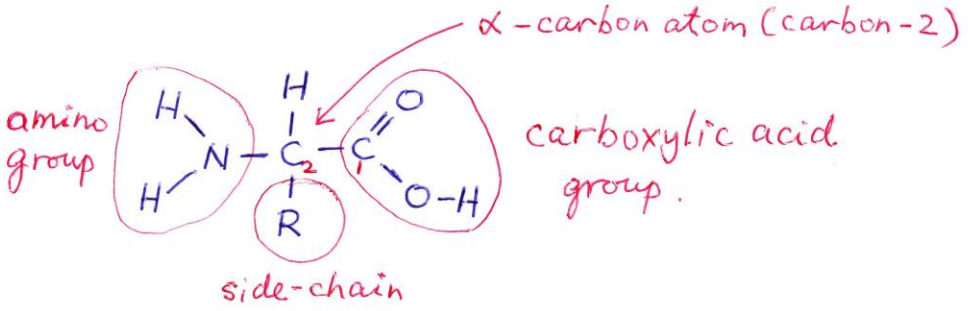
Protein (A2)

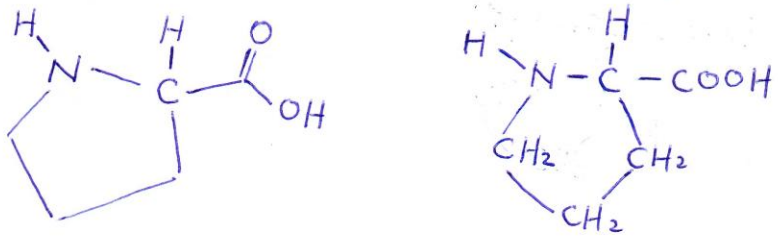
Amino acids

Amino acids are building blocks of proteins. Protein chains are synthesised from twenty different amino acids.

Nineteen of the molecules contain two functional groups: a carboxylic acid group ($-COOH$) and a primary amino group ($-NH_2$).



The amino acid proline is the exception. It is a cyclic compound and contains a secondary amino group. Proline is a secondary amino acid.



All twenty molecules have one common feature: the two functional groups are both attached to the same carbon atom.

When naming organic compound systematically, the carbon atom of an acid group is always counted as the first in the structure.

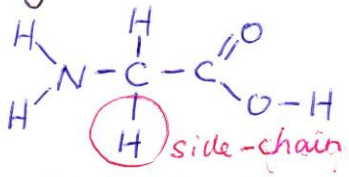
So the amino group is always attached to the second carbon atom (C-2), the one immediately adjacent to the carboxyl group.

These important molecules are all 2-amino acids (α-amino acids)

The 20 different amino acids that cells use to build proteins differ in the nature of the R-group.

These side-chains vary considerably in their complexity.

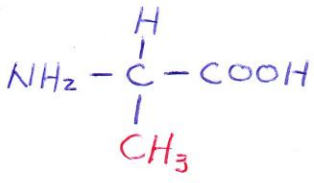
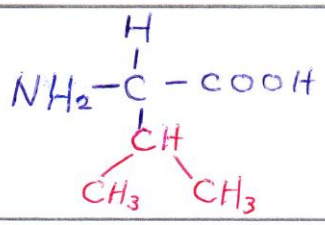
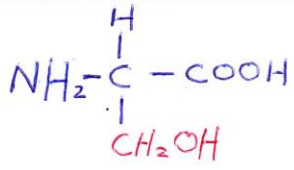
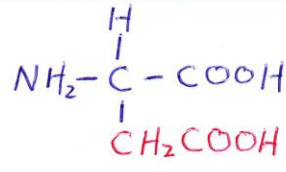
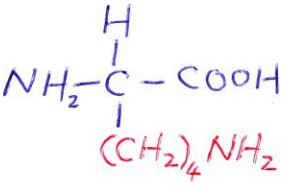
Eg.



2-aminoethanoic acid (Glycine - GLY)

Classification of amino acids

The 20 different amino acids can be categorized into seperate sub-groups according to the nature of the R-group. The side-chains can be classified as: 1.) non-polar
2) polar
3) electrically charged (acidic or basic)

R-group nature	Example	Structure
non-polar	alanin (ala)	
	valine (val)	
polar	serine (ser)	
electrically charged (acidic or basic)	aspartic acid (asp)	
	lysine (lys)	

The nature of the R-groups is of crucial importance. Once the amino acids have condensed together to form a polypeptide chain, the R-group is the remaining feature of a particular amino acid which is still distinctive.

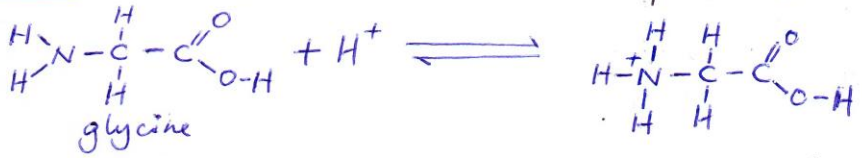
Interactions between the different R-groups influence the folding of the polypeptide chain and the shape of the final protein.

The ionisation of amino acids

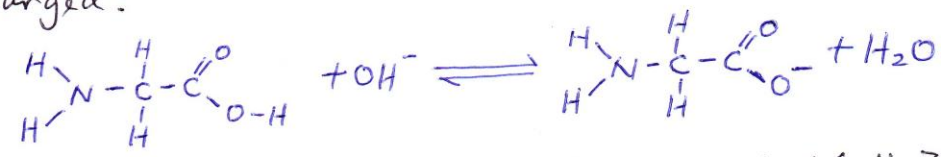
Each amino acid molecule contains an acidic group ($-COOH$) and a basic group ($-NH_2$)

These molecules show both the properties of an acid and those of a base. Amino acids are amphoteric.

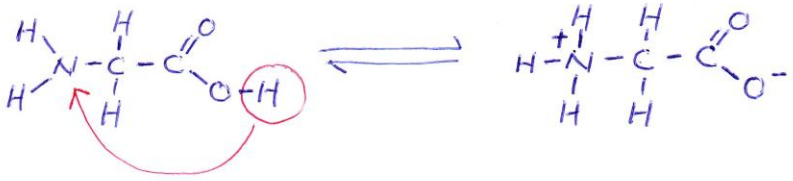
In acidic conditions, amino acids become positively charged:



In alkaline conditions, amino acids become negatively charged:



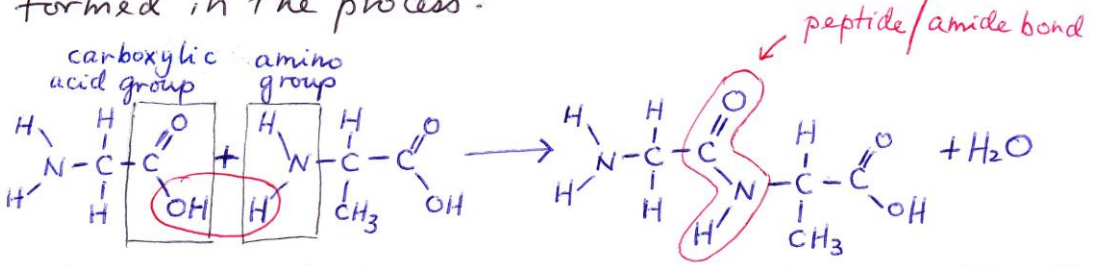
At physiological pH, which is just near neutral (pH=7), amino acids exist as zwitterions / dipolar ions



Condensation polymerisation of amino acids

The $-NH_2$ group of one amino acid can react with the $-COOH$ of another amino acid to form a dipeptide.

This is a condensation reaction because water is formed in the process.



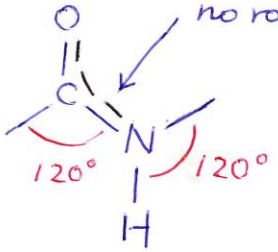
glycine alanine glycylalanine (a dipeptide) Gly-Ala

Additional amino acids can then react to form a tripeptide, a tetrapeptide and so on.

Eventually a polypeptide, containing many peptide bonds is formed.

The peptide bond consists of the group $-CONH-$ in which the four atoms lie in one plane, with all bond angles being about 120°.

There is no rotation around the C–N bond in a peptide group.

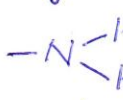


The structure of a peptide bond.

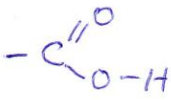
Exercise 1

Name and give the formulae of the two functional groups present in all amino acids.

Workings:



amine / amino group



carboxylic acid group.

Exercise 2

Which of the 20 amino acids found in proteins is a secondary amino acid and what is distinctive about its structure?

Workings

Proline.

It is a secondary amino acid / imino acid.

Because it has an $-NH-$ group rather than an $-NH_2$ group.

Exercise 3

Name an example of the following types of amino acid:

i) an amino acid with a non-polar side-chain.

ii) an amino acid with a $-COOH$ group on its side-chain.

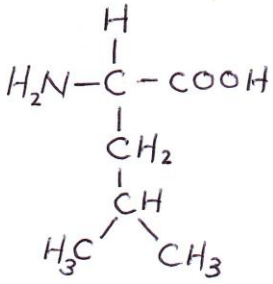
Workings

i) non-polar side-chain: alanine (or valine, leucine, isoleucine, phenylalanine. Glycine – simplest amino acid has a non-polar side-chain)

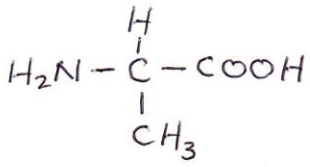
ii) $-COOH$ group: aspartic acid (or glutamic acid).

Exercise 4

Draw the formula for the dipeptide leucylalanine (Leu-Ala) using these formulae:

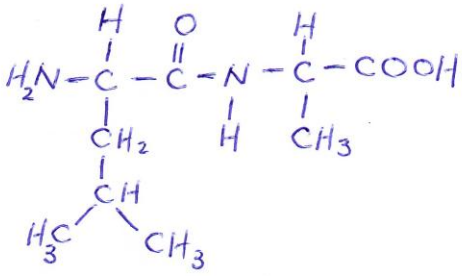


leucine



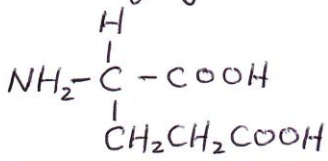
alanine

Workings.



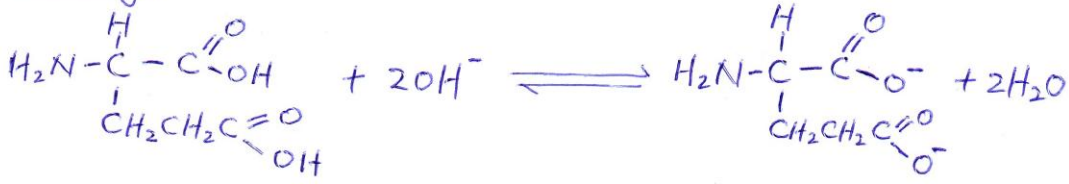
Exercise 5

The formula of glutamic acid is:



Draw the structural formula of the ion formed when glutamic acid is dissolved in alkali.

Workings



Polypeptide

A polypeptide chain may contain 50 to 2000 amino acids.

An amino acid unit within a polypeptide chain is called an amino acid residue.

When drawing the amino acid sequence in a polypeptide, the N-terminal end (free $-NH_2$ group) places on the left end.

$NH_2-\square-CONH-\ldots-\square-CONH-\square-COOH$

Proteins may contain one or more polypeptide chains.

Important facts about proteins

- proteins are formed by condensation polymerisation.
- the polypeptide chain in proteins is unbranched.
- each protein has a unique sequence of amino acids
- the sequence of amino acids is determined by DNA.
- each protein has a particular biological function. (the particular three-dimensional shape which the sequence generates).

Some proteins and their functions

Protein	Function	Location
myosin	muscle contraction	muscle tissue
actin		
chymotrypsin	digestive enzyme	small intestine
pepsin		stomach
insulin	hormone	blood
immunoglobulins	antibody	blood plasma
haemoglobin	oxygen transport	red blood cells
ferritin	iron storage	bone marrow, liver, spleen.
collagen	structural protein	skin, tendon
keratin		hair