**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 |