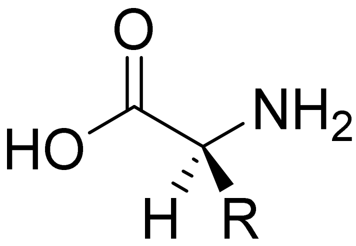
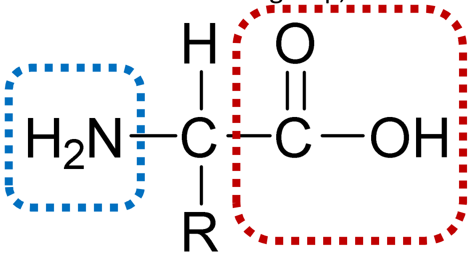
TA1 - Biochemistry Basics

AMINO ACIDS AND PEPTIDES

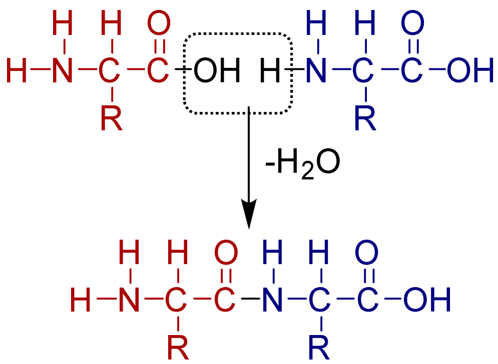
The study of **proteins** lies in the realm of **biochemistry**, which is a major area of scientific research. Biochemistry is the intersection between biology and chemistry, but to biologists it may seem to be chemistry, and to chemists it can look like biology! Because biologists and chemists have different approaches and fields of study, there can be confusion in terminology when these two disciplines are brought together. And this can cause confusion to students getting to grips with how biochemistry works.



Amino acids are small molecules, which have the same general structure. They are called amino acids because they have one basic **amine** group, and an **acidic** carboxyl group. Amino acids are the **monomers** which make up a protein.

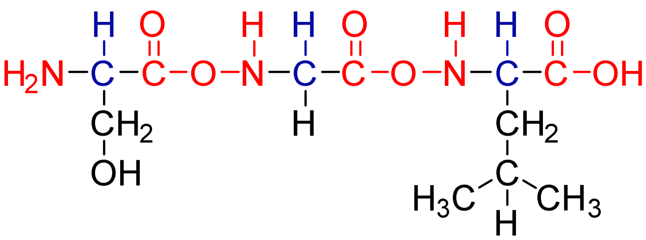


Two general representations of an amino acid are shown. The diagram on the left shows the stereochemistry – the 3D nature – of this amino acid. On the right is a simpler representation, showing the groups which make an amino acid. The amine group, and the carboxylic acid groups are clearly visible. Each amino acid has a CH group in the centre, which is attached to R. In this case, the R-group represents a number of varying side chains, which differ with each of the 20 amino acids.



Amino acids can **polymerise** to make a **peptide**. When two amino acids polymerise it makes a **dipeptide**, three a **tripeptide**, and many make a **polypeptide**. This process occurs through a type of reaction called a **condensation**. This is a reaction where two molecules join together, and **eliminate** a small molecule in the process. When amino acids condense, they eliminate a molecule of **water**. The bond which forms between two amino acids is called a **peptide bond**, because it is the bond which produces the peptides. However, it is also called an **amide bond**, because this is the chemical functional group which forms. In this way, a polypeptide, can also chemically be called a **polyamide**, and they are forms of condensation polymers.

Just like with addition polymers, such as polythene, these polymers have a chemical backbone. For polypeptides, this is a repeat unit consisting of peptide bonds. As you can see, the backbone is the same throughout, but it is these side chains which are unique. They go on to determine the **biochemical nature** of the polypeptide.



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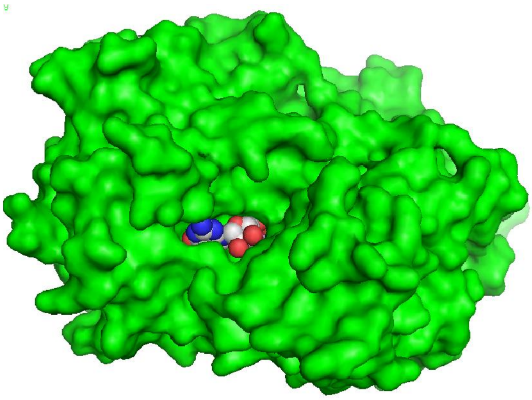
POLYPEPTIDES AND PROTEINS

A protein is a structure which is made from 1 or more polypeptides. So, a long polypeptide chain is a protein, as is a structure which is formed from 3 different polypeptide chains interacting together. Polypeptides can interact so that multiple polypeptide chains can create the **overall functional protein**. The term protein allows us to group together single polypeptide chains with structures which are made from multiple polypeptides. This is important because although many proteins are composed of multiple polypeptide chains combined, some proteins are made from only one polypeptide chain, which has folded into a specific 3D structure.

ENZYMES

Proteins are often classified into two general forms, **fibrous** or **globular**. Fibrous proteins extend in long, thin fibres, such as the protein **keratin** which makes up hair. They are often **structural proteins** – ones which give a larger structure its strength. Globular (globe-like) proteins are roughly shaped like a ball, and one important type of globular protein is the **enzyme**.

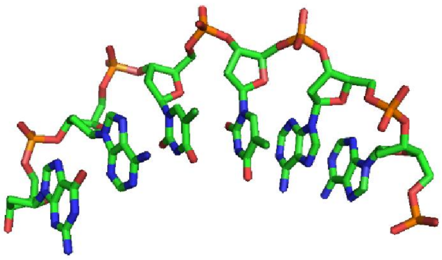


Enzymes are made when polypeptide chains fold in 3D to form a globular shape. The role of an enzyme is to **catalyse** a chemical reaction. It does this by accepting a molecule called a **substrate** into an '**active site'**, forming an **enzyme-substrate complex**, which then breaks down the substrate into the desired products. Substrates are also referred to biologically as **ligands**, these are just the names of the molecule which docks into the enzyme. It is important to be able to distinguish that a biological ligand, is just the substrate which binds onto an enzyme, and not to confuse it with the standard chemical definition of a ligand, which is a small molecule than binds to a metal complex.

An enzyme-substrate complex. The enzyme is shown in green, and is clearly globular. The substrate can be seen in the centre of the enzyme, within a nook on the surface of the protein.

DNA AS A POLYMER

Deoxyribonucleic acid, **DNA**, is also a polymeric molecule, but DNA is not a protein, as it doesn't form from amino acid subunits. DNA is a polymer instead of **nucleotides**, which makes DNA a **polynucleotide**. These nucleotides have a repeating backbone, called the **sugar-phosphate backbone**, and has side chains of the **DNA bases**, **adenine**, **cytosine**, **guanine**, and **thymine**.



A short strand of a polynucleotide. The backbone can be seen as alternating ribose sugars (5-membered rings), and phosphate groups (PO_4^{3-} groups). The DNA bases extend from the backbone chain, and alternate sporadically between A, C, G, and T.

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