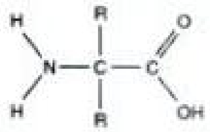
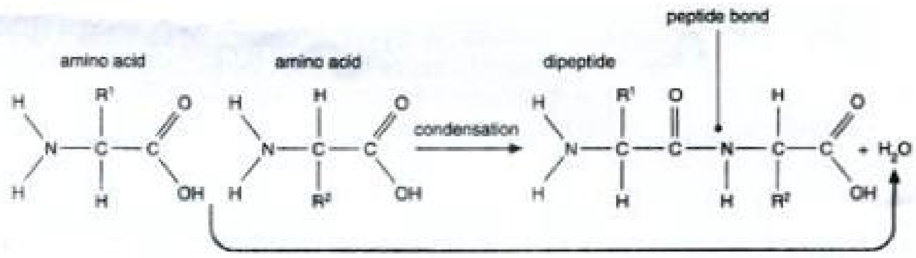
PROTEINS

- Proteins are large, complicated molecules containing the elements carbon, hydrogen, oxygen, nitrogen, and, in most cases, sulphur. They are found in all living organisms.
- Proteins are built out of **amino acids**. These are small molecules which are stuck together in a long chain to make a **polypeptide**. This polypeptide chain is then folded and coiled and, in some cases, attached to other polypeptide chains to produce the final protein.
- The general formula of an amino acid is shown left.



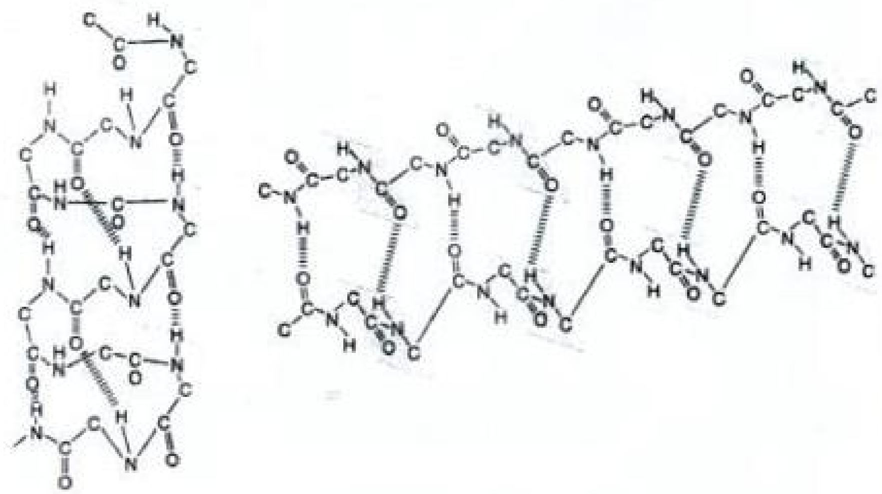
An amino acid

- There are twenty different types of amino acids which can be used in building a protein. They all have the same basic structure but have different collections of atoms in the place labelled R on the diagram. We say that different amino acids have different **R groups**.
- Two amino acids can be joined together using a condensation reaction in which an H and an OH are removed to release a molecule of water. In this way a **peptide bond** is formed between the two amino acids, as shown below.



If two amino acids are stuck together like this the result is a **dipeptide**. If many amino acids are stuck together the result is the polypeptide that we mentioned earlier.

- The **primary structure** of a protein is the order in which the amino acids are linked together to make the polypeptide chain.
- The **secondary structure** of a protein is the way that the polypeptide chain is coiled or folded. There are two very common ways in which this can happen. Either the chain is coiled like a spring to produce an **α-helix** shape, or lengths of the chain can line up side by side to produce a **β-pleated** sheet.



An α-helix (left) and a β-pleated sheet (right)

The dashed lines (IIIIIII) in the diagram represent hydrogen bonds which hold the coiled chain in its new shape.

- Having secondary structure is as complicated as some proteins get, but many large globular proteins, like enzymes, may have **tertiary structure**. This is the coiling and folding of the already coiled and folded chain, as below.

The coiled black line represents the polypeptide chain and each black dot is an amino acid. You can see that the chain has been folded to make an α helix and that this coiled helix has then been further folded to produce a roughly globular shape. (The **haem group** is a non-protein molecule that has been added in as well.)

- The tertiary coiling is held in place by hydrogen bonds, as was the secondary structure, but there are other, stronger bonds involved as well, including **disulphide bonds** and **electrovalent bonds**.
- Some proteins even have **quaternary structure** in which several different polypeptide chains are attached to each other. In **haemoglobin**, the oxygen-carrying molecule found in red blood cells, there are four chains. Each chain is folded into a globular shape and then all four are stuck together.
- The really important thing about a protein is the order in which the amino acids are linked to make the polypeptide. This is controlled by **DNA** (deoxyribonucleic acid) during **protein synthesis** (see unit 11).
- ***Which amino acids are stuck together, and in which order, determines how the polypeptide chain will fold up, and this determines the shape of the protein.***
- Because there are so many ways of ordering the twenty different amino acids, proteins can be built in almost any shape. As a result, living organisms can use proteins to do a whole range of different jobs. Each type of protein has a shape designed to suit its particular function.
- Here is a table listing some proteins and their functions.

Protein	Description
haemoglobin	a protein that carries oxygen (see unit 20)
amylase	an enzyme that breaks down starch (see unit 22)
FSH	a hormone involved in the menstrual cycle (see unit 23)
fibrinogen	a plasma protein involved in blood clotting
myosin	a contractile protein found in muscle
keratin	a fibrous protein found in hair and nails
albumin	an energy-storage protein found in egg white

- Proteins are also used to make bacterial flagella (see unit 5), active transport pumps in the plasma membrane (see unit 6), ribosomes (see unit 11), and spindle fibres (see unit 13). On almost every page of this book you will encounter proteins.