AL- MUSTAQBAL UNIVERSITY
College Of Health And Medical Techniques
Prosthetic Dental Techniques Department
Second Grade
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Advanced chemistry

Lecture 16 (The theoretical part)

(Amino Acids)

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Giving the lecture

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Lecture 16

Chemistry of Amino Acids-Amino Acid Classifications-Acid-Base Properties-Functional Significance of R-Groups-Optical Properties-The Peptide Bond

Chemical Nature of the Amino Acids:

*All peptides and polypeptides are polymers of alpha-amino acids.

*There are 20 α-amino acids that are relevant to the make-up of mammalian proteins (see below).

@ Several other amino acids are found in the body free or in combined states (i.e. not associated with peptides or proteins). These non-protein associated amino acids perform specialized functions.

e.g. *γ-Aminobutyric acid (GABA)*: involved in neurotransmission of nerve pulses.

e.*g β-alanine* : Part of the structure of Coenzyme A.

@ Several of the amino acids found in proteins also serve functions distinct from the formation of peptides and proteins: *e.g. tyrosine in the formation of thyroid hormones and other example is glutamate acting as a neurotransmitter.*

@ The α-amino acids in peptides and proteins *(excluding proline)* consist of a carboxylic acid (**-COOH**) and an amino (**$-NH_2$**) functional group attached to the same tetrahedral carbon atom. This carbon is the α-carbon.

Distinct R-groups, that distinguish one amino acid from another, also are attached to the alpha-carbon (except in the case of glycine where the R-group is hydrogen). The fourth substitution on the tetrahedral α-carbon of amino acids is hydrogen.

Neutral formula *Zwitterion formula*

Figure (1):General structure of amino acids. Neutral formula never found in the body.

*Crystalline amino acids are colourless, odorless, and melt with decomposition at temperature more than (200 °C). In aqueous solution amino acids exist predominantly in the form of zwitterion.

Amino Acid Classifications

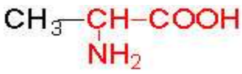
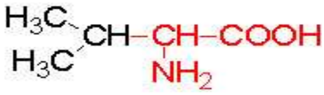
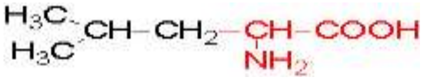
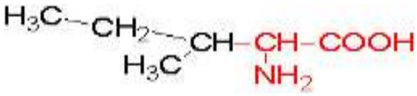
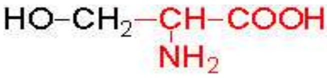
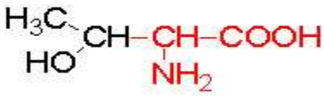
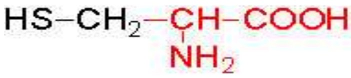
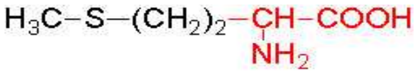
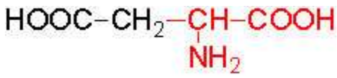
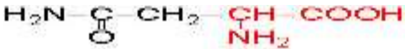
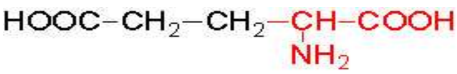
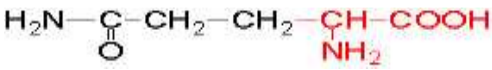
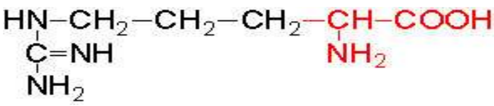
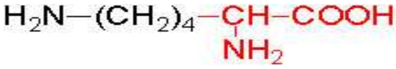
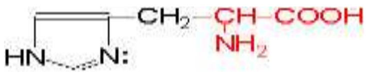
Each of the 20 α-amino acids found in proteins can be distinguished by the R-group substitution on the α-carbon atom. There are two broad classes of amino acids based upon whether the R-group is hydrophobic or hydrophilic.

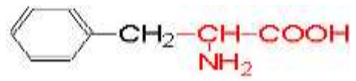
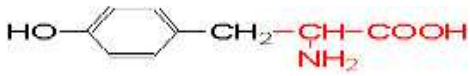
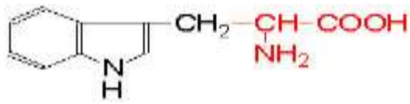
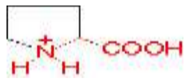
* The hydrophobic amino acids tend to repel the aqueous environment and, therefore, reside predominantly in the interior of proteins. This class of amino acids does not ionize nor participate in the formation of H-bonds.

* The hydrophilic amino acids tend to interact with the aqueous environment, are often involved in the formation of H-bonds and are predominantly found on the exterior surfaces proteins or in the reactive centers of enzymes.

Table of α-Amino Acids Found in Proteins

Amino Acid	Symbol	Structure*	pK_1 (COOH)	pK_2 (NH_2)	pK R Group
Amino Acids with Aliphatic R-Groups					
Glycine	Gly - G	H-CH-COOH NH_2	2.4	9.8	

Alanine	Ala - A		2.4	9.9	
Valine	Val - V		2.2	9.7	
Leucine	Leu - L		2.3	9.7	
Isoleucine	Ile - I		2.3	9.8	
Non-Aromatic Amino Acids with Hydroxyl R-Groups					
Serine	Ser - S		2.2	9.2	~13
Threonine	Thr - T		2.1	9.1	~13
Amino Acids with Sulfur-Containing R-Groups					
Cysteine	Cys - C		1.9	10.8	8.3
Methionine	Met-M		2.1	9.3	
Acidic Amino Acids and their Amides					
Aspartic Acid	Asp - D		2.0	9.9	3.9
Asparagine	Asn - N		2.1	8.8	
Glutamic Acid	Glu - E		2.1	9.5	4.1
Glutamine	Gln - Q		2.2	9.1	
Basic Amino Acids					
Arginine	Arg - R		1.8	9.0	12.5
Lysine	Lys - K		2.2	9.2	10.8
Histidine	His - H		1.8	9.2	6.0
Amino Acids with Aromatic Rings					

Phenylalanine	Phe - F		2.2	9.2	
Tyrosine	Tyr - Y		2.2	9.1	10.1
Tryptophan	Trp-W		2.4	9.4	
Imino Acids					
Proline	Pro - P		2.0	10.6	

*Backbone of the amino acids is red, R-groups are black

Acid-Base Properties of the Amino Acids

The α-COOH and α-NH_2 groups in amino acids are capable of ionizing (as are the acidic and basic R-groups of the amino acids). As a result of their ionizability the following ionic equilibrium reactions may be written:

R-COOH <--------> R-COO^- + H^+

R-NH_3^+ <---------> R-NH_2 + H^+

#-At physiological pH (around 7.4) the carboxyl group will be unprotonated and the amino group will be protonated. An amino acid with no ionizable R-group would be electrically neutral at this pH. This species is termed a **zwitterion**.

Like typical organic acids, the acidic strength of the carboxyl, amino and ionizable R-groups in amino acids can be defined by the association constant, K_a or more commonly the negative logrithm of K_a, the pK_a. The **net charge** (the algebraic sum of all the charged groups present) of any amino acid, peptide or protein, will depend upon the pH of the surrounding aqueous environment. As the pH of a solution of an amino acid or protein changes so too does the net charge. This phenomenon can be observed during the titration of any amino acid or protein. When the net charge of an amino acid or protein is zero the pH will be equivalent to the **isoelectric point: pI**.

Functional Significance of Amino Acid R-Groups

1. The imidazole ring of histidine is frequently found in the reactive center of enzymes.
2. The ability of histidines in hemoglobin to buffer the H^+ ions from carbonic acid ionization in red blood cells. It is this property of hemoglobin that allows it to exchange O_2 and CO_2 at the tissues or lungs, respectively.
3. The primary alcohol of serine and threonine as well as the thiol (-SH) of cysteine allow these amino acids to act as nucleophiles during enzymatic catalysis.
4. The thiol of cysteine is able to form a disulfide bond with other cysteines:

   Cysteine-SH + HS-Cysteine <--------> Cysteine-S-S-Cysteine

   (This simple disulfide is identified as cystine)
5. Disulfide bonding between cysteines in different polypeptide chains of oligomeric proteins plays a crucial role in ordering the structure of complex proteins, e.g. the insulin receptor.

Q/ Why metal catios such as (Pb^{+2} and Hg^{+2}) are toxic to most living organisms?

A/ The metal cations can react with (-SH) group in cystine within peptides structure to produce insoluble mercaptides, or can react with a carboxyl group of other amino acids to form insoluble salts and cause the protein to precipitate out of solution.

Optical Properties of the Amino Acids

A tetrahedral carbon atom with 4 distinct constituents is said to be **chiral**. The one amino acid not exhibiting chirality is glycine .

&&-Chirality describes the handedness of a molecule that is observable by the ability of a molecule to rotate the plane of polarized light either to the right (**dextrorotatory**) or to the left (**levorotatory**).

All of the amino acids in proteins exhibit the same absolute steric configuration as **L-glyceraldehyde**. Therefore, they are all L-α-amino acids.

&&-D-amino acids are never found in proteins, although they exist in nature. D-amino acids are often found in polypeptide antibiotics.

The aromatic R-groups in amino acids absorb ultraviolet light with an absorbance maximum in the range of 280nm. The ability of proteins to absorb ultraviolet light is predominantly due to the presence of the tryptophan which strongly absorbs ultraviolet light.

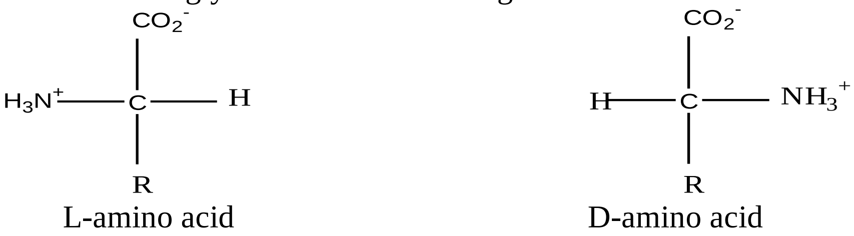


Figure: Isomers of amino acid. D-types never found in proteins

Essential Amino Acids: Obtained from diet because body cannot synthesize them: Phe, Trp, Val, Ile, Leu, Met, Lys, Thr.

Non Essential Amino Acids: All other Amino Acids body cannot synthesize them.

The Peptide Bond

The simplest peptide, a **dipeptide**, contains a single peptide bond formed by the condensation of the carboxyl group of one amino acid with the amino group of the second with the concomitant elimination of water. Peptide bond formation is a condensation reaction leading to the polymerization of amino acids into peptides and proteins. Peptides are small consisting of few amino acids.

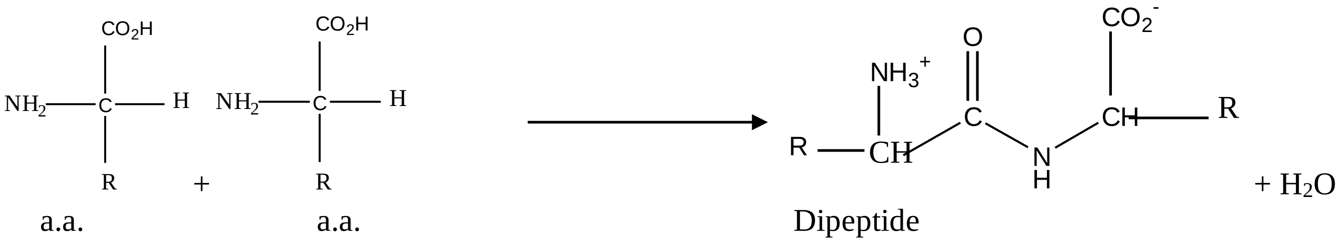
***Importance of Peptides:**

1. A number of hormones (e.g. Insulin) and some neurotransmitters are peptides.
2. Several antibiotics (e.g. Gramacidin and Valinomycin) are peptides.
3. Some antitumor agents are peptides (e.g.Bleomycin).

#-The presence of the carbonyl group in a peptide bond allows electron resonance stabilization to occur such that the peptide bond exhibits rigidity not unlike the typical -C=C- double bond. The peptide bond is, therefore, said to have **partial double-bond character**.

@ Poly peptide chain is unbrabched chain, rigid, and planer.

#-We started from amino group (N-terminal residue) from the left if we write the sequence of a.a. of P.P.Ch.



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