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Biochemistry team 438

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AMINO ACIDS

- Color Index:
  - Important.
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  - 438 notes
  - Extra information

Objectives:

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

➢ **Standard amino acids: the basic amino acids which are coded in the nucleus**

MED435

extra information that might help you

- *Acids are* proton donors.
- *Bases*: proton acceptors.
- PH is a numeric scale used to specify the acidity or alkalinity of an aqueous solution.

Low PH → acidic solution → high protons concentration
High PH→ basic solution → low protons concentration

What are the amino acids ?

1- the chemical units that combine to form proteins.

2- Type of organic acid that contain both a carboxyl group (COOH) and an amino group (NH2).
therefore cooh is functional group

There are 20 amino acids

A) Humans can produce about half of amino acids.

B) The others must be supplied in the food.

Amino Acids are usually formed from by-products of major metabolic pathways. Humans lack the ability to synthesize the necessary enzymes aiding the biochemical pathway reactions to make Essential Amino Acids, but can obtain the Essential Amino Acids through diet.

- **Amino acids play central roles:**

A. The building blocks of proteins.

B. They play intermediates role in metabolism.

When proteins are digested or broken down amino acids are left.

Note:

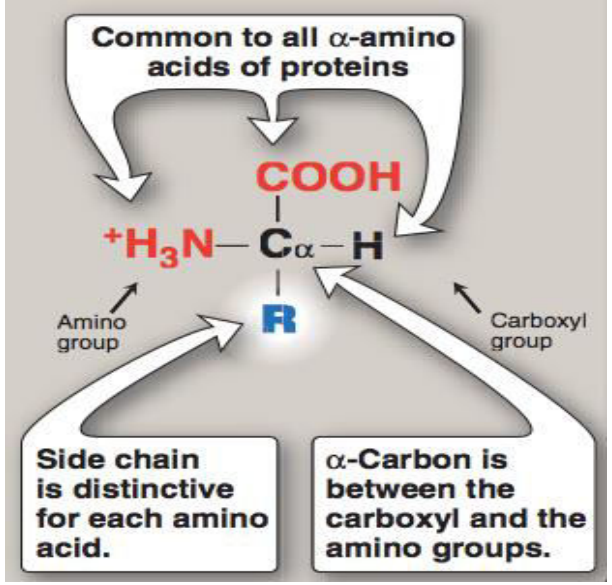
20 standard amino acid (not necessarily all of them) join together to make proteins

General structure of amino acids:

- Alpha carbon that is attached to:

- A) hydrogen atom (H)
- B) side chain (R) (which is distinctive for each amino acid and gives the amino acid a unique set of characteristics).
- C) carboxylic acid group (COOH)
- D) Primary Amino acid group (NH2) (except for proline which has a secondary amino group).

- **ALPHA CARBON:** is between the carboxyl and the amino group.

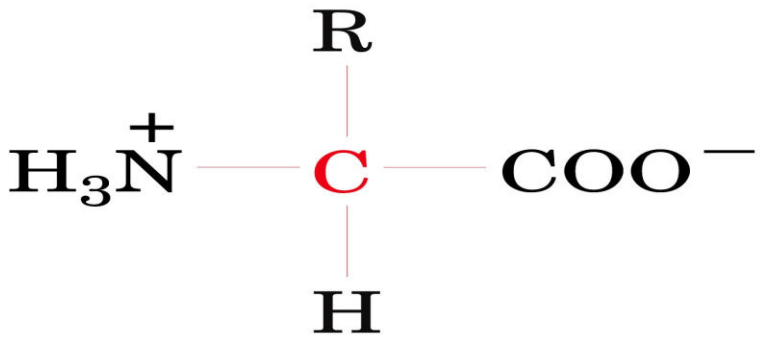


Isoelectric point (PI) and Zwitterion:

- **Zwitterions:** neutral amino acid.

they can have more than one charge. However, the sum of those charges MUST equal zero.

Unlike other compounds, zwitterions Simultaneously have both cationic and Anionic states.



- **THE ISOELECTRIC POINT (PI):**

IS THE PH OF THE MEDIUM AT WHICH THE MOLECULE CARRIES NO NET CHARGE.

Zwitterion is used to describe the molecule. Isoelectric point is used to describe the pH level.

note:
an amino acid that has ionized R side chain can not be zwitterion.

Different molecules can have different isoelectric points because they have different side chains.

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

- In an acidic solution:

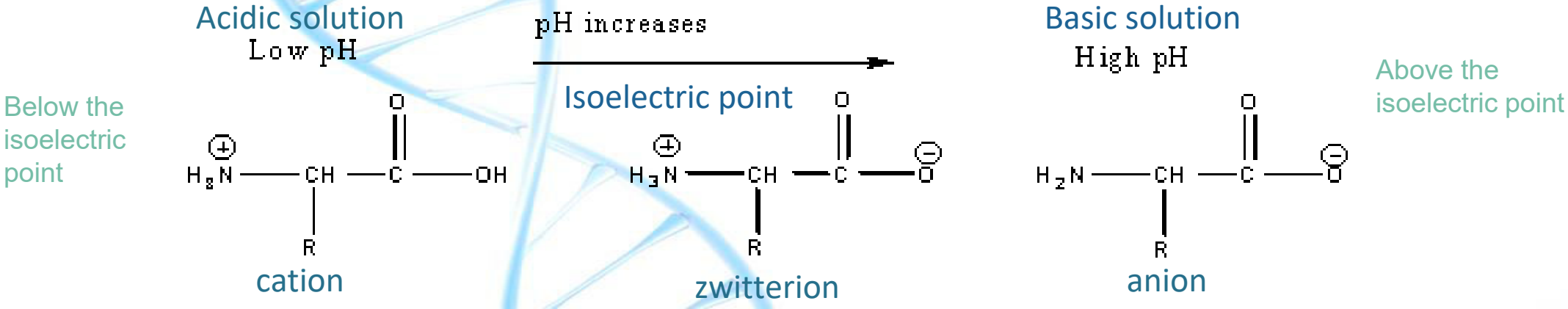
Acidic solutions have low pH,

The carboxylic acid will gain a proton (Hydrogen atom) and lose its negative charge.
Due to that, the overall charge on the molecule is now positive. **It becomes cationic.**

- In a basic solution:

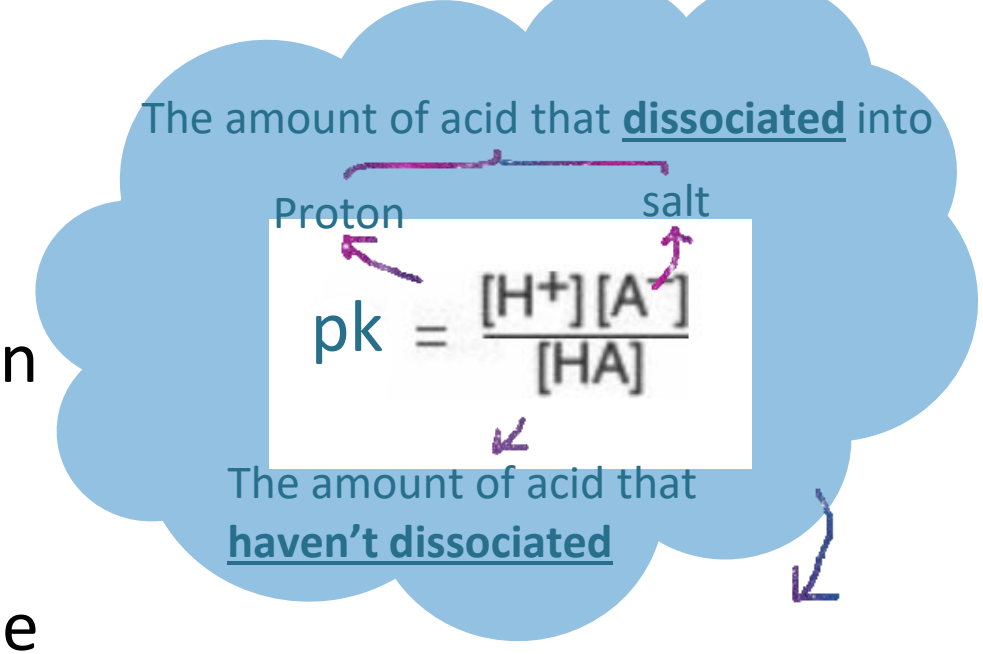
Basic solutions have high pH,

The amino group will lose a proton and lose its positive Charge.
Due to that, the overall charge on the molecule is now negative. **It becomes anionic.**



PK Value

- It is the ability of an acid to donate a proton (dissociate).
- Also known as pKa or acid dissociation constant.
- The pK values of α-carboxylic group is in the range of 2.2.
- The pK values of α-amino group is in the range of 9.4.



كلما كبر المقام قلت قيمة pk

كلما كبر البسط كبرت قيمة pk

والعكس صحيح

كلما قلت قيمة pK زادت قدرة المجموعة على منح المزيد من أيونات الهيدروجين (زادت حامضية المجموعة)

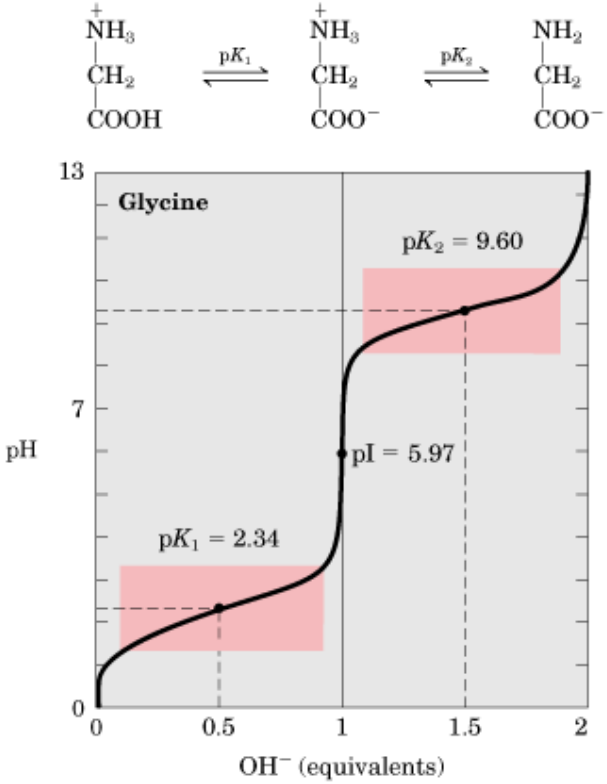
PK and acidity: Inverse relationship.

dr notes: carboxylic group is a stronger acids (with low pk value) than the amino group, so it will give off its proton first (first pk value = 2.2) then the amino group (higher pk value) will donate afterward (second pk group = 9.4) .

Titration curve of glycine

important slide*

- When pK1= pH (2.3) 50% of molecules are in cation form and 50% are in zwitterion form. (تبدأ تقل كمية 2.3لما ترتفع قيمة البي كي أكثر من ، هنا يصير كل المركب زويترأيون 5.9الكاتيون بالمحلول حتى تصل عند قيمة)
- When pK2 = pH (9.6) 50% of molecules are in anion form and 50% are in zwitterion form. 9.6نفس الفكرة اللي فوق لما ترتفع قيمة البي كي أكثر من تبدأ ترتفع نسبة الأنيون بالمحلول)
- Buffering action is maximum around pK values and minimum at PI.



dr. notes 436:

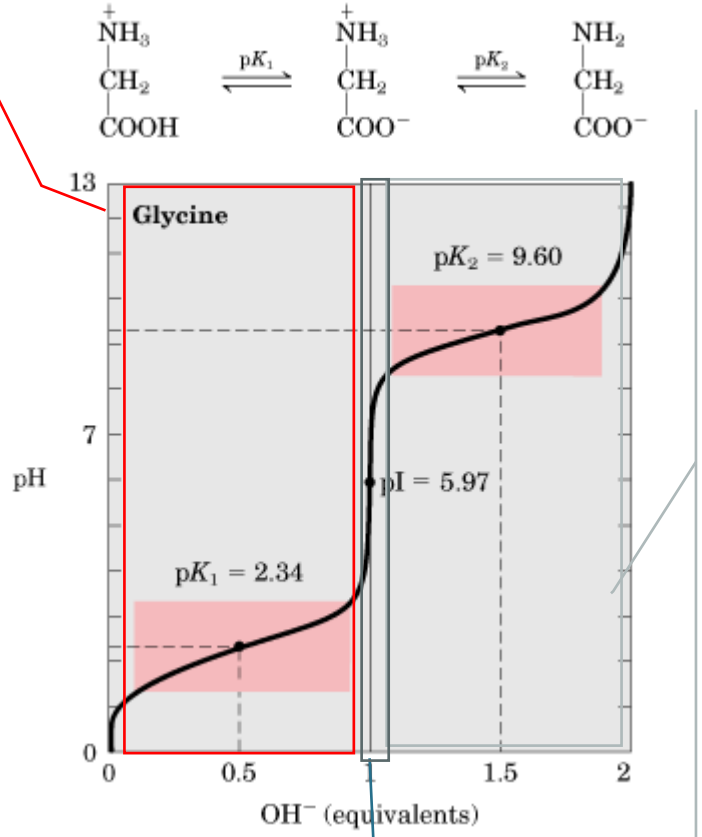
- zwitterion the amino acid itself that has no net charge.
- If the side chain contains an ionized group, in this case the amino acid is not a zwitterion.
- Buffer is a solution that resists change in pH when an acid or base is added into it.
- At physiological pH, the a-carboxyl and a- amino groups are dissociated.
- All free amino acids and charged amino acids in peptide chains, can serve as buffers.

Titration curve of glycine

Process: we are adding alkaline (OH-) to the solution.
This will increase the ph value of the medium.

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.



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.

At pH = pk2 = 9.6

The ammonia group starts donating protons, and becomes NH3 → NH2

Zwitterions will lose a positive .charge, & anions are formed

Buffering action is at its max.

Remember

- 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**

short video for better understanding

https://youtu.be/UT_YFQItvhM

Classification of amino acids

* تشبيه لتسهيل التذكر:
زي لما نذاكر الاشياء السهله والغير أساسية , والأشياء الاساسيه والمهمه مانقدر ونتهرب

* الأسامي تُحفظ
+ تحت اي تصنيف؟

Amino acids
According to:

Body requirement

Essential
[body CANNOT make]
- Histidine
- isoleucine
- leucine
- methionine
- phenylalanine
- threonine
- tryptophan
- valine

Nonessential
[body CAN make]
- Glutamic
- Alanine
- Asparagine
- Aspartic acid

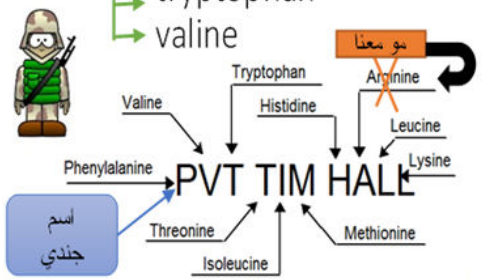
Glu Ala AsAs

* قلّه على أساس

Conditional
[not essential, except in time of illness or stress]
- Arginine
- Cysteine
- Glutamine
- Tryosine
- Glycine
- Proline
- serine

PGG CATS

* Big cats

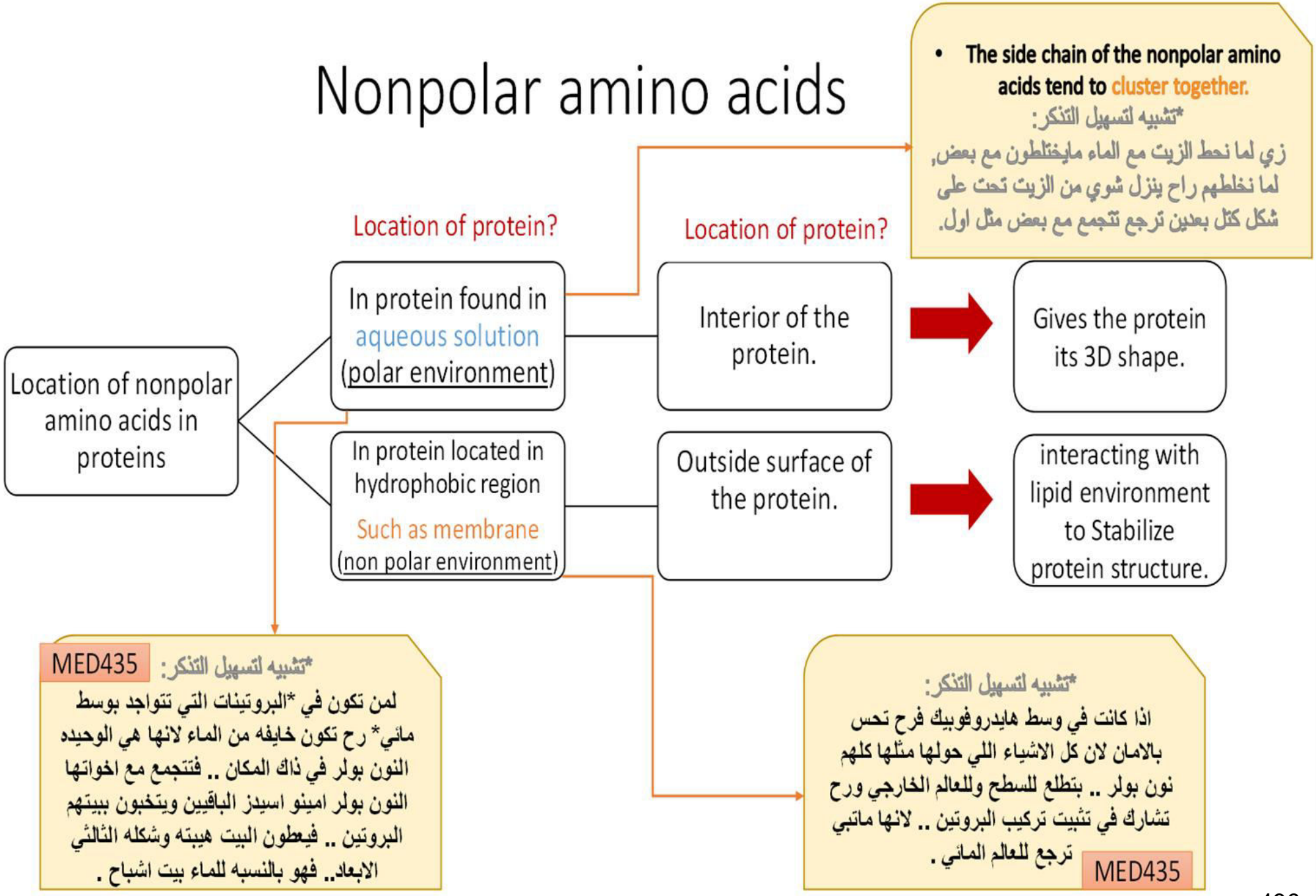


Properties of the side chain

Nonpolar
(hydrophobic)

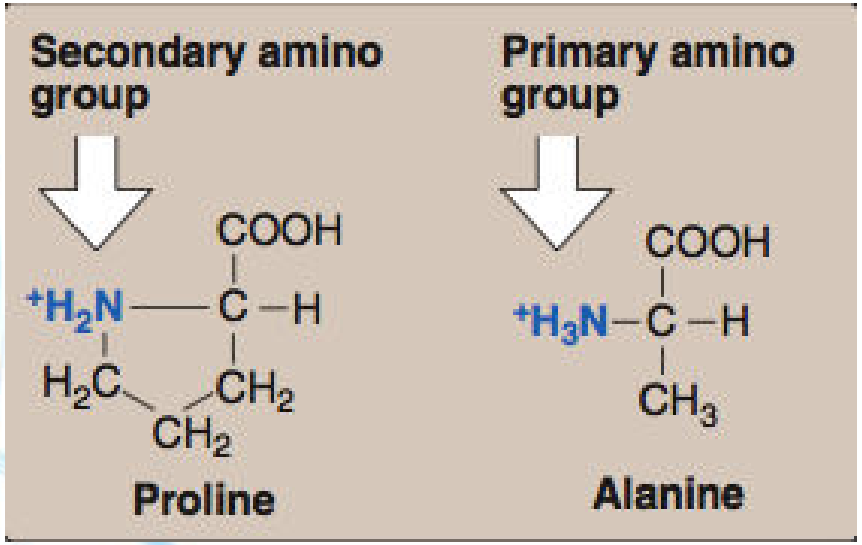
Polar
- charged
  - positive charge (acceptors)
  - negative charge (donators)
- uncharged

Nonpolar amino acids



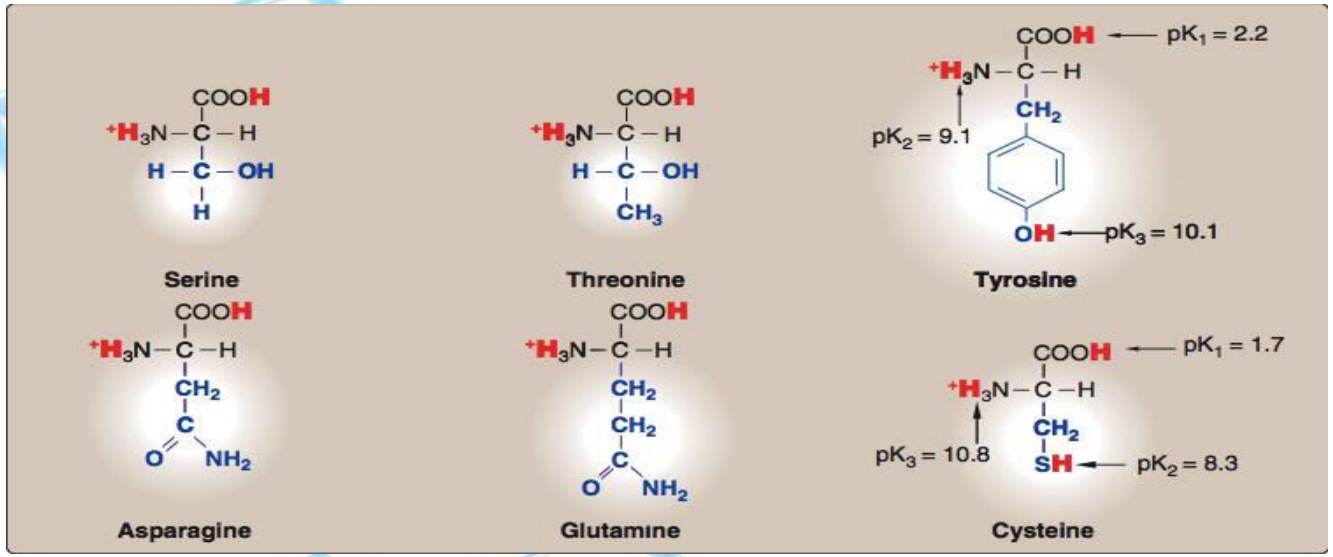
Continued …

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



Uncharged polar amino acids

These amino acids have zero net charge at neutral pH.



in alkaline pH , cysteine + tyrosine can lose a proton

serine , threonine and tyrosine → contain → polar hydroxyl group → participate in hydrogen bone

side chain of asparagine and glutamine → contain → carbonyl group + amide group → participate in hydrogen bone

Nonpolar	Uncharged polar	polar
• Won't mixed • Side chain does not bind or give off protons or participate in hydrogen or ionic bonds. • has no charge on the side chain	zero net charge at normal pH. (if we change pH they can become charged)	• Acidic amino acid – on -R • Basic amino acid + on -R
Hydrophobic interactions (Does not love H)	Hydrophilic (Loves H)	• **amino acid with Polar Acidic side chain:** have a negative charge on the R-group (Beacause they are fully ionized at neutral pH) 2 types: Aspartic acid , Glutamic acid When they are ionized we call them aspartate and glutamate. And they are proton donors.
Examples: Glycine, Alanine, Valine, Leucine, Isoleucine, Methionine, Phenylalanine, Tryptophan and Proline. Proline is an Imino acid. (because it has a secondary amino group NH2)	Examples: Serine, Threonine, Asparagine, Glutamine, Tyrosine and Cysteine.	• **amino acid with Polar Basic side chain:** have a positive charge on the R-group (Beacause they are fully ionized at neutral pH) 3 types: Histidine , Lysine , Arginine And they are proton acceptors.

*Important slide

Mnemonics

- Non-polar

ProGAV PIL TM

proline, glycine, alanine, valine, phenylalanine, isoleucine, leucine

, tryptophan, methionine

- Polar

"**S**ome**T**imes **C**ats **T**ry **A** **G**rowl"

serine, threonine, cysteine, tryrosine , asparagine, glutamine

- Charged

"**A** **G**ood **L**awyer **A**ims **H**igh"

Aspartate, Glutamate, Lysine, Arginine, Histidine

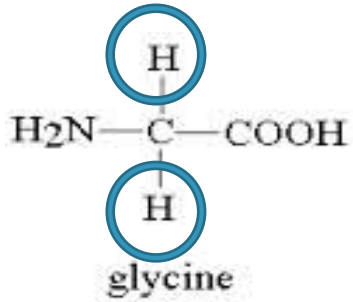
Optical properties

Asymmetric

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

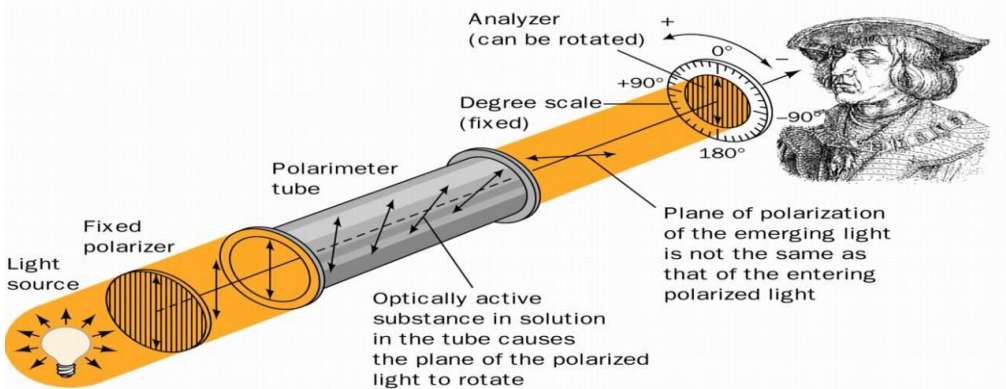
Symmetric

- Glycine is an example of symmetric amino acids “α-carbon is not attached to 4 different groups”



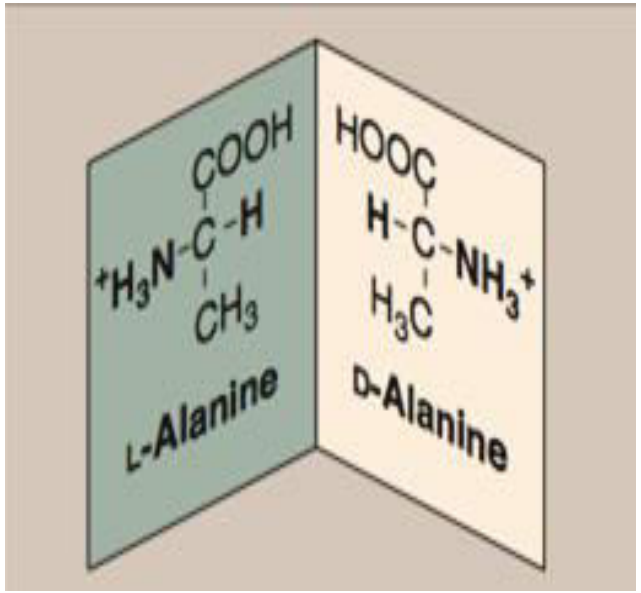
- symmetric molecules are optically inactive.

You don't have to memorize it just for better understanding

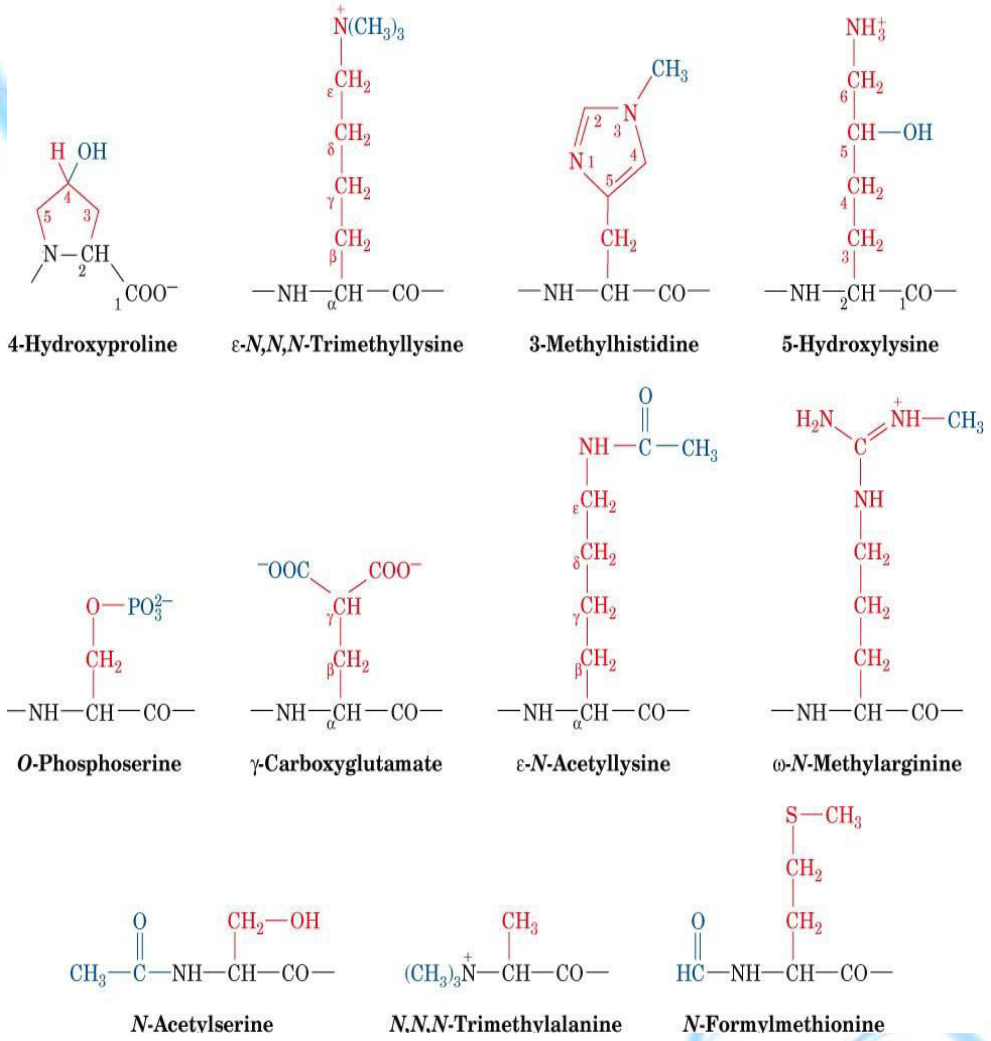


Amino acid configuration

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 the cell wall of microorganisms.



Non-standard amino acids



- Aside from the twenty standard amino acids, there are a vast number of "non-standard" amino acids.

*you don't have to memorize the names.

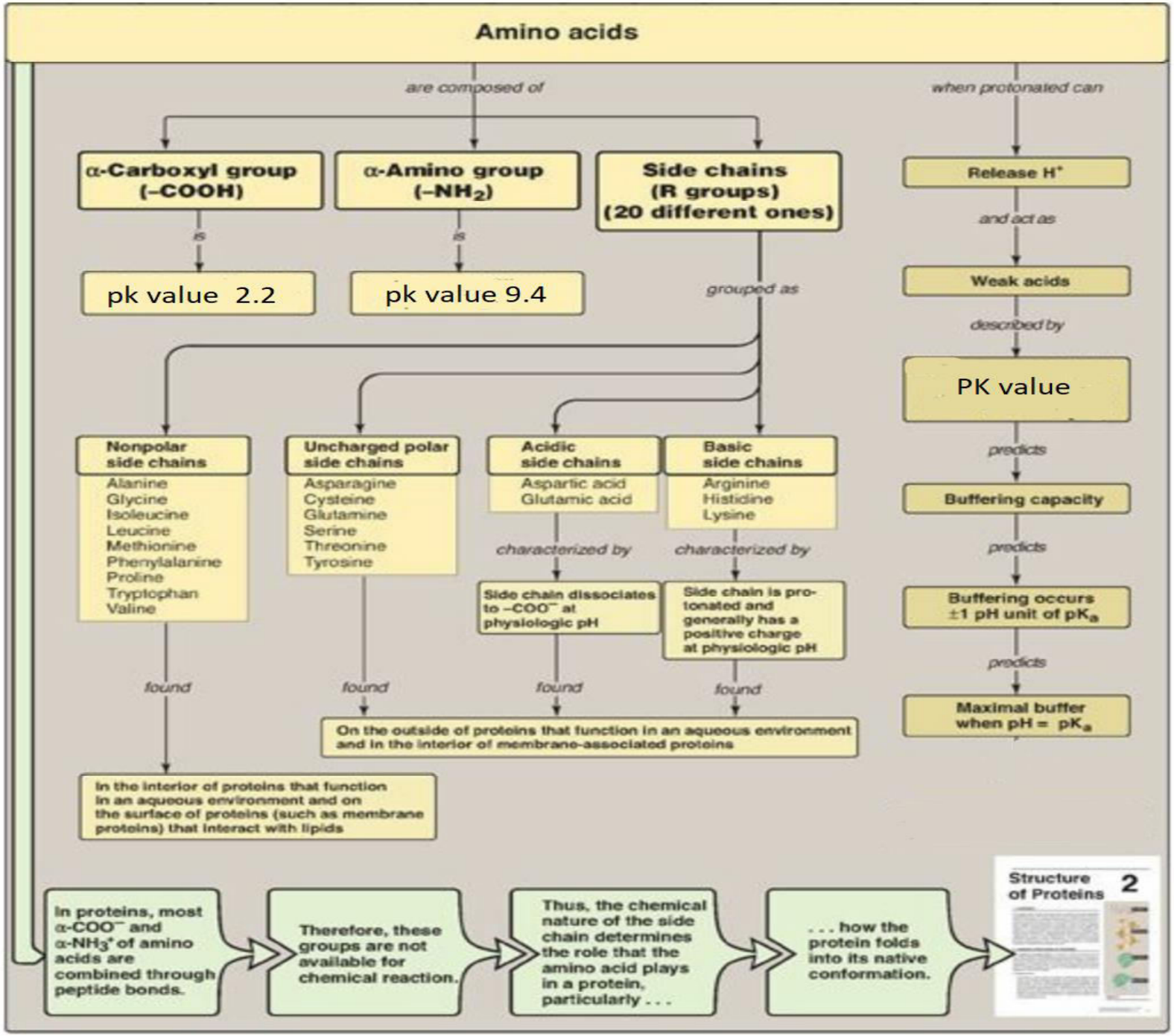
- These nonstandard amino acids are usually formed through modifications to standard amino acids.

Amino acids derivatives

	Gamma amino butyric acid (GABA)	Dopamine	thyroxine	Histamine
Derivative of:	Glutamic acid	Tyrosine		Histidine
Role	Neurotransmitter		An important thyroid hormone	the mediator of allergic reactions

Review

		ESSENTIAL	NON ESSENTIAL	CONDITIONAL
NON POLAR SIDE CHAINS		Isoleucine, Leucine, methionine, phenylalanine, tryptophan and valine.	alanine	Glycine, proline
UNCHARGED POLAR SIDE CHAINS		threonine	asparagine	Cysteine, glutamine, tyrosine and serine
POLAR SIDE CHAINS	ACIDIC	----------	Aspartic acid, glutamic acid	----------
	BASIC	Histidine, lysine	----------	arginine


Amino acids
are composed of
when protonated can
α-Carboxyl group (–COOH)
α-Amino group (–NH2)
Side chains (R groups) (20 different ones)
Release H+
and act as
is
is
pk value 2.2
pk value 9.4
grouped as
Weak acids
described by
PK value
Nonpolar side chains
Alanine
Glycine
Isoleucine
Leucine
Methionine
Phenylalanine
Proline
Tryptophan
Valine
Uncharged polar side chains
Asparagine
Cysteine
Glutamine
Serine
Threonine
Tyrosine
Acidic side chains
Aspartic acid
Glutamic acid
Basic side chains
Arginine
Histidine
Lysine
predicts
Buffering capacity
predicts
characterized by
characterized by
Side chain dissociates to –COO⁻ at physiologic pH
Side chain is protonated and generally has a positive charge at physiologic pH
Buffering occurs ±1 pH unit of pKa
predicts
found
found
found
found
Maximal buffer when pH = pKa
On the outside of proteins that function in an aqueous environment and in the interior of membrane-associated proteins
In the interior of proteins that function in an aqueous environment and on the surface of proteins (such as membrane proteins) that interact with lipids
In proteins, most α-COO⁻ and α-NH3+ of amino acids are combined through peptide bonds.
Therefore, these groups are not available for chemical reaction.
Thus, the chemical nature of the side chain determines the role that the amino acid plays in a protein, particularly . . .
. . . how the protein folds into its native conformation.
Structure of Proteins 2

Review

MCQs

Q1; Proline has a ..... amino group ?

A- Primary
B- secondary
C- tertiary

Q2: essential amino acid :

A- Leucine
B- asparagine
C- Cysteine

Q3: dopamine is a derivative from :

A- Tyrosine
B- glutamic acid
C-thyroxine

Q4: amino acid with basic side chain :

A- alanine
B- asparagine
C- arginine

Answer key:

1) B
2) A
3) A
4) C

SAQs

- Name three essential amino acid

.....,.....,.....

- name two uncharged amino acid

.....,.....

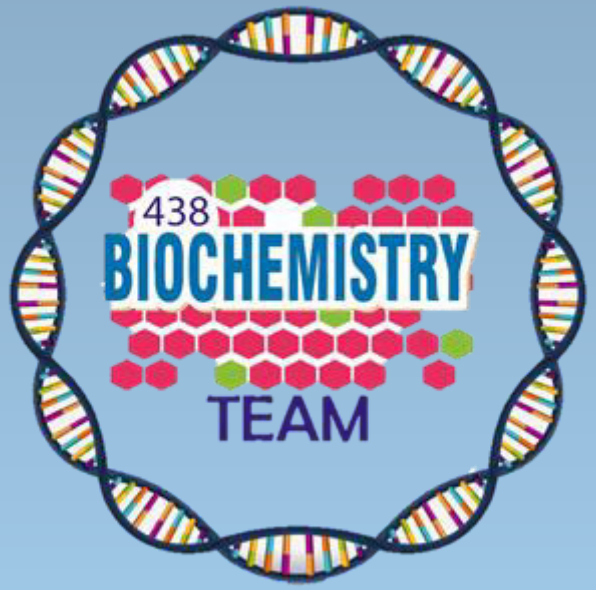
- Name the mediator of allergic reaction

.....

Answer key:

1) Isoleucine, Leucine, methionine
2) asparagine, threonine
3) Histamine

➢ Special thanks to:



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- غيداء البريثن
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