MEDICAL CHEMISTRY
GENERAL CHEMISTRY

University Of Fallujah
College Of Medicine

Lecture : Medical Chemistry (1) (Proteins & Amino Acids)

Stage : 1st Stage

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Department: Chemistry and Biochemistry department

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Learning Objective :

- Describe the Basic Structure of Amino Acids and Polypeptides.
- Classify Amino Acids Based on Their Side Chains (R-Groups).
- Relate Amino Acid Properties to Protein Structure and Function.
- Define and classify Peptides.
- Describe Peptide Bond formation and structure .

Outline

- Structure of amino acids:
- Classification of amino acids:

I- According to net charge on amino acid.

II- Classification according to polarity of side chain (R)

III- Nutritional classification

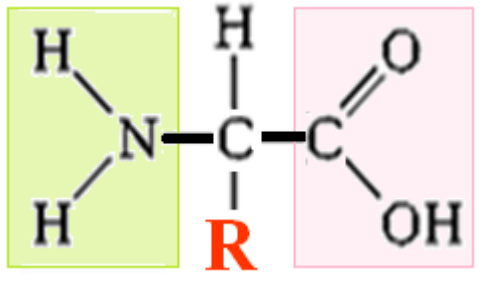
IV- Metabolic classification:

Amino Acids

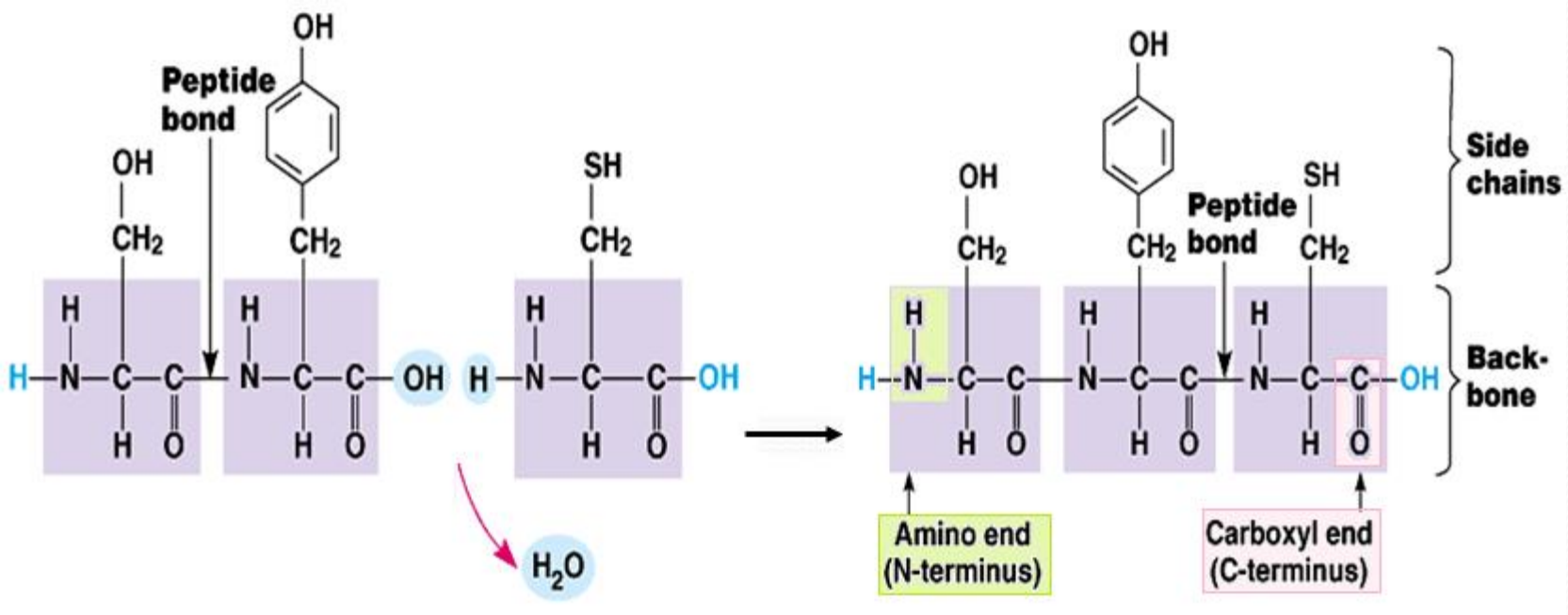
- **Amino Acids are the building units of proteins.**
- **Proteins are polymers of amino acids linked together by what is called " *Peptide bond* " (see latter).**

STRUCTURE OF AMINO ACIDS:

- **Each amino acid has 4 different groups attached to α- carbon (which is C-atom next to COOH).**
- **These 4 groups are :**
  - **Amino group (-NH2),**
  - **Carboxylic group (-COOH).**
  - **Hydrogen atom and side Chain (R)**



Peptide bond formation:



- Each polypeptide chain starts on the left side by free amino group of the first amino acid enter in chain formation . It is termed (N- terminus).
- Each polypeptide chain ends on the right side by free carboxylic group of the last amino acid and termed (C-terminus).

Amino Acids

- **At physiological PH (7.4), -COOH gp is dissociated forming a negatively charged carboxylate ion (COO^-) and amino gp is protonated forming positively charged ion (NH_3^+) forming Zwitter ion**

CLASSIFICATION OF AMINO ACIDS

Chemical classification: According to number of COOH and NH_2 groups i.e. according to net charge on amino acid.

Monobasic, monocarboxylic amino acids i.e. neutral or uncharged:

Subclassification of amino acids:

I- According to net charge on amino acid.

A- NEUTRAL AMINO ACIDS:

All structures are required

1- Glycine R= H

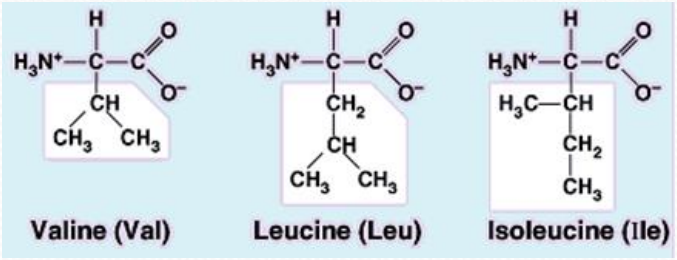
2- Alanine R= CH_3

3- Branched chain amino acids: R is branched such as in:

a - **Valine** R= isopropyl gp

b- **Leucine** R= isobutyl gp

c- **Isoleucine** R = is isobutyl



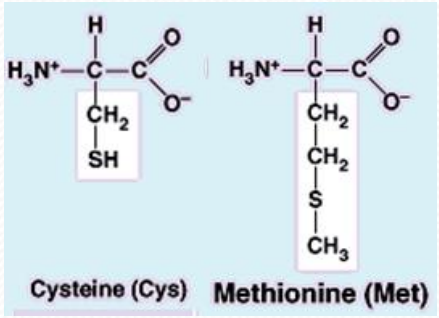
R is isobutyl in both leucine and isoleucine but branching is different:

in leucine → branching occurs on γ carbon

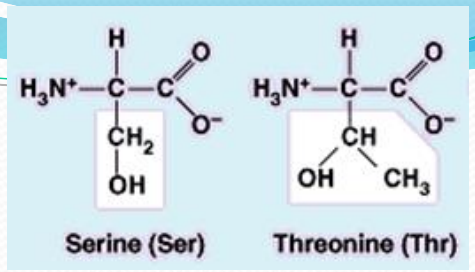
in isoleucine→ branching occurs on β- carbon

4- Neutral Sulfur containing amino acids:

e.g. Cysteine and Methionine .



5- Neutral, hydroxy amino acids:
e.g. Serine and Threonine.



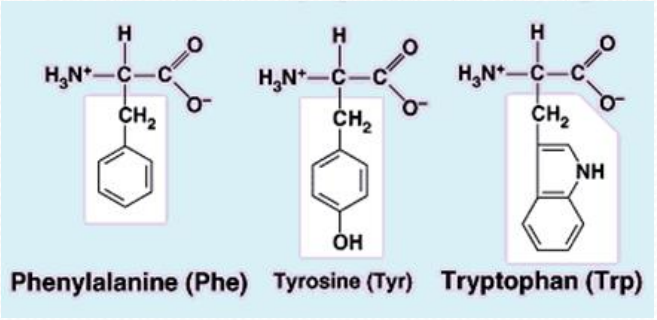
6- Neutral aromatic amino acids:

a- Phenyl alanine : It's alanine in which one hydrogen of CH_3 is substituted with phenyl group. So it's called phenyl alanine

b- Tyrosine: - it is P- hydroxy phenyl alanine

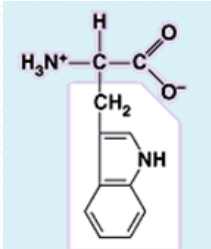
- it is classified as **phenolic amino acid**

c- Tryptophan: as it contains indole ring so it is classified as **heterocyclic amino acid**



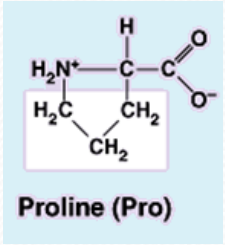
7- Neutral heterocyclic amino acids:

a- Tryptophan: contains indole ring



Tryptophan (Trp)

b- Proline: In proline, amino group enters in the ring formation being α-imino gp so proline is an α-imino acid rather than α-amino acid



Proline (Pro)

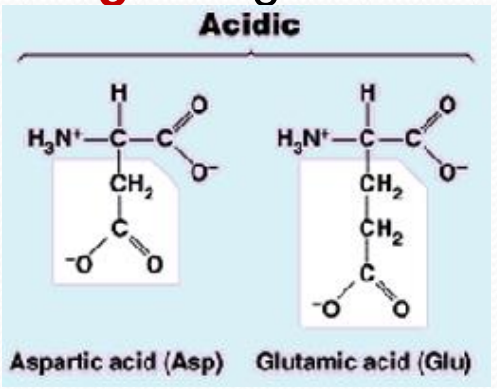
B- BASIC AMINO ACIDS: Contain two or more NH_2 groups or nitrogen atoms that act as base i.e. can bind proton.

At physiological pH, basic amino acids will be **positively charged**.e.g.

a- Lysine

b- Arginine: contains guanido group

c- Histidine: is an example on basic heterocyclic amino acids

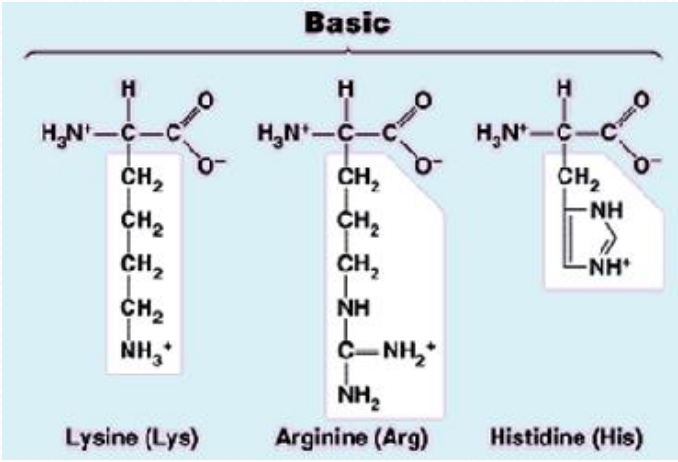


C- ACIDIC AMINO ACIDS: at physiological pH will carry negative charge.

e.g. Aspartic acid (aspartate) and Glutamic acid (glutamate). see structures in hand out.

Aspargine and Glutamine:

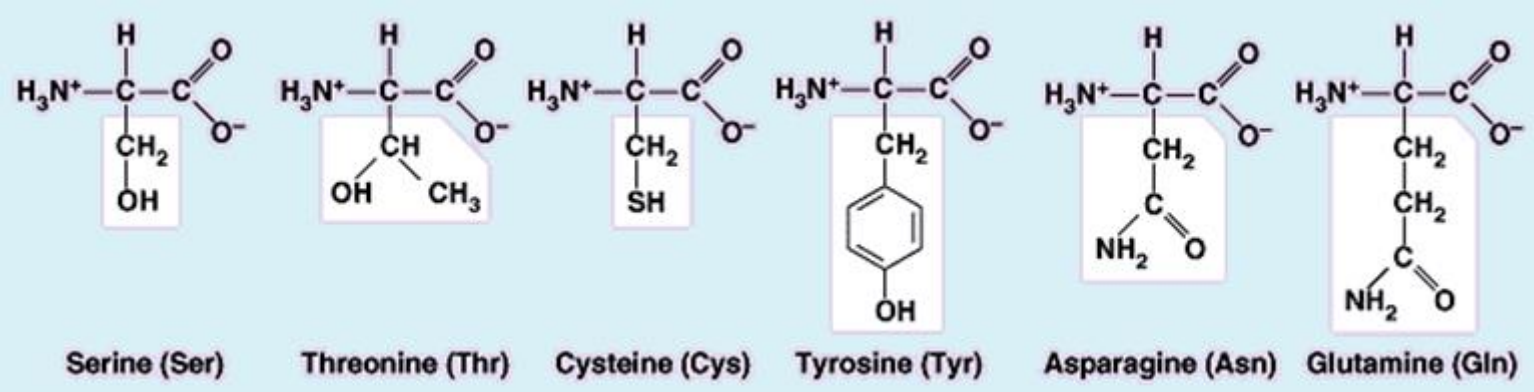
They are amide forms of aspartate and glutamate in which side chain COOH groups are amidated. They are classified as neutral amino acids.



II- Classification according to polarity of side chain (R):

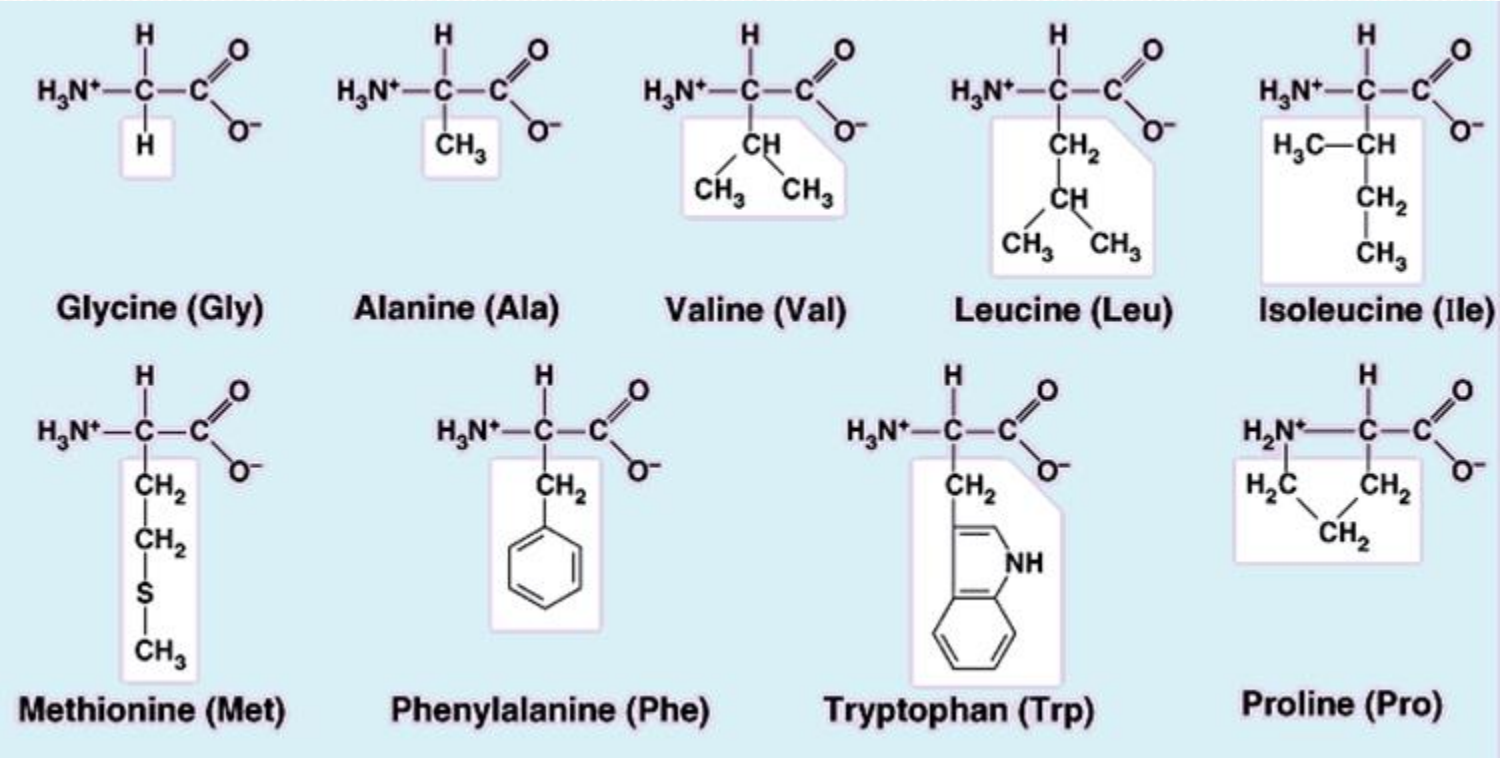
A- Polar amino acids: in which R contains polar hydrophilic group so can forms hydrogen bond with H_2O. In those amino acids, R may contain:

1- OH group : as in serine, threonine and tyrosine
2- SH group : as in cysteine
3- amide group: as in glutamine and aspargine
4- NH_2 group or nitrogen act as a base (basic amino acids): as lysine, arginine and histidine
5- COOH group (acidic amino acids): as aspartic and glutamic .



B- Non polar amino acids:

R is alkyl hydrophobic group which can't enter in hydrogen bonf formation. 9 amino acids are non polar (glycine, alanine, valine, leucine, isoleucine, phenyl alanine, tryptophan, proline and methionine)



III- Nutritional classification:

1- Essential amino acids: These amino acids can't be formed in the body and so, it is essential to be taken in diet. Their deficiency affects growth, health and protein synthesis.

Valine, Isoleucine, Lysine, Lucien, Methionine, Tryptophan, Threonine, Phenyl alanine

2- Semiessential amino acids: These are formed in the body but not in sufficient amount for body requirements especially in children.

Arginine, Histidine

3- Non essential amino acids: These are the rest of amino acids that are formed in the body in amount enough for adults and children. They are the remaining 10 amino acids.

IV- Metabolic classification:

according to metabolic or degradation products of amino acids they may be:

1- Ketogenic amino acids: which give ketone bodies .

Lysine and Leucine are the only pure ketogenic amino acids.

2- Mixed ketogenic and glucogenic amino acids: which give both ketone bodies and glucose.

Isoleucine, Phenyl alanine, Tyrosine , Tryptophan.

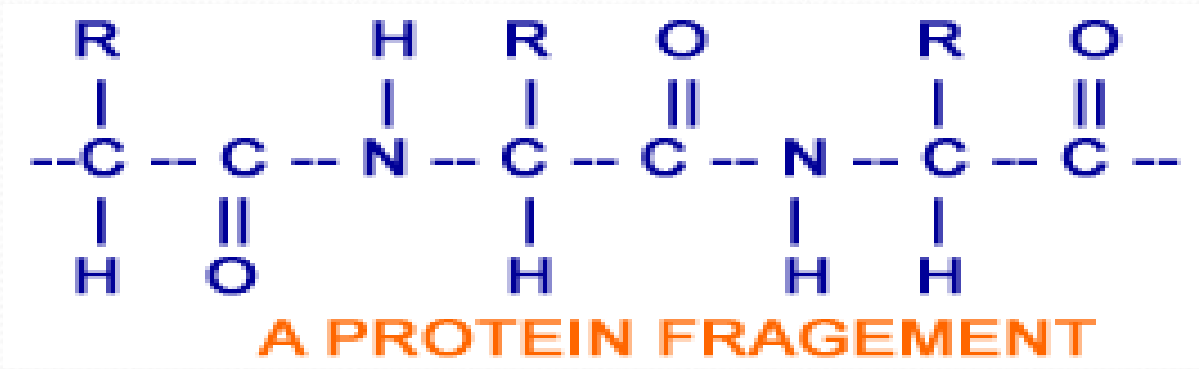
3- Glucogenic amino acids: Which give glucose. They include the rest of amino acids. These amino acids by catabolism yields products that enter in glycogen and glucose formation.

Composition of proteins

The proteins are polymers made of monomers called the **amino acids.**

There are 20 different kinds of amino acids that make up the proteins.

However, they are present in different proportions in each of the proteins.



PEPTIDES are short chains of between two and fifty amino acids (a.as), linked by peptide bonds. Chains of less than ten or fifteen amino acids are called oligopeptides, and include dipeptides (Two a.a), tripeptides (Three a.as), and tetrapeptides.

A POLYPEPTIDE is a longer, continuous, and unbranched peptide chain of up to fifty amino acids.

-Peptides (from the Greek word means "digested") are short polymers of amino acid (monomers) linked by peptide bonds, the covalent chemical bonds formed between two molecules when the carboxyl group of one molecule reacts with the amino group of the other molecule.

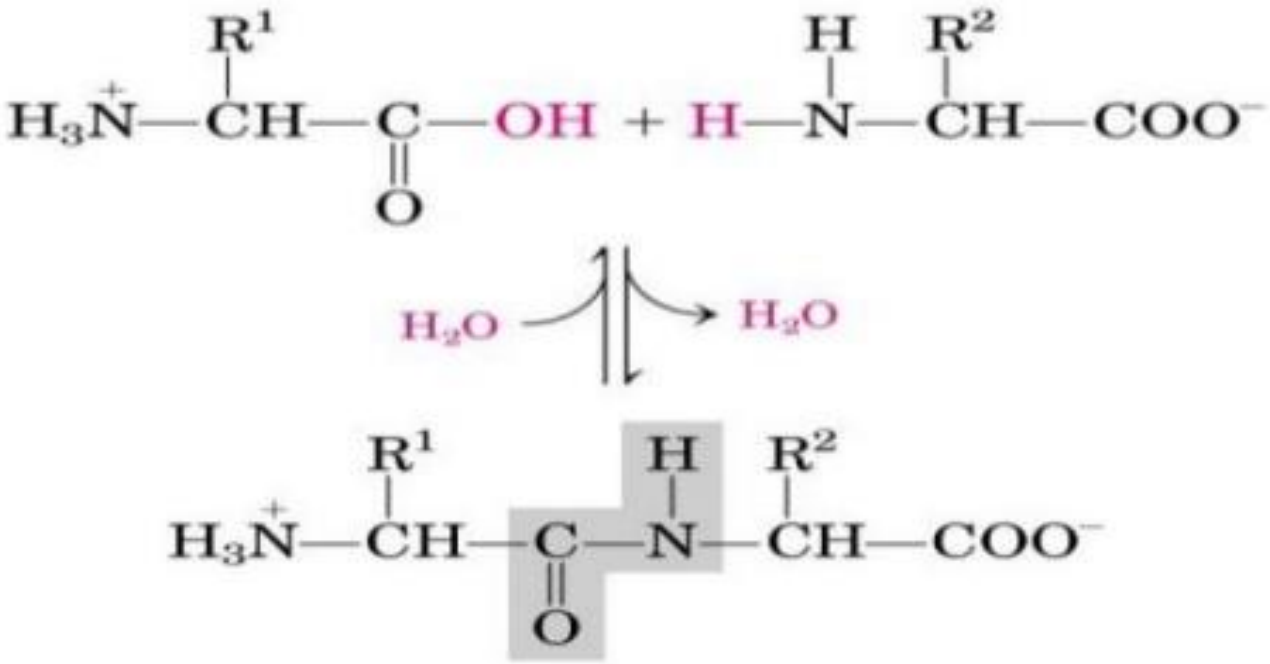
-Peptides are distinguished from proteins on the basis of size, typically containing fewer than 50 monomer (AA) units.

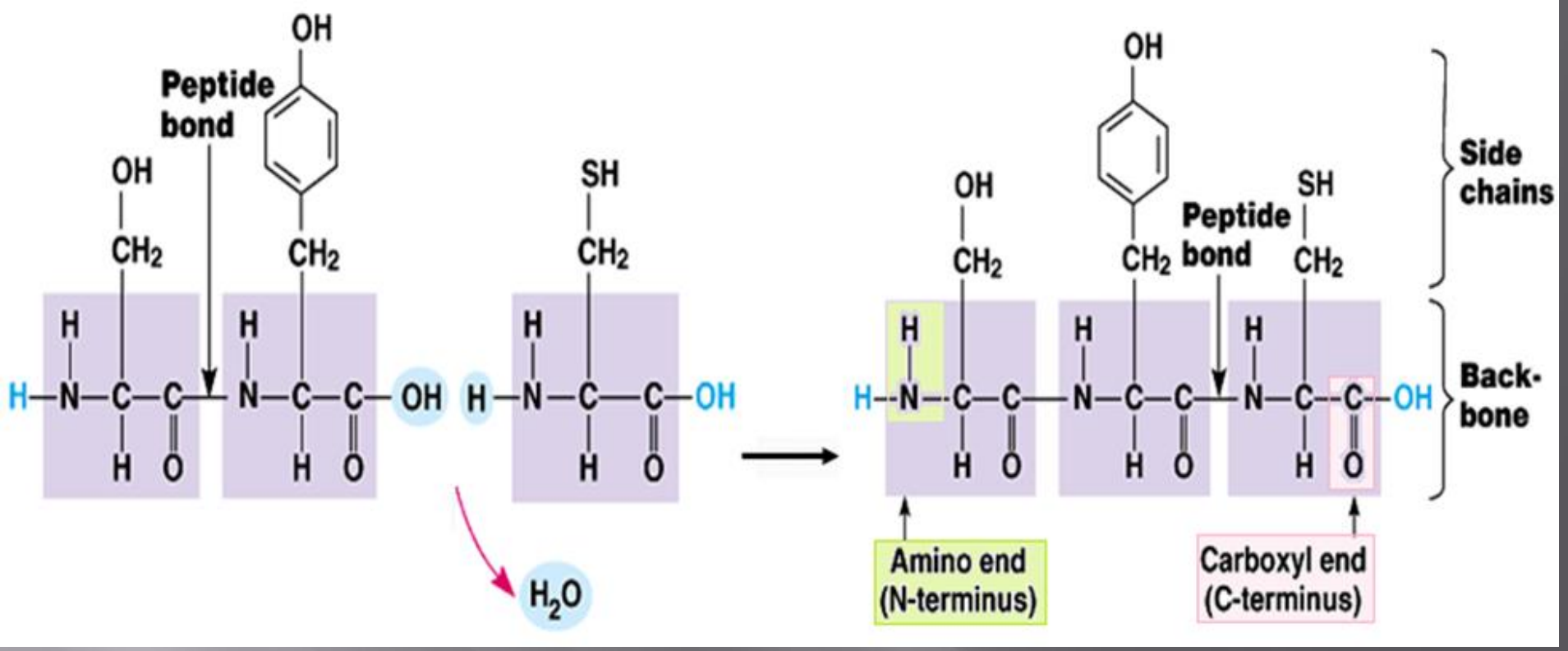
-The shortest peptides are dipeptides, consisting of two amino acids joined by a single peptide bond. There are also tripeptides, tetrpeptides, etc.

-Amino acids which have been incorporated into a peptide are termed "residues"; every peptide has a N-terminus and C-terminus residue on the ends of the peptide.

Peptide bonds

-Peptide bonds are formed by a condensation reaction of carboxylic group of an amino acid and amino group of another amino acid with removal of water molecule.





- Each polypeptide chain starts on the left side by free amino group of the first amino acid enter in chain formation . It is termed (N- terminus).
- Each polypeptide chain ends on the right side by free carboxylic group of the last amino acid and termed (C-terminus).

At physiological PH (7.4), -COOH group is dissociated forming a negatively charged carboxylate ion (COO-) and amino group is protonated forming positively charged ion (NH3+) forming Zwitter ion.

A polypeptide is a longer, continuous, and unbranched peptide chain of up to fifty amino acids. Polypeptides help make up proteins by bonding numerous amino acids together.

Proteins are created by the bonding of two or more polypeptides, which are then folded into a specific shape for a particular protein.

Proteins. often bound to ligands such as coenzymes and cofactors, or to another protein or other macromolecule such as DNA or RNA, or to complex macromolecular assemblies.