Tishk International University
Faculty of Applied Science
Department of Nutrition & Dietetics

NUT 207 Nutritional Biochemistry

Proteins

(Part I)

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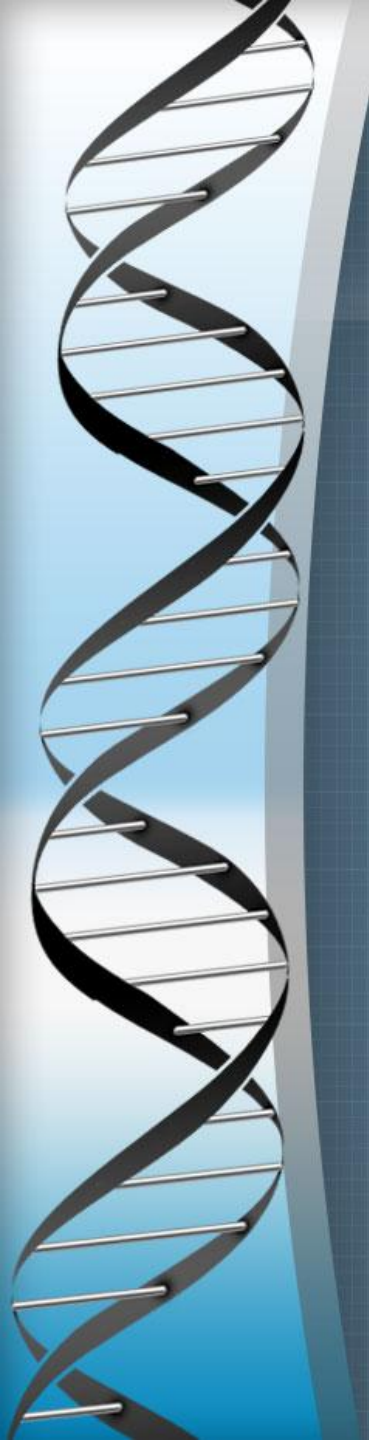
Outlines

- Introduction
- Classification
- Protein biosynthesis
- Amino acids
- Classification of amino acids
- Denaturation of proteins

PROTEINS

- *Are macromolecules with a backbone formed by polymerization of amino acids in a polyamide structure.*
- The word protein is derived from Greek word, proteios meaning primary.
- So, proteins are the major components of any living organism.
- Proteins contain Carbon, Hydrogen and Oxygen, they also contain Nitrogen and sometimes Sulfur and Phosphorous.



- Proteins are organic substances of high molecular weight. Formed by a number of α-amino acids united by a peptide linkage.
- Proteins are the most important constituent of cell membranes and cytoplasm. Muscle and blood plasma also contain specific proteins.
- Proteins have vital roles in building up and maintenances of the structure of body, giving as much energy as carbohydrates.
- During digestion, proteins are hydrolyzed into amino acids, these amino acids enter the amino acids pool of the body.

Classification

Proteins may be classified on the basis of their composition, solubility, shape, biological function and on their three dimensional structure.

I. Composition

A. **Simple protein:** are those that are made of amino acid units only, joined by peptide bonds. Upon hydrolysis, they yield a mixture of amino acids.

B. **Conjugated proteins** are composed of **simple proteins** combined **with a** non-proteinous substance.

e.g: Nucleoprotein, Lipoprotein, Phosphoprotein, Metalloprotein, Glycoprotein.

II. Solubility

a) **Albumins:** These proteins such as egg albumin and serum albumin are readily soluble in water and coagulated by heat.

b) **Globulins:** These proteins are present in serum, muscle and other tissues and are soluble in dilute salt solution but sparingly soluble.

c) **Histones:** Are present in glandular tissues (thymus, pancreas etc.) soluble in water; they combine with nucleic acids in cells and on hydrolysis yield basic amino acids.

III. Shape

A. Fibrous Proteins

1. Collagens: The major protein of the connective tissue.
2. Elastins: present in tendons, arteries, and other elastic tissues, not convertible to gelatin.
3. Keratins: protein of hair, nails,etc.

Cont.

B. Globular proteins:

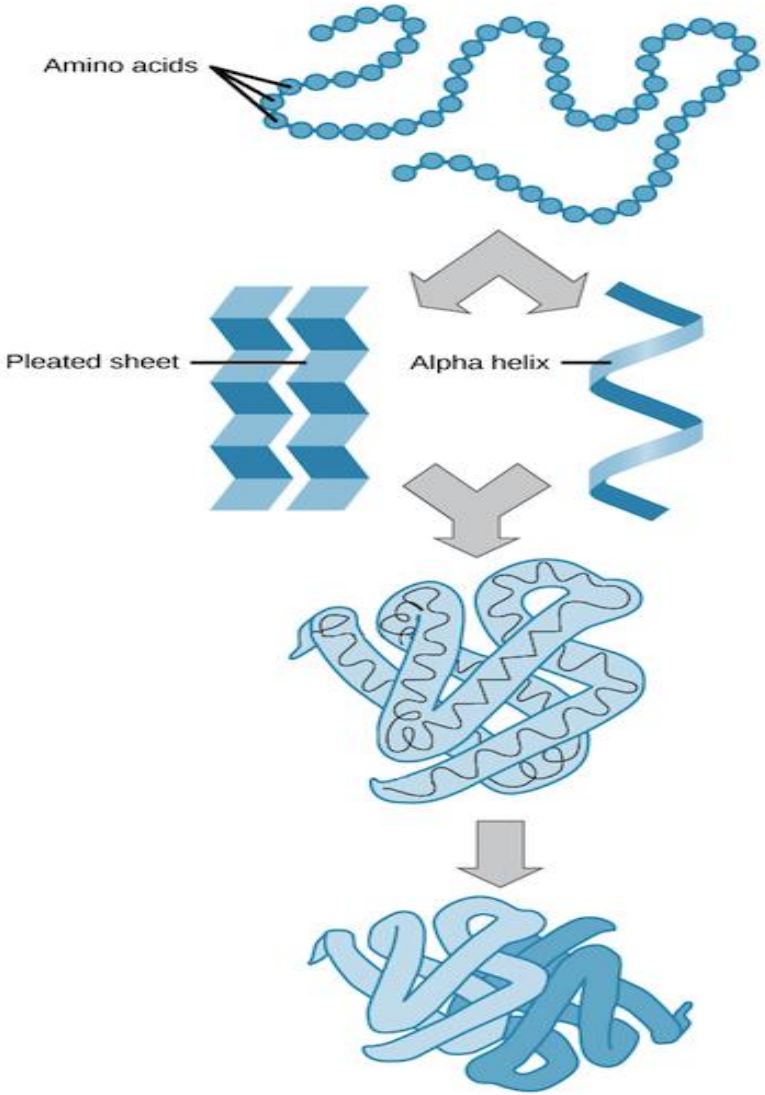
These are globular or void in shape, soluble in water and constitute the enzymes, oxygen carrying proteins, hormones etc.

Sub-classes include: Albumin, globulins and histones.

IV. Biological Functions

Enzymes	**kinases, transaminases..**
Storage proteins	**Myoglobin, ferritin**
Regulatory proteins	**Peptide hormones, DNA binding proteins**
Structural protein	**Collagen, proteoglycan**
Protective proteins	**Blood clotting factors, Immunoglobins**
Transport protein	**Hemoglobin, plasma lipoproteins**
Contractile or motile proteins	**Actin, tubulin**

V. On their level of organization



Primary protein structure
sequence of a chain of animo acids

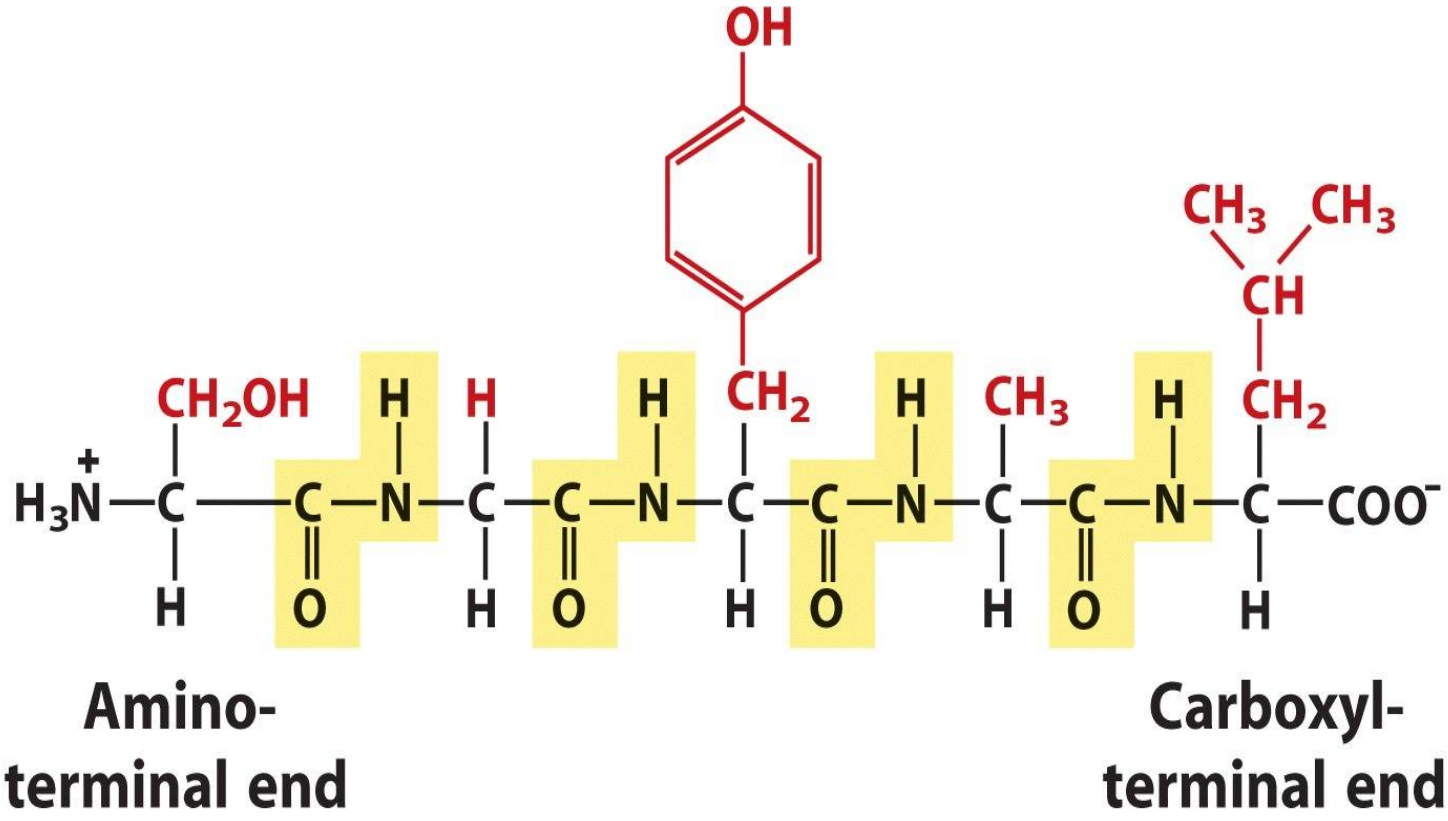
Secondary protein structure
hydrogen bonding of the peptide backbone causes the amino acids to fold into a repeating pattern

Tertiary protein structure
three-dimensional folding pattern of a protein due to side chain interactions

Quaternary protein structure
protein consisting of more than one amino acid chain

A. Primary structure of Proteins:

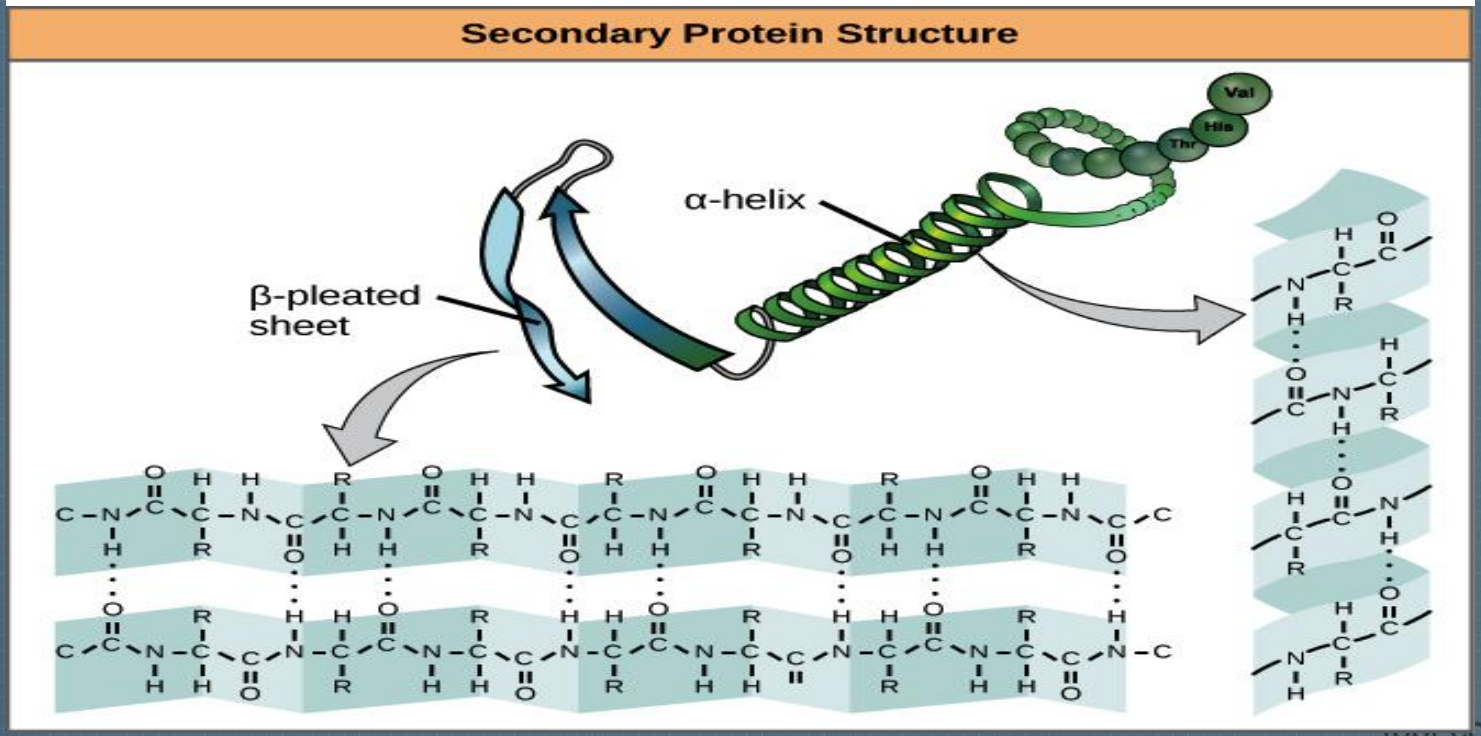
The primary structure of a protein is defined by the linear sequences of amino acid residues making up its polypeptide chain.



B. Secondary Structure:

The secondary structure of a protein refers to the local structure of a polypeptide chain, which is determined by Hydrogen bond.

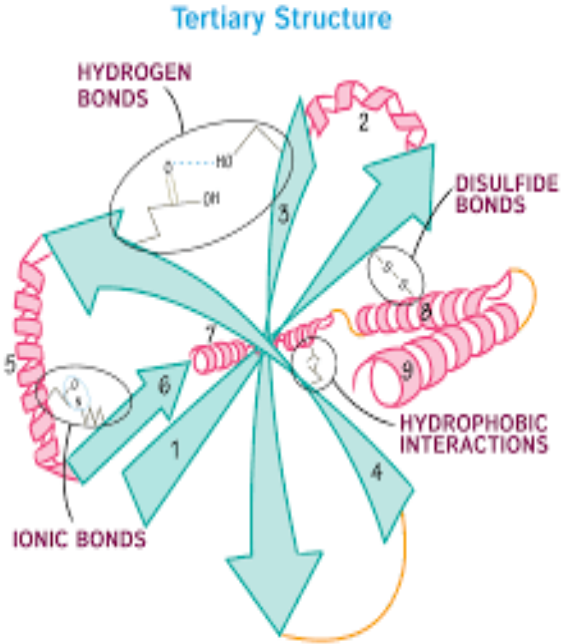
The interactions are between the carbonyl oxygen group of one peptide bond and the amide hydrogen of another by peptide bond.

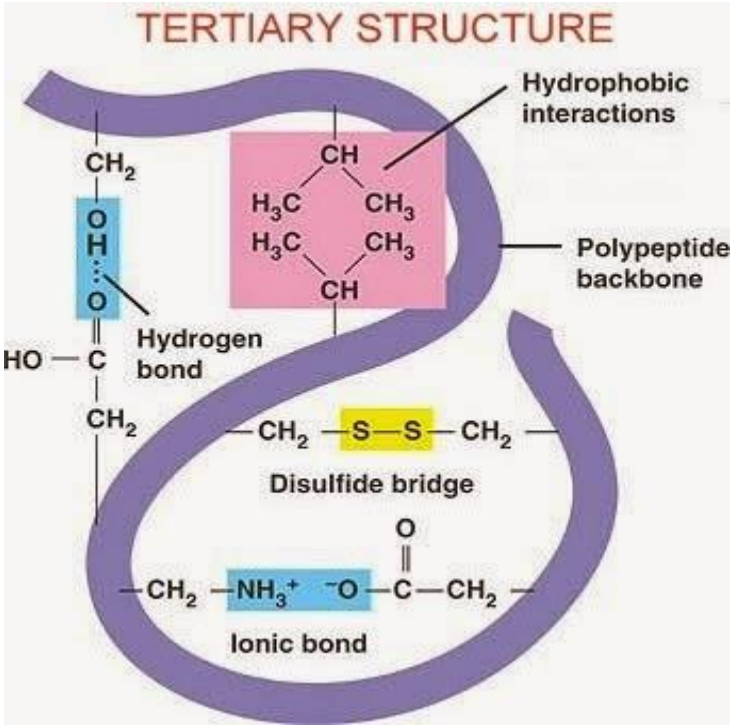


C. Tertiary Structure:

A protein's three-dimensional, folded, and biologically active conformation is referred to as tertiary structure.

The polypeptide chain with a secondary structure may be further folded (super-folded) or twisted about itself forming many sizes.

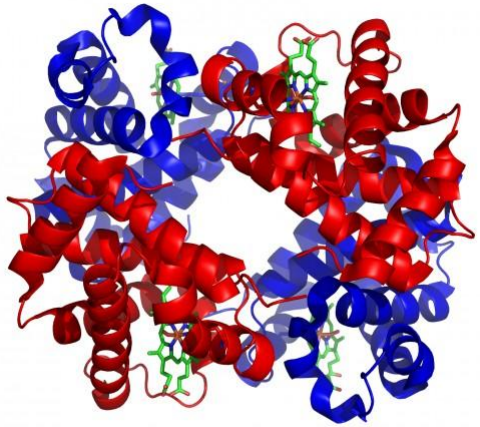




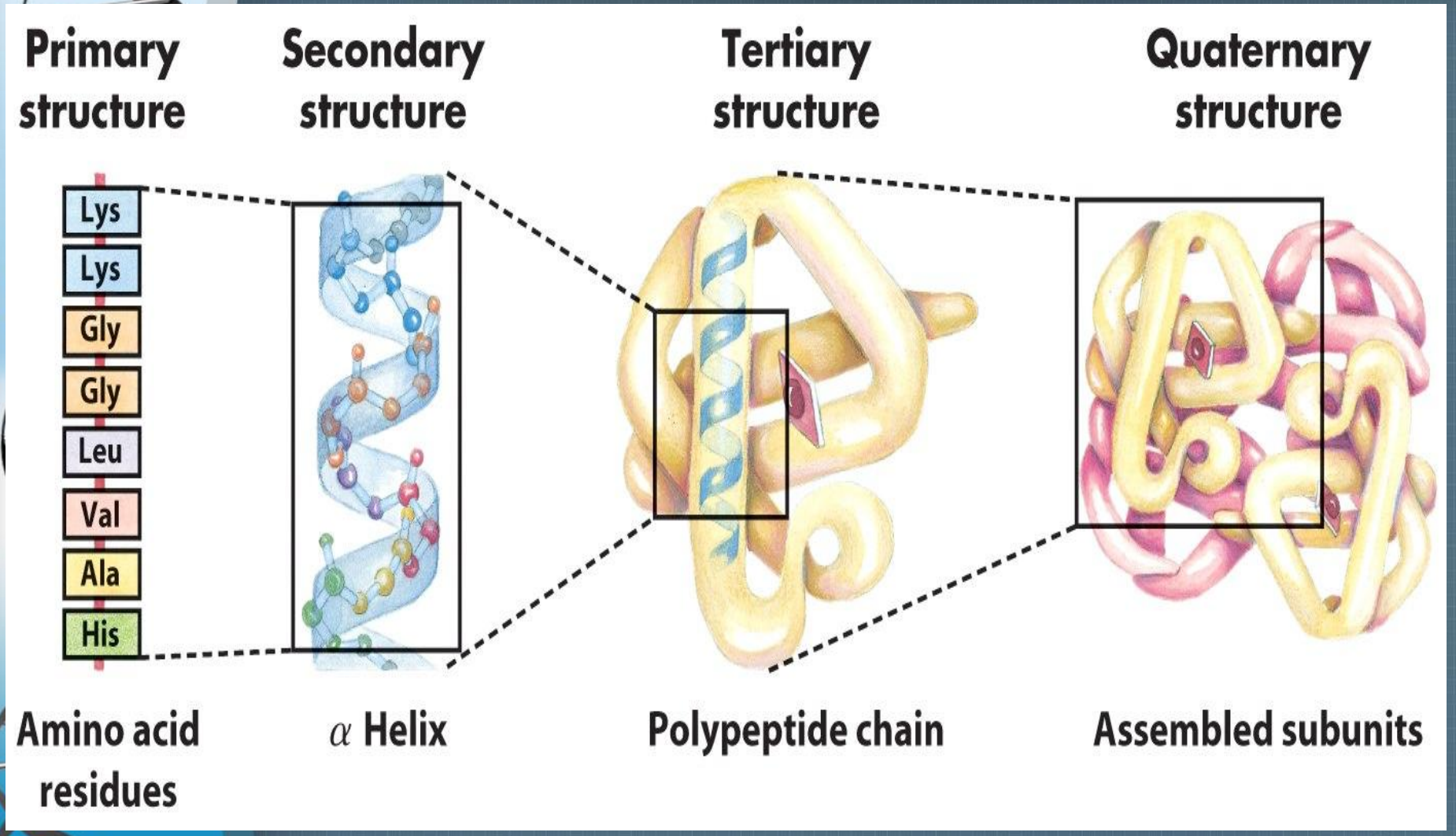
D. Quaternary Structure:

Refers to a complex or an assembly of two or more separate peptide chains held together by non-covalent or, in some cases, covalent interactions.

If the subunits are identical, it is a homogenous quaternary str., but if there are dissimilarities, it is heterogeneous.

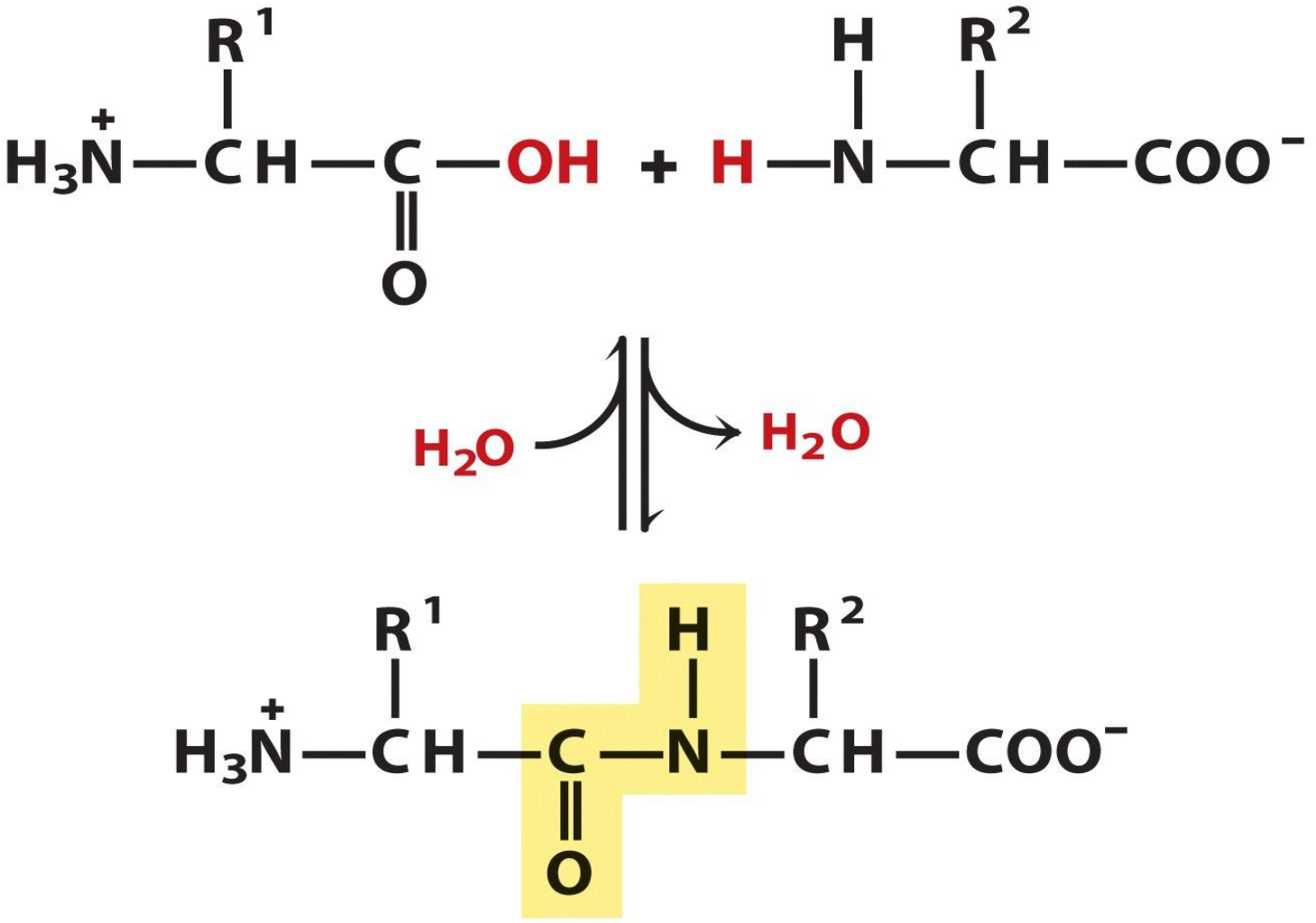


Levels of protein structure



PROTEIN BIOSYNTHESIS

- Proteins are linear polymers of amino acids.
- The carboxyl group of one amino acid is linked to the amino group of another amino acid.
- The amide bond formed in the reaction is called a peptide bond, to yield a dipeptide.



AMINO ACIDS

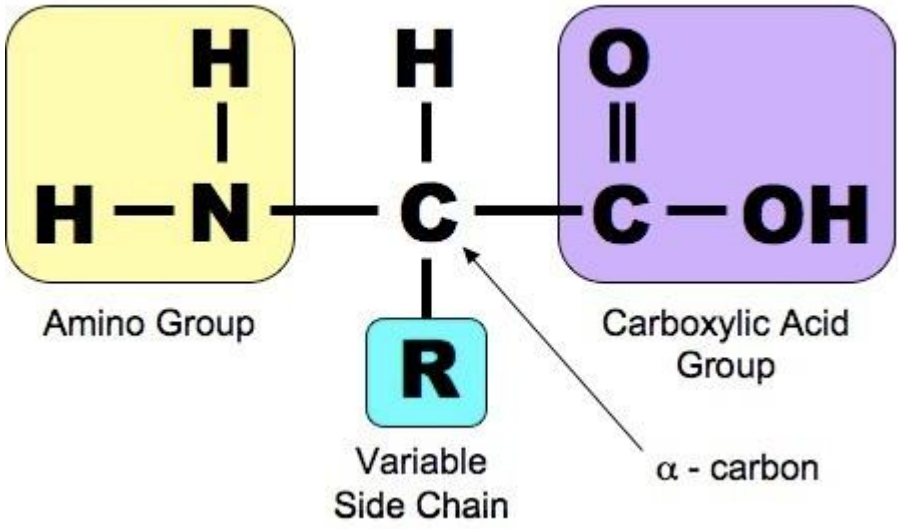
- Amino acids are the basic structural units of proteins consisting of an amino group ($-NH_2$).
- A carboxyl (-COOH) group, a hydrogen (H) atom and a variable (R) group.
- All of the substituents in amino acid are attached to a central α carbon atom.

(This carbon atom is called α because it is bonded to the carboxyl (acidic) group).

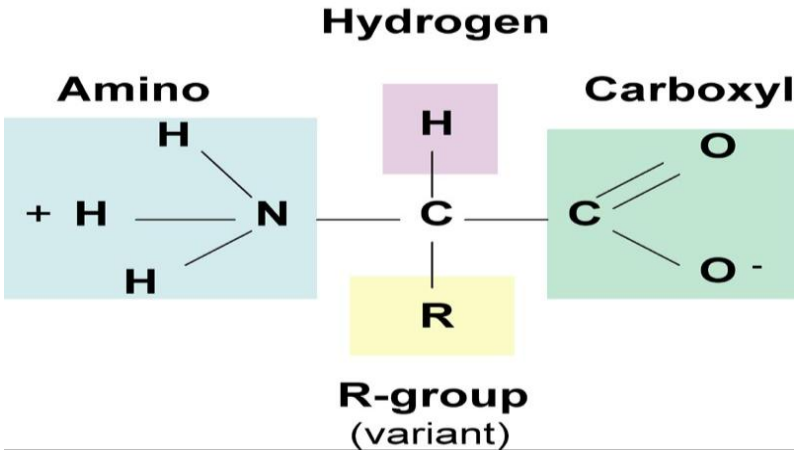
General Formula

- The general formula for the naturally occurring amino acids would be:

- A basic amino group (-NH2)
- An acidic carboxyl group (-COOH)
- A hydrogen atom (-H)
- A distinctive side chain (-R)



- In neutral solution (PH=7), both the α- amino and α carboxyl group are ionized resulting the charged form of amino acids called Zwitterion (dipolar).

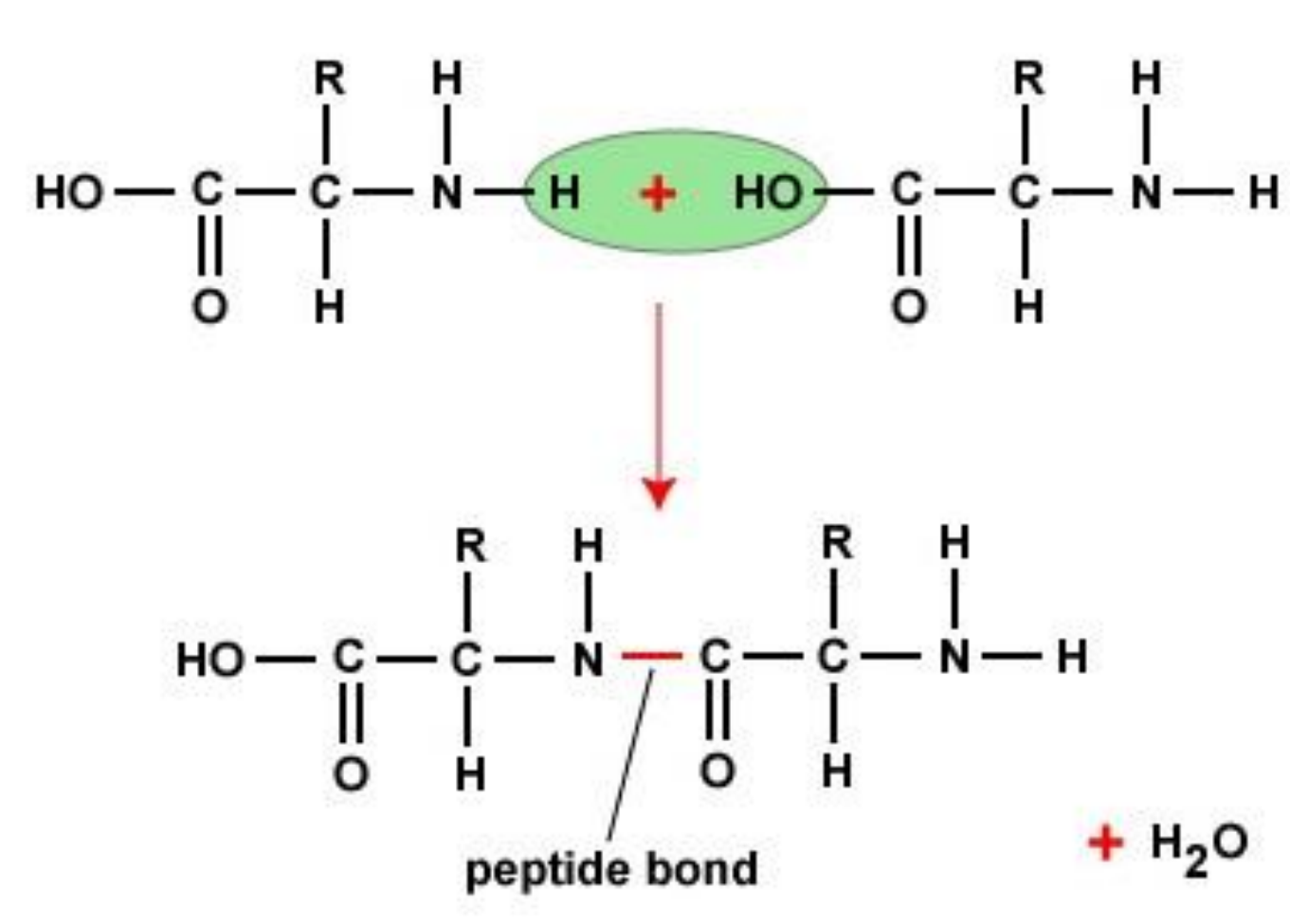


- In zwitterion form the amino group is protonated (NH_3^+) and the carboxyl group is deprotonated (COO^-) leading to a net charge zero.

Peptide linkage or peptide bond:

- The amide bonds in protein, known as peptide bonds formed by linkage of α carboxyl group of one amino acid with α-amino group of the next amino acid.
- During the formation of a peptide bond, a molecule of water is eliminated.

Peptide bond Synthesis



Classification of Amino acids

I. Structural classification:

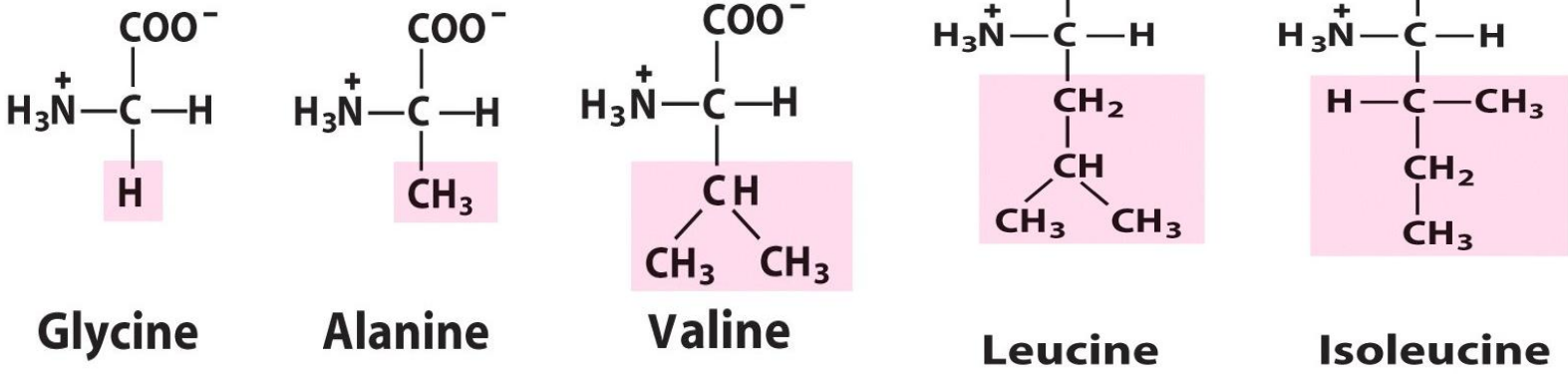
This classification is based on the side chain radicals (R-groups).

II. Biological classification:

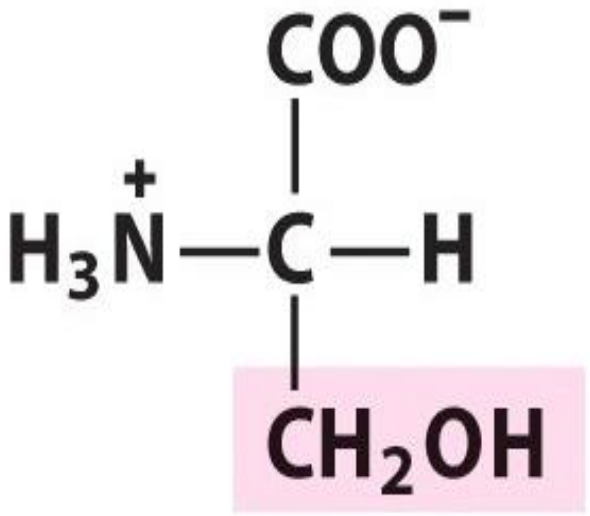
This classification is based on the functional property of amino acids for the organism.

Structural Amino acids

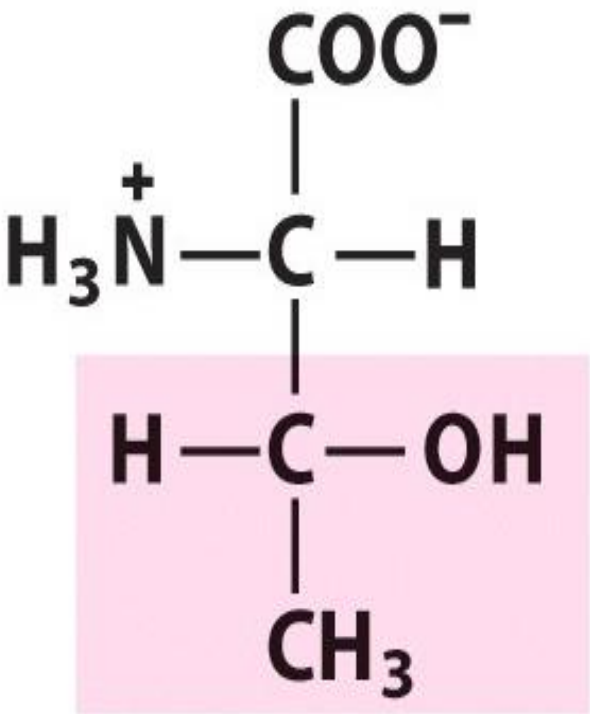
1- Aliphatic amino acids



2-Amino acids containing hydroxyl (-OH) group

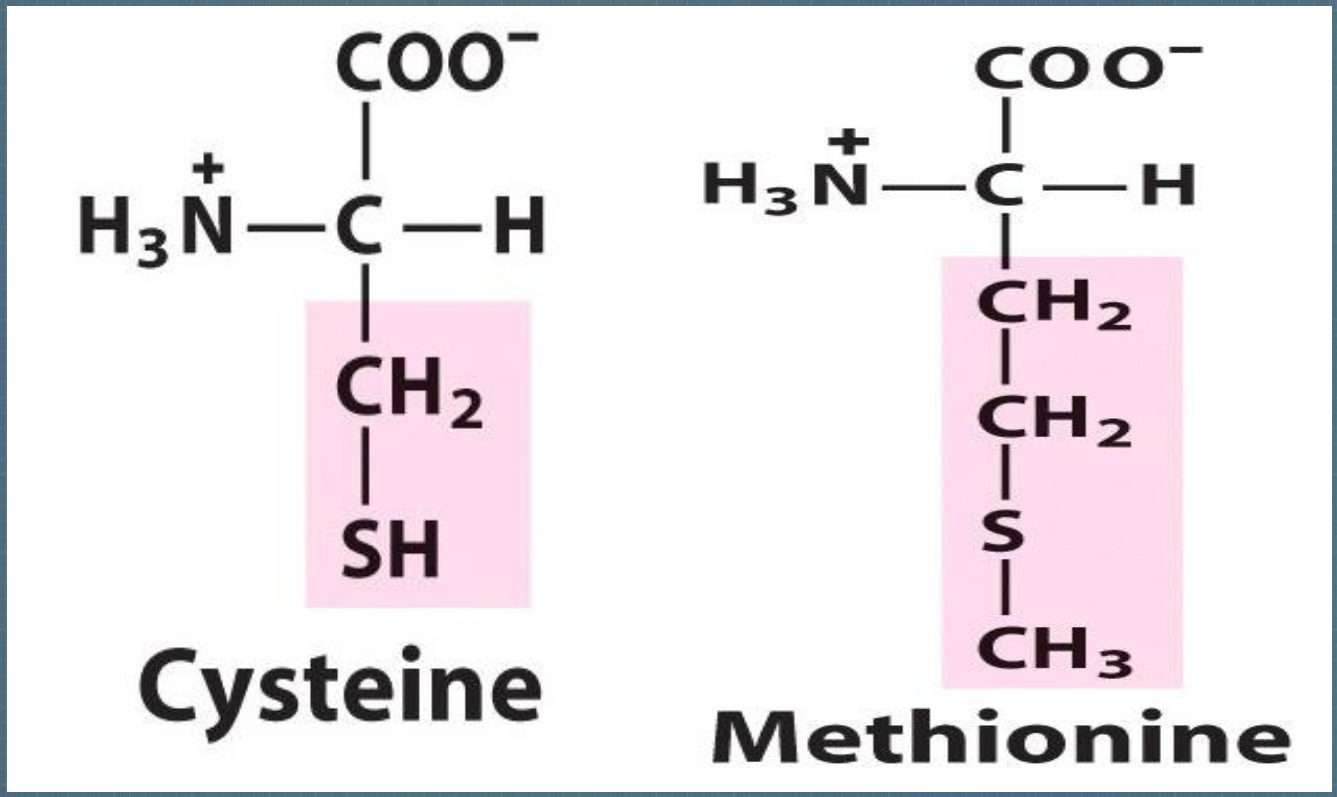


Serine

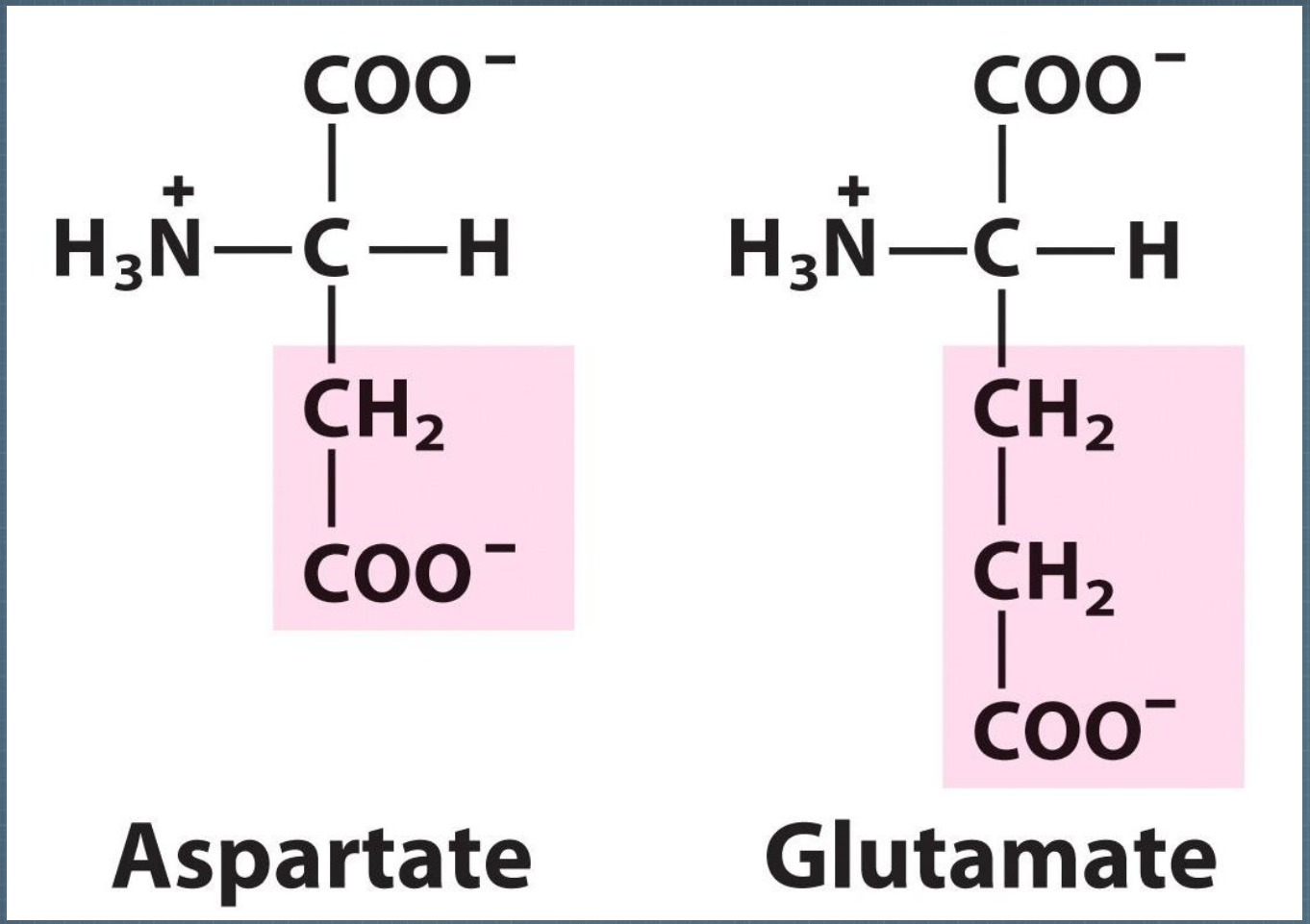


Threonine

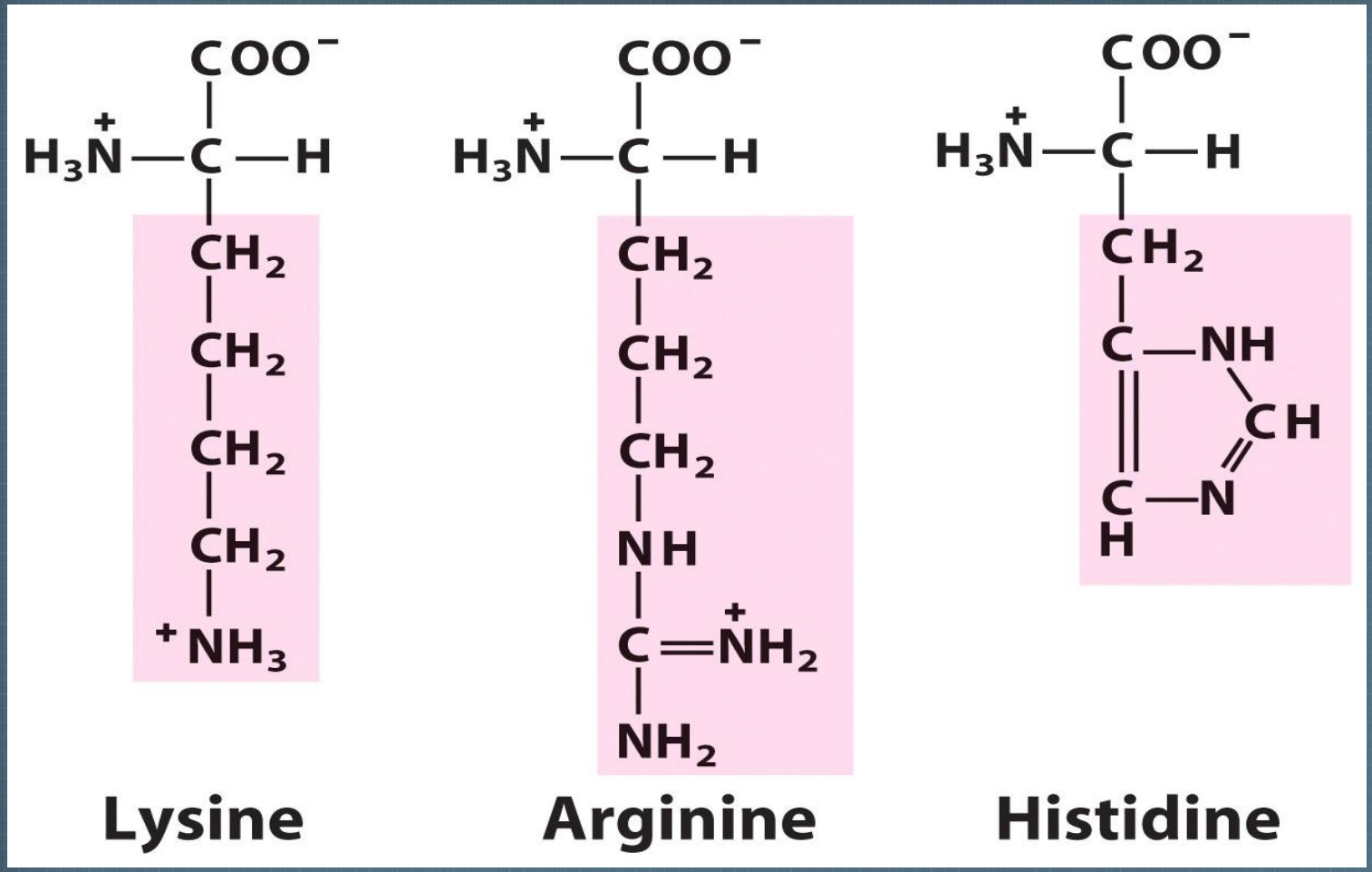
3-Amino acids containing thiol or (-SH) group



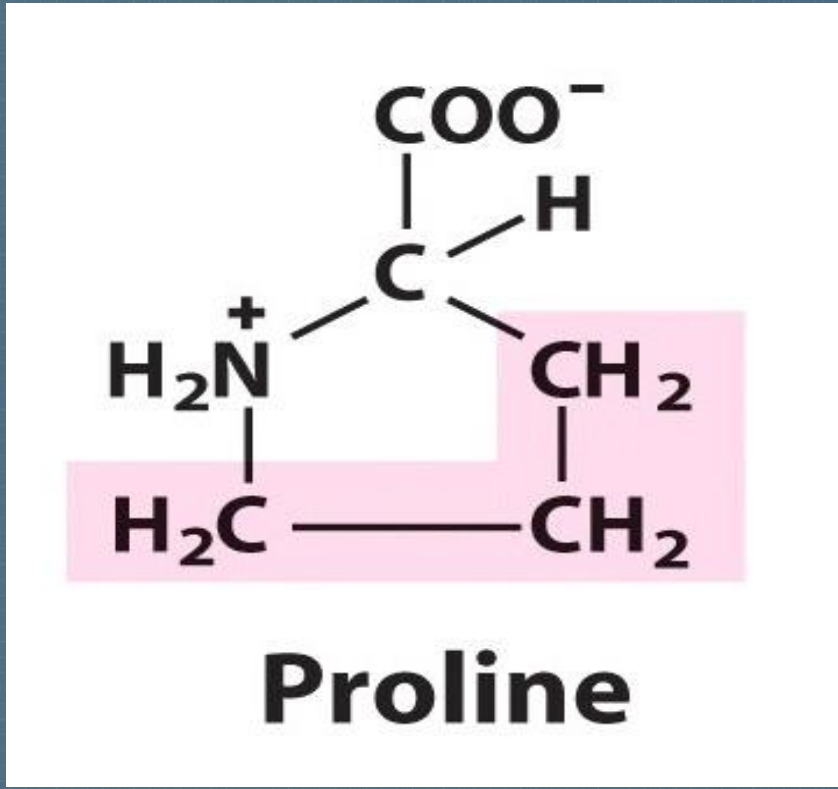
4-Acidic amino acids



5-Basic amino acids



6- Heterocyclic amino acids (Containing imino '-NH-' group)



Proline

Biological classification

1. Essential Amino acids:

- Amino acids which are not synthesized in the body and must be provided in the diet to meet body's metabolic needs.

- Required for growth and maintenance of normal nitrogen balance.

2. Non- essential Amino acids:

These amino acids can be synthesized in the body.

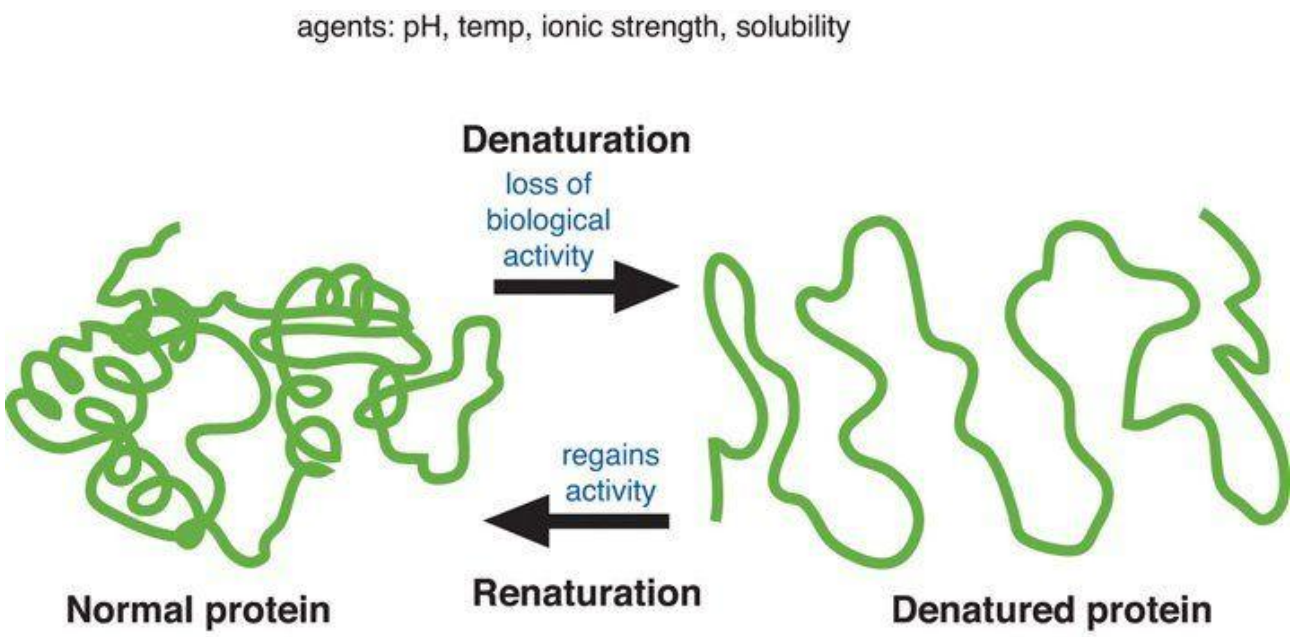
Essential	Non-Essential
Histidine	Alanine
Arginine	Asparagine
Lysine	Aspartic acid
Leucine	Cysteine
Isoleucine	Glutamic acid
Methionine	Glutamine
Phenylalanine	Glycine
Threonine	Proline
Tryptophan	Serine
Valine	Tyrosine

3. Semi-essential amino acids:

(*Arginine* and *Histidine*) are grouped under semi-essential amino acids since they can be synthesized within the organism but their synthesis is not in sufficient amounts. Thus, they should also be provided in the diet.

Denaturation of Proteins

Denaturation involves transformation of a well-defined folded structure of proteins under physiological conditions, to an unfolded state is called protein denaturation.



- Denaturation is a process in which a protein loses its native shape due to the disruption of weak chemical bonds and interactions, thereby becoming biologically inactive.

- In case of proteins:

a) A loss of three dimensional structure, sufficient to cause loss of function.

b) Loss of secondary, tertiary and quaternary structure of proteins.

c) Change in physical, chemical and biological properties of protein molecule.

Clinical Application of Denaturation

- The amounts of proteins found in the urine, serum and CSF are utilized to assess various pathological conditions.

Protein	Sample	Condition
Albumin, Globulin	Urine	Kidney impairment, glomerular permeability
Abnormal proteins (Bence-jons')	Urine	Multiple myeloma
ɣ- Globulins	CSF	Multiple sclerosis, Neurosyphilis
Albumin	CSF	Acute meningities