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

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	+ 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

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	+ 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 SynthesisTBD - Quizizz or Edmodo quiz \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |