Amino acids

Editing File

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Objectives

- What are the amino acids?
- General structure.
- Classification of amino acids.
- Optical properties.
- Derivatives of amino acids.
- Amino acid configuration.
- Non-standard amino acids.

What are Amino Acids?

Amino acids :

- Chemical units that combine to form protein, also known as (the building blocks of proteins).
- Organic acids that contain Carboxyl group (COOH) and an Amino group (NH)2. The functional group is the (COOH) since it is the strongest.

Central roles of amino acids :

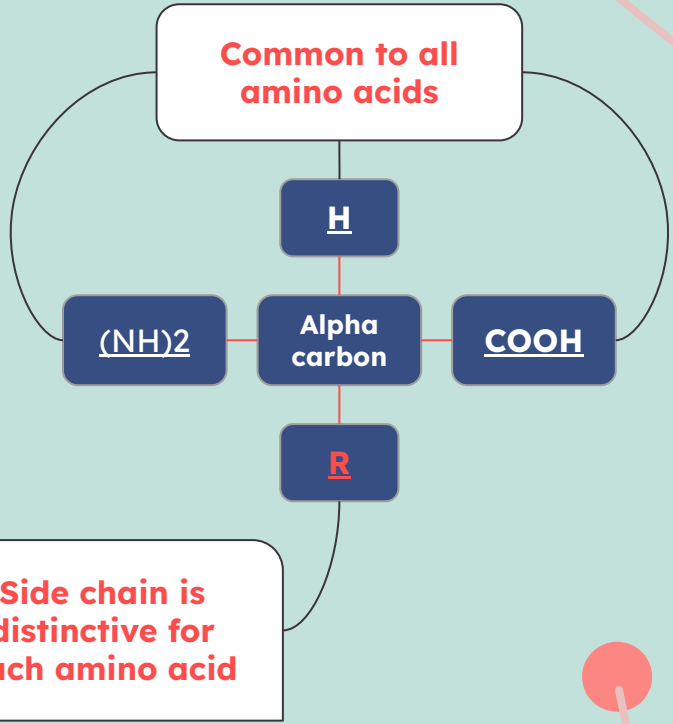
- Building blocks of proteins.
- Intermediates for metabolism.

- In the human body there are 20 amino acids
  - Humans produce about half of the amino acid (11).
  - The rest (9) are supplied in food (human should obtain from diet).
- When proteins are digested or broken down, amino acids are left.

General Structure

- R differs in each amino acid, which gives the amino acid its unique structure, function ,and chemical nature.
- NH2 all amino acids have a primary amino group, except for **Proline** which has a secondary amino group.
- Alpha carbon : is between the carboxyl and the amino group.

It's a carbon atom that bonded to a functional group in an organic compound.



Zwitterion

The zwitterion is a neutral amino acid with both a positive charge and a negative charge.
- Amino group has a positive charge (NH3 +) and the carboxyl group has a negative charge (COO-).

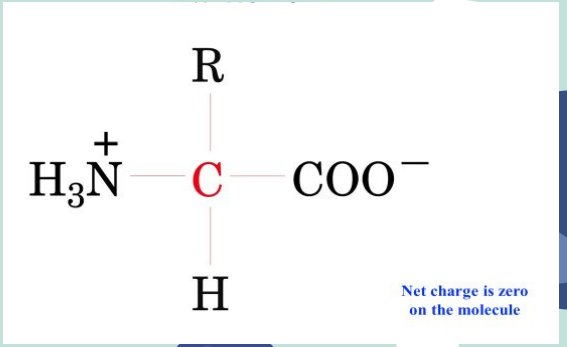
- Net charge on the molecule = zero

- NOTE: an amino acid with an ionized (charged) R cannot be zwitterion in neutral PH.

- The zwitterion is the usual form of amino acids that exists in solution.

- Depending on the pH there are two other forms: anion and cation.

- Zwitterion means hybrid because it has +ve and –ve at the same time.



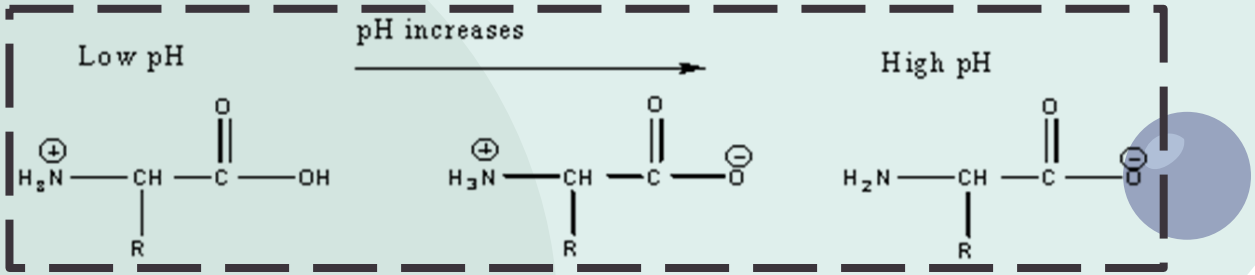
Isoelectric Point (pI)

-The pH of the medium at which the molecule carries no net charge (neutral) and becomes a zwitterion.

-In an **acidic** solution-**cationic**.

-In an **alkaline (basic)** solution-**anionic**.

Note : Each molecule has its own Isoelectric point depending on the side chain(R).



Isoelectric Point (pI)

We have a molecule at its isoelectric point (zwitterion) .
If we put it in an acidic or a basic solution, what will happen?

1- In an acidic solution: Low pH. Becomes Cation.
2- In a basic solution: High pH. Becomes Anion.

Cationic	Zwitterion	Anionic
Low pH (high conc. of proton H+)	pH=pI	High pH (low conc. of proton H+)
Positively Charged	No net charge	Negatively Charged
Explanation: The carboxylic acid will gain proton (Hydrogen atom) and lose its negative charge. The overall charge= +ve (Cationic)	Zwitterion is used to describe the Molecule. Isoelectric point is used to describe the pH level.	Explanation: The amino group will lose a proton (Hydrogen atom) and lose its positive charge. The overall charge= -ve (Anionic)

pK Value & The Titration Curve of Glycine

pK value (Also known as pKa or acid dissociation constant):

-pKa lets us know how strong or weak an acid is.
High pKa = Low acidity = Low concentration of protons.

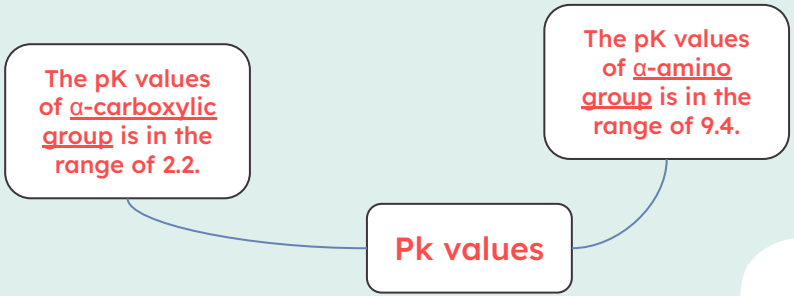
-The ability of an acid (COOH) to donate a proton (H+) (dissociate).

-Amino acids with ionized R **can not** be zwitterions in neutral pH.

Titration: a process where a solution of known concentration is used donating hydrogen instead of the to determine the concentration of an unknown solution.

TEAM436: COOH is a stronger acid (low pK) than NH2, so it will donate its proton first (1st pK value = 2.2) then NH2 (higher pK) will donate afterward (2nd pK group = 9.4)

TEAM438:
- pK = measurement of the acidity of the Group
- pH: measurement of the acidity of the Solution
- When pK= pH the group starts donating hydrogen instead of the medium



Titration Curve of Glycine

◆pK1- pH at which 50% of molecules are in cation form and 50% are in zwitterion form.
At pH = pK1 = 2.3: The COOH group in Glycine has lower pk value, so it will donate its protons first to neutralize the OH- in the medium, and becomes COO. As a result, zwitterions will be formed. (Buffering action is at its max).

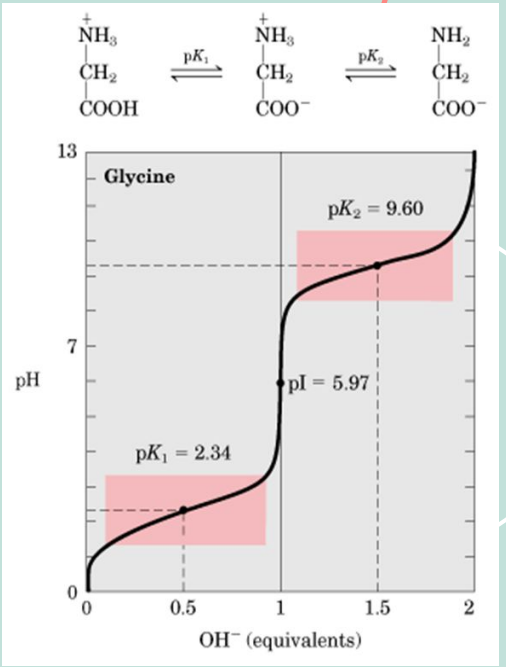
◆ pI- 100% of the molecules zwitterion net charge is zero.
At pH = pI = 5.9: All COOH became COO-, so there are no more protons to donate. 100% of molecules are zwitterions. (Buffering action at its min).

◆ pK2- pH at which 50% of molecules are in anion form and 50% are in zwitterion form.

At pH = pK2 = 9.6: The ammonia group starts donating protons, NH3 → NH2. Zwitterions will lose a positive charge, & anions are formed. (Buffering action is at its max).

◆ Buffering action is maximum around pK values and minimum at pI.

Note: all free amino acids and charged amino acids in peptide chains can serve as buffers.



Classification of Amino Acids:

Based on Body Requirements

Essential
(cannot be made in the body).

(PVT TIM HLL)
بڤت تيم هال, يقال انه اسم جندي
-Phenylalanine
-Valine
-Threonine
-Tryptophan
-Isoleucine
-Methionine
-Histidine
-Leucine
-Lysine

Nonessential
(produced by the body).

(Glu Ala AsAs)
قلة على اساس

-Glutamic acid
-Alanine
-Aspartic acid
-Asparagine

Conditional
(not essential, except in time of illness or stress).

(PGG CATS) Sounds like (Big cat)
-Proline
-Glycine
-Glutamine
-Cysteine
-Arginine
-Tyrosine
-Serine

Classification of Amino Acids:

(According to the side chain properties [R-group])

Non polar

VIP GAP TML

-Valine
-Isoleucine
-Proline
-Glycine
-Alanine
-Phenylalanine
-Tryptophan
-Methionine
-Leucine

Un charged

STC TAG

-Serine
-Threonine
-Cysteine
-Tyrosine
-Asparagine
-Glutamine

polar

HLA--AG

Basic side chain:

-Histidine
-Lysine
-Arginine

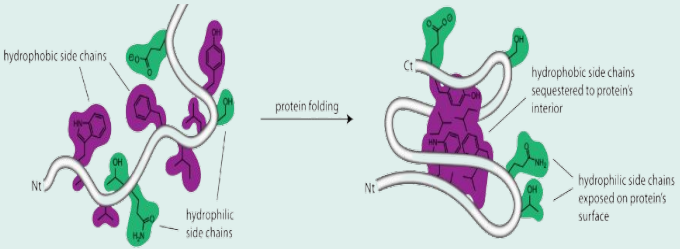
Acidic side chain:

-Aspartic acid
-Glutamic acid

1- Non-polar Amino acids:

Def: Each amino acid that does NOT: 1-bind 2-give off protons 3-participate in hydrogen and ionic bonds.. And they promote hydrophobic interactions.

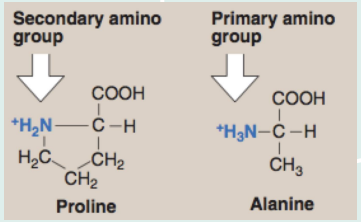
- Proteins found in hydrophilic environment (aqueous solution), the side chain (R) of the non-polar amino acids tend to cluster together and fill up the interior of the protein, which gives it its 3D shape.



TEAM442: Q- how many amino acids in the human body? We choose 19 Because proline is an imino acid.
If 19 is an option, otherwise 20

- Proteins located in hydrophobic environment, such as a membrane, the non-polar R-group are found on the surface interacting with the lipid environment to stabilize the protein.

- The structure of the proline amino acid differs from the other nonpolar amino acids that the side chain of proline and its α-amino group form a ring structure (an imino group).



Note: Each amino acid has α-carboxyl and a primary α-amino group (except for proline which is an imino acid that has a secondary amino group).

2- Uncharged Amino acids:

Def: Amino acids that have zero net charge at neutral PH.
*it has the potential to become charged if there is change in PH.

- The side chains of cysteine and tyrosine can lose a proton (H+) at an alkaline PH (high PH).

Serine, threonine ,and tyrosine contain a polar hydroxyl group (OH) that can form hydrogen bonds.

-The side chains of asparagine and glutamine each contain a carbonyl group and an amide group. Both can participate in hydrogen bonds.

TEAM439: Histidine (pk~6) is a weak base and there for in neutral pH it carries a neutral charge, (zwitterion form).

3- Polar Amino acids:

- Amino acids that are charged and it has 2 types:

1- Amino acids with acidic side chains:

- Aspartic and glutamic acids are proton donors.
- At neutral PH, these amino acids are fully ionized (negatively charged), so they are called aspartate and glutamate.

2- Amino acids with basic side chains:

- Histidine, lysine .and arginine are proton acceptors.
- At neutral PH, lysine and arginine are fully charged (positively charged).

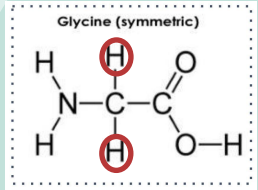
Optical properties

Asymmetric
(optically active)

- The **α-carbon** is attached to four **different** chemical groups, and They rotate the plane of polarized light in a polarimeter.
- All mammalian amino acids are optically active except glycine.

Symmetric
(optically inactive)

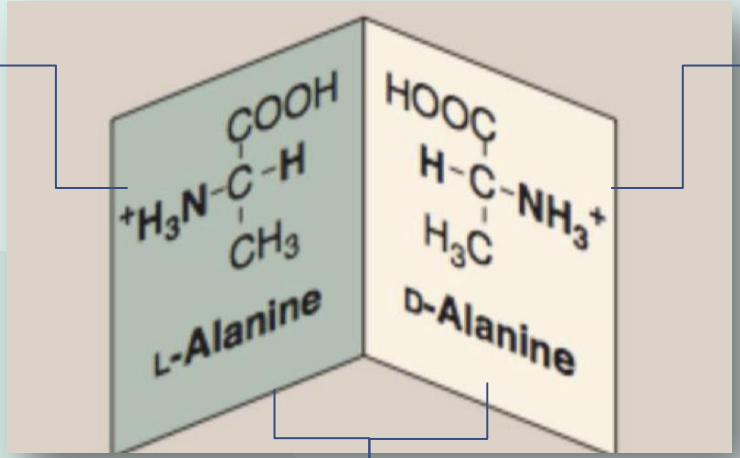
- The **α-carbon** is **not** attached to four **different** chemical groups
- **The only symmetric .amino acid is glycine**



Amino Acids Configuration

L-Amino acids: rotate polarized light to the Left.

- All mammalian amino acids are found in L-configuration.



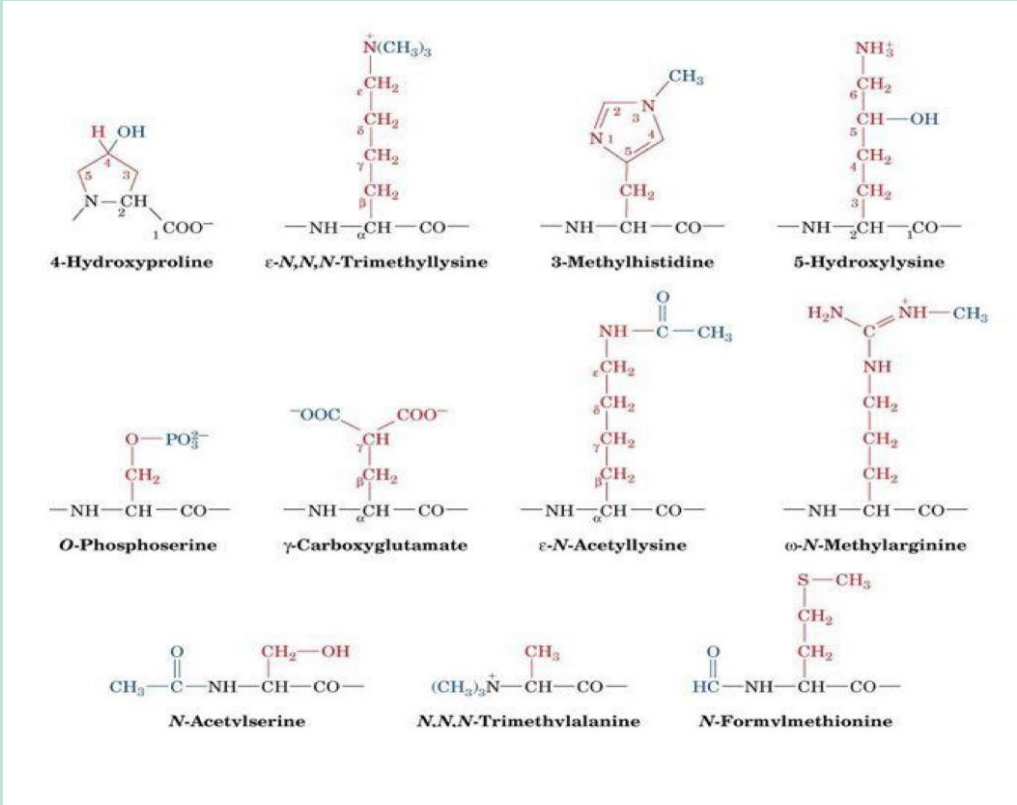
D-Amino acids: rotate polarized light to the Right.

- D-amino acids are found in antibiotics ,plants and in cell wall of microorganisms.

Both L and D forms are chemically the same.

Non-standard Amino Acids

- Apart from the 20 standard Amino Acids there are a vast number of Non-standard amino acids that are a modified version of the standard amino acid.
- **Exam question example: Which of the following is a modified or Non-standard amino acid? (MCQ)**
- **You don't have to memorize them if you know the standard Amino acid.**



Amino Acids Derivatives

- Neurotransmitters:

Gama amino butyric acid (GABA) → **Derived from** → Glutamic acid

Dopamine → **Derived from** → Tyrosine

-Important Thyroid Hormone:

Thyroxine → **Derived from** → Tyrosine

-Mediator for Allergic Reaction:

Histamine → **Derived from** → Histidine

Quizlet

Click here

Click here

Take Home Messages

- Each amino acid has an α-carboxyl and a primary α-amino group (except for proline, which is an imino acid).
- At physiological pH, the α-carboxyl is dissociated.
- Each amino acid also contains 20 distinctive side chains and the chemical nature of this side chain determines the function of the amino acid.
- All free amino acids and charged amino acids in peptide chains, can serve as buffers.
- Buffering action of proteins is maximum around pK values and minimum at isoelectric point.
- All mammalian amino acids are optically active except glycine.
- All mammalian amino acids are found in L-configuration.

Biochemistry Team

Yasser Almutairi

- Ahmad Addas
- Faisal Alomran
- Abdulrahman Almalki
- Ziyad Bukhari
- Talal Alrobaian
- Essam Nawaf

Alanoud Alnajawi

- Hossam Alhussain
- Abdullah Alzoom
- Ziyad Alenazi
- Tariq Alshumrani
- Mohammed Almurshid
- Abdullah Almutlaq

Lura Almusaeeb

- Ghala Alyousef
- Huda Bassam
- Manar Alqahtani
- Marwa Fal
- Jenan Al-Sayari
- Rahaf Aldawood
- Mays Altokhais

- Shaden Alotaibi
- Aljawharah Alyahya
- Norah Albahdal
- Ghaida Alotaibi
- Ghida Alkahtani
- Lama Alhayan
- Shaden Alshammari

Team Med444