Higher Human Biology Outcomes

UNIT 3

Neurobiology and Communication

The nervous system

Divisions of the nervous system and parts of the brain

- The nervous system analyses sensory information from the body and the external environment
- The information is analysed and appropriate voluntary and involuntary motor responses are made which lead to muscular contractions or glandular secretions
- Some of the information is stored for future use

Structures and functions of the central nervous system (CNS)

- The nervous system is divided into the central and peripheral nervous systems
- The CNS is composed of the brain and the spinal cord
- The peripheral nervous system is made up from sensory neurones carrying impulses from the receptors to the CNS and motor neurones which carry impulses from the CNS to the muscles
- The peripheral nervous system can be divide into the somatic and autonomic nervous system
- Sensory and motor neurones of the somatic nervous system (SNS) control the voluntary movement of skeletal muscles.
- The somatic system deals with functions under conscious control such as walking and speaking
- Bodily functions such as heart rate happen automatically and are controlled by the autonomic system
- The nerves that make up the autonomic nervous system arise from nerve cells in the brain and emerge at various points down the spinal cord to reach effectors such as cardiac muscle, smooth muscle and glands where they stimulate nerve impulses to carry out homeostatic control
- The autonomic nervous system can be divided into the sympathetic and parasympathetic system
- These systems are said to be antagonistic meaning that they affect the same structure, but have opposite effects on them
- The parasympathetic part of the autonomic system conserves resources as it is dominant at times of rest when the heart rate is low, breathing rate is reduced and blood flow is reduced in the muscles and increased to the digestive system and its muscles
- When the body is active or excited the sympathetic system is dominant causing increased heart and breathing rate, perspiration and the redistribution of blood away from the digestive system to the muscles
- Fight or flight response is caused by the sympathetic system preparing the body for action and the expenditure of energy increasing heart and breathing rate and slowing down peristalsis and intestinal secretions
- Rest and digest response is caused by the parasympathetic system calming the body down and returning it to normal helping the body to conserve resources and store energy. Heart and breathing rate slow and peristalsis and intestinal secretions increase

Parts of the brain

- Consists of three interconnected layers, the central core, the limbic system and the cerebral cortex (outer layer of cerebrum)
- The central core contains the medulla which regulates the basic life processes of breathing, heart rate, arousal (being awake and aware of external environment) and sleep
- It also contains the cerebellum which is responsible for controlling balance, posture and movement

The functions of the limbic system

- The limbic system is part of the brain involved with processing information for memories, regulating emotional states (e.g. anxiety, fear and aggression) and influencing biological motivation (e.g. hunger, thirst and sex drive)

The functions of the cerebral cortex

- The cerebral cortex is the outer layer of the cerebrum
- The cerebrum is divided into two cerebral hemispheres
- The left side processes information from the right visual field and controls the right side of the body. The reverse is true of the right hemisphere
- The cerebral hemispheres are connected by a large bundle of nerves called the corpus callosum which enables information to be exchanged between the hemispheres
- The cerebral cortex contains three types of functional area: sensory, association and motor
- The sensory areas receive information as sensory impulses from the body's receptors
- The association areas analyse and interpret these impulses 'make sense' of them and 'take decisions'
- The motor areas receive information from the association areas and 'carry out the orders' by sending motor impulses to the appropriate effectors
- A cerebral hemisphere consists of several distinct regions
- The rear of the cerebrum is the visual area which receives impulses from the retina
- The part of the cerebrum beneath the ears is the auditory area which receives impulses from the cochlea
- In front of the auditory area is the speech motor area which controls the tongue, lips and vocal cords
- The somatosensory area receives impulses from the sensory receptors in the skin, muscles and organs
- The motor area sends impulses to the skeletal muscles to cause the appropriate movement
- Close to each area is an association area which analyses, interprets and may 'act on' incoming impulses. It uses memories stored from previous experiences
- Each area is linked to other areas to integrate all the incoming information and also the response
- Cerebral cortex is the centre of conscious thought; it also recalls memories and alters behaviour in the light of experience.
- Areas of the cerebral cortex are also responsible for higher mental processes such as intelligence, personality, creativity, imagination and conscience

Perception and memory

- Perception is a process by which the brain analyses and makes sense out of incoming information by segregating objects from one another and their background, recognising what they are and judging their distance from us
- There are three areas of perception, segregation of objects, perception of distance and recognition
- Segregation of objects
    - Perceptual organisation into figure and ground- when an object appears to stand out from the background in an obvious manner
    - Perceptual organisation of stimuli into coherent patterns is determined by several visual cues such as relative size, superimposition and relative height in field

Perception of distance

- Perception of distance as objects become nearer – the further away an object from the eye the smaller it appears
- Superimposition—when one object partially blocks the view of another, the blocked object is perceived as further away
- Relative height in horizontal field—among a group of objects whose bases are below the horizon, those with their base in a relatively higher position appear to be further away, those with their bases in a lower position seem nearer
- Binocular disparity- each eye looks at an object from a slightly different relative position to the other eye. Therefore a slight disparity (difference) occurs between the images of the same object formed by the two eyes. The closer the object is to view the greater the disparity between the two images. The two images merge into one in the brain. This image indicates depth and distance of an image more effectively than either single eye.

Recognition

- The ability to perceive an object's physical properties such as shape, colour and texture is called object recognition

- Of these properties shape is considered to be the most important in the recognition of objects
- When a person perceives a shape a subconscious attempt is made to match the shape with one already stored in the brain
- If not recognised it could then be recognised as being similar, but not identical to an image held in the brain. The brain then infers that the object is related in some way to one or more of these visual images. It could be a familiar object seen from a different angle.
- Matching perceived shapes to shape descriptions in memory and

Perceptual set

- Perceptual set is the tendency of a person to perceive certain aspects of available sensory information and ignore others
- Perceptual set is affected by expectation, context and past experience. It influences the way a stimulus is perceived

Memory

- Memory is one of our mental faculties. It is the capacity of the brain to store, retain and recall information when required
- Memories include past experiences, knowledge and thoughts
- All information entering the brain passes through sensory memory and enters short term memory
- Information is then transferred to the long term memory or discarded
- The three stage of memorising are encoding, storage and retrieval

Sensory memory

- Stimuli from the outside world are continuously being perceived as sensory images by the brain
- These images are very short lived between 0.5 and 2 seconds
- Only a few are selected and transferred to the short term memory

Short term memory (STM)

- Short term memory allows us to remember information for a few seconds before it is replaced by more
- Short term memory has a limited capacity, or memory span, it can retain about 7 pieces of information for about 30 seconds
- If more items go into the STM they displace the previous items
- More information can be retained in the STM if it is organised
- Chunking can increase memory span by organising information of smaller units into a chunk eg telephone numbers can be chunked to give an area code which reduces 4 numbers to one piece of information—0141 for Glasgow etc
- Rehearsal involves repeating information to yourself many times. This extends the length of time the information is held in the STM and increases the chance that it will be transferred to the LTM
- Serial position effect is where the first few and last few items from a string of facts are remembered best
- The first few items are remembered as there has been time to rehearse them and they are now in the LTM
- The last few are remembered because they are still in the STM
- Working memory is an extension of the STM. It process, manipulates and controls information while held in the STM. This enables simple cognitive tasks to be carried out

Long term memory (LTM)

- LTM is thought to be able to hold an unlimited amount of information
- During encoding the items are organised into categories such as personal facts and useful skills
- The transfer of information from the short to long term memory happens upon successful encoding of the information in the STM
- Once in the LTM it is then stored and may be retrieve at a later date
- Successful transfer of information from the STM to LTM is promoted by rehearsal, organisation and elaboration of meaning
- Rehearsal facilitates the transfer of information from the STM to the LTM
- Organisation is where information is grouped or categorised in a way that is logical meaningful to the learner

- Elaboration is where facts are easier to transfer into the LTM if they are part of a bigger 'story'
- For example phosphofructokinase is easier to remember as part of the whole respiratory pathway than a single fact

Encoding
- Encoding is the conversion of one or more nerve impulses into a form that can be received and held by the brain and retrieved later from the STM or LTM. The quality of the memory is affected by the attention given to the task of encoding the material
- Information encoded by repetition is an example of shallow encoding
- Information encoded by linking it to previous memories is an example of elaborative encoding

Retrieval
- Contextual cues aid the recovery of information from the LTM
- A contextual cue is a signal or reminder relating to the conditions or circumstances that were present at the time when the information was encoded into the LTM

Location of memory in the brain
- Episodic and semantic memories are 'remembering that'…..
- Episodic memory is the recall of personal facts, experiences and events
- Semantic memory is the recall of general knowledge, non-personal facts and concepts
- Episodic and semantic memory are stored in the region of the cerebral cortex (e.g. temporal lobes) where the sensory information was first received and encoded#
- Procedural memories (remembering how to…)
- Procedural memories contain information needed to perform a motor skill(how to swim) and mental skills (how to read)
- Procedural memories are linked to the motor area of the cerebral cortex
- Emotional memories are formed as a result of positive or negative associations with certain stimuli and involve links between the cerebral cortex and the limbic system
- Spatial memory is located in the limbic system and is responsible for holding information about a person's environment and spatial orientation

Nerve cells and neural pathways

The cells of the nervous system

- Nerves are bundles of nerve fibres which carry electrical impulses from one part of the body to the other
- Nerve cells or neurones consist of a nerve cell body and nerve fibres
- The nerve cell body contains the nucleus and cytoplasm containing organelles including ribosomes which make various proteins including enzymes needed for the synthesis of neurotransmitters
- Dendrites are nerve fibres that receive nerve impulses and carry them towards the cell body
- An axon is a nerve fibre which carries impulses away from the cell body
- The direction in which a nerve impulse travels is always dendrite-cell body-axon
- Long axon fibres are covered in a myelin sheath which insulates the axon and speeds up impulse conduction from node to node
- Myelination is the development of myelin round axon fibres of individual neurons
- Myelination is not complete at birth and so nervous control increases over the first two years as many more neurons are myelinated. Myelination continues from birth to adolescence
- A motor neuron has short dendrites which make contact with other neurones in the CNS, a nerve cell body and a long myelinated axon that carries impulse to the many axon terminals within a muscle
- Sensory neurones have one or several dendrites making contact with receptors in a sense organ, these merge to form a myelinated fibre which carries impulses to the cell body, a short axon and axon branches make contact with the CNS neurones
- An inter neuron connects a sensory and a motor neurone

Glial cells

- Glial cells do not transmit nerve impulses they physically support the neurons
- Some glial cells produce myelin sheath for the axon, others help to control the chemical composition of the fluid surrounding the neurone

- By this means they maintain a homeostatic environment around the neurones
- Some glial cells are phagocytic removing debris and foreign material from the CNS

Neurotransmitters, mood and behaviour

Neurotransmitters at synapses

- Synapses are tiny gaps between two neurones
- Chemicals called neurotransmitters relay messages from nerve to nerve within and out with the brain
- Neurones connect with other neurones, muscle fibres and endocrine at a synaptic cleft.
- Neurotransmitters are stored in vesicles and released into the cleft on arrival of an impulse.
- They diffuse across the cleft and bind to receptors on nerve endings.
- If sufficient transmitter molecules reach the membrane of the next neurone the impulse continues
- Weak stimuli are filtered out because not enough transmitter molecules reach the next neurone
- Between impulses the transmitter molecules are removed from the synaptic cleft to prevent continuous stimulation of post-synaptic neurones.
- Examples of neurotransmitters acetylcholine and noradrenaline
- Acetylcholine is broken down by an enzyme and the non active products are reabsorbed by the presynaptic neurone and resynthesised into active transmitter
- noradrenaline is reabsorbed directly into the presynaptic membrane and stored in a vesicle ready for reuse
- The type of alteration to a postsynaptic membrane that occurs following the binding of a neurotransmitter depends on the type of receptor. The signal can be excitatory e.g. cause contraction in heart muscle or inhibitory e.g. reduces the rate an strength of contraction of heart muscle
- Synapses can filter out weak stimuli arising from insufficient secretion of neurotransmitters.
- Summation of a series of weak stimuli from many neurones at once can trigger enough neurotransmitter to fire an impulse.
- Converging path ways are where two or more neurones feed impulses to one neurone e.g. from rod cells in the eye
- Converging neural pathways increase the sensitivity to excitatory or inhibitory signals.
- Diverging neural pathways mean that an impulse in one neurone can have a simultaneous effect in many parts of the body
- Reverberating pathway neurones later in the pathway synapse with earlier ones sending the impulse back through the circuit.
- Plasticity of response is the ability of brain cells to become altered as a result of new environmental experiences
- Plasticity of response enable new neural pathways to form during early development, when learning new skills and in response to brain injury
- Major plasticity following brain damage is when undamaged cells form new neural pathways which take on the function of the damaged area
- Minor plasticity is when the brain suppresses reflexes e.g. blinking or suppresses sensory impulses causing distraction from a task

Neurotransmitters, mood and behaviour

The functions of endorphins and dopamine

- Endorphins are neurotransmitters that stimulate neurones involved in reducing the intensity of pain
- Increased levels are also connected with euphoric feelings, appetite modulation and release of sex hormones.
- Endorphin production increases in response to severe injury, prolonged and continuous exercise, stress and certain foods.
- Dopamine is a neurotransmitter produced in several regions of the brain
- When a survival related urge e.g. hunger is being satisfied by current behaviour neurones in centre ‘V’ secrete dopamine which travels to centre ‘N’ which also secretes and responds to dopamine inducing a pleasurable feeling. Therefore V and N are referred to as the pleasure centres and the route from V to N is called the brain’s reward pathway
- The brain’s reward pathway is activated on engagement of beneficial behaviours, e.g. eating when hungry

Neurotransmitter related disorders and their treatment

- Agonists bind to and stimulate receptors on the membrane of postsynaptic neurones mimicking the neurotransmitter and triggering a normal cellular response
- Antagonists bind to specific receptors on the postsynaptic membrane blocking the action of the neurotransmitter and reducing or halting transmission of nerve impulses
- Other drugs inhibit the enzymes (e.g. cholinesterase) which degrade neurotransmitters (e.g. acetylcholine) or inhibit re-absorption of the neurotransmitter (e.g. norepinephrine)
- Many drugs used to treat neurotransmitter related disorders are similar to neurotransmitters

Mode of action of recreational drugs

- Recreational drugs can mimic neurotransmitters
- They cause changes in neurochemistry leading to changes in mood, cognition, perception and behaviour
- Many recreational drugs affect neurotransmission in the reward circuit of the brain
- Recreational drugs interact with neurotransmitters in different ways by stimulate the release of neurotransmitters, imitate their action (agonists), block their binding (antagonists), and/or inhibit their re-uptake/enzymatic degradation

Drug addiction/tolerance

- Drug addiction can be defined as a chronic disease that causes the sufferer to compulsively seek out and use the drug regardless of the consequences
- As a result of the over stimulation of neuroreceptors by agonist drugs the brain reduces the number of receptors
- The brain also reduces the sensitivity of the remaining receptors and a larger dose of the drug is now required to stimulate these receptors
- These two responses by the brain cause desensitisation and lead to drug tolerance.
- The brain responds to antagonist drugs by increasing the number and sensitivity of neurotransmitter receptors and leads to addiction

<u>Communication and social behaviour</u>

Infant attachment

- Early infant attachment is important in laying the foundation for the future formation of stable relationships.
- Under normal circumstances nature provides an infant with a mother of primary carer who satisfies the baby's needs such as food and contact comfort
- The tie that binds the baby to the carer is called infant attachment
- At first attachment is indiscriminate on the baby's part
- Specific attachment to the mother and a few other carers becomes evident between 6 and 9 months.

Measures of attachment in the 'strange' situation

- The 'strange situation ' is a research tool used to investigate infant attachment
- Experts can assess whether a child is securely or insecurely attached to their primary carer
- It involves the following sequence of events
    - A mother brings her baby into an unfamiliar room containing toys
    - Mother and child are left alone in the room and the child may explore toys if they want to
    - A stranger enters the room and talks with the mother for a few minutes then tries to play with the child
    - The mother leaves the child with the stranger who tries to interact with the child. This stage is called the first separation episode
    - The mother returns and plays with the child while the stranger leaves. This is called the first reunion episode
    - The mother leaves the child alone. Second separation episode
    - The stranger returns and tries to engage with the child
    - The mother returns as the stranger leaves. The second reunion episode
- Hidden observers study the behaviour of the child in each situation to determine the type of attachment. Secure or insecure
- Signs of secure attachment include:- child explores freely and plays with toys on introduction to room, major distress is displayed when the mother leaves the room, child resists comfort from

stranger when offered in the absence of the mother, child goes to the mother immediately when she returns for comfort and then returns to playing
- Signs of insecure attachment can be separated into avoidant and ambivalent
- Avoidant includes:- child hardly plays or explores, when mother leaves child displays indifference, accepts comfort from stranger if required, ignores mother or looks away approaching her
- Resistant:- child does not explore freely or play with toys even when mother present, when mother leaves child shows major distress, resists comfort from stranger, both seeks and resists comfort at the same time when mother approaches
- Infants that form secure attachments are more likely to investigate their immediate environment helping the development of cognitive abilities.

Socialisation and learning
- Human children are dependant on their parents for a long period of time
- This provides opportunities for socialisation and learning to occur
- The quality of a developing child's social competence is affected by the method of control adopted by their parents
- These are authoritative and permissive control
- Authoritative can be either unreasonably strict or demanding but responsive
- Authoritative control generally results in greater social competence than permissive control

The effect of communication
- Communication is the exchange of information, facts, feelings, ideas and opinions between people
- Communication can be verbal or non-verbal
- Non-verbal communication comes in many forms
    - Smiling in infants
    - Facial expressions
    - Eye contact
    - Body language
    - Physical proximity
    - Touching
- Non –verbal communication can also give information about attitude and emotion and is important in the formation of relationships between individuals
- Non-verbal communication is at first all that infants can manage
- Smiling is an effective way for an infant to reinforce the bond between parent and child
- In adults non-verbal language enhances the effect of words, conveying mood, emotions and attitudes
- Non verbal communication is subconscious and so we are often unaware of the information we are conveying
- Verbal communication is used in the transmission of knowledge, development of culture and social evolution.
- Language uses symbols to represent information that can then be organised into categories (words) and hierarchies (phrases, sentences and paragraphs) thus accelerating learning and intellectual development.

The effect of experience
- Learning is a change in behaviour as a result of experience
- The repeated use of a motor skill results in a motor pathway in the brain being established
- Examples of 'motor memory' are riding a bike or driving a car, where eventually the skill becomes automatic
- Much of human behaviour is learnt through observing and imitating the behaviour of others e.g. learning how to operate a smart phone
- Many social skills and attitudes are learnt through imitating parents and older siblings

Trial and error learning
- Reinforcement is when behaviour patterns that have positive consequences for the individual are likely to be repeated.
- Shaping is the term used to for rewarding a behaviour that is nearly what was wanted, in the hope that the desired behaviour will eventually develop

- Unrewarded behaviour patterns are less likely to be repeated resulting in extinction of the behaviour due to lack of reward

Generalisation and discrimination

- Generalisation is the ability to respond in the same way to many different, but relates stimuli
- A well used example of generalisation is that of a child being afraid of all dogs because they were bitten by one dog. Other examples include buying a book because you enjoyed the authors last one or expecting a good meal at a restaurant where you have eaten previously and enjoyed it
- Discrimination is when people learn to distinguish between different but related stimuli and give different responses. For example to only fear large dogs

The effect of group behaviour and social influence

- Social facilitation causes increased performance in the presence of others
- People often perform tasks faster or better when in competition with others or in front of an audience
- De-individuation results when an individual within a group looses their personal identity and takes on the group identity.
- This often results in anti social behaviour which would not normally be shown by the individual on there own
- Internalisation is the changing of beliefs as a result of persuasion
- Politicians, government departments and big business all try to effect internalisation by attempting to persuade people to change their beliefs through radio, TV and newspapers
- Identification is the deliberate changing of beliefs to be like an admired influencing source.