

Chapter 5 Genetic control of protein structure and function

AICE Biology
Textbook outline

(F) Genetic control

Content

- Structure and replication of DNA
- Role of DNA in protein synthesis

Learning Outcomes

- describe the structure of RNA and DNA and explain the importance of base pairing and the different hydrogen bonding between bases;
- explain how DNA replicates semi-conservatively during interphase;
- state that a gene is a sequence of nucleotides as part of a DNA molecule, which codes for a polypeptide and state that a mutation is a change in the sequence that may result in an altered polypeptide;
- describe the way in which the nucleotide sequence codes for the amino acid sequence in a polypeptide with reference to the nucleotide sequence for HbA (normal) and HbS (sickle cell) alleles of the gene for the β -haemoglobin polypeptide;
- describe how the information on DNA is used during transcription and translation to construct polypeptides, including the role of messenger RNA (mRNA), transfer RNA (tRNA) and the ribosomes;
- use the knowledge gained in this section in new situations or to solve related problems.


The genetic molecules: DNA & RNA

- Carries out instructions from the central blueprint for the construction and behaviour of cells
- Instructions for the cells to collaborate to become tissues, organs and organisms
- Ability to be copied repeatedly and perfectly to create daughter cells
- The ability to decipher exactly what part to copy and what part not to

The structure of DNA & RNA

- Deoxyribonucleic acid and ribonucleic acid
- Both are polymers, made up of similar repeating units to become macromolecules
- Polynucleotides or more simply nucleotides

Nucleotides: 3 small components

- Nitrogen containing base
 - Only 5
 - DNA: cytosine=guanine and adenine=thymine
 - RNA: cytosine=guanine and adenine=uracil
 - = means a double hydrogen bond, \equiv is a triple
- Pentose sugar
 - DNA: deoxyribose (one fewer oxygen atom in the molecule than ribose)
 - RNA: ribose
- Phosphate group: circle P 

Polynucleotides

- DNA & RNA are replicated in the nucleus during interphase of the cell cycle
- Backbone is alternating phosphates and sugars held together by covalent bonds
- DNA (double helix) is two strands running parallel with the base pairs facing each other in a complementary way: A-T and G-C
- Adenine and guanine are the purines
- Cytosine and thymine are the pyrimidines
- Hydrogen bond between a purine and pyrimidine

DNA replication

- Semi conservative replication (Watson and Crick, 1953)
- Half the original molecule is kept when creating a new molecule for a daughter cell
- Meselsohn and Stahl (1958) semi-conservative experiments
 - Page 69, box 5A
 - assignment

DNA, RNA and protein synthesis

- Under DNA control
 - All chemical reactions in cells are controlled by enzymes
 - Enzymes are proteins
 - DNA is a code for proteins
 - Thus DNA controls the activities of the cell
 - Proteins are made of strings of amino acids
 - Shape of protein depends on the exact sequence (primary structure) which will determine folding and shape, which will determine function

The triplet code

- The sequence of nucleotides is a code for the sequence of amino acids in a polypeptide
- One sequence of three nucleotides will code for one amino acid
- Figure 5.7
 - DNA is unzipped
 - The bases are CAA TTT GAA CCC
 - Translated: valine, lysine, leucine and glycine

Genes and genomes

- DNA in a human cell is 3×10^9 base pairs long
- About 3% actually code for proteins, the rest is debated
- About 30,000 genes= total set of genes is the genome
- Different parts of the DNA will code for one specific gene

Protein synthesis: transcription

- Figure 5.8
- DNA is unzipped by an enzyme to expose a template to be read and constructed into a messenger, mRNA
- mRNA leaves the nucleus and attaches to a ribosome in the cytoplasm
- Transfer, tRNA is free floating in the cytoplasm and they have a region where an amino acid can attach at the opposite end of where their triplet code is
- There are at least 20 different tRNA's each with a specific amino acid attached

Protein synthesis, continued: translation

- The triplet base on tRNA is the anticodon
- The anticodons link to the codes on the mRNA, as they link
- Peptide bonds are formed between the amino acids (primary structure of a protein)
- Several ribosomes may work on a polypeptide at any given time
- The base sequence of the DNA matches the tRNA exactly (except that uracil has replaced thymine)

Resource

Jones, M., Fosbery, R., Taylor, D., & Gregory, J. (2007). *AS Level and A Level Biology*, 2nd ed. Cambridge, UK: Cambridge University Press.