جامعة الملك سعود
King Saud University

Biochemistry team 436

AMINO ACIDS

- Color Index:

- Important.
- Extra Information.
- **Doctors slides.**

436 Biochemistry team

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.

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).

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 play central roles:**

A. The building blocks of proteins.

B. They play intermediates role in metabolism.

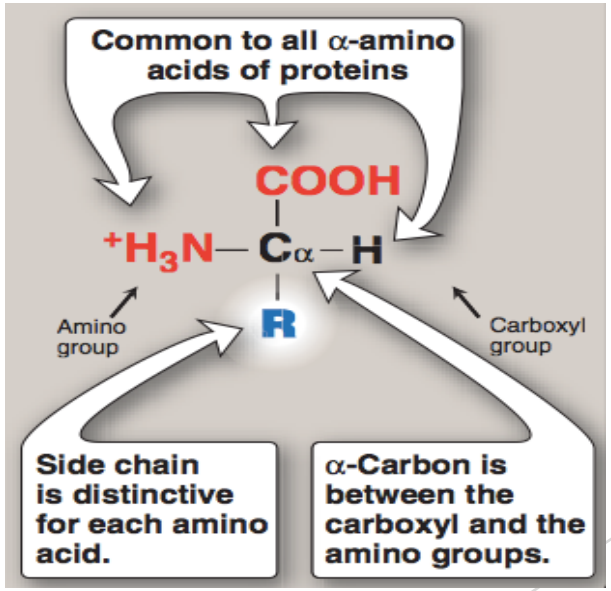
When proteins are digested or broken down amino acids are left.

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.



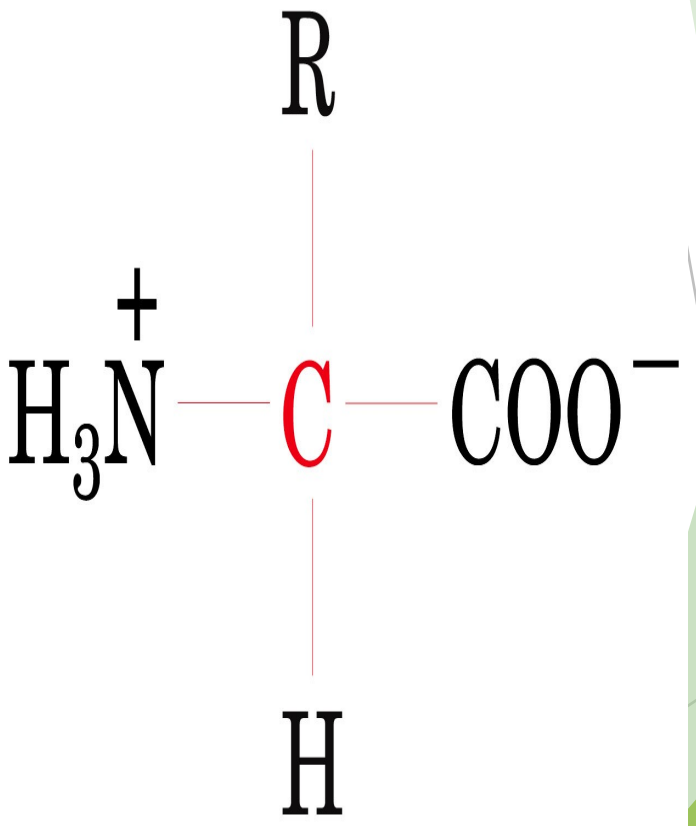
Isoelectric point (PI) and Zwitterion:

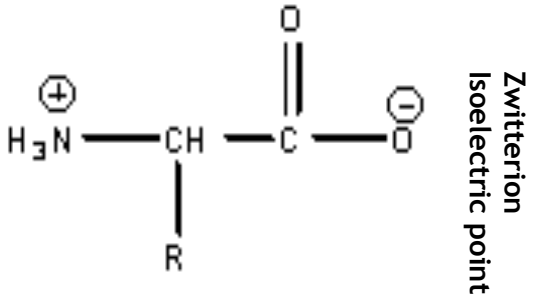
Zwitterions are neutral amino acid.

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

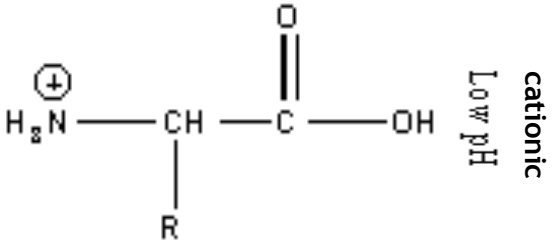
Unlike other compounds, zwitterions Simultaneously have both cationic and Anionic states.

- **The isoelectric point (PI):** is the pH at which the molecule carries no net charge.





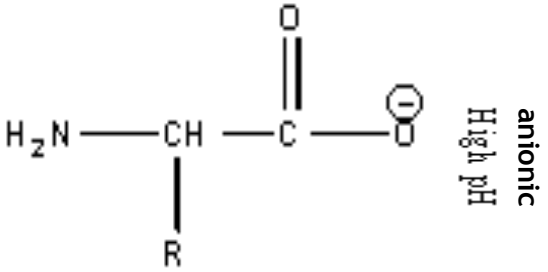
The molecule in its isoelectric point. If we put it in an acidic or a basic solution, what will happen?



- 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.**

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

PI and Zwitterion video

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.

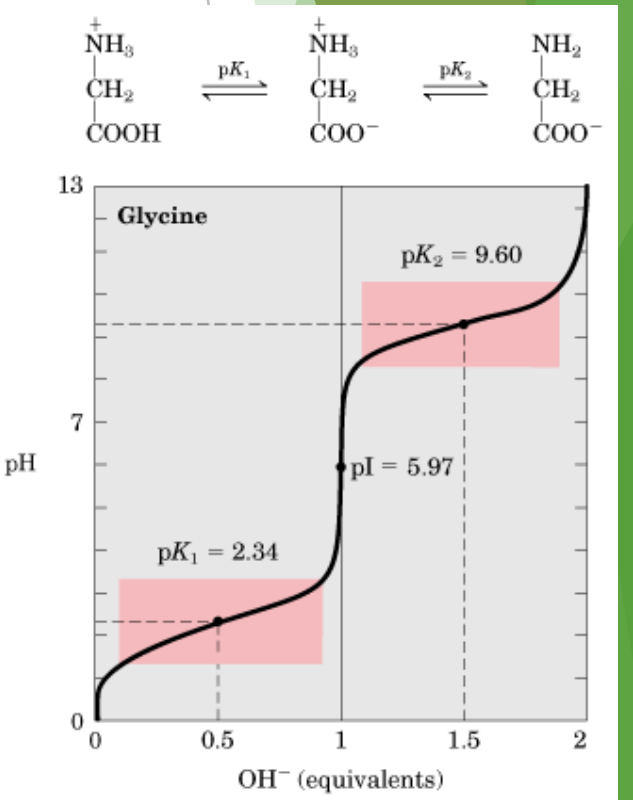
كلما قلت قيمة pK زادت حامضية المجموعة وقدرتها على منح المزيد من أيونات الهيدروجين.

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 it's 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

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



- Buffering action is maximum around pK values and minimum at PI.

dr. notes:

- 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 resists change in pH when an acid or base is added into it.

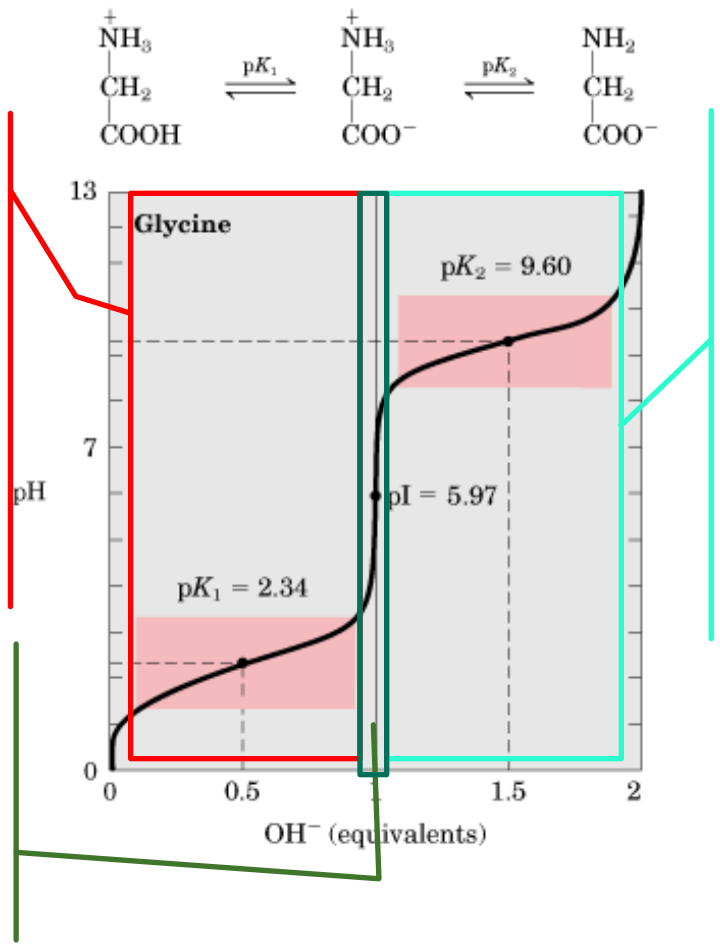
- At physiological pH, the a-carboxyl and a- amino groups are dissociated.

- All free amino acids and charged amino acids in peptide chains, can serve as buffers.

Titration curve of glycine

We are adding alkaline to the solution which means we are adding (OH-) to the solution. This will increase the ph value of the medium .

Since the COOH group in Glycine has lower pk value it will start donating its H proton to the medium first. at ph 2.3 , So it becomes COO and Zwitterion will formed.
At this stage (around pk value 1) the buffering will be at its max



When the ph value reaches a certain level (9.6) the ammonia group starts donating its H protons and becomes NH2.
At this point anionic formed.

The buffering hear is at its Max.

The buffering here is at its minimum

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

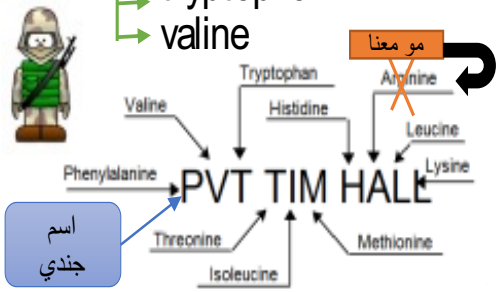
Glu Ala AsAs

* 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

- The side chain of the nonpolar amino acids tend to cluster together.

*تشبيه لتسهيل التذكر:

زي لما نحط الزيت مع الماء مايختلطون مع بعض, لما نخلطهم راح ينزل شوي من الزيت تحت على شكل كتل بعدين ترجع تتجمع مع بعض مثل اول.

Location of nonpolar amino acids in proteins

Location of protein?

- In protein found in aqueous solution (polar environment) → Interior of the protein. → Gives the protein its 3D shape.
- In protein located in hydrophobic region Such as membrane (non polar environment) → Outside surface of the protein. → interacting with lipid environment to Stabilize protein structure.

MED435 *تشبيه لتسهيل التذكر:

لمن تكون في *البروتينات التي تتواجد بوسط مائي* رح تكون خايفه من الماء لانها هي الوحيده النون بولر في ذاك المكان .. فتتجمع مع اخواتها النون بولر امينو اسيدز الباقيين ويتخبون ببيتهم البروتين .. فيعطون البيت هيبته وشكله الثالثي الابعاد.. فهو بالنسبه للماء بيت اشباح .

*تشبيه لتسهيل التذكر:

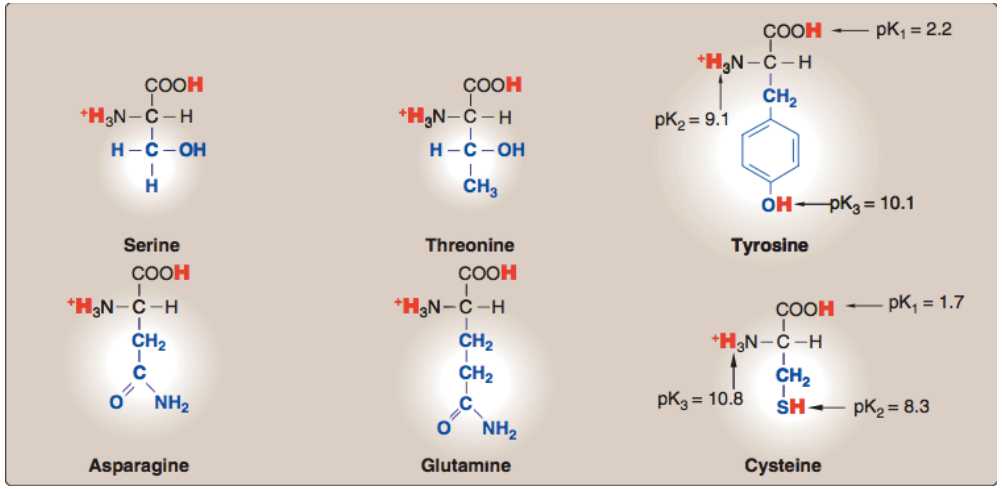
اذا كانت في وسط هايدروفوبيك فرح تحس بالامان لان كل الاشياء اللي حولها مثلها كلهم نون بولر .. بتطلع للسطح وللعالم الخارجي ورح تشارك في تثبيت تركيب البروتين .. لانها ماتبي ترجع للعالم المائي .

MED435

Uncharged polar amino acids

- Serine , Threonine and tyrosine **Contain** → Polar hydroxyl group

In an alkaline pH -> cysteine and tyrosine can lose a proton



- Side chain of asparagine and glutamine **Contain** → Carbonyl group + Amide group

Participate in hydrogen bonds

* الأسامي تُحفظ * الـ Structure حفتها غير مطلوبة مننا .

+ تحت اي تصنيف؟

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.

Mnemonics

- Non-polar

ProGAV PIL TM

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

, tryptophan, methionine

- Polar

"SomeTimes Cats Try A Growl"

serine, threonine, cysteine, tryrosine , asparagine, glutamine

- Charged

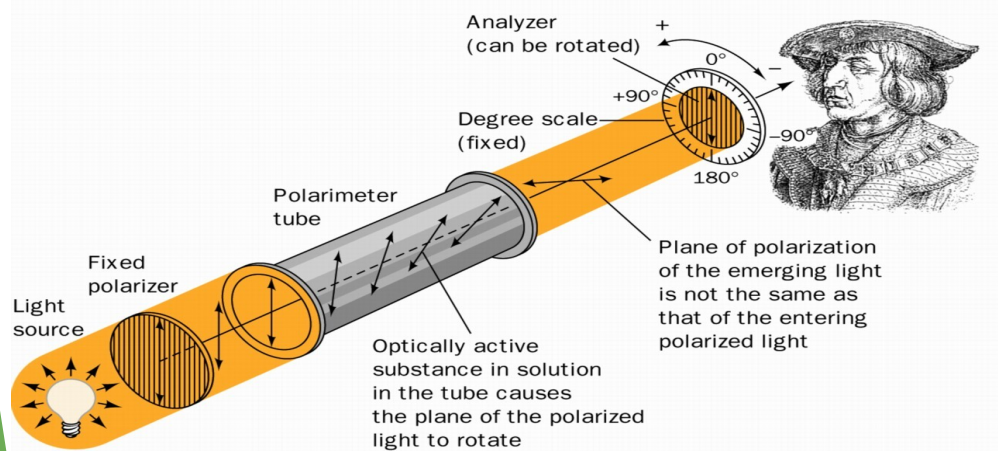
"A Good Lawyer Aims High"

Aspartate, Glutamate, Lysine, Arginine, Histidine

Optical properties

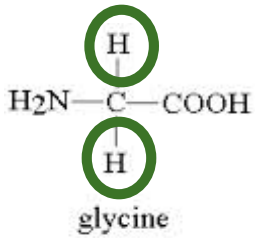
Asymmetric

- 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”

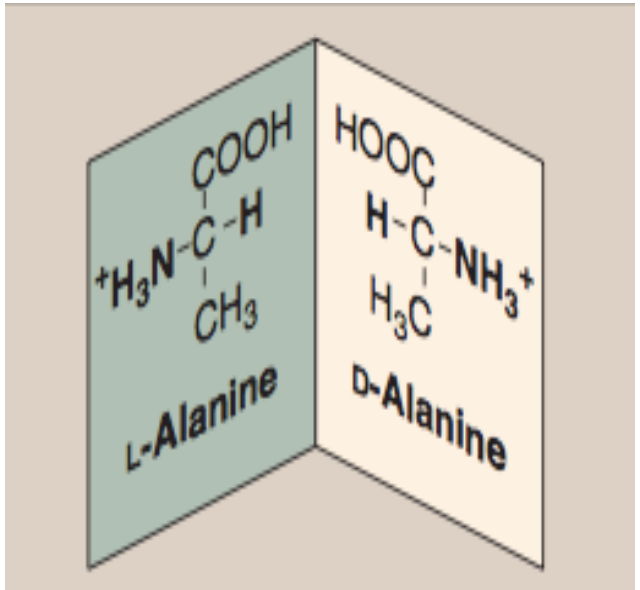


- symmetric molecules are optically inactive.

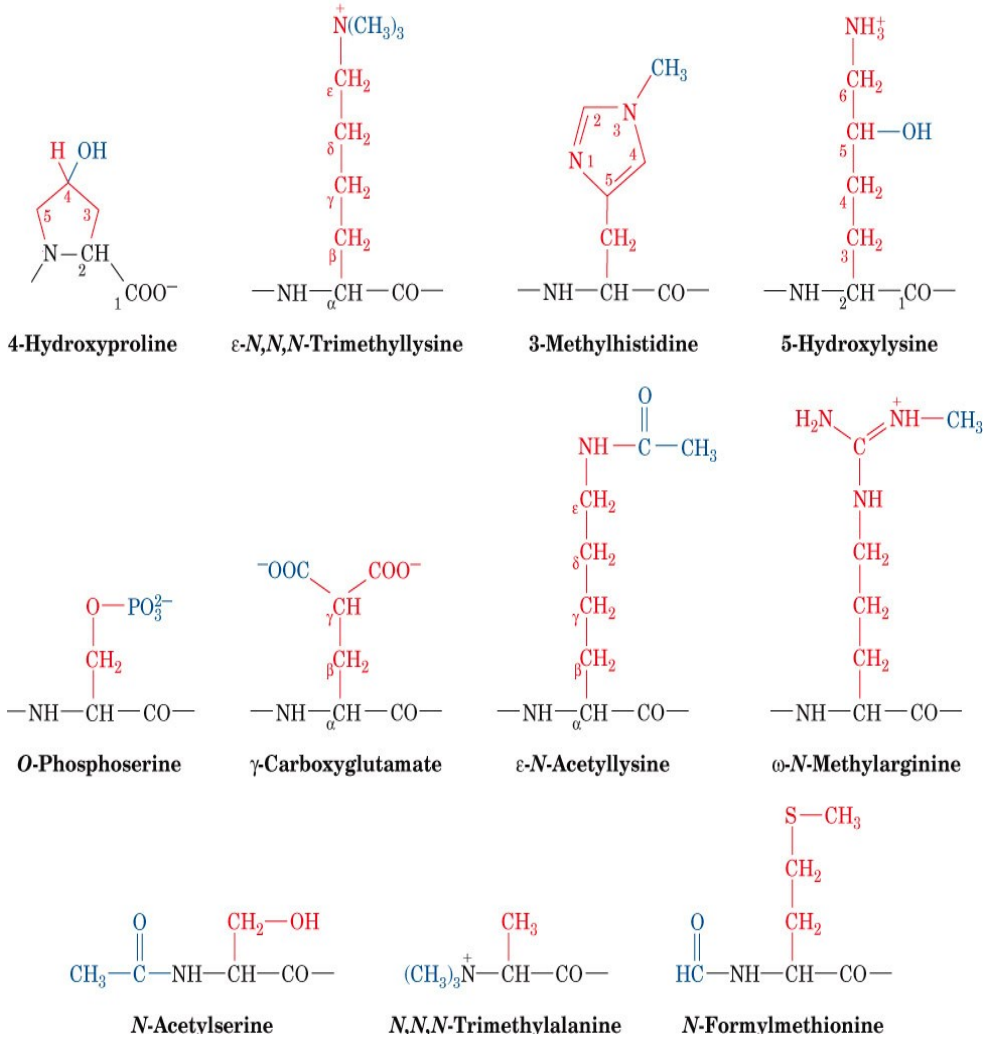
You don't have to memorize it just for better understanding

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

*you don't have to memorize the names.

Amino acids derivatives

Name	Derivative of	Role
•Gamma amino butyric acid (GABA)	•glutamic acid	•neurotransmitters
•Dopamine	•tyrosine	•neurotransmitters
•Histamine	•Histidine	•the mediator of allergic reactions
•Thyroxine	•Tyrosine	•An important thyroid hormone

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

MCQs + useful videos

- Proline has a ..... amino group ?

A) Primary B) secondary C) tertiary D) quaternary

*Proline is an imino acid

- Histamine derivative of ?

A) Glutamic acid B) tyrosine C) tyrosine D) histidine

- PK value
- Classification of amino acids
- Introduction to amino acids
- Isoelectric point and zwitterion

PI Calculation

	Formula	Example
neutral side chains:	**$pI = 1/2 (pKa_1 + pKa_2)$**	Glycine: pKa1= 2.34 and pKa2= 9.6 ----> pI= 5.97
acidic side chains	**$pI = 1/2 (pKa_1 + pKa_3)$**	Aspartic acid: pKa1= 1.88, pka3=3.65 pKa2= 9.68 ----> pI= 2.77
basic side chains	**$pI = 1/2 (pKa_2 + pKa_3)$**	Histidine: pKa1= 1.82, pka3=9.17 pKa2= 6.00 ----> pI= 7.59

Lowest two pKa

Highest two pKa

More details about pI calculation:
http://www.mhhe.com/physsci/chemistry/carey5e/Ch27/ch27-1-4.html

Girls team members:

1- أسيل السليماني.
2- روان الوادعي.
3- ريم السرجاني.
4- ربا آل سالم.
5- سارة الشمراني.
6- سمية الغامدي.
7- شهد السويدان.
8- لجين الزيد.
9- منيرة الضفيّان.

Boys team members:

1- عبدالعزيز الشديد.
2- فهد العتيبي.
3- محمد حبيب.
4- محمد العسيري.
5- محمد المهوس.
6- هشام القوسي.
7- حاتم النداح.

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