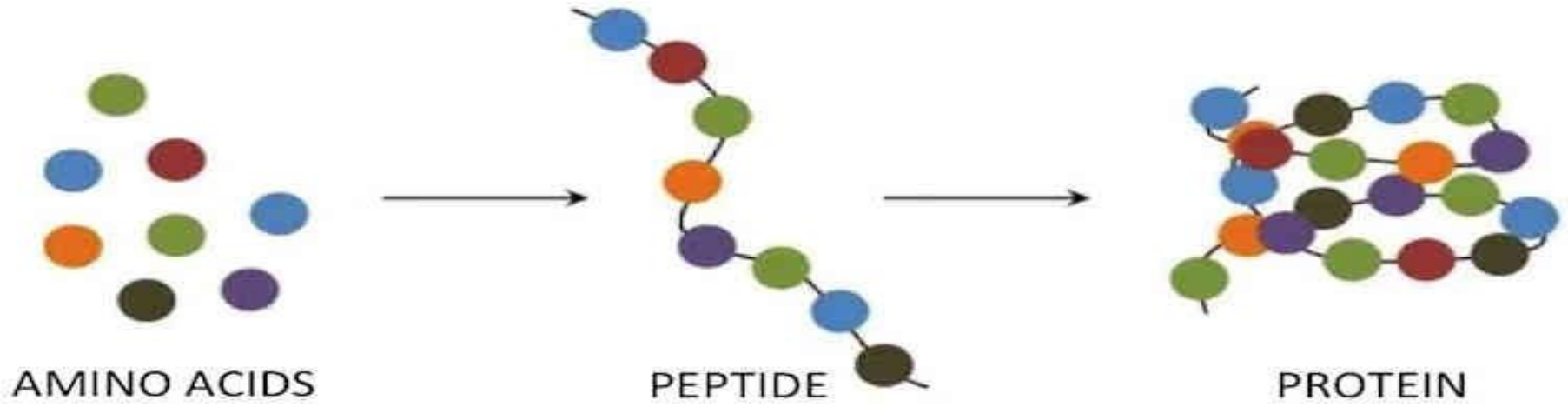
SEMESTER VI

PROTEINS AND AMINO ACIDS

JASMINE MARIYA A J
ASSISTANT PROFESSOR ON CONTRACT
LITTLE FLOWER COLLEGE ,GURUVAYUR

Amino acids and Proteins



- Proteins are the much abundant structural and functional organic constituents of living matter
- Each protein molecule is an unbranched linear **polymer** ,formed by condensation polymerisation of **amino acid** units through **peptide bonding**
- The term protein is applied for amino acid chain with molecular weight above 5000 Da and the term polypeptide is given to amino acid chain with molecular weight below 5000 Da.

Amino acids

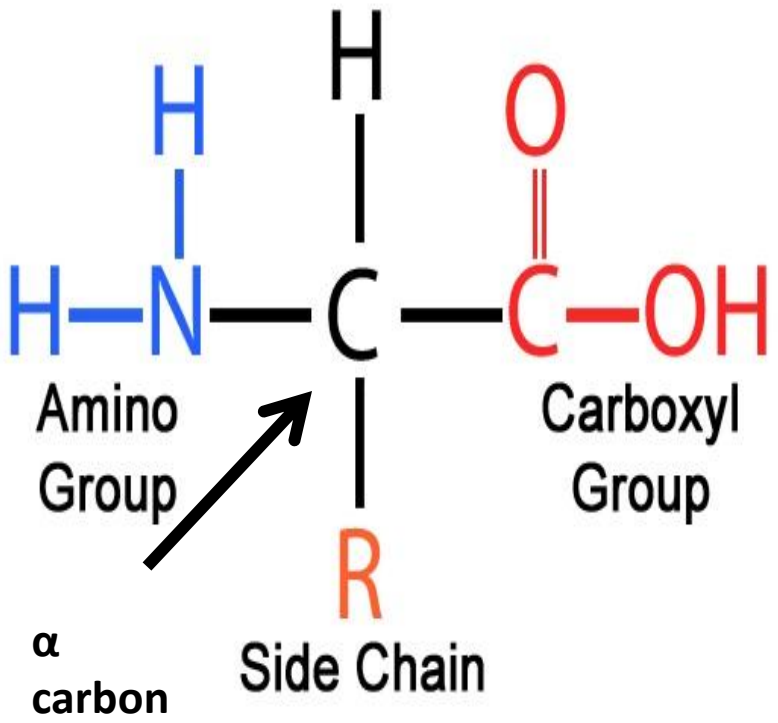
- Amino acids (Amino carboxylic acids) are organic carboxylic acids in which at least one C atom of the hydrocarbon chain is replaced by amino group
- **20** amino acids are known to be present in proteins ,they are known as standard amino acids or proteogenic amino acids

- The first discovered amino acid is **Asparagine**
- The last discovered one is **Threonine**
- Amino acids undergo condensation polymerisation through covalent peptide bonding to form poly peptide chains

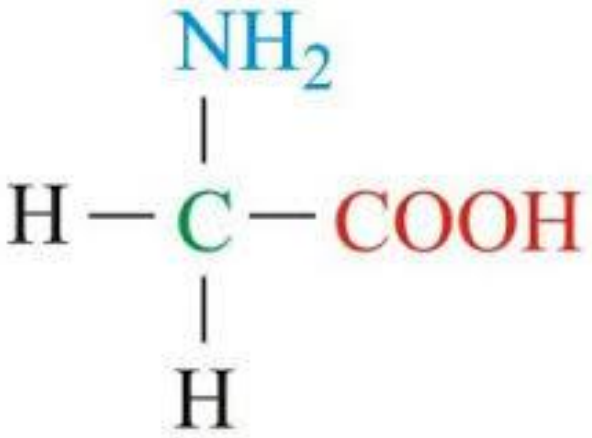
General structure of amino acids

- Typically an amino acid molecule have a central carbon atom ,known as alpha carbon
- To the alpha carbon ,four different groups are attached

1. Hydrogen atom
2. Amino group
3. Carboxylic acid group
4. Variable R group



- The α C of all amino acids except Glycine are asymmetric in nature
- Threonine , Isoleucine, hydroxy lysine, hydroxy proline , etc.have two asymmetric carbon atoms
- The variable R group determines the nature of the amino acid
- Amino acids differ from each other in the R group



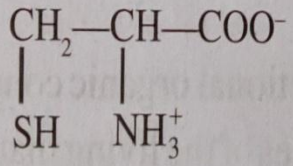
Glycine – The simplest amino acid

Standard amino acids

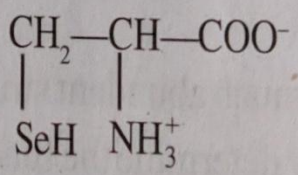
Name	Three letter symbol	One letter symbol	Name	Three letter symbol	One letter symbol
1. Alanine	Ala	A	11. Leucine	Leu	L
2. Arginine	Arg	R	12. Lysine	Lys	K
3. Asparagine	Asn	N	13. Methionine	Met	M
4. Aspartic acid	Asp	D	14. Phenylalamine	Phe	F
5. Cysteine	Cys	C	15. Proline	Pro	P
6. Glutamic acid	Glu	E	16. Serine	Ser	S
7. Gluamine	Gln	Q	17. Threonine	Thr	T
8. Glycine	Gly	G	18. Tryptophan	Trp	W
9. Histidine	His	H	19. Tyrosine	Tyr	Y
10. Isoleucine	Il	I	20. Valine	Val	V

Selenocysteine and pyrrolysine have been currently added to this list

Recently, two more amino acids have also been included under the list of proteogenic amino acids. They are *selenocysteine* and *pyrrolysine*. Selenocysteine is found at the active site of certain enzymes, called *selenoproteins* (e.g., glutathione peroxidase, glycine reductase, thioredoxin reductase, etc). It is unusual in having the trace element selenium in place of the sulphur of cysteine. Selenocysteine is specified by the codon UGA, which is normally a stop codon which terminates genetic tranlation (protein synthesis). Another unique feature of selenocysteine is that it is enzymatically generated directly from serine on the tRNA and then incorporated into protein.



Cysteine



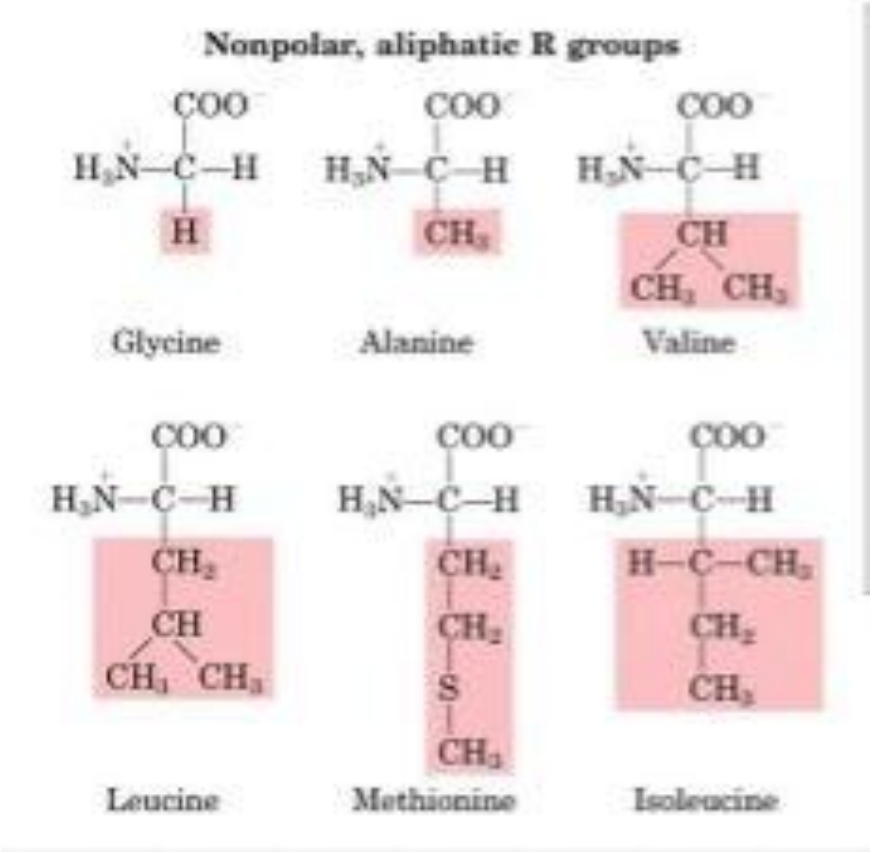
Selenocysteine

Pyrrolysine is also belived to be coded by UGA, but the proteins in which it is present are not definitely understood.

CLASSIFICATION OF AMINO ACIDS

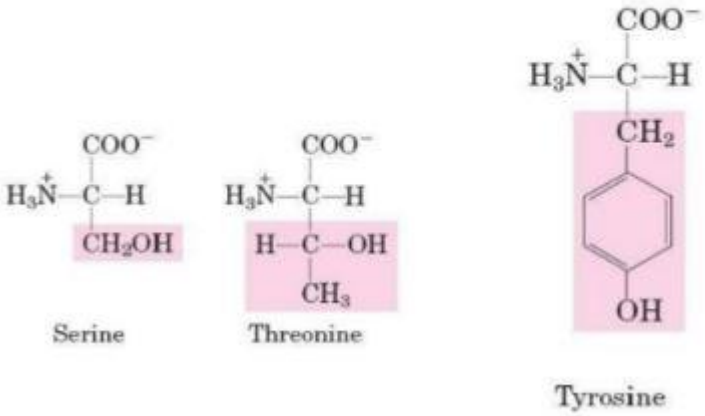
1.Based on structure and chemical nature

i. **Aminoacids with aliphatic side chain :**
They are monoamino monocarboxylic acids
Eg: Glycine ,Alanine,Valine ,Leucine,Isoleucine and Methionine



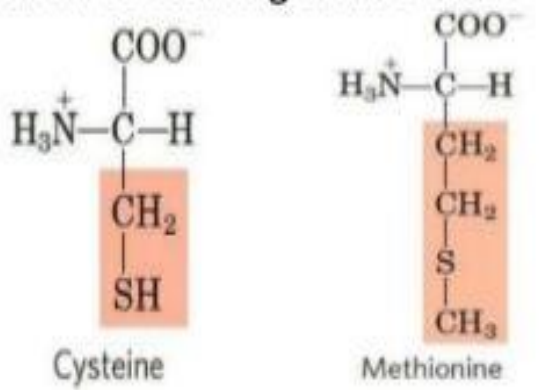
- ii) Amino acids with hydroxyl group

[Serine, Threonine, Tyrosine]

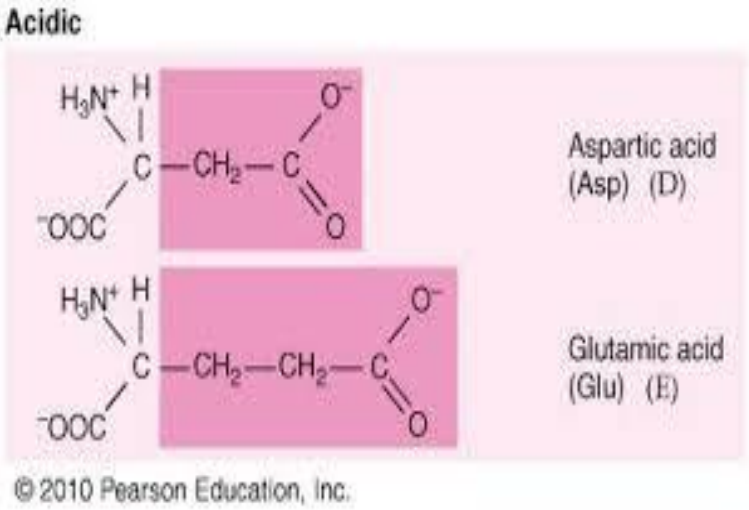


- iii) Sulphur containing amino acids

❑ Sulfur-containing amino acids

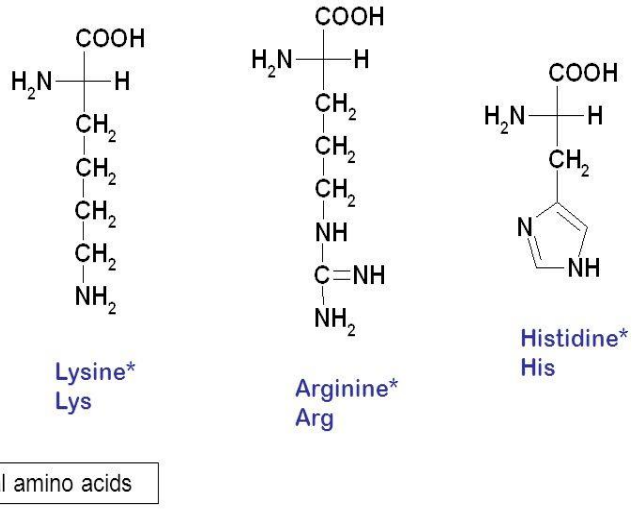


iv)Acidic amino acids :



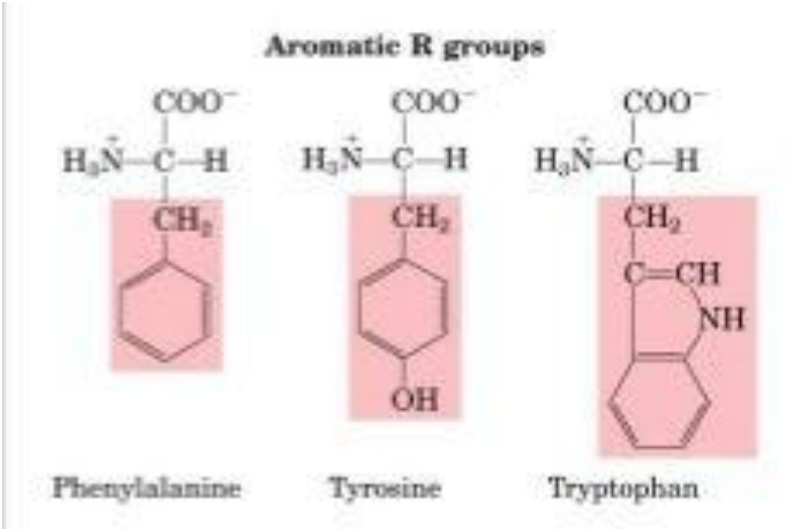
They are mono amino dicarboxylic acids

v) Basic amino acids

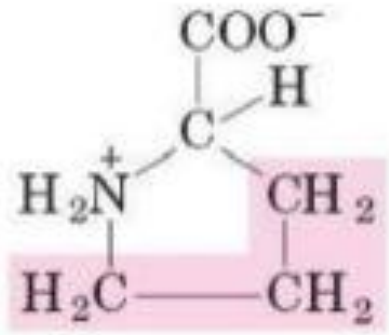


Diamino monocarboxylic acids

Vi)Aromatic amino acids



vii)Imino acids



B. Classification based on acid-base properties

[Acidic, basic and neutral amino acids]

Based on electro-chemical or acid-base properties, amino acids are classified under three major groups, *acidic, basic* and *neutral.* Acidic amino acids have an additional carboxyl (acidic) group in the side chain radical. They are *anionic, polar and hydrophilic*. Basic amino acids have an additional amino (basic) group in the side chain. They are *cationic*, *polar and hydrophilic*. Neutral amino acids have neither acidic nor basic groups in the side chain. They can be polar and hydrophilic, or non-polar and hydrophobic, as the case may be. Aspartic, glutamic and amino citric acids are acidic. Lysine, arginine, histidine, etc. are basic. Alanine, glycine, etc. are neutral.

C. Classification based on the number of carboxyl groups

Based on the number of carboxyl groups present, and also on the nature of the structure (whether aliphatic, aromatic, or heterocyclic), aminoacids are classified under six major groups as follows.

(i) Monoaminomonocarboxylic acids

(ii) Monoaminodicarboxylic acids

(iii) Diaminomonocarboxylic acids

(iv) Sulphur-containing amino acids

(v) Aromatic amino acids

(vi) Heterocyclic amino acids.

In addition to these, a seventh group has also been suggested, namely amino acids formed as metabolic intermediates.

(i) *Monoaminomonocarboxylic acids* - These are the neutral amino acids, with only one amino group and one carboxy group – e.g., alanine, glycine, isoleucine, leucine, serine, threonine, valine.

(ii) *Monoaminodicarboxylic acids* - Acidic amino acids, with one amino group and two carboxyl groups – e.g., aspartic acid, glutamic acid.

(iii) *Diaminomonocarboxylic acids* - Basic amino acids, with two amino groups and one carboxyl group – e.g., arginine, lysine.

(iv) *Sulphur-containing amino acids* - Amino acids, with sulphur-containing aliphatic side chains – e.g., cysteine, cystine, methionine.

(v) *Aromatic amino acids* - Amino acids, with aromatic side rings – e.g., phenylalanine, tryptophan, tyrosine.

(vi) *Heterocyclic amino acids* - Amino acids, with imidazole ring, or indole ring – e.g., histidine, hydoxyproline.

(vii) *Metabolic intermediates* - Physiologically important amino acids formed during metabolic reactions – e.g., citrulline, diodotyrosine, ornithine.

D. Classification based on polarity

i) Amino acids having non – polar side chain

These include Alanine ,valine,proline,leucine , isoleucine,methionine ,phenyl alanine ,tryptophan

They are hydrophobic and lipophilic

ii)Amino acids having polar side chain

These amino acids are hydrophilic

These include glycine ,serine, threonine,and asparaginecysteine, tyrosine,glutamine,

iii)Amino acids having charged side chains

Acidic amino acids and basic amino acids come under this category

E.Based on nutritional requirements

i)Essential aminoacids

Thses are amino acids ,which can not be synthesised in animal body ,hence should gain through the diet. Eg ; valine ,leucine,isoleucine, lysine,phenyl alanine ,methionine ,tryptophan ,and threonine

ii)Semi –essential amino acids :

Which can be synthesised only in adults ,and infants have to get it through the diet

Eg;Arginine and histidine

iii) Non-Essential amino acids :

Aminoacids which can be synthesised in the body hence need not be supplemented through diet.

Eg: alanine ,serine ,proline, glycine ,Glutamic acid ,aspartic acid, cysteine,,tyrosine ,

F. Based on metabolic fate

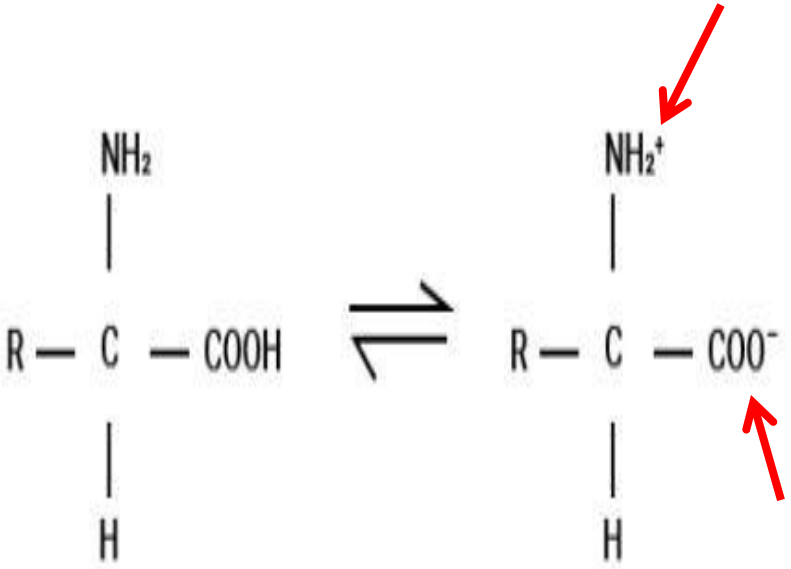
- **Glucogenic amino acids**: These amino acids serve as precursors of gluconeogenesis for glucose formation.
- **Ketogenic amino acids:** These amino acids breakdown to form ketone bodies,such as aceto acetate ,acetone ,beta –hydroxy pyruvate.
- **Both glucogenic and ketogenic amino acids:** These amino acids breakdown to form precursors for both ketone bodies and glucose.

Glucogenic and ketogenic amino acids			
Exclusively glucogenic		*Exclusively ketogenic*	*Glucogenic as well as ketogenic*
1. Alanine	8. Hydroxy proline		
2. Arginine	9. Methionine		1. Isoleucine
3. Aspartic acid	10. Proline	Leucine	2. Tryptophan
4. Cysteine	11. Serine		3. Phenyl alanine
5. Glutamic acid	12. Threonine	Lysine	4. Tyrosine
6. Glycine	13. Tryptophan		
7. Histidine	14. Valine		

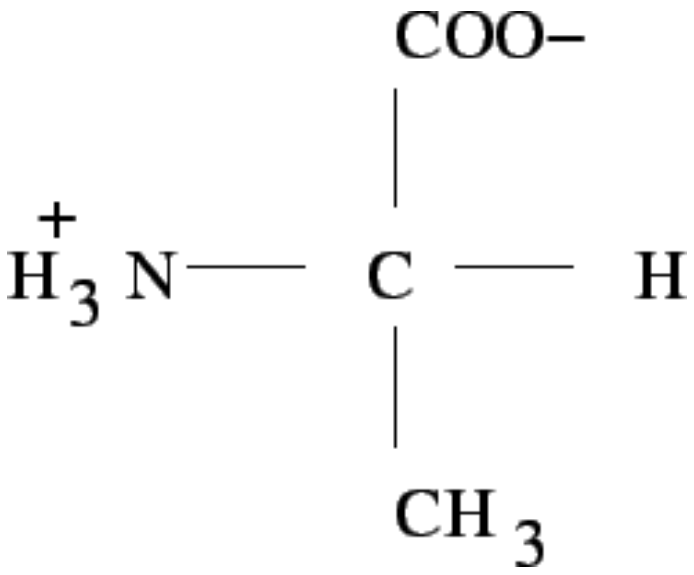
Amino acids –Ionization

- Amino and carboxyl groups of amino acids are ionisable
- Amino group of the amino acid can undergo protonation and a net gain of + charge .Thus it is basic and cationic
- Carboxyl group of the amino acid can undergo deprotonation and a net loss of one + charge. Hence it is acidic and cationic

- In the ionised form an amino acid will have both negative and positive charges simultaneously- Known as **dipolar form**
- They are also known as **zwitter ionic** form as they are cationic and anionic simultaneously
- The net charge of dipolar form is zero

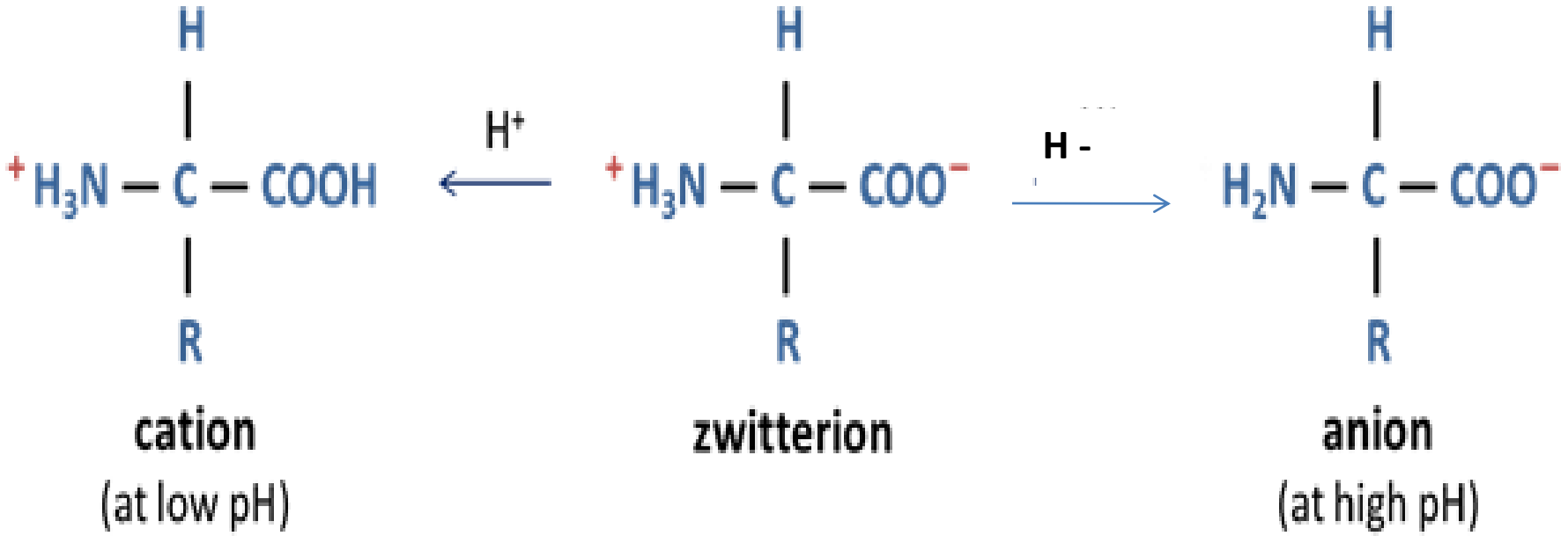


- In aqueous solution at neutral PH ,amino acids are ionised and predominantly dipolar , zwitterionic ,and amphoteric electrolytes ,with no net charge .
- **Amphoteric** means they can behave as both acid and base.
- They will be electrically neutral as the opposite charges will cancel each other
- In neutral pH ,as they carry no net charge ,that pH is also known as the isoelectric pH



Concept of isoelectric pH

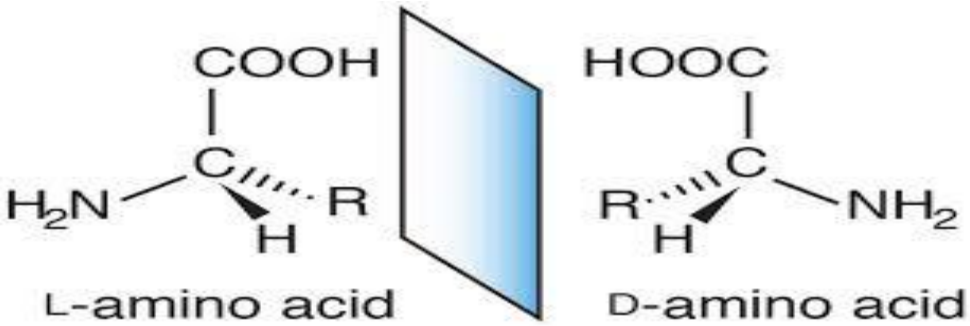
- The pH at which a molecule carries no net charge is known as isoelectric point or isoelectric pH.
- At isoelctric point those molecule will not show any mobility in electric field
- They will not have any charge
- As the pH of the medium changes to acidic or basic ,the molecules will attain positive or negative charge and will move towards the opposite charged electrode in the electric field



- At neutral pH ,(isoelectric pH) the amino acids will exist as zwitter ion ,with no net charge
- In acidic medium (decreased pH), there will be so many free H+ ions and they will occupy the possible locations ,which leads to the formation of a positively charged cationic form
- In basic medium (increased pH),there will not be any H+ ions in the medium ,so amino acids will loose the H+ ions to the medium and will become negatively charged anion
- Amino acids can exist in these three forms ,depending upon the pH of the solution

Optical isomerism of amino acids

- Amino acids having an asymmetric C atom shows optical activity
- All amino acids except glycine are optically active
- The mirror image forms produced with reference to alpha carbon atom are called D and L isomers
- L amino acids are occurring in nature ,hence called natural amino acids .D amino acids are present in small amounts in bacteria
- Isoleucine and threonine have two chiral centers hence ,they can form 4 diasteriomers

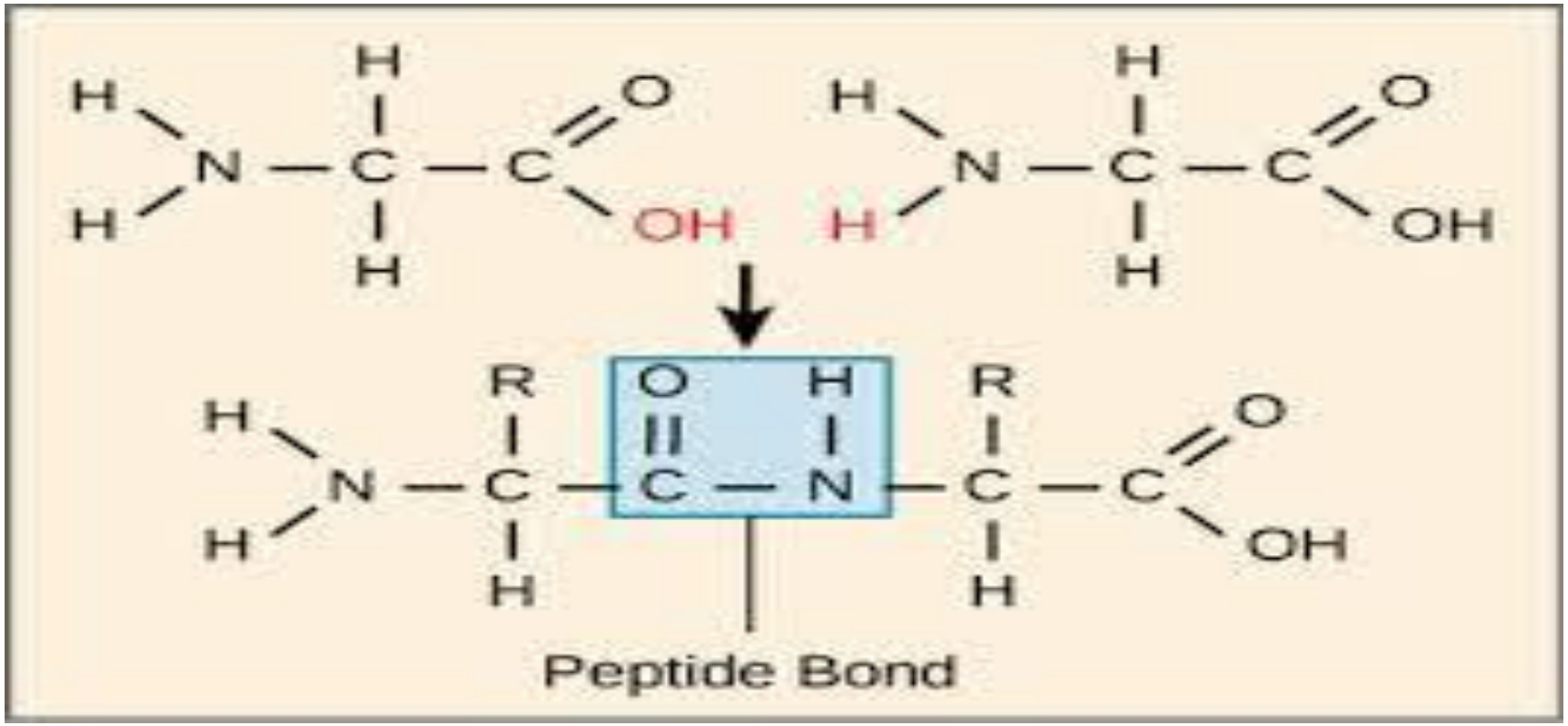


Some natural D-amino acids

Amino acid	*Occurrence*
D-alanine	Cell wall peptides of bacteria
D-glutamic acid	Cell wall peptides and capsules of bacteria
D-valine	Gramicidin S, actinomycin C
D-leucine	Basitracin
D-phenylalanine	Gramicidin S, tyrocidins
D-serine	Polymixin D
D-allohydroxyproline	Etamycin

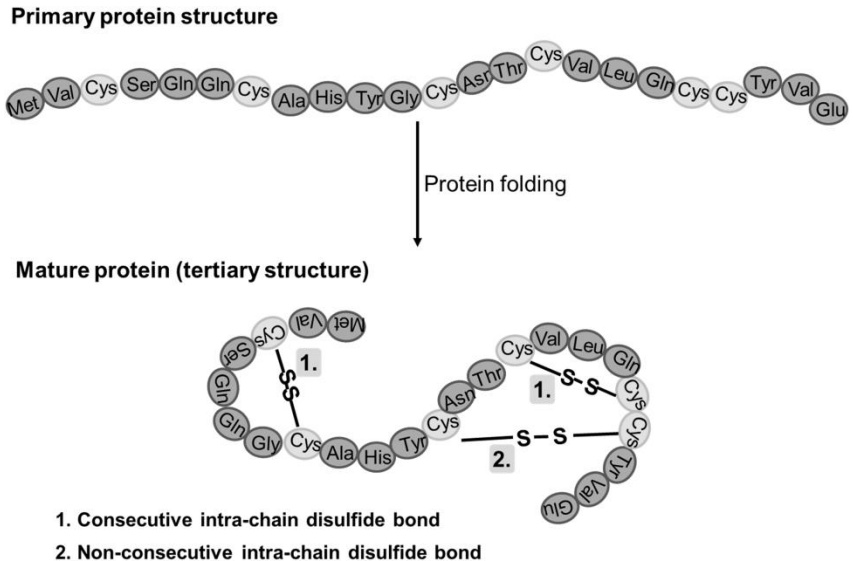
Chemical bonding

- Peptide bond formation
- Alpha carboxylic acid of one molecule reacts with alpha amino group of another molecule to form a peptide bond or CO-NH bridge
- It is a type of covalent bond
- One molecule of water is eliminated during this process
- Two amino acids linked through a peptide bond is called as dipeptide


Peptide Bond

Disulphide bond

- involves a reaction between the sulfhydryl (SH) side chains of two cysteine residues
- Important in protein folding
- It is also a type of covalent bond



Ionic bond

- Bond between ionised amino group of one amino acid reacts with ionised carboxyl group of another amino acid to form an ionic bond

Hydrogen bond

- Seen in secondary structure of protein
- -NH and –OH groups are involved in this type of bonding