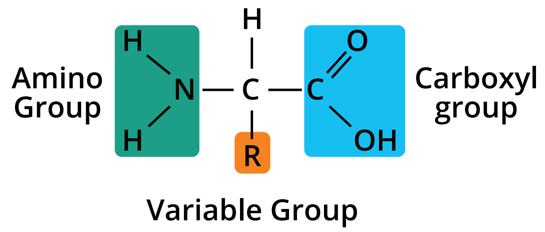
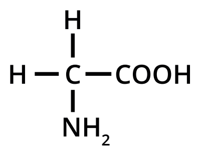
4.7 – Amino Acids

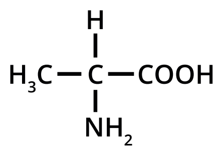
An α-amino acid has the $-NH_2$ group bonded to the carbon atom that is next to the $-COOH$ group. The general formula of an α-amino acid is



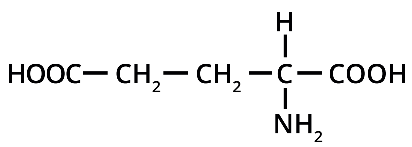
The simplest α-amino acid is aminoethanoic acid, where R is hydrogen. R can be a simple alkyl group such as $-CH_3$ in 2-aminopropanoic acid or a carbon-containing group that may also contain an $-OH$, $-SH$ or another $-NH_2$ or $-COOH$ group.



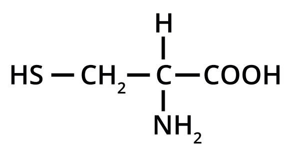
aminoethanoic acid (glycine)



2-aminopropanoic acid (alanine)

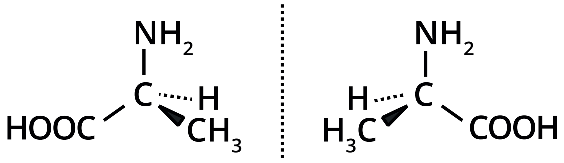


2-aminopentanedioic acid (glutamic acid)



2-amino-3-sulfhydrylpropanoic acid (cysteine)

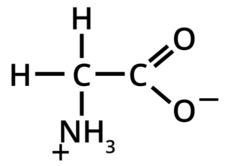
Apart from aminoethanoic acid, all α-amino acids have a chiral centre so can exist as optical isomers, e.g. 2-aminopropanoic acid.



Zwitterions

α-amino acids are white crystalline solids at room temperature with unusually high melting points. Hydrogen bonds cannot account for this. They exist as zwitterions with strong ion-ion interactions between zwitterions. A hydrogen ion (H^+) is lost from the carboxylic acid group and gained by the lone pair of electrons on the nitrogen atom of the amino group.

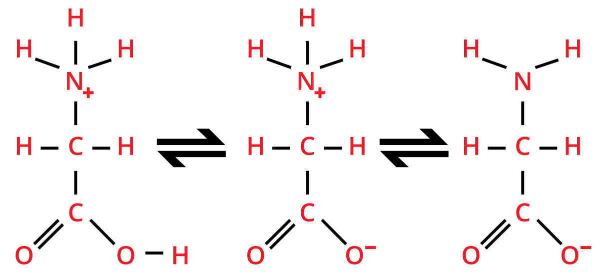
The zwitterion formula for aminoethanoic acid is:



Aminoethanoic acid is described as a neutral amino acid, as the positive and negative charges are balanced.

Amino acids are generally soluble in water and insoluble in non-polar organic solvents. This reflects the presence of the zwitterions. The extent of the solubility in water depends on the size and nature of the R group.

Although aqueous solutions of amino acids contain zwitterions, the compounds only exist as the zwitterion itself at a certain pH. This pH is called the isoelectric point and the value varies depending on the amino acid. If the pH of a solution is lower than the amino acid's isoelectric point, it acts as a base by accepting a hydrogen ion. If the pH is higher than its isoelectric point, it acts as an acid by losing a hydrogen ion. Therefore, amino acids are amphoteric.

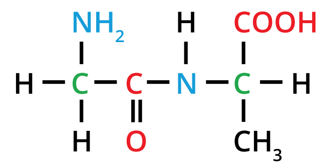


Dipeptide formation

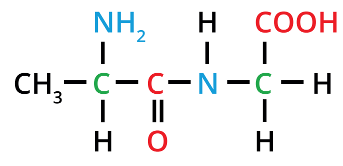
A dipeptide is formed when two amino acid molecules join together in a condensation reaction. A bond forms between the carboxyl group on one and the amino group on the other. This is known as a peptide bond. The product is an amide.

If the amino acids are the same, only one dipeptide forms.

If they are different, two dipeptides form, e.g. from glycine and alanine.



GlyAla



AlaGly

A chain of many amino acids joined together by peptide bonds is called a **polypeptide**. A protein consists of one or more polypeptides (more than about 50 amino acid units long).

The nature of proteins

Primary structure

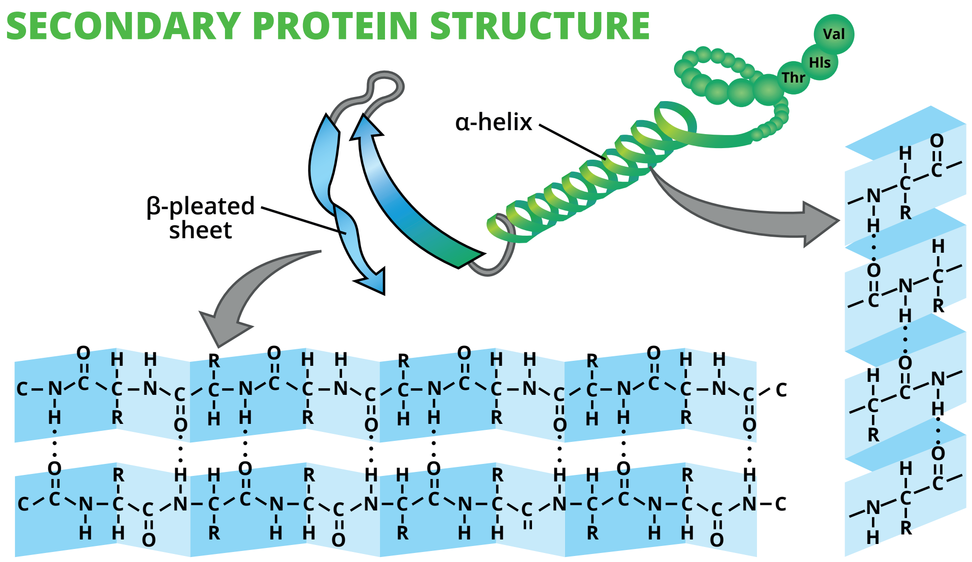
This is the sequence of amino acids in the chain. The sequence of the amino acids is very important. Even changing just one amino acid in a protein's sequence can affect the protein's overall structure and function.

Secondary structure

The secondary structure is concerned with how the amino acids are arranged. The two most common arrangements are an α-helix and a β-pleated sheet.

In an α-helix, the peptide is coiled into a spiral that is held in place by hydrogen bonds between the polar C=O and N–H bonds of different peptide bonds in the amino acid chain.

In a β-pleated sheet, the amino acids form a shape like a piece of paper stabilised by hydrogen bonds between amino acids in different polypeptide chains.



Tertiary structure

The tertiary structure refers to the protein as a whole and is the way in which the α-coils and β-pleated sheets of the protein fold with respect to each other. Interactions which contribute to this structure include hydrogen bonds, disulfide (–S–S–) bridges and salt bridges (ionic interactions between $RCOO^-$ and RNH_3^+).

Role of proteins

The functions of proteins are many. Proteins are an essential component of a healthy diet. Proteins are used in making rigid structures, e.g. collagen in cartilage and keratin in hair, nails and feathers. Enzymes are proteins; e.g. amylase is present in human saliva and it catalyses the hydrolysis of starch into sugars. Some proteins act as hormones, e.g. insulin.

About 150 enzymes have commercial uses, e.g. rennin in cheese making and protease in detergents to remove protein stains.