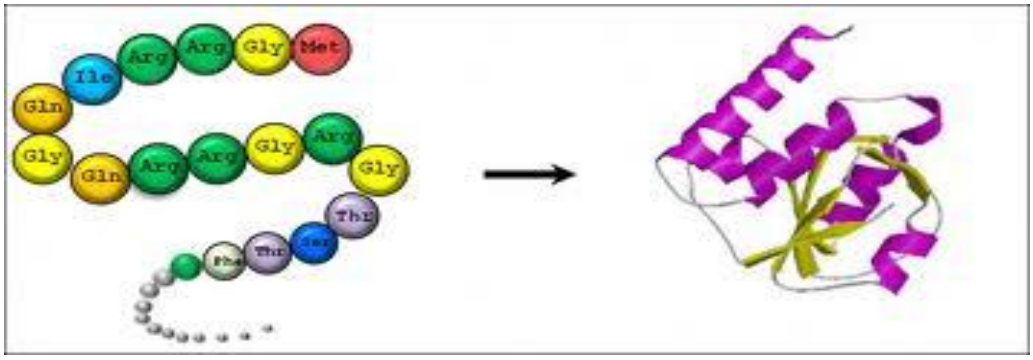
Cathkin High School
CfE Higher Chemistry

Nature's Chemistry
Proteins



No.	Learning Outcome	Understanding?
1	Proteins are the major structural materials of animal tissue.	☺ 😐 ☹
2	Proteins are involved in the maintenance and regulation of life processes.	☺ 😐 ☹
3	Enzymes are biological catalysts made from protein.	☺ 😐 ☹
4	Amino acids, the building blocks from which all proteins are formed, are relatively small molecules which all contain an amino group (NH_2) and a carboxyl group (COOH).	☺ 😐 ☹
5	The body cannot make all the amino acids required for body proteins are is dependent on dietary proteins for supply of certain amino acids known as essential amino acids.	☺ 😐 ☹
6	Proteins are made of many amino acid molecules linked together by condensation reactions.	☺ 😐 ☹
7	In these condensation reactions, the amino group on one amino acid and the carboxyl group of a neighbouring amino acid join together, with the elimination of water.	☺ 😐 ☹

8	The link which forms between two amino acids can be recognised as an amide link (CONH) also known as the peptide link.	☺ 😐 ☹
9	Proteins which fulfil different roles in the body are formed by linking differing sequences of amino acids together.	☺ 😐 ☹
10	During digestion, enzyme hydrolysis of dietary proteins can produces amino acids.	☺ 😐 ☹
11	The structural formulae of amino acids obtained from the hydrolysis of proteins can be identified from the structure of a section of the protein.	☺ 😐 ☹

Function of proteins

Proteins are large, important and complex molecules found in our bodies where they are involved in most reactions in cells. Each protein within the body has a specific function. The main functions of proteins in the body are structural, maintenance and regulation of life processes.

This is summarised in the table below.

Protein type	Nature of protein	Examples	Function
Structural protein	Fibrous	Keratin	Protection of hair
Structural protein	Fibrous	Collagen and elastin	Support for tendons and ligaments
Contractile protein	Fibrous	Actin and myosin	Movement of muscles
Protein hormones	Globular	Insulin	Glucose regulation
Enzymes	Globular	Amylase	Digestion of carbohydrates
Transport protein	Globular	Haemoglobin	Oxygen transport in the blood
Antibodies	Globular	Made naturally in the body or after vaccination	Fighting disease

Classifying Proteins

Proteins can be classified as fibrous or globular, this molecular shape is driven by hydrogen bonding within the protein molecule.

Proteins are made from amino acid molecules joined together with a structure known as the amide (or peptide) link. The amide links are regular distances apart along the chain and so there can be regular hydrogen bonding between amide links.

The way amino acids join to make long-chain proteins and amide links will be covered later.

Proteins which fulfil different roles in the body are formed by linking differing sequences of amino acids together.

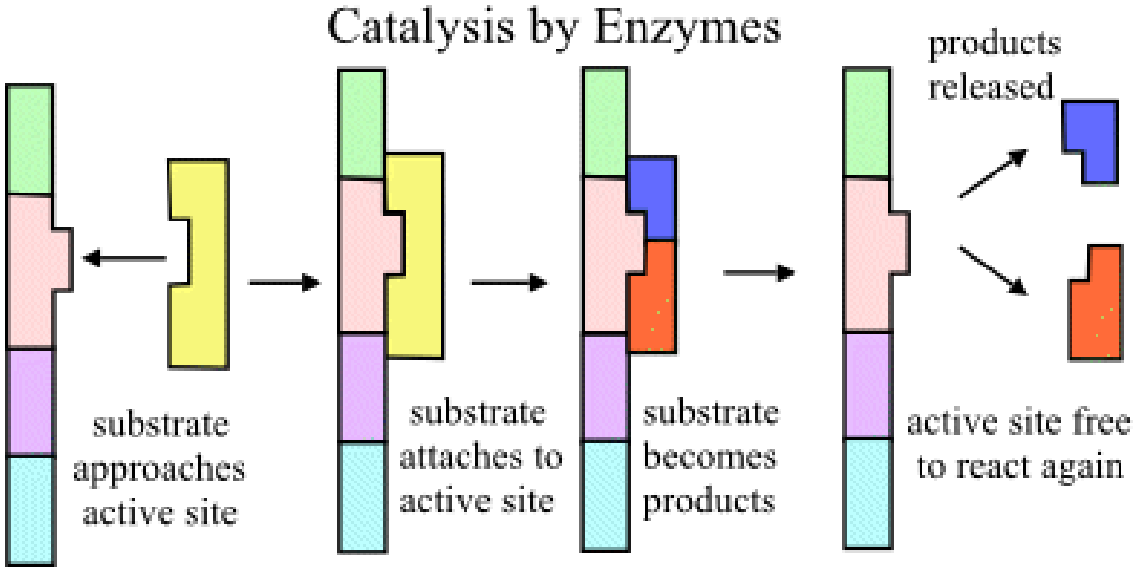
In *fibrous protein* the chains can form sheets and coils easily giving three-dimensional shape to the protein (spiral). However the polar groups are inside the structure and because the protein does not easily hydrogen bond with water it is not soluble in water. Fibrous proteins form the major structural material in animals as they are strong and generally insoluble in water, e.g. hair, skin, tendons, muscle

With *globular proteins* enough of the polar amide links are found on the outside of the structure and his allows hydrogen bonding with water. Globular proteins are generally soluble in water and involved in maintaining and regulating processes of life, e.g. haemoglobin, enzymes and hormones like insulin.

Proteins which are enzymes

An enzyme is a protein which is able to catalyse a biochemical reaction e.g. amylase, present in saliva, catalyses the hydrolysis of starch into the disaccharide maltose.

Certain sequences of amino acids form a region known as the active site. The shape of the active site allows specific reactants known as substrates to attach, like a lock and key. Incorrect substrates are unable to fit the shape of the active site and are not changed.

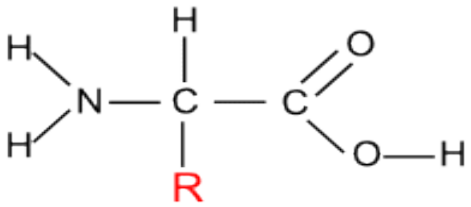


Enzyme function is therefore related to the molecular shapes of proteins.

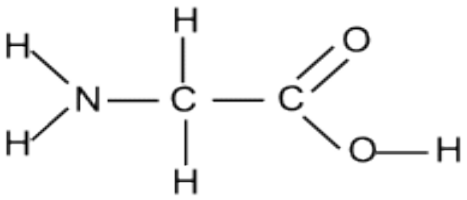
Amino acids

Proteins are constructed from building blocks called amino acids. *Amino acid* molecules have two functional groups, the carboxyl group (-COOH) and the amino group ($-NH_2$) as shown below.

Amino Acid Structure



R represents H, CH_3 etc



Aminoethanoic acid
(Glycine)

There are about 20 different amino acids in nature and these differ in the atoms which make the R group. **The body cannot make all the amino acids required for body proteins and is dependent on dietary protein for supply of certain amino acids known as *essential amino acids*.** Only eight amino acids are regarded as being essential for humans although a further two are required in childhood.

Some amino acids have more than one amino group or more than one carboxyl group and these allow chains to form branches.

With twenty different amino acids joining in large numbers, it is possible to produce a wide variety of protein molecules such as those found in skin, muscle, hair, fingernails and in enzymes. **These proteins are specific to the body's needs and are built up within the body by many condensation reactions.** The sequences of amino acids are controlled from information in the nucleus of the cell.

Nitrogen is essential for amino acid and protein formation by plants and animals.

Fertilisers and organic waste from living things contain soluble nitrogen compounds such as nitrates or ammonium compounds. Nitrifying bacteria living in root nodules on pea and bean plants convert nitrogen into soluble nitrogen compounds available to the plant.

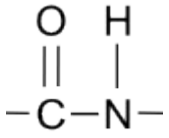
Lightning also adds to the useful nitrogen compounds available to plants.

Plants change these nitrogen compounds into proteins which then become available to animals. Animals can reconstruct digested protein to specific proteins for the body.

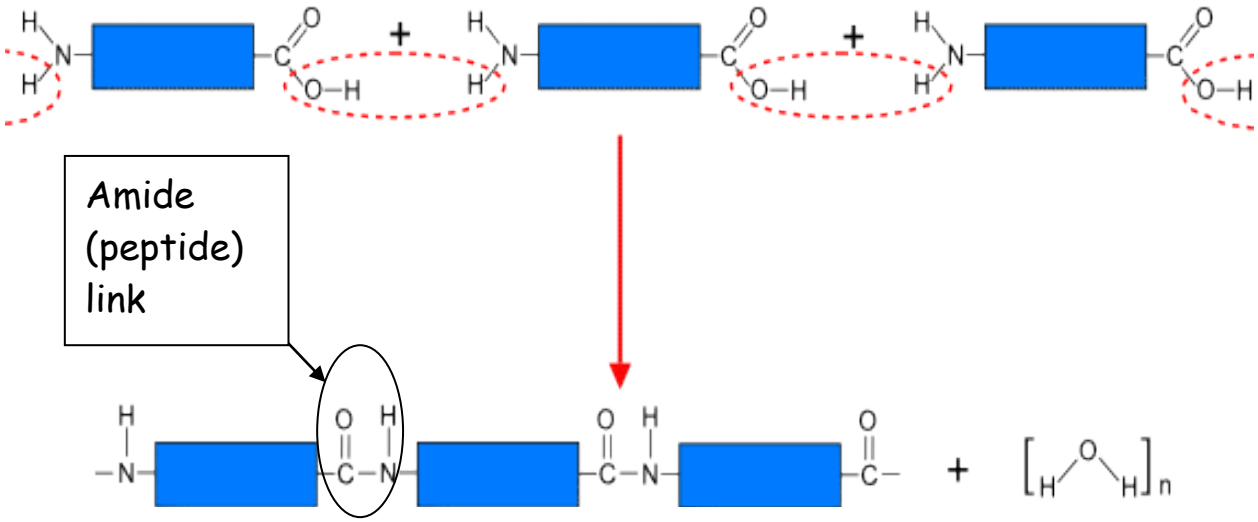
Amide links

Proteins are condensation polymers made up of many amino acid molecules linked together. In these *condensation reactions*, the amino group on one amino acid and the carboxyl group on a neighbouring amino acid molecules join together, with the elimination of water. In this reaction an amine group on one amino acid joins with a carboxyl group on another amino acid and this results in a water molecule being eliminated.

The link which forms between the two amino acids is called an *amide link* (CONH) (also known as a *peptide link*).



The amino acids condense together as shown. The sections shown by the rectangles represent part of the amino acid not involved in forming the amide link. You can get an idea of what this represents by comparing with the structure of an amino acid shown earlier.

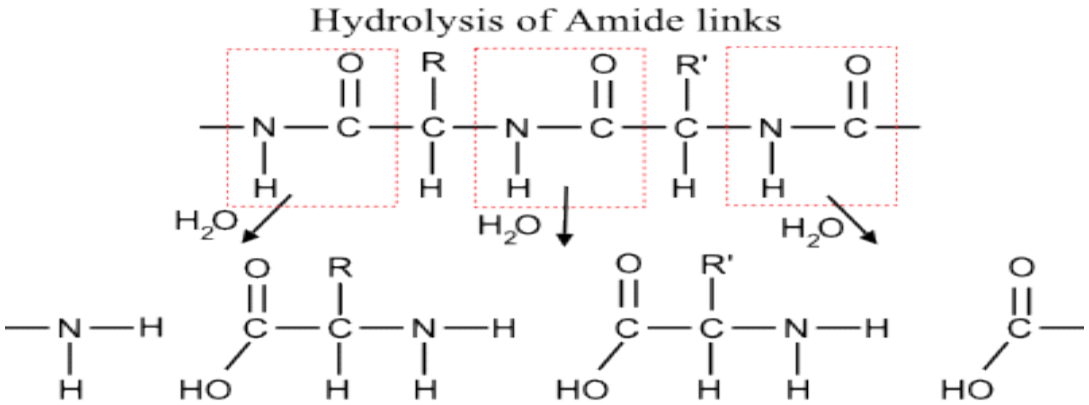


The structure of a section of protein is based on the constituent amino acids.

Digestion of proteins

Proteins obtained by eating plants or animals are broken up during digestion by a process called *hydrolysis* to produce amino acids. A water molecule, H-OH causes the splitting so that the H atom attaches to the N atom to restore the amino group and the OH group attaches to the C atom to restore the carboxyl group on the neighbouring amino acid.

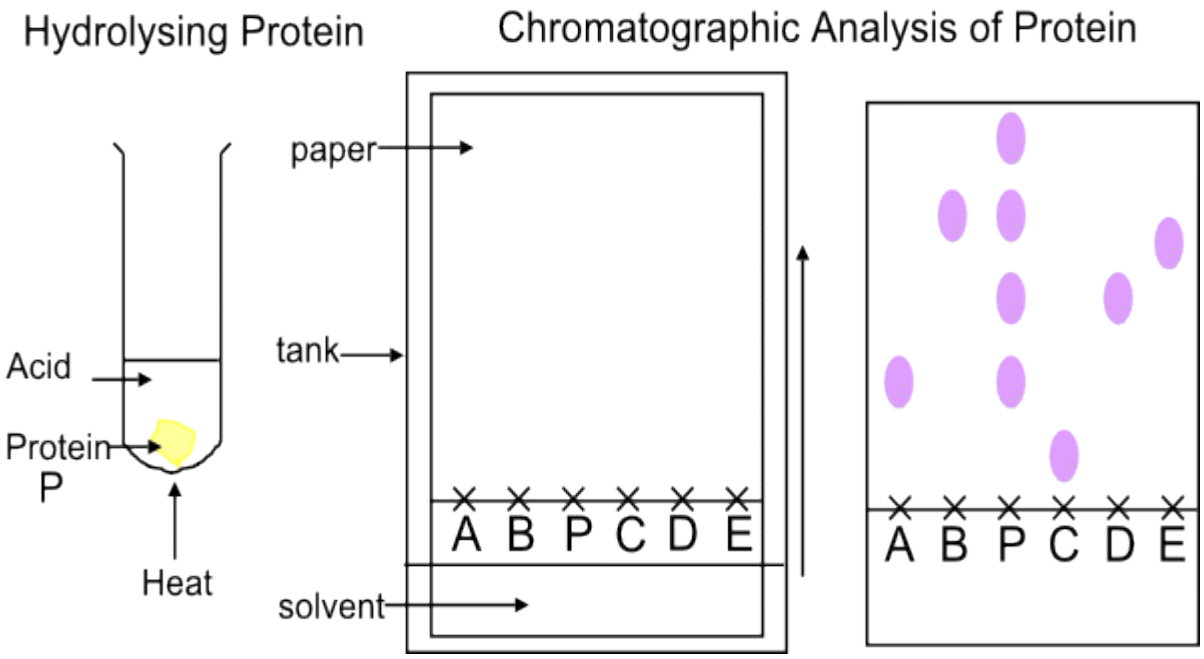
You can work out the structural formulae of the amino acids obtained from hydrolysis by looking at the structure of a section of the protein.



In the laboratory the amino acids present in a protein can be identified by first hydrolysing the protein using acid or alkali and then using chromatography.

By also applying known amino acids to the chromatogram alongside the hydrolysed protein allows identification of the amino acids in the protein.

Evidence of hydrolysis is shown by the solid protein changing into a solution.



A, B, C, D and E represent pure samples of five different and known amino acids. P represents the hydrolysed protein.

When the paper is removed from the tank, dried and stained, it can be seen that the protein contains four amino acids because 4 spots are present.
Three of these are A, B and D but C and E are not present. The hydrolysed protein also contains another unknown amino acid. This can be identified by running another chromatogram with different known samples of pure amino acids.

Techniques of this type allowed identification of the 51 amino acid molecules present in insulin and the sequence of them to be established. Insulin is a small protein with a molecular mass of over 5000.

Proteins - Glossary

Word	Meaning
Protein	Naturally occurring compounds containing the elements carbon, hydrogen, oxygen and nitrogen.
Amino acid	The constituent molecules which join together to form proteins.
Fibrous Protein	Where the sequences of amino acids are arranged to form long structures held together by internal hydrogen bonds.
Globular Protein	Where the chains of amino acids form folded coils with a significant number of the polar group (thus the hydrogen bonds) on the outside of the structure.
Enzyme	A biological catalyst which speeds up natural processes.
Active Site	The region on a protein chain that is able to catalyse a reaction by bonding with a specific substrate.
Essential Amino Acids	Amino acids which are vital to the body but that can only be obtained from the diet.
Condensation Reaction	Amino acid molecules join together to from protein chains by eliminating molecules of water.
Amide Link	A group of atoms, - CONH-, which joins amino acids in a protein. Sometimes called a peptide link.
Hydrolysis Reaction	A reaction where a bond is broken in a molecule using water. Here, protein chains are broken down into the component amino acid molecule by adding water across the amide link.