**BTEC Nationals in Applied Science**

**Additional Guidance**

**Unit 5 – Section B – Organs and Tissues**

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| **Essential Content** | **Additional Guidance** |

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| **B1 The cardiovascular system** | Learners should: |
| * Understand the structure and function of the heart, to include:
 | * know that circulation consists of the pulmonary and systemic circulatory systems
* know that the heart has four chambers and the left and right sides of the heart are completely separated from each other
* know the positions, names and functions of the major blood vessels associated with the heart
* know that coronary arteries provide the heart muscle with blood (*names not required, e.g. circumflex*)
 |
| * atria
 | * know the gross structure (relative size) and functions of the atria and ventricles
* know the septum divides the heart into left and right sides
 |
| * ventricles
 |
| * septum
 |
| * valves – semi-lunar, tricuspid, bicuspid
 | * understand that the semi-lunar valves are at the base of the arteries leaving the heart and prevent blood returning to the ventricle during diastole
* understand that the atrioventricular valves are between atria and ventricles and prevent backflow of blood from ventricles to atria during ventricular systole
* understand that the AV valve between left atrium and left ventricle is the bicuspid /mitral valve
* understand that the AV valve between right atrium and right ventricle is the tricuspid valve
* be able to identify the parts of the heart from diagrams and photographs
 |
| * vena cava
 | * know that the venae cavae return deoxygenated blood from the head and body to the right atrium of the heart
 |
| * pulmonary vein
 | * know that the pulmonary veins transport oxygenated blood from the lungs to the left atrium
 |
| * pulmonary artery
 | * know that the pulmonary artery carries deoxygenated blood from the right ventricle to the lungs
 |
| * aorta
 | * know that the aorta transports oxygenated blood from the left ventricle to the head and body
 |
| * myogenic muscle
 | * know that heart muscle is striated and resembles skeletal muscle but the fibres are less wide
* understand that the heart muscle cells are joined together at intercalated discs which allow swift transmission of impulses between the cells
* know that cardiac muscle cells need Ca2+ ions to contract
 |
| * sinoatrial node (SAN)
 | * know that although heart muscle is myogenic, heart has its own conduction system to co-ordinate contraction of individual muscle cells
* know the location of the SAN is in the wall of the right atrium
* know that role of the SAN is the heart’s pacemaker
* know that the SAN sets the heart rate at around 70 – 80 times per minute but can be altered during activity or rest
* understand the SAN causes impulses to be generated which propagate across the atria and then down conducting fibres in septum to the ventricles
 |
| * atrioventricular node (AVN)
 | * understand that the AVN is the gateway for electrical impulses to pass from the atria to the ventricles to initiate ventricular systole
 |
| * Bundle of His
 | * know that the Bundle of His consists of the left and right bundle branches
* know that the Bundle of His is specialised muscle fibres that conduct electrical impulses down the interventricular septum
* understand the significance of time delay, caused at the AVN, between the impulse leaving the atria and arriving at the apex
 |
| * Pukinje fibres
 | * know that the Pukinje fibres transmit impulses to the ventricle walls
* understand the significance of ventricle contraction starting at the apex
 |
| * be able to calculate cardiac output
 | * know and use the equation (using appropriate units)

*Cardiac output (CO) = stroke volume (SV) x Heart rate (HR)*  |
| * Understand the characteristic features of blood vessels and pressure changes, to include:
 | * know that arteries have thick walls with many muscle and elastin fibres to withstand the high pressure generated by the left ventricle during contraction
* know that the elastin in arterial walls allows recoil during pulsation
* know that pressure in major systemic arteries rises and falls during cardiac cycle (systolic and diastolic pressures)
* know that the veins have thin walls as the blood in them is at low pressure and have large lumens to give low resistance
* know that veins have semi-lunar valves to prevent backflow
* know that walls of capillaries consist of a single layer of endothelial cells, thin to allow exchange of materials with tissues by means of diffusion
 |
| * arteries – elastic, small lumen, thick muscle, high pressure
 |
| * veins – large lumen, valves, thin walled, low pressure
 |
| * capillaries – link arteries and veins, one cell thick, site of diffusion
 |
| * blood transfusion and the ABO rhesus system
 | * know that there are antigens on the surface membranes of red blood cells and antibodies in blood plasma
* know that normally the antigens on red blood cells do not interact with the antibodies in the blood plasma
* know that during blood transfusion interactions between antigens and antibodies may lead to incompatibility for blood transfusions if blood groups are not matched
* understand the importance of universal donors and universal recipients
* know the compatibilities and incompatibilities in ABO system
* know that the Rhesus antigen is used to classify blood as Rh+ or Rh-
 |
| * Understand the cardiac cycle, to include:
 | * know that contraction of atria (atrial systole) forces blood into ventricles during ventricular diastole, after which AV valves begin to close
* know that after the AV valves fully close, the ventricles contract (ventricular systole) which opens the semi-lunar valves and forces blood into aorta and pulmonary artery
* know that during atrial diastole and filling of atria, the AV valves are partly open so some blood trickles into ventricles
* recognise the stages of the cardiac cycle from diagrams
 |
| * atrial systole
 |
| * ventricular systole
 |
| * cardiac diastole
 |
| * role of major blood vessels – vena cava, pulmonary vein, pulmonary artery,aorta, coronary artery
 | * be able to identify the positions and function of these blood vessels
 |
| * opening and closing of the heart valves
 | * know when the semi-lunar and AV valves open and close during cardiac cycle
* know that heart sounds are caused by valves closing
 |
| * Understand the use of electrocardiograms (ECG), to include:
 |  |
| * significance of PQRST points on an ECG trace
 | * know the P wave represents atrial depolarisation and occurs at the beginning of atrial contraction
* know the PR interval is the time between the first deflection of the P wave and the first deflection of the QRS complex
* know the QRS complex represent the beginning of contraction of the ventricles
	+ the Q wave is depolarisation of the interventricular septum
	+ the R wave is depolarisation of the main mass of the ventricles
	+ the S wave is the final depolarisation of the ventricles, at the base of the heart
* know the ST interval is the period between ventricular depolarisation and repolarisation
* know the T wave represents ventricular repolarisation
* know that atrial repolarisation occurs at the same time as, and is obscured by, the QRS complex
* be able to calculate heart rate from an ECG trace
 |
| * identification of arrhythmias – tachycardia, bradycardia, ventricular fibrillation, sinus arrhythmia, flat line
 | * be able to identify the five types of arrhythmias from ECG traces
 |
| * Understand how factors can increase the risk of cardiovascular disease (CVD), to include:
 | * understand that CVD is multifactorial and more than one factor may be interacting
* understand that risk relates to probability, not cause
 |
| * genetics
 | * know that familial hyper cholesterolaemia (FHC) is a genetic condition where the blood plasma cholesterol level is raised and can increase the risk of cardiovascular disease (CVD)
 |
| * age
 | * understand that risk of CVD increases with age
 |
| * gender
 | * understand that women’s risk is generally less than that of men until menopause; after that risk is equal or slightly greater in females
 |
| * diet
 | * understand the link between high levels of saturated fat in the diet and blood plasma cholesterol
* understand that not all cholesterol is bad
* understand the importance of cholesterol for cell and nerve structure, brain development and for making steroid hormones
* understand the significance of ratios of HDL (high density lipoproteins)/LDL (low density lipoproteins) in blood
* understand the role of phagocytes/foam cells in formation of plaques in artery walls
* understand the possible role of dietary sugar as a risk factor
 |
| * high blood pressure
 | * know the causes of hypertension, including alcohol, diet (salt and saturated fat), genetics and air pollution
* understand the health effects of hypertension (increased risk of heart attack and/or stroke)
 |
| * smoking
 | * know the effects of nicotine on heart rate, platelets, red blood cells, and plasma cholesterol levels
* know the effects of carbon monoxide on the oxygen-carrying capacity of Hb/rbc
* understand the links between smoking and hypertension
 |
| * inactivity
 | * understand the benefits of exercise in reducing the risk of CVD
 |
| * Investigate the effect of caffeine on heart rate in *Daphnia*
 | * be able to interpret data of the effect of caffeine on the heart rate in *Daphni*a
 |
| * Understand the benefits and risks of treatments for CVD, including:
 | * understand the need to weigh benefits against a patient’s risk factors and possible side effects
* understand the benefits and risks of antihypertensives, including:
* ACE inhibitors inhibit angiotensin converting enzyme so antgiotensin I not converted to angiotensin II
* diuretics reduce blood volume by increasing water loss in urine
* calcium channel inhibitors reduce strength of heartbeat
* understand the benefits and risks of statins, including:
* lower blood cholesterol
* reduces inflammation
* reduces tearing and breaking of fatty deposits in artery walls
* more effective than stanols in dietary products
* understand the benefits and risks of transplantation:
* 1967 first heart transplant
* routine medical procedure
* donor availability – opt in/opt out systems
* shortage of suitable organs due to need to tissue type and match
* keeping heart in condition suitable for transplant
* understand the benefits and risks of immunosuppressants
* prevents rejection
* risk of side effects
* required long term
* suppression of immune system
* potential higher number of infections
* increased risk of cancers
 |
| * antihypertensives
 |
| * statins
 |
| * transplantation and immunosuppressants
 |
| **B2 Ventilation and gas exchange in the lungs** |  |
| * Understand the structure of the human lung and overall ventilation system, to include:
 | * be able to know the gross anatomy of the thoracic cavity
 |
| * trachea
 | * know the location and understand functions of ciliated epithelial cells, goblet cells, smooth muscle and cartilage in trachea and bronchi
* know the location and understand the functions of smooth muscle and ciliated epithelial cells in bronchioles
* know that mucous membranes line trachea and bronchi and produce mucus
 |
| * bronchi
 |
| * bronchioles
 |
| * alveoli
 | * know that the alveoli are sites of gaseous exchange
* understand the structure of alveoli walls, which consist of one layer of squamous epithelial cells, giving a short diffusion pathway; elastin in the walls allows stretch and recoil
* understand the effect of damage to, and loss, of alveolar walls on surface area and gaseous exchange
 |
| * capillary network
 | * understand that the extensive capillary network close to the alveoli decreases the diffusion pathway distance
* understand that blood flow in the capillaries maintains a steep concentration gradient to aid efficient gaseous exchange
 |
| * intercostal muscles
 | * understand the role of external intercostal muscles during inspiration
* understand the role of internal intercostal muscles during forced expiration
 |
| * diaphragm
 | * understand the role of the diaphragm during inspiration and expiration
 |
| * role of pleural membranes
 | * know that the pleural membranes
* are serous membranes
* one side lines body cavity wall and the other lines lungs
* secrete serous fluid that reduces friction and enables the membranes to slide over each other
* prevent lungs adhering to body cavity wall
 |
| * Understand the mechanics of ventilation of the lungs, to include:
 |  |
| * inspiration
* expiration
* action of intercostal muscles
* action of the diaphragm
* changes in the volume of thorax
* changes in air pressure and movement
* the use of a ventilator to assist breathing
 | * understand thatduring inspiration:
	+ external intercostal muscles contract to raise rib cage up and out
	+ diaphragm contracts and flattens
	+ increase in volume of the thoracic cavity reduces pressure in lungs
	+ so air enters, from outside, down the pressure gradient
* understand thatduring expiration
* external intercostal muscles relax so rib cage moves down and in
* internal intercostal muscles contract to pull ribs down and in during forced expiration
* diaphragm relaxes and domes
* decrease in volume of the thoracic cavity increases pressure inside lungs
* air is forced out down the pressure gradient, aided by the elastic recoil
* understand that ventilators are used for muscle weakness and in severe lung infection
 |
| * Understand the principles that relate to efficient gas exchange in the human lung:
 | * know that efficient movement of gases between air and blood in alveoli depends on:
* short diffusion pathway
* large surface area
* maintaining diffusion gradients
 |
| * proximity of alveoli to capillary network
* alveolar large surface area
 | * understand that the walls of the many small alveoli give a large surface area for gaseous exchange
 |
| * one-cell-thick capillary walls
 | * know that walls of alveoli and capillaries are very thin
 |
| * moisture
 | * know that surface of alveoli has to be moist so oxygen can dissolve in the water before it can diffuse through into blood in capillaries
 |
| * diffusion gradients
 | * know that steep concentration gradients between blood and alveoli are maintained by ventilation and by blood flow through the capillaries
 |
| * provision of oxygen for respiration and removal of carbon dioxide for efficient production of adenosine triphosphate (ATP) during cellular respiration
 | * understand that oxygen is essential for aerobic respiration
* know that oxygen is absorbed in to the blood in the lungs and transported to the tissues for aerobic respiration and production of ATP
* understand that carbon dioxide produced by aerobic respiration has to be removed from respiring tissues
* know that carbon dioxide is transported in blood to the lungs and breathed out
 |
| * Understand the importance of spirometer readings of lung volumes, to include:
 |  |
| * tidal volume
* inspiratory reserve volume
* residual volume
* expiratory reserve volume
* vital capacity
* total lung capacity
 | * understand how spirometer readings are used for lung function tests
* understand the use of medical grade oxygen, and use of soda lime to remove carbon dioxide
* understand the difference between open and closed systems
* understand terms tidal volume, inspiratory reserve volume, residual volume, expiratory reserve volume, vital capacity and total lung capacity
* be able to recognise tidal volume, inspiratory reserve volume, expiratory reserve volume, vital capacity and calculate their values from a spirometer trace
* be able to calculate tidal volume, inspiratory reserve volume, residual volume, expiratory reserve volume, vital capacity and total lung capacity from a spirometer trace
* know that the lungs can never be fully emptied and the remaining air is called residual air
* know that total lung capacity is vital capacity plus residual air
 |
| * Understand the importance of the methods used to measure lung function for respiratory conditions, to include:
 | * understand how lung function tests/measurements may aid diagnosis of respiratory conditions
* understand how to monitor the effectiveness of treatments of respiratory conditions such as asthma and emphysema
 |
| * peak expiratory flow
 | * understand that peak flow meters
	+ measure the maximum speed of expiration, known as peak expiratory flow rate (PEFR)
	+ measure the ability to breathe out air and can monitor degree of obstruction in airways
	+ are used to determine lung functionality and the severity of asthma and emphysema symptoms
* understand the that PEFR varies with age, gender and fitness levels
 |
| * forced vital capacity
 | * know that forced vital capacity (FVC) is the amount of air that can be forcibly exhaled after a deep breath in
* know that measurement of FVC helps determine the presence and severity of lung disease, such as asthma, bronchitis, emphysema and chronic obstructive pulmonary disease
* understand that FVC varies with age, gender and fitness levels
 |
| * Understand the effects of exercise on the following using data from spirometer traces, to include:
 |  |
| * tidal volume
 | * understand that tidal volume increases during and just after exercise
 |
| * breathing rate
 | * understand that breathing rate increases during and just after exercise
 |
| * respiratory minute ventilation
 | * know that respiratory minute volume (RMV) is the volume of air passing into and out of the lungs per minute
* be able to calculate the respiratory minute ventilation using the formula RMV = tidal volume x breathing rate
 |
| * oxygen consumption
 | * know that during exercise oxygen consumption increases as more aerobic respiration takes place
* be able to calculate oxygen consumption per minute from a spirometer trace
* know that the slope of trace is steeper during exercise as more oxygen is consumed
 |
| **B3 Urinary system structure and function** |  |
| * Understand the roles of the kidney in:
 |  |
| * excretion
 | * know that excretion is the removal of toxic metabolic waste
* know that osmoregulation is the regulation of the concentration of solutes in body fluids, by regulating salt and water in the body
 |
| * osmoregulation
 |
| * Know the function of the urinary system, to include:
 | * be able to identify the ureter, bladder, kidneys, renal arteries, renal veins
* know the functions of the main organs of the urinary system, including
	+ the ureter carries urine from kidneys to bladder
	+ the bladder stores urine prior to removal
	+ the renal artery supplies blood to the kidney
	+ the renal vein carries blood from the kidney
 |
| * ureter
 |
| * bladder
 |
| * renal artery and vein
 |
| * Understand the structure and function of a kidney nephron, to include:
 |  |
| * glomerulus and its role in ultrafiltration
* Bowman’s capsule
 | * be able to identify in diagrams glomerulus, Bowman’s capsule, proximal convoluted tubule, loop of Henle, distal convoluted tubule, collecting duct
* understand that water and dissolved materials are forced out of glomerulus by blood pressure (ultrafiltration)
* know that small molecules and ions are forced out of the capillaries in the glomerulus and but large molecules are left behind in the capillaries
* know that the walls of capillaries in glomerulus are very porous
 |
| * proximal convoluted tubule and its role in selective reabsorption of glucose
 | * know that glucose is an important energy source that the body cannot afford to lose
* know that normally all the glucose lost in the glomerulus is re-absorbed into the blood in the proximal convoluted tubule
 |
| * loop of Henle
 | * know that the loop of Henle sets up an area of high concentration in the renal medulla, through which the collecting duct passes
 |
| * distal convoluted tubule
 | * know that the distal convoluted tubule
* helps to control blood pH by adding or removing hydrogen ions
* helps control blood volume and concentration of urine, by absorbing ions into blood under the influence of aldosterone
 |
| * collecting duct
* osmoregulation
* the role of anti-diuretic hormone (ADH)
 | * know that the collecting duct passes through area of high concentration, therefore water is reabsorbed back into the blood by osmosis
* know the reabsorption of water is controlled by ADH
* know that ADH allows more water to be reabsorbed from tubule into blood, therefore less water lost in urine (anti-diuretic effect)
 |
| * electrolyte balance
* blood pressure and the role of the renin-angiotensin-aldosterone mechanism
 | * know that low blood pressure leads to production of angiotensin II by kidneys
* know that Angiotensin II causes arterioles to constrict, increasing BP
* know that Angiotensin II stimulates production of aldosterone, causes retention of sodium by kidneys
 |
| * Understand how the kidney is involved in water, electrolyte and acid base balances
 |  |
| * Understand how to treat kidney disease, to include:
 |  |
| * dialysis
* transplantation
 | * know that kidney failure is serious and causes problems with water, electrolyte and acid-base balance which impairs metabolism
* know that a dialysis machine is a replacement for normal kidney function and filters the blood
* know that kidney transplantation is a cure but depends on tissue match and control of rejection by immunosuppressants
 |
| **B4 Cell transport mechanisms** |  |
| * Understand the structure of the cell surface membrane with reference to the fluid mosaic model
 | * understand the structure of the fluid mosaic model , to include:
	+ phospholipid bilayer
	+ hydrophilic heads and hydrophobic tails
	+ extrinsic and intrinsic proteins
	+ cholesterol
	+ protein channels and protein carriers
	+ antigens and receptors
	+ proteins in the membrane are not fixed in one place and they can move laterally
 |
| * Understand the methods used to transport molecules through cell membranes, to include:
 |  |
| * passive transport brought about by diffusion
 | * know that molecules move down their concentration gradients
* know that diffusion does not use metabolic energy, is a passive process, ATP is not involved
* know that lipid soluble molecules that can dissolve in and pass through the phospholipid bilayer
* know that very small, uncharged molecules can diffuse through phospholipid bilayer
 |
| * facilitated diffusion (through carrier proteins and protein channels)
 | * understand that facilitated diffusion allows molecules and ions to cross membrane which otherwise would not be able to using:
	+ protein channels – specific for individual ions (Na+, K+, Ca++)
	+ carrier proteins – carry larger molecules (e.g. carbohydrates) through membrane
* know that ions diffuse through their specific protein channels, down their concentration gradient and channels can open and close
 |
| * osmosis (consideration of water potential is not required)
 | * understand that:
	+ osmosis is diffusion of water through a partially permeable membrane
	+ from a region of low solute concentration (high water concentration) to region of high solute concentration (low water concentration)
	+ passive process, does not use metabolic energy, ATP is not involved
 |
| * active transport, including the role of ATP as an immediate source of energy
 | * understand that:
	+ substances are moved across membranes against their concentration gradient
	+ uses ATP as an energy source
	+ involves protein carriers
 |
| * the processes of endocytosis and exocytosis in the transport of large molecules through the formation of vesicles
 | * understand that:
* both processes transport large molecules that cannot pass through the cell surface membrane by passive means
* exocytosis
	+ involves vesicles
	+ bulk transport, uses ATP
	+ transports molecules out of cell
* endocytosis
	+ internalises contents in a vesicle
	+ bulk transport, uses ATP
	+ engulfs macro molecules
 |
| * Understand how surface area to volume ratio affects transport of molecules in living organisms
 | * understand as the size of an organism increases, the surface area to volume ratio (SA/V) decreases
* understand the effect that SA/V ratio or a cell/organism has on the passage of molecules across its surface
* understand the need for specialised exchange surfaces and transport systems in large multicellular organisms due to their small SA/V ratio
* be able to carry out calculations involving SA/V ratios
 |