AQA Chemistry A-level

3.3.13: Amino Acids, Proteins and DNA

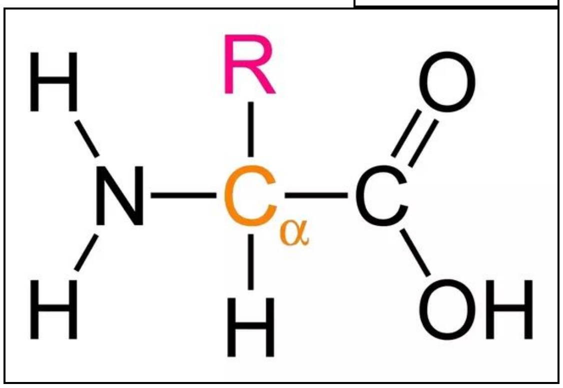
Detailed Notes

3.3.13.1 - Amino Acids

An amino acid is a compound with an **amine group and a carboxylic acid group** within the molecule. The amine group is always on the **second carbon** in the chain meaning they are always named as **'2-amino acids'**. As this is always the case, amino acids with this structure are also known as **'α-amino acids'**.

Example:

Image courtesy of Quora



This second carbon is often **chiral** as it has four different groups bonded to it meaning amino acids exist as **optical isomers**. However in nature, nearly all amino acids exist as **a single negative enantiomer** so that they 'fit' into the correct cells within living organisms.

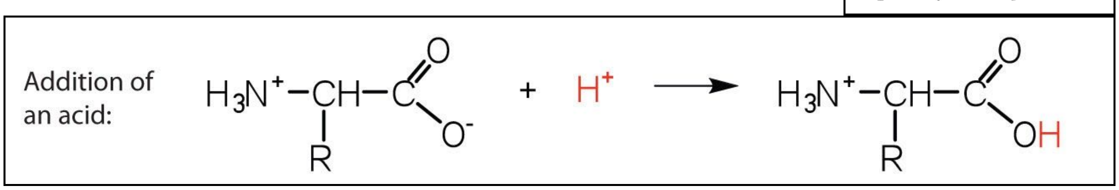
Zwitterions

The two functional groups within a single molecule means that amino acids can **react as both acids and bases** depending on the conditions of the reaction.

In **acidic conditions (low pH)**, the lone electron pair is more likely to accept a hydrogen atom, producing a **positive (acidic) end** to the molecule.

Example:

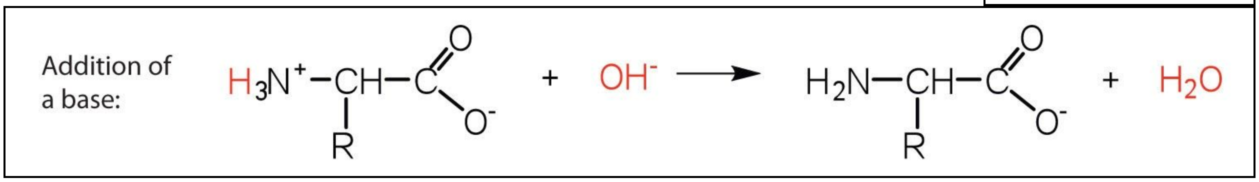
Image courtesy of Chemistry LibreTexts



In **basic conditions (high pH)**, the hydrogen atom on the -OH group is more likely to be lost, producing a **negative (basic) end** to the molecule.

Example:

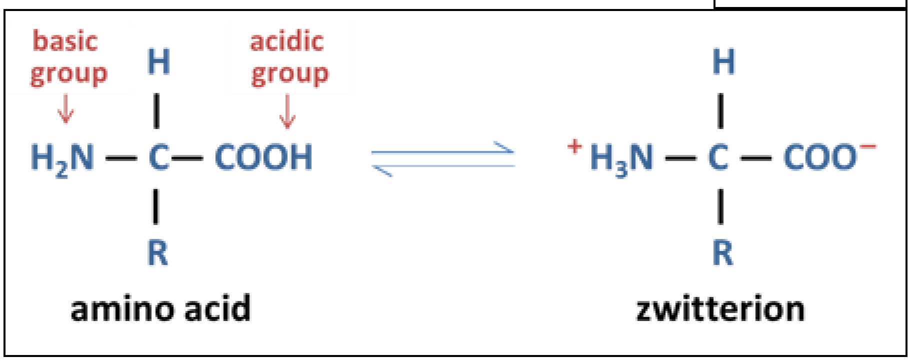
Image courtesy of Chemistry LibreTexts



A **zwitterion** forms when the overall pH of the molecule is **zero**, known as the **isoelectric** point.

Example:

Image courtesy of aquion



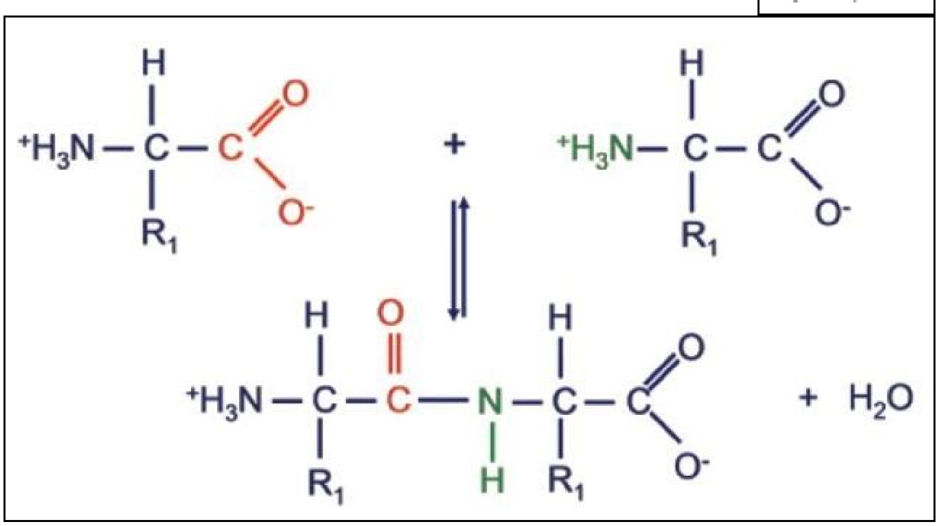
Thin-layer chromatography can be used to identify unknown amino acids using UV light to view the traces on the silica plate.

3.3.13.2 - Proteins

Proteins are sequences of amino acids joined together by **peptide links**.

Example:

Image courtesy of AZoM



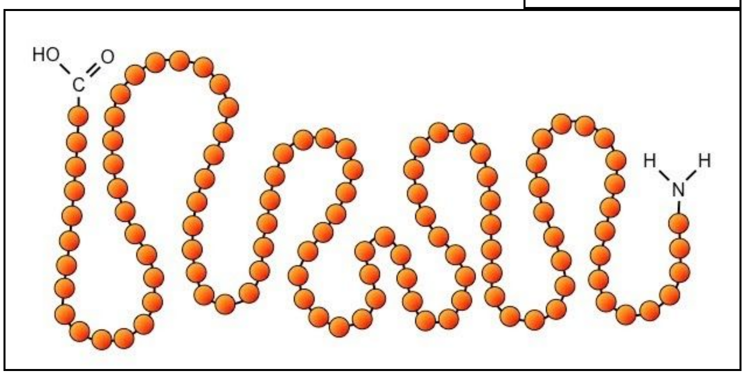
This reaction can be reversed by boiling the protein in **6.0 moldm^{-3} HCl for 24 hours** in a process called **hydrolysis**. In nature, this process is carried out by **enzymes** so such harsh conditions are not required.

Structures

Proteins have complex structures which are held together with **hydrogen bonds, van der waals forces and sulfur-sulfur bonds**.

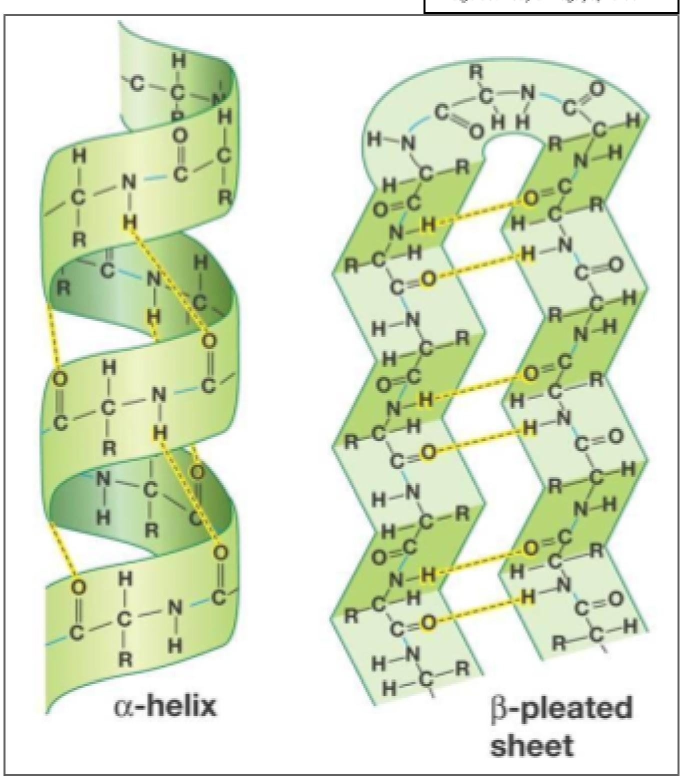
Primary Structure - a single polypeptide chain of amino acids.

Image courtesy of BioNinja

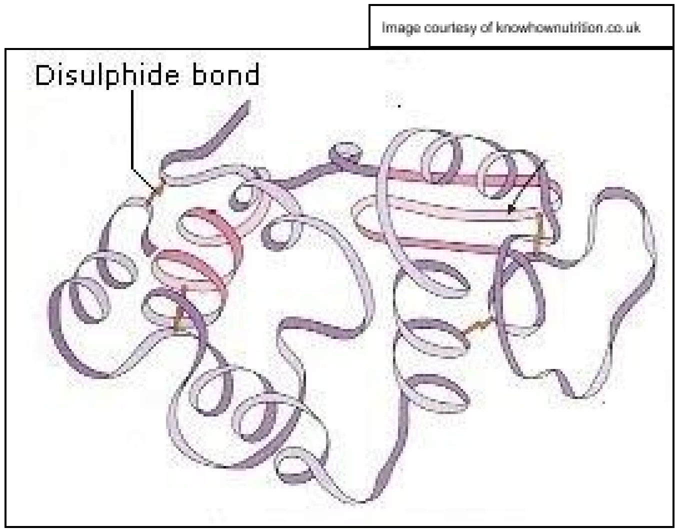


Secondary Structure - an α-helix or β-pleated sheet held with hydrogen bonds.

Image courtesy of hogayephd.com



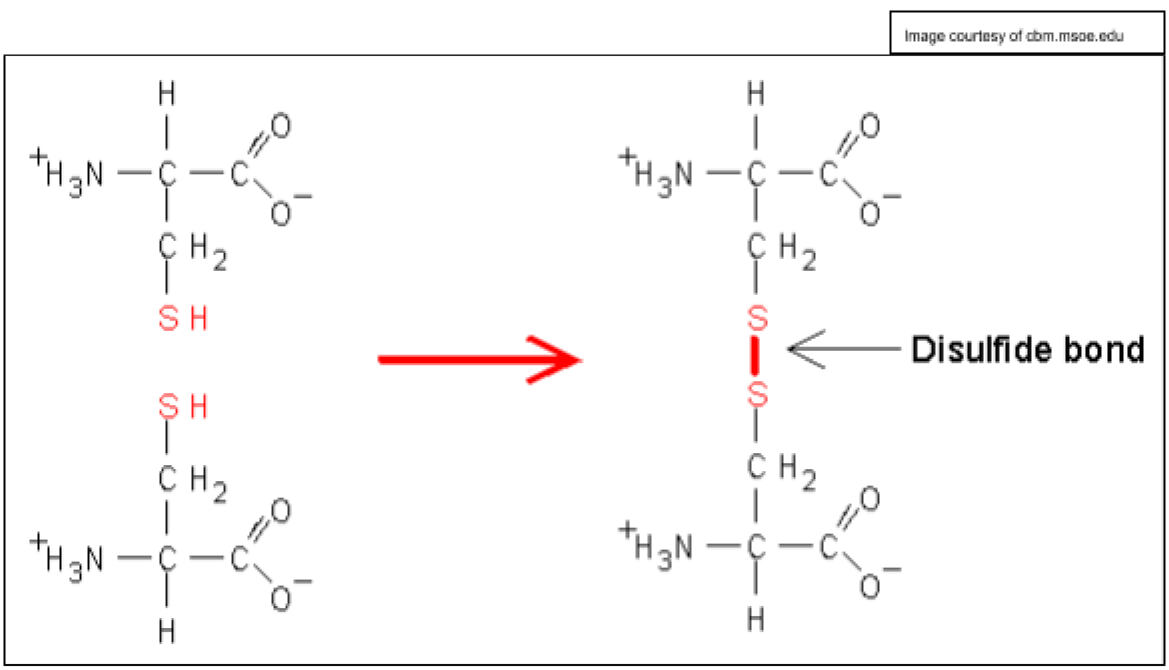
Tertiary Structure - chains folded into a 3D coil with hydrogen and disulfide bonding.



Disulfide Bonding

The sulfur-sulfur bonds that hold together tertiary structures are known as a **disulfide bridge**. They keep the protein structure **stable** by losing two hydrogen atoms.

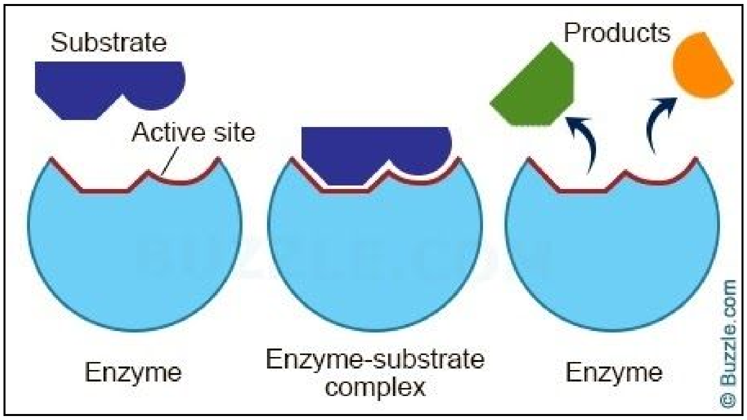
Example:



3.3.13.3 - Enzymes

Enzymes are proteins with a **tertiary structure** that act as **biological catalysts**. They contain **active sites** that are specific to a certain molecule that they break down, called a **substrate**.

Example:



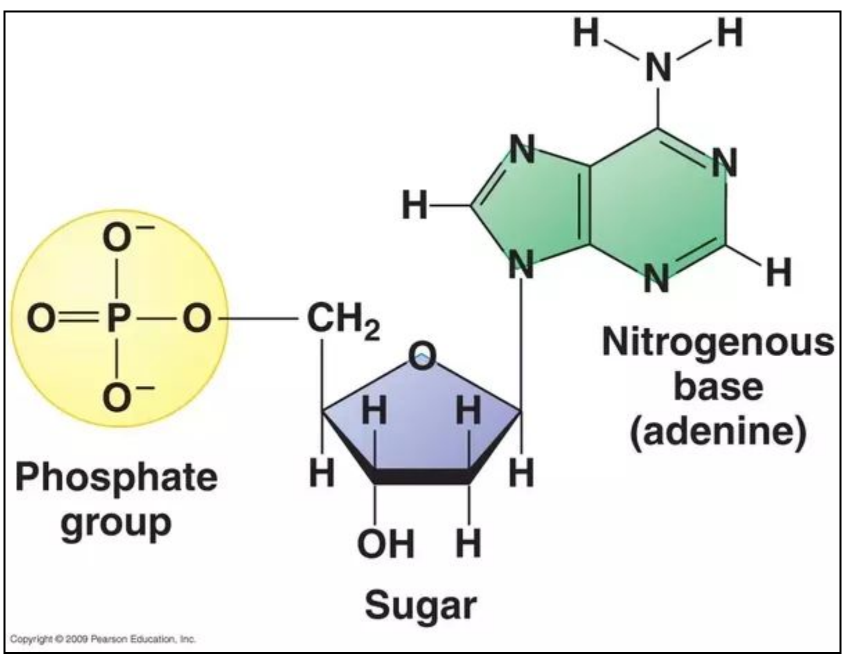
Enzymes are **stereospecific**, meaning they can only break down a single enantiomer and will have no effect on the other optical isomer.

3.3.13.4 - DNA

DNA (deoxyribonucleic acid) is a **condensation polymer** formed from a **sugar, a phosphate and a base**.

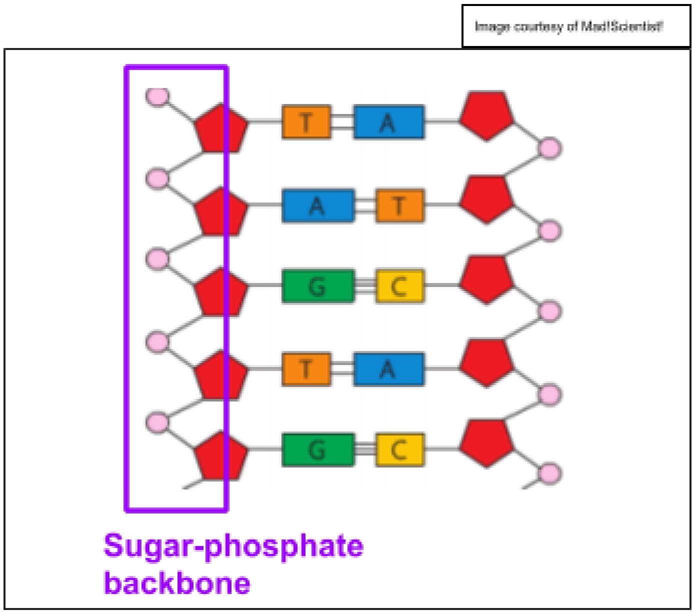
Nucleotides
These molecules join together to form a **nucleotide** which consists of one of each molecule.

Example:



The sugar present in the nucleotide that makes DNA is **2-deoxyribose**. Sugar-phosphate bonds hold together multiple nucleotides into a **polynucleotide strand**, these bonds make up what is known as a **'sugar-phosphate backbone'**.

Example:

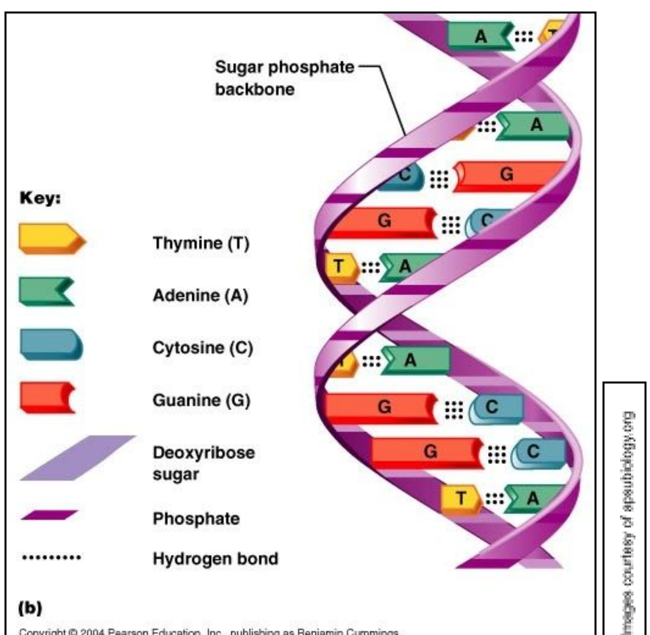


There are four possible bases that could be present in the nucleotide:

- Adenine
- Cytosine
- Thymine
- Guanine

These bases pair up to allow a single strand of DNA to join with another via **hydrogen bonding** to form a **double helix structure** of DNA.

Example:

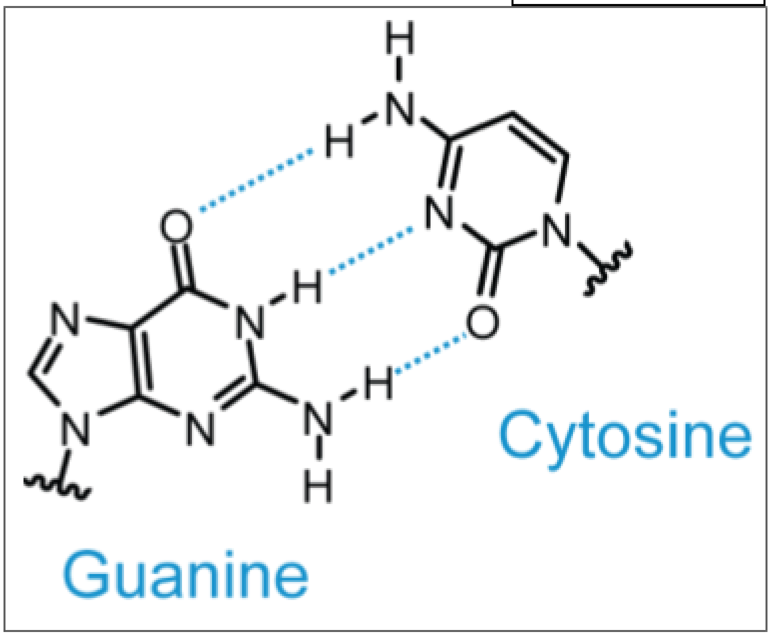


Complementary Bases

In order to join the protein strands, the bases pair up in specific, **complementary pairs**. **Guanine and Cytosine** are complementary bases that bond with **three** hydrogen bonds.

Example:

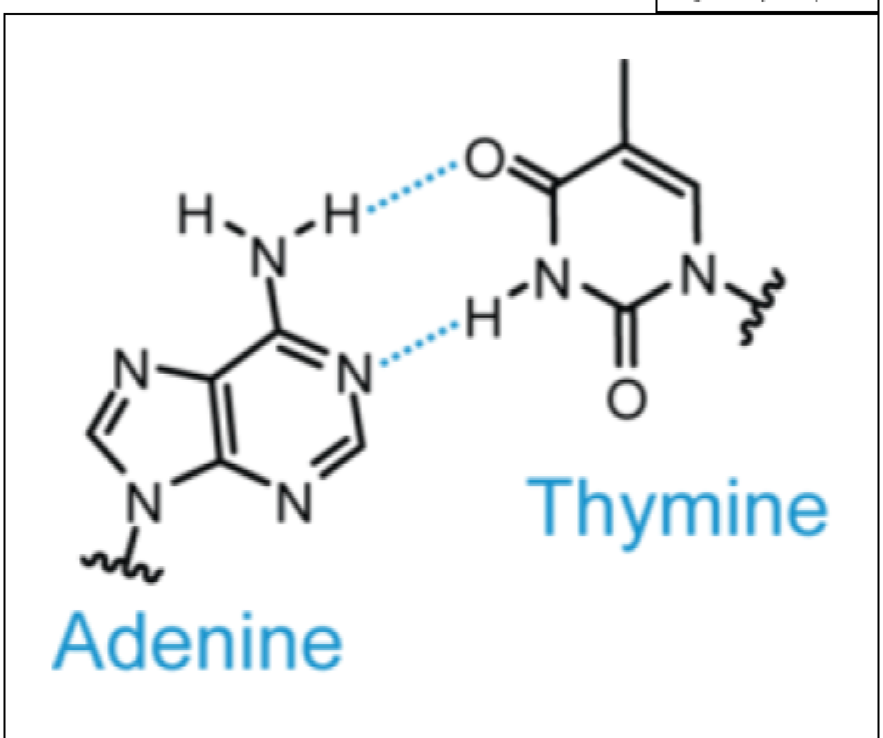
Image courtesy of cbm.msoe.edu



Thymine and Adenine are complementary bases that bond with **two** hydrogen bonds.

Example:

Image courtesy of Wikipedia

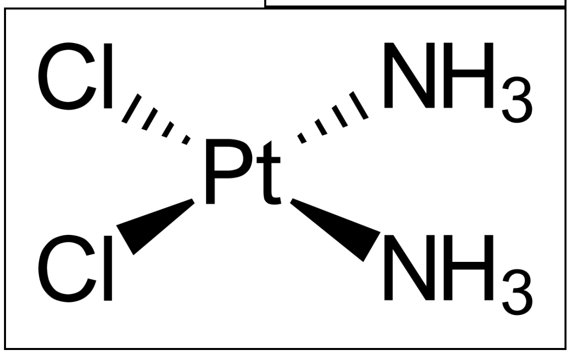


3.3.13.5 - Anticancer Drugs

Cisplatin is used as an anticancer drug. It is the ***cis* isomer** of a square planar complex of platinum.

Example:

Image courtesy of Wikipedia



Cells in the natural world are **chiral** so only the Z-isomer of the drug is effective and will be the correct orientation to 'fit' the cells. It has to be able to bond to **two adjacent Guanine bases**. Cancer spreads by replicating 'bad DNA'. Cisplatin bonds to strands of this mutated DNA to prevent it from replicating via **ligand replacement** with guanine.

However, cisplatin can occasionally bond to heated DNA strands causing serious **side effects** such as hair loss. To combat these side effects, the drug has to be administered in **small amounts** to try and reduce these effects.
The long term benefits of using cisplatin and its effectiveness as an anticancer drug means it continues to be used despite the short term side effects.