SQA - Highers Human - 2014

			Nervous System Controls & Responds to Body Functions & Directs Behavior												Nervous System Structure & Function Are Determined By Both Genes & Environment Throughout Life												The Brain is the Foundation of the Mind						Research Leads to Essential Understanding for Therapies							
			1. Brain is the body's most complex organ.						2. Neurons communicate using electrical and chemical signals.							3. Genetically determined circuits are foundation of the nervous system.							4. Life experiences change the nervous system.							5. Intelligence arises as brain reasons, plans, solves problems.				6. The brain makes it possible to communicate knowledge through language.		7. Human brain endows us with a natural curiosity to understand how the world works.			8. Fundamental discoveries promote healthy living and treatment of disease.			
Topic	**Learning Objective**	**Detail**	a	b	c	d	e	f	a	b	c	d	e	f	g	a	b	c	d	e	f	a	b	c	d	e	f	g	a	b	c	d	a	b	a	b	c	a	b	c	d
Human Cells																																									
1 Division and differentiation in human cells	(b) Cellular differentiation is the process by which a cell develops more specialised functions by expressing the genes characteristic for that type of cell.	Once a cell becomes differentiated it only expresses the genes that produce the proteins characteristic for that type of cell.	•					•								•						•						•							•			•	•	•	•
	(c) Stem cells — embryonic and tissue (adult) stem cells. Stem cells are unspecialised somatic cells that can divide to make copies of themselves (self-renew) and/or differentiate into specialised cells. Tissue (adult) stem cells are involved in the growth, repair and renewal of the cells found in that tissue. They are multipotent.	Tissue stem cells are multipotent as they can make all of the cell types found in a particular tissue type. For example, blood (haematopoietic) stem cells can make all of the cell types in the blood.																					•	•																	
	The main body tissue types are epithelial, connective, muscle and nerve tissue. The body organs are formed from a variety of these tissues.	Development of tissue (adult) stem cells in bone marrow into red blood cells, platelets and the various forms of phagocytes and lymphocytes. Epithelial cells cover the body surface and line body cavities, connective tissue includes blood, bone and cartilage cells, muscle cells form muscle tissue and nerve cells form nervous tissue.																					•																		
	The cells of the early embryo can make all of the differentiated cell types of the body. They are pluripotent. When grown in the lab scientists call these embryonic stem cells.	The inner cell mass cells of an early embryo (blastocyst stage) are pluripotent as they can make nearly all of the cell types in the body. These cells can self-renew, under the right conditions, in the lab. It is then they are termed embryonic stem cells.																					•																		
	(e) Research and therapeutic uses of stem cells by reference to the repair of damaged or diseased organs or tissues. Stem cells can also be used as model cells to study how diseases develop or for drug testing. The ethical issues of stem cell use and the regulation of their use.	Stem cell research provides information on how cell processes such as cell growth, differentiation and gene regulation work. The therapeutic uses of stem cells should be exemplified by reference to the repair of diseased or damaged organs, eg corneal transplants and skin grafts for burns.																							•												•					
2 Structure and replication of DNA																																									
3 Gene expression																																									
4 Genes and proteins in health and disease	Single gene mutations involve the alteration of a DNA nucleotide sequence as a result of the substitution, insertion or deletion of nucleotides. Nature of single-nucleotide substitutions including: missense, nonsense and splice-site mutations. Nucleotide insertions or deletions result in frame-shift mutations or an expansion of a nucleotide sequence repeat. The effect of these mutations on the structure and function of the protein synthesised and the resulting effects on health.	Missense (replacing one amino acid codon with another), nonsense (replacing an amino acid codon with a premature stop codon — no amino acid is made and the process stops) and splice-site mutations (creating or destroying the codons for exonintron splicing).						•															•						•												
5 Human genomics																																									
6 Metabolic pathways																																									
7 Cellular respiration																																									
8 Energy systems in muscle cells																																									
	(c) Types of skeletal muscle fibres Differences between slow twitch and fast twitch muscle fibres.	Slow twitch muscle fibres are good for endurance activities like long distance running, cycling or cross-country skiing. Slow twitch muscle fibres rely on aerobic respiration to generate ATP and have many mitochondria, a large blood supply and a high concentration of the oxygen storing protein myoglobin. The major storage fuel of slow twitch muscles fibres is fats.										•					•																								
	Slow twitch (Type 1) muscle fibres contract more slowly, but can sustain contractions for longer and so are good for endurance activities.											•					•																								
	Fast twitch (Type 2) muscle fibres contract more quickly, over short periods, so are good for bursts of activity.	Fast twitch muscle fibres are good for activities like sprinting or weightlifting. Fast twitch muscle fibres can generate ATP through glycolysis only and have few mitochondria and a lower blood supply than slow twitch muscle fibres. The major storage fuels of fast twitch muscles fibres are glycogen and creatine phosphate. Most human muscle tissue contains a mixture of both slow and fast twitch muscle fibres. Athletes show distinct patterns of muscle fibres that reflect their sporting activities.										•					•																								
Physiology and Health																																									
1 The structure and function of reproductive organs and gametes and their role in fertilisation																																									
2 Hormonal control of reproduction																																									
3 The biology of controlling fertility																																									
4 Ante- and postnatal screening																																									
5 The structure and function of arteries, capillaries and veins																																									
6 The structure and function of the heart																																									
	(c) The structure and function of cardiac conducting system including nervous control. Control of contraction and timing by cells of the sino-atrial node (SAN) and transmission to the atrio-ventricular node (AVN). Location of the SAN and AVN in the heart. Interpretation of electrocardiograms (ECG). The medulla regulates the rate of the SAN through the antagonistic action of the autonomic nervous system (ANS). Sympathetic accelerator nerves release noradrenaline (nor-epinephrine) and slowing parasympathetic nerves releaseacetylcholine.	The heart beat originates in the heart itself but is regulated by both nervous and hormonal control. The auto-rhythmic cells of the sino-atrial node (SAN) or pacemaker set the rate at which cardiac muscle cells contract. The timing of cardiac cells contracting is controlled by the impulse from the SAN spreading through the atria and then travelling to the atrio-ventricular node (AVN) and then through the ventricles. These impulses generate currents that can be detected by an electrocardiogram (ECG).				•																																			
7 Pathology of cardio vascular disease (CVD)	(a) Process of atherosclerosis, its effect on arteries and blood pressure and its link to cardiovascular diseases (CVD).	Atherosclerosis is the accumulation of fatty material (consisting mainly of cholesterol), fibrous material and calcium forming an atheroma or plaque beneath the endothelium. As the atheroma grows the artery thickens and loses its elasticity. The diameter of the artery becomes reduced and blood flow becomes restricted resulting in increased blood pressure. Atherosclerosis is the root cause of various cardio vascular diseases including angina, heart attack, stroke and peripheral vascular disease.						•																																	
	(b) Thrombosis— Events leading to a myocardial infarction (MI) or stroke.	Atheromas may rupture damaging the endothelium. The damage releases clotting factors that activate a cascade of reactions resulting in the conversion of the enzyme prothrombin to its active form thrombin. Thrombin then causes molecules of the plasma protein fibrinogen to form threads of fibrin. The fibrin threads form a meshwork that clots the blood, seals the wound and provides a scaffold for the formation of scar tissue. The formation of a clot (thrombus) is referred to as thrombosis. In some cases a thrombus may break loose forming an embolus and travel through the bloodstream until it blocks a blood vessel. A thrombosis in a coronary artery may lead to a heart attack (MI). A thrombosis in an artery in the brain may lead to a stroke. Cells are deprived of oxygen leading to death of the tissue.						•																	•																	
8 Blood glucose levels and obesity																																									
	Pancreatic receptors and the role of hormones in negative feedback control of blood glucose through insulin, glucagon and adrenaline (epinephrine).	Pancreatic receptors respond to high blood glucose levels by causing secretion of insulin. Insulin activates the conversion of glucose to glycogen in the liver decreasing blood glucose concentration. Pancreatic receptors respond to low blood glucose levels by producing glucagon. Glucagon activates the conversion of glycogen to glucose in the liver increasing blood glucose level. During exercise and fight or flight responses glucose levels are raised by adrenaline (epinephrine) released from the adrenal glands stimulating glucagon secretion and inhibiting insulin.		•	•	•				•	•	•					•																								
Neurobiology and Communication																																									
1 Divisions of the nervous system and parts of the brain	(a)Structures and functions of the central nervous system (CNS).	The nervous system analyses sensory information from the body and the external environment stores some aspects and makes decisions regarding appropriate responses and behaviours. It makes motor responses by initiating muscular contractions or glandular secretions. Sensory and motor neurons of the somatic nervous system (SNS) control the voluntary movement of skeletal muscles. Homeostatic control through sensory neurons and motor neurons conducting involuntary impulses to smooth muscle, cardiac muscle and glands.			•	•						•					•	•			•									•											
	(b) Structures and functions of the peripheral nervous system (PNS) to include the autonomic nervous system (ANS) and the somatic nervous system (SNS). The antagonistic action of the sympathetic and parasympathetic systems on heart rate, breathing rate and digestive	Sympathetic 'fight or flight' and parasympathetic 'rest and digest' responses on heart rate, breathing rate, peristalsis and intestinal secretions.		•	•	•											•																							
	(c) The functions of the medulla and cerebellum in the central core of the brain.	The central core contains the medulla that regulates the basic life processes of breathing, heart rate, arousal and sleep and the cerebellum which is responsible for controlling balance, posture and movement.			•	•																																		
	(d) The functions of the limbic system	Functions include processing information for memories and influencing emotional and motivational states.			•	•									•	•			•		•									•	•										
	(e) The functions of the cerebral cortex in receiving sensory information, coordinating voluntary movement and making decisions in the light of experience.	Cerebral cortex is the centre of conscious thought; it also recalls memories and alters behaviour in the light of experience.	•																•		•									•	•	•	•							
	(f) Localisation of brain functions to include sensory areas, motor areas and the association areas concerning language, personality, imagination and intelligence. Information from one side of the body is processed in the opposite side of the cerebrum, transfer of information occurs through the corpus callosum.	Some association areas deal with thought processes . The left cerebral hemisphere deals with information from the right visual field and controls the right side of the body and vice versa.				•									•		•			•		•							•				•							
2 Perception and memory	(a) Perception is the process by which the brain analyses and makes sense out of incoming sensory information. The three areas of perception involve segregation of objects, perception of distance and recognition.	Perception allows us to segregate objects from one another and their background, recognise what they are and to judge their distance from us.															•			•									•		•								
	(i) Segregation of objects. Perceptual organisation into figure and ground. Perceptual organisation of stimuli into coherent patterns. Visual cues such as relative size, superimposition and relative height in field.																•			•									•		•								
	(ii) Perception of distance. Binocular disparity in judging distance. Perceptual constancy as objects become nearer and the viewing angle changes.																•			•									•		•								
	(iii) Recognition. The importance of shape rather than detail in the recognition of objects. Matching perceived shapes to shape descriptions stored in memory and the role of inference in recognition. The influence of perceptual set where past experience, context or expectation influences the way a stimulus is perceived.																			•																			
	(b) Memory involves storage, retention and retrieval of information. Memories include past experiences, knowledge and thoughts. All information entering the brain passes through sensory memory and enters shortterm memory. Information is then transferred to long-term memory (LTM) or discarded.					•									•					•									•										
	(i) Sensory memory. This lasts a few seconds and retains all of the visual or auditory input.	Working memory is an extension of STM used to perform cognitive tasks.				•									•				•	•									•										
	(ii) Short-term memory (STM). This includes memory span, the serial position effect, maintaining items by rehearsal and loss of items by displacement and decay. Improvement of STM by 'chunking'.																			•									•		•								
	(iii) Long-term memory (LTM). The transfer of information from STM to LTM due to rehearsal, organisation and elaboration. Information is encoded using shallow encoding or elaborative encoding. Retrieval is aided by the use of contextual cues.	Repetition (shallow encoding) and previous memories (elaborative encoding). Contextual cues relate to the method of coding.																			•									•		•								
	(iv) Location of memory in the brain. Episodic and semantic memories are stored in the cortex. Procedural memories (skills) are linked to the motor cortex. Emotional memories involve links between the cortex and the limbic system. Spatial memory is located in the limbic system.	Episodic memory (the memory of events and experiences) and semantic memory (the record of facts and concepts). Episodic and semantic memory are stored in the region of the cortex where the sensory information was first received and encoded.				•															•									•		•								
3 The cells of the nervous system and neurotransmitters at synapses	(a) Structure and function of neurons to include dendrites, cell body and axons. Sensory, motor and inter neurons. Structure and function of myelin sheath in increasing the speed of impulse conduction. Myelination continues from birth to adolescence. Glial cells. Physically support neurons and produce the myelin sheath. They also maintain a homeostatic environment around the neurons and remove debris by phagocytosis.	Axons are surrounded by a myelin sheath which insulates the axon and increases the speed of impulse conduction from node to node. As a result responses to stimuli in the first two years of life are not as rapid or coordinated as those of an older child or adult. Certain diseases destroy the myelin sheath causing a loss of coordination.	•	•				•	•																															
	(b) Neurotransmitters at synapses. Chemical transmission at the synapse by neurotransmitters to include vesicles, synaptic cleft and receptors. The need for removal of neurotransmitters by enzymes or reuptake to prevent continuous stimulation of post-synaptic neurons. Receptors determine whether the signal is excitatory or inhibitory. Synapses can filter out weak stimuli arising from insufficient secretion of neurotransmitters. Summation of a series of weak stimuli can trigger enough neurotransmitter to fire an impulse.	Neurotransmitters relay messages from nerve to nerve within and out with the brain. Neurons connect with other neurons, 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.			•					•	•		•																											
	(c) Function of converging, diverging and reverberating neural pathways. Plasticity of response is created when new neural pathways are developed to create new responses, bypass areas of brain damage, to suppress reflexes or responses to sensory impulses.	Converging neural pathways increase the sensitivity to excitatory or inhibitory signals. Diverging neural pathways influence several neurons at the same time. Reverberating pathway neurons later in the pathway synapse with earlier ones sending the impulse back through the circuit.			•								•	•	•																								
	(d) Neurotransmitters, mood and behaviour. The functions of endorphins and dopamine. Endorphins are neurotransmitters that stimulate neurons 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.	The reward pathway involves neurons which secrete or respond to the neurotransmitter dopamine. The reward pathway is activated on engagement of beneficial behaviours, eg eating when hungry.			•	•				•		•					•		•																				
	Dopamine induces the feeling of pleasure and reinforces particular behaviour in the reward pathway.																																							
	Neurotransmitter related disorders and their treatment. Agonists bind to and stimulate receptors mimicking the neurotransmitter. Antagonists bind to specific receptors blocking the action of the neurotransmitter. Other drugs inhibit the enzymes which degrade neurotransmitters or inhibit re-uptake.	Many drugs used to treat neurotransmitter related disorders are similar to neurotransmitters.						•																																
	(e) Mode of action of recreational drugs. Can mimic neurotransmitters. Changes in neurochemistry alter mood, cognition, perception and behaviour. Many recreational drugs affect neurotransmission in the reward circuit of the brain.	Recreational drugs may stimulate the release of neurotransmitters, imitate their action (agonists), block their binding (antagonists), and/or inhibit their reuptake/ enzymatic degradation.												•			•																							
	Drug addiction/tolerance. Sensitisation is an increase in the number and sensitivity of neurotransmitter receptors as a result of exposure to drugs that are antagonists and leads to addiction. Desensitisation is a decrease in the number and sensitivity of receptors as a result of exposure to drugs that are agonists and leads to drug tolerance.													•																									
4 Communication and social behaviour																																									
Immunology and Public Health																																									
1 Non-specific defences																																									
2 Specific cellular defences																																									
3 The transmission and control of infectious diseases																																									
4 Active immunisation and vaccination and the evasion of specific immune response by pathogens																																									

KEY			Description
Nervous System Controls and Responds to Body Functions and Directs Behavior	1. The brain is the body's most complex organ.	a	There are a hundred billion neurons in the human brain, all of which are in use.
		b	Each neuron communicates with many other neurons to form circuits and share information.
		c	Proper nervous system function involves coordinated action of neurons in many brain regions.
		d	The nervous system influences and is influenced by all other body systems (e.g., cardiovascular, endocrine, gastrointestinal and immune systems).
		e	Humans have a complex nervous system that evolved from a simpler one.
		f	This complex organ can malfunction in many ways, leading to disorders that have an enormous social and economic
	2. Neurons communicate using electrical and chemical signals.	a	Sensory stimuli are converted to electrical signals.
		b	Action potentials are electrical signals carried along neurons.
		c	Synapses are chemical or electrical junctions that allow electrical signals to pass from neurons to other cells.
		d	Electrical signals in muscles cause contraction and movement.
		e	Changes in the amount of activity at a synapses can enhance or reduce its function.
		f	Communication between neurons is strengthened or weakened by an individual's activities, such as exercise, stress, and drug use.
		g	All perceptions, thoughts, and behaviors result from combinations of signals among neurons.
Nervous System Structure and Function are Determined by Both Genes and Environment Throughout Life	3. Genetically determined circuits are foundation of the nervous system.	a	Neuronal circuits are formed by genetic programs during embryonic development and modified through interactions with the internal and external environment.
		b	Sensory circuits (sight, touch, hearing, smell, taste) bring information to the nervous system, whereas motor circuits send information to muscles and glands.
		c	The simplest circuit is a reflex, in which sensory stimulus directly triggers an immediate motor response.
		d	Complex responses occur when the brain integrates information from many brain circuits to generate a response.
		e	Simple and complex interactions among neurons take place on time scales ranging from milliseconds to months.
		f	The brain is organized to recognize sensations, initiate behaviors, and store and access memories that can last a lifetime.
	4. Life experiences change the nervous system.	a	Differences in genes and environments make the brain of each animal unique.
		b	Most neurons are generated early in development and survive for life.
		c	Some injuries harm nerve cells, but the brain often recovers from stress, damage, or disease.
		d	Continuously challenging the brain with physical and mental activity helps maintain its structure and function - "use it or lose it."
		e	Peripheral neurons have greater ability to regrow after injury than neurons in the brain and spinal cord.
		f	Neuronal death is a natural part of development and aging.
		g	Some neurons continue to be generated throughout life and their production is regulated by hormones and experience.
The Brain is the Foundation of the Mind	5. Intelligence arises as brain reasons, plans, and solves problems.	a	The brain makes sense of the world by using all available information, including senses, emotions, instincts, and remembered experiences.
		b	Emotions are based on value judgments made by our brains and are manifested by feelings as basic as love and anger and as complex as empathy and hate.
		c	The brain learns from experiences and makes predictions about best actions in response to present and future challenges.
		d	Consciousness depends on normal activity of the brain.
	6. The brain makes it possible to communicate knowledge through language.	a	Languages are acquired early in development and facilitate information exchange and creative thought.
		b	Communication can create and solve many of the most pressing problems humankind faces.
Research Leads to Essential Understanding for Therapies	7. The human brain endows us with a natural curiosity to understand how the world works.	a	The nervous system can be studied at many levels, from complex behaviors such as speech or learning, to the interactions among individual molecules.
		b	Research can ultimately inform us about mind, intelligence, imagination, and consciousness.
		c	Curiosity leads us to unexpected but surprising discoveries that can benefit humanity.
	8. Fundamental discoveries promote healthy living and treatment of disease.	a	Experiments on animals play a central role in providing insights about the human brain and in helping to make healthy lifestyle choices, prevent disease, and find cures for disorders.
		b	Research on humans is an essential final step before new treatments are introduced to prevent or cure disorders.
		c	Neuroscience research has formed the basis for significant progress in treating a large number of disorders.
		d	Finding cures for disorders of the nervous system is a social imperative.