN CONTEXT

GARDENER'S TIP

One effect of the hormone auxin is to inhibit the growth of side shoots. This is why a gardener who wants a plant to stop growing taller and encourage it to become more bushy will take off the shoot tip, so removing a source of auxin.

The growth of shoots towards light can be explained by the response of auxin to light.

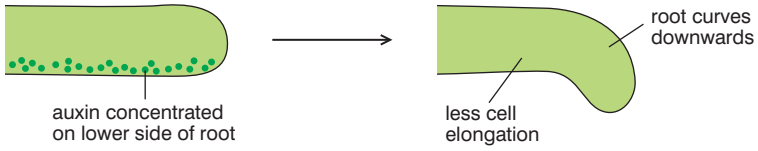
- When all sides of a shoot receive the same amount of light, equal amounts of auxin diffuse down all sides of the shoot. So cells all around the shoot are stimulated equally to grow longer. This means the shoot will grow straight up.
- When the light on the shoot comes mainly from the side, auxin on that side of the shoot moves across the shoot to the shaded side. The cells on the shaded side of the shoot will receive more auxin, and so grow longer, than those on the bright side. This causes the shoot to curve as it grows, so that it grows towards the light.



Δ Fig. 2.112 The effect of light and auxin on the growth of shoots.

The hormone is also made in root tips. However, it has the opposite effect on root cells compared with shoot cells, because it *reduces* how much the cells elongate.

- When roots are pointing straight down, all sides of the root receive the same amount of hormone, so all cells elongate by the same amount.
- When the root is growing at an angle to the force of gravity, gravity causes the hormone to collect on the lower side. This reduces the amount of elongation of cells on the lower side of the root, so that the root starts to curve as it grows until it is in line with the force of gravity.



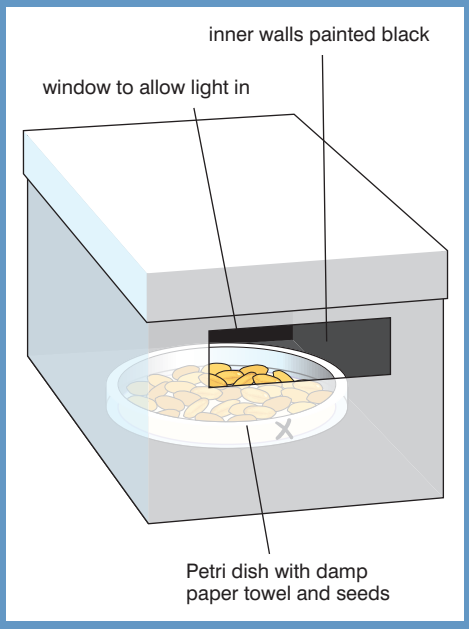
Δ Fig. 2.113 The effect of gravity on the growth of roots.

REMEMBER

A full understanding of the phototropic responses in stems is needed to gain higher marks. Remember that auxin causes shoots to curve by the elongation of existing cells, not by the production of more cells.

Developing investigative skills

Fig. 2.114 shows apparatus that can be used to investigate the effect of light on the growth of seedlings.



△ Fig. 2.114 Apparatus for investigating the effect of light on growing seeds.

Devise and plan investigations

❶ Describe how the apparatus could be used for this investigation.

❷ Describe how you would set up a control for this investigation.

Make observations and measurements

❸ **a)** If this investigation were set up correctly, what result would you expect to see in the seedlings from the windowed box, compared with your control?

b) Explain your answer.

Evaluate data and methods

❹ Suggest how this investigation could be extended to investigate whether roots also show a phototropic response.

QUESTIONS

1. Describe the term *tropism* in your own words.

2. Give one example of:

a) positive phototropism

b) positive geotropism.

3. Describe the action of auxin in a shoot growing in one-sided light.

Coordination and response in humans

There are two systems involved in coordination and response in humans.

- One is the **nervous system**, which includes the brain, the spinal cord, the peripheral nerves and specialist sense organs such as the eye and the ear. Communication in the nervous system is in the form of **electrical impulses** and responses may be very rapid.

- The other is the **hormonal** (or endocrine) **system**, which uses chemical communication by means of hormones. Hormones are secreted by **endocrine glands** and act upon target cells in other tissues and organs. The hormonal system helps to maintain basic body functions including metabolism and growth. It often has more long-term effects than the nervous system and usually its response is less rapid.

REMEMBER

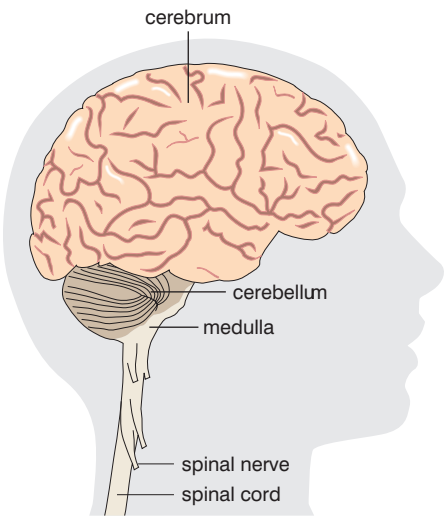
For the top marks you must be able to compare and contrast the two systems of coordination in humans.

Try also to identify the stimulus, receptor, effector and response in any example of the nervous or hormonal system.

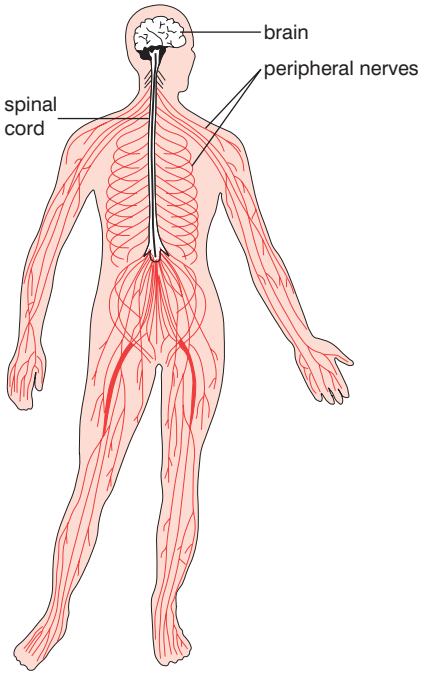
THE NERVOUS SYSTEM

In the human nervous system:

- Specialised **sense organs** that contain receptor cells sense stimuli (changes in conditions).
- Information about these stimuli is sent as electrical impulses from the receptor cells through nerves to the central nervous system.
- The **central nervous system** (**brain** and **spinal cord**) processes the electrical impulses and coordinates the response.
- The response passes as electrical impulses along nerves to effectors, which are often muscles but may be endocrine glands.
- The effectors produce the response to the stimulus.



Δ Fig. 2.115 The human central nervous system.



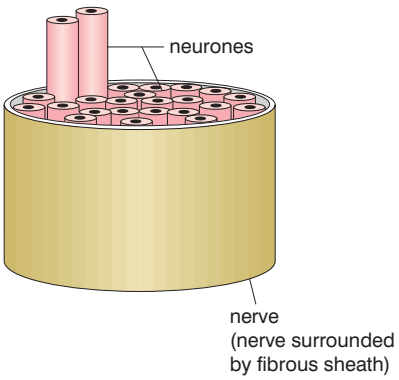
Δ Fig. 2.116 The nervous system.

Nerve cells

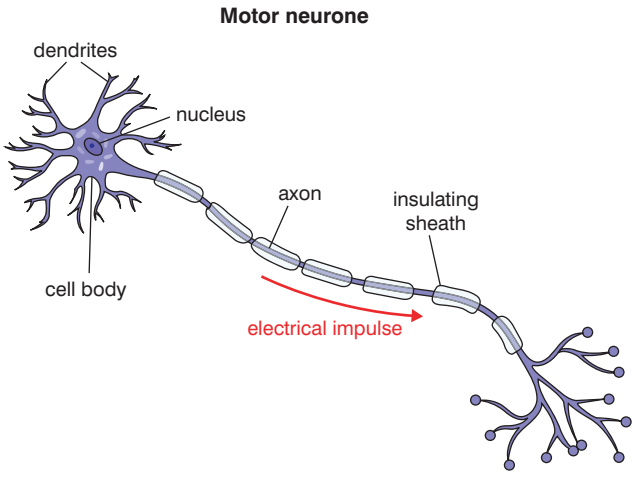
Nerves connect the sense organs to the central nervous system, and the central nervous system to effectors. Nerves, the brain and the spinal cord are all made of specialised cells called **neurones**.

Neurones are specially adapted for their function because they have many endings that connect with other neurones for passing electrical impulses, and long cell extensions, called axons and dendrons, that carry the electrical impulses.

- Neurones that link sense organs to the central nervous system are called sensory neurones.
- Neurones within the central nervous system may be very short, and are called relay (sometimes intermediate or connecting) neurones.
- Neurones that connect the central nervous system to an effector, such as a muscle, are called motor neurones.

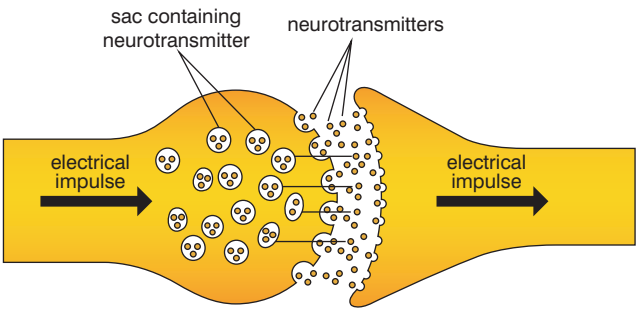


Δ Fig. 2.117 Nerves are large bundles of many neurones.



Synapses

Sometimes impulses may have to pass along several neurones. The place where an impulse passes from one neurone to another is called a **synapse**. This is a very small gap between the ends of two neurones. The electrical impulse itself does **not** travel across the gap, but instead causes chemicals called **neurotransmitters** to be released from the end of one neurone which diffuse across the synapse. When the neurotransmitters reach the next neurone they cause a new electrical impulse to be sent. Although the neurotransmitters travel by diffusion, because the synapse is so narrow (about 1/50,000th of a mm), the whole process happens very quickly.



Δ Fig. 2.118 When an electrical impulse arrives at a synapse, neurotransmitters are released which start a new impulse in the next neurone.

Synapses mean that impulses can only travel in one direction from one neurone to another. They also allow one neurone to pass impulses to several others at the same time, or to receive impulses from several others.

SENSE ORGANS

Different sense organs contain different specialised receptor cells that respond to different stimuli. The table shows the different sense organs in humans.

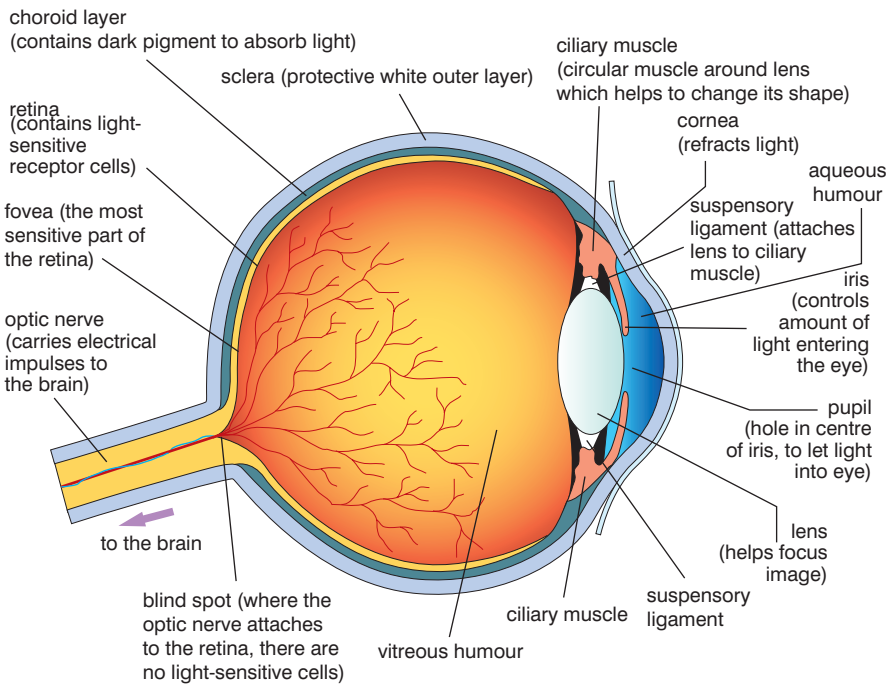
Sense organ	Sense	Stimulus
Skin	Touch	Pressure, pain, hot/cold temperatures
Tongue	Taste	Chemicals in food and drink
Nose	Smell	Chemicals in the air
Eyes	Sight	Light
Ears	Hearing	Sound (vibrations in air)
	Balance	Movement/position of head

Δ Table 2.9 Sense organs in humans.

The eye

In humans, the eye is the sense organ that responds to changes in light. The specialised light-sensitive receptor cells are found in the **retina** at the back of the eye. Light passing through the eye and reaching the retina causes changes in these cells, sending electrical impulses to the brain along the optic nerve. Other structures of the eye support this process.

- The **cornea**, lens, aqueous and vitreous humour are all transparent, to let light pass through. The cornea and lens refract (bend) light to form an image on the retina. The jelly-like aqueous and vitreous humour maintain the shape of the eyeball.
- The pupil is a hole in the iris that controls how much light enters the eye.
- The inside of the eye is very dark, to stop light reflecting and so cause multiple images.



Δ Fig. 2.119 Structure of the human eye.

There are two different kinds of light-sensitive cells in the retina.

- **Cone cells** respond to light of different *wavelengths*, and therefore respond to different colours. They only work well in bright light, so we only see colour images when the light is bright enough. The cone cells are mostly clustered at the fovea on the retina, where most light falls.
- **Rod cells** respond to differences in light *intensity*, not wavelength. They are more sensitive at low light intensities than cone cells, so we use these mostly in low light conditions. They can not distinguish different colours. Rod cells are found all over the retina.

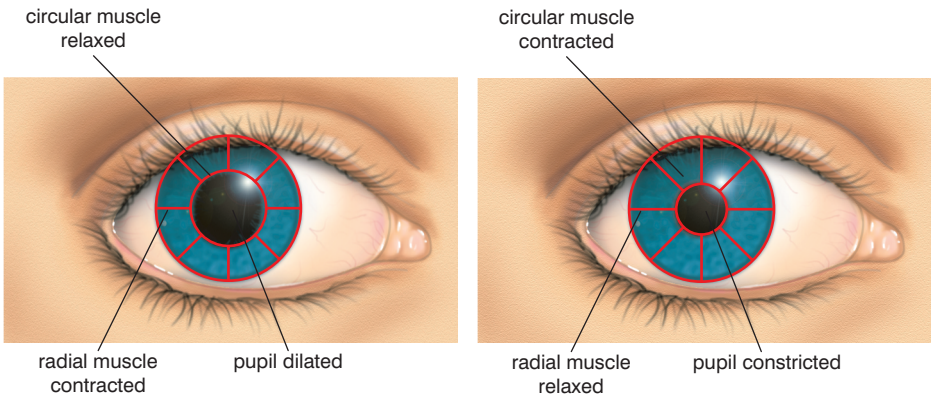
SCIENCE IN CONTEXT

DARK ADAPTATION

In bright light the rod cells lose their ability to respond. This is because the coloured pigment in the cells that responds to light is changed into another form. As the light becomes dimmer, the pigment slowly changes back into the form that detects light. However, it can take up to half an hour for the rods to fully recover. This is known as dark adaptation and explains why, if you move from a bright place to a darker place, it takes a while for your eyes to adjust and see clearly again.

Changing light conditions

The light-sensitive cells in the retina only respond to the stimulus of light above a certain light intensity. When it is so dark that the cells are not stimulated, we cannot see. Since vision is an important sense, at low light intensities our eyes need to gather as much light as possible. However, rod and cone cells are easily damaged by high light intensity – which is why you should NEVER look directly at a bright light source such as the Sun.



Δ Fig. 2.120 The pupil response to light. Left: in dim light. Right: in bright light.

The iris (ring-shaped, coloured part of the eye) controls the amount of light entering the eye by controlling the size of the hole in the centre, the pupil. The iris contains circular and radial muscles. In bright light

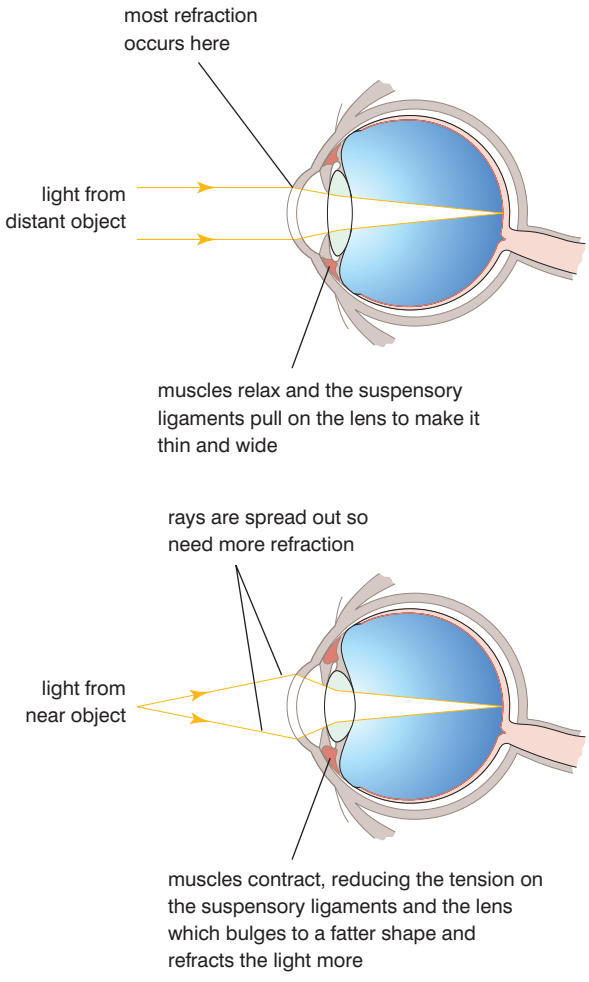
the circular muscles contract and the radial muscles relax, making the pupil smaller. This prevents damage to the cells in the retina by reducing the amount of light entering the eye. The reverse happens in dim light, when the eye has to collect as much light as possible to see clearly.

Focusing light

In order to see clear images of our surroundings, the light that enters our eyes needs to be focused properly on the retina.

The thick clear cornea bends light rays as they enter the eye in order to focus them on the retina. The lens provides fine focus to sharpen the image.

Rays of light from distant objects are almost parallel when they enter the eye. They require less refraction (bending) to come to a focus on the retina – the cornea can manage most of this without help from the lens. The ciliary muscles, which are circular, relax and the lens is pulled into a thinner shape by the suspensory ligaments. This provides the correct focusing power.



Δ Fig. 2.121 How the eye focuses light from distant and near objects.

Rays of light from near objects are diverging when they enter the eye. They need much more powerful refraction to bend them to a focus on the retina. The ciliary muscles contract, which means they pull less on the suspensionary ligaments. This allows the elastic lens to return to a more rounded shape. This refracts light more to achieve a focused image on the retina.

QUESTIONS

1. Explain how the following structures are adapted to support the role of the eye in sensing light:
   - **a)** cornea
   - **b)** pupil
   - **c)** retina.
2. Explain how the eye responds to changing light intensity.
3. Explain how the eye produces a focused image of an object that is near to the person.

REFLEX RESPONSES

The simplest type of response to a stimulus is a **reflex**. Reflexes are rapid, automatic responses to a specific stimulus that usually protect you in some way, for example blinking if something gets in your eye or sneezing if you breathe in dust.

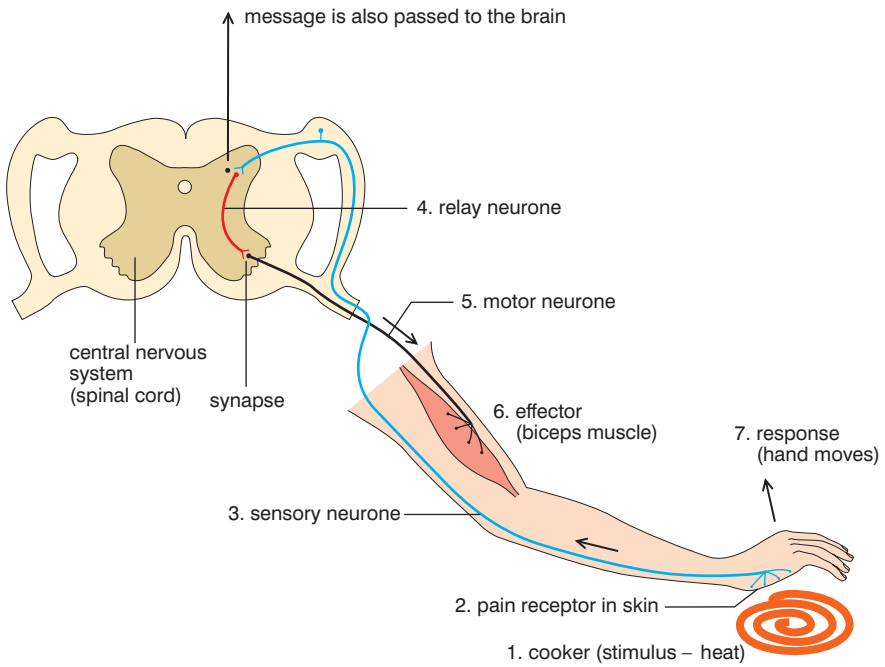
The pathway that nerve impulses travel along during a reflex is called a **reflex arc**:

stimulus → receptor → sensory neurone → relay neurone in CNS → motor neurone → effector → response

Simple reflexes are usually **spinal reflexes**, which means that the impulses are processed by the spinal cord, not the brain. The spinal cord sends an impulse back to the effector. Effectors are the parts of the body that respond, either muscles or glands. Examples of spinal reflexes include responses to standing on a pin or touching a hot object.

stand on pin → pain receptors → sensory neurone → spinal cord → motor neurone → leg muscles → leg moves

When the spinal cord sends an impulse to an effector, other impulses are sent on to the brain so that it is aware of what is happening. It also allows the brain to over-ride the reflex response. For example, if you were holding a large bowl of hot food that you were looking forward to eating, you might look around quickly for somewhere to put it down rather than drop it immediately and risk breaking the bowl.



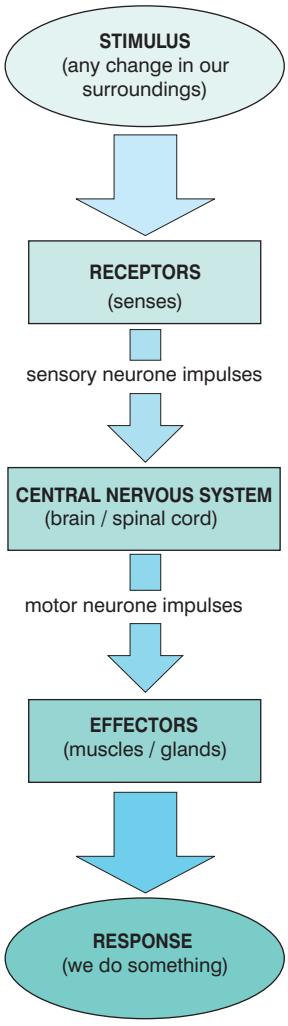
Δ Fig. 2.122 A spinal reflex to touching a hot object.

REMEMBER

For higher marks you will need to understand the structure and functioning of the reflex arc, and be able to interpret diagrams and describe what happens at each step.

QUESTIONS

1. What is meant by the term *reflex response* and why are these responses important for survival?
2. Describe the reflex response that occurs when you put your finger on something hot.



Δ Fig. 2.123 A diagrammatic reflex arc.

HOMEOSTASIS

For our cells to carry out all the life processes properly, they need the conditions in and around them, such as the temperature and amount of water and other substances, to stay within acceptable limits. Keeping conditions within these limits – that is, keeping the internal environment constant – is called **homeostasis**.

Temperature control

The temperature in the core of your body is about 37 °C, regardless of how hot or cold you may feel on the outside. This **core temperature** may naturally vary a little, but it never varies a lot unless you are ill.

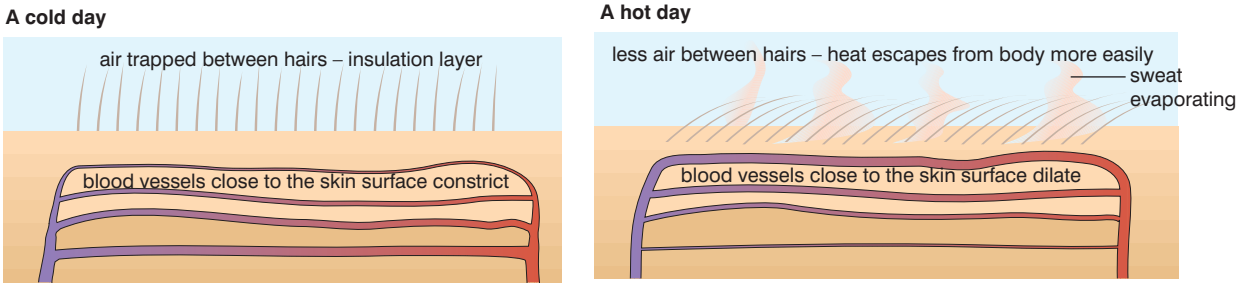
Heat energy is constantly released by cells as a result of respiration and other chemical reactions, and is transferred to the surroundings outside the body. To maintain a constant body temperature these two processes must balance. The temperature of the blood from the core of the body is monitored by the hypothalamus in the brain. If the temperature varies too much from 37 °C, the hypothalamus causes changes to happen that bring the temperature back to about 37 °C. The hypothalamus also receives electrical impulses from heat sensor cells in the skin surface.

If core temperature rises too far:

- Sweat is released on to the surface of the skin from glands. Sweat is mostly water, and this water evaporates. Evaporation needs heat energy, so heat energy is removed from the skin surface as the sweat evaporates, cooling the skin.
- Blood vessels carrying blood near the surface of the skin dilate (get wider) so more blood flows through them. This is known as **vasodilation**, and it is what makes light-skinned people look pink when they are hot. Vasodilation makes it easier for heat energy to be transferred to the skin surface and from there to the environment by radiation and conduction.

If core temperature falls too far:

- Blood vessels carrying blood near the surface of the skin constrict (get narrower), which reduces the amount of blood flowing through them. This is known as **vasoconstriction**. As the warm blood is kept deeper in the skin, this reduces the rate of heat transfer by conduction to the skin surface and from there to the environment.
- Body hair may be raised by muscles in the skin. This has little effect in humans (often called goose bumps) but is more effective in mammals with fur and in birds, because the fur or feathers trap air next to the skin. Air is not a good conductor of heat energy, so this still layer of air acts as insulation.
- Muscles may start to 'shiver'. This means they produce rapid, small contractions. Cellular respiration is used to produce these contractions, releasing heat energy at the same time which heats the blood flowing through the muscles.



Δ Fig. 2.124 The skin responds to maintain body core temperature.

Control of body water content

Our bodies gain water through:

- food – most foods contain water
- drink
- respiration and other chemical reactions – water is one of the waste products of respiration.

Our bodies lose water through:

- breathing
- sweating
- egestion – faeces contains water
- excretion of urine.

Although we are constantly gaining and losing water, it is important that our overall water content does not vary too much. If we contain too little water, and are in danger of dehydrating, we can drink more, and we produce less, more concentrated urine. (We still have to produce some urine to excrete urea.) If we contain too much water, and are in danger of overhydrating, we produce a larger volume of more dilute urine. The amount and concentration of urine produced is controlled by the hypothalamus in the brain, which monitors the body's water content by monitoring the concentration of the blood.

QUESTIONS

1. Describe the term *homeostasis* in your own words.
2. Give two examples of homeostasis in the human body.
3. Explain the role of skin blood vessels in maintaining core body temperature.

Developing investigative skills

You can use a test tube of warm water wrapped in wet paper towel as a model to investigate whether sweating really does cool the body, measuring how the temperature of the water changes over time.

Devise and plan investigation

❶ Explain how the tube models sweating in a human.

❷ How would you set up the control for this investigation? Explain your answer.

Make observations and measurements

The table shows the results of an investigation like the one described above.

	Time (min)	0	2	4	6	8	10	12	14	16
Temperature of water in tube (°C)	Wet towel	56	50	46	42	39	36	34	32	31
	Dry towel	56	52	49	46	44	44	41	40	39

❸ Use the results to draw a suitable graph.

Analyse and interpret data

❹ Describe any pattern shown in your graph.

❺ Draw a conclusion from the graph.

❻ Explain your conclusion using your scientific knowledge.

HORMONES

Hormones are chemical messengers. They are made in the **endocrine glands**.

Endocrine glands do not have ducts (tubes) to carry away the hormones they make: the hormones are secreted directly into the blood to be carried around the body in the plasma. (There are other types of glands, called exocrine glands, such as salivary and sweat glands, that do have ducts.)

Most hormones affect several parts of the body; others only affect one part of the body, called the **target organ**.

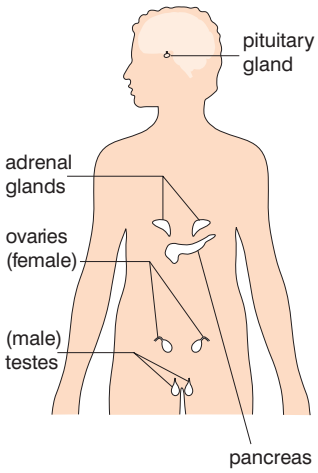
The changes caused by hormones are usually slower and longer-lasting than the changes brought about by the nervous system.

Adrenaline

The **adrenal glands** produce **adrenaline**. This hormone is released in times of excitement, anger, fright or stress, and prepares the body for 'flight or fight': the crucial moments when an animal must instantly decide whether to attack or run for its life.

The effects of adrenaline are:

- increased heart rate
- increased depth of breathing and breathing rate
- increased sweating
- hair standing on end (this makes a furry animal look larger but only gives humans goose bumps)
- glucose released from liver and muscles
- dilated pupils
- paling of the skin as blood is redirected to muscles.



Δ Fig. 2.125 The position of some endocrine glands in the human body.

ADH (Antidiuretic hormone)

ADH (antidiuretic hormone) is made by the hypothalamus but then stored and released by the **pituitary gland** in the brain. It helps regulate the body's water content. It causes the kidney tubules to reabsorb more water into the blood by increasing the permeability of the collecting ducts (see page 152).

The pituitary gland also produces many other hormones which control other processes in the body, such as growth.

Insulin

Insulin is secreted by the pancreas, which is also part of the digestive system. Insulin controls the concentration of glucose in the blood, which must remain within a small range. If it rises or falls too much, you can become very ill.

After a meal containing carbohydrates, the blood glucose concentration rises rapidly as glucose is absorbed from digested food in the small intestine. This rise is detected by the pancreas, and causes the pancreas to release insulin. The insulin travels in the blood to the liver. Here it causes any excess glucose to be converted to glycogen, another carbohydrate, which is insoluble and is stored in the liver.

Between meals, glucose in the blood is constantly diffusing into cells for use in cellular respiration. So the blood glucose concentration falls. When a low level of glucose is detected by the pancreas, the pancreas stops secreting insulin and secretes the hormone glucagon instead. Glucagon converts some of the stored glycogen back into glucose, which is released into the blood to raise the blood glucose concentration again.

EXTENSION

People with one kind of diabetes (called Type I) are unable to produce insulin. This means that their blood glucose concentration may become so high or so low that it damages cells, which in extreme cases may lead to unconsciousness and death. These people may need to inject insulin to help prevent this damage.

1. Control of blood glucose concentration is an example of homeostasis. Explain what this means.

2. Describe the role of insulin in controlling blood glucose concentration.

3. Patients need to check their blood glucose concentration with a simple blood test before deciding how much insulin to inject. Explain why this is important.

4. The amount of exercise that a person with diabetes does will affect the amount of insulin they inject. Explain why.

Δ Fig. 2.126 A portable kit for instant testing of blood glucose. People with Type I diabetes use this to check their blood glucose before and after meals, and throughout the day.

Testosterone

Testosterone is the male sex hormone and is secreted from the **testes**. Testosterone causes secondary sexual characteristics in boys (see page 203) and is needed for the production of sperm.

Progesterone and oestrogen

The **ovaries** produce the female sex hormones **progesterone** and **oestrogen**. Oestrogen is responsible for the development of secondary sexual characteristics in girls (see page 203), and together with progesterone it helps control the menstrual cycle (see page 204).

FSH and LH

FSH (follicle-stimulating hormone) and **LH** (luteinising hormone) are both produced by the pituitary gland in the brain. They work together with progesterone and oestrogen to control the menstrual cycle (see page 204).

QUESTIONS

1. Explain the meaning of the following terms:

a) hormone

b) endocrine gland

c) target organ.

2. Draw up a table to show the following hormones, where they are produced in the body, and what effects they have: adrenaline, insulin, testosterone, progesterone and oestrogen.

End of topic checklist

ADH (antidiuretic hormone) is a hormone produced in the hypothalamus but stored and released by the pituitary gland. It is involved in regulating water content in the blood by changing the permeability of the collecting duct of kidney nephrons.

Adrenaline is a hormone produced by the adrenal glands that is responsible for the 'fight or flight' response.

Auxins are plant hormones that control phototropism and geotropism.

The **central nervous system** is the part of the nervous system that coordinates and controls responses, consisting of brain and spinal cord.

An **effector** carries out the response to a stimulus; in animals these are muscles or glands.

Electrical impulses are the form in which information is sent along nerves.

The **endocrine glands** are a collection of cells that secrete hormones into the blood.

FSH (follicle-stimulating hormone) is a hormone produced by the pituitary gland that helps control the menstrual cycle.

Geotropism is a growth response in plants affected by the direction of the force of gravity.

Homeostasis is the maintenance of a constant internal environment.

A **hormonal system** is a chemical response system in humans where hormones produced by the endocrine glands are carried in the blood to target organs where they affect the cells.

Insulin is a hormone produced by the pancreas that causes muscle and liver cells to take glucose from the blood.

LH (luteinising hormone) is a hormone produced by the pituitary gland that helps control the menstrual cycle.

Nerves are bundles of neurones that connect receptors to the central nervous system, and the central nervous system to effectors.

A **neurone** is a nerve cell, which is specially adapted for carrying electrical nerve impulses.

Neurotransmitters are chemicals that pass from one neurone to another across a synapse.

The **nervous system** is a response system in humans that uses electrical impulses between receptor cells, neurones and effector cells to produce a response to a stimulus.

Oestrogen is a hormone produced by the ovaries that helps to control the menstrual cycle and produces secondary sexual characteristics in girls.

Phototropism is a growth response in plants affected by light.

Progesterone is a hormone produced in the ovaries that helps to control the menstrual cycle.

Receptor cells detect a stimulus, for example cells in the retina detect light.

A **reflex arc** is the pathway that nerve impulses travel along during a reflex.

Sense organs are organs containing receptor cells adapted for the receiving of a particular type of stimulus.

A **stimulus** is a change in the environment that triggers a response in an organism.

A **synapse** is a small gap between two neurones across which neurotransmitters travel.

A **target organ** is an organ of the body containing cells that respond to a particular hormone.

Testosterone is a hormone produced by the testes that produces secondary sexual characteristics in boys.

Vasoconstriction means narrowing of blood vessels.

Vasodilation means widening of blood vessels.

The facts and ideas that you should know and understand by studying this topic:

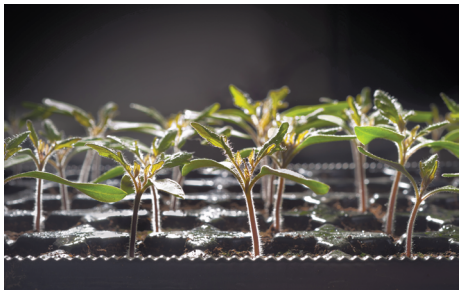
- ❍ Organisms respond to changes in their environment.
- ❍ A coordinated response requires a stimulus that is sensed by receptor cells, which results in a change in the organism brought about by a receptor (usually muscles or glands in an animal).
- ❍ Plants respond to stimuli by growth responses called tropisms, which are controlled by plant hormones called auxins.
- ❍ Plant shoots show positive phototropism when they grow towards light.
- ❍ Plant roots show positive geotropism when they grow towards the force of gravity. Plant shoots show negative geotropism when they grow in the opposite direction to the force of gravity.
- ❍ Rapid responses in humans are coordinated through nervous impulses in the nervous system, and longer-term responses are coordinated through chemicals (hormones) in the hormonal system.

End of topic checklist continued

- ❍ The central nervous system consists of the brain and spinal cord, which coordinate and control responses.
- ❍ Stimulation of receptor cells in sense organs causes electrical impulses to travel along nerves to the central nervous system.
- ❍ Neurotransmitters travel across synapses allowing an electrical impulse in one neurone to start another impulse along the next neurone.
- ❍ The reflex arc is a connection of sense organ, nerves and spinal cord, and effector, which allows rapid responses without thinking, such as when you rapidly pull your finger away after touching a hot object.
- ❍ The eye has many adaptations for its function in sensing light, including the light-sensitive cells in the retina, and the cornea and the lens for focusing light.
- ❍ Contraction or relaxation of the muscles in the iris change the size of the pupil in response to changes in light intensity, to control the amount of light entering the eye.
- ❍ Contraction or relaxation of the ciliary muscles supporting the suspensory ligaments attached to the lens change the shape of the lens to aid fine focusing of images on the retina.
- ❍ Homeostasis is the control of the internal environment of the body within narrow limits so that cells can function well.
- ❍ Examples of homeostasis in humans includes the regulation of blood water concentration and temperature regulation.
- ❍ Core body temperature is regulated by vasodilation near the skin surface and sweating when too hot, and vasoconstriction near the skin surface and muscle shivering when too cold.
- ❍ ADH is the hormone made in the hypothalamus and released by the pituitary gland, which controls the amount of water reabsorbed from urine passing through the collecting ducts in the kidney.
- ❍ Adrenaline is the hormone that is made in the adrenal glands and prepares the body in many ways for action, including increasing heart rate.
- ❍ Insulin is the hormone made in the pancreas that causes blood glucose concentration to be reduced when it is too high.
- ❍ Testosterone is the male sex hormone made in the testes that controls the development of secondary sexual characteristics in boys and is needed for sperm production.
- ❍ Progesterone and oestrogen are the female sex hormones made in the ovaries that help control the menstrual cycle; oestrogen also controls the production of secondary sexual characteristics in girls.
- ❍ FSH and LH are hormones made in the pituitary gland that help control the menstrual cycle.

End of topic questions

1. Some sprouting tomato seedlings are placed in a dimly lit room near to a brightly lit window.



Δ Sprouting tomato seedlings.

a) Which of these statements best describes the seedlings over the next few weeks? Explain your choice. **(2 marks)**

i) The seedlings wilt and bend towards the light.

ii) The seedlings grow towards the brightest light.

iii) The seedlings grow straight up.

iv) The seedlings bend towards the light.

b) What is meant by the term *positive phototropism*? **(1 mark)**

c) Explain the survival advantage to plants of having shoots that are positively phototropic. **(2 marks)**

d) What is meant by *positive geotropism*? **(1 mark)**

e) Explain the survival advantage to plants of having roots that are positively geotropic. **(2 marks)**

2. a) What is the purpose of the nervous and hormonal systems in humans? **(1 mark)**

b) Use the following table headings to compare the nervous and hormonal systems in humans. **(6 marks)**

System	Cells of system	Method of transmission	Speed of response

c) Explain as fully as you can why it is advantageous to have both systems. **(5 marks)**

3. a) Describe the sequence of sensing and response in the nervous system of one of Andy Roddick's opponents who returns a serve successfully. **(4 marks)**

b) Is this a reflex action? Explain your answer. **(2 marks)**

End of topic questions continued

4. Explain the following.

a) A student visiting a coal mine could not see anything in the mine when the lights were turned off. **(2 marks)**

b) A cataract is a clouded lens in the eye, caused by many conditions. A patient with cataracts cannot see clear images. **(2 marks)**

c) A person who is long-sighted needs to wear spectacles with converging lenses in order to read something near to them. **(2 marks)**

5. One example of homeostasis in humans is the control of core body temperature.

a) Identify the receptors, monitoring area, and effectors in the response to a change in external temperature. **(6 marks)**

b) Explain why changes in skin blood flow affect the rate of heat loss from the body. **(2 marks)**

c) Explain why homeostasis of core body temperature is important for survival. **(4 marks)**

6. For each of the following hormones, name the gland that produces it, one target organ, and describe its effect on that target organ:

a) insulin **(3 marks)**

b) adrenaline. **(3 marks)**