

BIOL 158: AMINO ACIDS

by

Caleb Kesse Firempong (PhD)

Email: calebuse@yahoo.com

Phone #: +233-208243995

Amino acids

- What are the structure and properties of amino acids, the building blocks of protein?
- What are the acid-base properties of amino acids?
- What reactions do amino acids undergo?
- How are amino acids mixtures separated and analyzed?

➤ Proteins: molecular machine-----large molecules

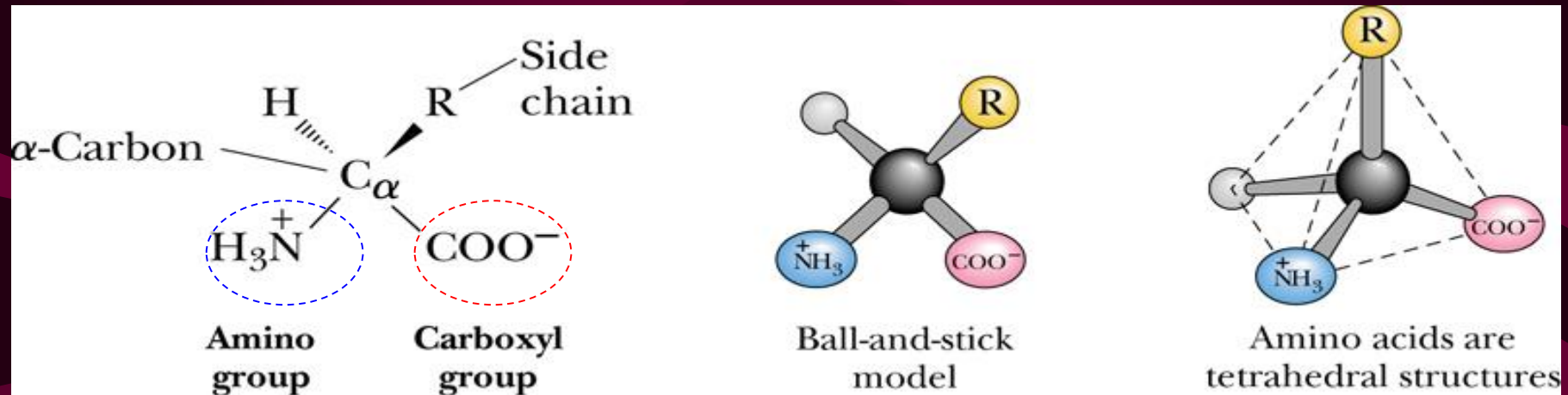
20 amino acids -----Small molecules

➤ Amino acids are the building blocks of proteins.

➤ Some characteristics of protein are dependent on the properties of amino acids.

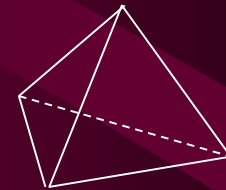
Structure and properties of amino acids, the building blocks of protein.

Typical amino acids contain a central tetrahedral carbon atom.



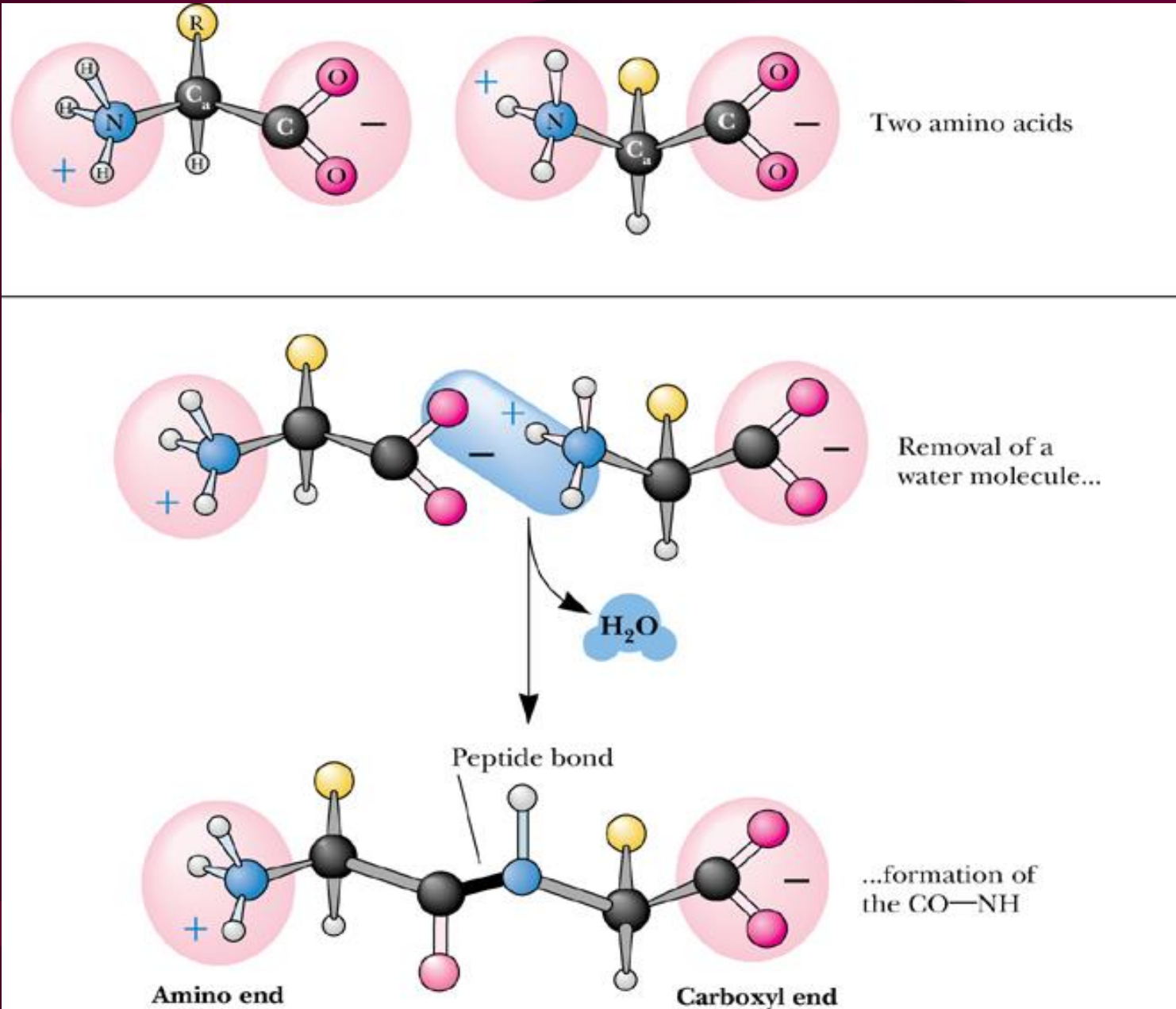
Universal structure

Individual R group



Identities of amino acids are dependent on their R groups

Amino acids can join via peptide bonds



Polypeptides
and proteins

20 amino acids commonly found in proteins

Classification is based on the polarity of the side chains.

Four categories:

1. **Nonpolar or hydrophobic amino acids** (8) :

Leucine, Isoleucine, Alanine, Phenylalanine,
Proline, Valine, Methionine, Tryptophan

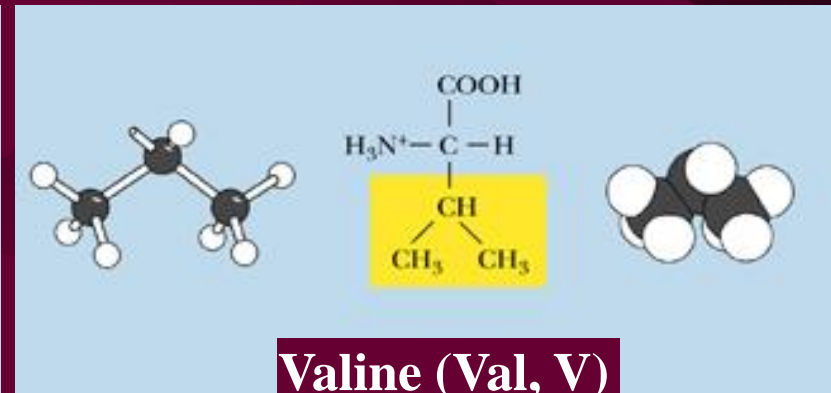
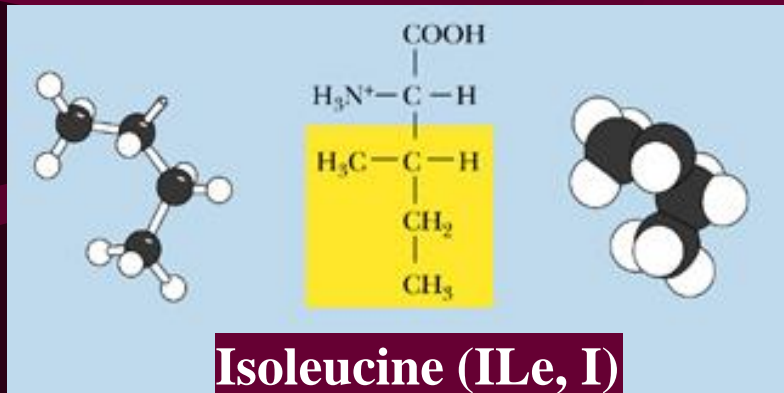
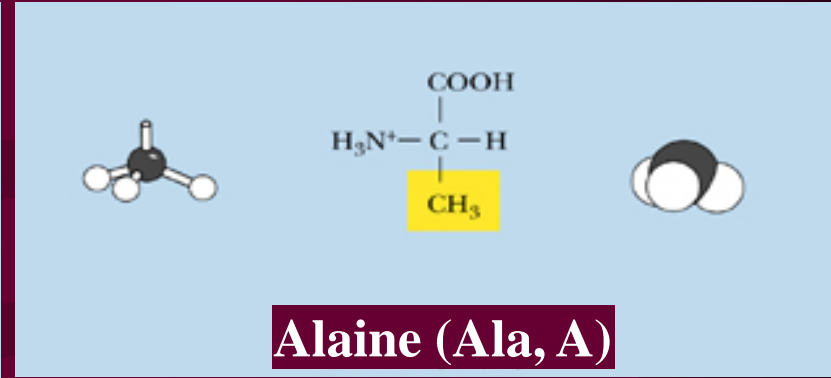
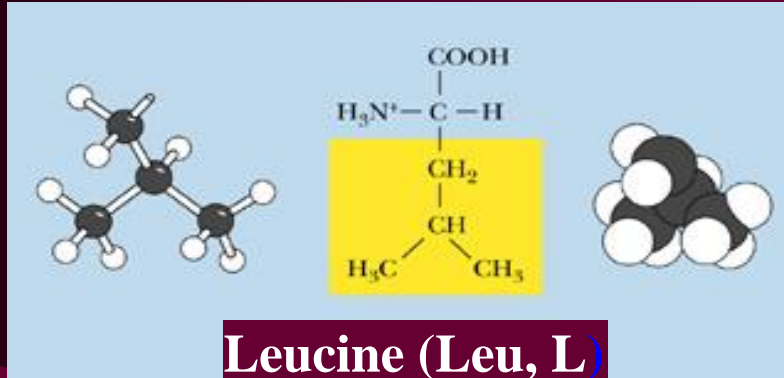
2. **Neutral (uncharged) polar amino acids** (8) :

Glycine, Serine, Threonine, Cysteine,
Tyrosine, Histidine, Asparagine, Glutamine

3. **Acidic amino acids** (2) : Aspartic acid, Glutamic acid

4. **Basic amino acids** (2) : Lysine, Arginine

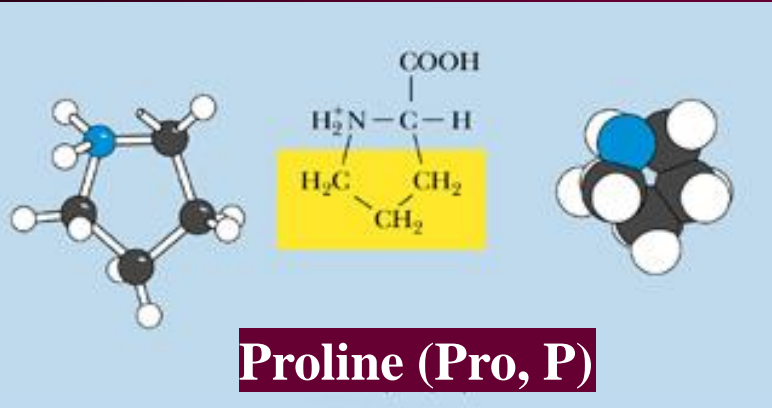
Nonpolar amino acids:



Alkyl chain group
Aliphatic amino acids

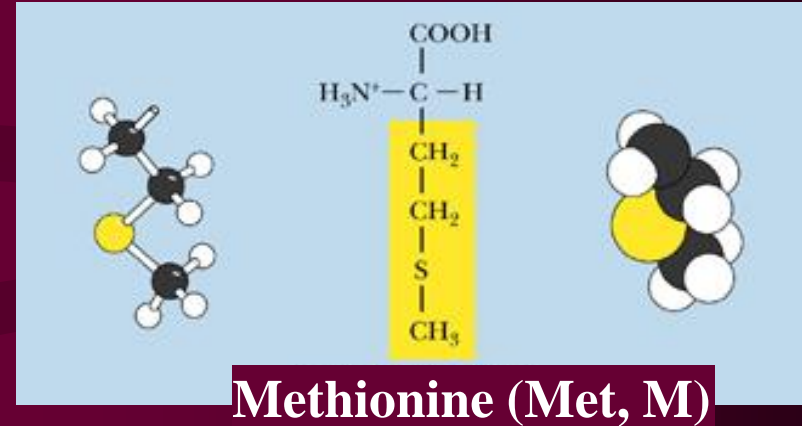
Nonpolar amino acids

Imino group

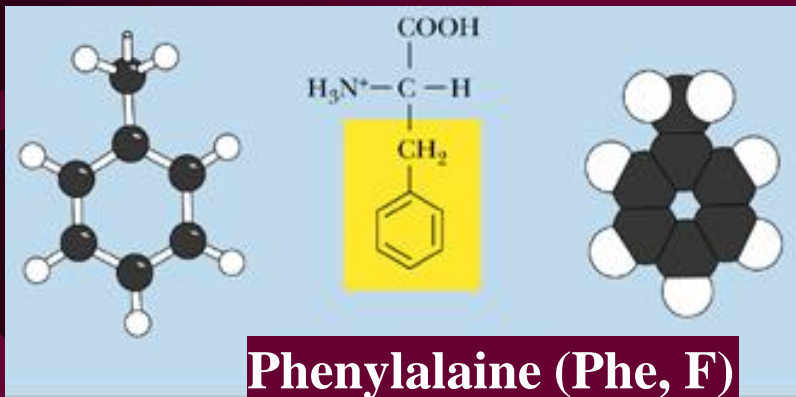


Unusual cyclic structure

Sulfur-containing

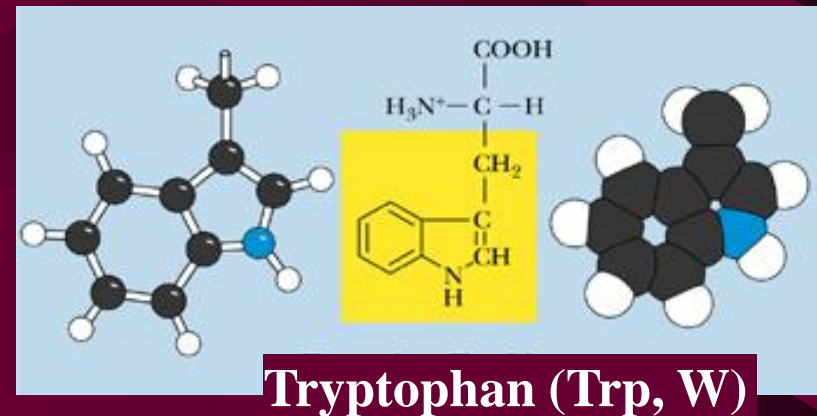


Methionine (Met, M)



Phenylalanine (Phe, F)

Aromatic aa

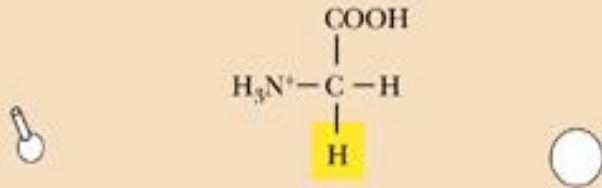


Tryptophan (Trp, W)

Indole ring

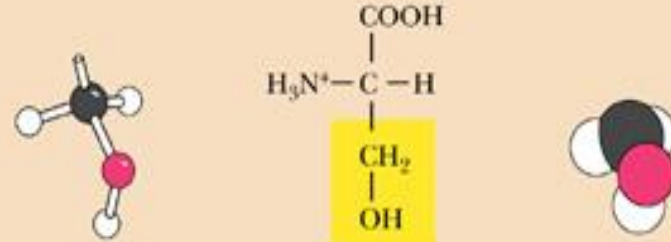
Neutral polar amino acids

R:H

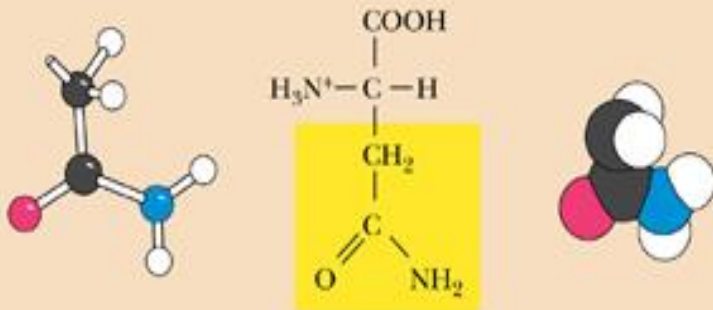


Glycine (Gly, G)

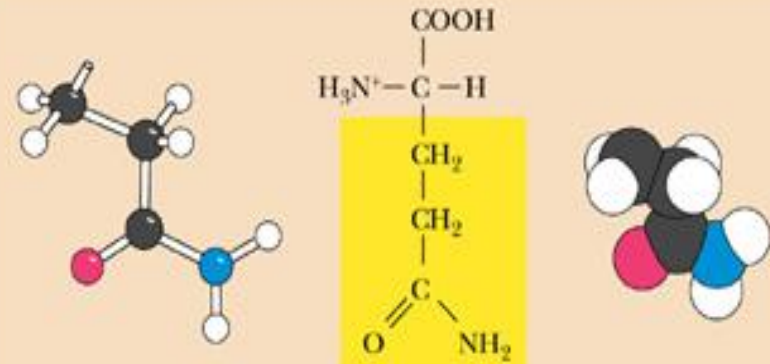
Hydroxyl group



Serine (Ser, S)



Asparagine (Asn, N)

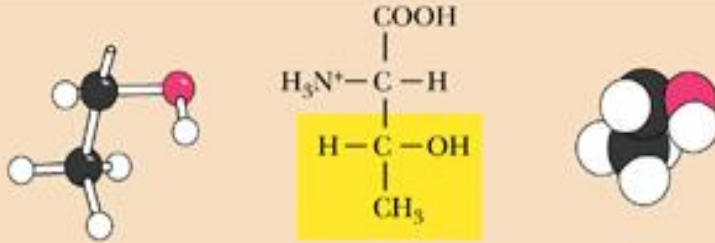


Glutamine (Gln, Q)

Amide group

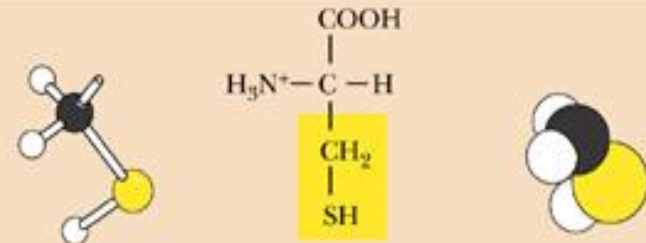
Neutral polar amino acids

Hydroxyl group

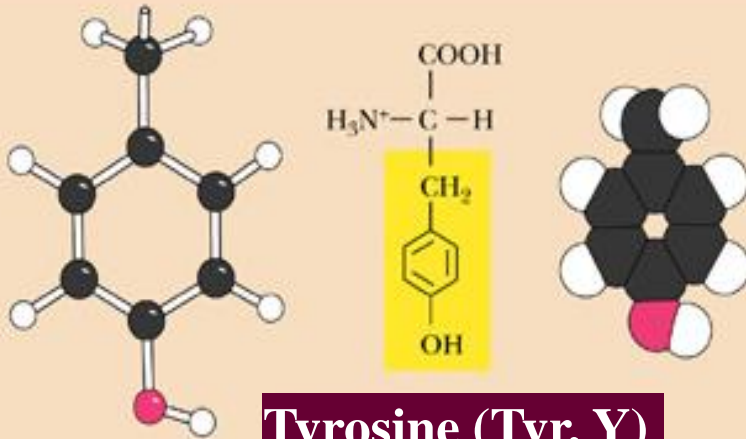


Threonine (Thr, T)

Sulfur-containing
Sulphydryl group

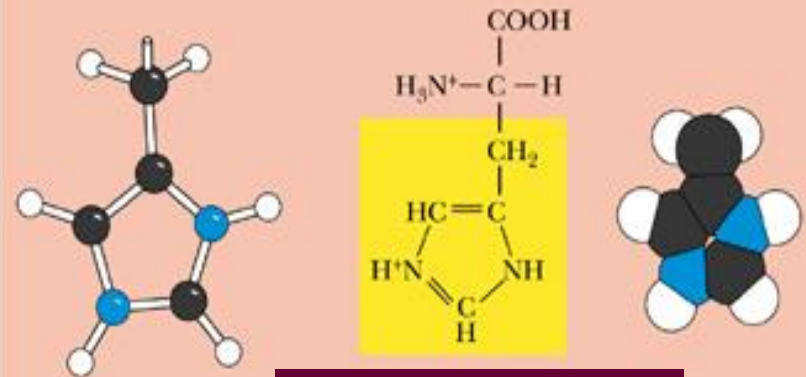


Cysteine (Cys, C)



Tyrosine (Tyr, Y)

Aromatic,
Phenolic hydroxyl group

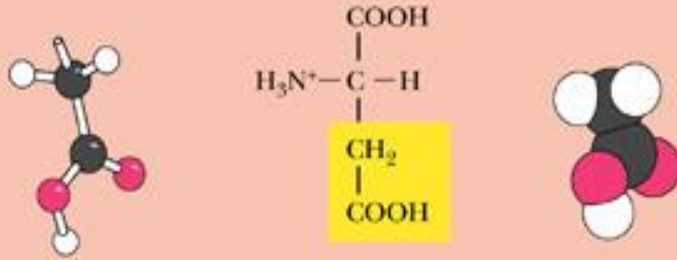


Histidine (His, H)

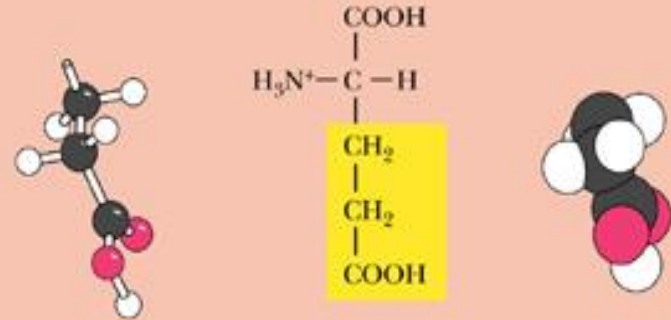
Imidazole group
Weak basic aa

Acid amino acids

Another Carboxyl group

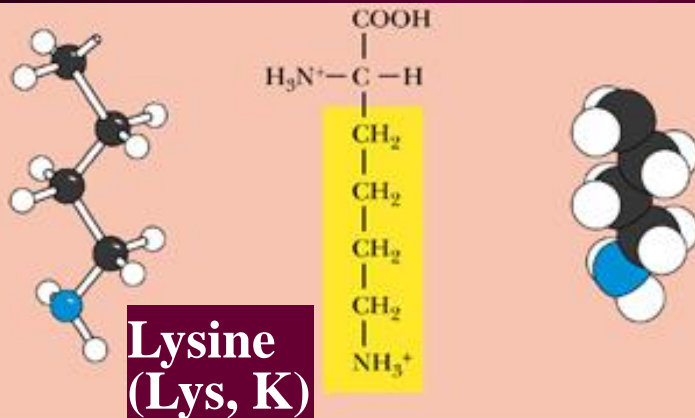


Aspartic acid (Asp, D)



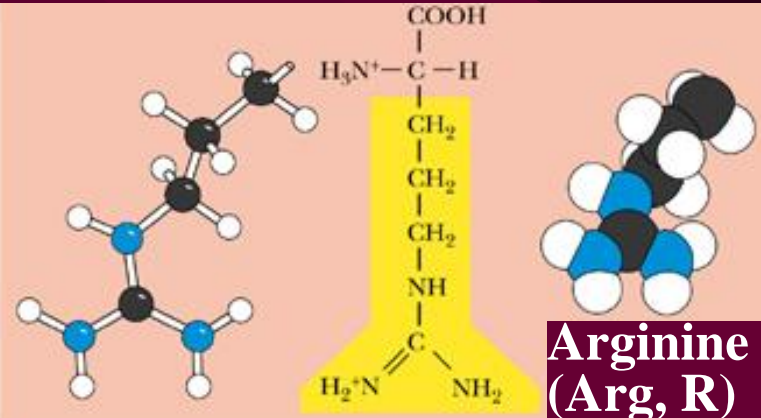
Glutamic acid (Glu, E)

Basic amino acids



**Lysine
(Lys, K)**

Alkyl amino group



**Arginine
(Arg, R)**

Guanidinium

- **Nonpolar or hydrophobic amino acids:**

Leucine (Leu, L), Isoleucine (Ile, I), Alanine (Ala, A),
Phenylalanine (Phe, F), Proline (Pro, P), Valine (Val, V),
Methionine (Met, M), Tryptophan (Try, W)

- **Neutral (uncharged) polar amino acids:**

Glycine (Gly, G), Serine (Ser, S), Threonine (Thr, T),
Cysteine (Cys, C), Tyrosine (Tyr, Y), Histidine (His, H),
Asparagine (Asn, N), Glutamine (Gln, Q)

- **Acidic amino acids:**

Aspartic acid (Asp, D), Glutamic acid (Glu, E)

- **Basic amino acids:**

Lysine (Lys, K), Arginine (Arg, R)

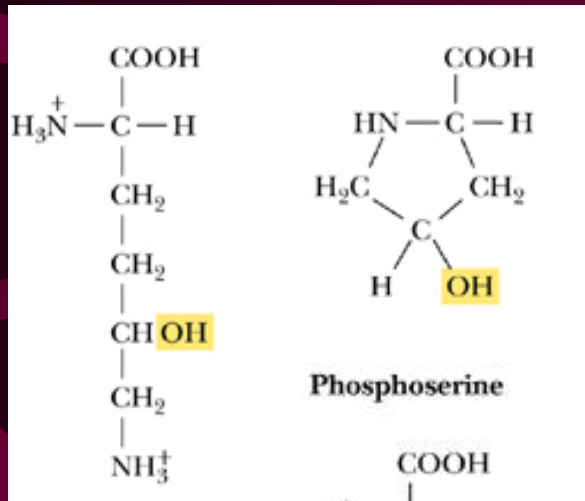
Uncommon amino acids:

Several amino acids occur only rarely in proteins

Hydroxylated aa: hydroxylysine, hydroxyproline,

Methylated aa: methylhistidine, methyllaysine, methylarginine

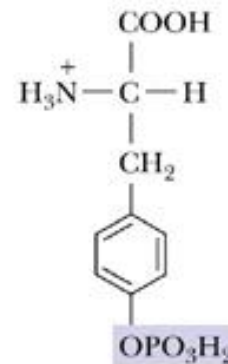
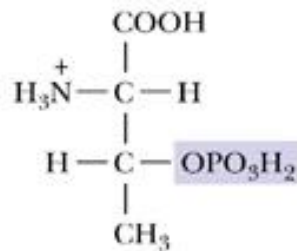
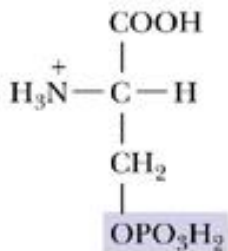
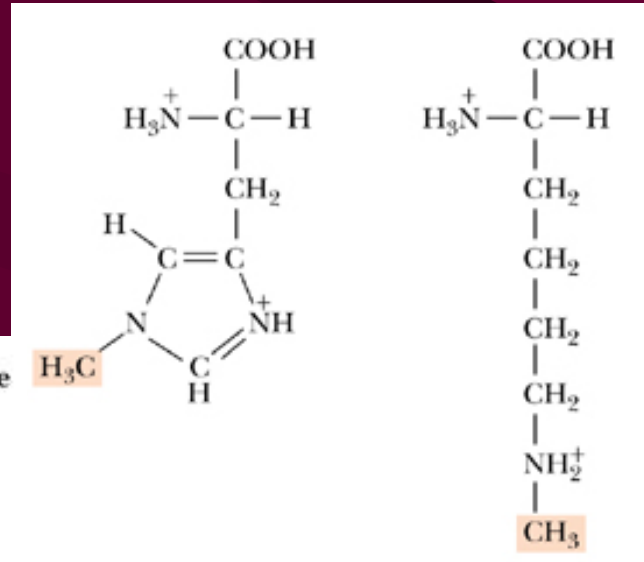
Phosphorylated aa: phosphoserine, phosphothreonine, phosphotyrosine



Phosphoserine

Phosphothreonine

Phosphotyrosine



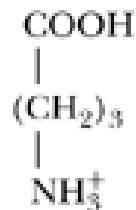
Some amino acids not found in proteins

Amino acids and their derivatives:

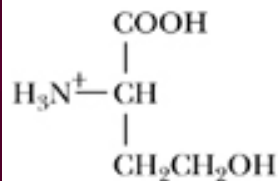
Gama-aminobutyric acid, GABA (from Glu)

Penicillamine, ornithine,

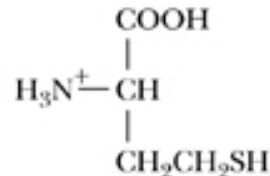
Homoserine, homocysteine



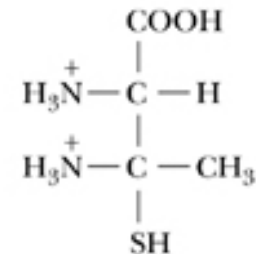
γ -Aminobutyric acid
(GABA)



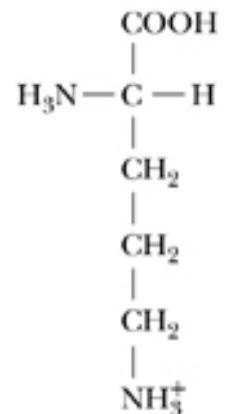
Homoserine



Homocysteine



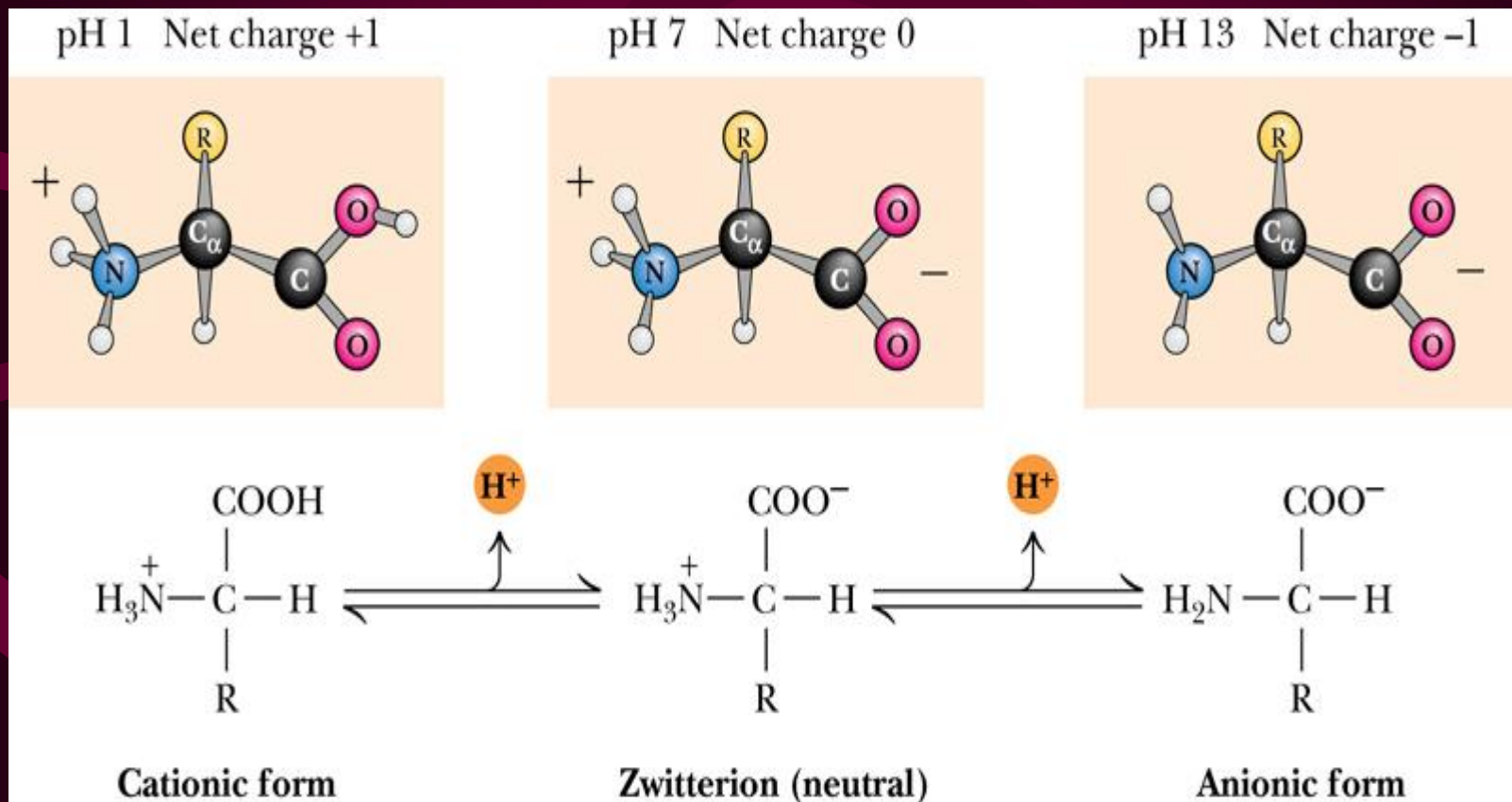
Penicillamine



Ornithine

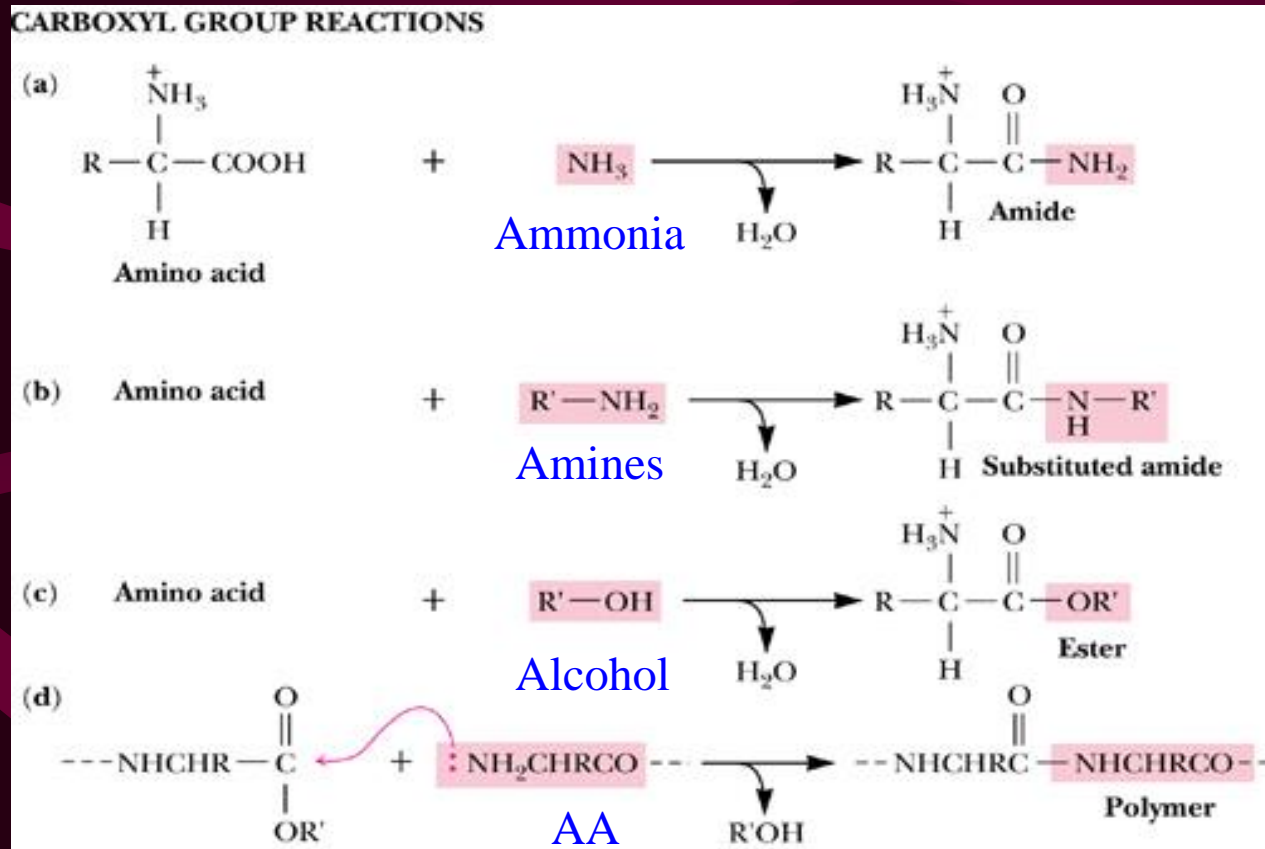
Acid-base properties of amino acids?

Amino acids are weak polyprotic acids



Reactions amino acids undergo

Carboxyl Group Reactions:



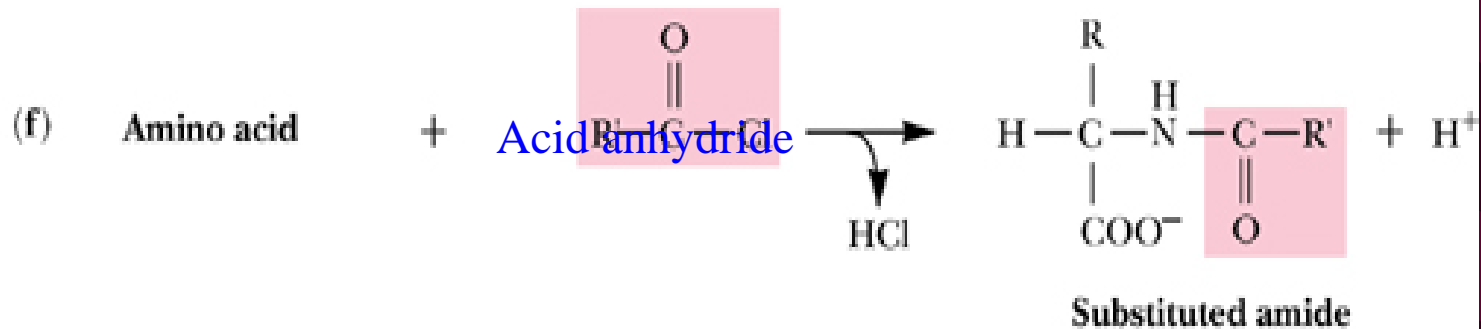
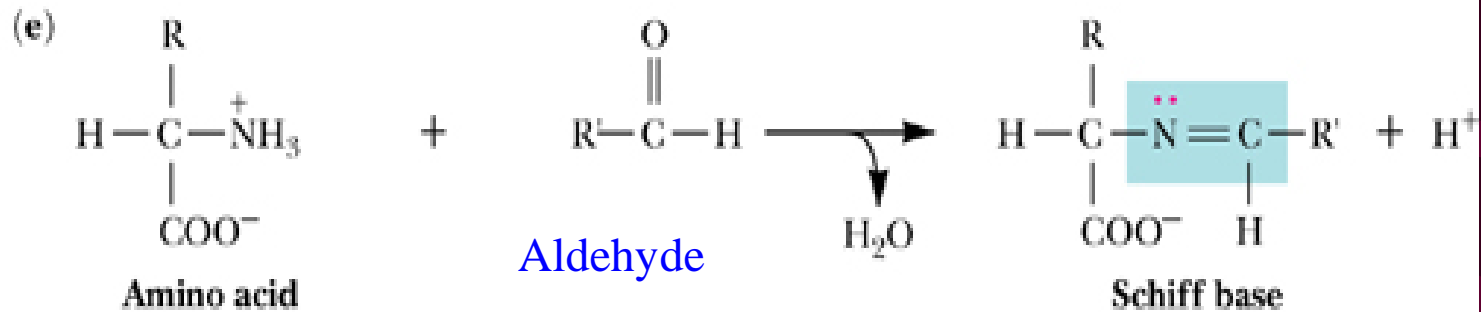
Amides formation

Esterification

Polymerization

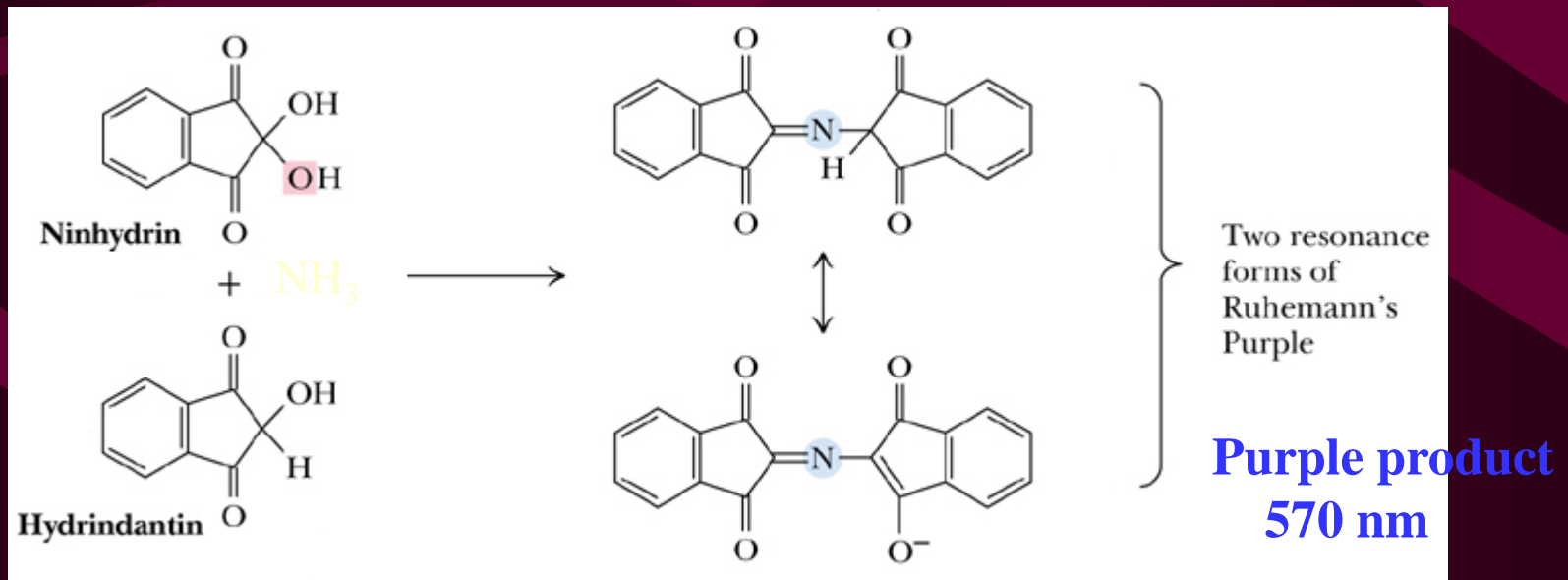
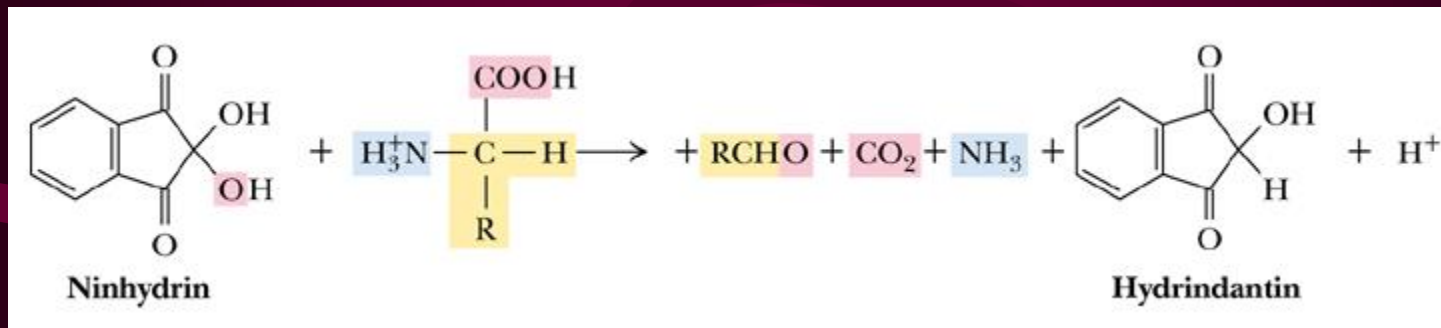
Amino Group Reactions:

AMINO GROUP REACTIONS



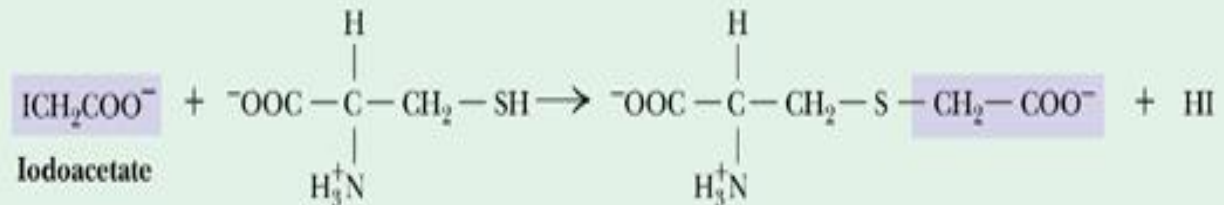
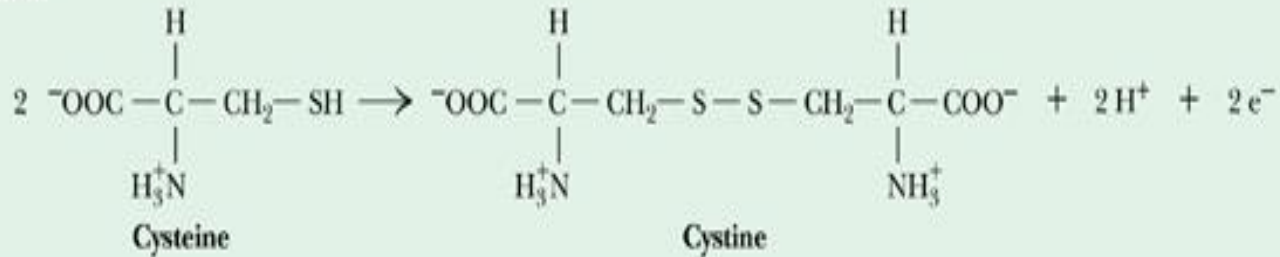
Ninhydrin Reaction (characteristic of amino acids)

Ninhydrin, or triketohydrindene hydrate, is a strong oxidizing agent and causes oxidative deamination of the alpha-amino function.

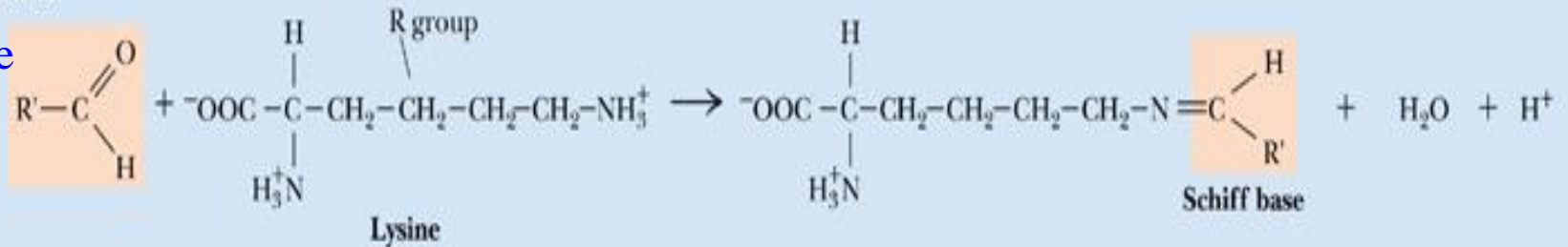


Specific Reactions of side chains

CYSTEINE



LYSINE



Aldehyde

Optical and Stereochemical Properties of Amino Acids

Asymmetric or chiral carbon

mirror-image isomers, enantiomers

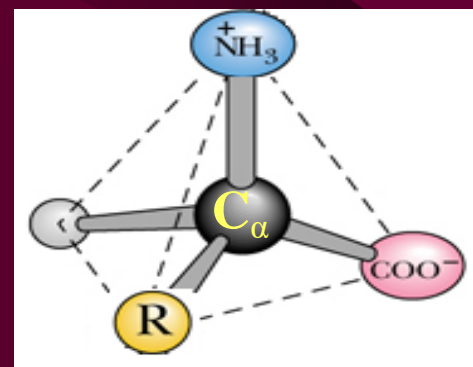
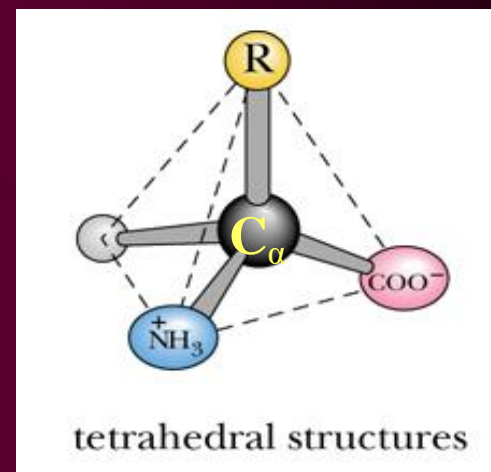
Optical activity:

the ability to rotate the plane of
polarization of plane-polarized light.

Dextrorotatory: clockwise rotation, (+); **D-**

Levorotatory: counterclockwise rotation, (-); **L-**

All of the amino acids derived from natural
proteins are of the **L-configuration**.



Spectroscopic Properties of Amino Acids

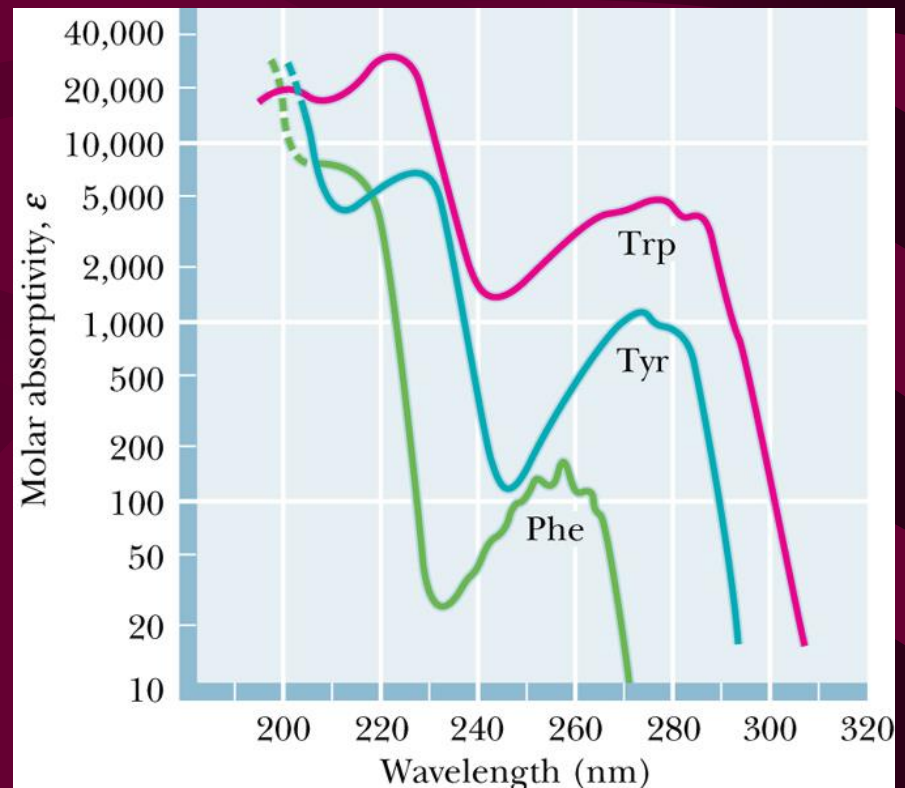
Spectroscopic methods: measure the absorption and emission of energy of different frequencies by molecules and atoms.

Absorption of Ultraviolet (UV) light

Only the aromatic amino acids (Phe, Tyr and Trp) exhibit significant UV absorption above 250 nm.

Detecting protein concentration

UV 280 nm



How are amino acids mixtures separated and analyzed?

Separation of amino acids based on:

Physical and chemical characteristics

Ionization behavior and solubility

Electrical charge and partition properties

Partition properties: through a medium (two phase), different distribution

Partition coefficient: ratio of concentration in two phase.

Chromatography

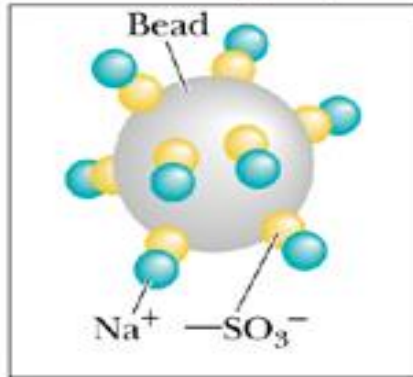
First for separation of colour solutes by partition

Methods important for aa separation include:

ion exchange chromatography, gas chromatography (**GC**),
and high-performance liquid chromatography (**HPLC**)

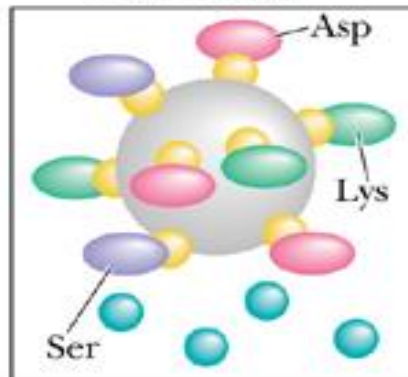
Ion exchange chromatography

Cation exchange bead
before adding sample



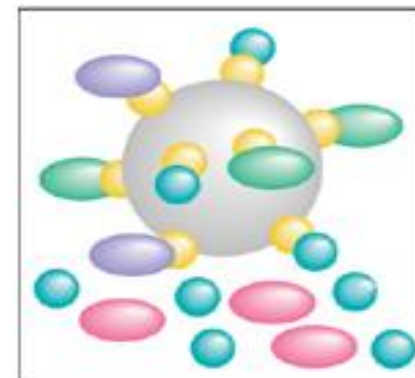
(a)

Add mixture of
Asp, Ser, Lys



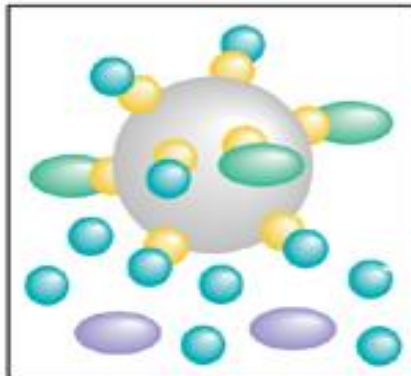
(b)

Add Na⁺ (NaCl)



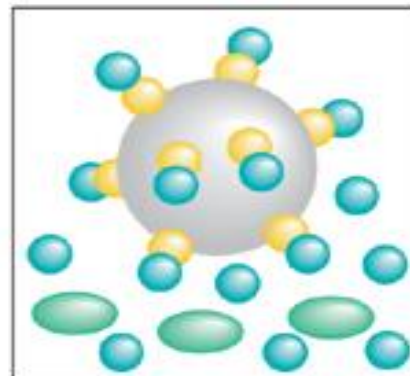
(c) Asp, the least positively charged amino acid, is eluted first

Increase [Na⁺]



(d) Serine is eluted next

Increase [Na⁺]

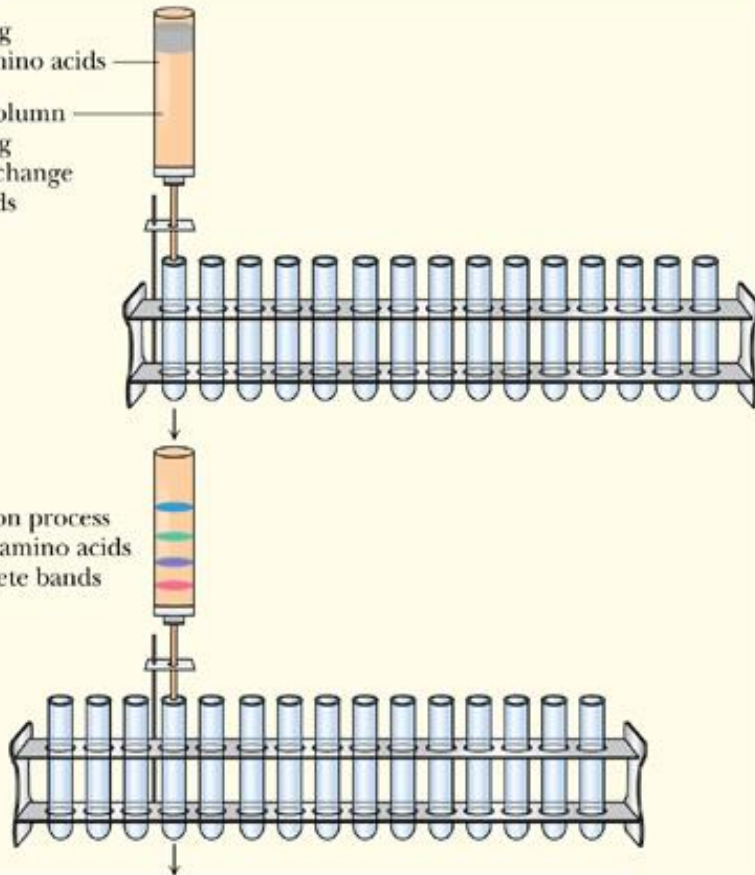


(e) Lysine, the most positively charged amino acid, is eluted last

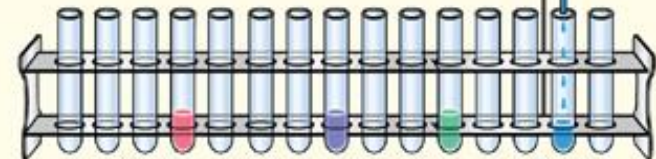
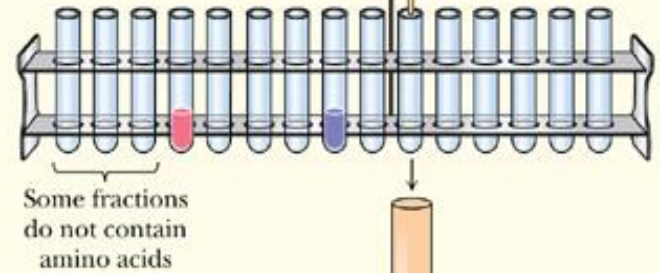
Sample containing several amino acids

Elution column containing cation exchange resin beads

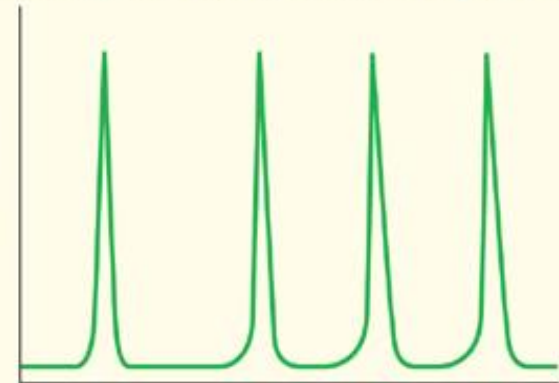
The elution process separates amino acids into discrete bands



Eluant emerging from the column is collected

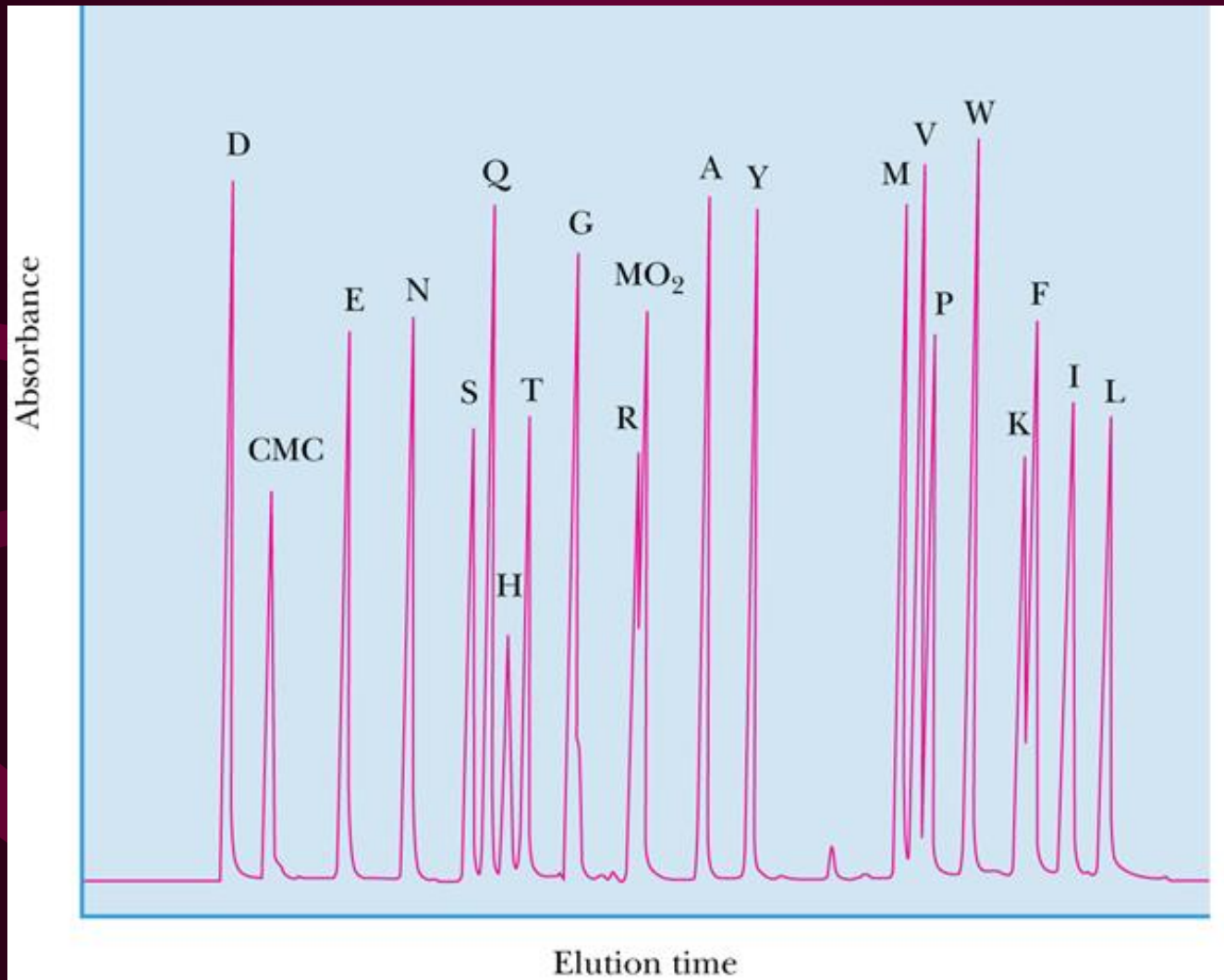


Amino acid concentration



Elution time →

HPLC: pre-modification of aa to form phenylthiohydantoin (PTH)



UV-269 nm
absorption

Key points:

- 20 amino acids: structure and classification
- Acid-base properties amino acids
- Optical and Stereochemical Properties

Question: What are the functions of amino acids?