Unit 1 – Molecular Biology

# Subunits – Molecules of life, Enzymes, DNA to Protein

# IB Topics covered – Topic 2.1-2.7, Topic 7, and Topic 8.1

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| **Subunit: Molecules of Life** | |
| **Topics covered:** 2.1-2.4 | |
| **Essential ideas**:  2.1 - Living organisms control their composition by a complex web of chemical reactions.  2.2 - Water is the medium of life.  2.3 - Compounds of carbon, hydrogen and oxygen are used to supply and store energy.  2.4 - Proteins have a very wide range of functions in living organisms. | |
| **IB Understandings, Applications, and Skills:**  **2.1**   * Molecular biology explains living processes in terms of the chemical substances involved. * Carbon atoms can form four covalent bonds allowing a diversity of stable compounds to exist. * Life is based on carbon compounds including carbohydrates, lipids, proteins and nucleic acids. * Metabolism is the web of all the enzyme-catalysed reactions in a cell or organism. * Anabolism is the synthesis of complex molecules from simpler molecules including the formation of macromolecules from monomers by condensation reactions. * Catabolism is the breakdown of complex molecules into simpler molecules including the hydrolysis of macromolecules into monomers. * Application: Urea as an example of a compound that is produced by living organisms but can also be artificially synthesized. * Skill: Drawing molecular diagrams of glucose, ribose, a saturated fatty acid and a generalized amino acid. * Skill: Identification of biochemicals such as sugars, lipids or amino acids frommolecular diagrams.   **2.2**   * Water molecules are polar and hydrogen bonds form between them. * Hydrogen bonding and dipolarity explain the cohesive, adhesive, thermal and solvent properties of water. * Substances can be hydrophilic or hydrophobic. * Application: Comparison of the thermal properties of water with those of methane. * Application: Use of water as a coolant in sweat. * Application: Modes of transport of glucose, amino acids, cholesterol, fats, oxygen and sodium chloride in blood in relation to their solubility in water.   **2.3**   * Monosaccharide monomers are linked together by condensation reactions to form disaccharides and polysaccharide polymers. * Fatty acids can be saturated, monounsaturated or polyunsaturated. * Unsaturated fatty acids can be cis or trans isomers. * Triglycerides are formed by condensation from three fatty acids and one glycerol. * Application: Structure and function of cellulose and starch in plants and glycogen in humans. * Application: Scientific evidence for health risks of trans fats and saturated fatty acids. * Application: Lipids are more suitable for long-term energy storage in humans than carbohydrates. * Application: Evaluation of evidence and the methods used to obtain the evidence for health claims made about lipids. * Skill: Use of molecular visualization software to compare cellulose, starch and glycogen. * Skill: Determination of body mass index by calculation or use of a nomogram.   **2.4**   * Amino acids are linked together by condensation to form polypeptides. * There are 20 different amino acids in polypeptides synthesized on ribosomes. * Amino acids can be linked together in any sequence giving a huge range of possible polypeptides. * The amino acid sequence of polypeptides is coded for by genes. * A protein may consist of a single polypeptide or more than one polypeptide linked together. * The amino acid sequence determines the three-dimensional conformation of a protein. * Living organisms synthesize many different proteins with a wide range of functions. * Every individual has a unique proteome. * Application: Rubisco, insulin, immunoglobulins, rhodopsin, collagen and spider silk as examples of the range of protein functions. * Application: Denaturation of proteins by heat or by deviation of pH from the optimum. * Skill: Drawing molecular diagrams to show the formation of a peptide bond. | **What you need to know from Honors Biology:**   * Definition of monomer and polymer * The four biological molecules: carbohydrates, lipid, proteins and nucleic acids * Elements that make up each type of molecule * Monomers that make up each type of molecule * Definition of monosaccharides, disaccharides, polysaccharide * Basic functions of each type of molecule (we will cover additional in class) * Carbohydrate-short term energy * Lipids- long term energy * Proteins- catalyst * Nucleic acids- carry genetic information * Function of enzymes * Proteins are synthesized at the ribosome * The cell membrane is a phospholipid bilayer * Plant cells have cell walls   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **Graded Homework Assignments:**  Plato – Chem Prereq  Plato – Polymers and Biological Molecules  Quizizz - Molecules of Life Basics  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **Labs:**   * Statistical Analysis Lab (Which is larger? M&M’s or Skittles?)   + Students will learn how to complete statistical analysis by hand and on excel (average, standard deviation, t-test)   + Students will learn how to make appropriate graphs on excel/word   + Focus will be on the data analysis portion of the lab * Water Properties Lab   + Students will examine how various factors influence the properties of water   + Focus will be on the data analysis portion of the lab * Biological Molecule Indicators   + Students will learn what an indicator is and how to use them to identify what molecules are found in various solutions   + Focus will be on exploration portion of the lab |

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| **Subunit: Enzymes** | |
| **Topics covered:** 2.5 and 8.1 | |
| **Essential ideas**:  2.5 - Enzymes control the metabolism of the cell.  8.1 - Metabolic reactions are regulated in response to the cell’s needs. | |
| **IB Understandings, Applications, and Skills:**  **2.5**   * Enzymes have an active site to which specific substrates bind. * Enzyme catalysis involves molecular motion and the collision of substrate with the active site. * Temperature, pH and substrate concentration affect the rate of activity of enzymes. * Enzymes can be denatured. * Immobilized enzymes are widely used in industry. * Application: Methods of production of lactose-free milk and its advantages. * Skill: Design of experiments to test the effect of temperature, pH and substrate concentration on the activity of enzymes. * Skill: Experimental investigation of a factor affecting enzyme activity. (Practical 3)   **8.1**   * Metabolic pathways consist of chains and cycles of enzyme-catalyzed reactions. * Enzymes lower the activation energy of the chemical reactions that they catalyze. * Enzyme inhibitors can be competitive or non-competitive. * Metabolic pathways can be controlled by end-product inhibition. * Application: End-product inhibition of the pathway that converts threonine to isoleucine. * Application: Use of databases to identify potential new anti-malarial drugs. * Skill: Calculating and plotting rates of reaction from raw experimental results. * Skill: Distinguishing different types of inhibition from graphs at specified | **What you need to know from Honors Biology:**   * Function of enzymes   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **Graded Homework Assignments:**  Plato – Enzymes  Edmodo quiz – Enzymes (will be open on certain dates)  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **Labs:**   * The Effect of Temperature on Enzyme Activity   + Students will examine the effect that temperature plays on enzyme activity   + Focus will be on the exploration portion of the lab |

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| **Subunit: DNA to Protein** | |
| **Topics covered:** 2.6 – 2.7 and 7.1-7.3 | |
| **Essential ideas**:  2.6 – The structure of DNA allows efficient storage of genetic information.  2.7 - Genetic information in DNA can be accurately copied and can be translated to make the proteins needed by the cell.  7.1 - The structure of DNA is ideally suited to its function.  7.2 - Information stored as a code in DNA is copied onto mRNA.  7.3 - Information transferred from DNA to mRNA is translated into an amino acid sequence. | |
| **IB Understandings, Applications, and Skills:**  **2.6**   * The nucleic acids DNA and RNA are polymers of nucleotides. * DNA differs from RNA in the number of strands present, the base composition and the type of pentose. * DNA is a double helix made of two antiparallel strands of nucleotides linked by hydrogen bonding between complementary base pairs. * Application: Crick and Watson’s elucidation of the structure of DNA using model making. * Skill: Drawing simple diagrams of the structure of single nucleotides of DNA and RNA, using circles, pentagons and rectangles to represent phosphates, pentoses and bases.   **2.7**   * The replication of DNA is semi-conservative and depends on complementary base pairing. * Helicase unwinds the double helix and separates the two strands by breaking hydrogen bonds. * DNA polymerase links nucleotides together to form a new strand, using the pre-existing strand as a template. * Transcription is the synthesis of mRNA copied from the DNA base sequences by RNA polymerase. * Translation is the synthesis of polypeptides on ribosomes. * The amino acid sequence of polypeptides is determined by mRNA according to the genetic code. * Codons of three bases on mRNA correspond to one amino acid in a polypeptide. * Translation depends on complementary base pairing between codons on mRNA and anticodons on tRNA. * Application: Use of Taq DNA polymerase to produce multiple copies of DNA rapidly by the polymerase chain reaction (PCR). * Application: Production of human insulin in bacteria as an example of the universality of the genetic code allowing gene transfer between species. * Skill: Use a table of the genetic code to deduce which codon(s) corresponds to which amino acid. * Skill: Analysis of Meselson and Stahl’s results to obtain support for the theory of semi-conservative replication of DNA. * Skill: Use a table of mRNA codons and their corresponding amino acids to deduce the sequence of amino acids coded by a short mRNA strand of known base sequence. * Skill: Deducing the DNA base sequence for the mRNA strand.   **7.1**   * Nucleosomes help to supercoil the DNA. * DNA structure suggested a mechanism for DNA replication. * DNA polymerases can only add nucleotides to the 3’ end of a primer. * DNA replication is continuous on the leading strand and discontinuous on the lagging strand. * DNA replication is carried out by a complex system of enzymes. * Some regions of DNA do not code for proteins but have other important functions. * Application: Rosalind Franklin’s and Maurice Wilkins’ investigation of DNA structure by X-ray diffraction. * Application: Use of nucleotides containing deoxyribonucleic acid to stop DNA replication in preparation of samples for base sequencing. * Application: Tandem repeats are used in DNA profiling. * Skill: Analysis of results of the Hershey and Chase experiment providing evidence that DNA is the genetic material. * Skill: Utilization of molecular visualization software to analyze the association between protein and DNA within a nucleosome.   **7.2**   * Transcription occurs in a 5’ to 3’ direction. * Nucleosomes help to regulate transcription in eukaryotes. * Eukaryotic cells modify mRNA after transcription. * Splicing of mRNA increases the number of different proteins an organism can produce. * Gene expression is regulated by proteins that bind to specific base sequences in DNA. * The environment of a cell and of an organism has an impact on gene expression. * Application: The promoter as an example of non-coding DNA with a function. * Skill: Analysis of changes in the DNA methylation patterns.   **7.3**   * Initiation of translation involves assembly of the components that carry out the process. * Synthesis of the polypeptide involves a repeated cycle of events. * Disassembly of the components follows termination of translation. * Free ribosomes synthesize proteins for use primarily within the cell. * Bound ribosomes synthesize proteins primarily for secretion or for use in lysosomes. * Translation can occur immediately after transcription in prokaryotes due to the absence of a nuclear membrane. * The sequence and number of amino acids in the polypeptide is the primary structure. * The secondary structure is the formation of alpha helices and beta pleated sheets stabilized by hydrogen bonding. * The tertiary structure is the further folding of the polypeptide stabilized by interactions between R groups. * The quaternary structure exists in proteins with more than one polypeptide chain. * Application: tRNA-activating enzymes illustrate enzyme–substrate specificity and the role of phosphorylation. * Skill: Identification of polysomes in electron micrographs of prokaryotes and eukaryotes. | **What you need to know from Honors Biology:**   * DNA is an example of a nucleic acid * DNA is double stranded * DNA is made up of nucleotides * Base pair rules in DNA * The product of DNA replication * DNA codes for amino acids * Amino acids make up polypeptides   **Graded Homework Assignments:**  Plato – DNA and Protein Synthesis  TBD - Quizizz or Edmodo quiz  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |