# 01 – DNA AND PROTEINS *Learning Intentions*

| I understand that… | I can… | Mastery Check |
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| **1.1 - DNA STRUCTURE** | | |
| **1.1.1** DNA stores and transmits genetic information; it functions in the same way in all living things. | |  |
| **1.1.2** DNA is a helical double-stranded molecule. | |  |
| **1.1.3** In eukaryotes, DNA is bound to protein histones in linear chromosomes, which are found in the nucleus. | |  |
| **1.1.4** DNA is unbound and circular in the cytosol of prokaryotes and in the mitochondria and chloroplasts of eukaryotes. | ☑ Compare chromosomes in prokaryotes and eukaryotes. |  |
| **1.1.5** Replication of DNA allows for genetic information to be inherited. | |  |
| **1.1.6** Base-pairing rules and method of DNA replication are universal. | ☑ Describe the structural properties of the DNA molecule, including:<br>• nucleotide composition and pairing<br>• the weak bonds between strands of DNA that allow for replication<br><br>☑ Explain the importance of complementary base pairing (A-T and C-G).<br><br>☑ Describe and represent the process of semi-conservative replication of DNA. |  |

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| **1.2 - STRUCTURE AND FUNCTION OF PROTEINS** | | |
| **1.2.1** A gene consists of a unique sequence of nucleotides that code for a functional protein or an RNA molecule. | ☑ Distinguish between exons and introns as coding and non-coding segments of DNA found in genes in eukaryotes.<br><br>☑ Describe how both exons and introns are transcribed but only the information contained in exons will be translated to form a polypeptide. |  |
| **1.2.2** Protein synthesis involves<br>• transcription of a gene into messenger RNA (mRNA), and<br>• translation of mRNA into an amino acid sequence [polypeptide] at the ribosomes. | ☑ Describe and illustrate the role of DNA, mRNA, transfer RNA (tRNA), ribosomal RNA (rRNA) in transcription and translation.<br><br>☑ Describe the relationship between DNA codons and RNA codons, anticodons, and amino acids.<br><br>☑ Distinguish between coding (gene) and template strands<br><br>☑ Recognize that DNA strands are directional and are read 5' to 3'. |  |
| **1.2.3** In eukaryotic cells, transcription occurs in the nucleus. | |  |
| **1.2.4** The folding of a polypeptide to form a protein with a unique three-dimensional shape is determined by its sequence of amino acids. (peptide bonds for $1^0$, h-bonds for $2^0$, disulfide bridges for $3^0$) | ☑ Describe the factors that determine the primary, secondary, tertiary, and quaternary structure of proteins. | |
| **1.2.5** Proteins are essential to cell structure and function. | |  |
| **1.2.6** Examples of proteins with specific [3D] shapes include<br>• enzymes,<br>• some hormones, | ☑ Explain why the three-dimensional structure of a protein [its specificity] is critical to its function, especially in:<br>• Enzyme + substrate binding |  |

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| • receptor proteins,<br>• and antibodies. | • Cell membrane receptors<br>• Hormone action | |
| **1.3 – ENZYMES** | | |
| **1.3.1** Enzymes:<br>• are specific for their substrate<br>• increase reaction rates by lowering activation energy. | ☑ Describe the induced-fit model of enzyme–substrate binding.<br><br>☑ Explain why enzymes have specific functions and how they can be affected by factors including:<br>• temperature<br>• pH<br>• presence of inhibitors<br>The rate of an enzyme-controlled reaction is affected by:<br>• concentrations of reactants<br>• concentration of the enzyme |  |
| **1.4 – GENE EXPRESSION AND MUTATION** | | |
| **1.4.1** The phenotypic expression of genes depends on factors controlling transcription and translation. These include the products of other genes and the environment. | |  |
| **1.4.2** Cellular differentiation associated with tissue growth and development is controlled by gene expression. | ☑ Recognise that changes in DNA methylation and histone modification can alter gene expression. |  |
| **1.4.3** Epigenetic changes can lead to phenotypic differences between identical siblings, phenotypic differences between clones; and may cause human diseases | ☑ Explain how epigenetic modifications in genes that control cell division, such as changes in DNA methylation, can lead to cancer. |  |
| **1.4.4** Changes in the DNA sequence are called ‘mutations’. | |  |

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| **1.4.5** Mutations in genes and chromosomes can result from errors in DNA replication or cell division, or from damage by physical or chemical factors in the environment. | ☑ Describe the effect of mutations such as point, frameshift, or involving parts of or whole chromosomes on the genetic code and overall protein formation. |  |
| **1.4.6** Mutation rate can be increased by:<br>• ionising radiation<br>• mutagenic chemicals<br>• viruses. | ☑ Explain how inheritable mutations can lead to changes in the characteristics of the descendants.<br><br>☑ Compare the different potential consequences of mutations in germ cells and somatic cells. |  |
| **1.5 – DNA PROFILING** | | |
| **1.5.1** DNA can be extracted from cells. | |  |
| **1.5.2** Modern techniques can be used to analyse even small amounts of DNA. | |  |
| **1.5.3** Segments of DNA can be multiplied using the polymerase chain reaction (PCR) | ☑ Describe PCR, including the roles of<br>• heating and cooling<br>• primers<br>• free nucleotides<br>• heat-resistant enzymes |  |
| **1.5.4** The base sequence of DNA can be determined by electrophoresis. | ☑ Describe electrophoresis |  |
| **1.5.5** The results of electrophoresis may be displayed in an electropherogram | ☑ Interpret electropherograms that illustrate DNA sequences. |  |
| **1.5.6** DNA sequencing enables mapping of species genomes. | |  |

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| **1.5.7** The results of electrophoresis can be used to construct DNA profiles. They may be displayed in an electropherogram or in a table of data. | |  |
| **1.5.8** DNA profiling identifies the unique genetic makeup of individuals | ☑ Interpret electropherograms and tables of data that illustrate DNA profiles<br><br>☑ Explain how differences in DNA fragments, identified by DNA profiling, can be used; for example, in forensic science.<br><br>☑ Discuss the ethical, economic, and cultural issues related to the collection of genetic information. |  |
| **1.6 – GENETIC ENGINEERING & BIOTECHNOLOGY** | | |
| **1.6.1** Biotechnology can involve the use of<br>• plasmids<br>• and viruses as vectors<br>• bacterial enzymes<br>• and yeasts | ☑ Describe how particular genes can be selected using **probes** and removed using restriction enzymes. |  |
| **1.6.2** Techniques include, bacterial transformations, electroporation, microinjection | ☑ Describe how particular genes can be selected using probes and removed using restriction enzymes.<br><br>☑ Describe how particular genes can be transferred between species; *for example, using bacterial plasmids, viruses, and microinjection.* |  |
| **1.6.3** | ☑ Describe how CRISPR such as CRISPR-Cas9 can be used to edit and/or transfer genes. |  |

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| **1.6.4** | ☑ Discuss the design of new proteins and their uses. |  |