CLASSIFICATION OF AMINO ACIDS

Nebras Melhem

Introduction

Antibodies → enzymes + Hormones

hormone + enzyme

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

- Composed of carbon, hydrogen, oxygen, nitrogen +/- sulphur (maybe)
- 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.

70% → Water + 17% protein.

Introduction

Amino acids participate in the biosynthesis of:

- Purines → A, G
- Pyrimidines → T, U, C
- Urea

إضافي

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

- Hormones
- Neurotransmitters

دورها: Peptides

*Peptide (2 → to 50)

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

- Plasma membrane
- Hormones
- Enzymes

دور: Protein

Protein (0 > 50)

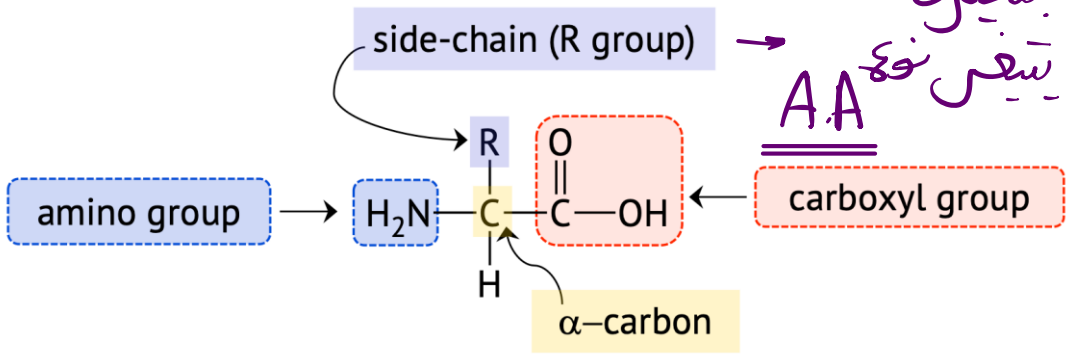
* مهم * راح يتكرر lec. 10

الدكتورة سألت عن أدوارهم بالمحاضرة ١٠ مركزوا عليها.

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

Basic structure of AA.



بتغيرها: بتغير نوع A.A

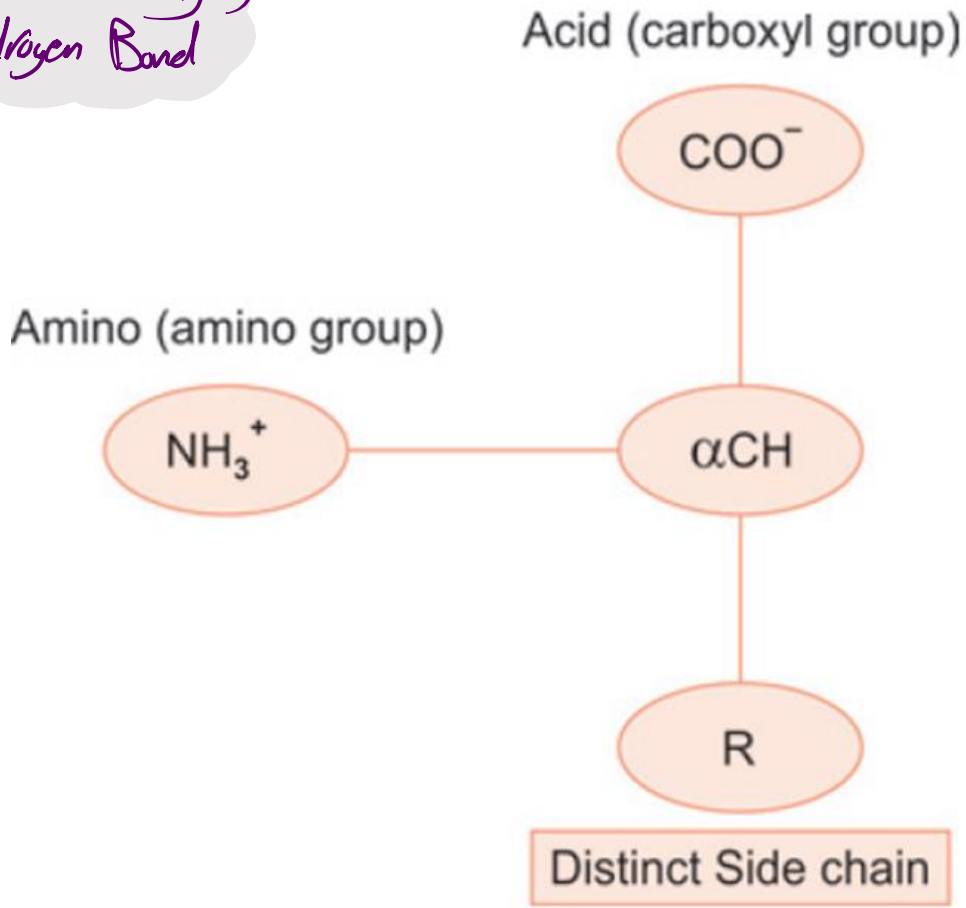
* المسؤول عن تنوع A.A.

R-Group OR Side Chain

General Structure of Amino Acids

Hydrophobic يكون
OR Non-Polar
(Don't make any Hydrogen Bond)
← A.A. اذا كان
فقط مكون من
(C+H)

- 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.
  → Non-Polar → hydrophobic.
- Other R groups contain other atoms and can ionize or make hydrogen bonds, so these are **hydrophilic**—they like water.



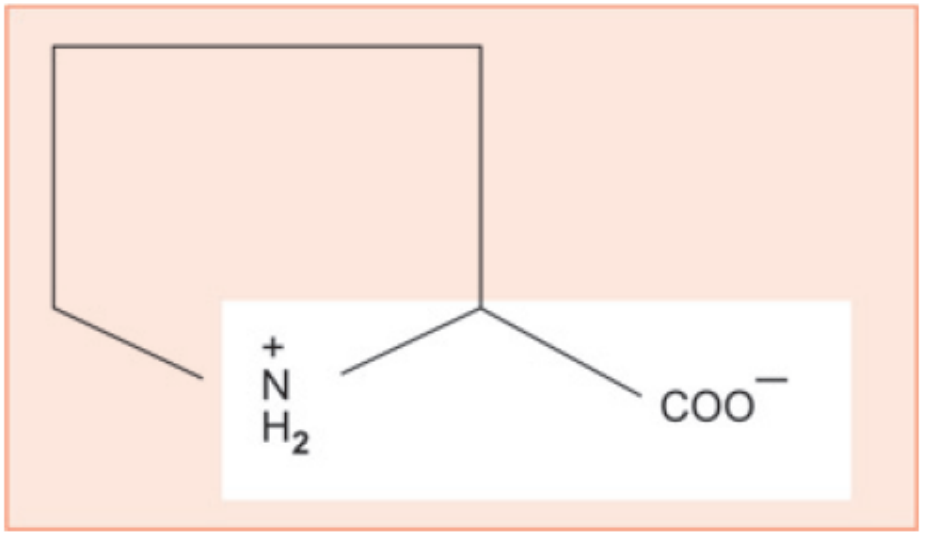
General structure of alpha amino acid

Imino Acid → Proline

هو الوحيد Structure مختلف

- Secondary Amine.
- Proteinogenic → it can synthesis Protein from it.

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



Structure of imino acid

it contains imene group : C=N

BASED ON CHEMICAL CLASSIFICATION

الاختلاف في ال side chain

CHEMICAL CLASSIFICATION

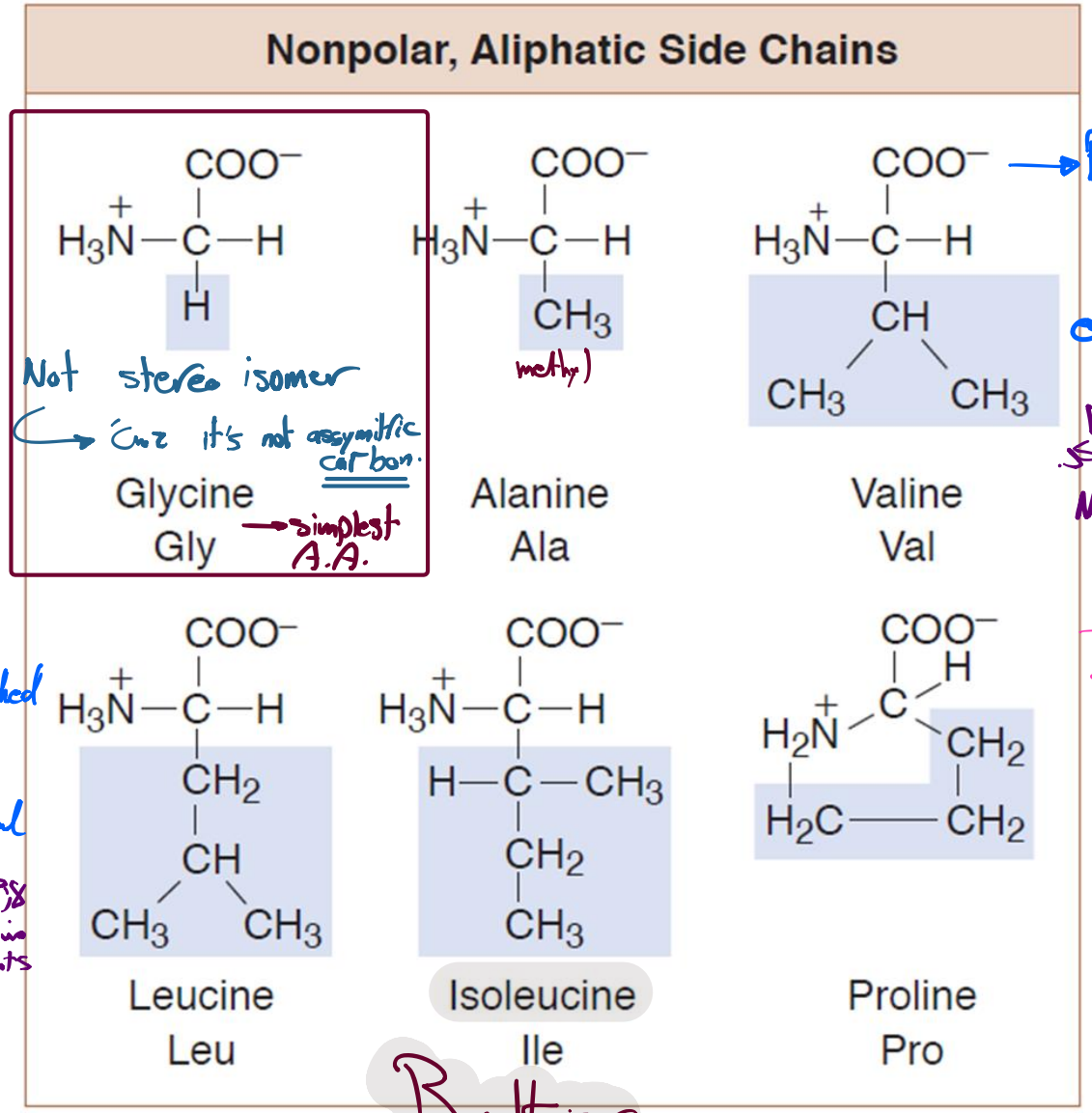
- ALIPHATIC (Non Polar amino acids)
  - Hydrophopic
  - → No hydrogen bonds
  - → Just (C+H)
- POLAR UNCHARGED
  - ↳ Neutral.
- AROMATIC
- POLAR CHARGED
  - BASIC (+)
  - ACIDIC (−)

الدكتورة عامل اهمية حفظ

• ضرورة ال structure

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.



Polar Uncharged R groups

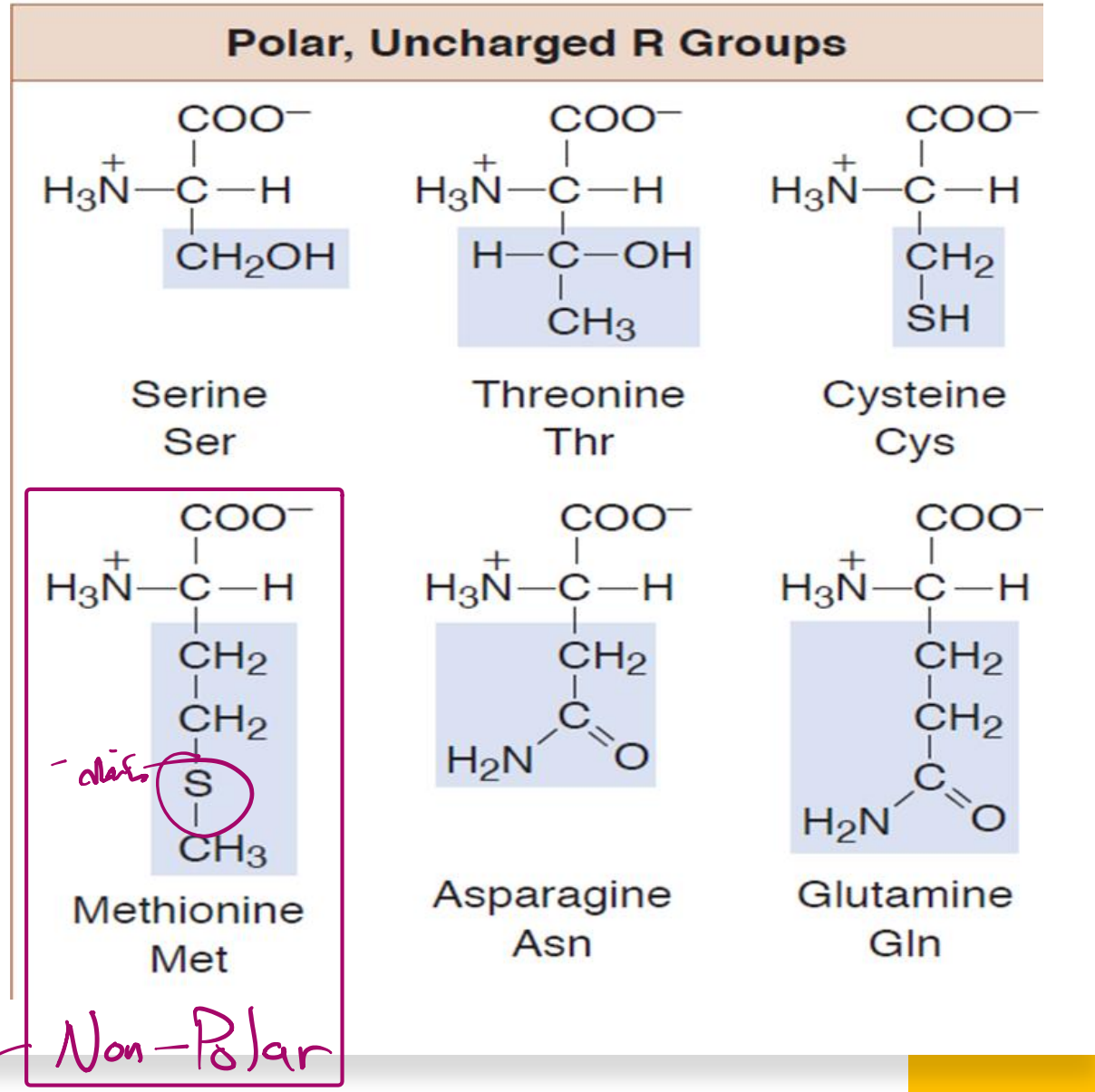
More soluble in water than the non-polar aliphatic group.

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

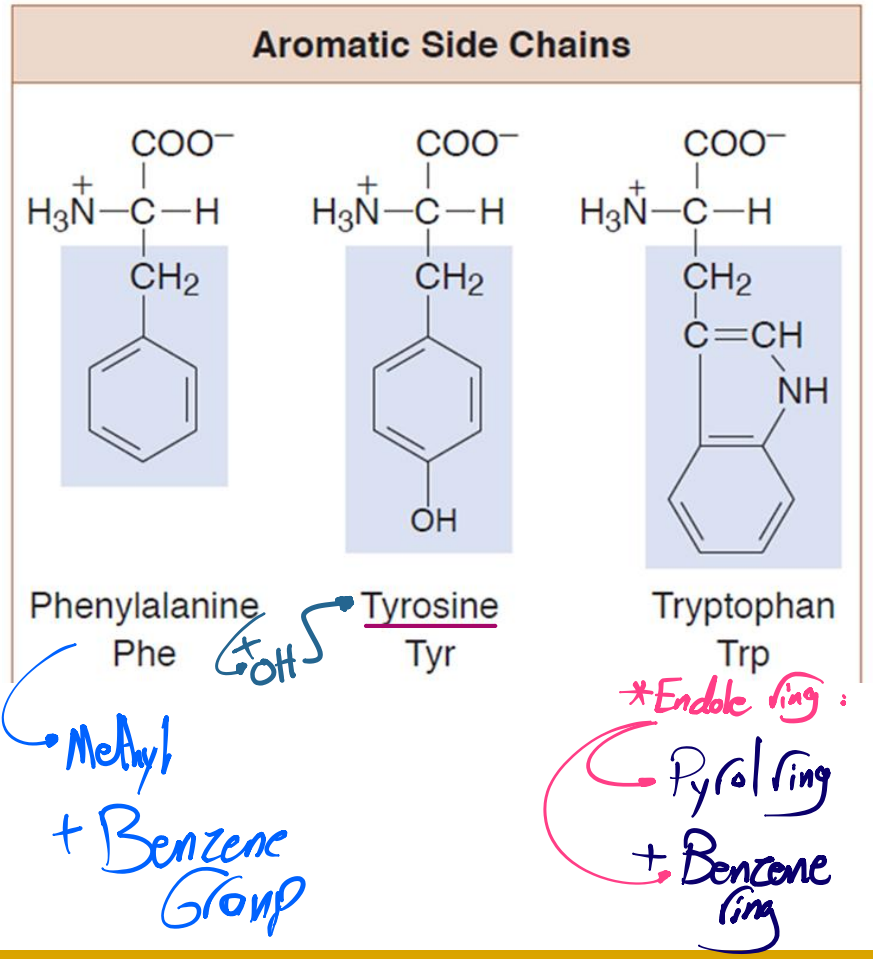
1- Serine, threonine (contain hydroxyl group)

2- Cysteine (contains thiol group)

3- Asparagine and glutamine (contain amide group)



Aromatic Side Chains

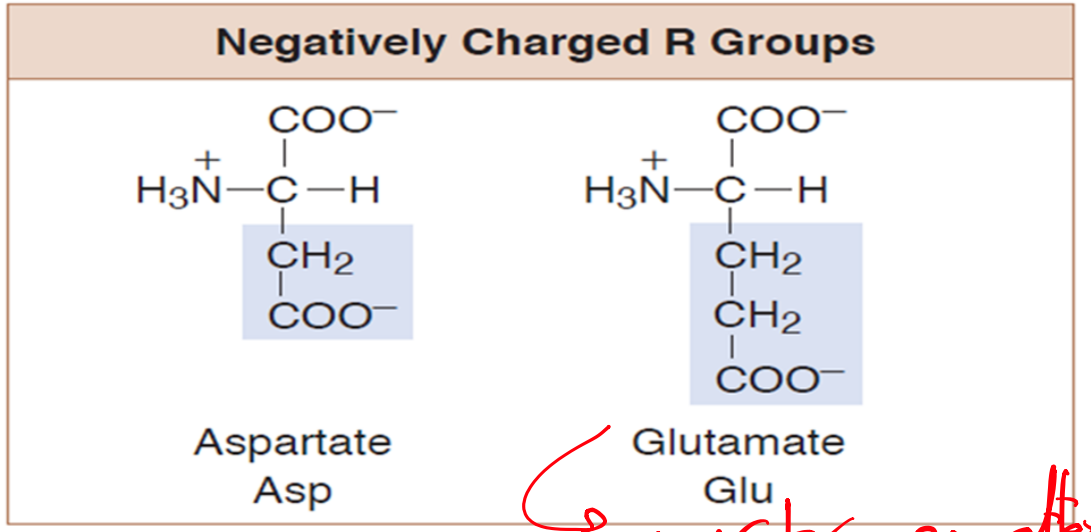


- A subgroup of the hydrophobic amino acids is the aromatic amino acids, named for the large and quite stable aromatic ring structures in their side chains.
- **Phenylalanine**, is a phenyl ring of 6 carbons attached to an alanine. The R group is hydrophobic. It exhibits some properties of hydrophilic 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.*

Negatively Charged R Groups

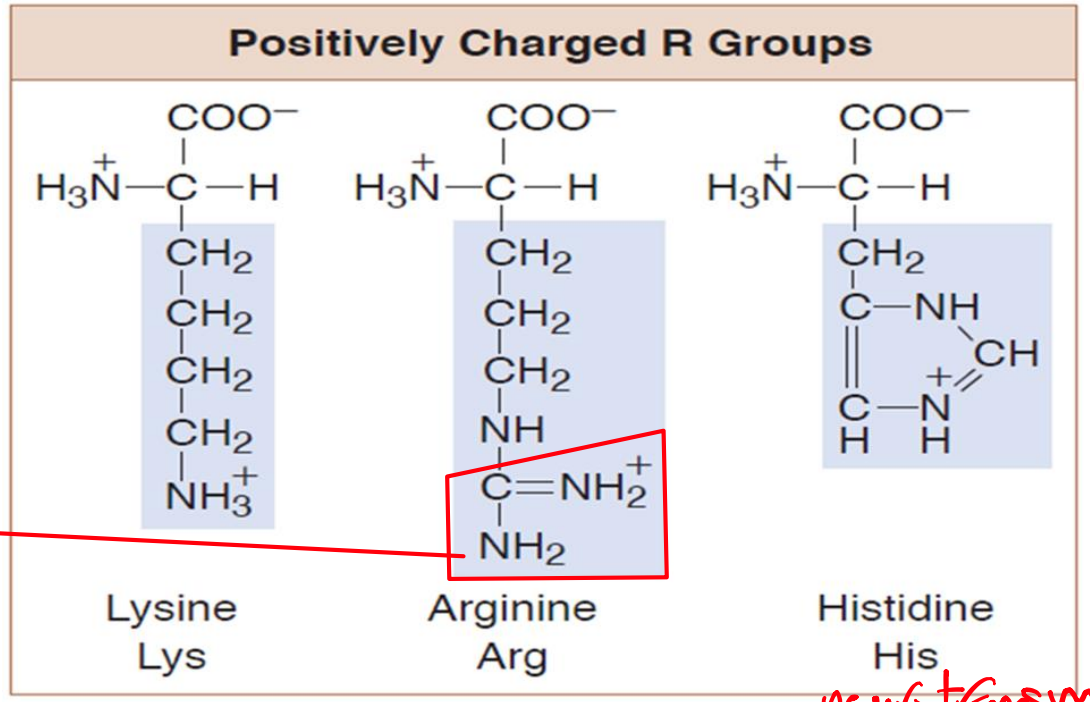
- The acidic amino acids contain carboxyls in their R groups—**aspartic acid** and **glutamic acid**. Ionized forms of these are called aspartate and glutamate.

- 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.



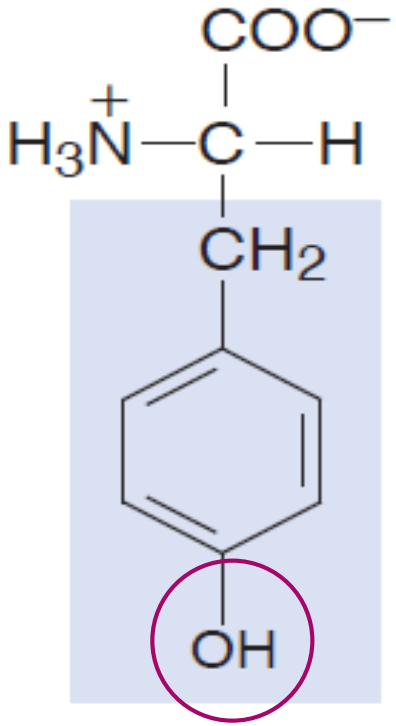
Positively Charged R Groups

- 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.

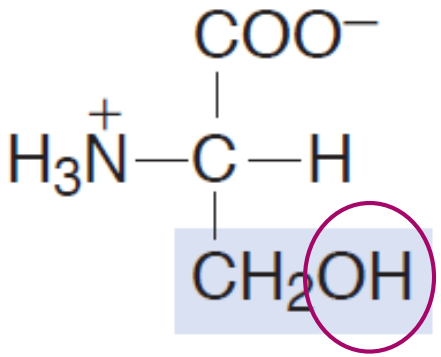


neurotransmitters

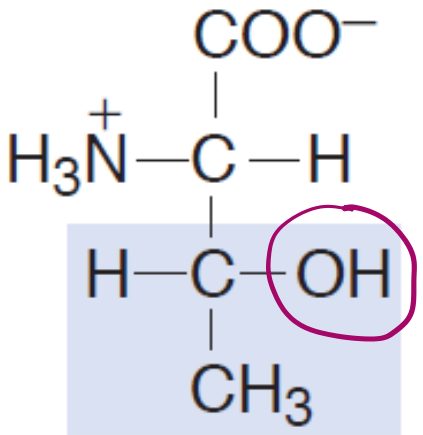
Amino Acids with Hydroxyl Group



Tyrosine
Tyr

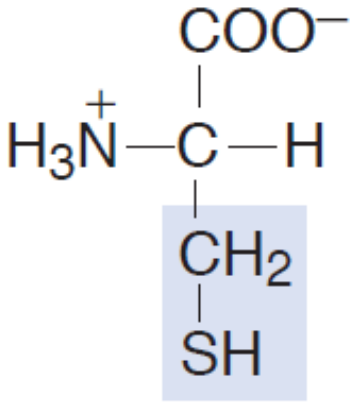


Serine
Ser

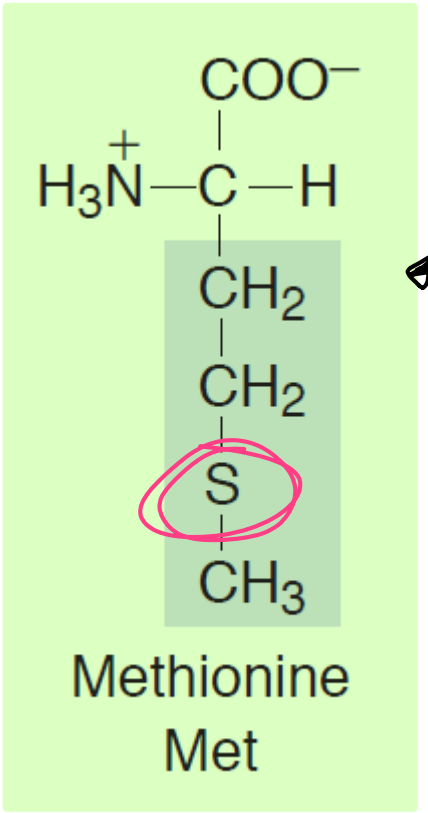


Threonine
Thr

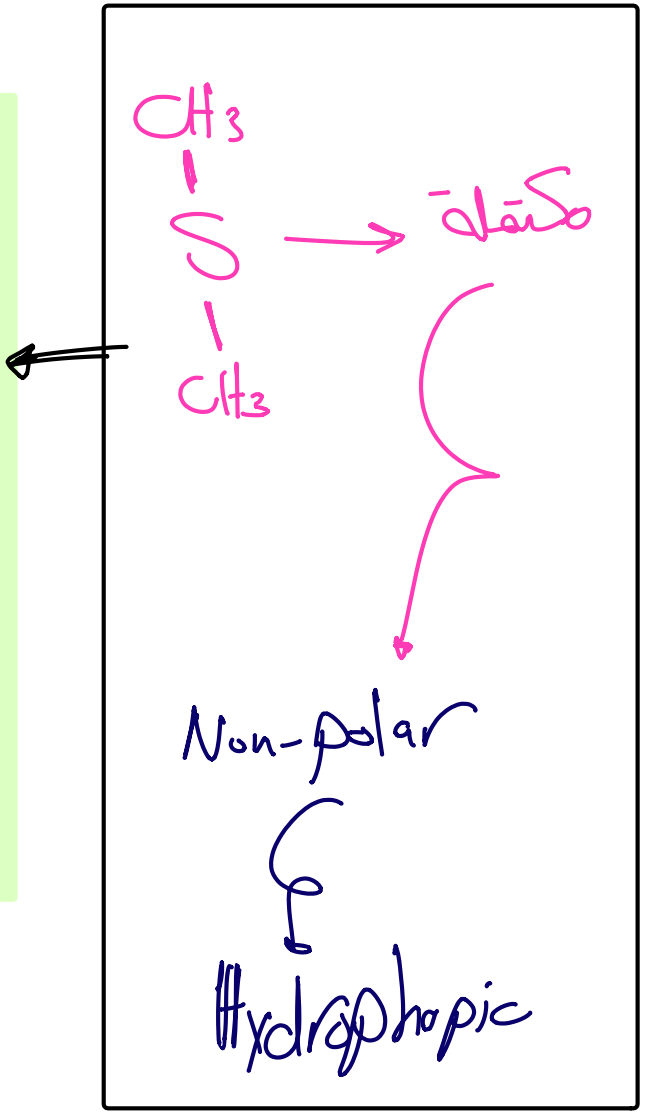
Amino Acids with Sulfur



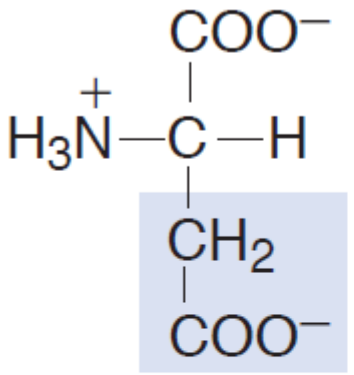
Cysteine
Cys



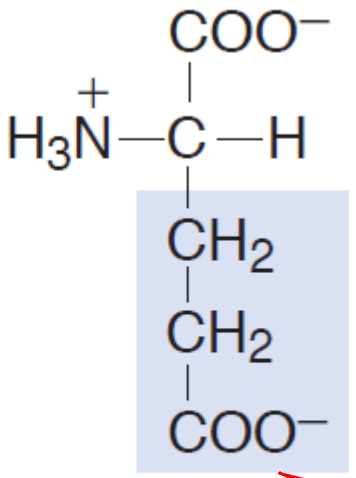
Methionine
Met



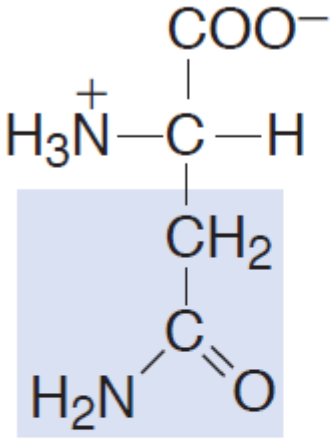
Amino Acid with Amide Group



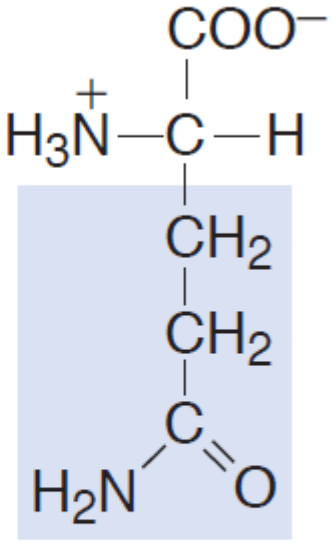
Aspartate
Asp



Glutamate
Glu



Asparagine
Asn



Glutamine
Gln

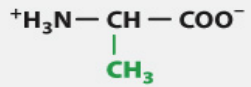
...ate

...mine

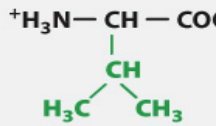
Can cross the Blood Brain Barrier (BBB)

Conversion → Glutamate

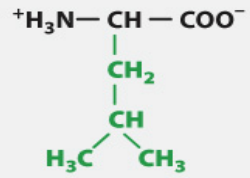
HYDROPHOBIC AMINO ACIDS



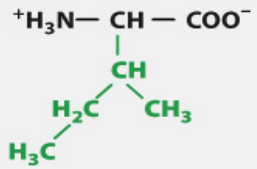
Alanine
(Ala, A)



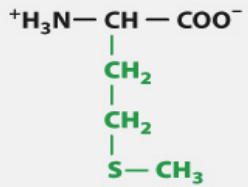
Valine
(Val, V)



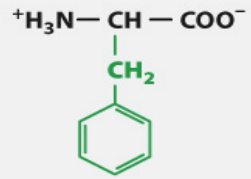
Leucine
(Leu, L)



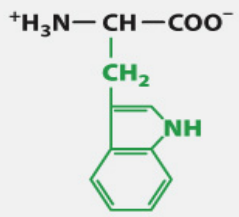
Isoleucine
(Ile, I)



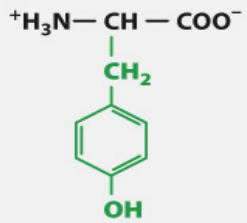
Methionine
(Met, M)



Phenylalanine
(Phe, F)

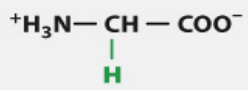


Tryptophan
(Trp, W)

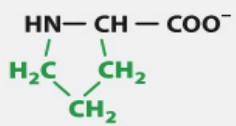


Tyrosine
(Tyr, Y)

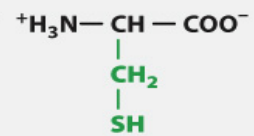
SPECIAL AMINO ACIDS



Glycine
(Gly, G)



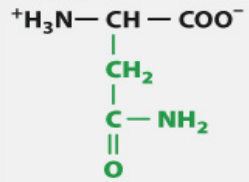
Proline
(Pro, P)



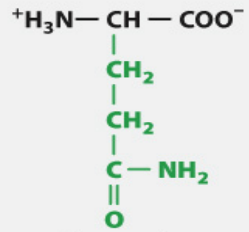
Cysteine
(Cys, C)

HYDROPHILIC AMINO ACIDS

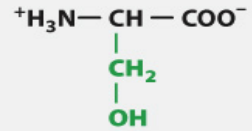
Polar



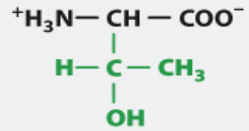
Asparagine
(Asn, N)



Glutamine
(Gln, Q)

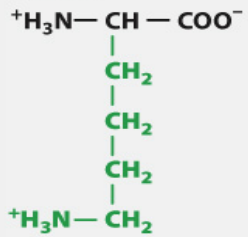


Serine
(Ser, S)

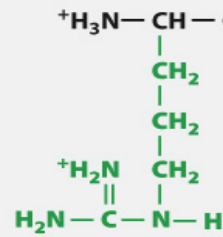


Threonine
(Thr, T)

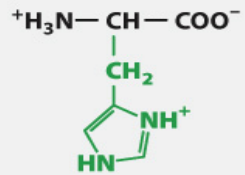
Basic



Lysine
(Lys, K)

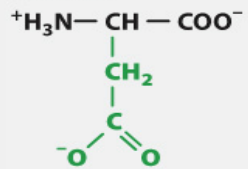


Arginine
(Arg, R)

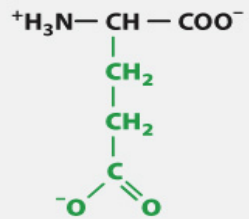


Histidine
(His, H)

Acidic



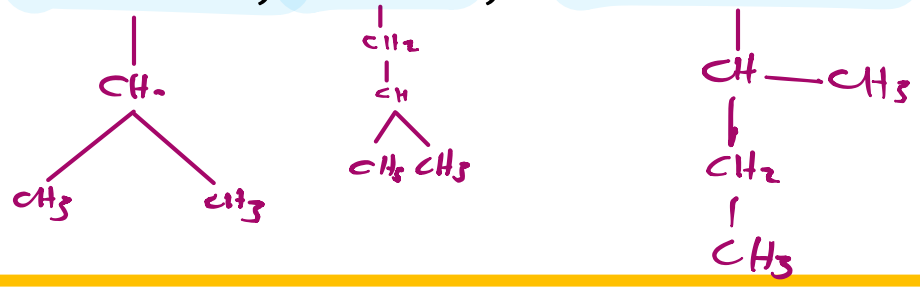
Aspartic acid
(Asp, D)



Glutamic acid
(Glu, E)

Hydrophobic amino acids

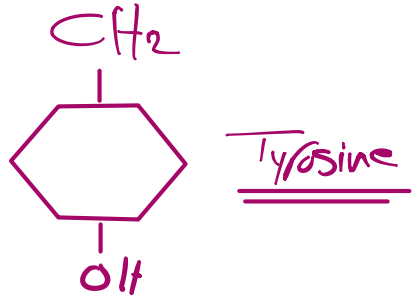
- **Phenylalanine** and **tyrosine** are precursors for catecholamines.
- **Tryptophan** can form serotonin and niacin.
- **Valine, leucine, and isoleucine** are branched-chain amino acids.



Hydrophilic Amino Acids

- 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!

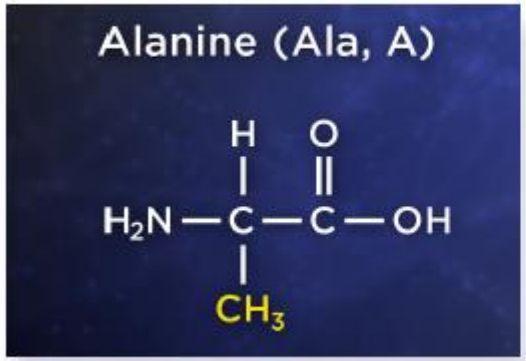


- **Tyrosine** can be considered nonpolar or polar because of the ability of the -OH group to form a hydrogen bond.
- **Methionine** can be considered nonpolar or polar because it contains a sulfur.

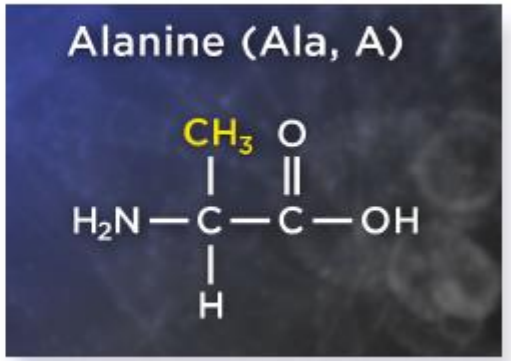
Optical Activity

- 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.** → only in one form.

L FORM



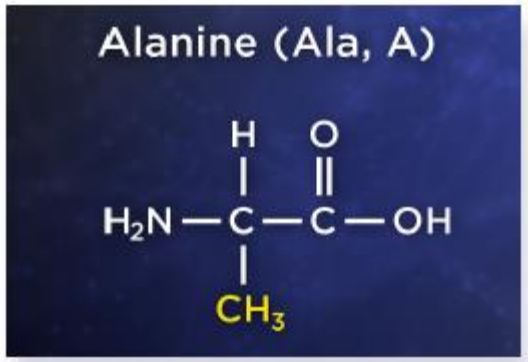
D FORM



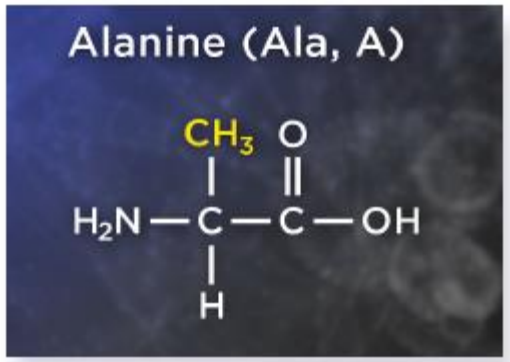
Optical Activity

- 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.**

L FORM



D FORM

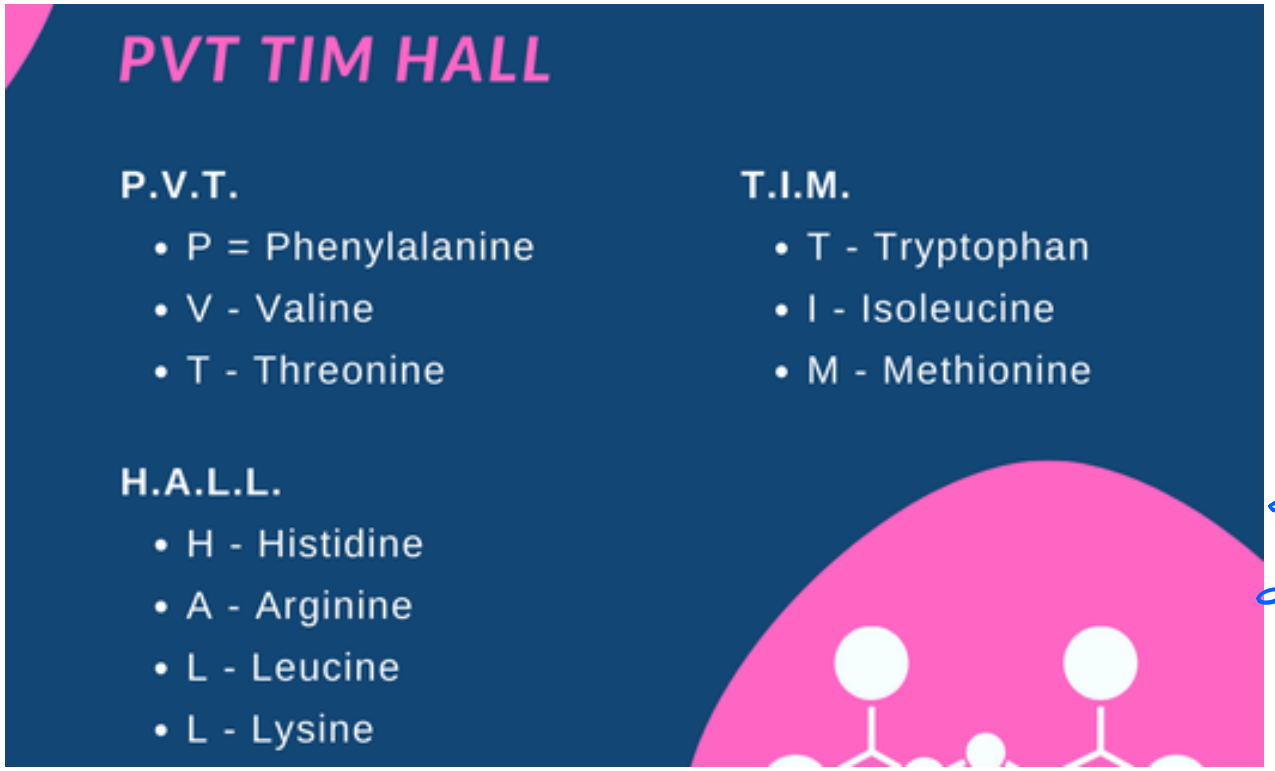


BASED ON NUTRITIONAL REQUIREMENT

20 amino acids are needed for protein synthesis.

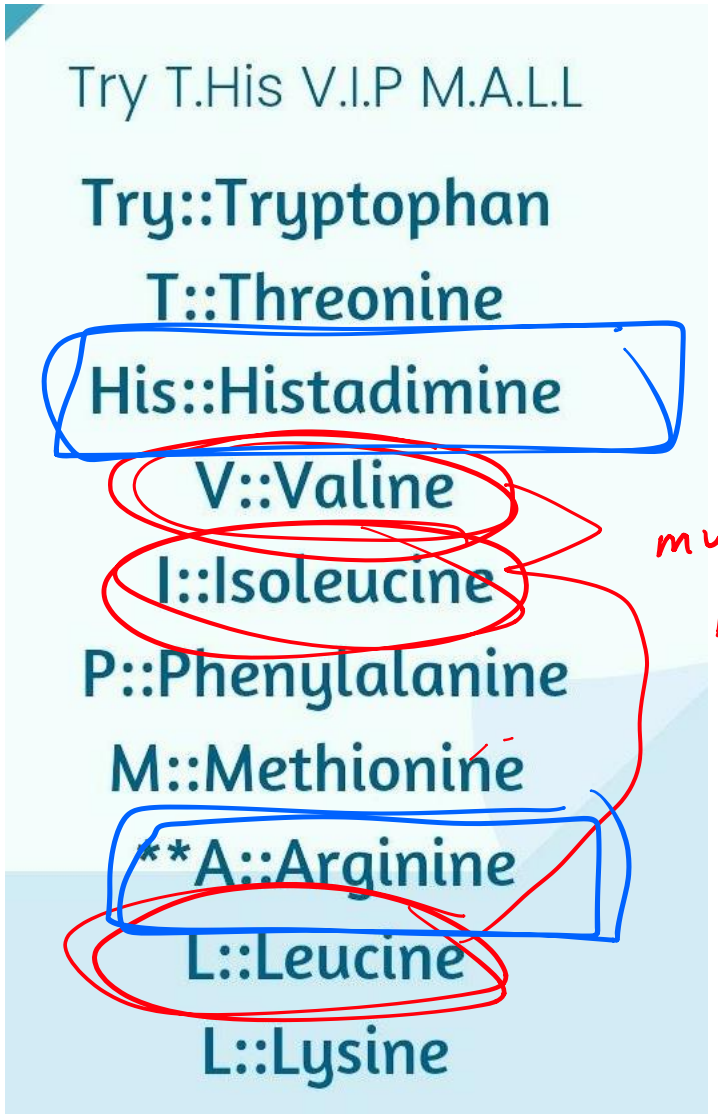
- **Essential**: Those amino acids which cannot be synthesized in the body. Hence these amino acids are to be supplied in the diet.
- **Semi-essential**: Growing children require them in the food, but not essential in adults (ex: Arginine).
- **Nonessential**: Amino acids which can be synthesized in the body, hence not required in the diet.

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.

semi. essential



muscle reg.

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

Essential Amino Acids:

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

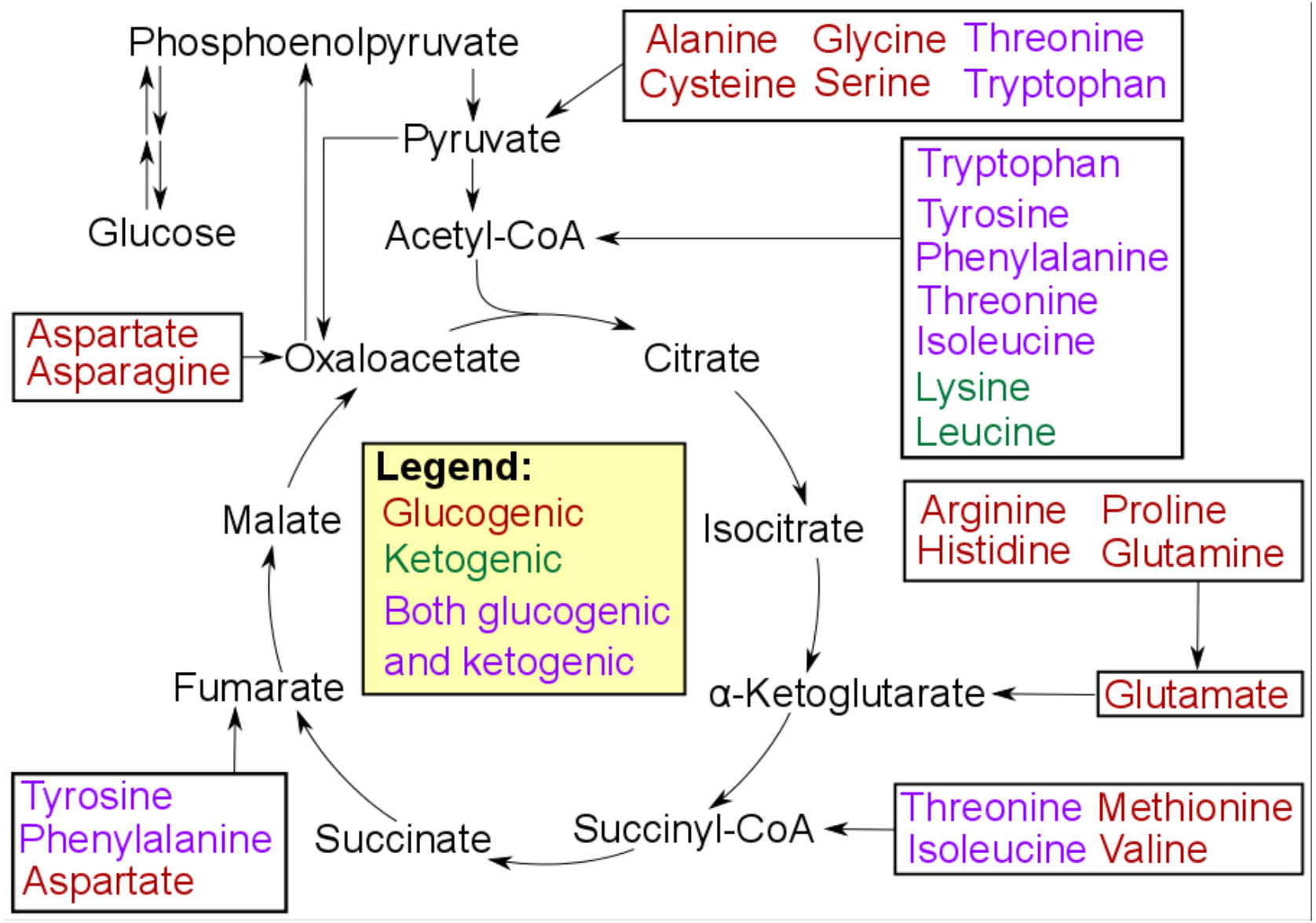
Non-Essential Amino Acids:

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

BASED ON METABOLIC FATE

- **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

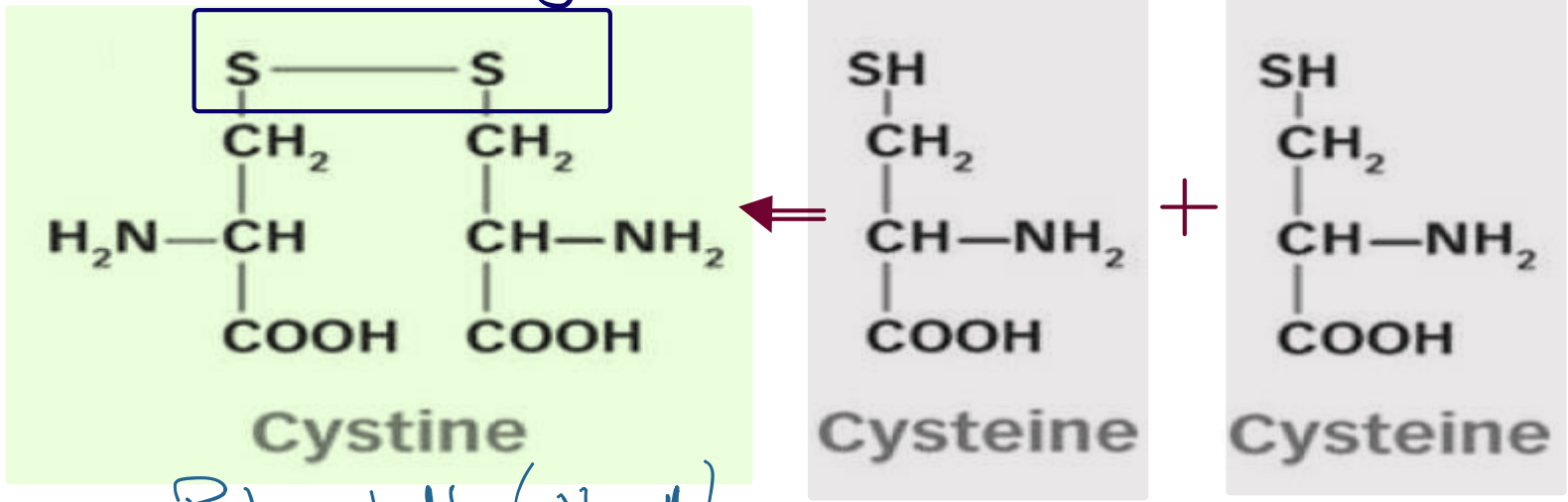
PROPERTIES OF AMINO ACIDS

- 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

Bisulfure Bridge



Poorly soluble (Not well).

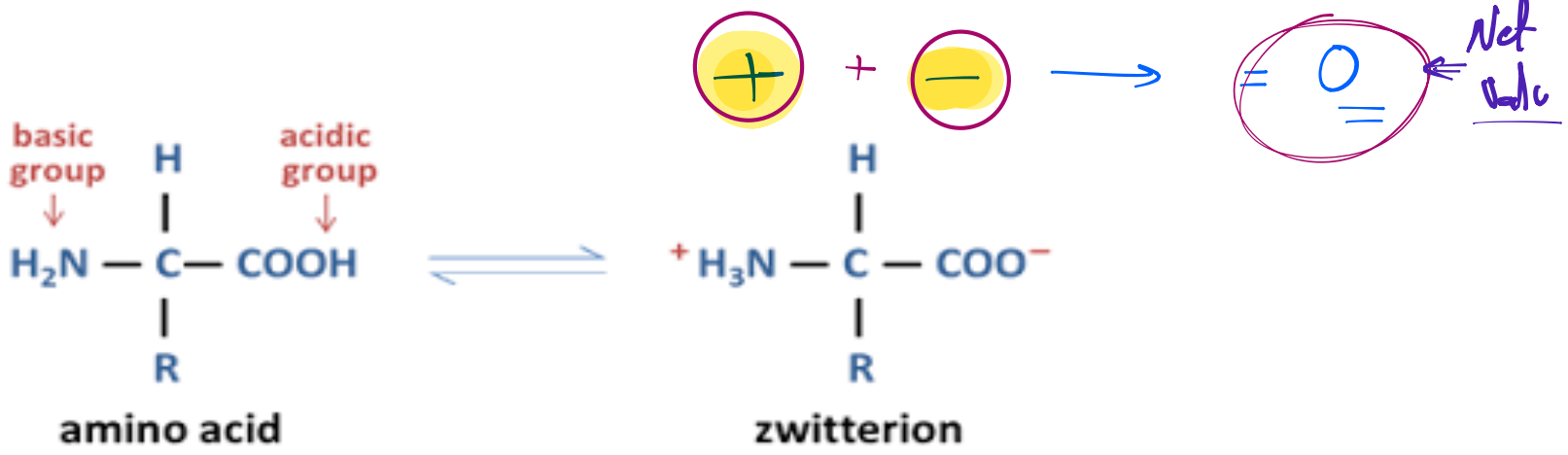
PROPERTIES OF AMINO ACIDS

Amphoteric properties:

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

- **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.

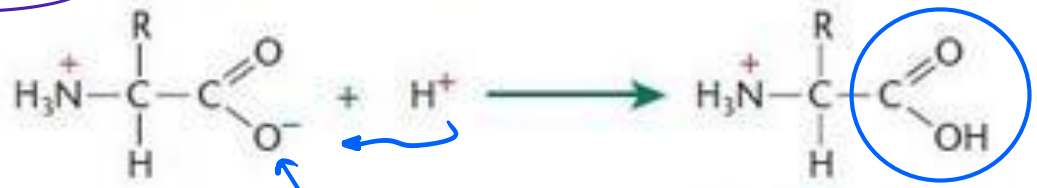
At the physiologic pH the amino acid carries both positive and negative charges and has the following structure:



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.

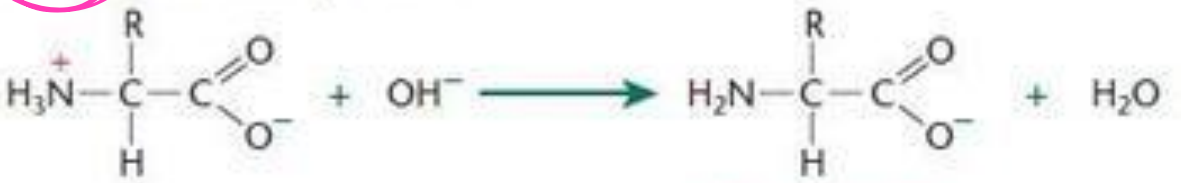


positive ion

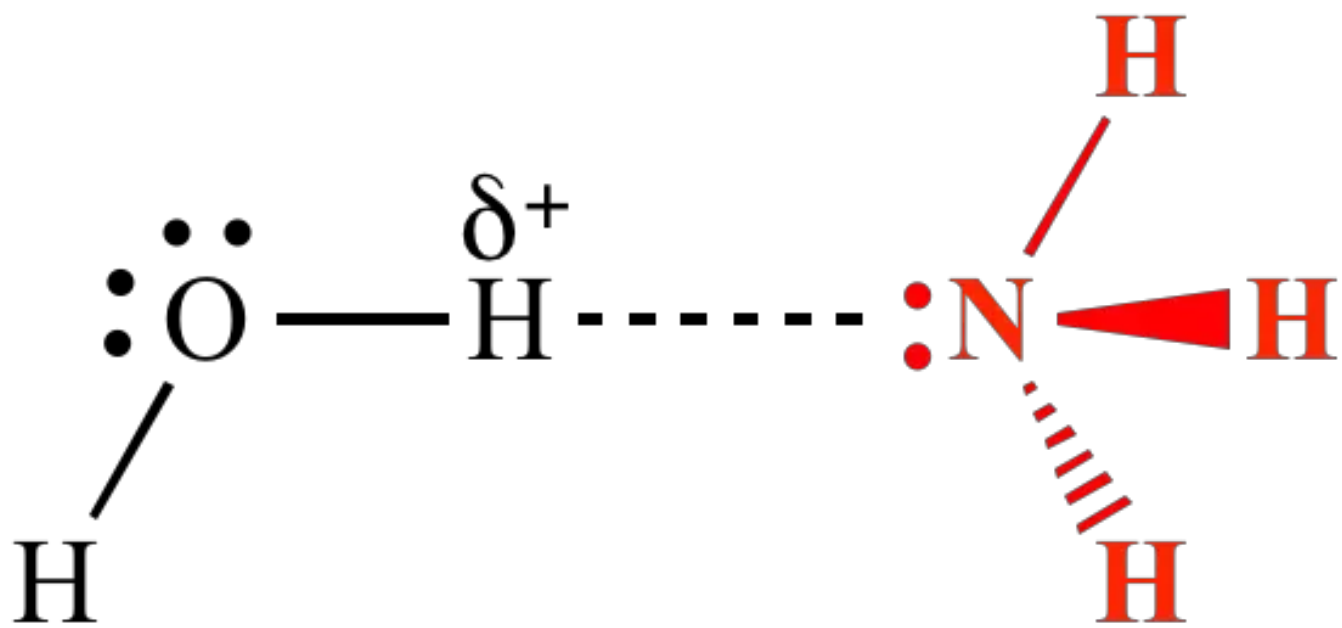
Amino acids as acids

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

PROPERTIES OF AMINO ACIDS

- 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

* هاي الصفحة حفظ كتير مهم

: ex مثل *

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.

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)

isoelectric point And the pH for thyrocin ⇒ in the medium is 5,7 is 2 ?!

What will thyrocin act as ?!

Thyrocin will act as Positively charged.

***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

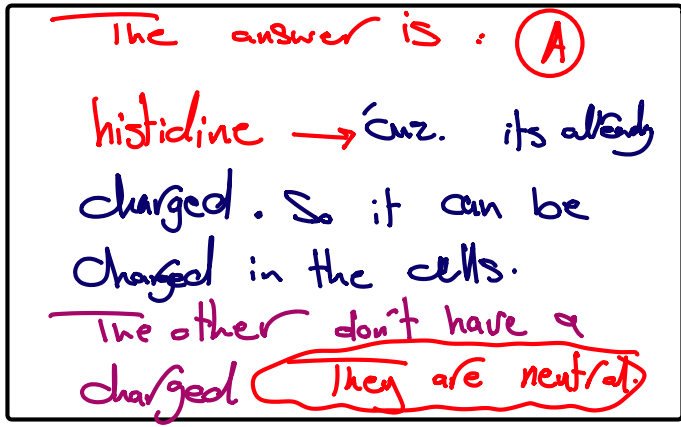
- Which of these amino acids has a side chain that can become ionized in cells?

A. Histidine

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

The answer: C

Questions

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

A. positively charged compounds.

B. zwitterions.

C. negatively charged compounds.

D. hydrophobic molecules.

The answer: