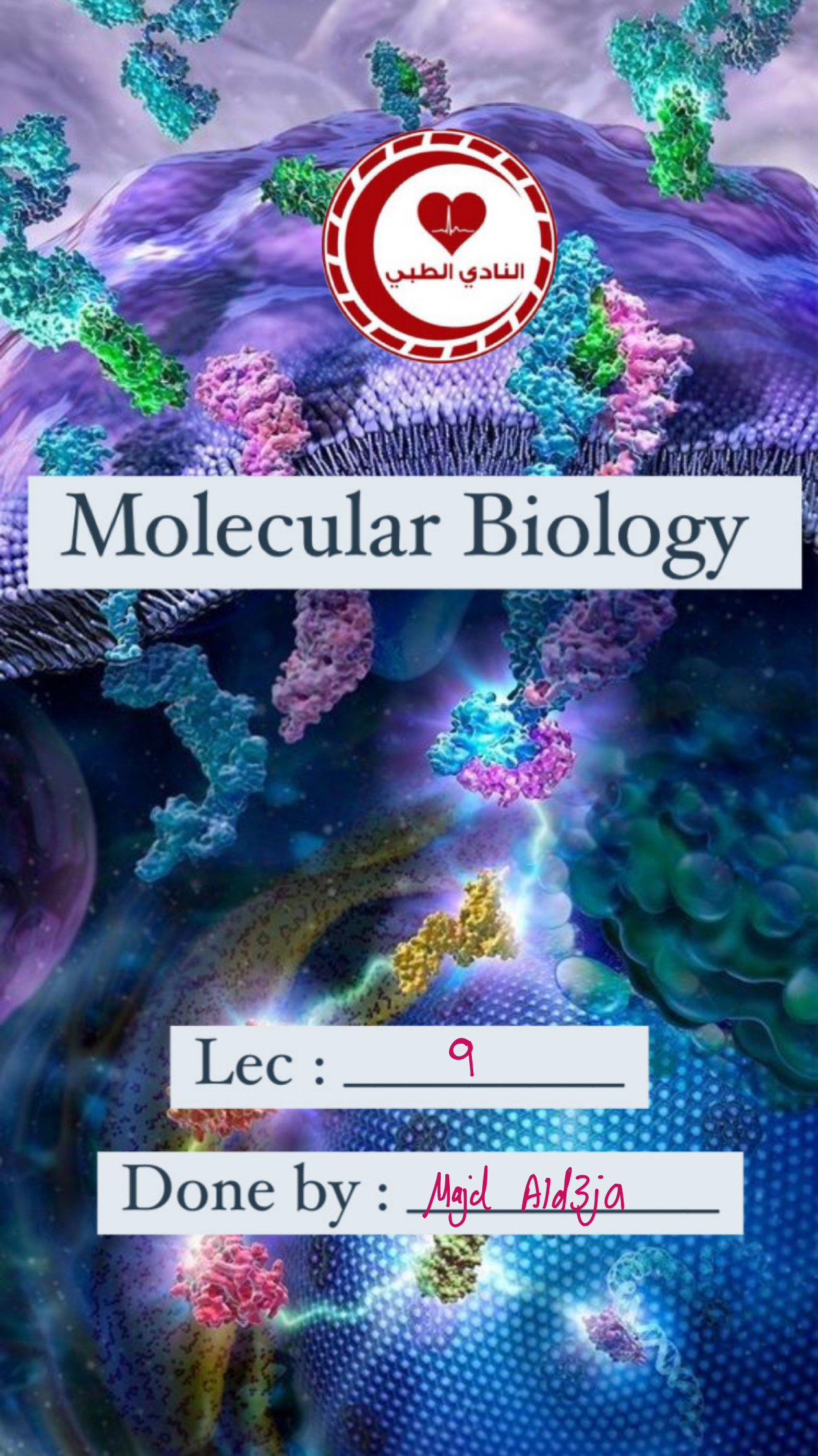


Molecular Biology

Lec : 9

Done by : Majd Aldaja

CLASSIFICATION OF AMINO ACIDS

Nebras Melhem

رح نحكي بهاد الشابتر عن 3 شغلات

Proteins

Peptides ← الوحدة البنائية للبروتين

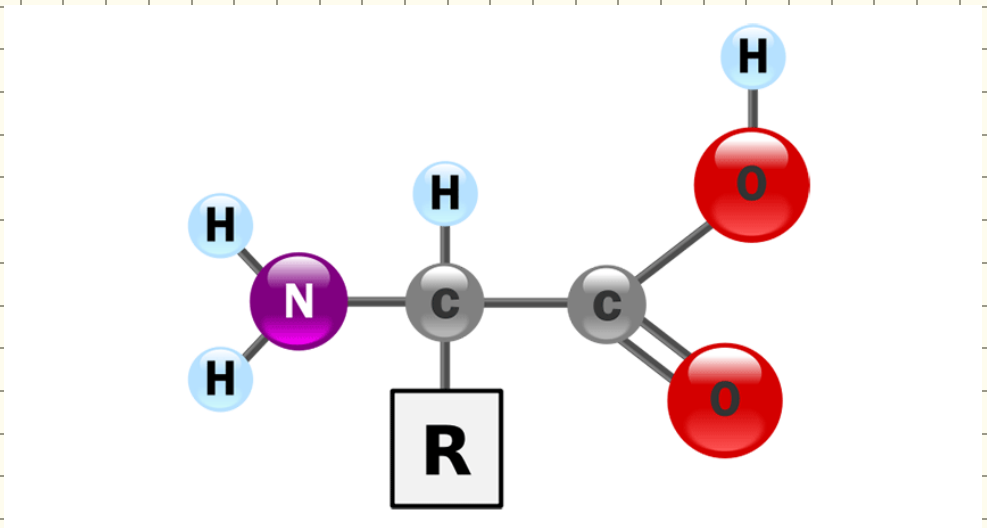
Amino Acids ← الوحدة البنائية للببتايد

Amino Acid

NH_2 ← amino

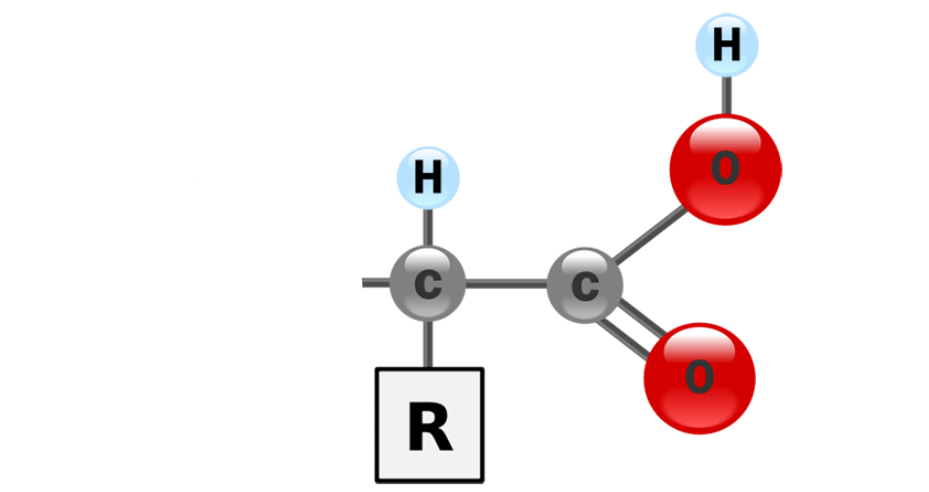
الحمض الكربوكسيلي ← $-C(=O)OH$

طيب أنا بدي اربطهم مع بعض الحمض مع ال amino بروح اجيب كربونة بتعمل رابطتين معها بنقصها رابطتين ف بشبعها بH أو ممكن H و R

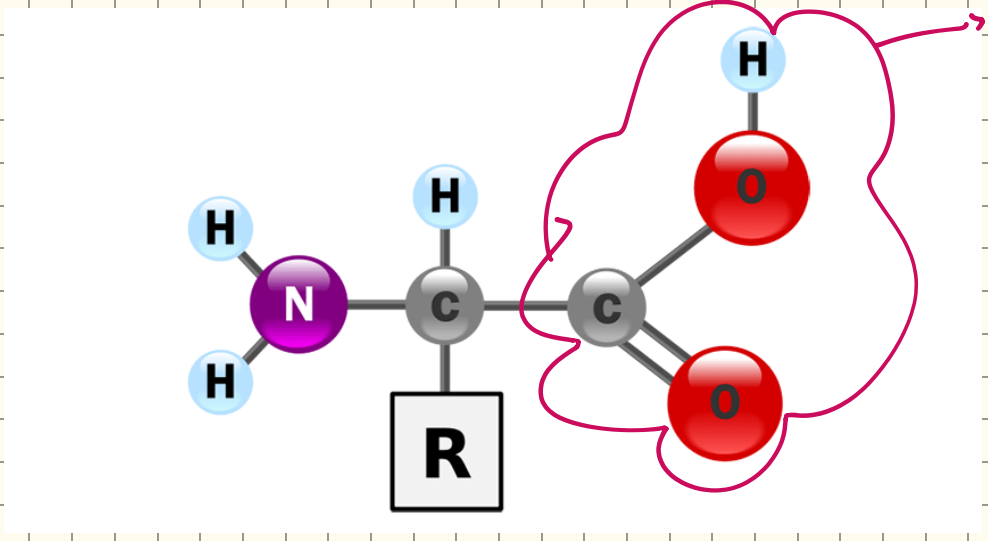


هاد الشق بذكرنا بال Fatty acids معناها

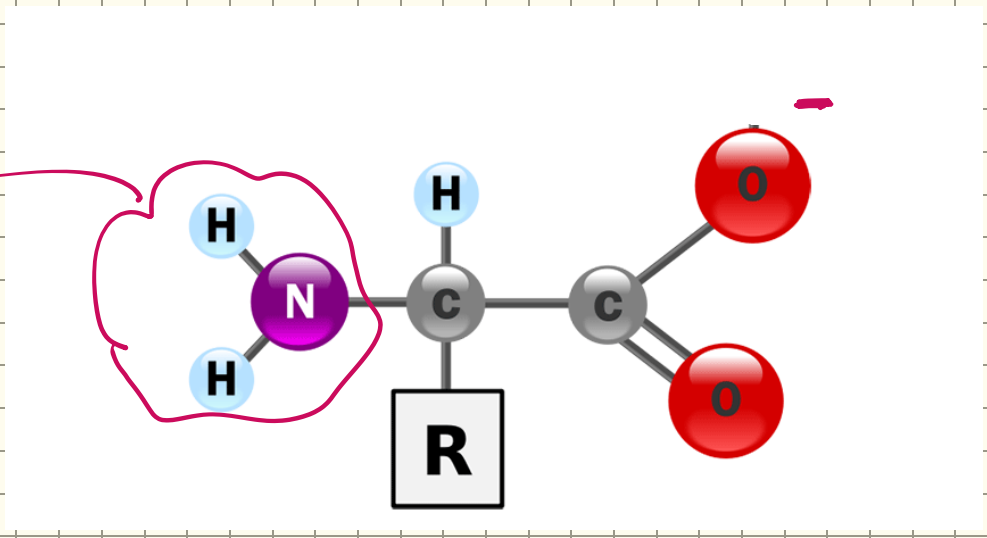
Amino acids = fatty acids + amino



بدنا نتذكر بعض المصطلحات

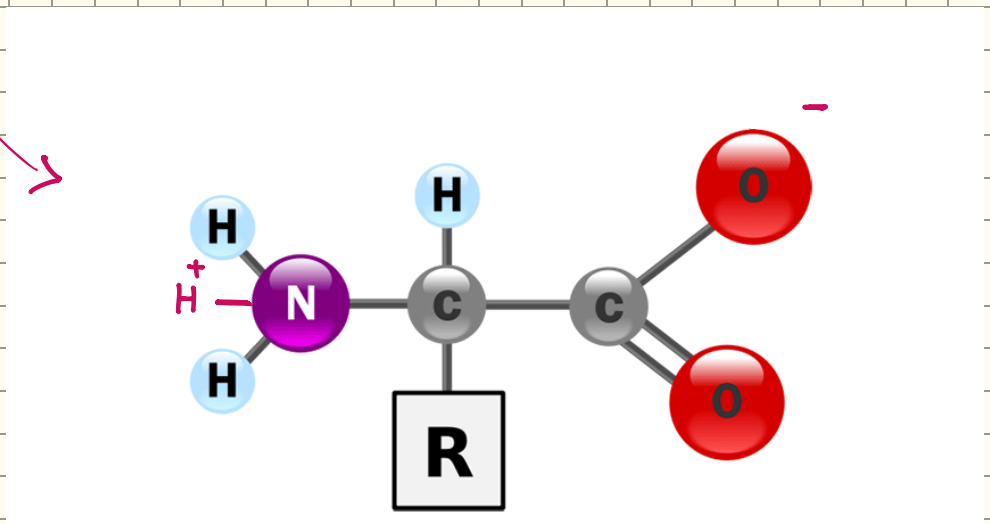


الحمض يعني رح يمنح H^+



القاعدة وهكذا رح تستقبل H^+

ورح تصير شحنة الحمض سالبة



هل نعتبرها asymmetric carbon atom ؟ نعم نعتبرها لأنه حواليها أربع مجموعات مختلفة

طيب معناها رح تعطيني optical activity الي همه L / D

هون رح أتفرج على مجموعة الأمينو المرتبطة بالكربون هل هي للشمال أو لليمين و احنا الي بجسمنا بتكون L amino acids و بالتحديد L الفا amino acid

يعني رح نعتمد طريقة التسمية الي تحتوي على الفا و بيتا

طبعًا المخطط بس الي شرحته الدكتورة

Introduction

Protein: Organic compounds with high molecular weight formed from amino acids

- Composed of carbon, hydrogen, oxygen, nitrogen +/- sulphur
- Nitrogen forms appx 16% of their weight (characteristic for proteins)

Besides water, proteins are the most abundant molecules in all known forms of life. Proteins are the most diverse class of biological molecules, making up everything from enzymes and hormones to antibodies.

- About 70% of your body weight is water, and about 17% is protein.

Introduction

Amino acids participate in the biosynthesis of:

- Purines → DNA
- Pyrimidines → DNA
- Urea

AA form peptides (2-50 amino acids) which have a roles as:

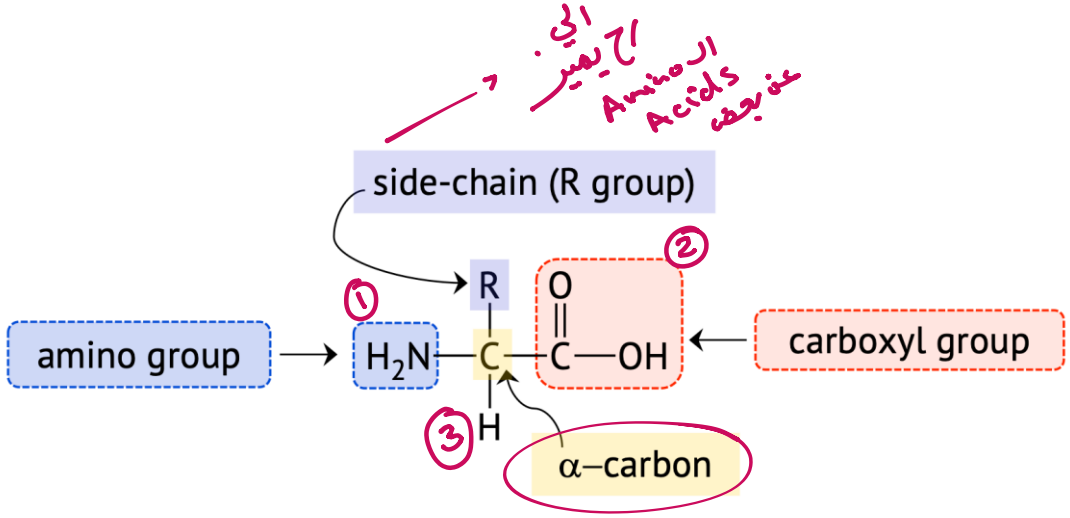
- Hormones
- Neurotransmitters → glutamate / Histidine —(a. acid)→ Histamine

AA form proteins (>50 amino acids) which have a roles as:

- Plasma membrane
- Hormones
- Enzymes

General Structure of Amino Acids

- All amino acids have a central carbon atom attached to a carboxyl group, an amino group, and a hydrogen atom.



- The amino acids differ from one another only in the chemical nature of the side chain (R).

* 500 Amino Acids → في الطبيعة

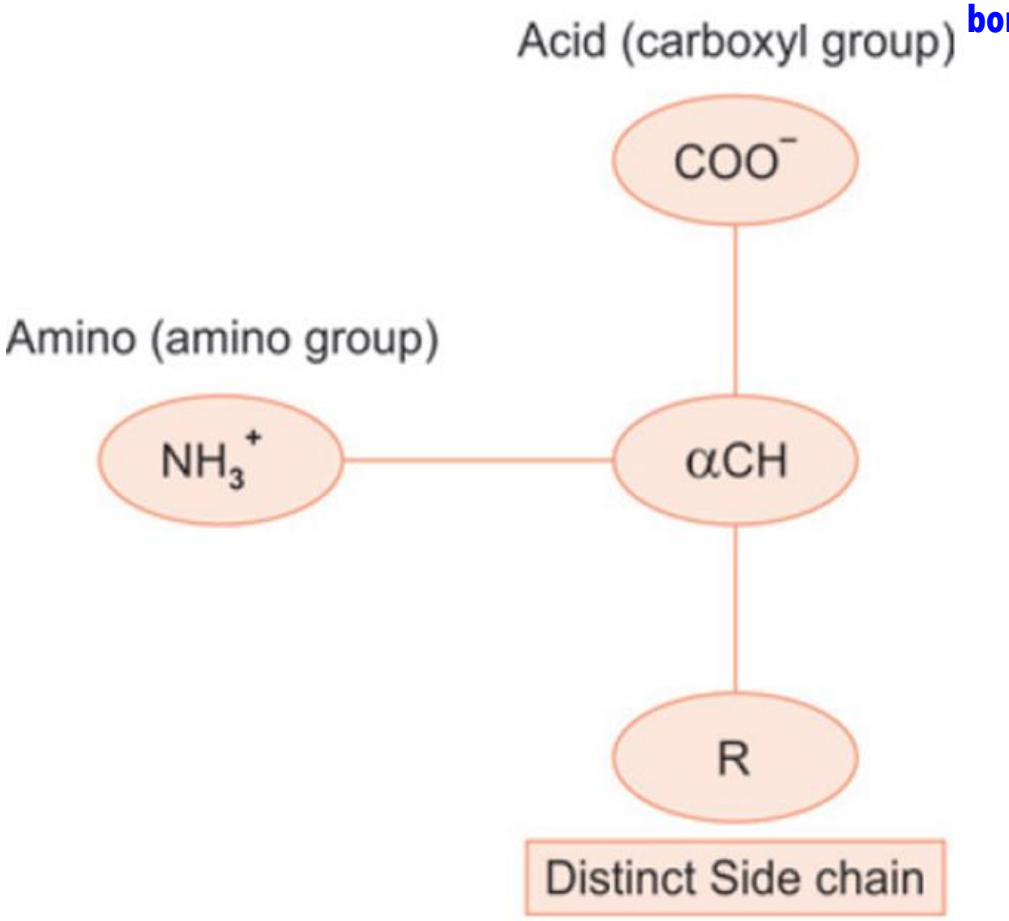
- There are hundreds of amino acids in nature, but only 20 are used as building blocks of proteins in humans.

→ 21st → Seleno cystine → بعض العلماء ذكرته وبعض لا

بدنا نركز هون إذا الside chain كانت بس فيها كربون و هيدروجين بتكون Aliphatic يعني
Electronegativity تقريبا متشابهة وهيك بكون non polar و بكون hydrophobic ما بقدر يعمل
Hydrogen bonds
لكن إذا ال side chain بحتوي على groups غير الكربون و الهيدروجين ف الElectronegativity بتكون
غير و هيك بتكون polar amino acids و بهاي الحالة بتقدر انه تتفاعل مع المي و تكون hydrogen
bonds

General Structure of Amino Acids

- The R group is the only part of an amino acid's structure that varies from one to the other; the other parts of the structure are common to all of them.
- R groups are aliphatic when they contain only carbons and hydrogens, which are so similar in electronegativity that they are **nonpolar**—meaning they are **hydrophobic** or can't make hydrogen bonds with water and therefore avoid it.
- Other R groups contain other atoms and can ionize or make hydrogen bonds, so these are **hydrophilic**—they like water.

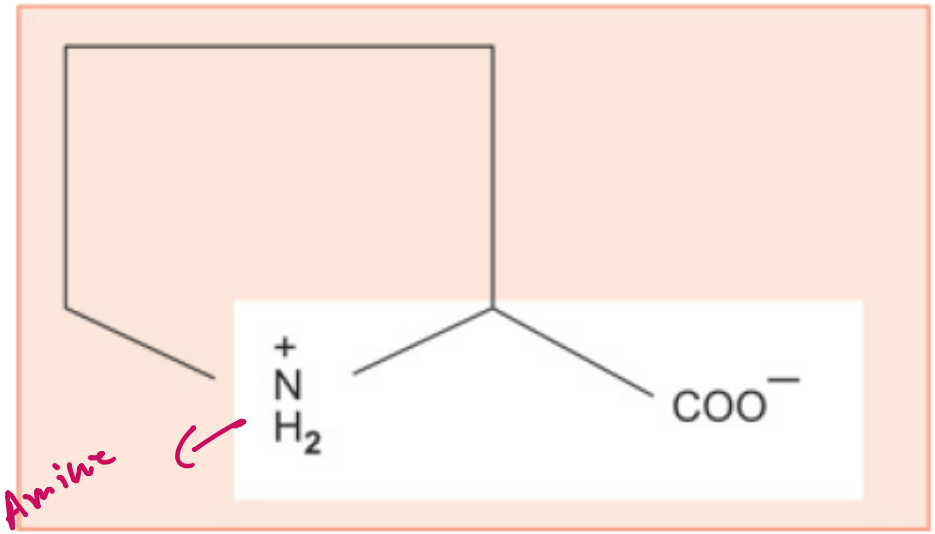


General structure of alpha amino acid

Imino Acid

It is a molecule that contains both Imine (carbon double bonded with NH + carboxyl group)

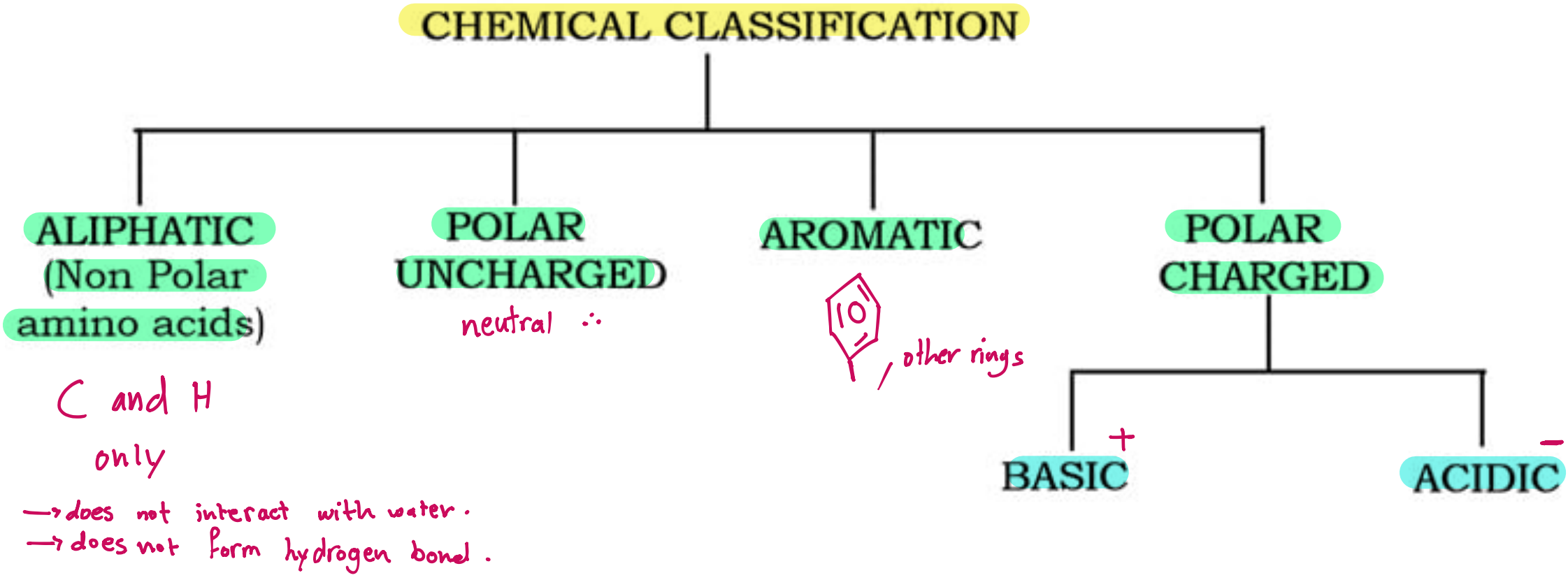
- Amino acid group not free
- The nitrogen of amino group is seen inside the ring
- **Proline** is an imino acid



Structure of imino acid

BASED ON CHEMICAL CLASSIFICATION

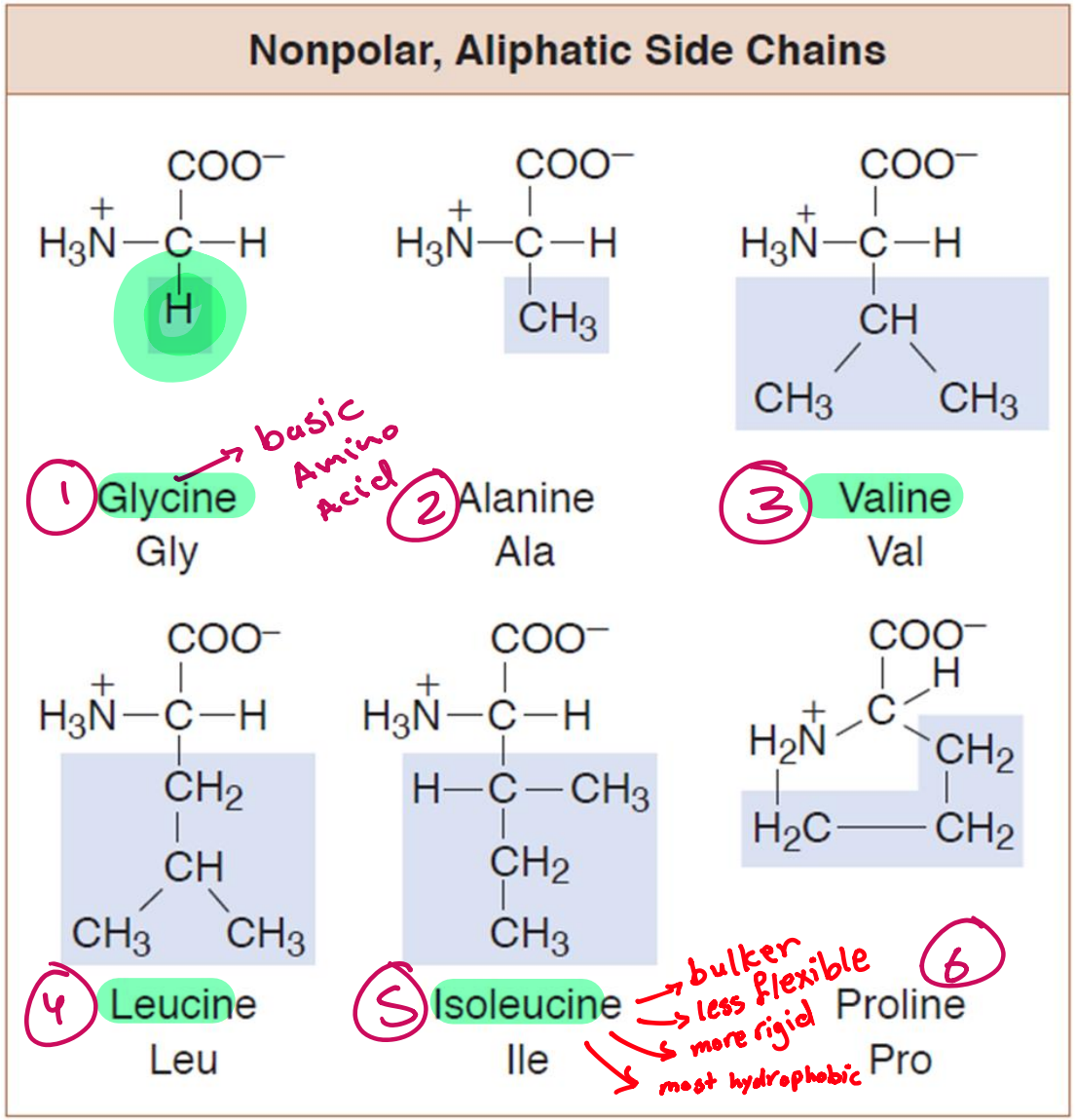
متل ما قلنا الاختلاف الوحيد بالAmino Acids هو ال side chains



١

Non-Polar Aliphatic Side Chain

- **Hydrophobic amino acids**, which have R groups that mostly contain carbons and hydrogens, include glycine, alanine, valine, leucine, isoleucine & proline.
- The degree of **hydrophobicity increases steadily from glycine to isoleucine** as the R groups increase in size and complexity.



structure تركيب

* Valine / Leucine / Isoleucine → branched chain amino acids

↳ essential amino acids → our body can not produce them

Polar Uncharged R groups

رح نلاقي بال side chain غير C و H متل ال OH group

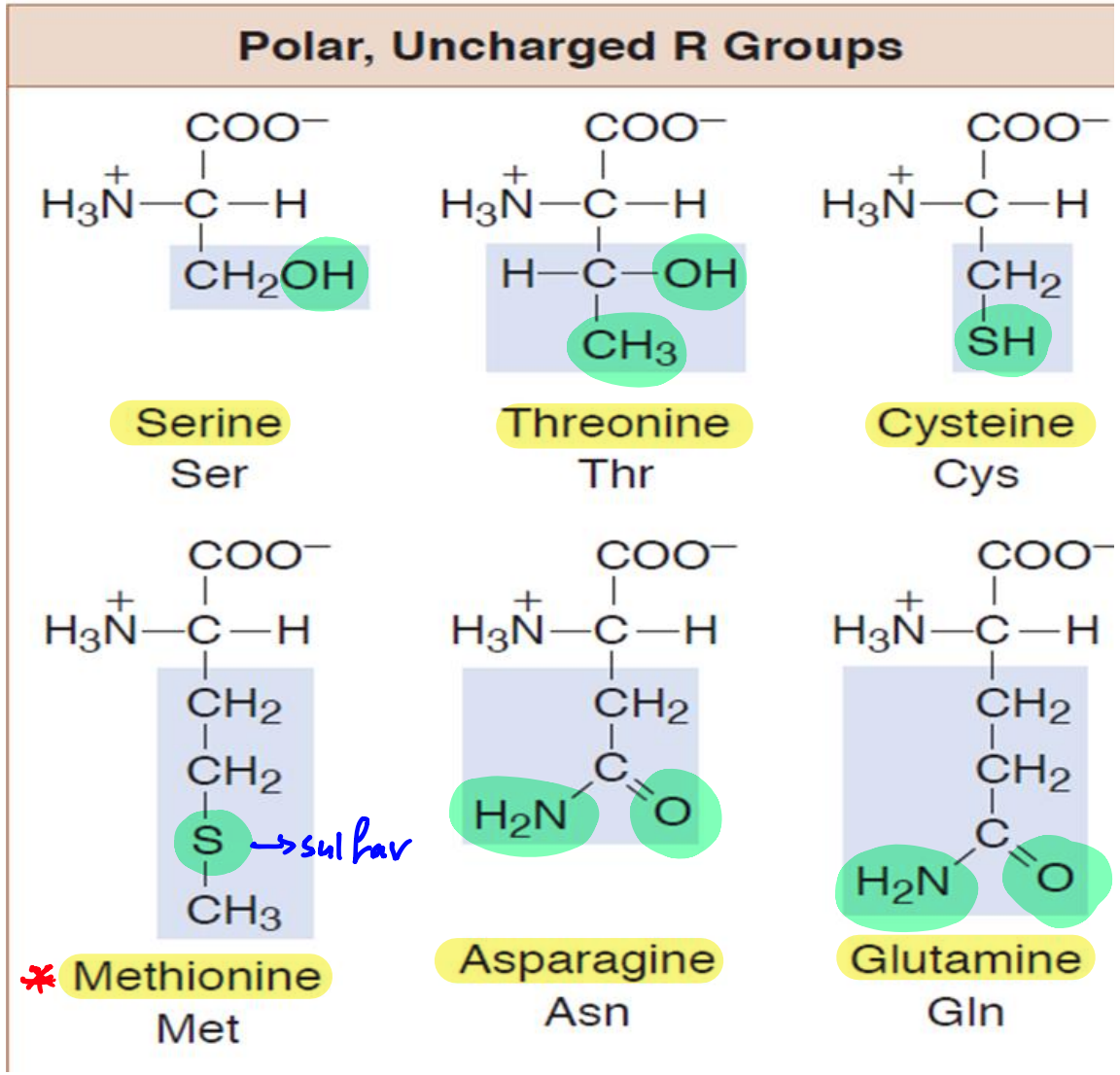
More soluble in water than the non-polar aliphatic group.

Their (R) groups contain **neutral polar functional groups**, which form hydrogen bonds with water.

1- Serine, threonine (contain hydroxyl group)

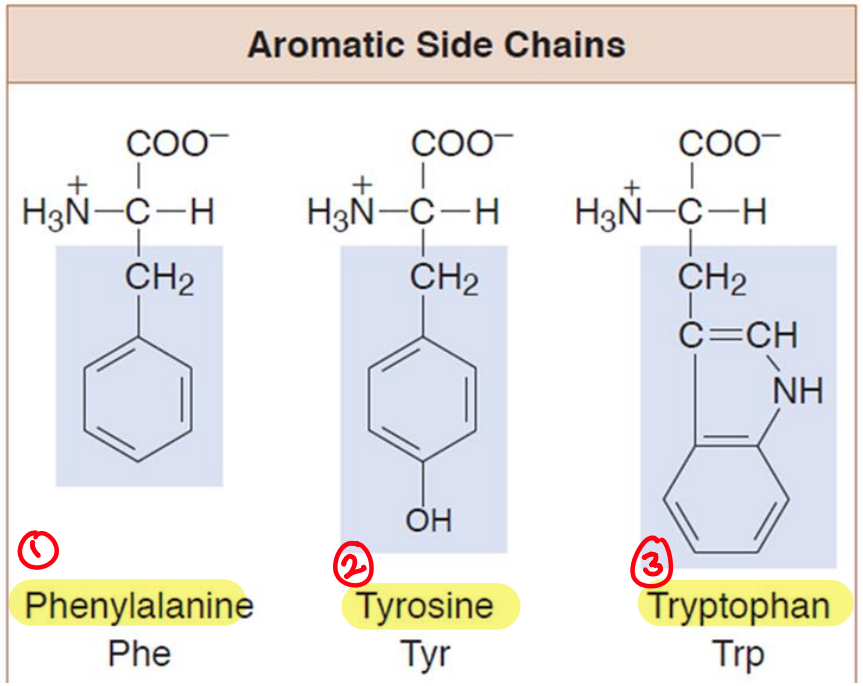
2- Cysteine (contains thiol group)

3- Asparagine and glutamine (contain amide group)



معلومة مهمة جدًا انه الMethionine انه احنا خليناه مع الpolar group لانه يحتوي على sulfar لكن هو بالحقيقة (من وجهه نظر biochemistry) non polar هو hydrophobic لأنه الside chain فيها sulfar had the same electronegativity as carbon

Aromatic Side Chains



نفس الأول بس اضافة الو OH

- A subgroup of the hydrophobic amino acids is the aromatic amino acids, named for the large and quite stable aromatic ring structures in their side chains.
- **Phenylalanine**, is a phenyl ring of 6 carbons attached to an alanine. The R group is hydrophobic. It exhibits some properties of hydrophilic amino acids, but the ring makes it also hydrophobic.
- The largest hydrophobic amino acid is **tryptophan**, which has an R group of 9 carbons and 1 nitrogen in a structure known as an **indole ring**. *Tryptophan is also a component of the neurotransmitter serotonin.*

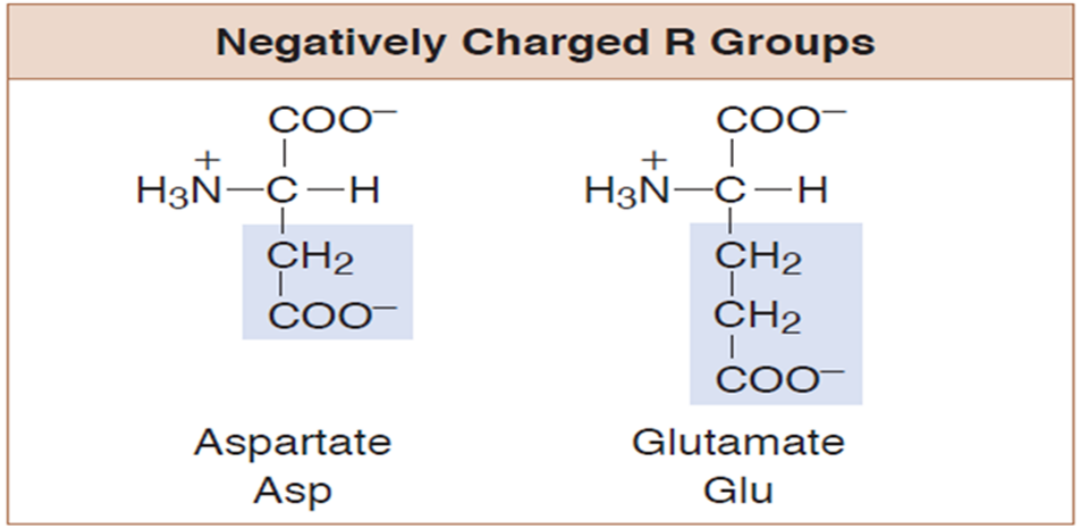
Benzene ring مرتبط مع hypo ring

الTryptophan بمر ب pathway معينة و بصنع من Tryptophan ناقل عصبي هو serotonin

Negatively Charged R Groups

- The acidic amino acids contain carboxyls in their R groups—**aspartic acid** and **glutamic acid**. Ionized forms of these are called aspartate and glutamate.

- Both aspartate and glutamate help cells use protein as an energy source when supplies of sugar run low or when a person goes on a low-carbohydrate diet. In cells, aspartate and glutamate are important in managing ammonia (NH3), a toxic by-product of metabolism.



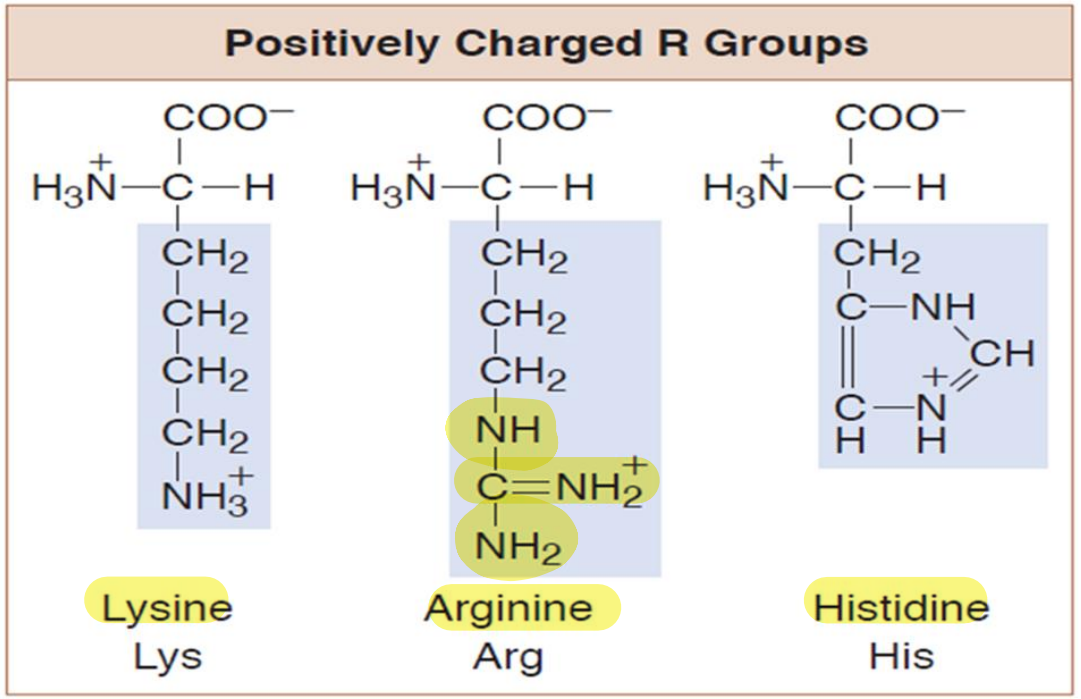
Alanine بس مرتبط فيه OH

Very important neurotransmitter

Positively Charged R Groups

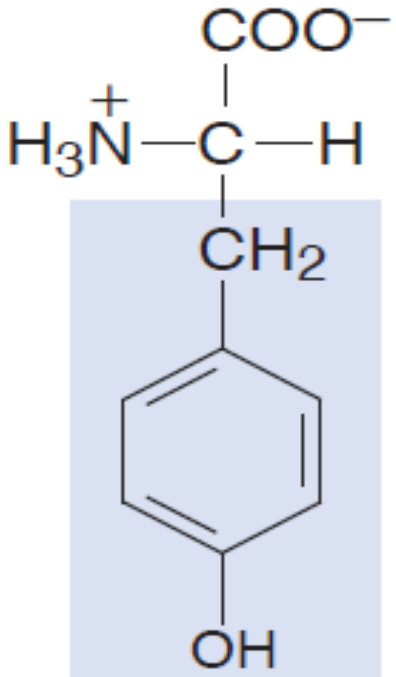
Polar

- The 3 basic amino acids—lysine, histidine, and arginine—are called basic because their R groups accept protons at physiological pH, giving them positively charged R groups.
- **Arginine** plays an important role in the urea cycle as the source of urea – (Guanidine group).
- **Histidine** is important in many enzymes and in the blood proteins myoglobin and hemoglobin.

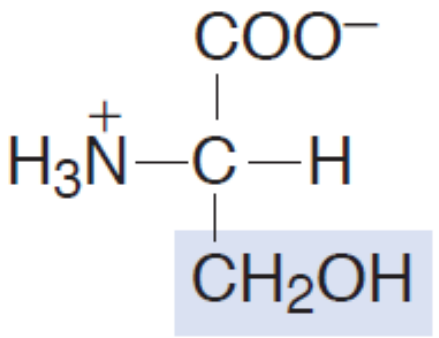


Has a role in neurotransmitter , can convert to Histamine

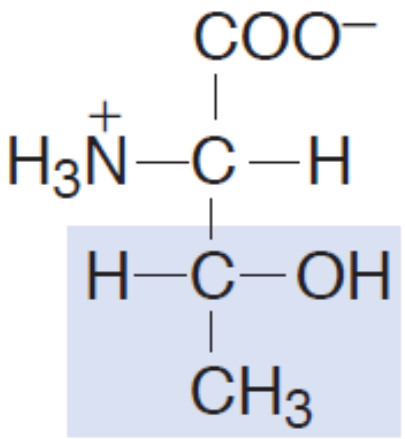
Amino Acids with Hydroxyl Group



Tyrosine
Tyr

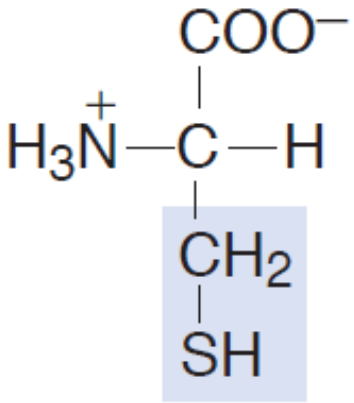


Serine
Ser



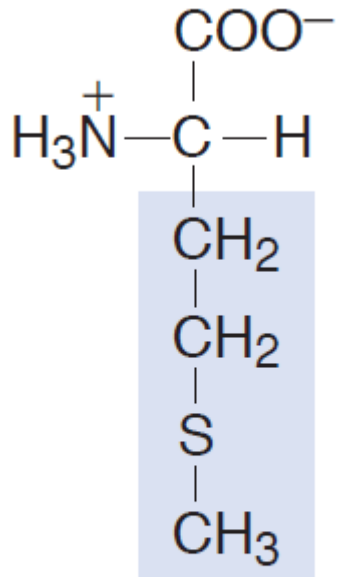
Threonine
Thr

Amino Acids with Sulfur



Cysteine

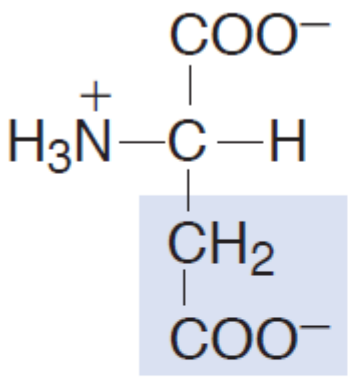
Cys



Methionine

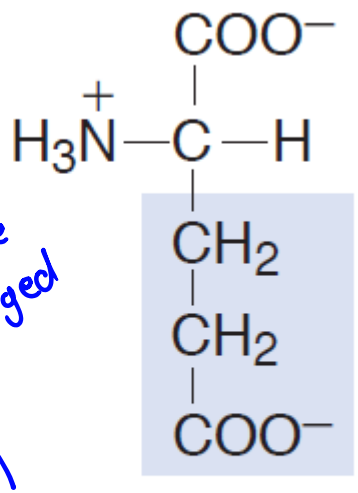
Met

Amino Acid with Amide Group



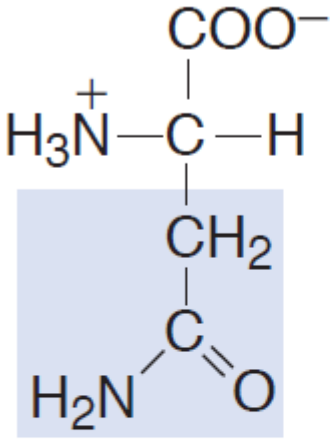
Aspartate
Asp

negative charged

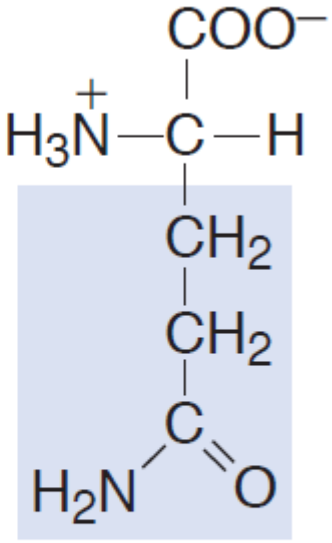


Glutamate
Glu

→ neuro transmitter
→ does not cross the BBB (Blood Brain Barrier)



Asparagine
Asn



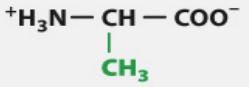
Glutamine
Gln

cross the BBB
بقدر أحوله عن طريق انزيم في brain إل glutamate

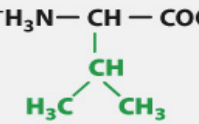
Enzyme → glutaminase

Contain carboxylic acid

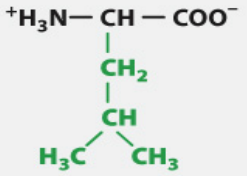
HYDROPHOBIC AMINO ACIDS



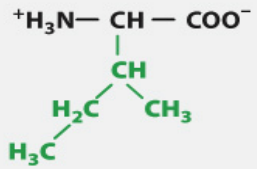
Alanine
(Ala, A)



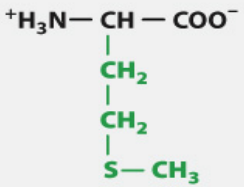
Valine
(Val, V)



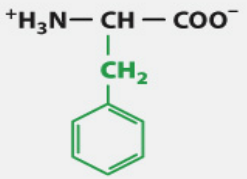
Leucine
(Leu, L)



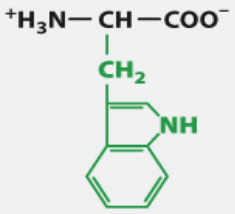
Isoleucine
(Ile, I)



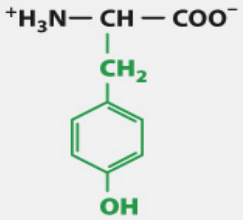
Methionine
(Met, M)



Phenylalanine
(Phe, F)

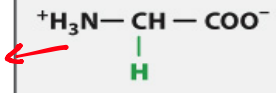


Tryptophan
(Trp, W)

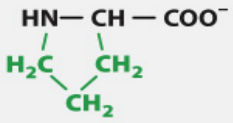


Tyrosine
(Tyr, Y)

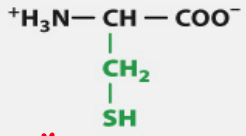
SPECIAL AMINO ACIDS



* Glycine
(Gly, G)



* Proline
(Pro, P)



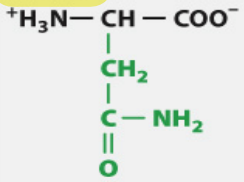
* Cysteine
(Cys, C)

It does not have stereoisomer

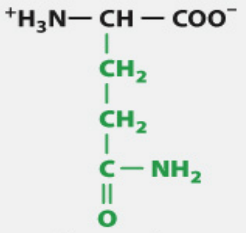
Imino Acid

HYDROPHILIC AMINO ACIDS

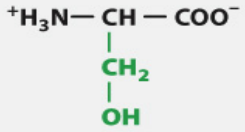
Polar



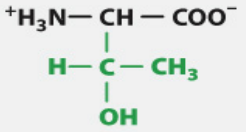
Asparagine
(Asn, N)



Glutamine
(Gln, Q)

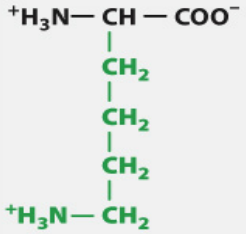


Serine
(Ser, S)

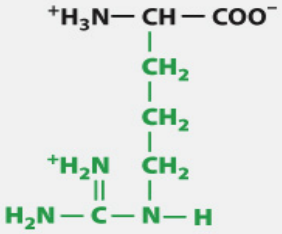


Threonine
(Thr, T)

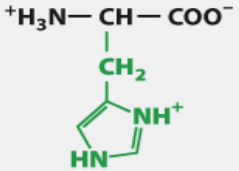
Basic



Lysine
(Lys, K)

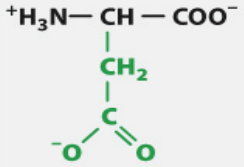


Arginine
(Arg, R)

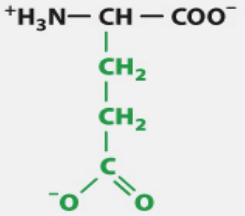


Histidine
(His, H)

Acidic

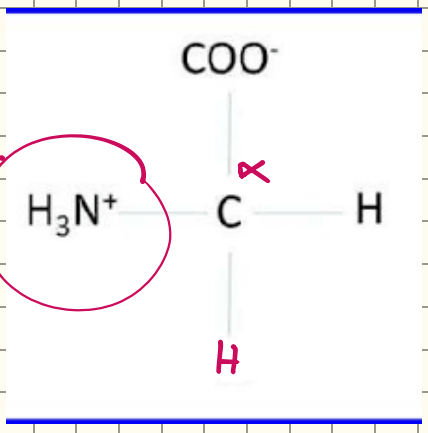


Aspartic acid
(Asp, D)



Glutamic acid
(Glu, E)

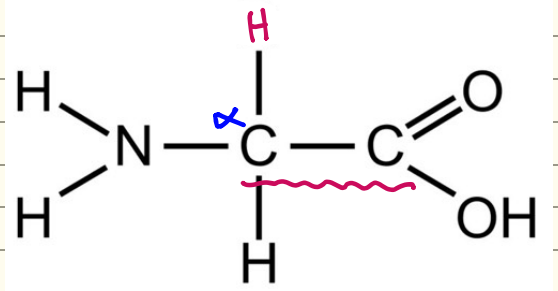
طيب Amino acids الموجودين في جسمنا عبارة عن L الفا amino acid لانو
رح نلاقي مجموعة الamino على الشمال



L-α- Amino Acid

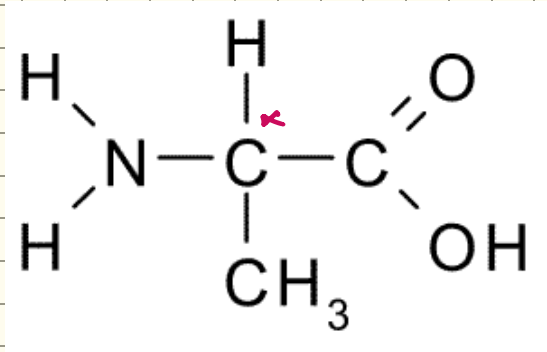
💗 Amino acids 20 في جسم الإنسان عنا

💗



طيب لما نيجي نتفرج أقصر سلسلة ممكون إنها تتكون من كربونتين ف
هاد ابسط Amino acid

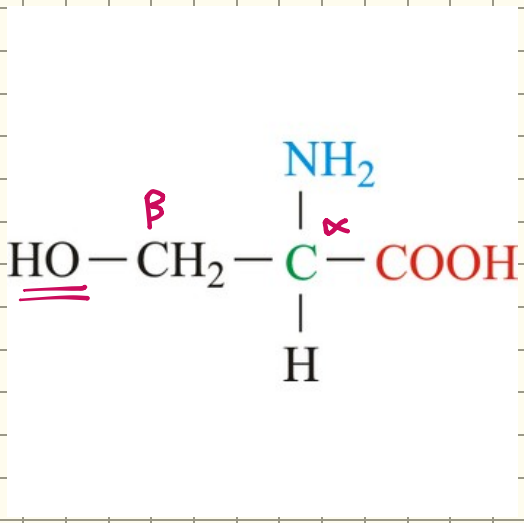
Common name ← Glycin ← لـ



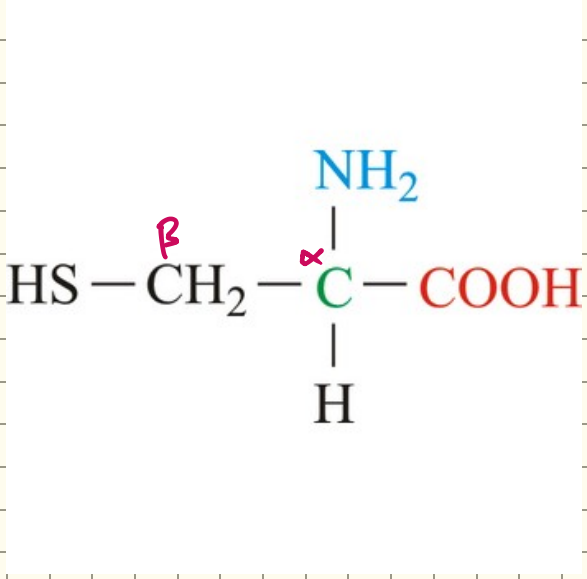
* common name ⟶ Alanine

لو ضفنا ل Alanine مجموعة OH رح نضيفها على
الكربونة التالتة عند C بيتا

Serine

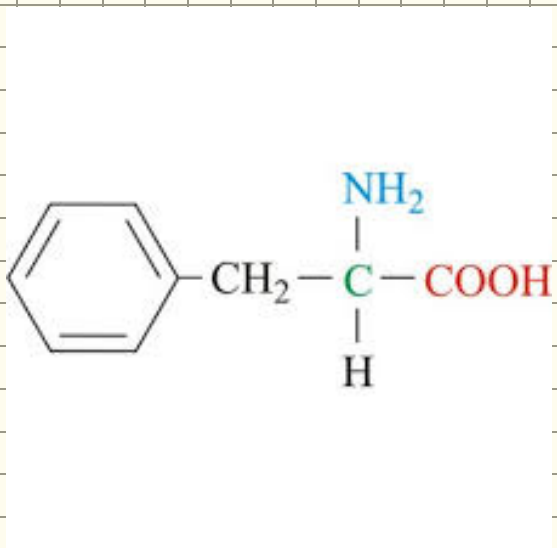


في عنا مجموعة اسمها Thiol هي SH
ف أنا جبت Alanine و ضفت الSH



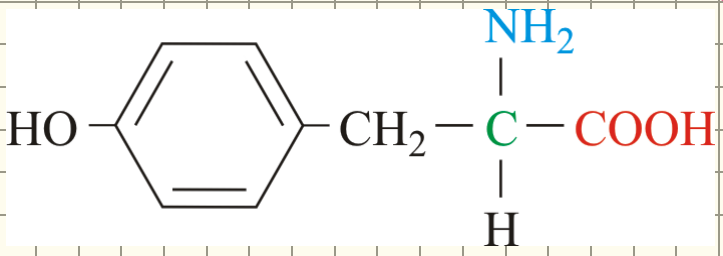
* common name ⟶ cysteine

طيب لو جبت Alanine و ضفت عليه حلقة
بنزين رح يكون اسمه Phenylalanine



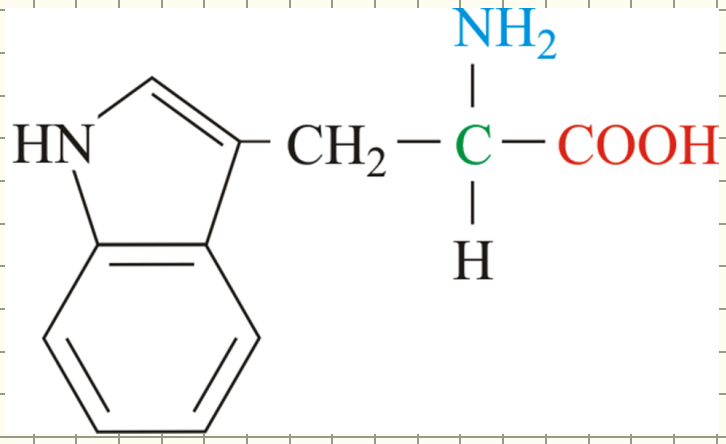
طيب لو ضفت phenol حلقة بنزين عليها OH بصير اسمه

Tyrosine أو Phenolalanine



ممكن انه نضيف حلقات كمان ، حلقات خماسية و سداسية أو خماسية لحال

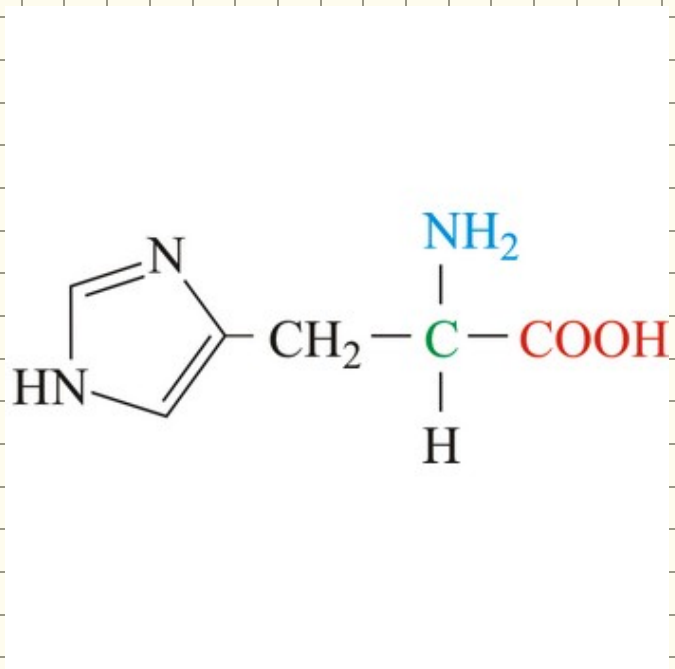
Tryptophan

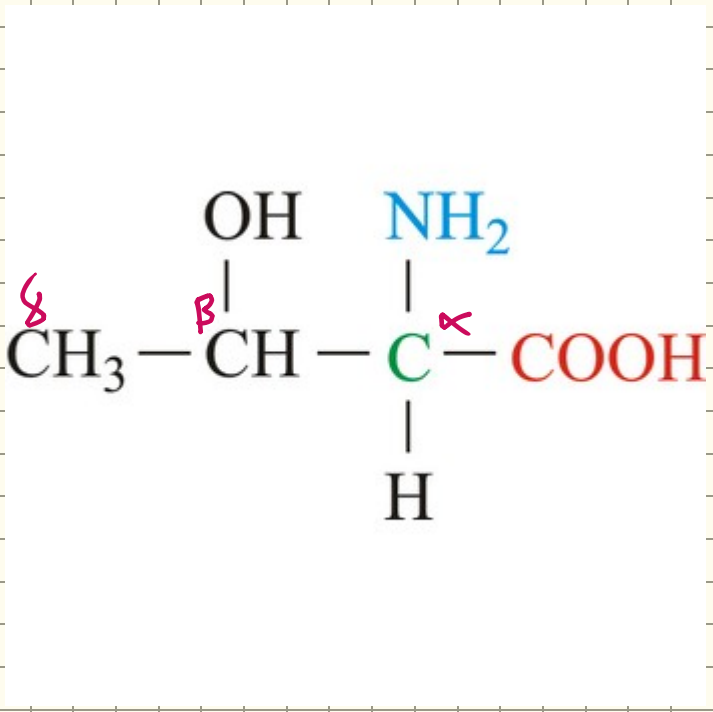


indol ← حلقة غابية + حلقة سداسية

imidazol = حلقة غابية

Histidine

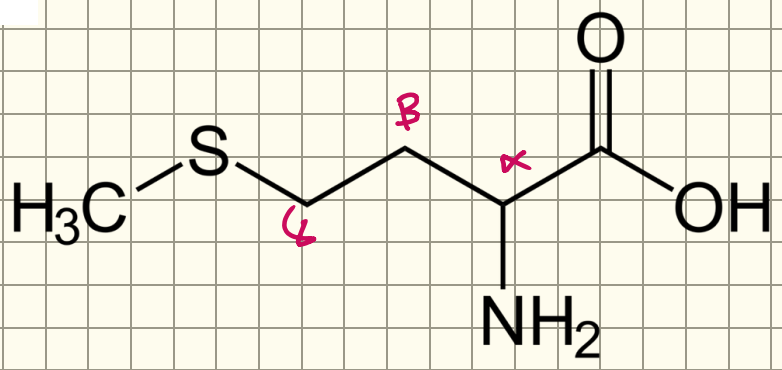




Threonine

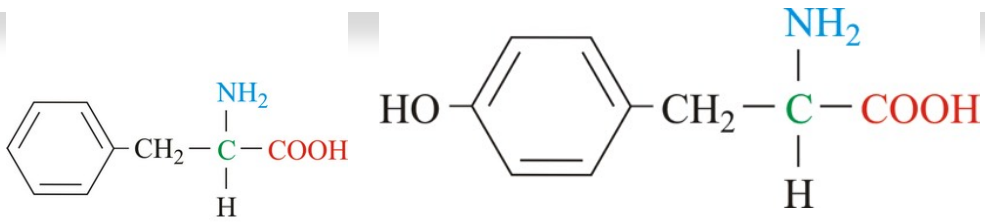
لو ضفت عليه Thiol مع methyl

CH3 + SH



Methionin

Hydrophobic amino acids



- **Phenylalanine** and **tyrosine** are precursors for catecholamines.
- **Tryptophan** can form serotonin and niacin.
- **Valine, leucine, and isoleucine** are branched-chain amino acids.

Vitamin B3

catecholamines(neurotransmitters) بقدر اصنع منهم
يعني أنا بحول اولًا

Phenylalanine
|
Tyrosine
|
Dopamine
|
Norepinephrine
|
Epinephrine

Hydrophilic Amino Acids

اعادة

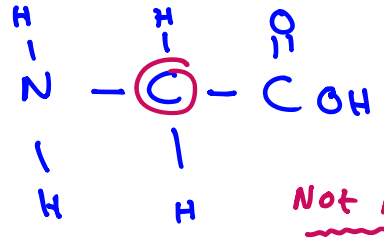
- Have side chains that contain O or N atoms; some of the hydrophilic side chains are charged at physiologic pH.
- The acidic amino acids (**aspartic** and **glutamic acids**) have carboxyl groups that are negatively charged, whereas the basic amino acids (**lysine, arginine**, and **histidine**) have nitrogen atoms that are positively charged.

Side notes!

معظم المصادر تعتبر Tyrosine انه non polar بسبب حلقة البنزين لأنه رح اعتبر الكهروسلبية نفس الشي
بس في مصادر بتحكي انه بسبب وجود OH group ف الكهروسلبية تتغير ف بعتبرو polar
بس اغلب الأحيان هو non polar و hydrophobic

- **Tyrosine** can be considered nonpolar or polar because of the ability of the -OH group to form a hydrogen bond.
- **Methionine** can be considered nonpolar or polar because it contains a sulfur.

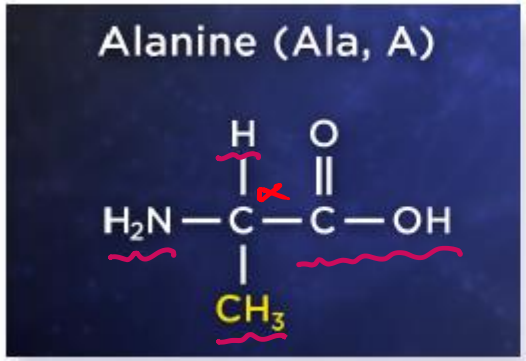
Optical Activity



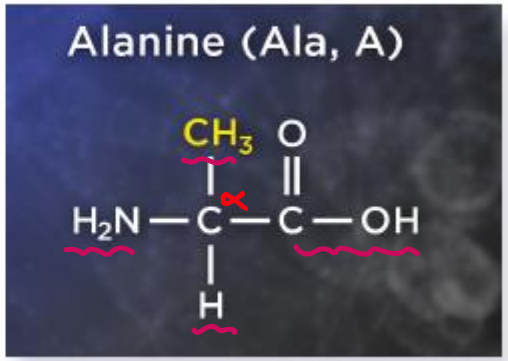
Not Asymetric carbon

- All amino acids except glycine can exist in 2 mirror image forms.
- These differ in the arrangement of the 4 groups around the alpha carbon.
- It's like right and left hands that cannot be superimposed on each other.
- The 2 forms are called stereoisomers: the L form and the D form.
- Glycine is different from all the other amino acids in having an H across from another H, so there's **only one form of glycine.**

L FORM



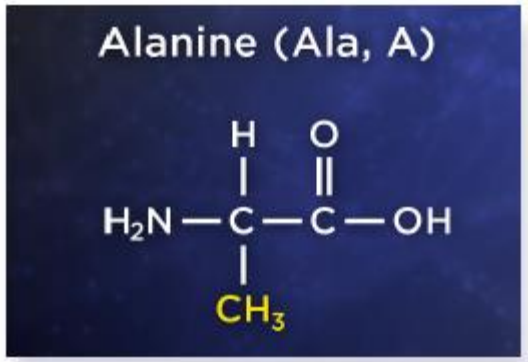
D FORM



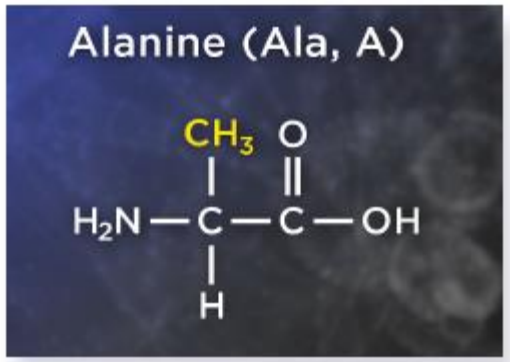
Optical Activity

- All chiral compounds, such as amino acids when made apart from cells, have a 50/50 mixture of the D and L forms.
- However, amino acids made in cells for use in protein synthesis are **almost completely in the L form.** في بعض البكتيريا و micro organisms بتكون D form

L FORM



D FORM



BASED ON NUTRITIONAL REQUIREMENT

20 amino acids are needed for protein synthesis.

- **Essential**: Those amino acids which cannot be synthesized in the body. Hence these amino acids are to be supplied in the diet.

8 Amino Acids

- **Semi-essential**: Growing children require them in the food, but not essential in adults (ex: Arginine).

2 Amino Acids

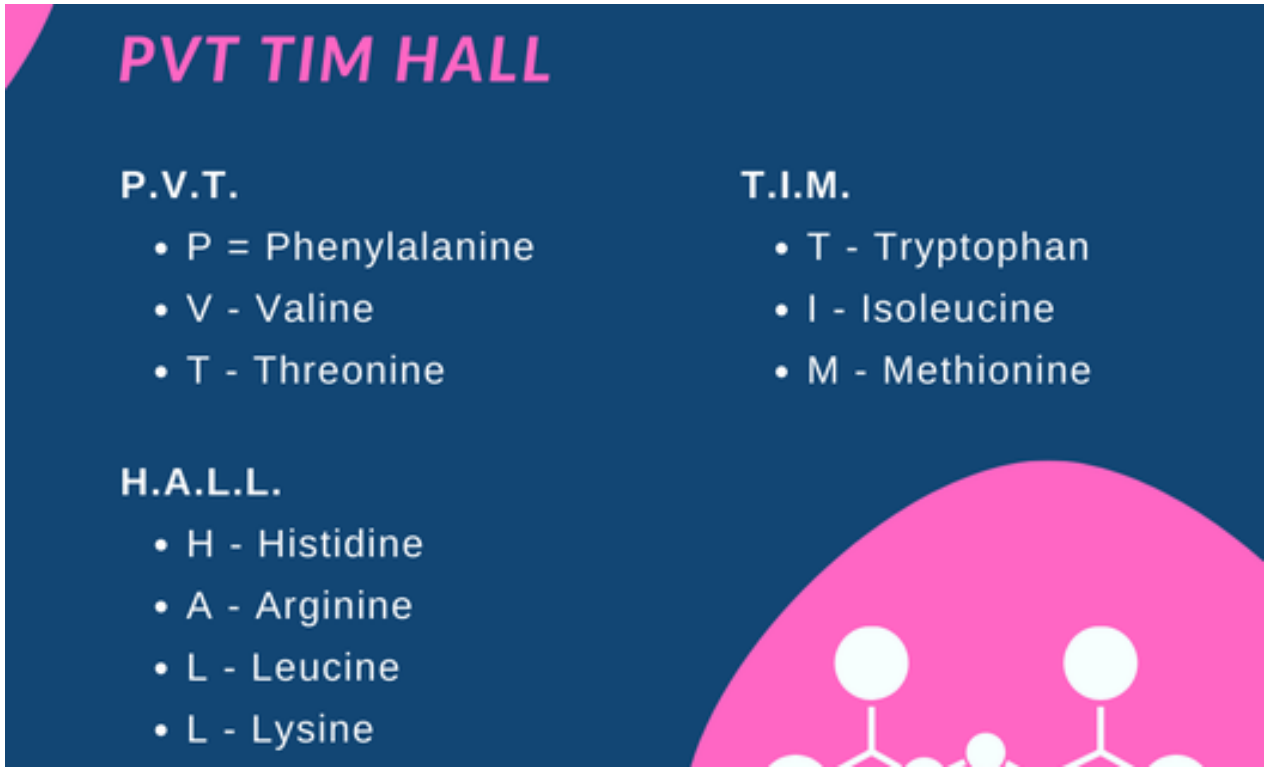
Histidine, Arginine

بتتصنع بطريقة بطيئة بالجسم ، بتتصنع بأوقات معينة بالجسم فقط أو بعد عمر معين

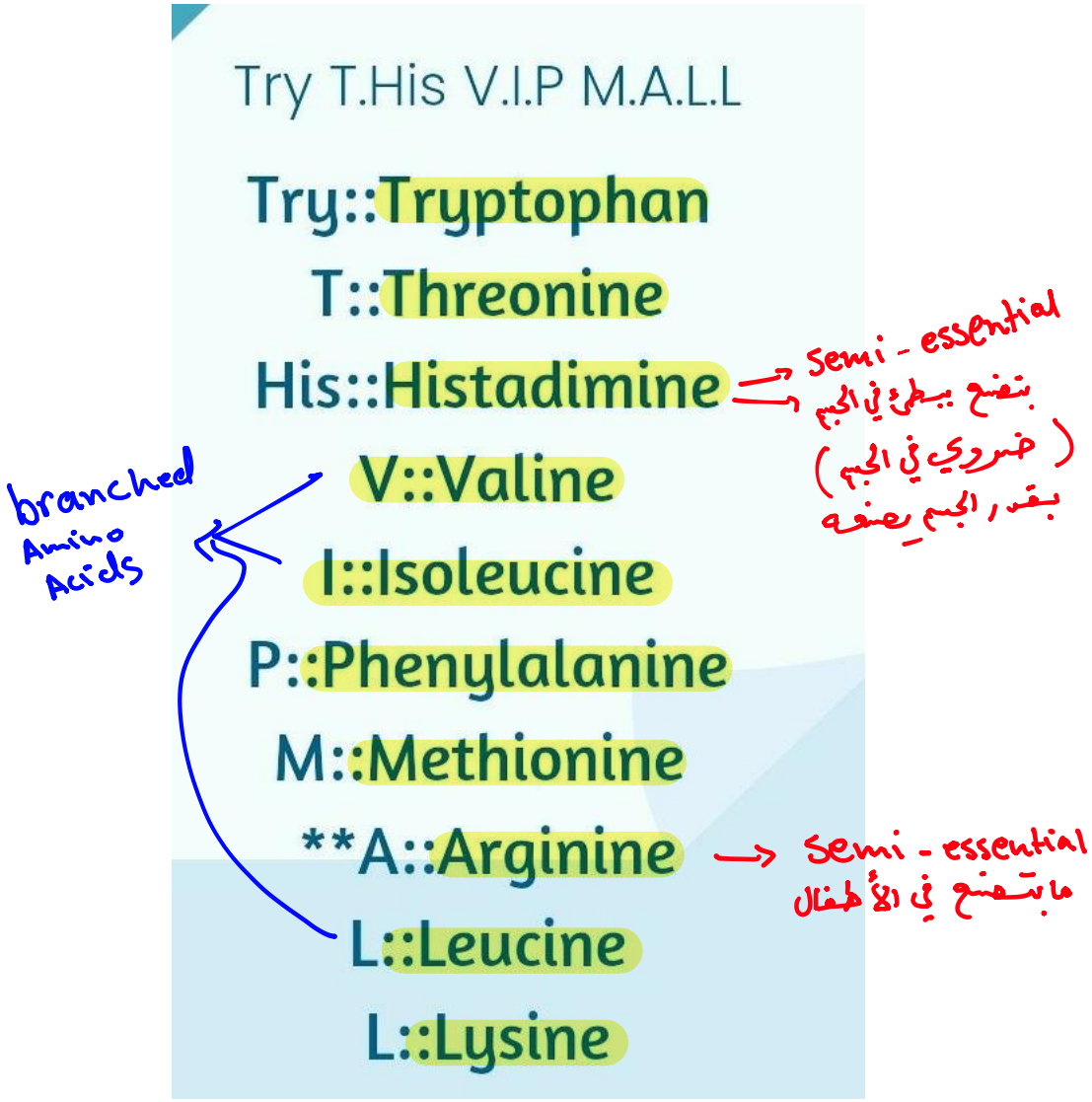
- **Nonessential**: Amino acids which can be synthesized in the body, hence not required in the diet.

10 Amino Acids

Essential Amino Acids



"**A**ny **H**elp In **L**earning **T**hese **L**ittle **M**olecules **P**roves **T**ruely **V**aluable"
This stands for
Arginine, Histidine, Isoleucine, Leucine, Threonine, Lysine, Methionine, Phenylalanine, Tryptophan and Valine in that order.



Non-essential Amino acids

- The remaining 10 amino acids are non-essential, because their carbon skeleton can be synthesized by the body.
- The non-essential amino acids are **Alanine**, **Asparagine**, **Aspartate**, **Cysteine**, **Glutamine**, **Glutamate**, **Glycine**, **Proline**, **Serine** and **Tyrosine**.

Essential & Non-Essential Amino Acids

هلأSemi essential كان تصنيف جديد ف كانو يعتبرو semi essential من التنين essential و nonessential

Essential Amino Acids:

- Arginine
- Isoleucine
- Histidine
- Leucine
- Methionine
- Lysine
- Phenylalanine
- Tryptophan
- Threonine
- Valine

Non-Essential Amino Acids:

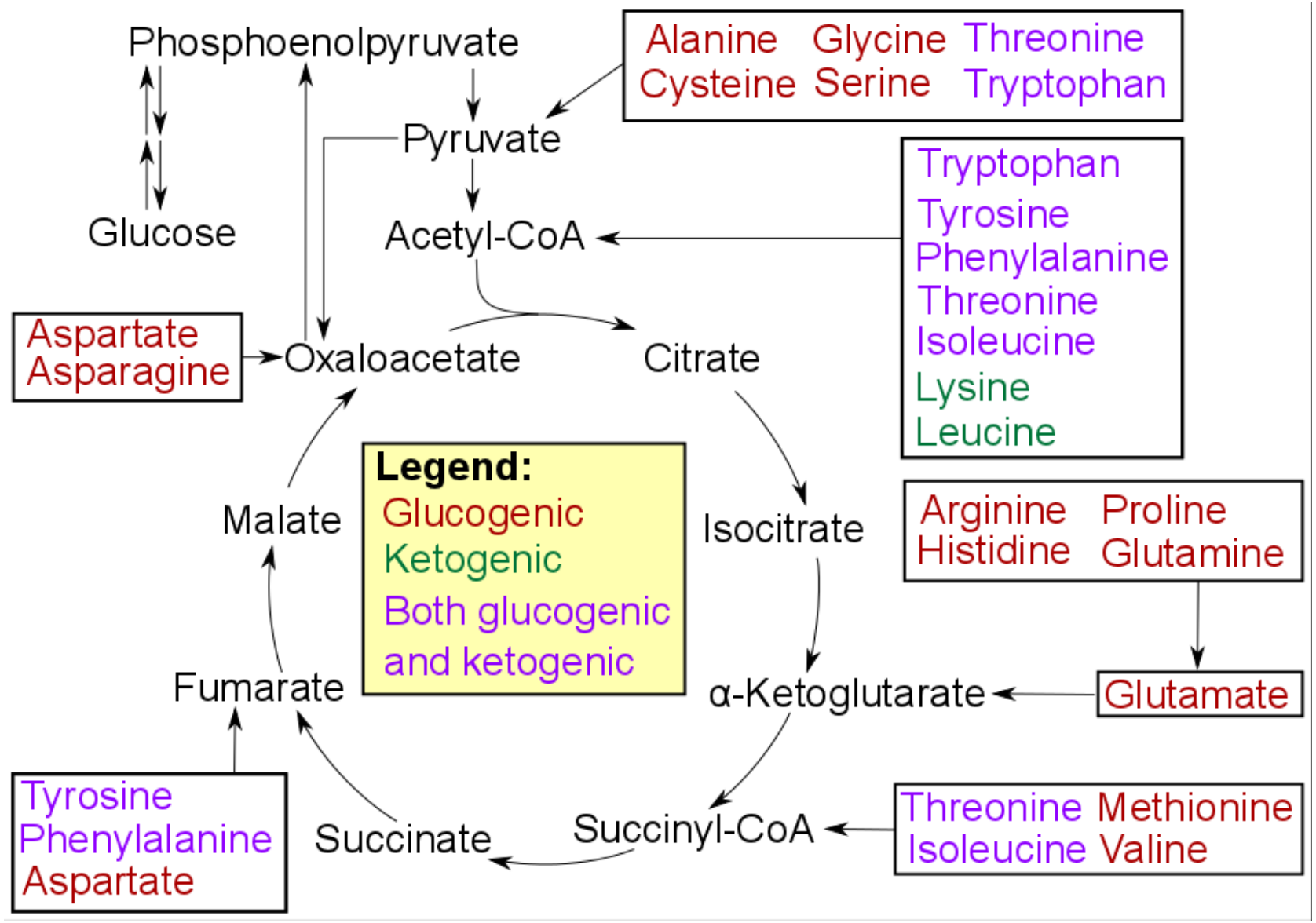
- Alanine
- Arginine
- Asparagine
- Aspartic Acid
- Cysteine
- Glutamic Acid
- Glutamine
- Glycine
- Proline
- Serine
- Tyrosine

BASED ON METABOLIC FATE

في أوقات بصنف ال Amino acids حسب metabolic fate تبعهم هل رح يصنعوا غلوكوز (glucogenic)أو keton bodies بسميهم (ketogenic)

- **Purely ketogenic: Leucine** & **Lysine** are purely ketogenic because they are converted to ketone bodies
- **Ketogenic and glucogenic: Isoleucine**, **Phenylalanine**, **Tyrosine** and **Tryptophan** are partially ketogenic and partially glucogenic. During metabolism, part of the carbon skeleton of these amino acids will enter the ketogenic pathway and the other part to glucogenic pathway.
- **Purely glucogenic:** All the remaining 14 amino acids are purely glucogenic as they enter only into the glucogenic pathway

Ketogenic Amino Acide	Glucogenic and Ketogenic Amino Acides	lucogenic Amino Acid
• Leucine • Lysine	• Tyrosine • Tryptophan • Threonine • Isoleucine • Phenylalanine	• Rest all are Glucogenic


Phosphoenolpyruvate
Alanine Glycine Threonine
Cysteine Serine Tryptophan
Pyruvate
Glucose
Acetyl-CoA
Tryptophan
Tyrosine
Phenylalanine
Threonine
Isoleucine
Lysine
Leucine
Aspartate
Asparagine
Oxaloacetate
Citrate
Legend:
Glucogenic
Ketogenic
Both glucogenic and ketogenic
Malate
Isocitrate
Arginine Proline
Histidine Glutamine
Fumarate
α-Ketoglutarate
Glutamate
Tyrosine
Phenylalanine
Aspartate
Succinate
Succinyl-CoA
Threonine Methionine
Isoleucine Valine

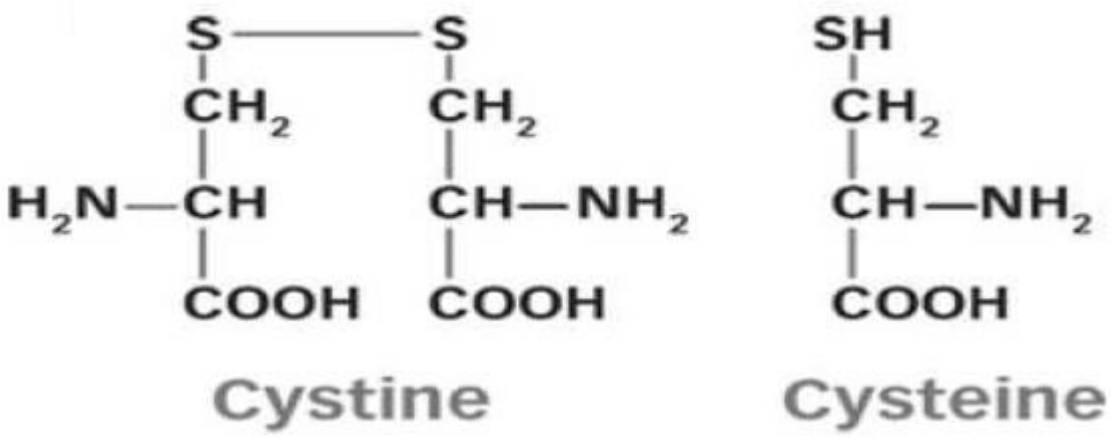
PROPERTIES OF AMINO ACIDS

احنا اعتبرنا الcysteine هو special amino acid لأنه مرات بشكل رابطة مع cysteine تاني و يكون Cystine وهو poorly soluble في الجسم

- Solubility: all amino acids are soluble in water.

- However, cystine is poorly soluble; that is why excretion of large amounts of cystine in urine (cystinuria) leads to stone formation.

kidney stones



PROPERTIES OF AMINO ACIDS

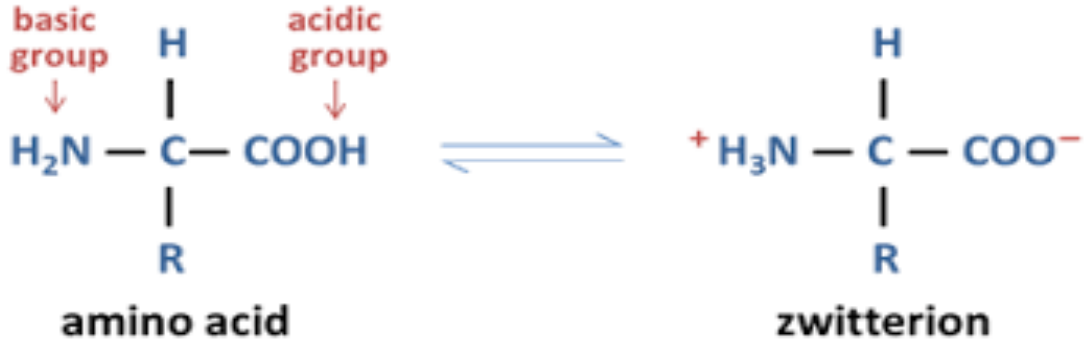
Amphoteric properties:

Amino acids contain at least one carboxyl and one amino group.

net charge → zero

- **The carboxyl group** is acidic and can dissociate into a negatively charged carboxylate ion and a hydrogen ion.
- **The amino group is basic**; it combines with a hydrogen ion to form the positively charged ammonium ion.

At the physiologic pH the amino acid carries both positive and negative charges and has the following structure:

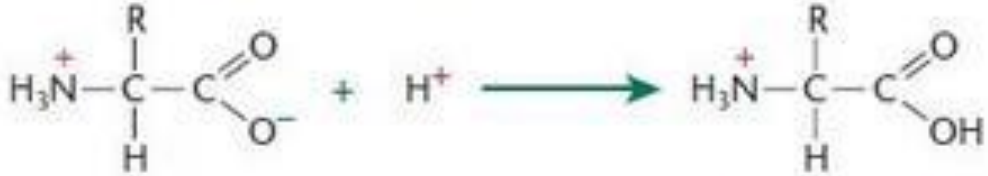


عنا حالتين Amino acid بقدر انه يكون كBase أو Acid

١ Amino acids as bases

In strongly acidic conditions a positive ion forms:

- an amino acid behaves as a base
- the COO^- ion gains a proton.

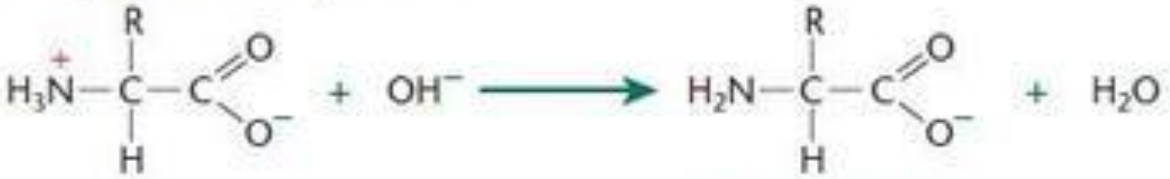


positive ion

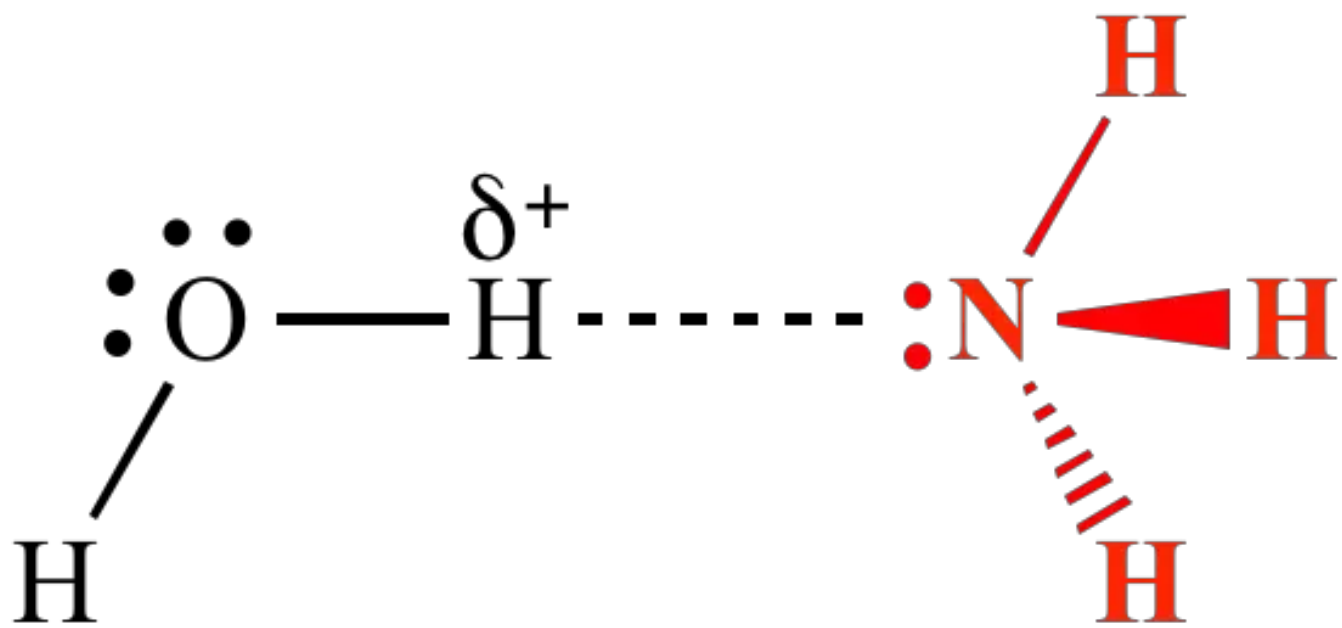
2 Amino acids as acids

In strongly alkaline conditions a negative ion forms:

- an amino acid behaves as an acid
- the NH_3^+ ion loses a proton.



negative ion


δ+
O
H
N
H
H
H

في عنا شي اسمه isoelectric point of the amino acid و هاي النقطة الي بكون فيها الAmino acid zwitterions يعني محصلة الشحنة صفر

PROPERTIES OF AMINO ACIDS

كل amino acid الو different isoelectric point

- Amino Acids exist in three charged states, **positive**, **negative** & **neutral**.

This depends on two factors:

1. Isoelectric pH of the amino acid.
2. pH of the surrounding medium.

Isoelectric pH of amino Acids:

1. At pH = Isoelectric pH
2. At pH < Isoelectric pH
3. At pH > Isoelectric pH

The isoelectric point of an amino acid is **the point at which the amino acid has no net electrical charge**.

PROPERTIES OF AMINO ACIDS

1. **At pH less than isoelectric pH**
   Amino acid exists as positively charged.

2. **At pH more than isoelectric pH**
   Amino acid exists as negatively charged.

سؤال : مثلاً isoelectric point لل tyrosine هي
What the ف 2 هي Ph in the medium و 5.7
؟ tyrosine act as
Positively charged

3. **At pH = Isoelectric pH**
   - The amino acid carries equal number of positive and negative charges, i.e. no net charges.
   - Amino acid exists as Zwitter ion (ampholyte)

***A zwitterion is an ion that contains two functional groups. In simple terms, it is an ion possessing both positive and negative electrical charges. Therefore, zwitterions are mostly electrically neutral (the net formal charge is usually zero)**

Questions

- Which of these amino acids has a side chain that can become ionized in cells?

A. Histidine → already charged

B. Leucine

C. Proline

D. Threonine

Questions

- Which of these amino acids has a chiral carbon in its side chain?

I. Serine

II. Threonine

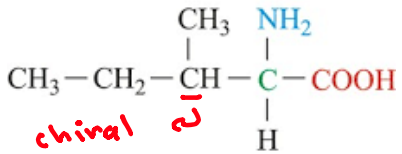
III. Isoleucine

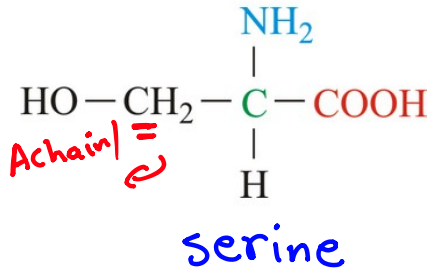
A. I only

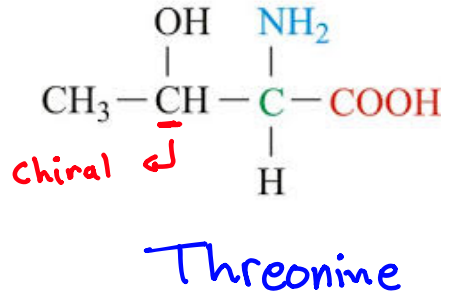
B. II only

C. II and III only

D. I, II, and III







Questions

- In a neutral solution, most amino acids exist as:

A. positively charged compounds.

B. zwitterions. → zero net charged

C. negatively charged compounds.

D. hydrophobic molecules.