3.3.13 Amino Acids, Proteins and DNA

★ A-LEVEL ONLY — not examined at AS level

3.3.13.1 *Amino acids: acidic/basic properties, zwitterion formation.*

Amino acids have both –NH2 (basic) and –COOH (acidic) groups.

Zwitterion (at neutral pH): ■NH3–CHR–COO■ (internal salt).

In acid: ■NH3–CHR–COOH (cation — both groups protonated).

In alkali: NH2–CHR–COO■ (anion — both groups deprotonated).

High melting points (ionic interactions in solid); soluble in water (ionic character).

3.3.13.2 *Proteins: peptide links, primary/secondary/tertiary structure. Hydrolysis. Chromatography and Rf values.*

Peptide bond (–CONH–): formed by condensation between –COOH of one amino acid and –NH2 of another (+ H2O lost).

Primary structure: sequence of amino acids.

Secondary structure: alpha-helix or beta-pleated sheet — maintained by H-bonds between C=O and N–H of peptide bonds.

Tertiary structure: overall 3D shape — maintained by H-bonds, ionic interactions, van der Waals forces, and disulfide bridges (S–S).

Hydrolysis: heat with 6 mol dm■^{3} HCl under reflux → individual amino acids.

Chromatography (TLC): separate amino acids. Rf = distance by spot / distance by solvent front. Visualise with ninhydrin or UV. Compare with standards.

3.3.13.3 *Enzymes: stereospecific active sites. Drugs as enzyme inhibitors. Computer modelling.*

Enzymes are biological catalysts (proteins) with a stereospecific active site.

Lock-and-key model: active site has complementary shape to the substrate.

Only one enantiomer of a chiral substrate fits the active site.

Enzyme inhibitors (drugs): block the active site → substrate cannot bind → reaction inhibited.

Computer modelling: used to design drug molecules with the correct 3D shape to fit a specific enzyme active site.

3.3.13.4 *DNA: nucleotides, double helix, complementary base pairing by H-bonding.*

Nucleotide = phosphate group + 2-deoxyribose (pentose sugar) + organic base (A, C, G, or T).

DNA strand: polymer of nucleotides linked by covalent bonds between phosphate and sugar → sugar–phosphate backbone with bases attached.

Double helix: two complementary strands held by H-bonds between base pairs:

A–T: 2 H-bonds. C–G: 3 H-bonds.

Complementary base pairing enables DNA replication.

3.3.13.5 *Cisplatin: anticancer drug. Mechanism, benefits vs adverse effects.*

Cisplatin [$PtCl_2(NH_3)_2$] is a square planar Pt(II) complex.

Mechanism: Cl ligands replaced by bonds to N atoms on guanine bases in DNA (ligand substitution). Cross-links the two DNA strands → strands cannot separate for replication → cancer cell cannot divide.

Benefits: effective against several cancers (testicular, ovarian).

Adverse effects: affects healthy, rapidly dividing cells (hair, gut lining) → nausea, hair loss.

Society must balance benefits (treating cancer) vs risks (side effects).