Coordination and Response

Nervous control in humans

- All organisms are sensitive to changes in the environment, known as stimuli, (singular stimulus)
- Receptors are cells that detect stimuli
- Effectors are the organs, such as glands and muscles that bring about responses
- Glands secret useful substances and muscles contract to bring about movement
- The actions they take as a result are called responses
- Two systems are involved- the sensory system for detecting changes in the environment and the nervous system for coordinating responses and initiating actions

Human Nervous System

- The human nervous system consists of two parts: the central nervous system (CNS) and the peripheral nervous system (PNS)
- The central nervous system is made up of the brain and spinal chord
- The brain is protected by the skull and the spinal cord by the vertebral column
- The cranial nervous system is connected to different parts of the body by nerves that make up the peripheral nervous system
- Cranial nerves and spinal nerves are in pairs on either side of the brain and spinal cord respectively
- Cranial nerves link the brain with all the organs in the head and also some in the thorax and abdomen
- Spinal nerves link the brain to the arms, thorax, abdomen and legs
- Spinal nerves leave the spinal cord in pairs through spaces between the vertebrae
- Each nerve is made up of lots of nerve cells or neurones surrounded by a protective fibrous tube
- Neurones transmit information in the form of nerve impulses which are like pulses of electricity passing along a wire

Involuntary and Voluntary actions

- Voluntary actions are under conscious control and involve the brain in decision making
- Involuntary actions occur unconsciously without us having to think of them, but we can choose to control them occasionally
- Sequence of events in a simple reflex reaction:

$$stimulus \rightarrow receptor \rightarrow coordinator \rightarrow effector \rightarrow response$$

- The coordinator is part of the body that connects information about the stimulus to the effector
- This always happens inside the central nervous system to allow communications with other parts of the body and brain to be aware of stimuli
- Inside the spinal cord, neurones from pain receptors connect with neurones to the muscles

Neurones and reflex arcs

Neurones

- Neurones are highly specialised cells
- Their structure allows them to transmit information as nerve impulses over long distances
- The cell body contains nucleus and almost all of the cytoplasm
- However, neurone have thon extensions that may be quite short but extend a long way through the body
- Sensory neurones transmit impulses from sense organs to the brain and spinal cord
- Motor neurones transmit impulses away from the brain and spinal cord to effector organs- muscles and glands
- Sensory and motor neurones are surrounded by insulation
- This insulation is known as myelin, formed by separate cells that grow around the neurones to form a layer rich in fat
- Relay (connector) neurones are short and pass on impulses from sensory neurones to motor neurones inside the brain and spinal cord
- When any two neurones meet, they do not touch, there is a tiny gap called a synapse
- When an impulse reaches a synapse a chemical transmitter substance is released from the first neurone
- It diffuses across the synapse and triggers an impulse in the second neurone
- Since the chemical transmitter is only produced on one side of the synapse, it ensures that impulses travel in one direction through the nervous system

Reflex arcs

- A reflex arc is the pathway of the impulse along the neurones
- A hot flame is an example of a stimulus
- The receptor is the heat sensor in the skin
- When it is stimulated the heat sensor generates an impulse
- The impulse travels to the spinal cord along a sensory neurone
- Inside the grey matter of the spinal cord the impulse passes across a synapse to a relay neurone
- The relay neurone passes the impulse across a second synapse to a motor neurone
- The motor neurone transmits the impulse to a muscle in the arm
- The muscle is the effector and it contracts to remove the hand from the hot object
- The action is the response
- Many reflexes are protective, they happen very quickly to prevent injury

Synapses and drugs

- A synapse is a junction between two neurones
- The gap between two neurones is called the synaptic gap
- The neurone that carries the impulse to the synapse is called the presynaptic neurone
- The neurone that carries the impulse away from the synapse is called the postsynaptic neurone
- Chemicals known as neurotransmitters are released by the presynaptic neurone and diffuse across the synaptic gap to trigger an impulse in the postsynaptic neurone

Structure of the synapse

- The axons of neurones end in swellings called synaptic bulbs
- The surface of the synaptic bulb is called the presynaptic membrane
- It is separated by the synaptic gap from the postsynaptic membrane of the cell body or axon of the next neurone
- The synaptic bulb has many vesicles containing neurotransmitter molecules
- It also contains many mitochondria which suggests that energy is required in synaptic transmission
- The post synaptic membrane has a large number of protein molecules on its surface which act as receptor sites for the neurotransmitter substance

Synaptic transmission

1. When an impulse arrives at the synaptic bulb it causes vesicles containing the neurotransmitter to move across the presynaptic membrane
2. The vesicles fuse with the presynaptic membrane, releasing the neurotransmitter into the synaptic gap
3. The neurotransmitter diffuses across the synaptic gap and attaches to specific receptor sites on the post synaptic membrane. The receptor sites have a complimentary shape to the neurotransmitter, but the binding is only temporary
4. The binding of the neurotransmitter triggers an impulse in the postsynaptic neurone. Once this has happened the neurotransmitter is broken down by an enzyme in the synaptic gap
5. The mitochondria provide energy to reform the neurotransmitter

- Nerve impulses only travel in one direction i.e. from presynaptic neurone to postsynaptic neurone
- This happens because vesicles of the neurotransmitter are only present in the presynaptic bulb and the receptors are only found on the postsynaptic membrane

The effect of drugs on synaptic transmission

- Most drugs that affect the nervous system have their effects at synapses
- These drugs influence the release of neurotransmitter s
- Interact with receptor by either stimulating or inhibiting them
- Amphetamines are a type of excitatory drug that increases activity in the nervous system:
    i. Stimulate the release of neurotransmitters in the brain, increasing brain activity, making the person more alert
    ii. They also have the effect of suppressing appetite
- Heroin and beta-blockers are examples of inhibitory drugs, that reduce the effects on neurotransmitters
- Heroin acts on the presynaptic neurones to reduce the release of neurotransmitter and this reduced the sensation of pain
- Beta-blockers are drugs that block receptors for neurotransmitters and are taken by people to reduce blood pressure and heart rate

Sense Organs

- Sense organs are groups of receptor cells that respond to specific stimuli
- The eyes respond to light rays and gives us our sense of sight
- The nose responds to chemicals in the air and gives us our sense of smell
- The tongue responds to chemicals in our food and drink and gives us our sense of taste
- The ears respond to sound vibrations that gives us our sense of hearing, the ear also detect movement and position of the body, providing information about balance
- The skin responds to pressure and gives us our sense of touch, it also detects pain and temperature

Eye Structure

- Your eye sits inside a socket in the skull and is moved about by 3 pairs of eye muscles
- The eye is a complex of organ composed of different tissues
- At the front of the eye is a delicate, transparent layer, through which light enters the eye
- Light then passes through the pupil which is a hole in the centre of the pigmented iris, through the lens to the retina at the back of the eye
- The retina is a tissue with light-sensitive receptor cells
- At the very front of the eye is a delicate, transparent layer, which provides protection.
- It is kept moist by tear glands, that clean your eyes every time you blink
- Tears also contain lysosome, an enzyme that kills bacteria
- What you see in front of you is called your visual field
- Each eye views the same visual field but from a slightly different angle
- When shutting the eyes, the two fields overlap to give stereoscopic visions, which allows us the ability to judge distances accurately
- Essential for tree-dwelling animals and predators which need to judge distances accurately to survive

Control of the pupil reflex

- The size of the pupil is controlled by a pair of antagonistic muscles in the iris
- The circular muscles are arranged around the pupil
- The radial muscles run outwards from the pupil like spokes in a wheel
- Antagonistic muscle pair
- Circular muscles contract to reduce the size of the pupils
- The radial muscles contract to increase the size of the pupils

Focusing

- Light enters the eye through the transparent cornea
- Passes through the lens to be focused on the retina
- The image is inverted because of the way the light rays reflected from the top and bottom of the object enter the eye and cross over behind the lens
- Information about this inverted image goes to the brain to be interpreted the right way up
- We learn how to do this in the first few months of life

Rods and Cones

- Rods and cones are light receptor cells on the retina
- Rod cells are sensitive to light of low intensity and send impulses only when it is dark, responsible for night vision
- Cone cells are only sensitive to light of high intensity
- There are three types of cone cell, each sensitive to different wave lengths of light
- The brain interprets impulses from cone cells to give us coloured vision
- The fovea is the centre of the retina which contains no rods nor cones
- Each cone has its own neurone to the brain so this area in the middle of our visual field gives us a detailed image
- The rest of the retina contains rods and few cones
- This area gives us peripheral vision which is not very detailed
- The position of the fovea is in the centre of the retina on the horizontal level as the blind spot

Accommodation

- Term used to describe the changes that occur in the eye when focusing on far and near objects
- As light enters the eye it must be refracted to see the image clearly
- The lens is surrounded by elastic tissue that can stretch and recoil
- The shape of the lens is controlled by the ciliary muscles

Whilst seeing distant objects	Whilst seeing close objects
The ciliary muscles relax Pressure inside eye pulls sensory ligaments tight Lens pulled into elliptical (thin) shape Light rays refracted as they pass through lens and focus on the retina The distant object is in focus	The ciliary muscles contract to counteract pressure in the eye Suspensory ligaments are slack Elastic tissue recoils and becomes spherical (fat) Light rays are refracted more The near image is now in focus

Hormones

The endocrine system

- A hormone is a chemical substance produced by an endocrine glad and transported in the blood to alter the activity of target organs

Adrenaline

- Secreted by adrenal gland
- Makes you more aware and ready to take action
- Fight or flight reaction:
    i. Increasing the breathing rate
    ii. Increasing pulse
    iii. Widening pupils for more light to enter eyes
- Stimulates increase in rate of chemical activity
- Stimulates liver cells to convert glycogen to glucose
- Adrenaline coordinates uptake of oxygen and changes in the blood

Effects of adrenaline

- Air passages widen, allow more air into alveoli, increases volume of oxygen to be absorbed
- Breathing rate increases to increase the uptake of oxygen and excrete carbon dioxide at a faster rate
- Arterioles in the brain and muscles dilate to deliver more glucose and oxygen for respiration in these organs
- Arterioles in the gut and other organs constrict to deliver blood to the muscles
- If too much adrenaline is realised, as a result of prolonged strength/anxiety, high blood pressure and heart disease may result
- Beta-blockers help to reduce blood pressure and heart rate

Comparing the endocrine and nervous system

Feature	Nervous system	Endocrine system
Structures	Nerves	Secretory cells in glands
Forms of information	Electrical impulses	Hormones
Pathways	Along neurones	In the blood
Speed of information transfer	Fast	Slow
Longevity of action	Short time	Usually slow and long lasting
Target area	Only the area at the end of a neurone	Whole tissue or organ
Response	Muscle contraction or secretion by glands	Conversion of glucose to glycogen, protein synthesis, rate of respiration

Controlling conditions in the body

- Homeostasis is the maintenance of constant or balanced internal conditions of the body so that enzymes can control metabolism efficiently
- Negative feedback loop creates responses to counteract the effect of a variable
- Positive feedback loop increases the intensity of the variable to trigger response

Controlling body temperature

The skin

Functions:

- Protects body from damage
- Stops pathogen from entering
- Prevents too much water loss
- Detects changes in temperature
- Detects pressure (touch) and pain
- Loses heat by conduction, convection, radiation and evaporation
- Mammals have fur or hair which traps a layer of air close to the skin

- Air is a poor conductor of heat
- Air pockets reduce the amount of heat loss to the atmosphere by keeping convection currents of air away from the skin
- When it is cold hair erector muscles contract so that the hair stand erect to trap a thick layer of air reducing heat loss
- When it is hot hair muscles relax so hairs lie fat
- Less air is trapped close to the skin so more heat can't be lost via convectional currents of air
- Mammals also have a layer of fatty tissue beneath the skin that is a good insulator

Controlling temperature in the body

- A very effective way to regulate body temperature is to change how much blood flows through the capillaries near the surface of the skin
- Arterioles supply these capillaries with blood
- The muscle around the arteriole can relax
- Increase in blood flow in the capillaries
- Known as vasodilation
- Heat lot to surroundings by convection and radiation
- In the cold, walls of arterioles constrict
- Reduces blood flow through capillaries
- Blood diverted to stay in the fatty layer in the skin
- Known as vasoconstriction

Tropic responses

Gravitropism

- A gravitropism is a growth response to the stimulus of gravity
- Roots are positively gravitropic because they grow in the same direction as gravity
- Shoots are negatively gravitropic, they grow in the opposite direction to gravity

Auxin

- Plant hormone that controls growth
- Stimulates shoot growth by causing cells to elongate
- Inhibits root growth by slowing down elongation
- If a seedling is put on its side then the auxin builds up on the lower side of the shoot and root
- In the shoot the auxin stimulates the cells there to elongate and therefore grow more on the lower side
- This causes the shoot to bend upwards
- In the root the auxin builds up on the lower side
- Auxin slows down growth by inhibiting elongation
- As a result the cells on the upper side of the root elongate more than those on the lower side so the root bends downwards
- Auxin is made in the shoot tip
- Auxin moves away from the shoot tip down the stem
- Auxin is unequally distributed so most is found on the shaded side
- The auxin stimulates the cells on the shaded side to elongate more than the cells on the side of direct light

- The shoot grows more on the shaded side and bends towards the light
- Roots are not sensitive to light

Phototropism

- (Positive) phototropism, or positively phototropic plants grow towards the light
- Advantage: leaves are exposed to maximum surface area to the light

Synthetic plant hormones

- Synthetic auxins are very effective as selective weed killers
- Important crops (cereals) have narrow leaves, whilst weeds have broad leaves
- Herbicides [2,4-D] are sprayed on the crop but tend to run off the leaves of the cereal because they are thin and point upwards
- The weed killers are more likely to be absorbed by the broad leaved weeds
- The auxins increase the growth rate of the affected leaves, by increasing rate of cell division
- The weeds cannot provide enough food from photosynthesis to maintain this rate of growth and will soon die