Unit BY1 Basic Biochemistry and cell organisation

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| **What you need to know** | Done? | Understood? | Revised? | | |
| **1.1 Biological Compounds** | | | | | |
| Candidates should distinguish between the terms: atom, molecule, element, compound, organic, inorganic. |  |  |  |  |  |
| The most common elements in living organisms are hydrogen, carbon, oxygen and nitrogen. |  |  |  |  |  |
| The role of magnesium, iron, phosphate and calcium in cell metabolism. |  |  |  |  |  |
| Water is essential since all reactions of life rely on water and key elements are found in aqueous solution. |  |  |  |  |  |
| The importance of water in terms of its polarity, ability to form hydrogen bonds, surface tension, as a solvent, thermal properties, as a metabolite. |  |  |  |  |  |
| Candidates should differentiate between monomers and polymers. |  |  |  |  |  |
| Small molecules can be combined by condensation reactions and large molecules broken down by hydrolysis. |  |  |  |  |  |
| Carbohydrates consist of carbon, hydrogen and oxygen with the general formula C(H2O)n and are monosaccharides, disaccharides (soluble, sweet) and polysaccharides. |  |  |  |  |  |
| Monosaccharides are monomers named according to the number of carbon atoms: triose, pentose, hexose |  |  |  |  |  |
| The structural formula may be a straight chain or a ring, as shown by glucose. |  |  |  |  |  |
| Disaccharides are formed by joining two hexose units (as shown by sucrose, maltose and lactose). |  |  |  |  |  |
| Glucose exists as two isomers (alpha and beta) glucose, which form different polymers; starch (amylose and amylopectin) and cellulose. |  |  |  |  |  |
| Hydrogen bonding is important in maintaining the shape of biological molecules. |  |  |  |  |  |
| Starch and glycogen are storage polysaccharides because glucose can be added or removed easily and they have no osmotic effect in cells because they are insoluble. |  |  |  |  |  |
| Cellulose and chitin are similar structural polysaccharides with the alternating isomers allowing cross linking between chains, forming microfibrils. In chitin some –OH groups are replaced by amino acids. |  |  |  |  |  |
| The elements which make up lipid molecules are carbon, hydrogen and oxygen plus phosphorus as phosphate in phospholipids. |  |  |  |  |  |
| The main types of lipids are described as either oils or fats, depending on their melting points. They are immiscible with water but soluble in some organic solvents. Their functions include insulation, energy storage, protection. |  |  |  |  |  |
| Candidates should understand the structure of triglycerides and the structural formula for glycerol and general formula for a fatty acid. Unsaturated fatty acids contain double bonds. |  |  |  |  |  |
| Lipids are used, rather than carbohydrates, as an energy store in seeds and animals because of a high yield of energy per gram. |  |  |  |  |  |
| The products of lipid hydrolysis are fatty acids and glycerol. |  |  |  |  |  |
| The components of phospholipids are glycerol, fatty acids and a phosphate group. |  |  |  |  |  |
| Glycerol is hydrophilic and fatty acids hydrophobic. |  |  |  |  |  |
| A high intake of fat, notably saturated fats, is a contributory factor in heart disease. |  |  |  |  |  |
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| Proteins are polymers of amino acids of which there are twenty types which differ by the R group. (Candidates are not expected to recall names of amino acids but can be expected to identify them, given a structural formula and a  suitable table showing -R groups). |  |  |  |  |  |
| Polymerisation occurs by condensation, to form peptide bonds giving rise to dipeptides and polypeptides. Candidates should be able to complete a diagram showing this, given the structural formula of an amino acid. |  |  |  |  |  |
| Proteins show a primary, secondary, tertiary and quaternary structure. |  |  |  |  |  |
| Primary is the type, number and sequence of amino acids linked by peptide bonds only. |  |  |  |  |  |
| The most common secondary structure is an alpha helix formed by hydrogen bonding between the peptide bonds in the polypeptide chain (no details of beta pleated sheets required). |  |  |  |  |  |
| The tertiary structure is the folding of the alpha helix, as shown by globular proteins, to form very specific three-dimensional shapes. |  |  |  |  |  |
| Projecting from the helix are -R groups which may interact to form bonds which help to maintain the tertiary structure’s three dimensional shape. |  |  |  |  |  |
| Candidates should be able to identify disulphide, ionic, hydrogen and hydrophobic bonds between -R groups. |  |  |  |  |  |
| The quaternary structure is where two or more polypeptide chains in tertiary form combine to form complexes joined by bonds similar to those in tertiary structure. Only some proteins, such as haemoglobin, exhibit quaternary structure (detailed structure of haemoglobin not required). |  |  |  |  |  |
| Proteins can be classified according to function which is determined by structure: globular proteins function as enzymes, antibodies and hormones; fibrous proteins such as keratin and collagen have alpha helices linked into strands. |  |  |  |  |  |

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| **1.2 CELL STRUCTURE AND ORGANISATION** |  |  |  |  |  |
| The cytoplasm of eukaryotic cells is organised by membranous structures e.g. Golgi body/apparatus, nuclear envelope, endoplasmic reticulum, lysosomes, mitochondria, chloroplasts, and the membranes of these structures may be referred to as internal cell membranes. |  |  |  |  |  |
| Internal cell membranes are important in providing a transport system, separating areas from the rest of the cytoplasm, providing a large surface area for the attachment of enzymes and other reactants, ATP synthesis. |  |  |  |  |  |
| Candidates should be able to recognise on a diagram or electron micrograph, and draw on a generalised diagram of a cell, the above organelles and ribosomes, understanding their relative size. |  |  |  |  |  |
| Mitochondria consist of an outer and inner double membrane; intermembrane space; cristae; matrix; DNA and ribosomes. Their function is energy production (ATP). |  |  |  |  |  |
| The endoplasmic reticulum(ER) forms an extensive membrane system of flattened sacs, cisternae, continuous with the nuclear membrane and may link to Golgi body. ER may be smooth, without ribosomes and function in lipid and steroid synthesis or rough, with associated ribosomes and function in protein synthesis as a transport system. |  |  |  |  |  |
| Ribosomes consist of two subunits, large and small, made of ribosomal RNA and protein. They may be free in the cytoplasm or bound to ER and function in protein synthesis. |  |  |  |  |  |
| The Golgi body/apparatus is a series of dynamic, flattened sacs which function in packaging proteins for secretion by the coalescence of vesicles at one end and budding off at the other. |  |  |  |  |  |
| Lysosomes are secretory vesicles, from the Golgi body, containing enzymes used in phagocytosis. |  |  |  |  |  |
| Centrioles are used in spindle formation during cell division. |  |  |  |  |  |
| Chloroplasts consist of a double outer membrane containing stroma with ribosomes, lipid, circular DNA and possibly starch. Through the stroma are parallel flattened sacs, thylakoids, stacked in places as grana, which are the site of photosynthetic pigments. Between the grana the thylakoids form lamellae. Chloroplasts, along with mitochondria are self replicating. |  |  |  |  |  |
| Vacuoles are small vesicles in animal cells and are large and surrounded by a tonoplast in plant calls. Plant cell vacuoles function as storage sites whilst animal cell vacuoles may be formed during phagocytosis or act as contractile vacuoles. |  |  |  |  |  |
| The nucleus is bounded by a double membrane the nuclear envelope, with pores to allow transport of messenger RNA (mRNA) and nucleotides. It contains chromatin, extended loosely coiled chromosomes of DNA and histone protein, and the nucleolus where ribosomal RNA (rRNA) is produced. |  |  |  |  |  |
| Both plant and animal cells possess: plasma/cell surface membrane, membrane bound nucleus, nucleolus, chromatin, mitochondria, rough and smooth ER, ribosomes, Golgi body/apparatus. |  |  |  |  |  |
| Only plant cells possess: chloroplasts, cell wall and plasmodesmata, large vacuole and tonoplast. |  |  |  |  |  |
| Cells with distinct membranous organelles are eukaryotic those without are prokaryotic. |  |  |  |  |  |
| Prokaryotic cells have no membrane bound organelles or structures such as nuclear membrane or ER. DNA is circular and lies free in the cytoplasm and ribosomes are smaller than those in eukaryotes. |  |  |  |  |  |
| The prokaryotic cell wall is not made of cellulose; the site of respiration is infoldings of the cell membrane, the mesosomes. A protective outer layer, the capsule, may be present, as well as small circular structures of DNA, the plasmids. |  |  |  |  |  |
| In multicellular organisms cells are specialised according to the functions they perform leading to division of labour. |  |  |  |  |  |
| An aggregation of similar cells carrying out the same function is a tissue. Epithelia (cuboidal, ciliated), muscle (striated, smooth) and connective tissue (collagen) should be studied in relation to their functions. |  |  |  |  |  |
| An organ is an aggregation of several tissues to carry out a particular function for the whole organism. |  |  |  |  |  |

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| **1.3 CELL MEMBRANES AND TRANSPORT** |  |  |  |  |  |
| All cells are surrounded by a membrane which may be called the cell surface membrane or the plasma membrane. |  |  |  |  |  |
| The cell membrane appears under the electron microscope as a double line. |  |  |  |  |  |
| The usual distance across the cell membrane under the electron microscope is 7-8nm. |  |  |  |  |  |
| The principal biochemical constituents of the cell membrane are protein and phospholipid. |  |  |  |  |  |
| The phospholipid molecules are arranged as a bilayer with hydrophilic heads and hydrophobic tails. |  |  |  |  |  |
| Some proteins lie on the surface of the bilayer and some are partly embedded, whilst others extend completely across it. |  |  |  |  |  |
| This model is referred to as the ‘fluid mosaic’ model because the components are free to move with respect to each other. |  |  |  |  |  |
| Candidates should be able to draw a simple diagram to illustrate the fluid mosaic model including the labels: phospholipid bilayer, proteins, hydrophilic pores/channels (in some proteins), glycoproteins. |  |  |  |  |  |
| The major functions of the cell membrane include taking up nutrients and other requirements; secreting chemicals; cell recognition. |  |  |  |  |  |
| The cell surface membrane is selectively permeable to water and some solutes. |  |  |  |  |  |
| Candidates should be able to interpret the results of an investigation into factors, heat and organic solvents, affecting the permeability of a cell membrane. |  |  |  |  |  |
| Lipid-soluble substances can move through the cell membrane more easily than water-soluble substances, which use temporary protein channels. |  |  |  |  |  |
| Candidates should be able to define the term ‘diffusion’. It is the movement of molecules or ions from a region of high concentration to one of low concentration. |  |  |  |  |  |
| The rate of diffusion across the membrane depends on: the concentration gradient, temperature, size of the molecule, lipid solubility. |  |  |  |  |  |
| Candidates should be able to define the term ‘osmosis’. It is a particular form of diffusion in which water molecules move down a water potential gradient through a selectively permeable membrane. |  |  |  |  |  |
| Water potential is the potential for water to move out of a solution by osmosis. It has the symbol **Ψ** (psi). Pure water has the highest water potential, given the value 0. All solutions have a lower potential than water because they have a lower proportion of water molecules, therefore **Ψ**s always has a  negative value. |  |  |  |  |  |
| In a plant cell the water potential is the sum of two factors: the solute potential (**Ψ**s) which is the effect of solutes lowering the water potential of the cell sap (negative value) and **Ψ**p which is the opposite pressure provided by the cell wall and is usually positive (**Ψ**cell = **Ψ**s+ **Ψ**p). |  |  |  |  |  |
| Candidates should be able to use a given equation and interpret data. |  |  |  |  |  |
| When a cell loses water it shrinks; the cytoplasm of a plant cell will draw away from the cell wall and the cell is described as being plasmolysed. |  |  |  |  |  |
| A cell will gain water if placed in a hypotonic solution; an animal cell will burst but a plant cell will continue to take in water until prevented by the opposing wall pressure when the cell is described as being fully turgid. |  |  |  |  |  |
| Facilitated diffusion allows rapid exchange due to substances being helped across the membrane by special carriers. ATP is not needed. |  |  |  |  |  |
| Phagocytosis is where a large particle may enter the cell, become enclosed by a membrane to form a vesicle and be transported through the cytoplasm. |  |  |  |  |  |
| Candidates should be able to draw a diagram to illustrate phagocytosis. |  |  |  |  |  |
| Secretion or exocytosis refers to substances leaving the cell after being transported through the cytoplasm in a vesicle. |  |  |  |  |  |
| The cell membrane is continually having portions removed or added to it through phagocytosis and secretion. |  |  |  |  |  |
| Pinocytosis is the entry of liquid by the same mechanism as phagocytosis. |  |  |  |  |  |
| Active transport requires energy from respiration and takes place against a concentration gradient so allowing a solute to be accumulated within a cell. |  |  |  |  |  |
| Active transport will not take place in the presence of a respiratory inhibitor such as cyanide. |  |  |  |  |  |
| A solute may be taken across a cell membrane by a special carrier molecule. |  |  |  |  |  |

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| **1.4 Enzymes** |  |  |  |  |  |
| The general characteristics of enzymes are due to their biochemical nature as globular proteins, showing specificity, requiring certain conditions and with a mode of action lowering the activation energy of a reaction. |  |  |  |  |  |
| The substrate binds to part of the protein called the active site. |  |  |  |  |  |
| Candidates should understand the action of enzymes explained in relation to enzyme structure - lock and key hypothesis; the theory of induced fit, whereby the specific substrate for the enzyme alters the shape of the active site on binding as illustrated by lysozyme (structural details not required). |  |  |  |  |  |
| Enzymes are proteins made inside living cells but may act inside the cell (intracellular) or outside (extracellular) such as the digestive enzymes of the alimentary canal. |  |  |  |  |  |
| The rate of an enzyme catalysed reaction increases with increasing temperature due to increased frequency of collisions as shown by a graph. |  |  |  |  |  |
| The rate of an enzyme catalysed reaction will vary with changes in pH as shown by a graph. |  |  |  |  |  |
| The rate of an enzyme catalysed reaction will vary with changes in enzyme concentration as shown by a graph. |  |  |  |  |  |
| The rate of an enzyme catalysed reaction will vary with changes in substrate concentration as shown by a graph. |  |  |  |  |  |
| Candidates should be aware of the need for buffers in enzyme experiments and the requirement for adequate controls. |  |  |  |  |  |
| Environmental conditions such as temperature and pH change the three dimensional structure of enzyme molecules. Bonds are broken and hence the configuration of the active site is altered. |  |  |  |  |  |
| High temperatures and extreme changes in pH cause permanent change in protein structure, causing denaturation. |  |  |  |  |  |
| Small changes in pH cause small reversible changes in enzyme structure, causing inactivation. |  |  |  |  |  |
| Inhibition is when enzyme action is slowed down or stopped by another substance. |  |  |  |  |  |
| Enzyme inhibition may be competitive whereby an inhibitor, which is structurally similar to the substrate, associates with the enzyme active site. If the substrate concentration is increased so will the rate of reaction. |  |  |  |  |  |
| Non-competitive inhibition involves an inhibitor combining away from the active site often altering the enzyme shape as illustrated by potassium cyanide. The rate of reaction is unaffected by substrate concentration. |  |  |  |  |  |

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| **1.5 MEDICAL AND INDUSTRIAL APPLICATIONS OF ENZYMES.** |  |  |  |  |  |
| Biosensors work because enzymes are specific so they select one type of molecule from a mixture. |  |  |  |  |  |
| When a mixture is passed over the enzyme a reaction occurs. The energy released is proportional to the concentration of the substrate and is converted into electrical impulses. Consequently an accurate digital display of concentration is produced e.g. glucose oxidase electrode detects glucose in blood. |  |  |  |  |  |
| An enzyme can detect the presence of its substrate even in very low concentrations. |  |  |  |  |  |
| The enzyme is immobilised so its structure is stabilised in an inert support e.g. on alginate beads or gel membrane. |  |  |  |  |  |
| Industrially an immobilised enzyme can be recovered for re-use. Therefore, a small amount of enzyme may be used to carry out a large-scale reaction. |  |  |  |  |  |

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| **1.6 NUCLEIC ACIDS** |  |  |  |  |  |
| The components of a nucleotide are pentose sugar, phosphate plus organic base which contains nitrogen. |  |  |  |  |  |
| Nucleotide bases are purines or pyrimidines, linked by condensation reactions to form polymers, RNA and DNA, which can be represented in symbolic form. |  |  |  |  |  |
| DNA consists of two chains linked via the base pairs, by hydrogen bonds, to form a double helix. |  |  |  |  |  |
| The base pairs are C-G and A –T but in RNA thymine is replaced by uracil. |  |  |  |  |  |
| DNA has two major functions: replication, in dividing cells, and carrying the information for protein synthesis in all cells. |  |  |  |  |  |
| Replication allows accurate copying of DNA for cell division.  (No details of Meselson-Stahl required). |  |  |  |  |  |

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| **1.7 Cell Division** |  |  |  |  |  |
| Mitosis results in genetically identical daughter cells. |  |  |  |  |  |
| Candidates should appreciate the significance of mitosis in growth, cell replacement / regeneration, and asexual reproduction. |  |  |  |  |  |
| Candidates should understand the behaviour of chromosomes during interphase and the main stages of mitosis -, prophase, metaphase, anaphase and telophase. |  |  |  |  |  |
| Candidates should be able to recognise the mitotic stages from diagrams, prepared slides and photographs. |  |  |  |  |  |
| Meiosis occurs during sexual reproduction, when it is important that haploid gametes are produced. |  |  |  |  |  |
| Meiosis produces four genetically different cells and involves two consecutive divisions. (no details of the stages of meiosis are required.) |  |  |  |  |  |