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**Knowledge Rich Curriculum Plan**

GCE Biology- Unit 3.1 Biological Molecules



| **Lesson/Learning Sequence** | **Intended Knowledge:**  *Students will know that…* | **Prior Knowledge:**  *In order to know this, students need to already know that…* | **Tiered Vocabulary and Reading Activity** |
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| **Lesson 1:**  **Review** | Students will know that Carbon, Hydrogen, Oxygen are the main constituents of biological (organic) molecules. The position of these elements in the Periodic Table influences the chemistry of the molecules they form. The main type of bonding involved in these molecules is covalent. Planets with resources based on these elements may have biological molecules and potentially life forms.  Students will know how to draw simple covalent molecules involving C, H and O atoms.  Students will recall simple chemical reagents used to identify these molecules (food tests) | Students need to already know that Carbon is in G4, oxygen is in G6 and hydrogen is not in a G. They will know the reagents used in common tests for biological molecules: Benedict’s changes from blue to brick red precipitate in the presence of glucose; Biuret changes from blue to lilac in the presence of protein, ethanol changes from colourless to cloudy white suspension in the presence of lipids.  Students need to already know how to draw C, O, H atoms. Draw simple covalent molecules e.g., H2O, CO2, O2. | *Covalent bond*  *Group (cf periodic table)* |
| **Lesson 2:**  **Carbohydrates - monosaccharides** | Students will know that biological molecules can be simple units called monomers and that when these molecules are combined to form long chains they are known as polymers. Glucose is a monomer known as a monosaccharide. Starch is a polymer known as a polysaccharide. There are two other required monosaccharides: fructose and sucrose. Glucose exists in two different forms known as isomers: alpha and beta glucose. (Alpha has the hydroxyl group below the ring at position C1. Beta has the OH group above the ring at position C1). Molecules with 6C atoms are collectively known as hexose sugars even though some of them do not have a hexagonal ring e.g., fructose has a pentagonal molecular shape. Galactose has a similar shape to glucose but the OH group on C4 is the one that needs consideration. They will know the roles of each monosaccharide and where they can be found.  Students will know how to draw molecules of the three monosaccharides listed above. | Students need to already know the structural formula for glucose. They will recall qualitative test for glucose: Benedict’s Reagent and that a positive result involves a range of colours from green, to orange. A negative result involves no change in colour ie the chemicals remain turquoise-blue (direct consequence of containing copper sulfate)  Students need to already know how to safely, carry out the test for a reducing sugar based on GCSE Required Practical. | *Polymer*  *Monomer*  *Monosaccharide*  *Polysaccharide*  *Alpha glucose*  *Beta glucose*  *Isomer*  *Hydroxyl*  *Fructose*  *Hexose* |

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| **Lesson 3:**  **Carbohydrates - disaccharides** | Students will know that the chemical bond between individual monomers in a disaccharide is called a glycosidic bond. This is a covalent bond that arises when a molecule of water is removed by taking an H atom from one monomer and an OH group from the other. This type of reaction is known as a condensation reaction. A single molecule of water is always produced in the formation of a disaccharide. Students will also learn that this chemical reaction is reversible and that if water is added to the disaccharide, a hydrolysis reaction occurs which then produces two monosaccharides when the water molecule is used to separate the individual monosaccharides. Students will know specific examples of disaccharides: glucose + glucose = maltose; glucose + fructose = sucrose; glucose + galactose = lactose. The description of the bond includes reference to which particular atom on the molecule is involved in the glycosidic bond: 1 - 4 glycosidic bond; 1 - 6 glycosidic bond. (This means that C position one is bonded to the C atom in position 6)  Students will know how to draw a disaccharide molecule to represent maltose, lactose and sucrose. They will be able to represent the chemical reaction that occurs when the removal of a water molecule from two adjacent monosaccharides. They will be able to describe the chemical test that distinguishes between reducing and non-reducing sugars: Benedict’s solution and a modification of the procedure to demonstrate that sucrose can be shown to include the non-reducing sugar, glucose if the bonds is hydrolysed with acid. (Excess acid needs to be neutralised before the standard glucose test procedure is used) | Students need to already know the structural formula for glucose. They will recall qualitative test for glucose: Benedict’s Reagent and that a positive result involves a range of colours from green, to orange. A negative result involves no change in colour ie the chemicals remain turquoise-blue (direct consequence of containing copper sulfate)  Neutralisation reactions restore pH to 7/neutral  Students need to already know how to safely, carry out the test for a reducing sugar based on GCSE Required Practical. | *Glycosidic bond*  *Condensation reaction*  *Disaccharide*  *Hydrolysis reaction*  *Maltose*  *Fructose*  *Sucrose*  *Lactose*  *Reducing*  *Non-reducing* |
| **Lesson 4:**  **Polysaccharides** | Students will know that the formation of polymer molecules based on monosaccharides will lead to polysaccharides. The bond between the monomers is the glycosidic bond. Specific examples of polysaccharides to cover: glycogen, starch and cellulose. Students will know that the structure of a polysaccharide is a significant factor that influences the properties of the polysaccharide. In particular, starch  Students will know how to recognise individual polysaccharides from structural diagrams. They will be able to infer properties of the molecules from the structures. Specifically: Starch, starch is a plant polysaccharide formed from α – glucose. Starch is a mixture of two polysaccharides, amylose and amylopectin. Amylose is a helical shape and amylopectin is a curved brush shape and branched. It is the position of the OH groups that causes the starch to form a helix or curved brush shape as they all point inwards.  Starch is a good storage carbohydrate because it is insoluble and therefore does not affect water potential *(cf unit 2 concept)* i.e. it does not draw water into a cell by osmosis which could lead to cell damage. Helical /spiral/ coiled shape so it is compact. Many molecules can fit into a small area.  Glycogen is another storage polysaccharide formed from α-glucose. It is found in the liver and muscles of animals, and also in bacteria. It is very similar to starch but is more branched and has shorter chains. This means that glycogen can be more quickly hydrolysed to glucose when it is needed for respiration. It is also coiled so lots of contains a large number of α-glucose molecules which can be used for respiration after hydrolysis. Too large to cross the cell membrane and thus remains where it is formed. Branched so easily hydrolysed by amylase into maltose and then by maltase into glucose for respiration. Cellulose is formed from β-glucose molecules. The β-glucose molecules join together to form straight, unbranched chains. Hydrogen bonds form between the chains, joining them together to make strong microfibrils. Cellulose is the main component of plant cell walls and provides rigidity to the cell. This means that when water enters a cell through osmosis the cell will become turgid, but not burst. In cellulose alternate β-glucose molecules are upside down, this allows the OH groups to form hydrogen bonds with oxygen on adjacent chains and also means that cellulose is straight and unbranched. | Students need to already know that glucose exists as isomers known as alpha and beta glucose. They will know that glycosidic bonds form between C1 and C4/C6 of the adjacent molecule. They will know that starch is how glucose is stored in plants whilst glycogen is the storage molecule in eukaryotic cells.  Students need to already know how interpret molecular diagrams and associated conventions e.g., numbering of C atoms to locate functional groups or bonds in the molecule. | *Glycogen*  *Starch*  *Alpha-glucose*  *Amylose*  *Helical*  *Amylopectin* |
| **Lesson 5:**  **Carbohydrate review** | Students will know that carbohydrates are made of monomers called monosaccharides that are chemically joined by glycosidic bonds that are formed when two monosaccharides undergo a condensation reaction: a disaccharide and a water molecule are produced. 3 disaccharides that students must know are: maltose (2 glucose units); sucrose: a glucose joined to a pentose called fructose; galactose: glucose combined with a lactose molecule. They must know the biochemical reagent used to test for a carbohydrate is Benedict’s Solution. The way that the reagent is used to test for a reducing sugar is to heat a mixture of the unknown and the reagent for approx. 15 minutes. A precipitate will form of varying shades to indicate the quantity of reducing sugar present. A non-reducing sugar will require breaking down into constituent monosaccharides before the reagent is added. (Use HCl to break bonds and then neutralise the acid with sodium hydgrogencarbonate.) In terms of polysaccharides, students must know how | Students need to already know that monomers build polymers. In the case of saccharides, the reaction is a condensation reaction and produces a water molecule. They will know that covalent bonds are stronger than H bonds. They will recall that cellulose is the material that forms cell walls in plant cells and that starch is the storage molecule for plant cells whilst glycogen has the same role in animal cells.  Students need to already know how polysaccharides are formed by representing the reaction to illustrate how a water molecule is produced. |  |

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| **Lesson 6:**  **Amino acids** | Students will know that an amino acid is a monomer used to build proteins. It has a central C atom with four groups attached (a H group; a (carboxyl) COOH group, an (amino group) NH2 and a variable group known as R. There are 20 naturally occurring R groups that students do not need to learn). The shape of the molecule is tetrahedral ie the bond angles are not 90o  Students will know how to draw the structural molecule for a general amino acid. | Students need to already know that amino acids are produced when proteins are digested.  Students need to already know how to represent molecules using the convention of a single line as a covalent bond existing between two atoms. Where a double line occurs, that is known as a double covalent bond. | *Carboxyl group*  *Amino group*  *Variable group*  *Tetrahedral*  *Double covalent*  *functional* |
| **Lesson 7:**  **Dipeptides** | Students will know that a peptide bond forms following a condensation reaction and produces a water molecule. The peptide bond involves a covalent bond between C and N.  Students will know how to represent formation of a dipeptide using a molecular diagram. They will draw dotted lines to show how the atoms are removed from each of the adjacent amino acids. | Students need to already know that amino acids are the monomers that build a protein.  Students need to already know how to draw covalent molecules | *Peptide bond*  *Condensation reaction*  *adjacent* |
| **Lesson 8:**  **Proteins as polypeptides** | Students will know that the polymerisation of amino acid molecules using condensation reactions leads to polypeptide molecules that have side groups that interact through various bonds and that this affects the shape of the molecule. Specific levels of structure are assigned the terms: primary, secondary and tertiary structure. Primary structure is simply the sequence of the amino acids; secondary structure results from hydrogen bonds and there are two common shapes known as alpha-helix and beta-pleated sheets. Tertiary structure arises when electrostatic bonds form between r groups that have charges or between cysteine r groups involving S atoms resulting in disulphide bonds. The highest level of structure is known as quaternary structure: this occurs when there are multiple polypeptide chains that combine to form a single unit. Example: haemoglobin. | Peptide bonds form between individual amino acids to form a polypeptide. | *Primary*  *Secondary*  *Tertiary*  *Quaternary*  *Cysteine*  *R group*  *Electrostatic*  *Alpha-helix*  *Beta-pleated sheets* |
| **Lesson 9:**  **Types of protein and their uses** | Students will know that there are two main groups of proteins: fibrous and globular. Keratin is a fibrous protein. Enzymes are globular proteins. In particular they will learn that the structure matches the function and heavily influences the role proteins play in cells/organisms. They will specifically know that enzymes are globular, soluble and are vital for metabolic reactions. Antibodies are composite comprising four polypeptide chains: two light and two heavy; transport proteins include channel proteins in cell membranes and the role is to move ions and molecules across the membrane; structural proteins eg., keratin and collagen) are strong because they have parallel chains aligned with cross-links between them. | They will know that long chains of amino acids form polypeptide molecules. They will recall that the R group attached to an amino acid is the key influence on interactions between polypeptide regions ie the tertiary structure. They will know that the interactions may be disulphide bridges, intermolecular forces, electrostatic forces but not covalent bonds. | *Globular*  *Fibrous*  *Keratin*  *Collagen*  *Metabolism* |
| **Lesson 10:**  **Models for Enzyme structure** | Students will know that the latest model for enzyme activity is termed the ‘Induced Fit model’ based on new ideas about the shape of the molecule changing after the enzyme-substrate complex has formed. This change in shape locks the substrate even more tightly to the enzyme.  If the tertiary structure of n enzyme is changed by pH or temperature, the specificity of the active site will be altered.  When the substrate binds to the active site, the energy needed to perform the chemical change is reduced. This is either because the two molecules that are reacting are now closer together or if the substrate is being broken down, the re is a strain in the molecule caused by being at the active site. This strain promotes the catabolic reaction at a lower energy. | Enzymes are a group of proteins that act as catalysts. They drive metabolic reactions. They can be intracellular or extracellular. They will recall that enzymes have an active site and this is the place where reactions are catalysed. Enzymes are specific as a consequence of tertiary structure.  Students will recall the phrase ‘lock and key mechanism’ used to describe how the substrate and enzyme molecules are complementary structures which act akin to a lock matching a key.  Energy is measured in Joules.  From chemistry: energy changes during reactions can be represented in a graphical form. Exothermic and endothermic reaction pathways. | *Induced*  *Specificity*  *Catabolic*  *Anabolic*  *Activation energy* |
| **Lesson 11:**  **Factors affecting enzyme activity** | Students will know that rate of enzyme-controlled reactions are affected by temperature and pH. They will link the knowledge to ideas about particles and energy that have been learned at GCSE. Denaturation is explained in terms of loss of tertiary structure that means that the active site is no longer complementary. Students will know how to use tangents to the line at any point to determine the rate of a reaction, including the initial rate. They will be able to draw appropriate tangents and make the line suitably big to attract full marks for the skill. | Students will recall the terms: rate (speed of a chemical change); optimum (the best value for the reaction to occur); gradient (how steep a line is – calculated using the y value/x value.); denatured (enzymes stop functioning as a catalyst) | *Rate*  *Gradient*  *Denature*  *Optimum* |
| **Lesson 12: Inhibitors prevent enzyme activity** | Enzyme activity can be prevented by inhibitor molecules. There are two types of inhibitor: competitive (A) and non-competitive (B). A) The shape of a competitive inhibitor is similar to the shape of the substrate. Hence the two molecules will compete for the same position on the enzyme molecule. If an inhibitor molecule occupies the active site, the reaction involving the substrate cannot occur. The extent of inhibition depends on the concentration of the inhibitor. At higher concentrations, it is more likely that an inhibitor molecule would occupy the active site. (B) Non-competitive inhibitors bind to the enzyme at a position away from the active site. This changes the conformation of the tertiary structure and renders the active site with no catalytic function. In this case, the substrate does not compete with the inhibitor. Increasing concentration of substrate will not overcome the inhibitor effect. | In chemistry, students will have learned that molecules react when they particles collide with sufficient energy to break existing bonds and allow new bonds to form. They will have used graphs to explain the rate of reaction and used gradients to determine the rate at certain stages in the reaction pathway. | *Inhibitor*  *Concentration* |
| **Lesson 13:**  **Required Practical**  **Measuring the rate of an enzyme-controlled reaction and determining the effect of temperature on the rate.** | Students will know that casein is a protein found in milk and that trypsin is an enzyme that digests casein. They will know that a buffer is a chemical that is used to maintain the pH of a solution. They will use the AQA protocol to guide them in collecting data for the effect of changing temperature on the rate of this particular reaction. They will complete the work for 5 different values of temperature and produce suitable table/graph and calculations for the required skill. | Students will know how to handle the range of apparatus: water bath, glassware, pipettes, thermometers, stopclocks, measuring cylinders. They will know how to follow CLEAPPS guidelines to manage risks and work safely. They will know how to measure volume accurately. They will recall how to use a colorimeter (KBH lessons) | *Casein*  *Trypsin*  *Buffer*  *Tangent* |
| **Lesson 14:**  **Nucleic acids as polymers: DNA** | Students will know the significance of this type of polymer is to support the production of protein molecules in cells. They will know that both DNA carry information. DNA carries all the information required to grow and develop to fully mature adult.  DNA is made from monomers known as nucleotides. Each nucleotide has 3 components: a pentose sugar, a nitrogen-containing organic base and a phosphate group. The sugar molecule is ribose in RNA. There are 4 possible base components: adenine, cytosine, guanine and uracil. (In DNA the uracil is swapped for a different base called thymine.) Polymerisation reactions produce RNA from single nucleotides in a condensation reaction between the phosphate and the pentose molecule. The bond is a phosphodiester bond. | From KBH lessons, ribosomes are protein factories and they themselves are made of RNA and proteins.  From GCSE, they will know that there are four bases: C,G,A,T. They will recall that DNA has a double-helxi structure first described by Watson and Crick. | *Base*  *Thymine*  *Adenine*  *Guanine*  *Cytosine*  *Antiparallel*  *Phosphodiester*  *Polynucleotide*  *Nucleotide*  *Nitrogenous-base* |
| **Lesson 15**  **Nucleic acids as polymers: RNA** | Students will know the significance of this type of polymer is to support the production of protein molecules in cells.  RNA is similar in structure and one its main functions is to transfer information from the nucleus to the ribosomes.  DNA and RNA are polymers made from monomers known as nucleotides. Each nucleotide has 3 components: a pentose sugar, a nitrogen-containing organic base and a phosphate group. The sugar molecule is deoxyribose in DNA and ribose in RNA. There are 4 possible base components: adenine, cytosine, guanine and thymine. In RNA the thymine is swapped for a different base called uracil. Polymerisation reactions produce DNA/RNA from single nucleotides in a condensation reaction between the phosphate and the pentose molecule. The bond is a phosphodiester bond. In DNA, two polynucleotide strands become loosely associated using H bonds to maintain the structure. The H bonds form between the bases on each polynucleotide. Repeated H bonds make the two strands strongly associated overall. Because the two polynucleotides run in opposite directions, we describe the arrangement as antiparallel.  RNA is a single-stranded molecule that is much shorter than DNA (because it only has the code for a single protein rather than the entire proteome). | Students will recall the structure of a nucleotide as 3 components: sugar, base and phosphate group. | *Uracil* |
| **Lesson 16:**  **DNA replication** | Students will know that there are several different mechanisms that could explain how a cell copies the genome: conservative, semi-conservative and dispersive. The first two ideas will be explored. They will learn that Meselsohn and Sthal conducted the original exploration of this issue. Students will know that enzymes involved in replicating DNA are helicase and polymerase. Helicase will break the H bonds and polymerase will encourage nucleotides to be added to the growing polynucleotide strand being formed. Using the idea od semi-conservative replication: students will know that the double-stranded original polynucleotide separates and that new nuclotides position themselves adjacent to bases that they are complememtary to. The enzyme catalyses the formation of the phosphodiester bond. They will describe how the experiment used the position of the ‘heavy’ and ‘light’ bands of polynucletodies that had been spun in the centrifuge to infer that replication involves semi-conservative replication rather than conservative replication based on expected patters for both situations. (If it was conservative replication, two bands would be expected; if it is semi-conservative, only one band would occur in a new position corresponding to a hybrid density. | From KBH lesson on cell division: students will know that when cells divide they must first copy the entire genome. They will recall that bacteria cells are cultured in agar/broth and that cell division is quite fast compared with eukaryotic cells. They will know that a centrifuge is used to separate cell components. | *Helicase*  *DNA polymerase*  *Template*  *3’-5’ (prime)*  *Replication*  *Conservative*  *Semi-conservative*  *Nitrogenous-base*  *E. Coli*  *Isotope*  *Heavy isotope*  *Light isotope*  *Desntiy* |
| **Lesson 17:**  **Water** | Students will know that water makes up about 80% of cells contents. Functions include: being a metabolite eg., condensation, hydrolysis; acts as a solvent for many metabolic reactions; helps with temperature control. They will know that water molecules are cohesive which aids in water transport in plants. | Students will know the molecular formula for water (H20). They will know what a covalent bond is. They will know what a hydrogen bond is. They will know the general properties of water: good solvent, neutral pH, changes state within a narrow temperature range, conducts electricity, has a high latent heat and specific heat capacity. | *Cohesion*  *Latent*  *Metabolism*  *Dipole* |
| **Lesson 18:**  **Lipids** | Students will know that triglycerides and phospholipids are two groups of lipid. Triglycerides are formed by the condensation of one molecule of glycerol and three molecules of fatty acid. A condensation reaction between glycerol and a fatty acid (RCOOH) forms an ester bond. The R-group of a fatty acid may be saturated or unsaturated. In phospholipids, one of the fatty acids of a triglyceride is substituted by a phosphate-containing group. The different properties of triglycerides and phospholipids related to their different structures. The emulsion test for lipids. Students will be able to recognise saturated and unsaturated fatty acids from diagrams. They will explain the different properties of triglycerides and phospholipids. (Long hydrocarbon tails contain lots of chemical energy – approx.. twice as much as a carbohydrate. They are insoluble as a consequence of the hydrophobic tail. | From GCSE, they will recall the food test that was used to identify whether a food contained fats: use of ethanol/Sudan III. | *Triglyceride*  *Lipid*  *Fatty acid*  *Glycerol*  *Ester bond*  *Saturated*  *Unsaturated*  *Condensation reaction*  *Phospholipid*  *R group*  *Hydrophobic*  *Hydrophilic*  *Emulsify/emulsion* |
| **Lesson 19:**  **Inorganic ions** | Students will know that inorganic ions have an electric charge. They will know the significance of this in terms of specific examples: iron in haemoglobin, hydrogen affecting pH, sodium role in transport of glucose and amino acids across membranes, phosphate for the role in making ATP/DNA. | Students will recall how ions form from chemistry GCSE. They will be familiar with the terms cation and anion. They will recall symbols for elements that can be used to represent the ions. | *Cation*  *Anion*  *pH*  *phosphate* |
| **Lesson 20:**  **ATP** | Students will know that ATP is a nucleotide that has similar characteristics to the nucleotides found in DNA and RNA: it has 3 main components – nitrogenous base, pentose sugar and inorganic phosphate. However, the base is always ‘adenine’ and there are three phosphate groups linked together in a side chain. Students will know that ATP is a chemical store of energy that relies on the bond energy value for it’s role. The bonds between adjacent phosphate groups is broken releasing energy that can be used for chemical reactions/metabolism. They will know that this nucleotide cannot polymerise to form a polynucleotide. ATP is resynthesised by the condensation of ADP and Pi . This reaction is catalysed by the enzyme ATP synthase during photosynthesis, or during respiration. | Students will recall the symbol for phosphate ions. They will recall the model for a nucleotide and in particular the form of nucleotide found in DNA and RNA. They will be able to distinguish between these two molecules already. | *Inorganic phosphate*  *Energy value*  *covalent* |