IB Study Guide: Topics 2.4-2.7 and 7.1-7.3

DNA to Proteins

**Enzyme/Protein Identification:**

Helicase

DNA gyrase

Single-stranded binding proteins

DNA polymerase III

DNA polymerase I

DNA primase

DNA ligase

RNA polymerase

Transcription factors

tRNA activating enzyme

**SL (you are expected to know this info, so I would look over last year’s notes or visit bioninja)**

**Topic 2.4**

**Understandings:**

* 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.

**Applications and skills:**

* 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.

**Topic 2.5**

**Understandings:**

* Enzymes have an active site to which specific substrates bind.
* Enzyme catalysis involves molecular motion and the collision of substrates with the active site.
* Temperature, pH and substrate concentration affect the rate of activity of enzymes.
* Enzymes can be denatured.

**Topic 2.6**

**Understandings:**

* 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.

**Applications and skills:**

* 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.

**Topic 2.7**

**Understandings:**

* 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.

**Applications and skills:**

* 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.

**NEW STUFF – HL**

**Topic 7.1**

**Understandings:**

* 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.

**Applications and skills:**

* Application: Rosalind Franklin’s and Maurice Wilkins’ investigation of DNA structure by X-ray diffraction.
* Application: Use of nucleotides containing dideoxyribonucleic 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 analyse the association between protein and DNA within a nucleosome.

**Topic 7.2**

**Understandings:**

* 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 and skills:**

* Application: The promoter as an example of non-coding DNA with a function.
* Skill: Analysis of changes in the DNA methylation patterns.

**Topic 7.3**

**Understandings:**

* 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 and skills:**

* Application: tRNA-activating enzymes illustrate enzyme–substrate specificity and the role of phosphorylation.
* Skill: Identification of polysomes in electron micrographs of prokaryotes and eukaryotes.
* Skill: The use of molecular visualization software to analyse the structure of eukaryotic ribosomes and a tRNA molecule.

**Heavy Hitters**

* Nucleosome structure
* Process of Replication
  + 5’ to 3’
  + Enzymes
* Process of Transcription
  + 5’ to 3’
* Ribosome and tRNA structure
* Process of translation
* 4 levels of protein structure
  + Primary, secondary, tertiary, quaternary
* Epigenetics
  + Methylation, Acetylation
  + Coiled vs. uncoiled around nucleosomes
* Functions non-coding DNA
* Alternative splicing