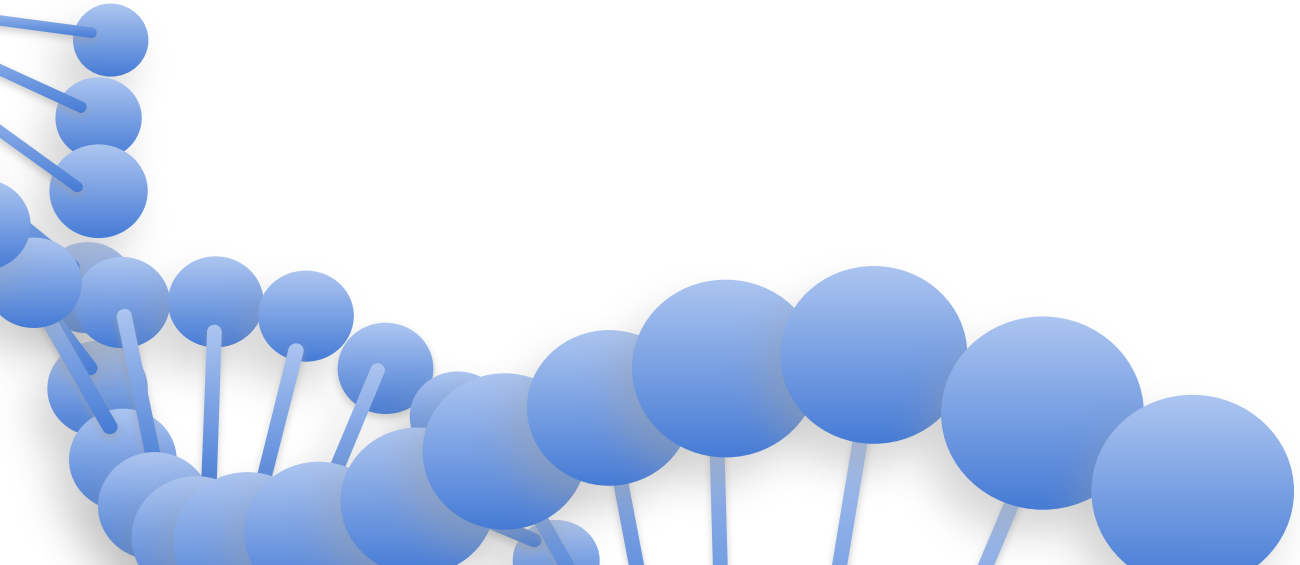
Lecture 1

Amino Acids



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- Girls' slides
- Boys' slides
- Doctors' notes
- Important
- Extra info

Editing File

Biochemistry
442

M E D 4 4 2

Objectives

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

What are amino acids?

Amino acids are the chemical units that combine to form proteins.
Amino acids are a type of organic acid.

Amino acids contain:

- Carboxyl group (**COOH**) (The functional group)
- Amino group (**NH2**)

Amino acids plays central role as:

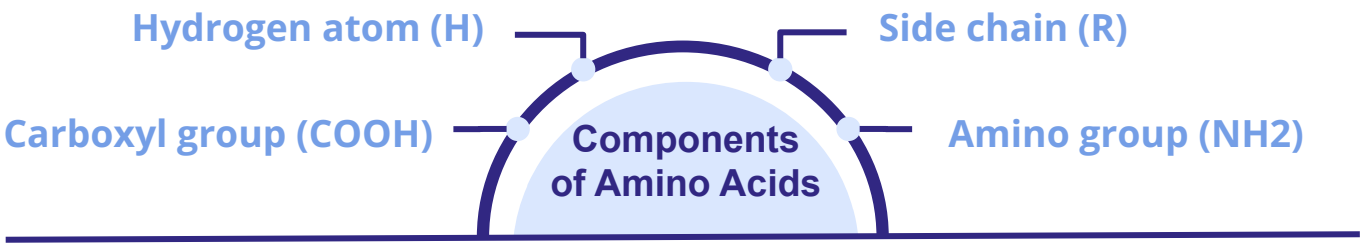
- Building blocks of proteins
- intermediates in metabolism

In the human body, there are **20** amino acids

- Humans can produce about half (**11**) of amino acids
- The rest (**9**) must be supplied in the food.
- When proteins are digested or broken down, **amino acids** are left.

**Note439: Amino acids are monomers to proteins.
Amino acids join together to give each protein its own unique structure and function. (Not every protein contains all of the 20 amino acids).**

General Structure of Amino Acids

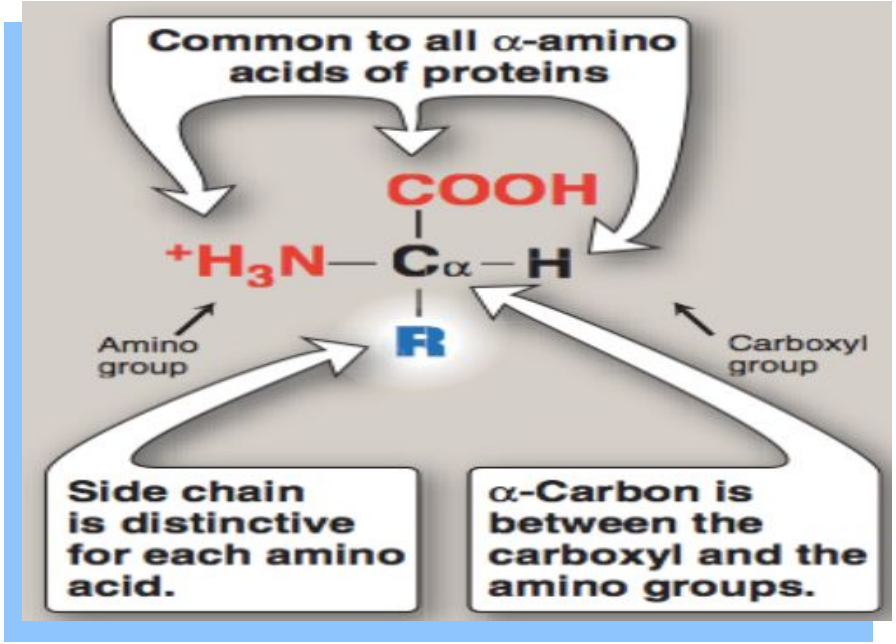


R differs in each amino acid, which gives the amino acid its **unique structure** and **set of characteristics.**

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's bonded to a functional group in an organic compound.

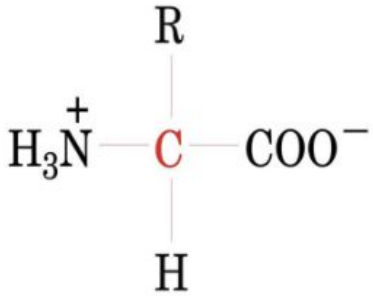
General Structure of Amino Acids



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 = **zero.**
- NOTE: an amino acid with an ionized (charged) R can **not** 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.

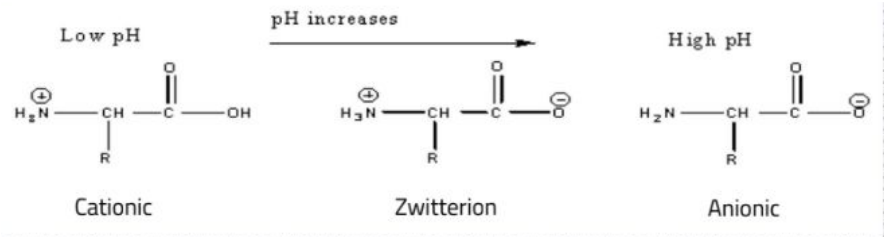


Zwitterion means hybrid because it has (+ve) and (-ve) at the same time.

Isoelectric Point (pI)

Isoelectric point:

- 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**.
- Each molecule has its own isoelectric point depending on the side chain (R).



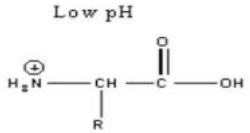
Isoelectric Point (pI)

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

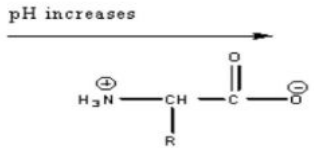
1- In an acidic solution: Low pH. Becomes Cation.

2- In a basic solution: High pH. Becomes Anion.

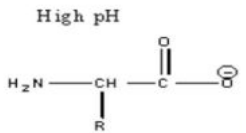
Cationic:	Zwitterion:	Anionic:
Low pH (high conc. of proton H+)	pH=pI	High pH (low conc. of proton H+)
Positively Charged	No net charge	Negatively Charged
explanation: The carboxylic acid will gain proton (Hydrogen atom), and lose its negative charge. The overall charge= +ve (Cationic)	**Zwitterion** 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)



Cationic



Zwitterion



Anionic

pK Value & the Titration Curve of Glycine

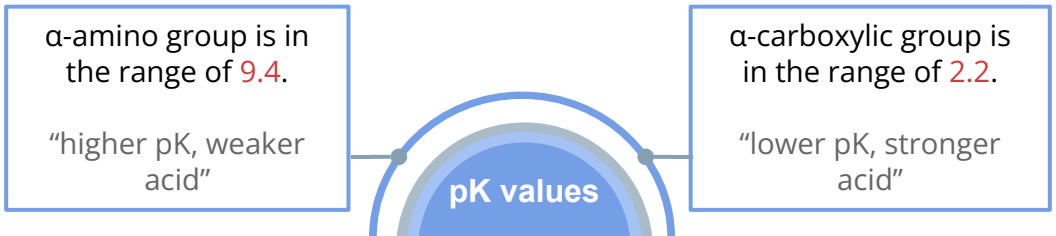
pK value (Also known as pKa or acid dissociation constant**):**

- pKa lets us know how strong or weak an acid is. High pKa = Low acidity = Low concentration of protons.
- The ability of an acid to donate a proton (dissociate)
- Amino acids with ionized R **can not** be zwitterions in neutral pH.

Titration: a process where a solution of known concentration is used 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

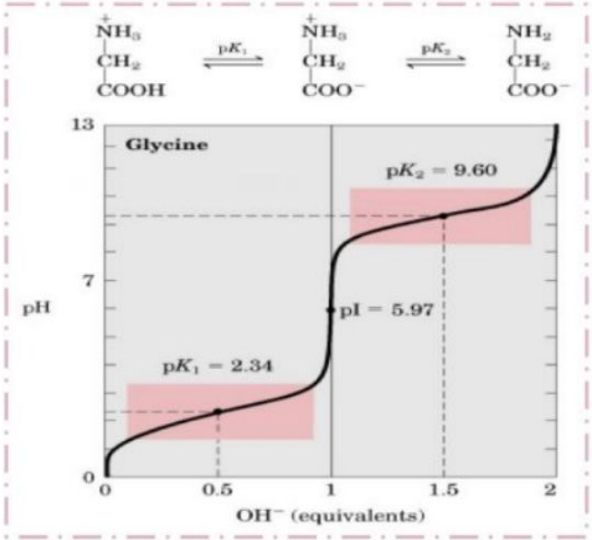
GRAPH EXPLANATION:

- **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**.



Helpful Video :)

Classification of Amino Acids:

Properties of side chain (R):

Polar "**uncharged**"

(STC TAG)

Serine
Threonine
Cysteine
Tyrosine
Asparagine
Glutamine

Polar " **charged** "

Basic side chain:
-Histidine
(week basic)
-Lysine
-Arginine
Acidic side chain:
Glutamic acid
Aspartic acid

Non-polar

Proline
Glycine
Alanine
Valine
Phenylalanine
Isoleucine
Leucine
Tryptophan
Methionine

Body requirements:

Essential: (cannot be made by the body).

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

Nonessential: (produced by the body).

(Glu Ala AsAs)
قلّه على اساس

-Glutamic acid
-Alanine
-Aspartic acid
-Asparagine

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

(PGG CATS)
Sounds like (Big cat)

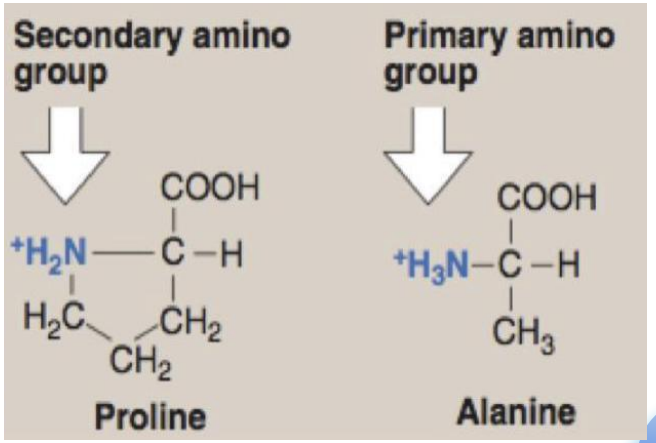
-Proline
-Glycine
-Glutamine
-Cysteine
-Arginine
-Tyrosine
-Serine

Nonpolar Amino Acids:

- Each amino acids **does not** bind or give off protons or participate in hydrogen or ionic bonds.
- These amino acids promote hydrophobic interaction.
- Non polar amino acids in proteins found in aqueous solution, the side chains of the non polar amino acids tend to cluster together in the interior of the protein.

The structure of proline amino acid differs from other non polar amino acids because the side chain of proline and its a α-amino group form a ring structure an ***imino*** group] So if we have a question that says: how many amino acids in the human body? We choose ***19*** Because proline is an imino acid. ***If 19 is an option, otherwise 20.***

All the amino acids have primary a amino group, except proline has a secondary amino group (an imino group).



Locations of **Nonpolar** Amino Acids in Proteins:

In proteins found in aqueous solution **hydrophilic** (**polar**) environment.

The **nonpolar R-groups** fill up the **interior** of the folded protein and help give it its 3D shape.

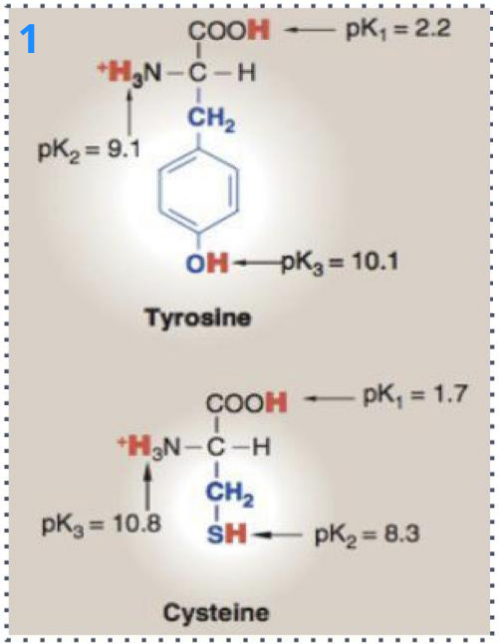
In proteins located in **hydrophobic** environment (**nonpolar**), such as a membrane.

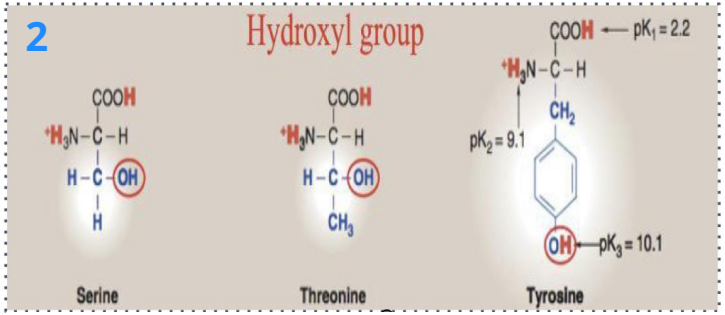
The **nonpolar R-groups** are found on the **outside** surface of the protein,interacting with lipid environment to stabilize protein structure.

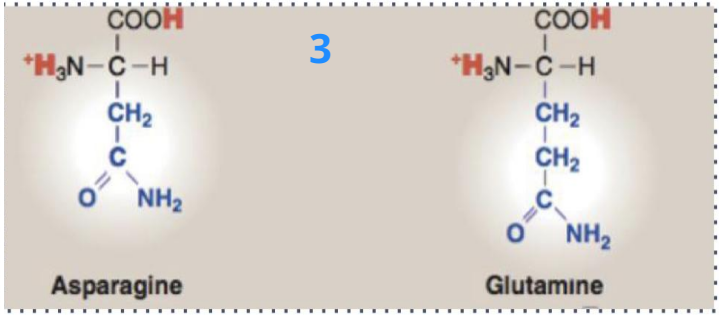
Uncharged Amino Acids:

Uncharged amino acids=zero net charge at neutral pH. However:

1- The side chains of Cysteine and Tyrosine can lose a proton at an alkaline pH (high pH)







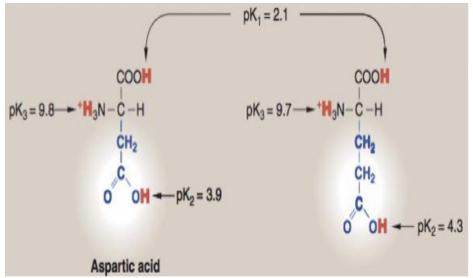
2- Serine, Threonine and Tyrosine each contain a polar hydroxyl group that can participate in hydrogen bond formation.

3- The side chains of Asparagine and Glutamine each contain a carbonyl group and an amide group, both of which can also participate in hydrogen bonds.

Polar (Charged) Amino Acids:

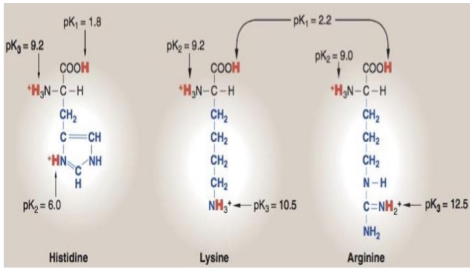
Amino acids with **acidic** side chains:

- **Aspartic** and **Glutamic** acids are proton donors. حمض يمنح بروتون
- At neutral pH, these amino acids are fully ionized (negatively charged) .So, they are called aspartate and glutamate.



Amino acids with **basic** side chains:

- **Histidine**,**Lysine** and **Arginine** are proton acceptors. قاعدة تستقبل بروتون
- At neutral pH, Lysine and Arginine are fully ionized (positively charged).
- **MED439:** Histidine (pK ~ 6) is a weak base and therefore in neutral pH it carries a neutral charge, (Zwitterion form).



Optical Properties

Asymmetric
Optically Active

The **α-carbon** is attached to four **different** chemical groups.

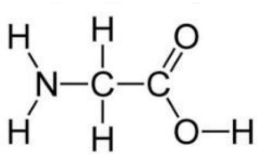
They rotate the plane of polarized light in a polarimeter.

All mammalian -الثدييات- amino acids are optically active except glycine.

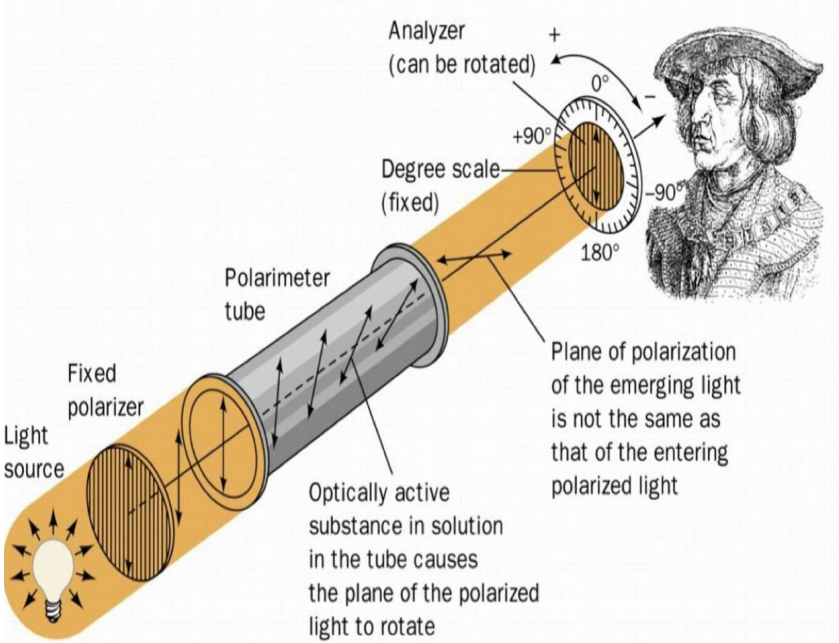
Symmetric
Optically Inactive

The **α-carbon** is **not** attached to four **different** chemical groups.

The only symmetric amino acid is glycine.

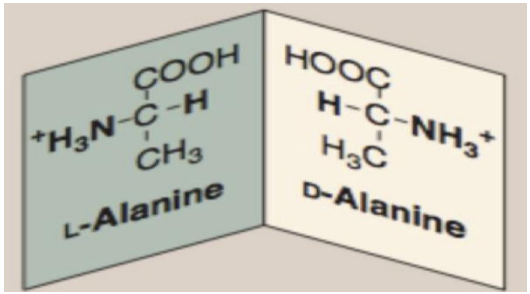


Optical Properties:



Amino Acids Configuration:

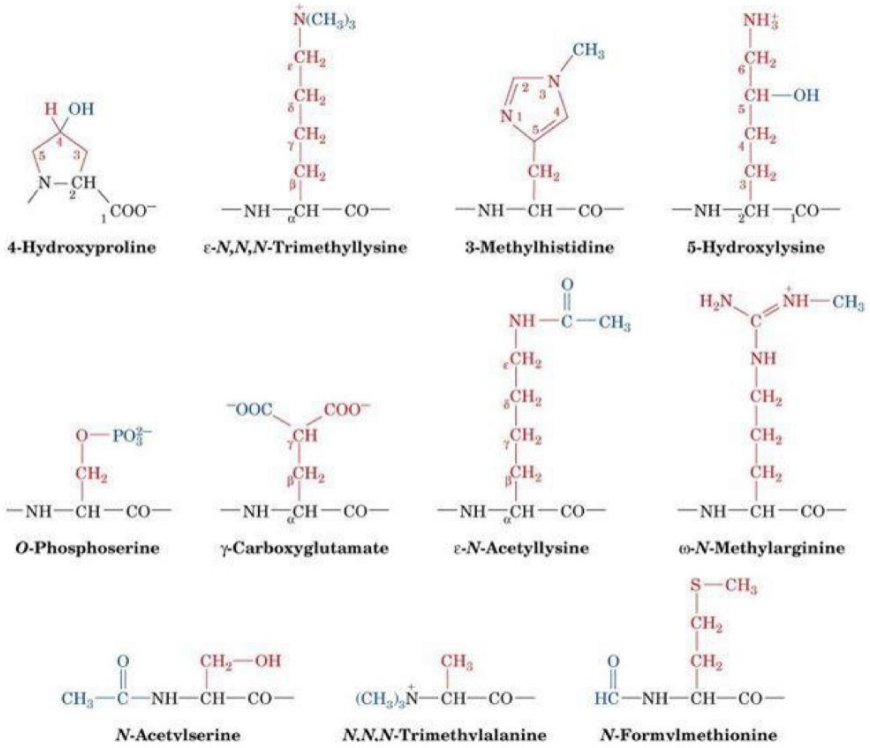
L-Amino acids:	D-Amino acids:
Rotate polarized light to the left.	Rotate polarized light to the right.
Both L and D forms are **chemically same.**	
All mammalian amino acids are found in L-configuration.	D-amino acids are found in antibiotics,plants and in cell wall of microorganisms.



Non-Standard Amino Acids:

- Apart from the twenty standard amino acids, there are a vast number of "non-standard" amino acids.
- These nonstandard amino acids are usually formed through modifications to standard amino acids.

غير ال20 أو بالأصح 19 الأحماض الأمينيه في غيرها زيادة تتكون من خلال التعديل على الأحماض الأمينية الأساسية.



Amino Acids Derivatives

Name:	Derivative of:	Role:
Dopamine	Tyrosine	Neurotransmitters
Thyroxine		An important thyroid hormone.
Histamine	Histidine	The mediator of allergic reactions
Gamma Amino Butyric Acid (GABA)	Glutamic Acid	Neurotransmitters

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 and the α- amino group is protonated.
- All free amino acids and charged amino acids in peptide chains, can serve as buffers.
- Each amino acid also contains twenty distinctive side chains and the chemical nature of this side chain determines the function of the amino acid.
- 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

Quiz

1-At isoelectric point, amino acids are:			
a) 50% cation 50% zwitterion	b) 50% anion 50% zwitterion	c) 50% cation 50% anion	d) 100% zwitterion
2- At which point is buffering action minimized?			
a) pK1	b) pK2	c) pI (isoelectric)	d) none
3- Which one is a non-essential amino acid?			
a) Valine	b) Methionine	c) Asparagine	d) Leucine
4- Which one is a nonpolar amino acid?			
a) Proline	b) Tyrosine	c) Lysine	d) Serine
5- From which amino acid is dopamine derived from?			
a) Glutamic acid	b) Histidine	c) Tryptophan	d) Tyrosine

1. D
2. C
3. C
4. A
5. D

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