GCE

GCE

Life and Health Sciences

Teacher Guidance Booklet

For first teaching from September 2016

Definitions and Clarification of Terms for Examination Units

INTRODUCTION

This document has been produced to help support teachers in regards to definitions or clarification of terms or equations used within the examination units of the current GCE Life and Health Sciences specification.

The list of definitions and clarifications provided are an indication of what might be required or useful for an examination. Some of the information provided is quite short and some longer. It is not a requirement that every word be reproduced exactly as provided during an examination.

Please note that some of the information provided within this document is based on current Government or health guidelines, which may be liable to change and may have slight variance from other valid sources. At all times examiners will exercise discretion in what marks to award for information supplied by candidates, as alternative answers may be acceptable.

I hope that this document is useful for you. It is not intended as a basis for discussion as to the information supplied, however if you have any questions please contact me directly:

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AS 2: Human Body Systems

Specification Reference	Concept/Term	Definition/Clarification
2.1.3	Cardiac cycle	The sequence of events that occur during one heartbeat. The cardiac cycle is composed of diastole, atrial systole and ventricular systole.
2.1.3	Diastole	Relaxation of atrial walls. Blood enters the atria from the vena cava and pulmonary vein. Relaxation of ventricular walls. AV valves open, semilunar valves closed. Blood enters ventricles from atria.
2.1.3	Atrial systole	Contraction of atrial walls. Ventricular walls relaxed. AV valves open, semilunar valves closed. Blood enters ventricles from atria.
2.1.3	Ventricular systole	Relaxation of atrial walls. Ventricular walls contract. Av valves close. Semilunar valves are forced open forcing blood into the arteries.
2.1.4	Electrocardiogram (ECG)	A graphical representation of the electrical activity of the heart. An ECG trace is composed of the P wave, QRS complex and the T wave.
2.1.4	P wave	The wave of electrical stimulation that triggers atrial contraction.
2.1.4	QRS complex	The electrical activity that stimulates ventricular contraction.
2.1.4	T wave	This represents ventricular relaxation.
2.1.4	Arrhythmia	The general term for problems with heartbeat, when the heart is either beating too fast or too slowly.
2.1.4	Tachycardia	A rapid heartbeat, typically >100 beats per minute at rest.
2.1.4	Ventricular Fibrillation	An abnormal heart rhythm, reflecting the fact that the heart is being stimulated irregularly and contracting in an uncontrolled manner.
2.1.4	Bradycardia	A slow heartbeat, typically <60 beats per minute at rest.
2.1.5	Typical pulse rate range	The typical resting heart rate is between 60-100 beats per minute.
2.1.5	Blood pressure	Blood pressure is a measure of the force that the heart pumps blood round the body. It is measured in mm of mercury (mmHg) and is given as two numbers representing; systolic blood pressure/diastolic blood pressure.

		Systolic pressure represents the maximum pressure exerted on the arteries when the heart beats. Diastolic blood pressure represents the pressure in the arteries when the heart is at rest. As a general guide (NHS): • Ideal blood pressure is considered to be between 90/60mmHG and 120/80mmHg; • High blood pressure is considered to be 140/90mmHg or higher; • Low blood pressure is considered to be 90/60mmHg or lower. Physiological status (age, gender, stress, exercise, medication etc) can lead to variation.
2.2.2	Chemical composition of Haemoglobin	A three-dimensional conjugated globular protein, consisting of four polypeptide chains (two alpha and two beta) with prosthetic haem groups containing iron. Haemoglobin is found in red blood cells and is used for oxygen transport.
2.2.2	Haemoglobin and oxygen transport	In a single molecule of haemoglobin, each haem group (4) can bind with an oxygen molecule to form oxyhaemoglobin. $Hb + 4O_2 \leftrightarrow HbO_8$ One molecule of haemoglobin can carry up to four molecules of oxygen. This reaction is reversible. In high oxygen conditions (e.g. lungs) oxyhaemoglobin is formed; in low oxygen conditions (respiring tissues) oxygen dissociates from haemoglobin.
2.2.2	Haemoglobin saturation	If every molecule of haemoglobin is carrying 4 oxygen molecules, the haemoglobin (blood) is 100% saturated. If 50% of all available haemoglobin molecules are carrying 4 oxygen molecules, the blood is 50% saturated. The degree of haemoglobin saturation is dependent of the amount of oxygen available in an environment.

2.2.3	Partial pressure of oxygen (pO_2)	The oxygen concentration within an environment measured in kPa. High partial pressures of oxygen are found where oxygen levels are high and are low where oxygen levels are low, usually due to active cellular respiration taking place. Lung alveoli - 12-14 kPa. Tissues - 2-5 kPa.
2.2.3	Oxygen dissociation curve	A sigmoidal (S-shaped) graph of 'saturation of haemoglobin with oxygen/%' (Y axis) against 'Partial pressure of oxygen/kPa' (X axis). At high partial pressures of oxygen (e.g. 12-14 kPa in the lung alveoli) oxyhaemoglobin is readily formed and haemoglobin is almost completely saturated. At low partial pressures of oxygen (e.g. 2-5 kPa in the tissues) oxyhaemoglobin readily dissociates so that the released oxygen can diffuse into the tissues where it is required for cellular respiration. The oxygen dissociation curve shows that haemoglobin remains saturated at partial pressures of oxygen between @8- 12 kPa. These partial pressures of oxygen are found in the heart, aorta, pulmonary vein and other arteries, i.e. oxyhaemoglobin does not release its bound oxygen until it is in an environment which requires oxygen such as respiring tissue or exercising muscle.
2.2.4	Bohr effect	The shift in the oxygen dissociation curve to the right caused by increases in the concentration of carbon dioxide in the blood. The Bohr shift also occurs in response to a decrease in blood pH and increase in body temperature.
2.2.8	Tidal Volume	The volume of air that a human breathes into and out of their lungs while at rest

		(approx. 500 cm^3) which provides enough oxygen for a human's resting needs.
2.28	Inspiratory reserve volume	The maximum amount of air (above tidal volume) that may be inspired. The typical adult value is 2 to 3.2 dm^3.
2.28	Expiratory reserve volume	The maximum amount of air (above tidal volume) that may be expired. The typical adult value is 0.75 dm^3 to 1 dm^3.
2.2.8	Vital Capacity	The maximum amount of air a person can expel from the lungs after a maximum inhalation. Vital Capacity = Tidal volume + inspiratory reserve volume + expiratory reserve volume.
2.2.8	Peak Expiratory Flow	PEF is the force with which an individual can exhale measured in l/min or dm^3/min.
2.3.2	Cellular Respiration	The stepwise breakdown of glucose in the presence or absence of oxygen which generates energy in the form of adenosine triphosphate (ATP). Oxygen + glucose → carbon dioxide + water + energy (ATP).
2.3.4	Adenosine triphosphate	The molecule which stores energy released during the stepwise breakdown of glucose in the presence or absence of oxygen. ATP is composed of the nucleotide base adenine attached to a ribose sugar, to which three phosphate groups are attached. ATP is the immediate source of energy for the chemical reactions in cells.
2.3.5	Glycolysis	The process occurring in the cytoplasm which results in the production of two molecules of pyruvate (3C) from one molecule of glucose (6C) and results in a net yield of 2 ATP.
2.3.6	Aerobic Respiration	Cellular respiration which, involves glycolysis + link reaction + Krebs cycle + electron transport chain, requires oxygen and generates a net yield of ≥38 ATP.
2.3.6	Link Reaction	The Production of Acetyl CoA (2C) from Pyruvate (3C). This occurs in the mitochondrial matrix.
2.3.7	Krebs Cycle	A series of reactions that begin with the joining of acetyl CoA (2C) to oxaloacetate

		(4C). The Krebs cycle produces hydrogen atoms (in the form of FADH and NADH) which are used in the electron transport chain. This occurs in the mitochondrial matrix.
2.3.8	Electron transport chain	A series of hydrogen carriers located in the inner membrane of the mitochondria. The hydrogen atoms collected by NAD and FAD in the Krebs cycle pass through these hydrogen carriers which undergo a series of oxidation-reduction reactions to form ATP.
2.3.8	Oxidative Phosphorylation	The production of ATP in the electron transport chain, so named due to the requirement for oxygen in this process. At the end of the electron transport chain oxygen combines with hydrogen to form water. Oxygen is the final hydrogen (electron) acceptor.
2.3.9	Anaerobic Respiration	Cellular respiration which, only involves glycolysis, does not require oxygen and generates a net yield of 2 ATP.
2.3.10	Basal Metabolic Rate	The metabolic rate (rate of cellular respiration) when an animal is at rest which supports vital functions such as heartbeat, breathing, kidney function, nerve transmissions, cellular repair and maintaining body temperature.
2.4.1	Homeostasis	The maintenance of constant or steady state conditions within the body.
2.4.1	Homeostatic mechanism	A variable is fixed at a desirable internal level (set point). Internal sensors or receptors monitor the variable and detect if there is any change to the set point. Change in the set point is usually due to a stimulus. Corrective mechanisms are activated and restore the variable to the set point; Negative feedback systems stop the corrective mechanisms and prevent over adjustment.
2.4.2	Hormone	A chemical messenger produced by endocrine cells, which is carried in the blood and acts on target cells which have specific hormone receptors. Hormones are essential for communication within the body.

		Hormones produce slow, long-lasting responses throughout the body.
2.4.3	Insulin	A hormone produced by the pancreatic beta cells in response to raised blood glucose levels and which reduces blood glucose levels by, increasing glucose uptake by cells, increasing cellular respiration and converting glucose to its storage form glycogen in the liver.
2.4.3	Glucagon	A hormone produced by the pancreatic alpha cells in response to lowered blood glucose levels and which increases blood glucose levels by converting stored glycogen (in the liver) back into glucose.
2.4.3	Diabetes	Diabetes is a condition in which regulation of blood glucose levels by insulin fails. In diabetes insulin is either, at very low levels or no longer produced (Type 1) or does not work effectively (Type 2).
2.4.4	Thyroxine	A hormone produced by the thyroid gland which increases, BMR, heart rate, cardiac output, ventilation rate, protein and carbohydrate metabolism and sympathetic activity. Thyroxine also promotes growth, enhances brain development and thickens the womb lining in females.
2.4.4	Thyroid releasing hormone (TRH)	A hormone produced by the hypothalamus which causes the pituitary gland to produce TSH.
2.4.4	Thyroid stimulating hormone (TSH)	A hormone produced by the pituitary gland which causes the thyroid gland to produce thyroxine.
2.4.5	Aldosterone	A hormone produced by the adrenal glands which increases sodium re-uptake (back into the bloodstream) in the kidneys, so preventing loss of sodium in the urine.
2.4.5	Antidiuretic hormone (ADH)	A hormone produced by the pituitary gland which increases water re-uptake (back into the blood stream) in the kidneys, resulting in lower sodium concentrations in body fluids.
2.4.7	Blood pH range	The normal blood pH range is between pH 7.35-7.45.
2.4.7	Acidosis	A blood pH<3.5 due to increases in hydrogen ion concentrations.
2.4.8	Alkalosis	A blood pH>7.45 due to decreases in hydrogen ion concentrations.

2.4.9	Oxygen Saturation (SpO_2)	The percentage of haemoglobin-bound oxygen compared to the total oxygen-binding capacity of the haemoglobin. One molecule of haemoglobin can carry a maximum of four oxygen molecules. If one haemoglobin molecule is carrying three molecules of oxygen, it is carrying 75% (3/4) of the maximum amount of oxygen it could carry. Normal SpO_2 levels for a healthy person are 94-98% (British Thoracic Society). If the oxygen level is below this, it can be an indicator that there is a lung problem or other factor affecting oxygen levels.
2.5.9	Cholesterol	This is a lipid (fat) made by the liver or found in the diet (meat, fish, dairy products). Cholesterol is required to build and maintain cell membranes and to make bile salts and steroid hormones such as testosterone and oestrogen. Normal levels of cholesterol 4.0-6.5 mmol/L.
2.5.12	UK Alcohol Intake Recommendations	Safest not to drink regularly more than 14 units per week (both men and women), Spread 14 units evenly over 3 days or more. Have several drink-free days each week. No level of alcohol is safe to drink during pregnancy.

AS 3: Aspects of Physical Chemistry in Industrial Processes

Specification Reference	Concept/Term	Definition/Clarification
3.1.2	Theoretical yield	The maximum mass of product that can be obtained in a reaction.
3.1.2	Actual yield	The mass of product actually produced in a reaction, in the laboratory.
3.1.2	Percentage yield	% yield = $\frac{actual\ yield}{theoretical\ yield}$x 100
3.2.1	Standard solution	A solution for which the concentration is known.
3.2.5	Concentration	The number of moles (or mass) of a solute that is dissolved in 1 dm^3 of solution.
3.2.6	Molarity	Concentration in mol dm^{-3} expressed using M.
3.3.2	Exothermic	A reaction in which heat energy is given out.
3.3.2	Endothermic	A reaction in which heat energy is taken in.
3.3.3	Standard enthalpy change ($\Delta H^{\ominus}$)	The change in heat energy in a reaction at constant pressure measured at standard conditions.
3.3.4	Standard conditions	298K (25°C) and 100 kPa
3.3.5	Standard enthalpy change of combustion ($\Delta_c H^{\ominus}$)	The enthalpy change when one mole of a substance is completely burnt in oxygen under standard conditions.
3.3.5	Standard enthalpy change of neutralisation ($\Delta_n H^{\ominus}$)	The enthalpy change when one mole of water is produced in a neutralisation reaction under standard conditions.
3.3.8	Principle of the conservation of energy	Energy cannot be created or destroyed but it can change from one form to another.
3.3.9	Hess's law	Thee enthalpy change for a reaction is independent of the route taken, provided the initial and final conditions are the same.
3.3.11	Average bond enthalpy	The energy required to break one mole of a given bond averaged over many compounds.
3.4.1	Rate of reaction	The change of the concentration (amount) of a reactant or product with respect to time.
3.4.1	Activation energy (E_a)	The minimum amount of energy required for a reaction to occur.
3.4.8	Catalyst	A substance which increases the rate of a chemical reaction without being used up.
3.4.9	Heterogeneous catalysis	When the catalyst and the reactants are in different states.

3.5.1	Reversible reaction	A reaction which goes in both the forwards and backwards direction.
3.5.1	Dynamic equilibrium	When the rates of the forward and backwards reactions are equal, and the amounts/concentrations of reactants and products remain constant.
3.5.3	Le Châtelier's principle	If a change is made to the conditions of a system at equilibrium, then the position of the equilibrium moves to oppose that change in conditions.
3.6.1	Batch process	An intermittent process where reactants are added, a reaction occurs and products are removed. The vessel is then cleaned, and the process started again with new reactants.
3.6.1	Continuous process	A continuous process is a non-stop process where products are removed at the same time as new reactants are added.
3.6.2	Capital cost	The cost of setting up a business or plant.
3.6.2	Direct cost	The cost per unit of the product is directly proportional to this cost and are ongoing costs to run the process.
3.6.2	Indirect cost	The cost per unit of the product is not directly proportional to this cost.

Unit AS 5: Material Science

Specification Reference	Concept/Term	Definition/Clarification
5.1.2	Chemical resistance	The ability of a material to withstand chemical attack.
5.1.2	Electrical conductivity	A measure of the amount of electrical current a material can carry or conduct.
5.1.2	Thermal conductivity	A measure of the ability of a material to conduct heat.
5.1.2	Coefficient of friction	Ratio of the force of friction between an object and a surface and the reaction at the surface.
5.1.2	Ductility	A measure of a materials ability to be drawn into wires OR ability to deform under stress.
5.1.2	Malleability	A measure of a materials ability to be hammered/bent.
5.1.2	Elasticity	A material is showing elastic behaviour when it returns to its original dimensions following tension or compression.
5.1.2	Tensile strength	The maximum stress that a material can withstand while being stretched or pulled before breaking.
5.1.2	Stress	Force applied per unit cross section area of a material.
5.1.2	Strain	Extension per unit length of a material.
5.1.2	Young modulus	Ratio of stress to strain of a material, within the limit of proportionality.
5.1.2	Yield strength	Stress at which elastic deformation ends and plastic deformation begins.
5.1.2	Plasticity	A material is showing plastic behaviour when it undergoes permanent deformation when in a state of tension or compression. (It will not return to its original shape or size when the deforming force is removed).
5.1.9	Creep	The deformation (change in shape) that occurs when a force is applied on a material over time.
5.1.9	Fatigue strength	The deformation that occurs when a material is repeatedly being stressed and having the stress removed.
5.2.1	Polymer	A large molecule (or macromolecule) composed of many repeated units called monomers joined in a long chain molecule. OR A chain of monomers.

5.2.1	Composite	Combines the properties of two (or more) materials to form a better, more useful (improved) product / one with better properties.
5.3.3	Crystalline	A regular or ordered arrangement of particles.
5.3.3	Amorphous	Particles have no regular arrangement / no pattern / no structure.
5.3.7	Polarised light	Vibrations are confined to a single plane, perpendicular to the direction of the light propagation.
5.4.1	Alloy	A mixture of two or more elements, of which (at least) one is a metal. The resulting mixture has metallic properties.
5.5.1	Biomaterial	A material inserted into the body as part of an implanted medical device.
5.5.2	Biotolerant	A material which is not rejected when implanted into living tissue. Toxins released are negligible.
5.5.2	Bioactive	A material which interacts with or causes a (chemical/biological) response when in contact with living tissue.
5.5.2	Bioinert	A material which is not rejected by the body, does not release toxins and does not interact with biological tissue in the body.
5.6.1	Smart material	A material in which the property can change when there is a change to the surroundings.
5.8.1	Semiconductor	A material that has the ability to conduct electricity under some conditions but not others.
5.8.2	Doping	The process of adding impurities to a semiconductor to change its electrical properties.

Equations

The list of equations given below is an indication of what might be expected in an examination.

Specification Reference	**Equation**
5.1.2	Electrical conductivity $(\sigma) = \dfrac{\text{Length (l)}}{\text{Resistance (R) x cross sectional area (A)}}$ Units: Siemens per metre, Sm^{-1}

5.1.2	Thermal conductivity (k) is the rate of flow of heat (Q/t) through a material in the form of a bar of uniform cross section area A, length d and having a temperature difference ΔT across its ends. $$\frac{Q}{t} = \frac{kA\Delta T}{d}$$ Units: W m^{-1} $^{o}C^{-1}$
5.1.2	Coefficient of Friction (μ) = Friction (F) / Normal Reaction (R) Normal Reaction = W = mg No units
5.1.4	Stress (σ) = $\frac{\text{force (F)}}{\text{cross sectional area (A)}}$ Units: Pa or Nm^{-2}
5.1.5	Strain (ε) = $\frac{\text{change in length } (\Delta l)}{\text{original length } (l_o)}$ No units
5.1.6	The Young modulus (E) = $\frac{\text{stress } (\sigma)}{\text{strain } (\varepsilon)}$ Units: Pa or Nm^{-2}
5.1.10	Density (ρ) = $\frac{\text{Mass (m)}}{\text{Volume (V)}}$ Units: kgm^{-3} or gcm^{-3}

A2 2: Organic Chemistry

Specification Reference	Term	Definition/Clarification
8.1.1	Hydrocarbon	Contains carbon and hydrogen only.
8.1.2	Empirical formula	A formula which shows the simplest whole number ratio of atoms of each element in a compound.
8.1.2	Molecular formula	A formula which shows the actual number of atoms of each element in a molecule.
8.1.5	Structural formula	This shows the arrangement of atoms in a molecule, carbon by carbon, with the attached hydrogens and functional groups with or without showing the bonds.
8.1.5	Homologous series	Compounds which have the same general formula, similar chemical properties, show a gradation in physical properties and successive members differ by a CH_2 unit.
8.1.5	Functional group	A reactive group within a compound.
8.1.7	Addition	A reaction when a small molecule adds across a double bond.
8.1.7	Elimination	A reaction in which a small molecule is removed from a larger molecule.
8.1.7	Substitution	Replacing one atom or group with a different atom or group.
8.1.7	Oxidation	A reaction in which oxygen is gained or hydrogen is lost.
8.1.7	Reduction	A reaction in which hydrogen is gained or oxygen is lost.
8.1.7	Hydrolysis	Breaking up molecules by reaction with water.
8.1.7	Polymerisation	Joining together of many small molecules (monomers) to form a large molecule.
8.1.8	Structural isomers	Molecules which have the same molecular formula but a different structural formula.
8.1.10	Stereoisomers	Molecules which have the same molecular formula but a different arrangement of atoms in 3D space.
8.1.10	Geometric isomers	Molecules with the same structural formula, but a different arrangement of atoms due to the presence of one or more C=C bond.
8.2.2	Saturated	A molecule which contains no C=C or C≡C bond.
8.2.4	Fractional distillation	The separating of a mixture of liquids of different boiling points by repeated evaporation and condensation.

8.2.4	Cracking	The breakdown of larger saturated hydrocarbons (alkanes) into smaller more useful ones, some of which are unsaturated (alkenes).
8.2.4	Reforming	A process in which the hydrocarbon molecules of petroleum are rearranged to improve their properties, usually with the loss of a small molecule such as hydrogen.
8.2.6	Combustion	The reaction of fuels with oxygen, forming oxides and releasing heat energy.
8.2.10	Renewable	A resource that can be replaced as it is used.
8.2.10	Non-renewable resource	A resource that once used, cannot be replaced in a human lifetime**.**
8.2.10	Biodiesel	A fuel that is produced from renewable organic materials such as vegetable oils and animal fats.
8.3.2	Unsaturated	A molecule which contains at least one C=C or C≡C bond.
8.3.5	Sigma bond	A covalent bond formed by the linear overlap of atomic orbitals.
8.3.5	Pi bond	A covalent bond formed by the sideways overlap of p orbitals.
8.3.6	Hydrogenation	Addition of a hydrogen molecule across a C=C.
8.3.6	Electrophile	An ion or molecule that attacks a region of high electron density.
8.3.6	Hydration	The addition of water to a molecule.
8.4.1	Primary alcohol	An alcohol which has one carbon atom directly bonded to the carbon atom that is bonded to the –OH group. (Exception is methanol).
8.4.2	Secondary alcohol	An alcohol which has two carbon atoms directly bonded to the carbon atom that is bonded to the –OH group.
8.4.3	Tertiary alcohol	An alcohol which has three carbons atoms directly bonded to the carbon atom that is bonded to the –OH group.
8.4.5	Reflux	Repeated boiling and condensing of a (reaction) mixture.
8.4.6	Fermentation	The breakdown of sugars to produce ethanol and carbon dioxide using yeast.
8.5.1	Monomers	Many small molecules which can join together to form a polymer.
8.5.1	Polymer	A large molecule formed when monomers join together.

8.5.1	Biodegradable polymer	A polymer which can be hydrolysed by the action of microorganisms.
8.7.1	Recrystallisation	A method of purifying a solid by dissolving the impure crystals in the minimum volume of hot solvent, filtering whilst hot and cooling the filtrate to crystallise.
8.81	Condensation polymerisation	Polymers formed by the elimination of small molecules such as water or hydrogen chloride when monomers bond together.

Unit A2 3: Medical Physics

Specification Reference	Term	Definition/Clarification
9.1.1	Body temperature	Normal human body temperature is usually between 36.5 – 37.5°C. Body temperature can vary slightly due to age, time of day, physical activity etc. and its reading will be slightly different depending on where the reading is taken: rectum, oral, under arm, ear or forehead. Hyperthermia occurs when the body is exposed to high temperatures and cannot dissipate enough heat through normal processes such as sweating. Body temperatures of 41°C or more are considered life-threatening, with 44°C or more resulting in almost certain death. Hypothermia occurs when the body temperature is too low and cannot heat up by normal processes such as shivering. Body temperatures of 32°C or less are considered as medical emergencies with temperatures as low as 26°C or less will also likely result in death.
9.1.3	Blood pressure	Blood pressure is a measure of the force that the heart pumps blood round the body. It is measured in mm of mercury (mmHg) and is given as two numbers representing; systolic blood pressure/diastolic blood pressure. Systolic pressure represents the maximum pressure exerted on the arteries when the heart beats. Diastolic blood pressure represents the pressure in the arteries when the heart is at rest. As a general guide (NHS): • Ideal blood pressure is considered to be between 90/60mmHG and 120/80mmHg; • High blood pressure is considered to be 140/90mmHg or higher; • Low blood pressure is considered to be 90/60mmHg or lower.

		Physiological status (age, gender, stress, exercise, medication etc) can lead to variation.
9.1.6	Electrocardiogram	An electrocardiogram is a test which measures the electrical activity of the heart and indicates how the heart is functioning. Each heartbeat causes an electrical impulse to travel through the heart. Sensors are attached to the skin and they detect these electrical impulses. ECGs can help to detect arrhythmias, where the heart beats too slow or fast or beats irregularly. ECGs can also be used to detect coronary heart disease and heart attacks. ECG exams are non-invasive and last only a few minutes.
9.1.7	Electroencephalogram	An electroencephalogram is a test which uses electrodes to measure brain activity. The sensors are attached to the scalp and measure the electrical signals produced when the brain cells communicate. An EEG can help diagnose epilepsy, head injuries, brain tumours, sleep disorders and comas.
9.1.8	EEG traces	Delta waves 0.5 – 3 Hz are generated in dreamless sleep. Theta waves 3 – 8 Hz are also generated in sleep when dreaming Alpha waves 8 – 12 Hz are dominant when relaxed. Beta waves 12 – 38 Hz are dominant when alert. Gamma waves 38 – 42 Hz appear when the brain is in a state of altruism. The brain wave traces do not have a regular pattern with fixed frequency and amplitude, but instead vary with time.
9.2.1	X rays	X-rays are EM waves with wavelength shorter than UV rays and longer than gamma rays. They are generated in an X-ray tube. An X-ray scan is a 2D shadow image on photographic film or X-ray sensor. X-rays are absorbed by higher density materials and passes more readily though less dense materials. X-rays are used to diagnose broken bones, fractures, tumours and dental decay. The X-ray takes a few seconds and is non-

		invasive. However, the radiation that is absorbed by the body tissue is ionising.
9.2.1	CT scan	A CT scan is a 3D scan made up of a series of 2D images (like an egg slicer). The patient lies on a movable bed whilst the scanner and detector rotate about the patient. The scan takes a few seconds to perform and is non-invasive. The dose of X-ray radiation is larger and more ionising than a normal 2D X-ray scan. The image is clearer and can distinguish more detail. It is used to diagnose small structures and different densities within tissue. It can be used to image all body parts.
9.2.1	Endoscope	This is a flexible tube which is inserted into the body. It is used to image hollow cavities such as bowels and, in many cases, prevents the use of major surgery. In other cases, only a small incision, keyhole surgery (laporoscopy) is performed. The instrument has tools attached to enable procedures, like biopsies, to take place. The endoscope contains two fibre bundles, a coherent bundle (where fibre order is maintained throughout) to observe images of internal body parts and non-coherent bundle (where fibre order in not maintained throughout) to illuminate the body cavity. The images are viewed using a camera.
9.2.1	Lasers	A source of high-intensity optical, infrared, or ultraviolet radiation. The photons involved in the emission process all have the same energy and phase so that the laser beam is monochromatic and coherent, allowing it to be brought to a sharp focus. Lasers can be used in surgery to shrink tumours or growths and cauterise tissue including nerve endings.
9.2.1	Optical Fibres	Are long, thin, flexible, transparent fibres usually made from glass. They have a high refractive index and are surrounded by a cladding of lower refractive index and a buffer to protect the fibre. Light is totally internally reflected in the fibre providing the angle of incidence is greater than the critical angle.
9.2.1	A scan	This is an amplitude scan usually used to determine the depth of a structure, e.g. the eyeball. Ultrasound is directed into

		the body and reflects of regions of different densities, i.e. the front and back of the structure under observation.
9.2.1	B scan	This is a brightness scan and it produces a visual image of internal body structures, e.g. real-time beating of the heart. Ultrasound is directed into the body and reflects of regions of different densities, i.e. the structure under observation.
9.2.1	MRI scan	Magnetic resonance imaging (MRI) is a type of scan that uses strong magnetic fields and radio waves to produce detailed images of the inside of the body. An MRI scanner is a large tube that contains very powerful magnets. The patient lies inside the tube for a long time. Although non-invasive, patients will experience a lot of noise, may be claustrophobic and must lie extremely still. An MRI scan can be used to examine almost any part of the body in detail although scans are not recommended for certain patients, e.g. those with pacemakers or those with metal implants. When you lie under the powerful scanner magnets, the protons in the hydrogen atoms in your body line up in the same direction. Short bursts of radio waves are then sent to certain areas of the body, knocking the protons out of alignment. When the radio waves are turned off, the protons realign. This sends out radio signals, which are picked up by receivers. These signals provide information about the exact location of the protons in the body.
9.2.1	Gamma ray imaging	In this a radioisotope that emits gamma rays is administered to a patient. A gamma ray detector then images the gamma radiation emitted by the radioisotope inside the patient to build up an image of where the radioisotope went in the body. Gamma radiation is ionising.
9.2.2	Ionising radiation	Ionisation radiation such as alpha, beta, gamma and X-rays all remove electrons from atoms. This causes cell damage and can lead to cell death or cancers.

9.2.3	X ray tube	High speed electrons are produced at the cathode using a large potential difference and accelerate towards the anode, a metal target. These electrons rapidly decelerate and a small amount of the energy is converted into X-rays. This takes place in a vacuum. The remaining energy is dissipated as heat in the rotating anode. An aluminium filter is used to remove weaker X-rays which will not contribute to a medical image but will be absorbed by the body causing cell damage.
9.2.8	Specific acoustic impedance	Acoustic impedance (Z) is a physical property of tissue. It describes how much resistance an ultrasound beam encounters as it passes through body tissue. $Z = p \times v$ where p = the density of the tissue in kgm^{-3} and v = speed of the sound wave in ms^{-1}.
9.2.9	Intensity reflection coefficient	The intensity reflection coefficient, R is the fraction of the incident ultrasound is reflected at the boundary between two media of specific acoustic impedance Z_1 and Z_2. $R = (Z_2 - Z_1)^2 / (Z_2 + Z_1)^2$ If the value of R is large, then the ultrasound is mostly reflected.
9.2.11	Resolution of fine structures	Low-frequency ultrasound (1-6 MHz) energy penetrates (travels further through tissue without being absorbed) better than high-frequency ultrasound (7-18MHz); however, higher-frequency ultrasound provides for greater spatial resolution of fine structures i.e. better image quality.
9.3.2	Alpha	Helium nuclei relative charge 2+ and containing 2 protons and 2 neutrons. Alpha particles have a short range in air and are stopped by paper. The particles are the most ionising of the three radiations. They are the least penetrating.
9.3.2	Beta	Beta particles are electrons and have relative charge 1-. Beta particles can travel a few metres in air and are stopped by a few mm of aluminium. Beta particles are less ionising than alpha particles but can penetrate further that alpha.

9.3.3	Gamma	Gamma radiation is high frequency EM radiation. It is uncharged and can travel many km. Gamma rays are stopped by a few cm of lead. Gamma rays are the lease ionising but the most penetrating type of radiation.
9.3.4	Radioactive decay	Radioactive decay occurs when an unstable nuclei loses energy by emitting ionising radiation. Radioactive decay is a random process and it is impossible to predict when a particular nuclei will decay.
9.3.5	Activity	Activity is the number of radioactive disintegrations per second and is measured in Becquerel, Bq.
9.3.6	Physical half-life	Time taken for the activity of a radioactive sample to decrease to half of its original value.
9.3.9	Biological half-life	Time taken for half of the radioisotope to be removed from the body by metabolic processes, e.g. excretion.
9.3.12	Radiopharmaceutical	Radiopharmaceuticals are a group of pharmaceutical drugs which are radioactive. Radiopharmaceuticals can be used for diagnostic purposes. They must be chemically available, have suitable biological behavior and have suitable radiation characteristics.
9.3.12	Technetium-99	Technetium-99 is a metastable nuclear isomer of Technetium-99, symbolized as ^{99m}Tc that is used in medical diagnostic procedures. Technetium-99m is used as a radioactive tracer and can be detected outside the body. It emits readily detectable gamma rays and its half-life for gamma emission is 6.0058 hours.
9.3.12	Rubidium-82	Rubidium-82, ^{82}Rb injection is used in a procedure called a positron emission tomography (PET) scan. Positrons are anti-matter beta-particles emitted from the radioactive substance injected to the patient. When a positron interacts with an electron in the body annihilation occurs and two gamma rays are produced that fly off in opposite directions. The PET scanner detects this pair of gamma rays making it possible to compute where they originated from in the body.

		Myocardial Perfusion Imaging (MPI) is a non-invasive imaging test that shows how well blood flows through (perfuses) heart muscle. It can show areas of the heart muscle that are not getting enough blood flow.
9.3.12	Thallium-201	Thallium-201, is a radioactive isotope of thallium having a half-life of 3.05 days and decaying by electron capture with emission of gamma rays. It is used as a diagnostic aid in the form of thallous chloride ^{201}T. The radioisotope is injected into the patient. A scintillation camera produces an image of the distribution of the radioisotope. The Thallium-201 is administered while the patient is resting and then again when exercising on a treadmill.
9.3.14	Background radiation	The counts observed when no radioactive source is present.

Unit A2 4: Sound and Light

Specification Reference	Concept/Term	Definition/Clarification
10.1.1	Transverse wave	The vibrations of the medium are perpendicular to the direction of propagation of the wave.
10.1.1	Longitudinal wave	The vibrations of the medium are parallel to the direction of propagation of the wave.
10.1.3	Amplitude	The maximum displacement of a particle from the position of equilibrium.
10.1.3	Wavelength (λ)	Distance between successive crests (or compressions).
10.1.4	Time period (T)	Time taken for one complete wave/oscillation.
10.1.4	Frequency (f)	Number of complete waves passing a point in one second.
10.1.5	Wave speed (v)	The distance travelled by the wave in one second.
10.1.8	Phase difference	The difference in wavelength or fraction of a cycle that one point on a wave leads or lags another. It is expressed as a fraction or as an angle in degrees. Phase difference = $\frac{x}{\lambda}$ x 360° or $\frac{t}{T}$ x 360° Where: x = distance between the two points; and t = time interval between the two points.
10.1.10	Electromagnetic waves	EM waves are composed of oscillating electric and magnetic fields which oscillate at right angles to the direction of propagation of the wave.
10.3.1	Sound intensity	The sound energy per second through unit area of $1m^2$.
10.3.2	Threshold intensity	The smallest detectable sound intensity for humans. It is taken as $1x10^{-12}$ Wm^{-2}.
10.3.7	Decibel scale	0 dB is the quietist audible sound to a normal human ear. Each 3 dB increase corresponds to a doubling (x2) of sound intensity. Each 10 dB increase corresponds to a x10 increase in intensity.
10.4.1	Standing wave	Standing waves are formed when two waves of the same frequency are travelling in opposite directions meet, for example a wave travelling on one direction meets its reflection travelling in the opposite direction.

10.4.2	Resonance	When an object is forced to vibrate at its natural frequency. It is characterised by observing maximum amplitude vibrations (waves on a stretched string) or loudest observed sound (sound waves in a closed pipe).
10.4.3	Node	Points on a standing wave where there is no displacement of the medium at all times.
10.4.3	Antinode	Points on a standing wave where the amplitude of the vibrations is maximum.
10.4.4	Harmonics	Standing wave patterns are only created in a medium at certain frequencies. The simplest harmonic is called the fundamental or first harmonic. Subsequent standing waves are called the second harmonic, third harmonic etc. Note, only odd numbered harmonics are observed in a closed pipe.
10.5.3	Loudness is subjective	Whilst the intensity of a sound is definitive, the loudness is perceived by the listener and will be different for each listener as each listener's ear will be sensitive to different frequencies.
10.5.5	Phon	The phon is a unit of loudness which is used to measure the perceived loudness of sounds of different tones. To measure loudness, the volume of a 1000 Hz reference source is adjusted until it is perceived by the listener to be equally loud as the sound being measured. The dB reading of the reference sound is noted and is given as the loudness of the sound being measured in phons.
10.5.7	Microphone	A device which changes sound energy into electrical signals.
10.5.7	Amplifier	An electronic device which increases the amplitude of an electrical signal.
10.5.7	Speaker	A device which converts electric signals into sound energy.
10.6.1	Lens	A transparent material with curved surfaces which refracts rays of light to form focused images on the retina.
10.6.1	Cornea	A curved transparent material covering the front of the eye causing the largest amount of refraction.
10.6.1	Pupil	The opening through which light can enter the eye.
10.6.1	Iris	The coloured part of the eye surrounding the pupil. It controls the amount of light

		entering the eye by changing the size of the pupil.
10.6.1	Ciliary muscles	Controls the thickness of the lens by contracting to make the lens thicker or relaxing to make the lens thinner.
10.6.1	Retina	Contains light sensitive cells. Focused real, inverted, diminished images form here.
10.6.1	Macula	Located near the centre of the retina. Contains a very high concentration of cones and is responsible for fine detail, colour vision.
10.6.1	Fovea	A tiny pit in the macula that receives light directly and contains only cones.
10.6.1	Optic nerve	Transfers visual information from the retina to the brain via electric impulses.
10.6.1	Aqueous Humour	Clear fluid filling the space in the front of the eyeball containing water, vitamins and nutrients. It nourishes the lens and provides shape to the eye.
10.6.1	Vitreous Humour	Transparent gelatinous tissue filling the eyeball behind the lens giving the eye its spherical shape.
10.3.6	Rods	Photoreceptor cells in the periphery of the retina which respond to all wavelengths of visible light. Several rods are attached to one nerve cell. There are a larger number of rods in the retina and they are very sensitive to light. They are mainly used to see in low lighting.
10.3.6	Cones	Photoreceptor cells mostly in the centre of the retina. There are 3 different types each of which respond to different wavelengths of light, thus enabling colour vision. Cone cells are each attached to one nerve cell allowing fine detail vision. There are less cones than rods and they are less sensitive to light. Cones are mainly used for daytime vision.
10.4.6	Stereoscopic vision	Ability to perceive depth leading to three-dimensional vision based on the brain's ability to combine visual information from two eyes.
10.6.5	Accommodation	Ability of the eye to change its focus from distant to nearby objects by adjusting the thickness of the lens.
10.6.6	Optical power	Ability of a lens to refract light and is the reciprocal to the focal length.
10.6.9	Near point	The closest distance from the eye that on object can be placed and the eye can

		focus on it comfortably. It is usually 25 cm from the eye. Although the eye can focus on objects as closer than 25 cm, the eye muscles will quickly become strained.
10.6.9	Long sight	An eye defect which occurs when the eyeball is too short, so the focus point is behind the retina. A long-sighted eye has no difficulty focusing on far away objects but cannot produce enough converging power to create a focused image of nearby objects.
10.7.1	Critical angle	The angle of incidence in the denser material which causes an angle of refraction of 90^{o} in the less dense material.
10.7.1	Total internal reflection	When the angle of incidence is greater than the critical angle all the light in internally reflected in the denser medium.
10.7.2	Optical communication	Long distance communication using light transmitted along optical fibres.
10.7.3	Fibre-optic cable	A long, thin, flexible, transparent fibre made from a glass or plastic core surrounded by a cladding made of a lower refractive index. A layer known as a buffer surrounds the cladding and acts like a protective jacket around each strand. There are many of these strands if a fibre optic bundle.
10.7.5	Single mode fibre	A very thin fibre in which only axial mode transmission can occur. The signal has low attenuation and is therefore suitable for long distance communication although it is more expensive fibre.
10.7.5	Multi-mode fibres	A larger diameter core, this fibre can accommodate more light paths and so can send larger amounts of data. However, there is greater attenuation, so the signal is distorted over longer distances, making it suitable for only short-range communication.
10.8.1	Dipole antenna	This is the simplest type of radio antenna, consisting of a conductive wire rod that is half the length of the maximum wavelength the antenna is used to generate. This wire rod is split in the middle and the two sections are separated by an insulator. Radio frequency voltages are applied to the dipole antenna. Electrons oscillate in the

		wire and create radiowaves at the same frequency.
10.8.1	Receiving antenna	The antenna receives the radiowaves and this causes electrons to oscillate in the wire. This produces small alternating currents which are applied to the receiver.
10.8.2	Bluetooth	Bluetooth is a wireless technology used to exchange data between two or more devices over short-range using radio waves.
10.8.3	Radar	Radio detection and ranging (RADAR) uses radio waves to detect the position or movement of an object. It works by transmitting radio waves and monitoring the echo reflected from objects.
10.8.4	Doppler effect	The changing in frequency of a signal reflected from a moving object. The bigger the change in frequency, the faster the object is moving towards or away from the object. If the frequency increases then the object is moving towards the observer and if the frequency decreases, the object is moving away from the observer.

A2 5: Genetics, Stem Cell Research and Cloning

Specification Reference	Term	Definition/Clarification
11.1.2	DNA	Deoxyribonucleic acid (DNA) is a double stranded molecule arranged in a double helix. Two anti-parallel strands are held together by hydrogen bonds between adjacent bases. Composed of sub-units called DNA nucleotides. DNA contains the genetic code.
11.1.2	DNA nucleotide	Composed of deoxyribose sugar, phosphate and a nitrogenous base (adenine, guanine, cytosine or thymine).
11.1.4	RNA	Ribonucleic acid (RNA) is a single stranded molecule. Composed of sub-units called RNA nucleotides. There are three types of RNA: messenger RNA, transfer RNA and ribosomal RNA.
11.1.4	RNA nucleotide	Composed of ribose sugar, phosphate and a nitrogenous base (adenine, guanine, cytosine or uracil).
11.1.4	Ribosomal RNA (rRNA)	Primary component of ribosomes; rRNA forms over half the mass of each ribosome.
11.1.4	Transfer RNA (tRNA)	Single stranded molecule twisted into a clover leaf shape. Contains an anticodon and an amino acid binding site.
11.1.4	Messenger RNA (mRNA)	A long, single stranded, linear molecule.
11.1.5	Gene	A length of DNA coding for a particular polypeptide.
11.1.5	Polypeptide	A chain of amino acids.
11.1.6	Gene locus	The specific location of a gene on a chromosome.
11.1.9	Mutation	A change in the base sequence to the DNA of an organism.
11.1.10	Triplet codon	A sequence of three bases in DNA or mRNA that code for a particular amino acid.
11.1.12	Genotype	The genetic makeup, or two alleles for a particular characteristic (trait).
11.1.13	Phenotype	The outward appearance of a particular characteristic (trait) determined by its genetic makeup.
11.1.15	Diploid	The normal number of chromosomes (2n) in the cells of an organism.
11.1.15	Allele	A particular form of a gene.
11.1.15	Homozygous	Both alleles of the gene are the same.

11.1.15	Heterozygous	The alleles of the gene are different.
11.1.16	Dominant	In the heterozygous condition the dominant allele will be expressed over the recessive (non-dominant) allele. Shown with a capital letter (e.g. Tall = T, Brown = B).
11.1.16	Recessive	An allele that will only show itself in the phenotype if there are two recessive alleles. Shown with a lower-case letter (e.g. short = tt, blue = bb).
11.1.16	Codominant	Neither allele is dominant or recessive, they have equal dominance. Both alleles are expressed.
11.1.16	Sex-linkage	The inheritance of a gene present on a sex chromosome.
11.1.16	Autosomal linkage	The inheritance of a gene located on autosomes. In humans twenty-two pairs of chromosomes (1-22) are referred to as autosomes.
11.1.16	Multiple alleles	A trait where there are more than two possible alleles for a particular gene.
11.1.16	Epistasis	A form of gene interaction where one gene interferes with the expression of another gene.
11.2.2	Fragmentation theory/dispersive theory of DNA replication	The parent molecule breaks into segments. New nucleotides fill in the gaps precisely.
11.2.2	Conservative theory of DNA replication	The complete parent DNA molecule acts as a template for the new daughter molecule. The parent molecule is unchanged.
11.2.2	Semi-conservative theory of DNA replication	Each new molecule of DNA contains one strand conserved from the parent molecule and one newly synthesised strand.
11.2.3	Meselsohn and Stahl	The scientists who provided evidence to support the semi-conservative theory of DNA replication.
11.2.3	DNA helicase	An enzyme that unwinds and unzips double stranded DNA by breaking hydrogen bonds between complementary base pairs.
	DNA polymerase	An enzyme that catalyses the attachment of adjacent nucleotides.
11.2.3	DNA ligase	An enzyme that joins complementary sticky ends. E.g. joins human gene for insulin and bacterial plasmid.

11.3.1	Meiosis	A type of cell division in sexually reproducing organisms to produce gametes that contain half the chromosome number of the original cell. It halves the number of chromosomes (n) in gametes to produce haploid cells. Produces genetic variation as each gamete is genetically different.
11.3.1	Haploid	A cell with half the normal number of chromosomes.
11.3.1	Gamete	A sex cell e.g. sperm or egg that contains only one chromosome from each pair of chromosomes. It is haploid (n).
11.3.1	Homologous chromosomes	A matched pair of chromosomes, one from each parent.
11.3.1	Independent segregation of homologous chromosomes	Occurs during metaphase 1 of meiosis. Chromosomes of a homologous pair line up randomly at the cell equator. The way one chromosome pair lines up is totally independent of how any other pair aligns.
11.3.1	Crossing over	Occurs during prophase 1 of meiosis. Non-sister chromatids break and exchange sections with each other forming recombinants.
11.4.1	Insulin	A hormone produced by pancreatic beta cells which reduces blood glucose levels. It increases glucose uptake by cells, increases cellular respiration and converts glucose to glycogen which is stored in the liver.
11.4.2	Diabetes mellitus	Diabetes is a condition in which the regulation of blood glucose levels by insulin fails.
11.4.4	Plasmid	A small circular ring of DNA in a bacterium.
11.4.4	Restriction endonuclease	An enzyme used in genetic engineering to cut DNA at a specific base sequence (called the recognition site).
11.4.4	Sticky ends	The overlapping (non-paired) strand of DNA that is left when DNA is cut by a restriction endonuclease enzyme.
11.4.6	Haemophilia	A sex-linked condition that affects the blood's ability to clot. Haemophiliacs suffer from a defective gene that fails to produce factor VIII or IX.
11.5.3	Transgenic organism	An organism that has had DNA introduced into its genome from another organism.

11.6.1	Gene therapy	The insertion of a healthy/functional gene into cells so that the normal gene is expressed and a functional protein is produced.
11.6.2	Vector	Used to transfer functional DNA into recipient cells.
11.6.3	Cystic fibrosis	A genetic condition caused by a mutation of the gene producing the protein CFTR. The protein does not function as normal, membranes become covered with thick sticky mucus.
11.7.1	Germ cell therapy	The replacement of a defective gene(s) in a fertilised egg (or defective gamete).
11.7.1	Somatic cell therapy	The replacement of a defective gene(s) into body cells.
11.7.5	Aneuploidy	The presence of an abnormal number of chromosomes in which chromosomes are present in extra copies or are deficient in number.
11.7.6	DNA sequencing	The process of determining the nucleotide sequence of DNA.
11.7.6	Polymerase Chain Reaction (PCR)	A laboratory technique used to produce many copies of a selected section of DNA in a very short time.
11.7.6	Genetic screening	The process of testing an individual for the presence of a genetic condition caused by a particular gene.
11.7.6	DNA probe	A short single strand of DNA that identifies a particular section of DNA.
11.7.7	Oncogene	A sequence of DNA that has been mutated from its original form (the proto-oncogene). Can result in DNA replication and mitosis being permanently activated to make cells divide continually.
11.9.5	Gel Electrophoresis	A laboratory technique used to separate sections of DNA of different sizes. An electric current flows through a buffer solution, through an agarose gel. Smaller fragments travel further.
11.10.1	Stem cell	An undifferentiated cell that can differentiate into a specialised cell.
11.10.5	Embryonic stem cell	A stem cell that can differentiate into any cell type (totipotent).
11.10.5	Adult stem cell	A stem cell than can differentiate into a limited range of cell types (pluripotent).

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