



**ABDUR REHMAN
BIOLOGY**

14 Coordination and Control

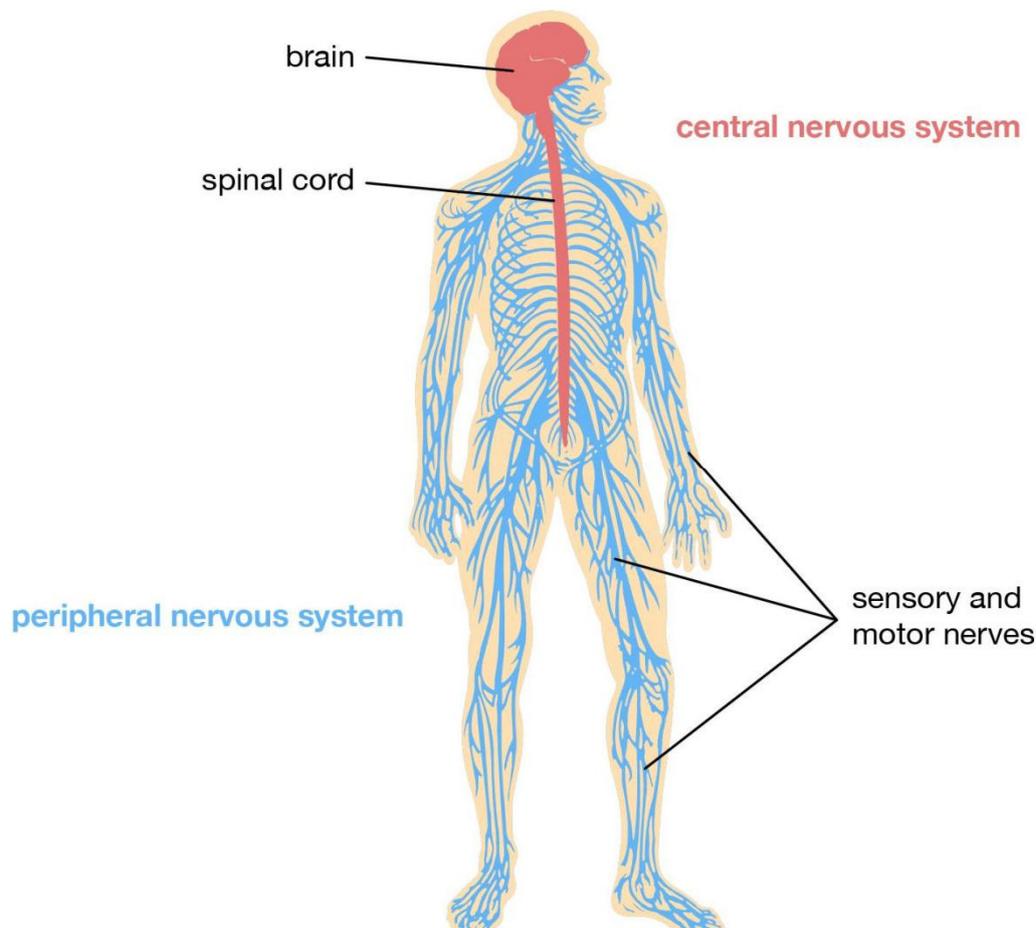
14.1 Mammalian nervous system

State that the nervous system (brain, spinal cord and nerves) coordinates and regulates body functions.

Coordination

Coordination is the way all the organs and systems of the body are made to work efficiently together. For example, if the leg muscles are being used for running, they will need extra supplies of glucose and oxygen. To meet this demand, the lungs and heart respond. The lungs breathe faster and deeper to obtain the extra oxygen and the heart pumps more rapidly to get the oxygen and glucose to the muscles more quickly.

The brain detects changes in the oxygen and carbon dioxide content of the blood and sends nervous impulses to the diaphragm, intercostal muscles and heart. In this example, the nervous system coordinates the systems and regulates body functions



Describe the mammalian nervous system in terms of:

(a) the central nervous system (CNS) consisting of the brain and the spinal cord.

(b) the peripheral nervous system (PNS) consisting of the nerves outside the brain and spinal cord.

Central Nervous System (CNS):

The CNS consists of the brain and the spinal cord.

Brain

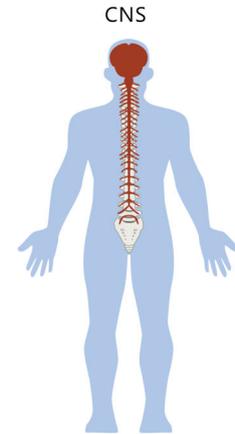
It is the main control centre of the nervous system and is responsible for processing sensory information, initiating voluntary movements, regulating involuntary functions (such as heart rate and breathing), and higher cognitive functions (such as thinking, learning, and memory).

Spinal Cord

The spinal cord is a long, cylindrical structure that extends from the base of the brain through the vertebral column. It serves as a pathway for transmitting sensory information from the body to the brain and motor commands from the brain to the body. The spinal cord also coordinates reflex responses which are rapid, involuntary reactions to sensory stimuli that do not require input from the brain.

Relay Neurons

Relay neurons inside the CNS make connections with other neurons through junctions or gaps called synapse.



Peripheral Nervous System (PNS):

The PNS consists of all the nerves outside the brain and spinal cord. It includes sensory nerves, motor nerves, and mixed nerves.

Sensory nerves

These (afferent nerves) transmit sensory information from sensory receptors (such as those for touch, temperature, pain, and proprioception) to the CNS.

Motor nerves

The motor nerves (efferent nerves) transmit motor commands from the CNS to muscles and glands, controlling voluntary and involuntary movements and physiological processes.

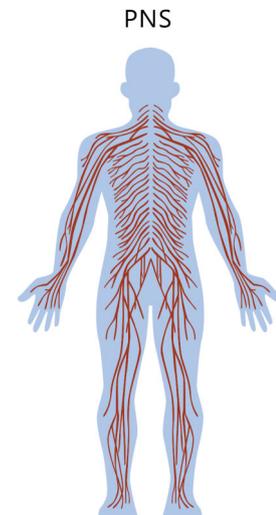
Mixed nerves

These contain both sensory and motor fibres and can transmit both sensory information and motor commands.

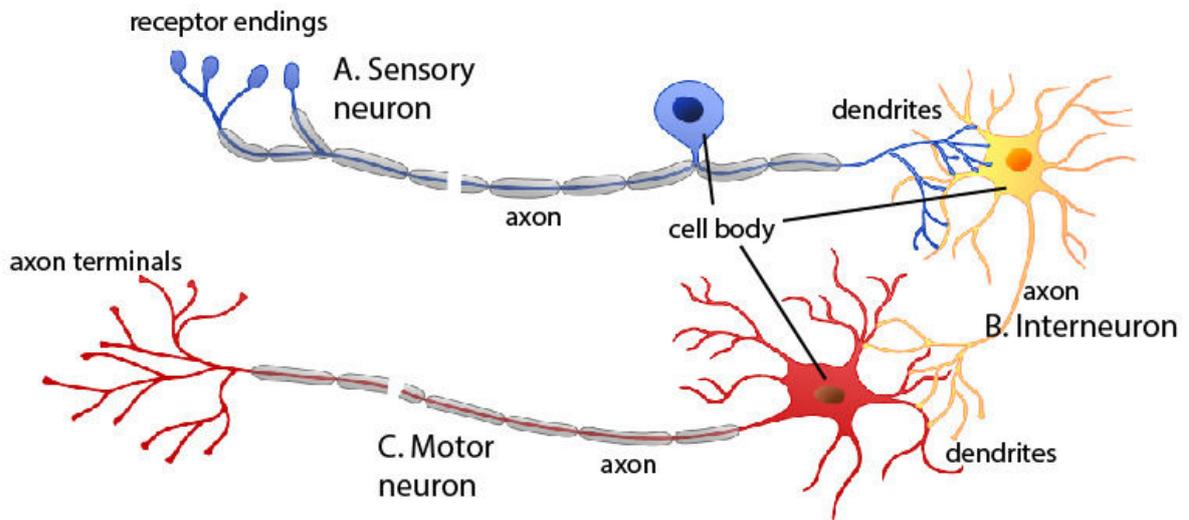
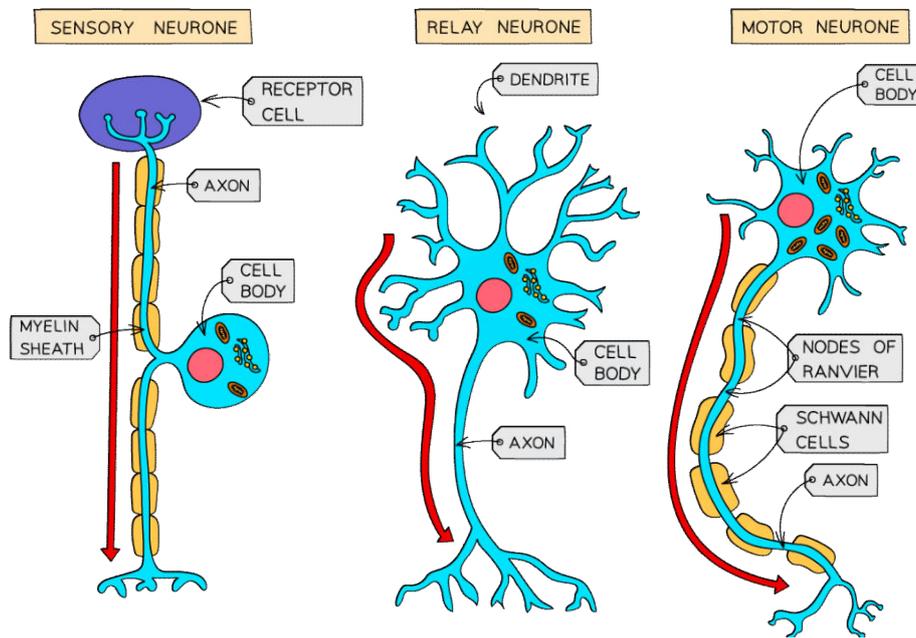
Ganglia

The PNS also includes **ganglia**, which are clusters of nerve cell bodies located outside the CNS. Ganglia are involved in the processing and integration of sensory information and the regulation of autonomic functions.

Each neurone has a cell body consisting nucleus surrounded by cytoplasm. Dendrites are fibre, which branch from the cell body to make contact with other neurones. A long filament of cytoplasm, surrounded by an insulating sheath, runs from the cell body of the neurone. This filament is called a nerve fibre. The cell bodies of the neurones are mostly found in the brain or in the spinal cord. The nerve fibres run in the nerves. Most nerves will contain a mixture of sensory and motor fibres, so a nerve can carry many different impulses. These impulses will travel in one direction in sensory fibres and in the opposite direction in motor fibres. Some of the nerve fibres are very long. The cell bodies of the nerve fibres are found in the spinal cord. Those fibres connected to the foot run inside the nerves continuously to the skin of the toes or the muscles of the foot. A single nerve cell may have a fibre 1m long.



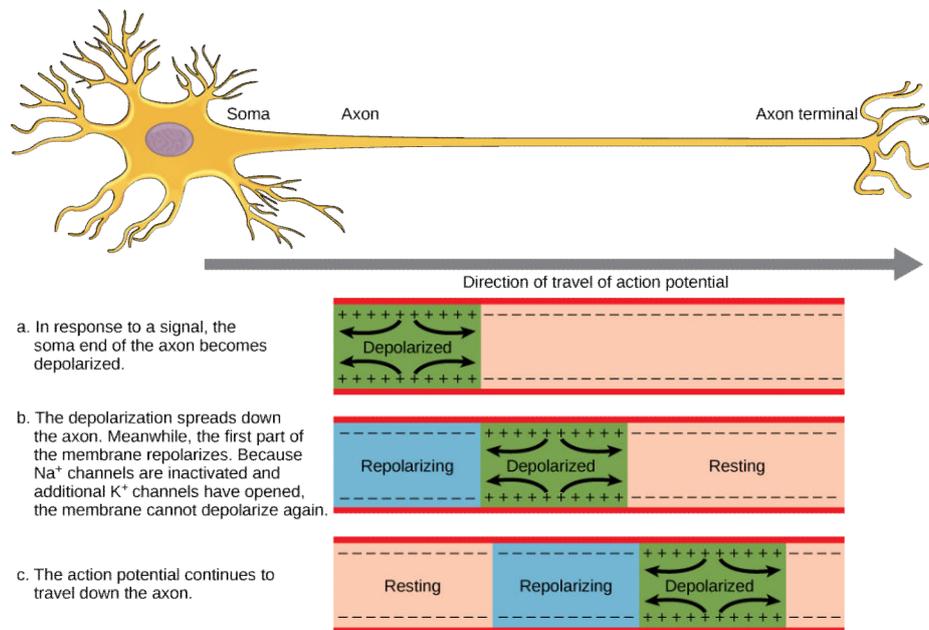
Identify, on diagrams, sensory, relay and motor neurones.



State that electrical impulses travel along neurones.

Electrical impulses, also known as action potentials, are electrical signals that travel along neurons, which are specialized cells in the nervous system. These impulses are the means by which neurons communicate with each other and transmit information throughout the body.

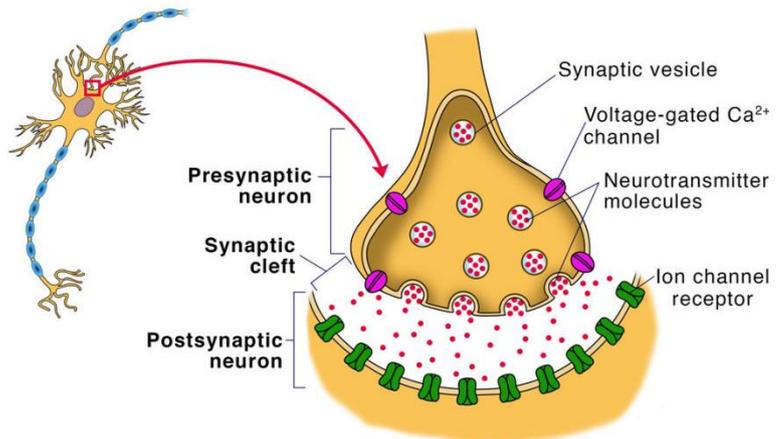
Each impulse lasts about 0.001s and travels at speed of up to 100ms^{-1} . The nerves from the eye go to the part of the brain concerned with sight. So, when impulses are received in this area the brain recognises that they have come from the eyes and the organism see something.



Describe a synapse as a junction between two neurones. Describe the structure of a synapse, including the presence of vesicles containing neurotransmitter molecules, the synaptic gap and receptor proteins.

Describe the events at a synapse: (a) an impulse stimulates the release of neurotransmitter molecules from vesicles into the synaptic gap (b) the neurotransmitter molecules diffuse across the gap and bind with receptor proteins (c) an impulse is stimulated in the next neurone. State that synapses ensure that impulses travel in one direction only.

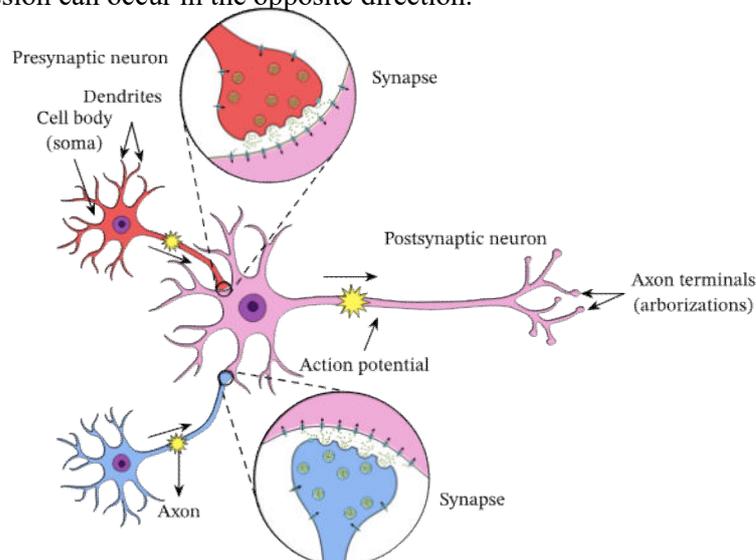
A synapse is a specialized junction between two neurons, where communication occurs. It is the point of contact where one neuron (the presynaptic neuron) communicates with another neuron (the postsynaptic neuron or with an effector cell, such as a muscle cell or gland cell). The presynaptic neuron contains vesicles called neurotransmitter vesicles. These carry neurotransmitter molecules which are released into the synaptic cleft and binds to the post synaptic neurone or an effector cell. The post synaptic neurone contains receptor proteins to which these neurotransmitter molecules bind. This binding of neurotransmitters to receptors triggers changes in the postsynaptic neuron, either depolarizing or hyperpolarizing its membrane potential, hence conducting the impulse to the next neuron.



Here is an outline of the sequence of events that occurs.

- An action potential occurs at the cell surface membrane of the first neurone or presynaptic neurone.
- The action potential causes the release of molecules of transmitter substance into the cleft.
- The molecules of transmitter substance diffuse across the cleft and bind temporarily to receptors on the postsynaptic neurone.
- The postsynaptic neurone responds to all the impulses arriving at any one time by depolarising; if the overall depolarisation is above its threshold, then it will send impulses.

Synapses ensure one-way transmission. Impulses can only pass in one direction at synapses. This is because neurotransmitter is released on one side and its receptors are on the other. There is no way that chemical transmission can occur in the opposite direction.

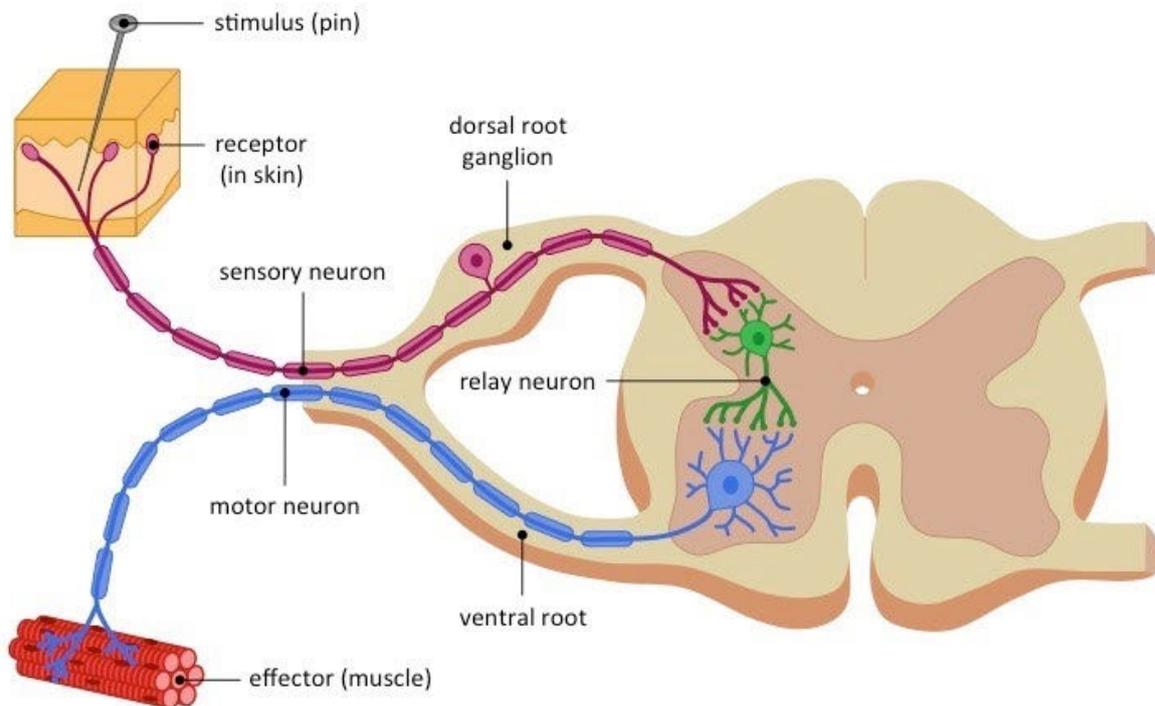


Describe simple reflex arcs in terms of receptor, sensory neurone, relay neurone, motor neurone and effector (muscles and glands).

Describe a reflex action as a rapid and automatic response to a stimulus.

Simple reflex arcs are neural pathways that mediate reflex actions, which are rapid, involuntary responses to specific stimuli. They involve the coordination of sensory input and motor output within the nervous system. It provides a means of linking a stimulus with an effector to get a response of an effector (a muscle or a gland) without the need for thought or a decision. It is automatic. When a particle of dust touches the cornea of the eye, the receptors detect this change and the sensory neuron then delivers this information to the relay neuron. Relay neurons integrate and process the incoming sensory information and synapses with a motor neuron. Motor neurons carry signals from the CNS to effectors, such as muscles or glands (which in this case may be both). So as a result of the dust particle in eye, you will blink; you cannot stop yourself from blinking. A particle of food touching the only lining of the windpipe will set off a coughing reflex that you cannot stop. This nervous pathway is called as reflex arc.

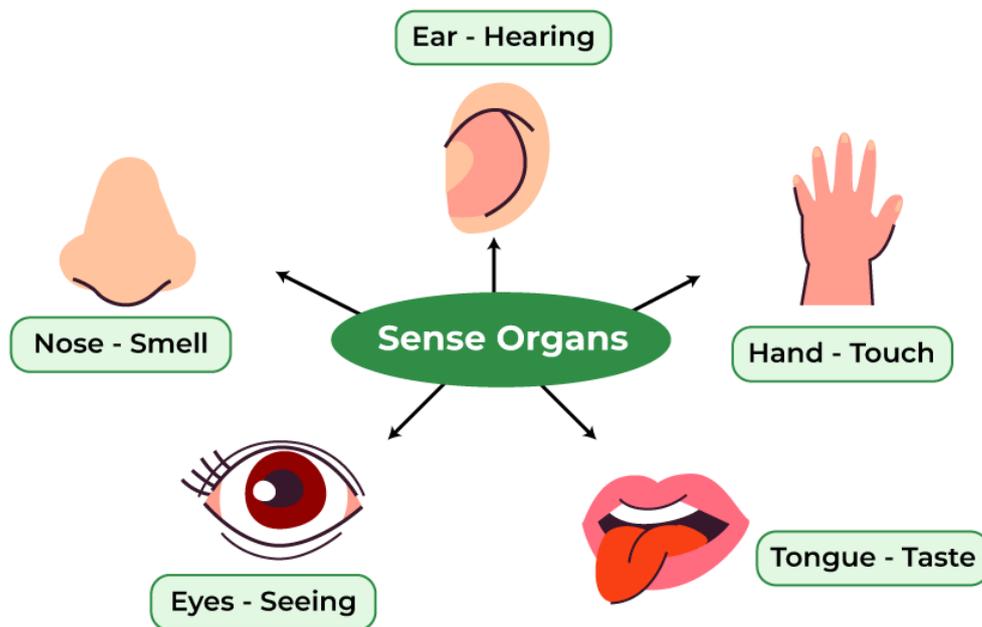
A reflex action is a rapid and automatic response to a stimulus, occurring without conscious thought. It helps protect the body from harm or maintain balance. Reflex actions are essential for survival, enabling quick reactions to potential threats. They occur involuntarily and often precede conscious awareness of the stimulus.



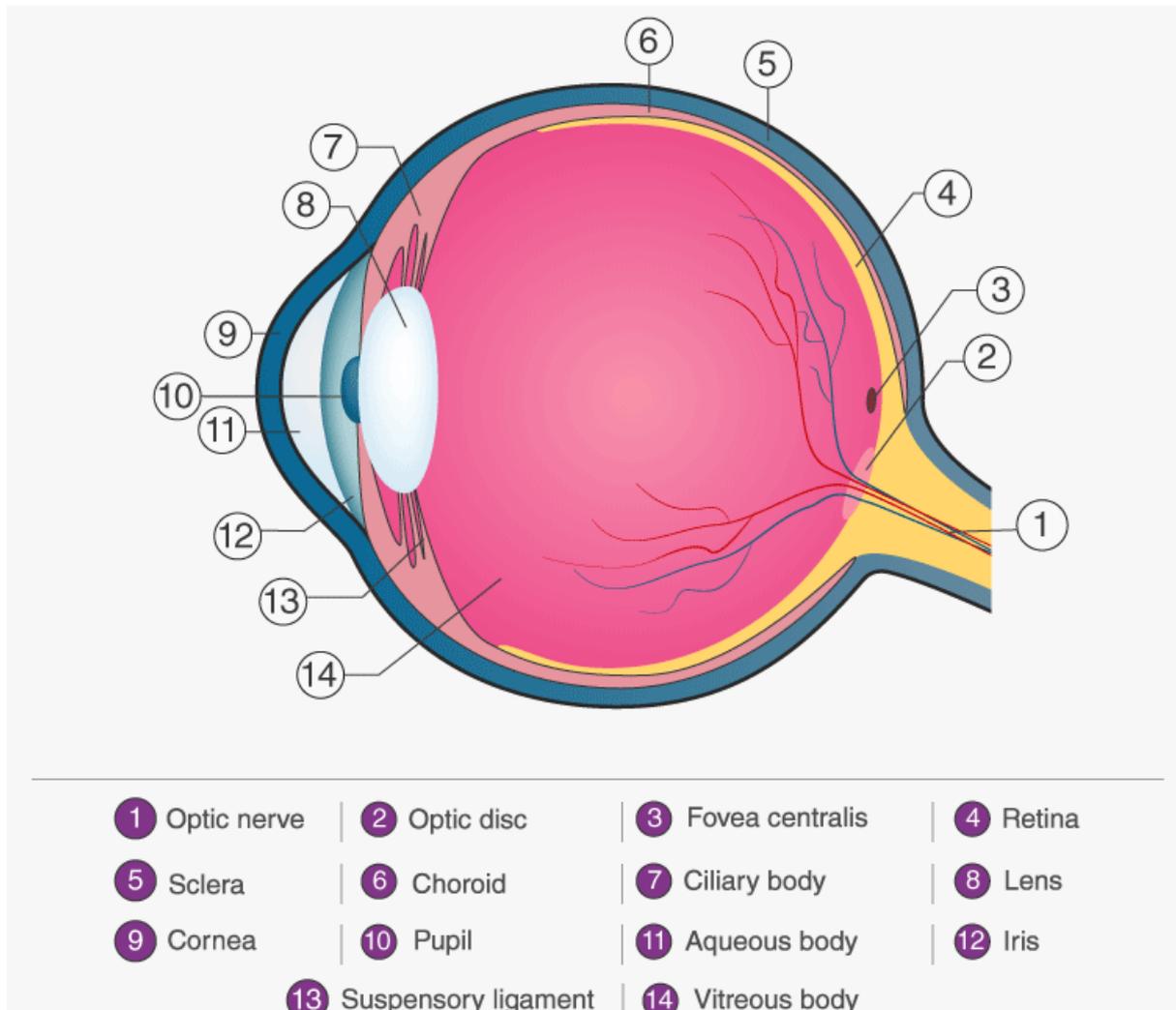
14.2 Mammalian sense organs

Describe sense organs as groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals.

Sense organs are the organ of the body which responds to external stimuli by conveying impulses to the sensory nervous system. They are specialized organs composed of sensory neurons, which help us to perceive and respond to our surroundings. These organs enable organisms to perceive and interact with their surroundings through various senses, including sight, hearing, touch, taste, and smell. Sense organs are equipped with specialized cells called receptors, which respond to specific types of stimuli, such as light, sound, pressure, chemicals, and temperature.



Identify, on a diagram, the structures of the eye, limited to: cornea, iris, pupil, lens, ciliary muscles, suspensory ligaments, retina, fovea, optic nerve and blind spot.



Describe the function of each part of the eye, limited to:

(a) cornea – refracts light (b) iris – controls how much light enters the pupil (c) lens – focuses light onto the retina (d) ciliary muscles and suspensory ligaments – control the shape of the lens (e) retina – contains light receptors, some sensitive to light of different colours (f) fovea – contains the greatest density of light receptors (g) optic nerve – carries impulses to the brain.

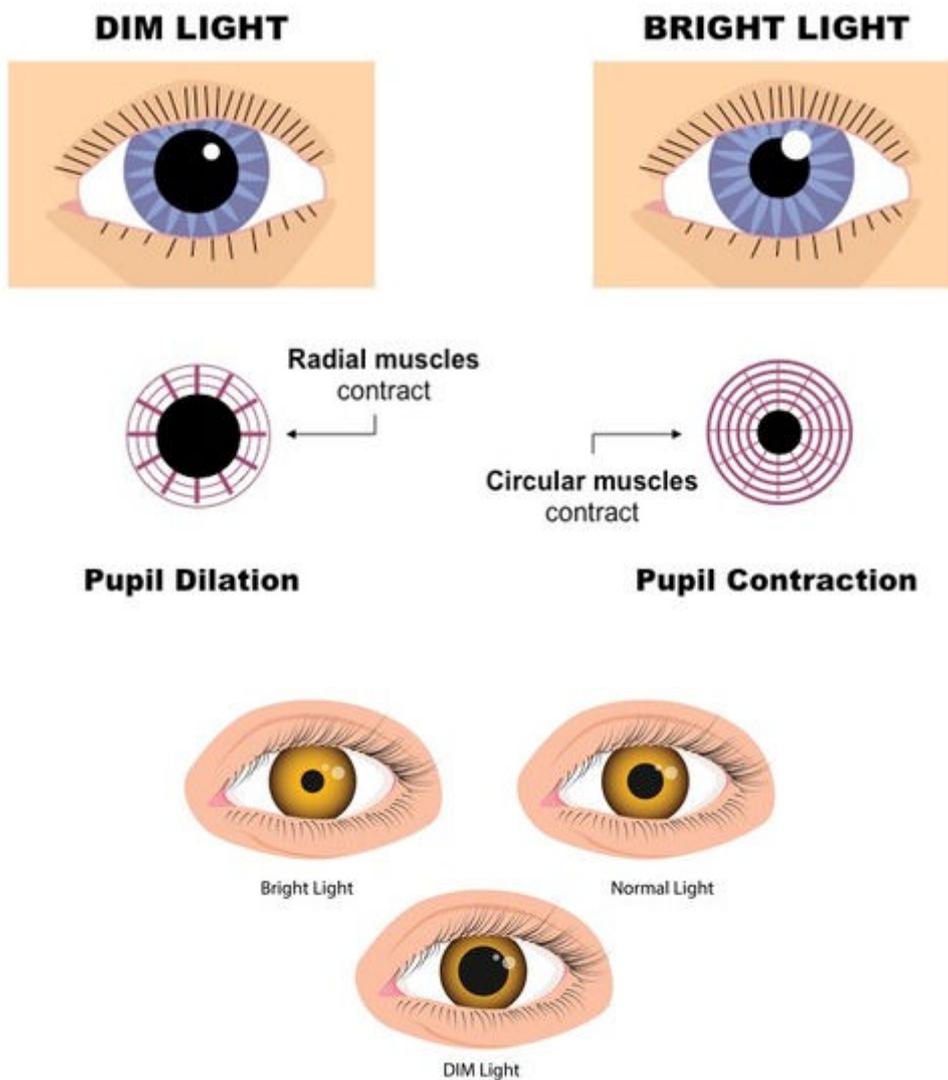
The cornea serves as the transparent outer layer of the eye, responsible for refracting light as it enters the eye. This helps to focus incoming light rays onto the lens. The iris, located behind the cornea, regulates the amount of light entering the eye by adjusting the size of the pupil. This is achieved through the contraction or relaxation of the muscles within the iris, controlling the size of the pupil opening. The lens, positioned behind the iris, further focuses the incoming light onto the retina. Its shape can be adjusted by the ciliary muscles and suspensory ligaments, which alter the curvature of the lens to facilitate focusing on objects at different distances. The retina, located at the back of the eye, contains light-sensitive cells called photoreceptors, including rods and cones, which convert light into electrical signals. Some cones are sensitive to different colours of light, allowing for colour vision. The fovea, situated at the centre of the retina, contains the highest concentration of cones, providing the sharpest and clearest vision. Finally, the optic nerve, composed of nerve fibres, carries the electrical impulses generated by the photoreceptors to the brain, where visual information is processed and interpreted.

| Structure | Function |
|-----------------|---|
| Cornea | It refracts the light and protects the eye. |
| Iris | Controls how much light enters the pupil. |
| Lens | Focuses light onto the retina. |
| Optic Nerve | The bundle of sensory neurones that carry the impulses to the brain. |
| Retina | Layer of tissue at the back of the eye that contains photoreceptor cells called rods and cones. |
| Fovea | Area of the retina with highest concentration of cone cells that provides sharp vision. |
| Aqueous Humour | Maintains the pressure in the eye and nourishes the cornea. |
| Vitreous Humour | Maintains the shape of the eye and attaches to the retina. |
| Ciliary muscles | Help change the shape of the lens in accommodation. |
| Sclera | Tough outer layer that extraocular muscles can attach to. |
| Pupil | Hole in the center of the eye that lets light in. |

Explain the pupil reflex in terms of light intensity and antagonistic action of circular and radial muscles in the iris.

The pupil reflex is a mechanism that regulates the amount of light entering the eye to maintain optimal visual clarity and protect the delicate structures of the retina from damage due to excessive light exposure. This reflex is controlled by the iris, the coloured part of the eye surrounding the pupil. If the light intensity is high, it causes a contraction in a ring of muscle fibres (circular muscle) in the iris. This reduces the size of the pupil and cuts down the intensity of light entering the eye. High-intensity light can damage the retina, so this reaction has a protective function. Conversely, in dim lighting conditions, the circular muscles of the iris relaxes and radial muscle fibres contract., which dilates pupil, allowing more light to enter the eye to enhance visibility.

The pupil reflex is achieved through the antagonistic action of two sets of muscles within the iris, the circular muscles and the radial muscles. This means that they oppose each other in their actions. The pupil reflex is an involuntary action and cannot be controlled consciously.



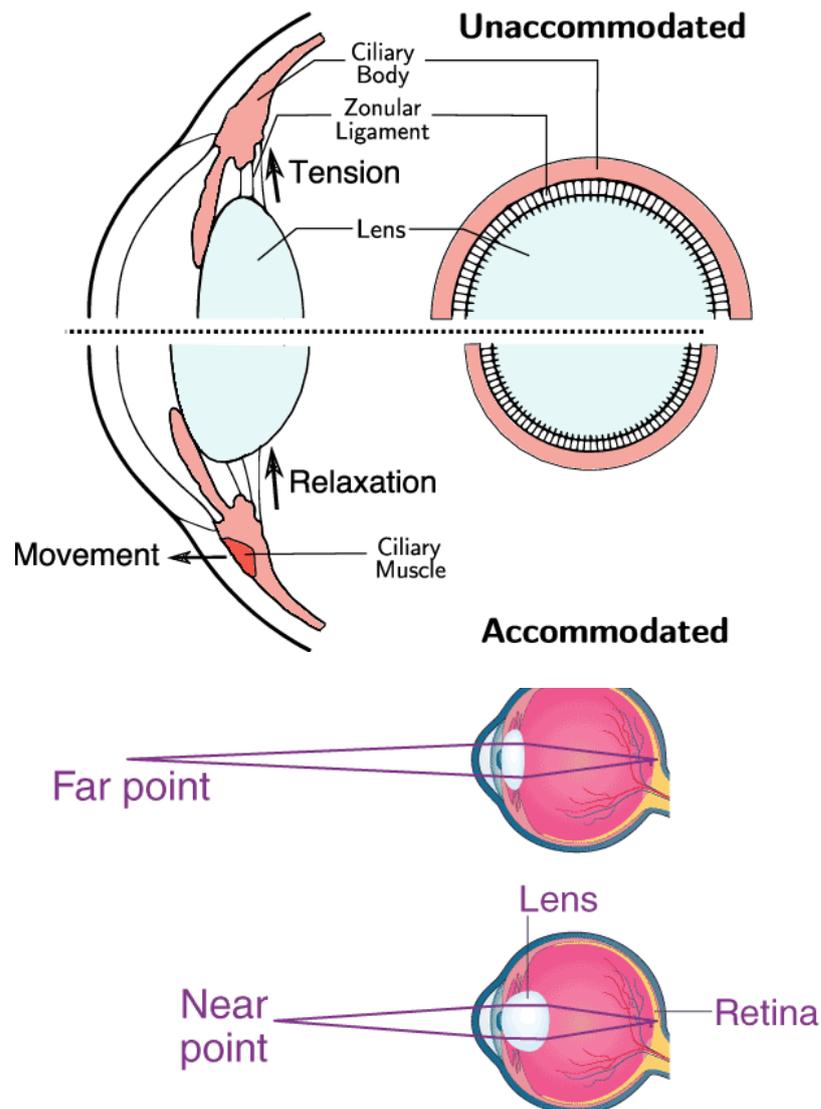
Explain accommodation to view near and distant objects in terms of the contraction and relaxation of the ciliary muscles, tension in the suspensory ligaments, shape of the lens and refraction of light.

Definition

Accommodation refers to the ability of the eye to adjust its focus in response to changes in the distance of objects being viewed. It is mediated by the contraction and relaxation of the ciliary muscles, which alter the shape and thickness of the lens, allowing it to refract light effectively for near and distant objects.

The eye can produce a focused image of either a near object or a distant object. To do this the lens changes its shape, becoming thinner for distant objects and fatter for near objects. This change in shape is caused by contracting or relaxing the ciliary muscle, which forms a circular band of muscle in the ciliary body. When the ciliary muscle is relaxed, the outward pressure on the sclera pulls on the suspensory ligament. This stretches the lens to its thin shape so it refracts light less. The eye is now accommodated (i.e. focused) for distant objects.

To focus a near object, the ciliary muscle contracts to a smaller circle and this takes the tension out of the suspensory ligament. The lens changes its shape and become flatter.

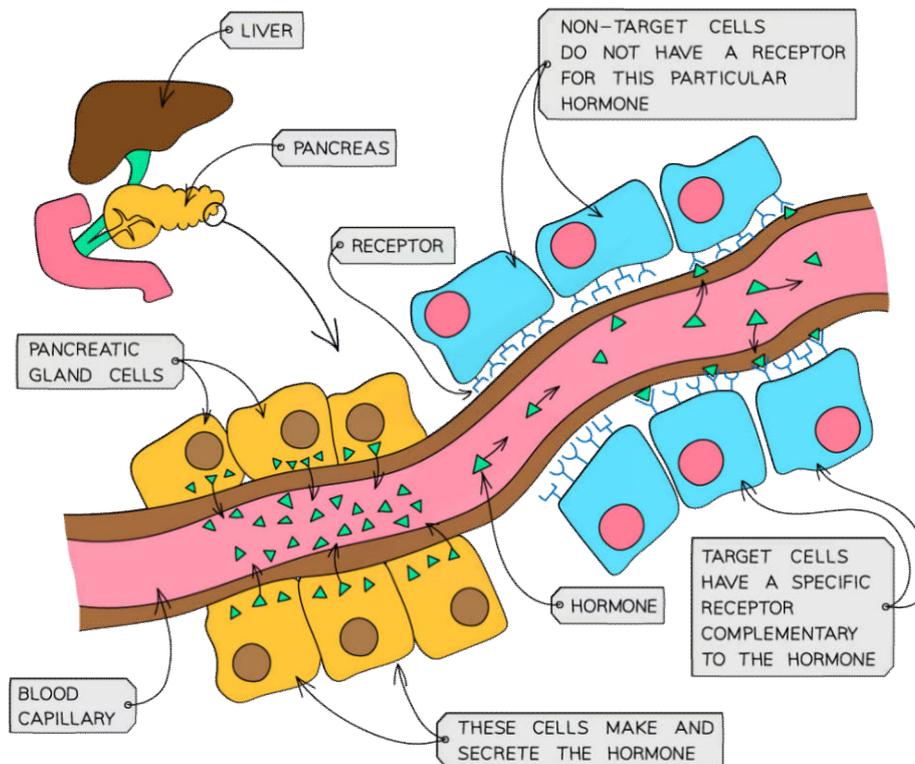


14.3 Mammalian hormones.

Describe a hormone as a chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs.

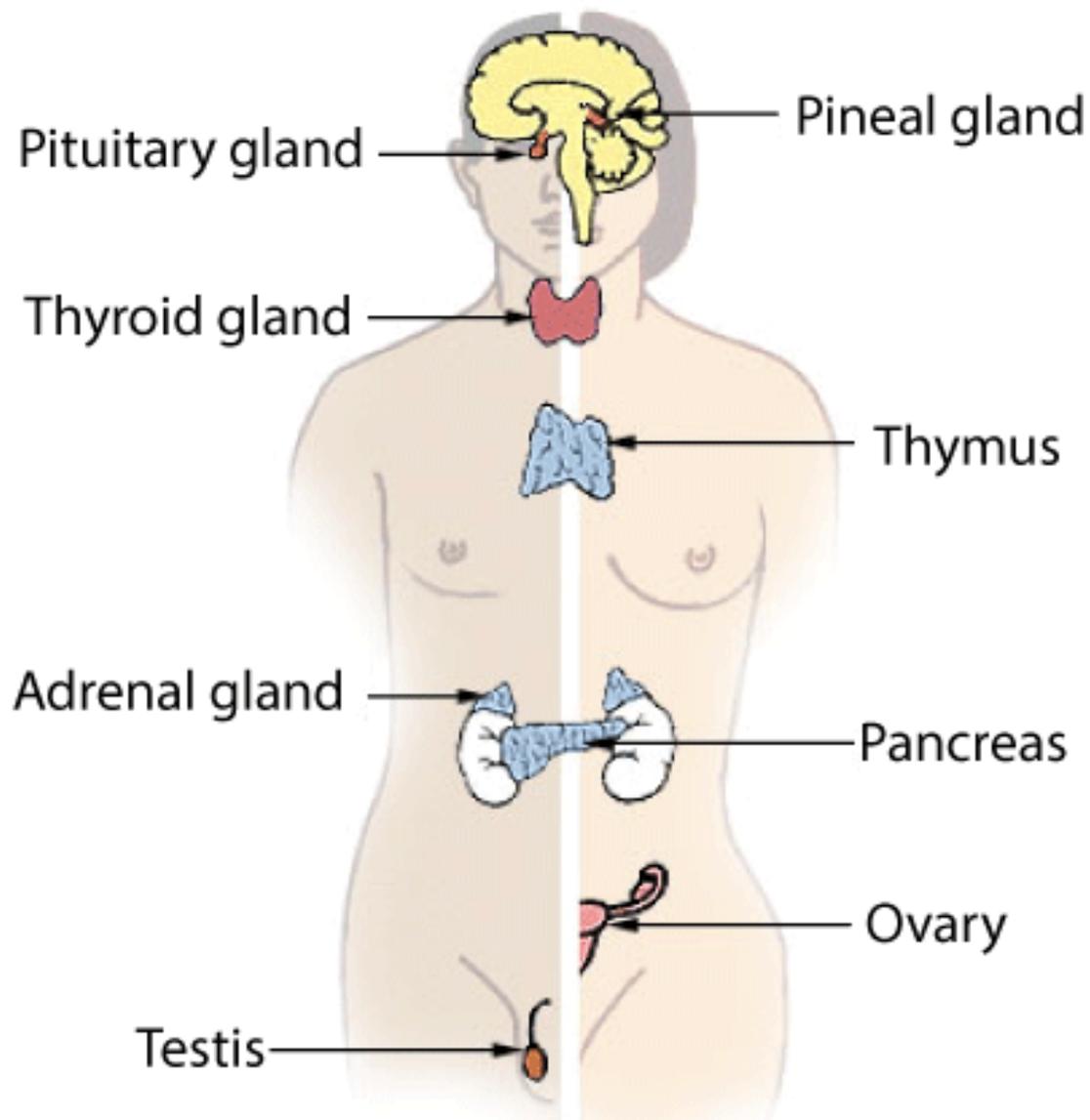
A hormone is a chemical substance produced by specialized glands or cells in the body, known as endocrine glands. These hormones are secreted into the bloodstream and are carried throughout the body, where they exert specific effects on target organs or tissues. Hormones play crucial roles in regulating various physiological processes and maintaining homeostasis within the body. A different kind of coordination is brought about by the endocrine system than nervous system. This system depends on chemicals, called hormones, which are released into the bloodstream from special glands, called endocrine glands.

The hormones circulate around the body in the blood and eventually reach their target organs. Hormones speed up, slow down or alter the activity of those organs. After being secreted, hormones only remain temporarily in the blood. They are changed by the liver into inactive compounds and excreted by the kidneys.



Identify, on a diagram, endocrine glands that produce hormones and state the hormones they produce, limited to:

(a) the adrenal glands – produce adrenaline (b) the pancreas – produces insulin and glucagon (c) the pituitary gland – produces follicle stimulating hormone (FSH) and luteinising hormone (LH) (d) the testes – produce testosterone (e) the ovaries – produce oestrogen and progesterone.

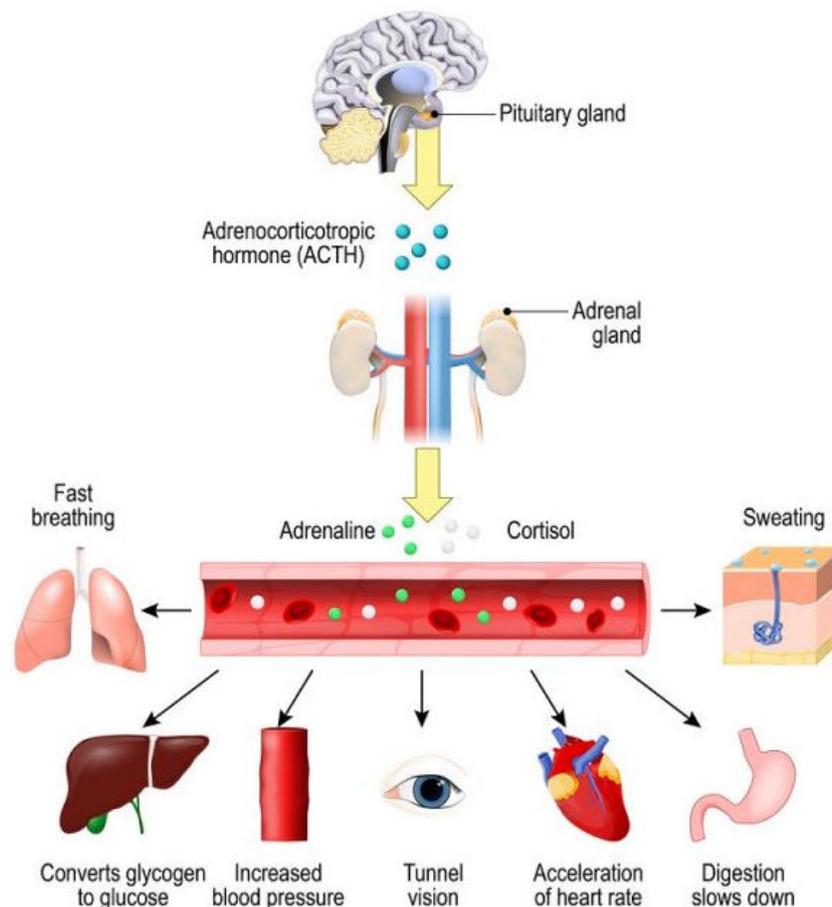


Understand the role of the hormone adrenaline, produced by the adrenal glands, in increasing the blood glucose concentration and heart rate and give examples of situations in which these may occur.

Adrenal glands are attached to the back of the abdominal cavity, one above on the distal end of each kidney. Adrenaline, also known as epinephrine, is a hormone produced by the adrenal glands in response to stress or excitement. It plays a crucial role in the body's fight-or-flight response, preparing the body for action in times of perceived danger or stress. Adrenaline exerts its effects by binding to specific receptors on target cells throughout the body, particularly in the cardiovascular system and liver. In response to a stressful situation, nerve impulses are sent from the brain to the adrenal gland, which releases adrenaline into the blood. Its presence causes breathing to become faster and deeper. The heart beats faster, resulting in an increase in pulse rate. This increase in heart rate can be quite worrying, making us feel as if our heart is going to burst out of our chest. The pupils of our eyes dilate, making them look much blacker.

In the liver it stimulates the conversion of glycogen to glucose. The glucose passes into the bloodstream. Its increased concentration increases the heart rate and cardiac output, preparing the body to respond quickly to the threat by either fighting or fleeing. Adrenaline has an important role in the control of metabolic activity. Increased levels of glucose available to cells enable them to respire faster, making more energy available.

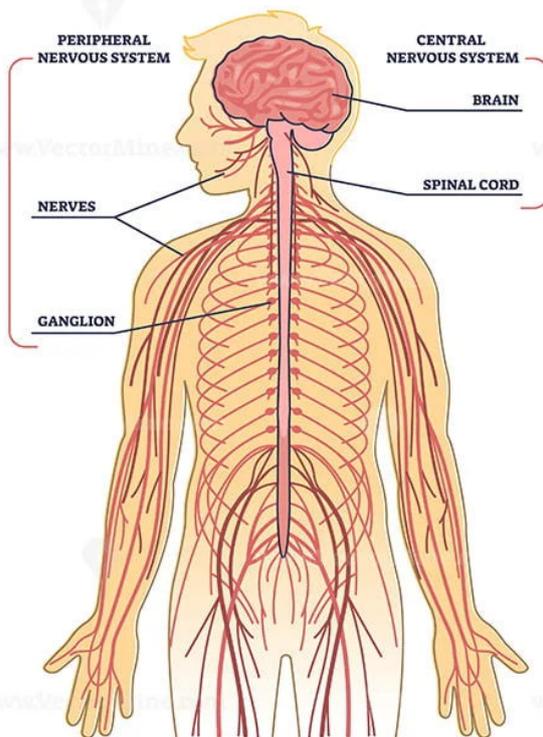
STRESS RESPONSE



Compare nervous and hormonal control, limited to speed of action and duration of effect.

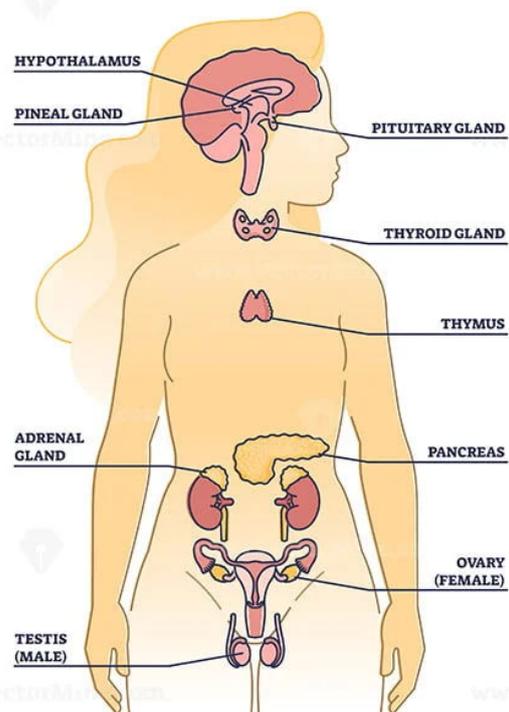
| Sr. No. | Endocrine System | Nervous System |
|--------------------------|---|---|
| Transmission | Transmission of chemicals. | Transmission of electrical impulses. |
| Transmission medium. | Transmission through blood. | Transmission through nerves. |
| Speed of transmission. | Slow transmission. | Rapid transmission. |
| Dispersal or target sit. | Hormones dispersed throughout the body. | Impulses sent directly to the target organ. |
| Duration of effect | Long-term effects. | Short-term effect. |

NERVOUS SYSTEM



MESSENGERS: ELECTRICAL IMPULSES

ENDOCRINE SYSTEM



MESSENGERS: CHEMICAL HORMONES

14.4 Homeostasis

Describe homeostasis as the maintenance of a constant internal environment.

Explain the concept of control by negative feedback with reference to a set point.

Homeostasis

Homeostasis is a Greek word meaning similar state. It refers to the body's ability to maintain a stable and relatively constant internal environment despite external changes or fluctuations. It involves the regulation of various physiological parameters, such as temperature, pH, blood glucose levels, and fluid balance, within narrow ranges that are optimal for cellular function and overall health.

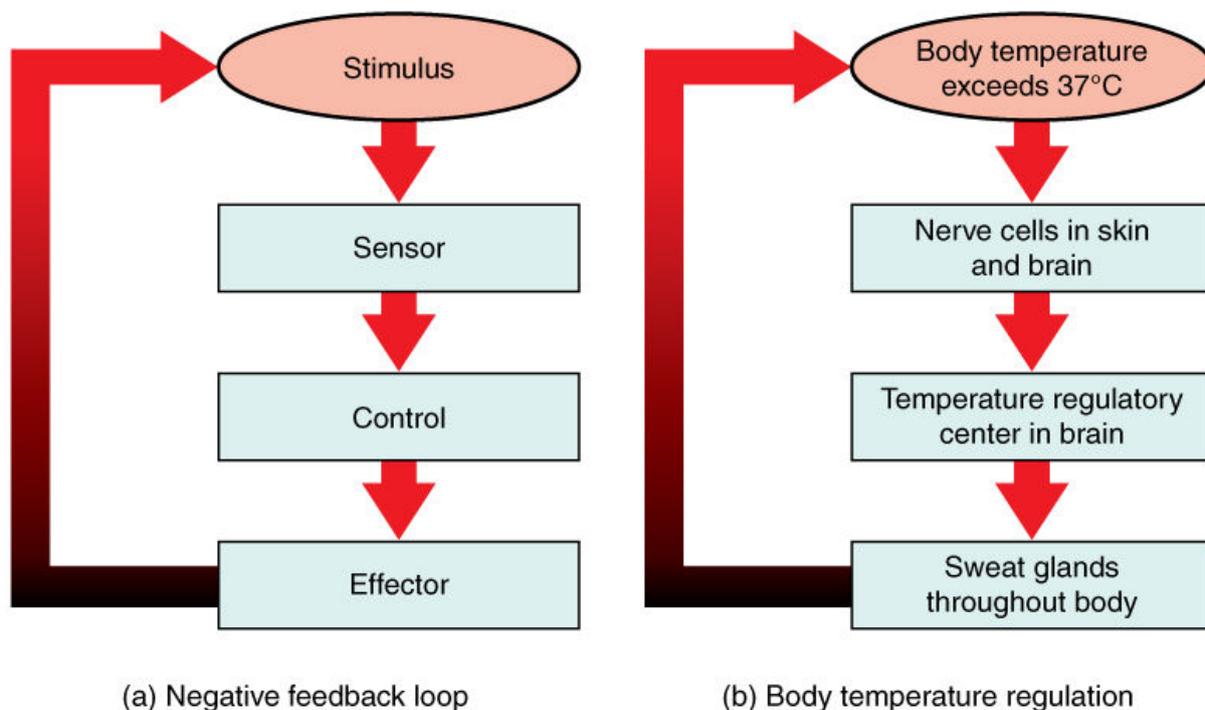
Set point

Set point is the physiological value around which the normal range fluctuates.

Homeostasis works through a system of control feedback mechanisms. Control by negative feedback is a fundamental principle in homeostasis, where the body maintains stable internal conditions by counteracting deviations from a set point. Negative feedback mechanisms work to minimize or reverse changes in physiological parameters, bringing them back to the set point or optimal level.

The outgoing bloc impulses counteract the effects produced by the incoming impulses. For example, a rise in blood glucose levels triggers responses that counteract the rise (e.g. through the release of insulin).

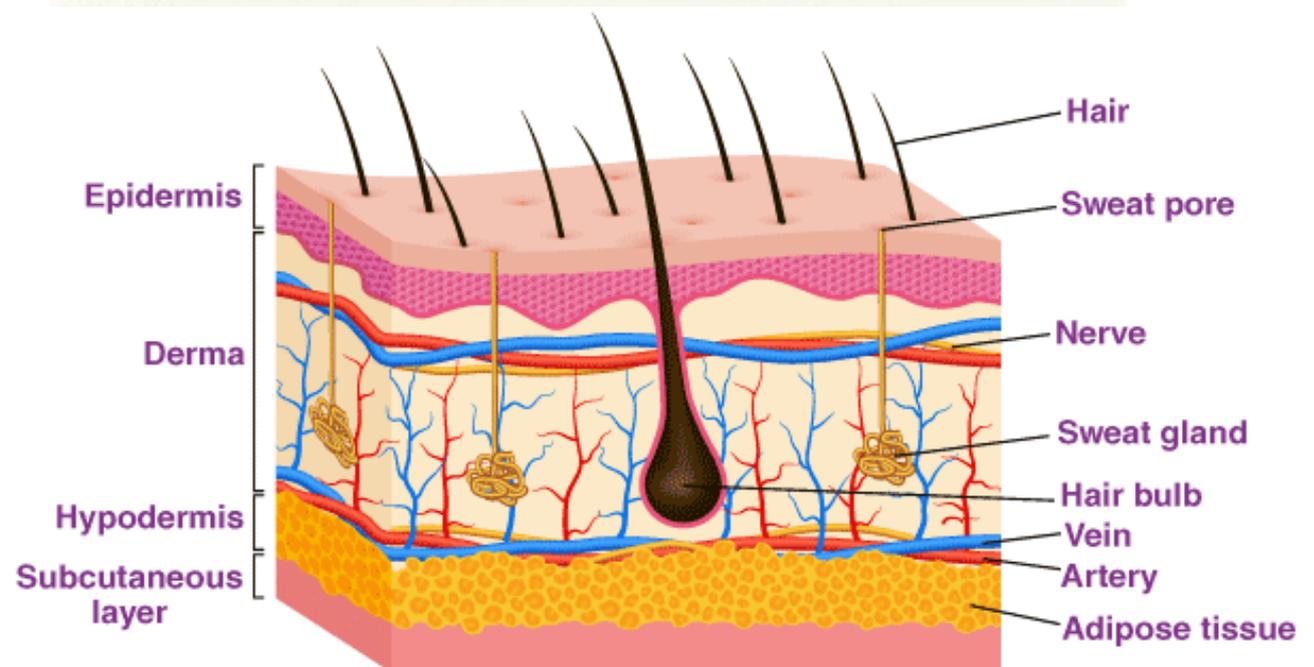
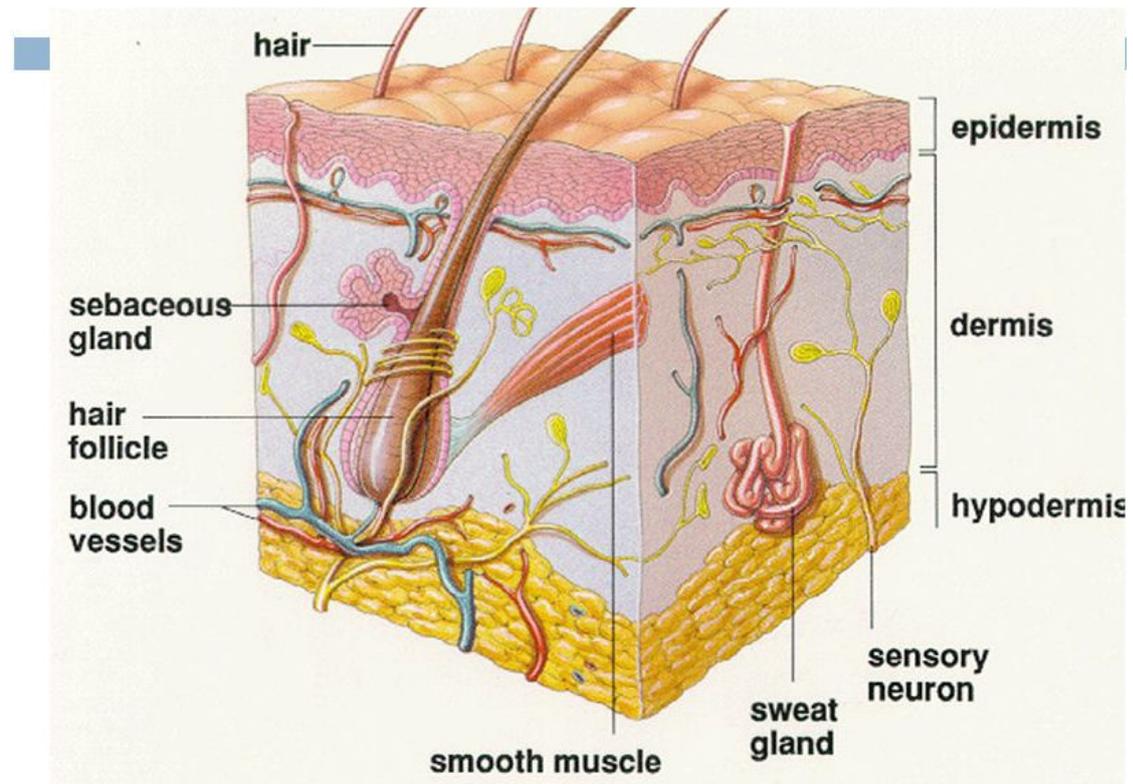
In the brain of a warm-blooded animal there is a thermoregulatory center. This center monitors the temperature of the blood passing through it. It also receives sensory nerve impulses from temperature receptors in the skin. A rise in body temperature is detected by the thermoregulatory center and it sends nerve impulses to the skin, which result in vasodilation and sweating. In the same way, a fall in body temperature will be detected and will trigger impulses that produce vasoconstriction and shivering.



14.5 Temperature control

Identify, on a diagram of the skin: hairs, hair erector muscles, sweat glands, receptors, sensory neurones, blood vessels and fatty tissue.

SKIN OF THE MAMMAL



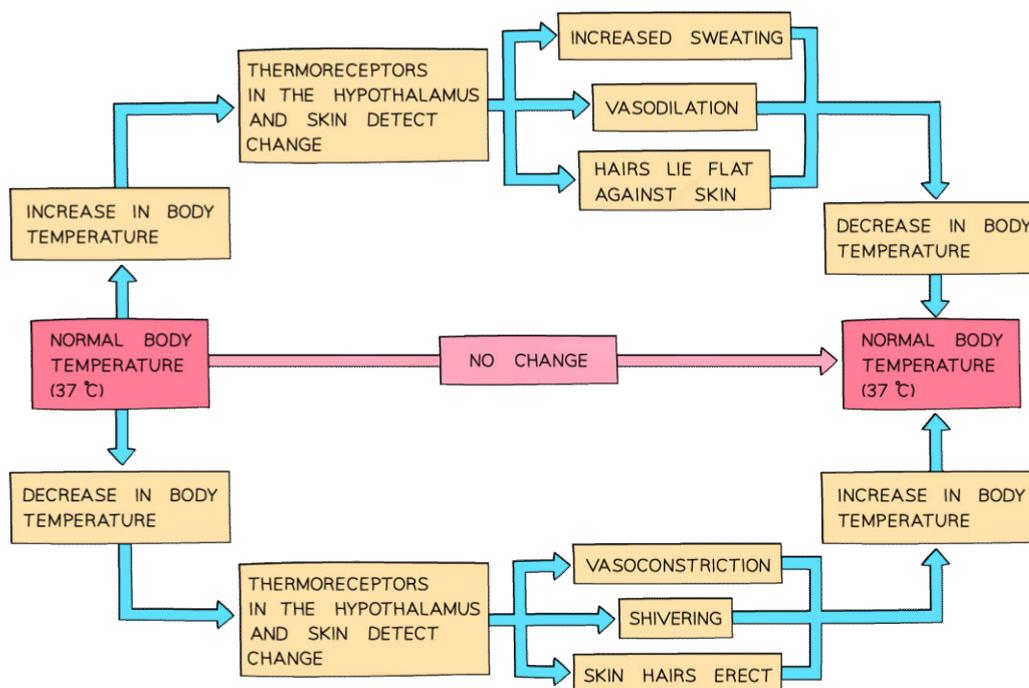
Describe the role of insulation in maintaining a constant internal body temperature in mammals.

Describe the roles of the hypothalamus and of temperature receptors in the skin in maintaining a constant internal body temperature in mammals.

Mammals have evolved various mechanisms to conserve metabolic heat produced by cellular respiration and maintain stable internal conditions despite fluctuations in external temperature. Insulation plays a crucial role in maintaining a constant internal body temperature in mammals by reducing heat loss to the surrounding environment and helping to regulate body temperature effectively.

Heat is lost from the body surface by conduction, convection, radiation and evaporation. The insulating properties of fatty tissue in the dermis help to reduce the amount of heat lost. Some mammals living in extreme conditions, like whales and seals, make much greater use of this, they have thick layers of blubber to reduce heat loss more effectively. The thickness of blubber depends on the amount of water in the tissue. A smaller proportion of water and more fat give better insulating properties.

The hypothalamus and temperature receptors in the skin play key roles in maintaining a constant internal body temperature in mammals. It receives input from temperature receptors located throughout the body, including those in the skin, as well as from the blood. Based on the information it receives, the hypothalamus continuously monitors the body's internal temperature and compares it to a set point, typically around 37°C. In response to a decrease in body temperature (hypothermia), the hypothalamus narrows the arterioles in the skin, which reduces the blood flow towards external surfaces. This conserves the heat into the body. This process is known as vasoconstriction. Hypothalamus may also trigger shivering and increase the metabolic rate to produce more heat. Conversely, in response to an increase in body temperature (hyperthermia), the hypothalamus widens the arterioles, allowing more blood flow towards the extremities resulting in heat loss. This is called as vasodilation. Sweating also helps in controlling hyperthermia.



Explain how each of the following processes contributes to the maintenance of constant internal body temperature in mammals:

- (a) sweating (b) shivering (c) contraction of hair erector muscles (d) vasodilation and vasoconstriction of arterioles supplying skin surface capillaries**

Each of the following processes contributes to the maintenance of constant internal body temperature in mammals by helping to regulate heat exchange between the body and the external environment.

Sweating.

Sweating is the process by which the body releases heat through the evaporation of sweat from the skin's surface. The sweat glands secrete sweat on to the skin surface. When this layer of liquid evaporates, it takes heat from the body and cool it down.

Shivering.

Shivering is the involuntary contraction of skeletal muscles, primarily in the limbs, to generate heat through friction and muscle activity. The repetitive contractions of shivering muscles increase metabolic activity and produce heat, helping to warm the body and restore temperature to the optimal range.

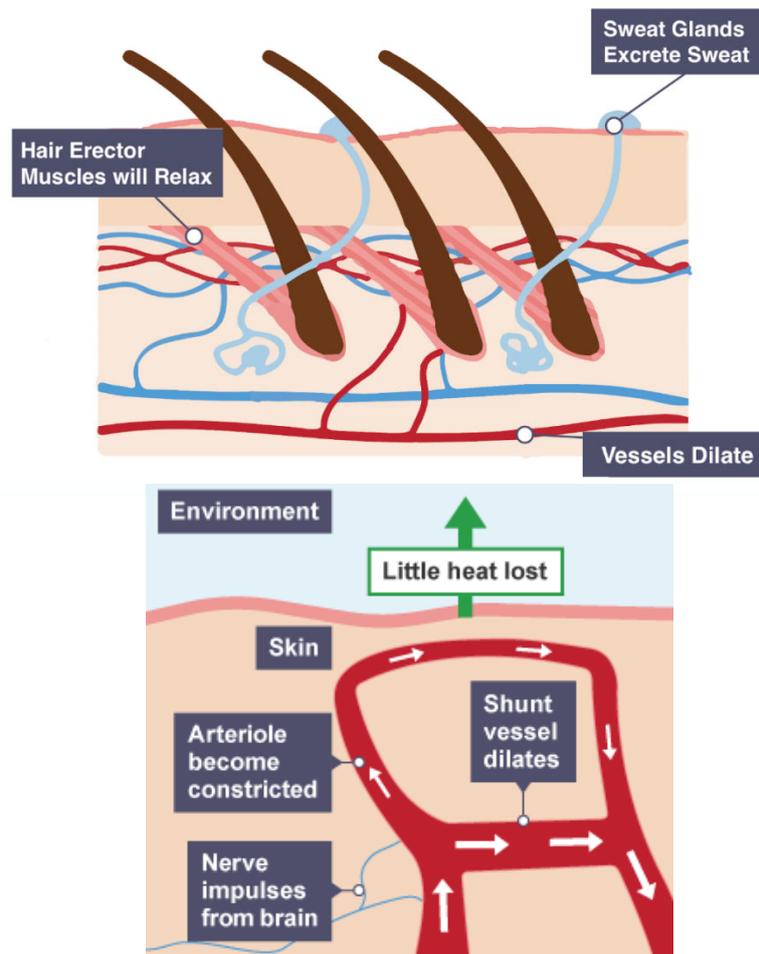
Hair erector muscles.

Hair erector muscles contract pulling the hairs so that they stand upright. In doing so they trap air against the surface of the skin which helps to insulate it against further heat loss.

Vasodilation and Vasoconstriction.

Vasodilation is the widening of blood vessels (arterioles) supplying capillaries near the skin's surface, allowing more blood to flow through and dissipate heat.

Vasoconstriction, on the other hand, is the narrowing of these blood vessels, reducing blood flow and conserving heat.



14.6 Blood glucose control

Explain the need to control blood glucose concentration.

Describe the control of blood glucose concentration by the liver and pancreas and the roles of insulin and glucagon.

Maintaining the optimal blood glucose levels is vital for sustaining overall health and supporting essential bodily functions. Glucose serves as the principal fuel source for cells across the body, with the brain predominantly relying on glucose for energy production. It provides energy in the form of ATP so its deficiency will result in reduced cellular activity indicating a fall in heart and brain function. Whether a higher glucose concentration can also result in various health complications. If left untreated, hyperglycemia can lead to serious conditions such as diabetes mellitus and its associated complications, including cardiovascular disease, kidney damage, nerve damage, and vision problems.

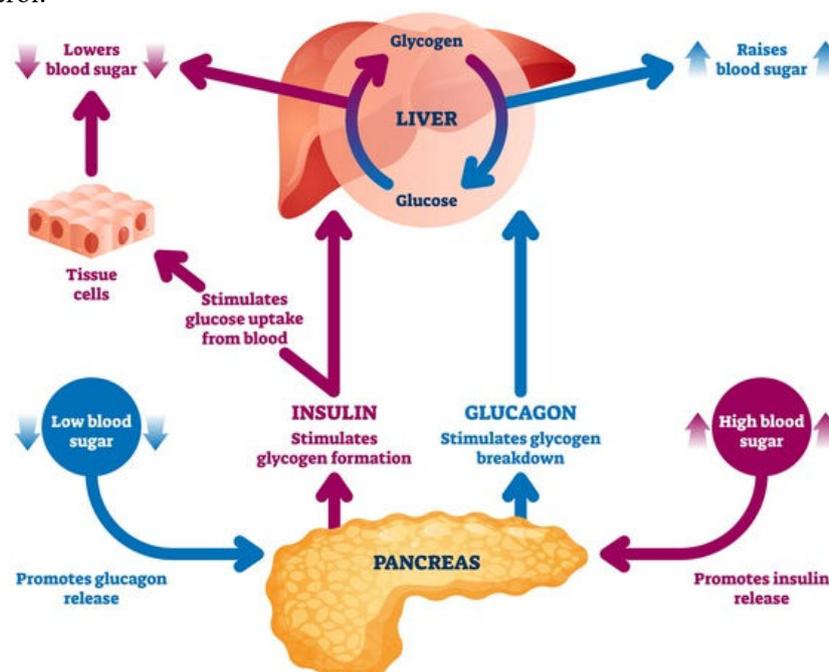
The control of blood glucose concentration involves a dynamic interplay between the liver and pancreas, with insulin and glucagon playing key roles in regulating glucose levels.

Pancreas

Pancreas controls the sugar level by the secretion of peptide hormones Insulin and Glucagon both of which has an antagonistic function to each other. Insulin is secreted by beta cells in the pancreas in response to elevated blood glucose levels, such as after a meal. Insulin promotes glucose uptake by cells, enhances glycogen synthesis in the liver and muscles, and inhibits gluconeogenesis and glycogenolysis. Overall, insulin helps lower blood glucose levels by facilitating glucose uptake and storage in tissues. Glucagon is secreted by alpha cells in the pancreas in response to low blood glucose levels, such as during fasting or between meals. Glucagon stimulates glycogenolysis and gluconeogenesis in the liver, leading to the release of glucose into the bloodstream and raising blood glucose levels. Glucagon acts in opposition to insulin to maintain blood glucose homeostasis during periods of fasting or energy demand.

Liver

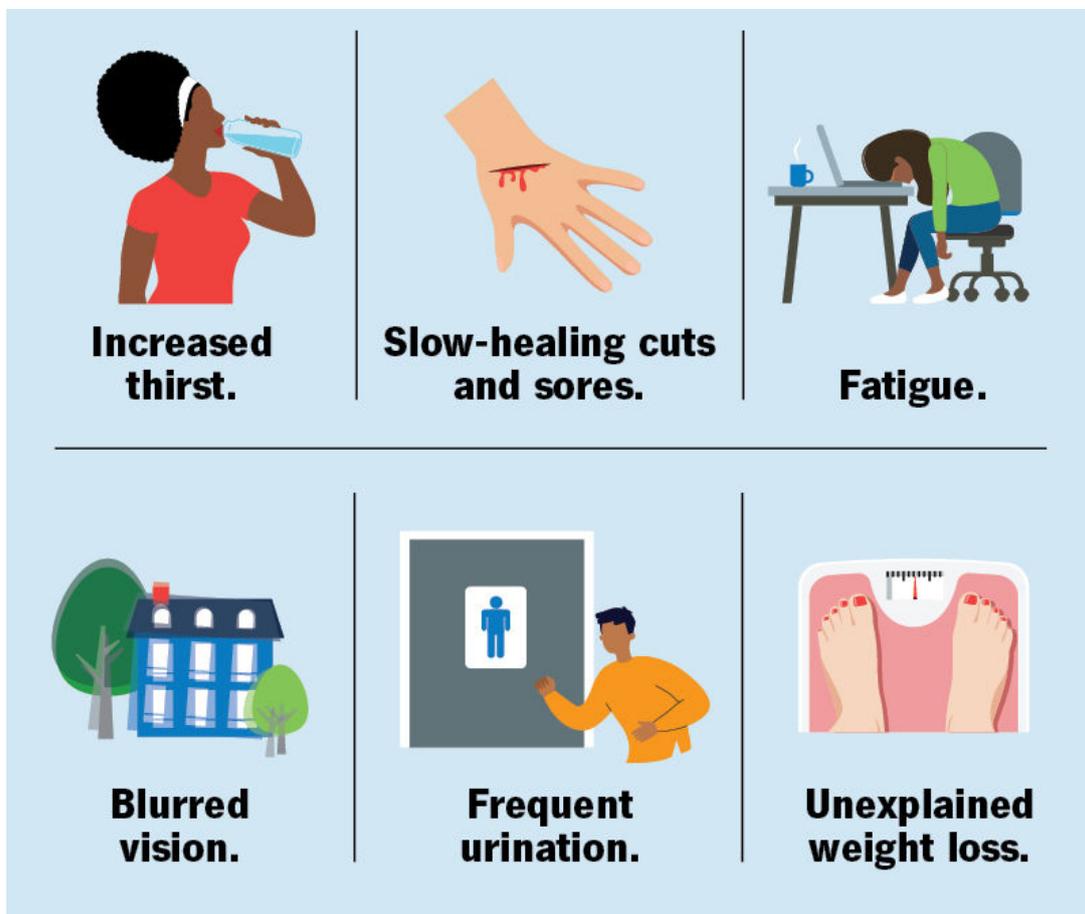
The liver plays its homeostatic control in the maintenance of blood glucose through the processes of glycogenesis, glycogenolysis, and gluconeogenesis. Glycogenesis involves the synthesis of glycogen from glucose molecules. It is done when glucose levels in the body are elevated. Glycogenolysis is the breakdown of glycogen into glucose molecules. It is done when glucose levels fall off the optimal value. Gluconeogenesis is the production of glucose from non-carbohydrate sources, such as amino acids and glycerol.



Describe the signs of Type 1 diabetes (limited to increased blood glucose concentration and glucose in urine) and its treatment (administration of insulin)

There are two types of diabetes and Type 1 is the less common form. It happens when the islet cells of the pancreas do not produce enough insulin. As a result the patient's blood is low in insulin and he or she needs regular injections of the hormone in order to control blood sugar level and so lead a normal life. This form of the disease is sometimes called insulin- dependent diabetes. The patient is unable to control the level of glucose in the blood. It may rise to such a high level that it is excreted in the urine, or fall so low that the brain cells cannot work properly and the person goes into a coma. The signs of diabetes include increased blood glucose concentration and the presence of glucose in urine. The symptoms include feeling tired, feeling very thirsty, frequent urination and weight loss. The weight loss is because the body starts to break down muscle and fat.

Diabetics with Type 1 diabetes need a carefully controlled diet, to keep the blood sugar within reasonable limits, and must take regular exercise. They need to have regular blood tests to monitor their blood sugar levels, with regular injections of insulin to control them.





**ABDUR REHMAN
BIOLOGY**