Chemistry of protein

- Proteins are the building material for body structure.
- Proteins are composed of carbon, oxygen, hydrogen, nitrogen and small amounts of other elements, notably sulphur.

Amino acids are the building blocks of ***proteins***, which have structural and functional properties in our bodies.

Proteins function as follows:

- They transport oxygen in the blood.
- They are the primary components of skin and muscle.
- They work as defense mechanisms against infection.
- They serve as biological catalysts called ***enzymes***.
- They also control the metabolism of hormones

- **Amino acids are building blocks of proteins.**

- **Proteins are composed of 20 different amino acid (encoded by standard genetic code, construct proteins in all species).**

- **Amino acids containing both amino and carboxyl groups attached to the same α-carbon (L-α-amino acids).**

- **Their chemical structure influences three dimensional structure of proteins.**

- **They are important intermediates in metabolism (porphyrins, purines, pyrimidines, creatin, urea etc).**
- **They can have hormonal and catalytic function.**
- **Several genetic disorders are cause in amino acid metabolism errors (aminoaciduria - presence of amino acids in urine)**

There are 20 different amino acids identified by their side chains.

Each amino acid has a unique name, and a three-letter abbreviation, as well as a one-letter designation.

21 st -Selenocysteine .

Found at active site of some enzymes .

Encoded by a ***UAG*** codon .

22nd- Pyrolysine .

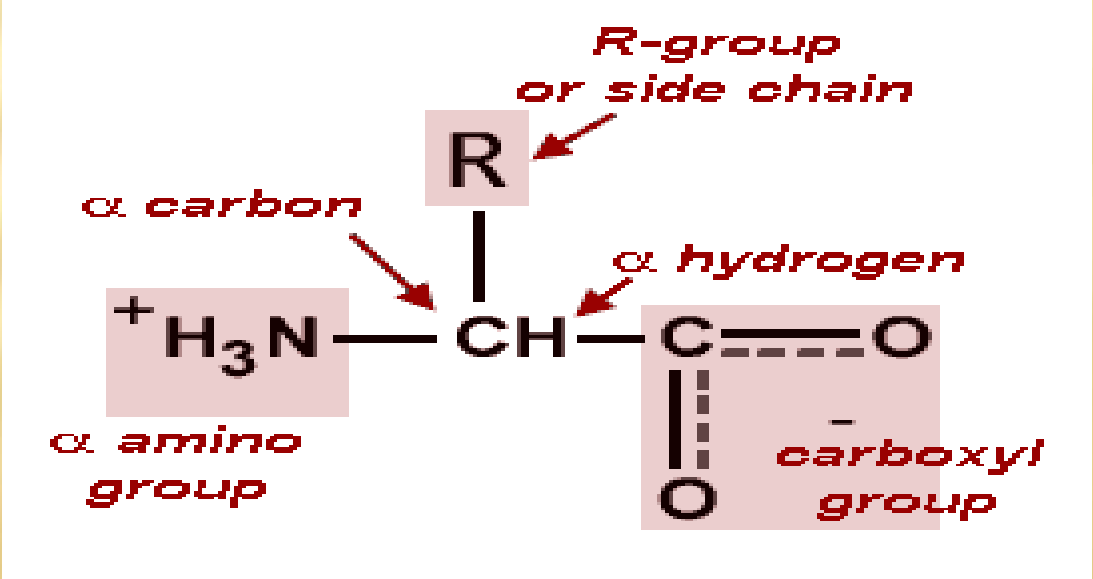
Discovered in 2022.

Similar to Lysine with a pyrroline ring at the end of side chain.

It is encoded by **UAG** codon

AMINO ACIDS

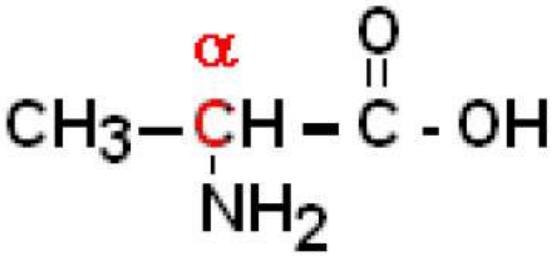
- Amino acids are the structural units (monomers) of proteins. An amino acid is made up of two functional groups—amino ($-NH_2$), carboxyl ($-COOH$). They also contain a hydrogen atom and a side chain (R) linked to the carbon atom.
- Amino acids differ from each other in their side chains.



AMINO ACIDS

α– amino acids

Amino acids found in proteins are α– amino acids. The amino group is always found on the carbon adjacent to the carboxyl group

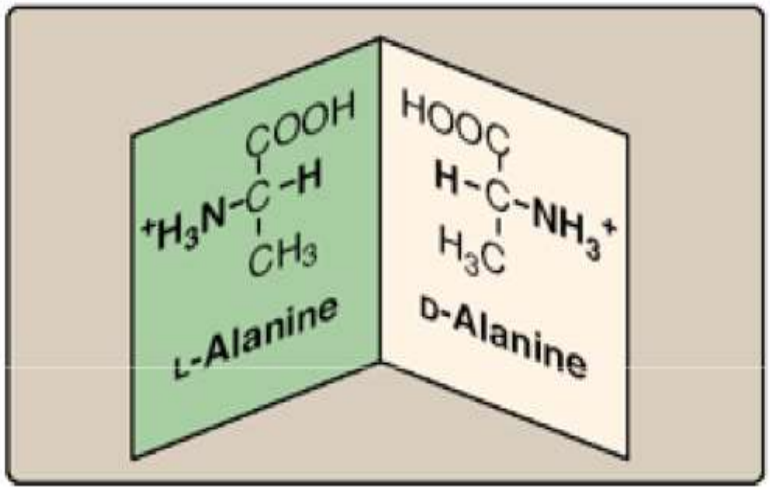


Alanine is an α amino acid

GENERAL PROPERTIES OF ALPHA-AMINO ACIDS.

- Amino acids can be present in two Configurations the L-isomer and the D-isomer which are mirror images , which differ in the arrangement of the chemical groups around the α-carbon atom.

All amino acids in proteins are in the L-configuration . L-amino acids.



D and L forms of alanine are mirror images.

GENERAL PROPERTIES OF ALPHA-AMINO ACIDS.

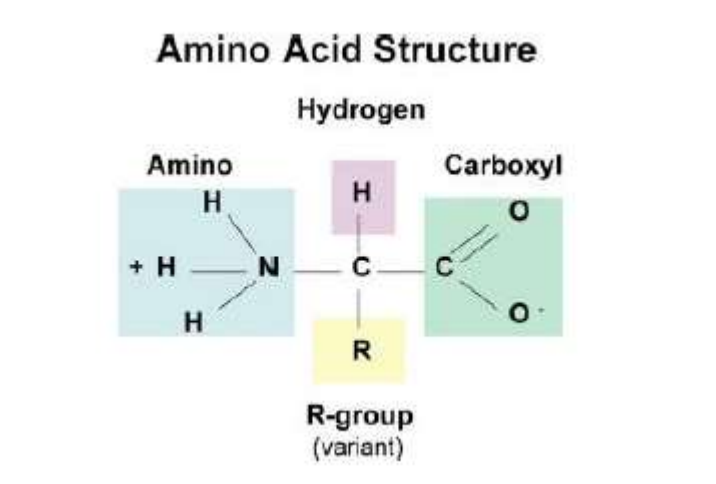
Physical properties of amino acids;

1-Amino acids are mainly *water soluble* which is explained by its polarity and the presence of charged groups. They are soluble thus in polar solvents and not soluble in non-polar solvents.

2-They have a high melting point reflecting the high energy needed to break the ionic forces maintaining the crystal lattice.

It is important to note that the general properties of amino acids is shared by all the amino acids and is in many cases contributed by its α-amino and α- carboxyl group . Amino acids can posses other specific properties dictated by they unique side chain.

GENERAL PROPERTIES OF ALPHA-AMINO ACIDS.



Amphoteric properties of amino acids; amino acids due to the presence of their ionizable α-amino and α-carboxylic group can act sometimes as acids and sometimes as bases depending on the pH of their media .

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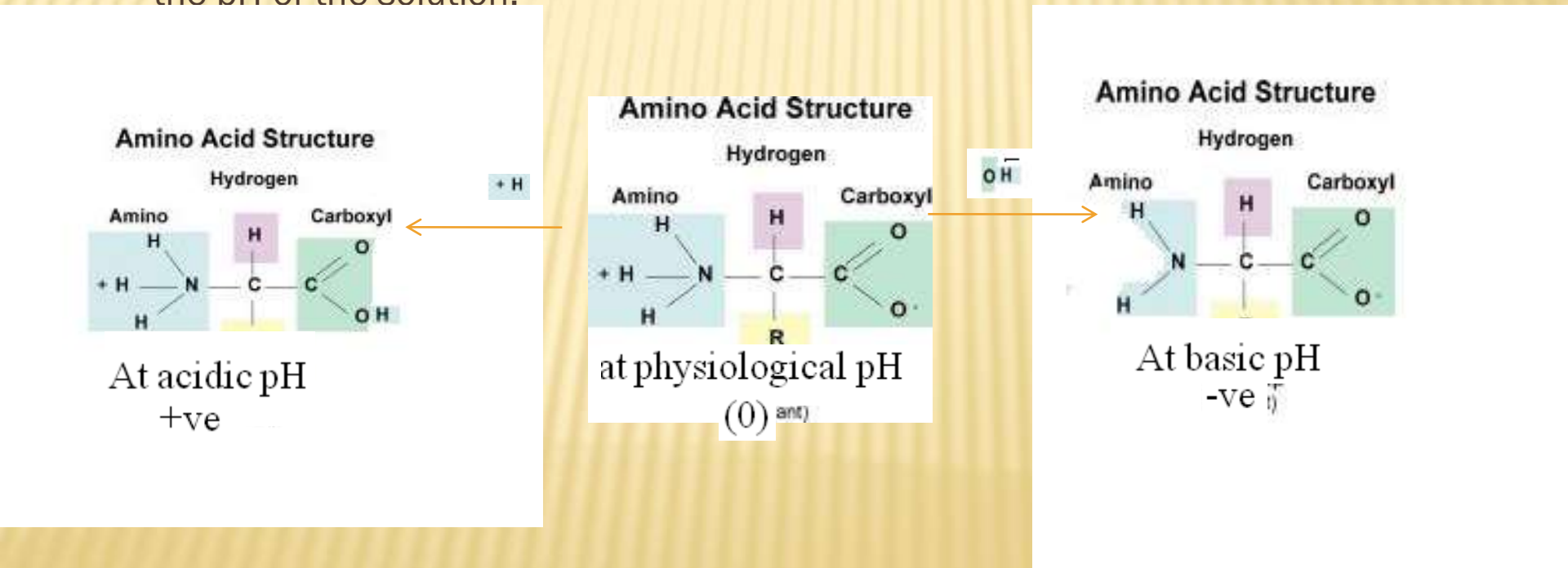
GENERAL PROPERTIES OF ALPHA-AMINO ACIDS.

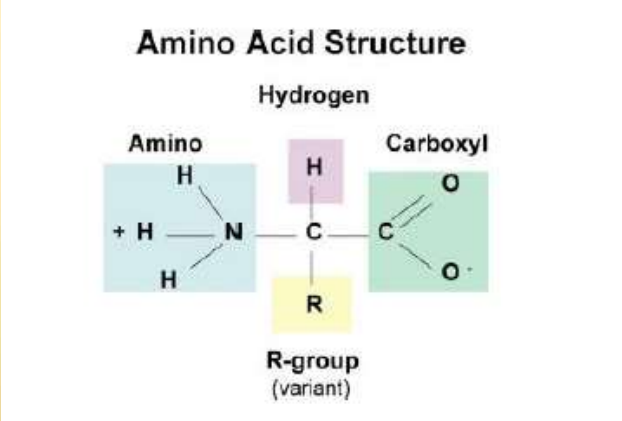
- In solutions more basic than the pI of the amino acid, the amino group —$NH3^+$ in the amino acid donates a proton.
- In solution more acidic than the pI of the amino acid, the carboxylic group COO- in the amino acid accepts a proton.
- Thus behaving sometimes as an acid and other times as a base depending on the pH of the solution.



GENERAL PROPERTIES OF ALPHA-AMINO ACIDS.

a)Polarity of amino acids;

Since amino acids are present in the Zwitterions form at physiological pH. Where it carries a +ve charge on the α-amino group and a –ve charge on the α-carboxylic group , thus creating two opposite charges On both sides of the molecule thus showing polar properties.



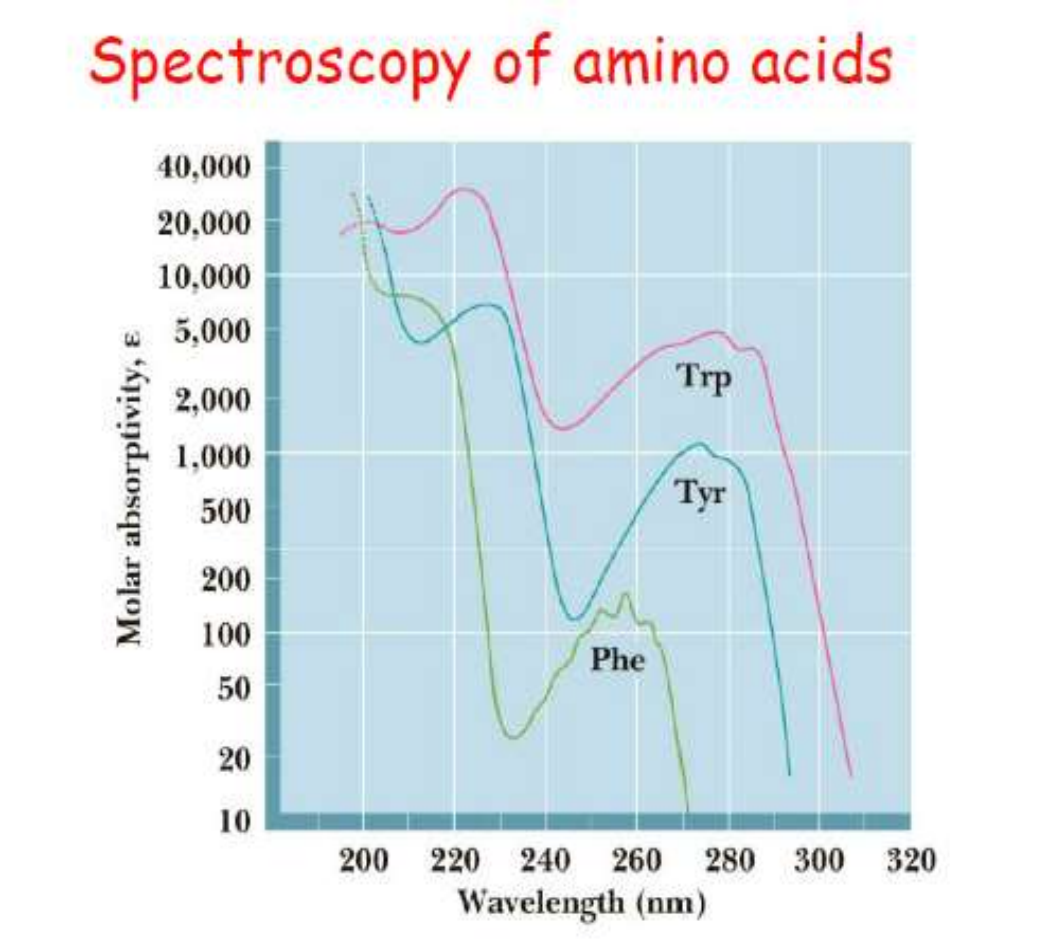
b)Isoelectric point pI ;

It is that pH at which the amino acid net electrical charge is equal to zero ,and thus cannot move in an electrical field.

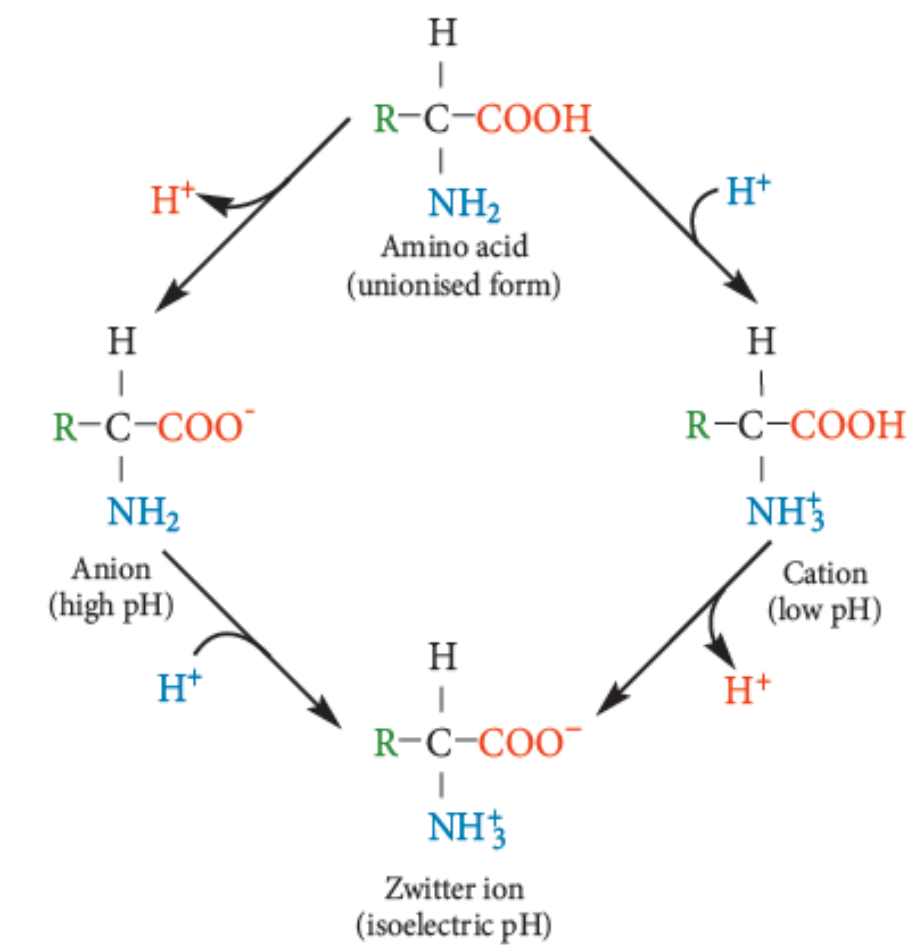
-ULTRAVIOLET ABSORPTION SPECTRUM OF AROMATIC AMINO ACIDS;

3-Ultraviolet Absorption Spectrum of Aromatic amino acids;

The aromatic amino acids tryptophan , tyrosine , histidine and phenyl alanine absorb ultraviolet light at 280nm ,which explains the absorption of proteins at 280nm.



ISOELECTRIC pH



Various ionic forms of amino acid at different pH.

CLASSIFICATIONS OF AMINO ACIDS

- **1-Classification according to the structure of the side chain R.**
- **2-Classification according to the polarity of the side chain R.**
- **3- Classification based on their nutritional value.**
- **4-Classification based on their metabolic fate.**

1-CLASSIFICATION ACCORDING TO THE STRUCTURE OF THE SIDE CHAIN R.

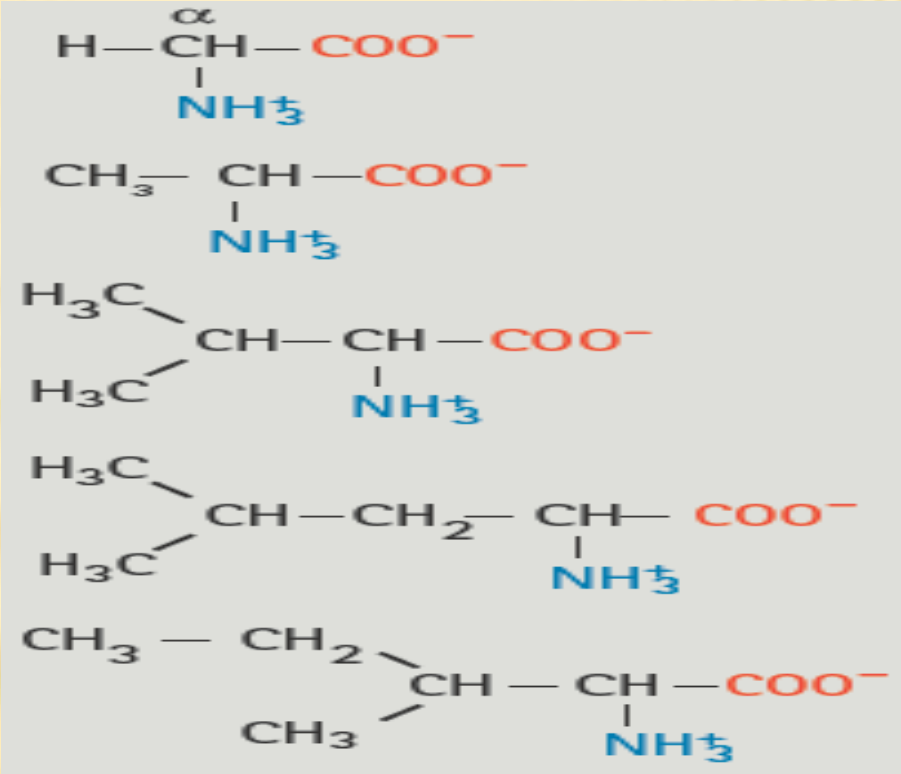
Neutral amino acids,

- **Aliphatic side chain**– Glycine, Alanine
  Valine, Leucine, Isoleucine
- **Hydroxy amino acids** (-OH group) – Serine, Threonine
- **Sulfur amino acids** – Cysteine, Methionine
- **Aromatic amino acids** – Phenylalanine, Tyrosine, Tryptophan
- **Acidic amino acids and their derivatives** – Aspartate, Asparagine, Glutamate, Glutamine
- **Basic amino acids** – Lysine, Arginine, Histidine
- **Imino acid** - Proline

CLASSIFICATION OF AMINO ACIDS

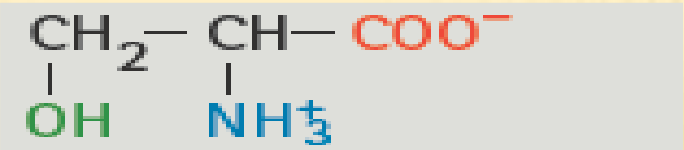
I. **Amino acids with aliphatic side chains**

1. Glycine
2. Alanine
3. Valine
4. Leucine
5. Isoleucine

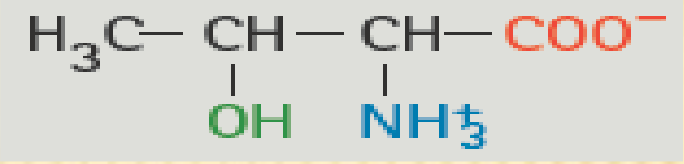


II. Amino acids containing hydroxyl (–OH) groups

6. Serine



7. Threonine

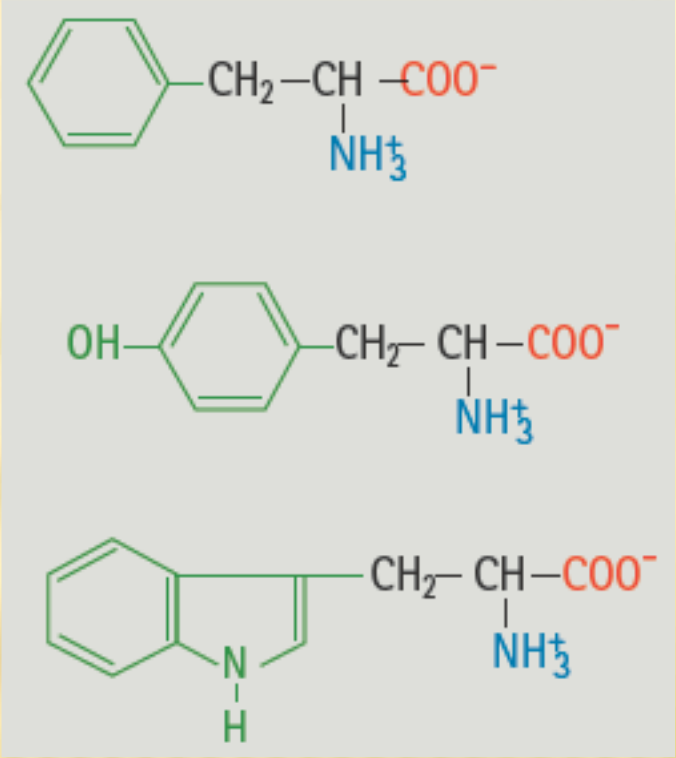


VI. Aromatic amino acids

17. Phenylalanine

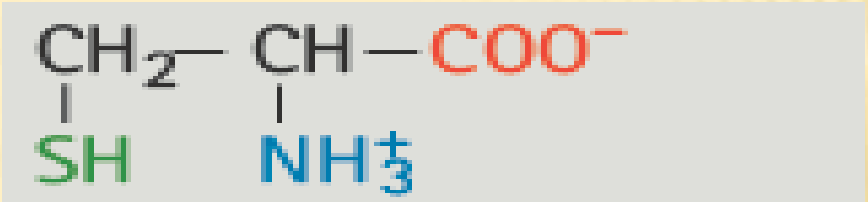
18. Tyrosine

19. Tryptophan

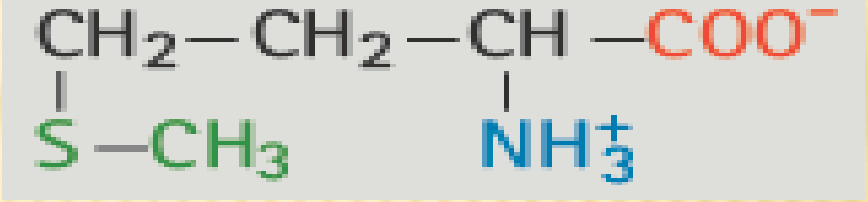


III. Sulphur containing amino acids

8. Cysteine

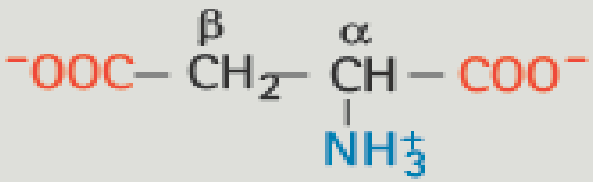


9. Methionine

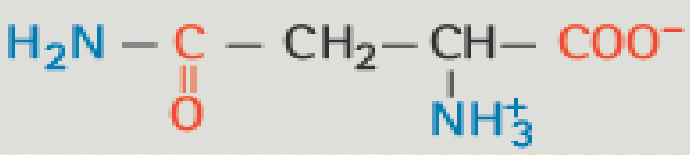


IV. Acidic amino acids and their amides

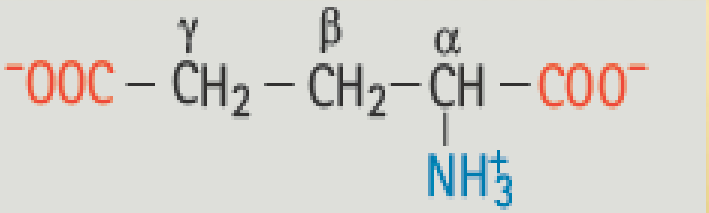
10. Aspartic acid



11. Asparagine



12. Glutamic acid



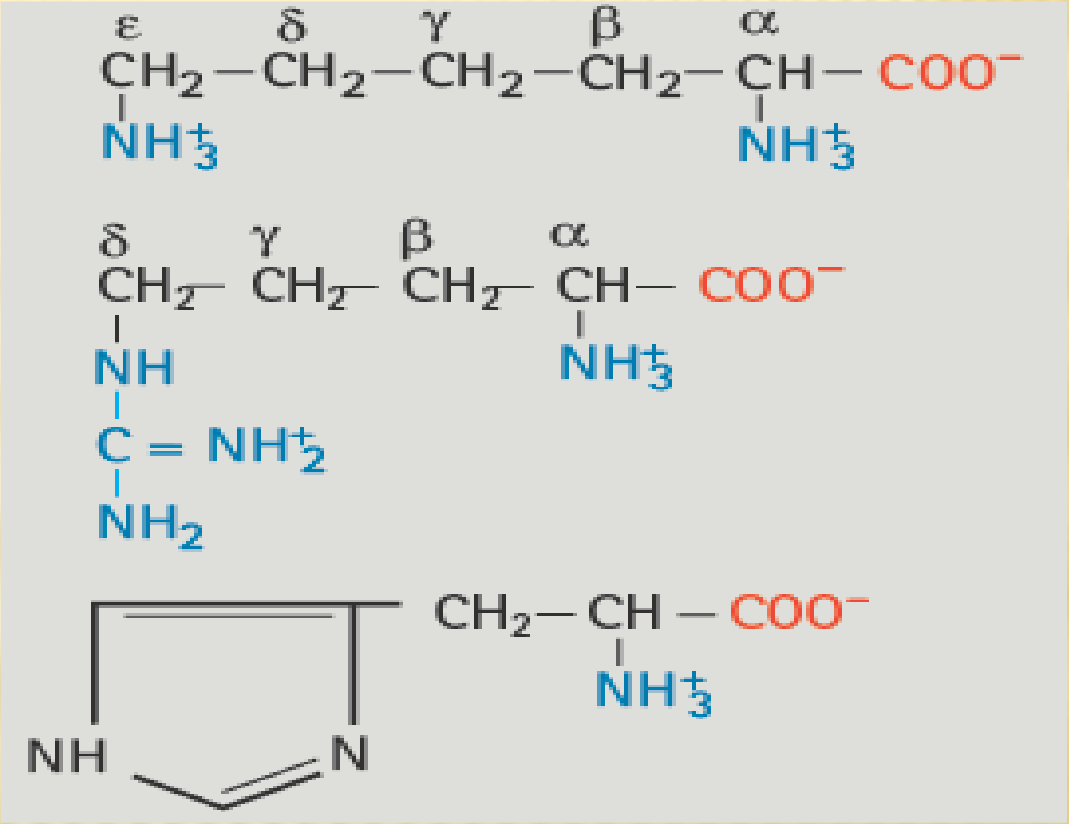
13. Gultamine

V. Basic amino acids

14. Lysine

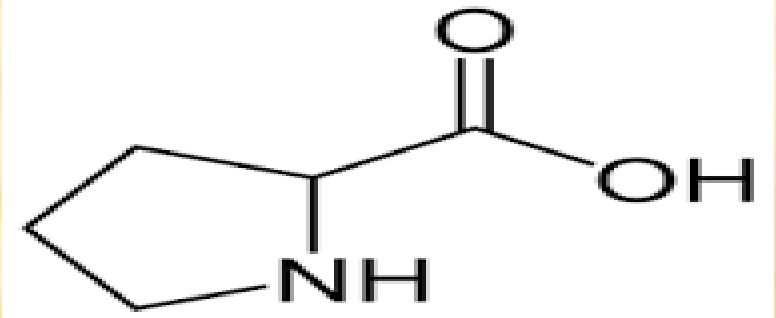
15. Arginine

16. Histidine



Imino acid

20. Proline



CLASSIFICATION OF AMINO ACIDS BASED ON THEIR SOLUBILITY

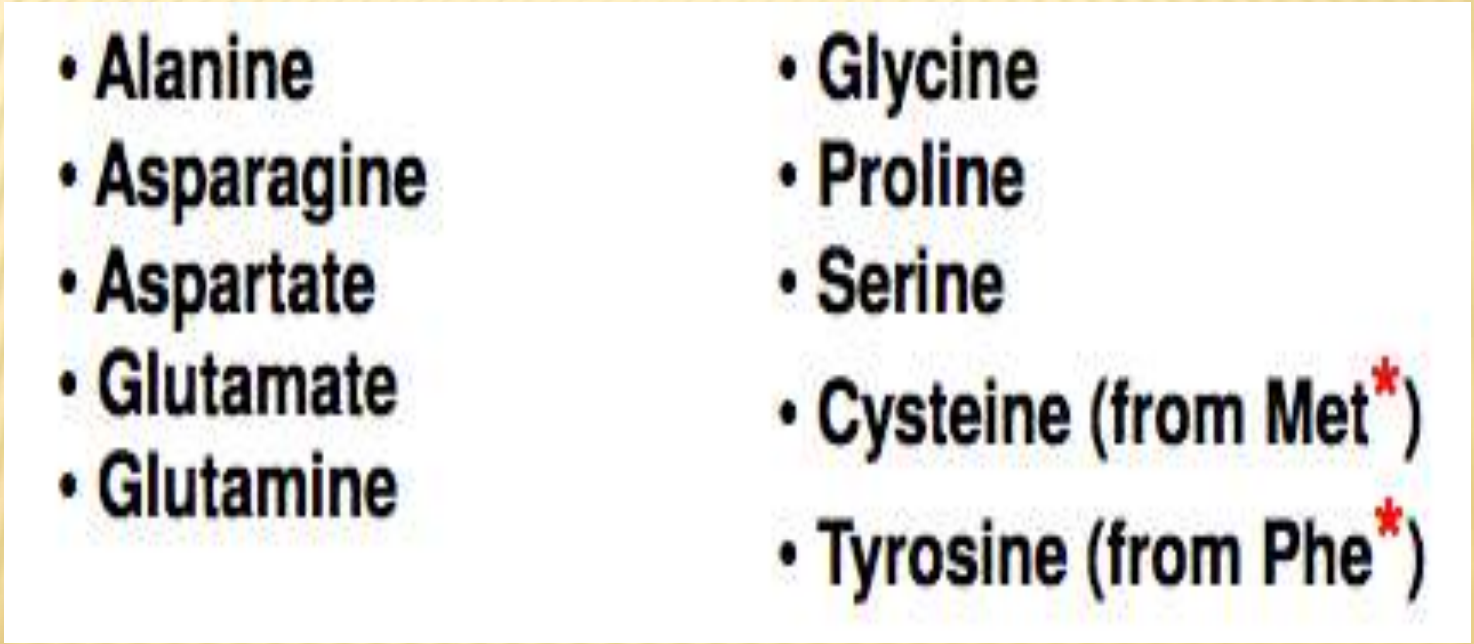
- **Polar (hydrophilic) amino acids**
  glycine, serine, threonine, cysteine, asparagine, glutamine and tyrosine.
- **Non-polar (hydrophobic) amino acids**
  Phenyl alanine, tryptophan and proline.
- **Polar Basic amino acids.(positively charged)-histidine lysine and arginine**
- **Polar acidic amino acids- Aspartic acid and glutamic acid .**

Classification of amino acids based on their nutritional value

- The amino acids which cannot be synthesised by the body and hence need to be supplied through diet are called ***essential amino acids***. Some are ***conditionally essential.***
- The ten essential amino acids in ascending order of dietary requirement:

1. Arginine
2. Tryptophan
3. Histidine
4. Methionine
5. Threonine
6. Isoleucine
7. Valine
8. Phenylalanine
9. Lysine
10. Leucine

- Non-essential amino acids; They are those amino acids that can be synthesized in the body thus they are non-essential in the diet.



CLASSIFICATION BASED ON METABOLIC FATE

- **Glucogenic amino acids**

14 amino acids are used for the synthesis of glucose or glycogen.

- Aspartate
- Asparagine
- Arginine
- Phenylalanine
- Tyrosine
- Isoleucine
- Methionine
- Valine
- Glutamine
- Glutamate
- Proline
- Histidine
- Alanine
- Serine
- Cysteine
- Glycine
- Threonine
- Tryptophan

CLASSIFICATION BASED ON METABOLIC FATE

- **Ketogenic amino acids**

  Leucine is the only exclusive ketogenic amino acid.

- **Ketogenic and glucogenic amino acids**

  Isoleucine, lysine, phenylalanine, tyrosine and tryptophan.

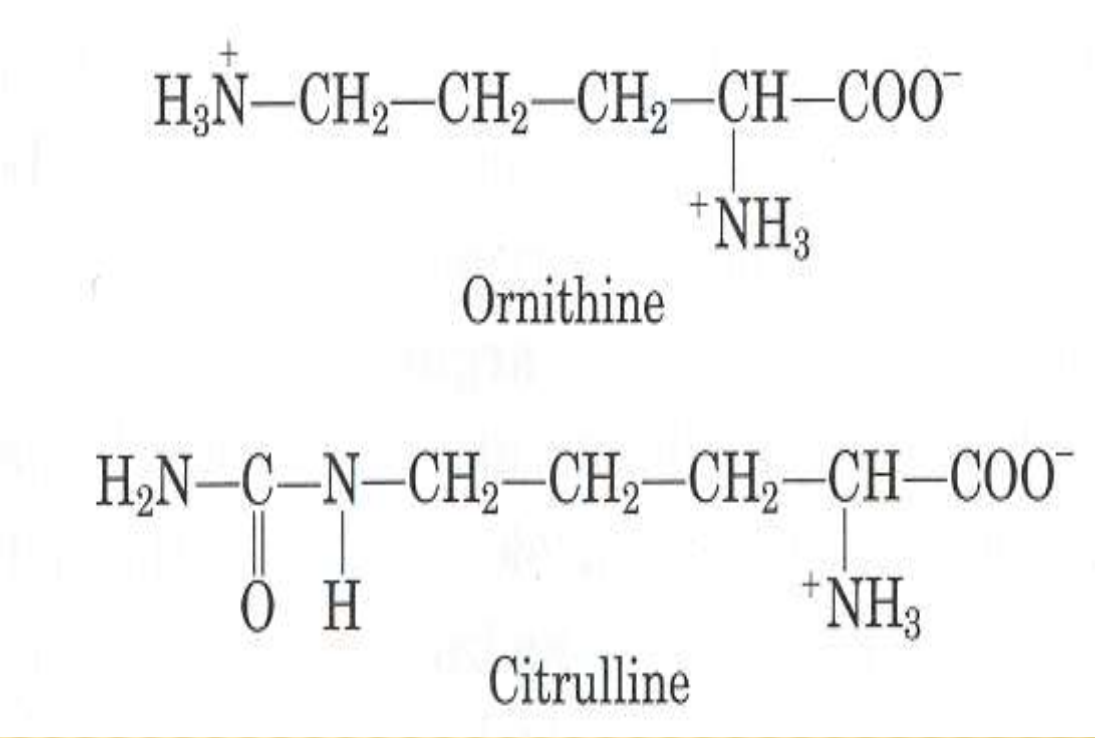
NON-STANDARD AMINO ACIDS

- Non-Protein amino acids
- Ornithine , citrulline , homocysteine s-adenosyl methionine.

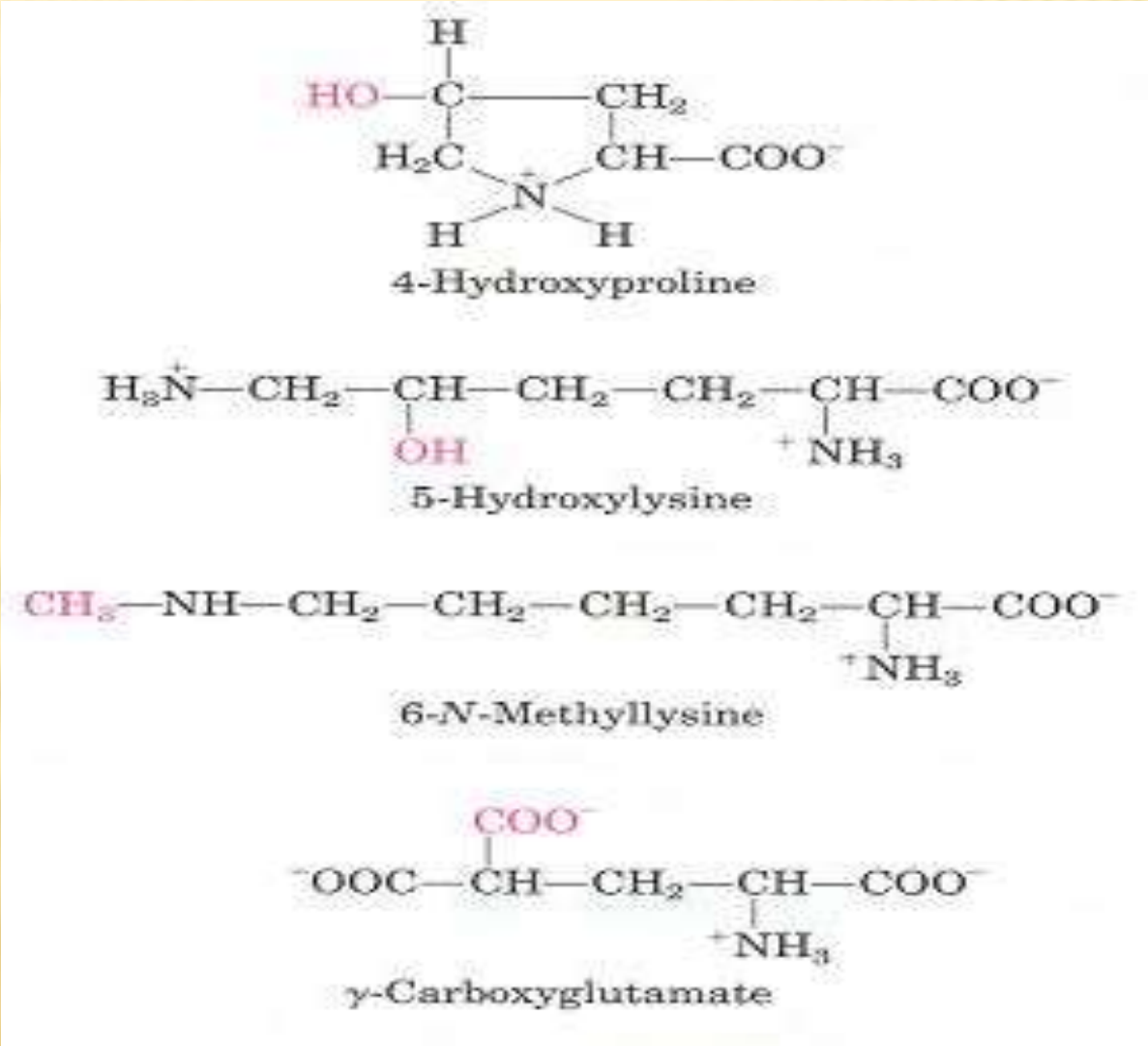
AMINO ACID DERIVATIVES

- Dopamine, melanin, T_3 , T_4 are derived from Tyrosine .
- Serotonine (neurotransmitter) and Melatonine are derived from Tryptophan,
- GABA (Gamma amino butyric acid) is an inhibitory neurotransmitter formed from Glutamic acid by decarboxylation.
- Cystine is formed from condensation of two cysteine molecules.

INTERMEDIATES OF BIOSYNTHESIS OF ARGININ AND IN UREA CYCLE



UNCOMMON AMINO ACIDS FOUND IN PROTEINS



GENERAL REACTIONS OF AMINO ACDS

A] Due to carboxylic group :

1) Decarboxylation:

Histidine → Histamine + CO_2

Tyrosine → Tyramine + CO_2

Tryptophan → Tryptamine + CO_2

Lysine → Cadavarine + CO_2

Glutamic acid →Gamma Amino Butyric Acid (GABA) + CO_2

2) **Amide Formation :** The COOH grp of amino acids other than α carboxyl can combine with ammonia to form the corresponding amide .

e.g.

Aspartic acid + NH_3 → Aspargine

Glutamic acid + NH_3 → glutamine

B] REACTION DUE TO AMINO GROUP

3) Transamination : α amino group of amino acid transferred α keto acid to form corresponding new amino acid and α keto acid .

e.g.

Alanine + α keto glutarate → Pyruvate + Glutamate

4) Oxidative Deamination The α amino group Is removed from the corresponding keto acid and ammonia

e.g.

Glutamate → α Keto Glutarate

5)Formation OF Carbamino compound :

CO_2 adds to the α amino group of amino acids to form carbamino compound .The reaction at alkaline p H and serves as a mechanism for the transport of CO_2 from tissue to lungs by Hb.

$$Hb - NH_2 + CO_2 \rightarrow Hb - NH - COOH$$

C] REACTIONS DUE TO SIDE CHAINS

6)Transmethylation:: The methyl group of methionine after activation may be transferred to an acceptor which becomes methylated .

e.g.

Methionine + Acceptor → Methylated

Acceptor + Homocysteine

7)Ester formation by the OH group The OH amino acids can form ester with phosphoric acid .

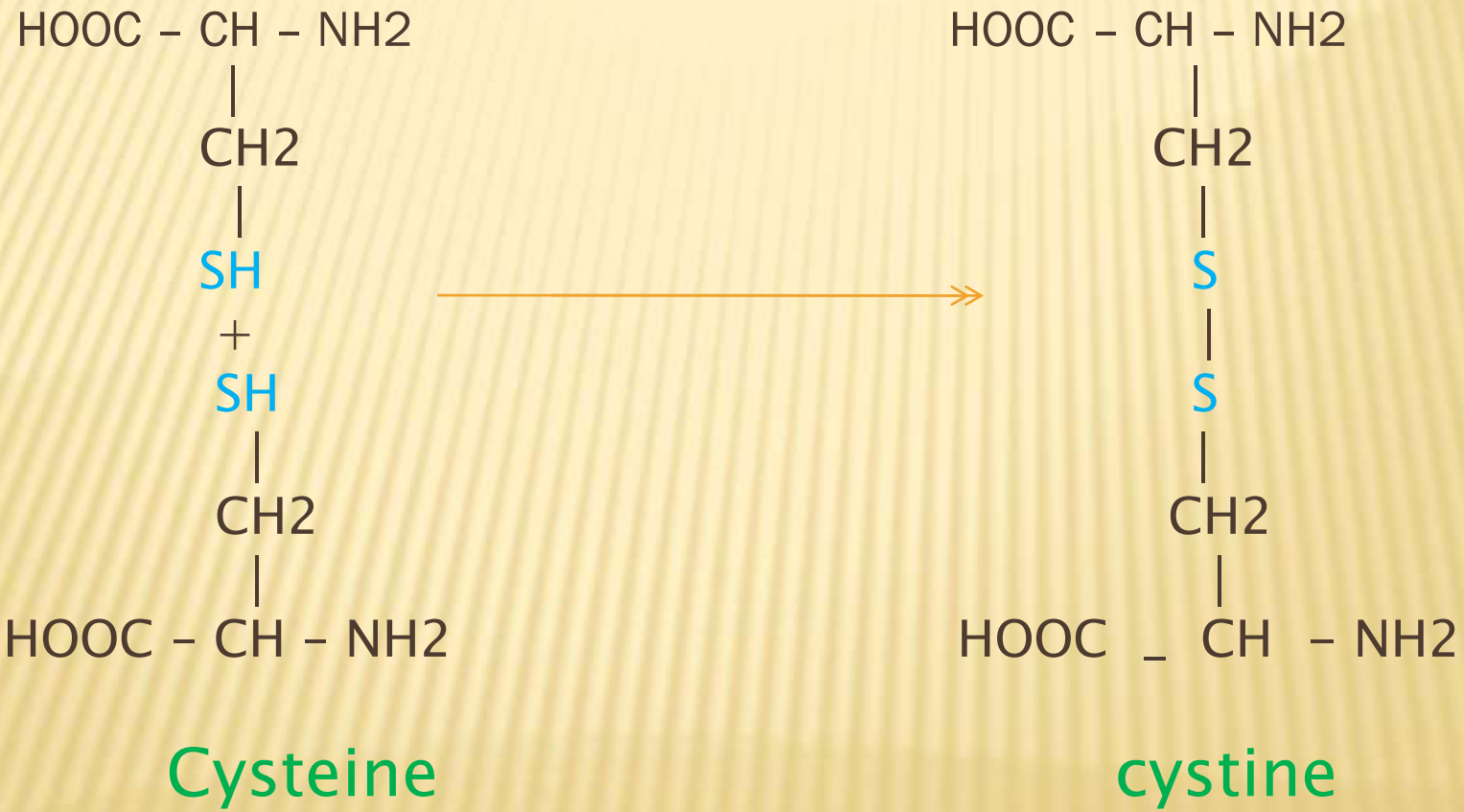
e.g. Serine and Threonine

8) Reaction of the amide group :

The amide groups of Glutamine and Aspargine can form N- glycosidic bonds with carbohydrate residues to form glycoproteins.

9)Reactions of SH group :

Cysteine has a sulfhydryl (SH) group & it form a disulphide (S – S) bond with another cysteine residue.The two cysteine residues can connect two polypeptide chains by formation of inter chain disulphide bonds / links.



Cysteine

cystine

SPECIAL FUNCTIONS OF AMINO ACIDS

1) GABA & Dopamine are neurotransmitters.
2) Histamine is mediator of allergic reactions.
3) Thyroxine is important thyroid hormone.
4) Serine forms the active centre of many proteolytic enzymes .
5) Histidine residues are important in buffering action of proteins.
6) Lysine group is involved in the binding of co- enzymes PLP & Biotin.
7) Ornithine and citrulline are derivatives of arginine & are essential for urea synthesis.