Lecture 3

Amino Acids & Protein

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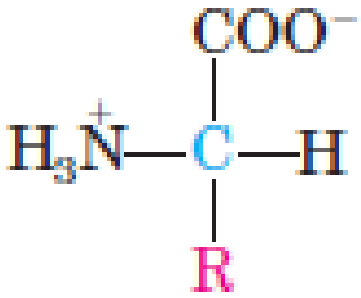
Amino acids

- Amino acids are organic compounds that combine to form proteins. Amino acids and proteins are the building blocks of life.
- When proteins are digested or broken down, amino acids are left
- Amino acids are a group of organic compounds containing two **functional groups**
- — **amino** and **carboxyl**.
- The amino group (—NH2)

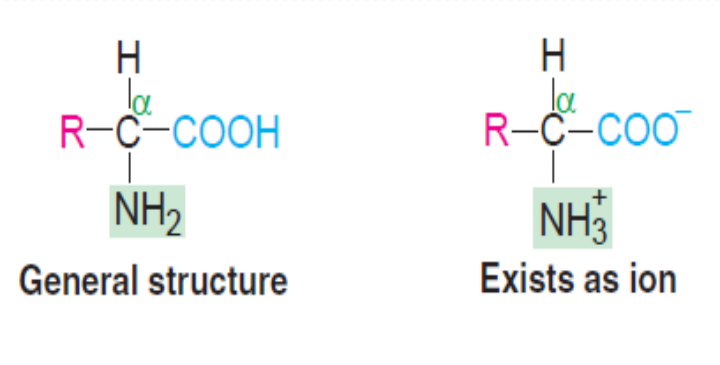
  is basic while the carboxyl group

  (—COOH) is acidic in nature.



General structure of amino acids

- The amino acids are termed as α-amino acids, if both the carboxyl and amino groups are attached to the same carbon atom
- The α -carbon atom binds to a side chain represented by R which is different for each of the 20 amino acids found in proteins.



- The amino acids mostly exist in the ionized form in the biological system

Classification of amino acids

- There are different ways of classifying the amino acids based on the

A. structure and chemical nature of R group in amino acids
B. nutritional requirement
C. Metabolic classifiion

etc.

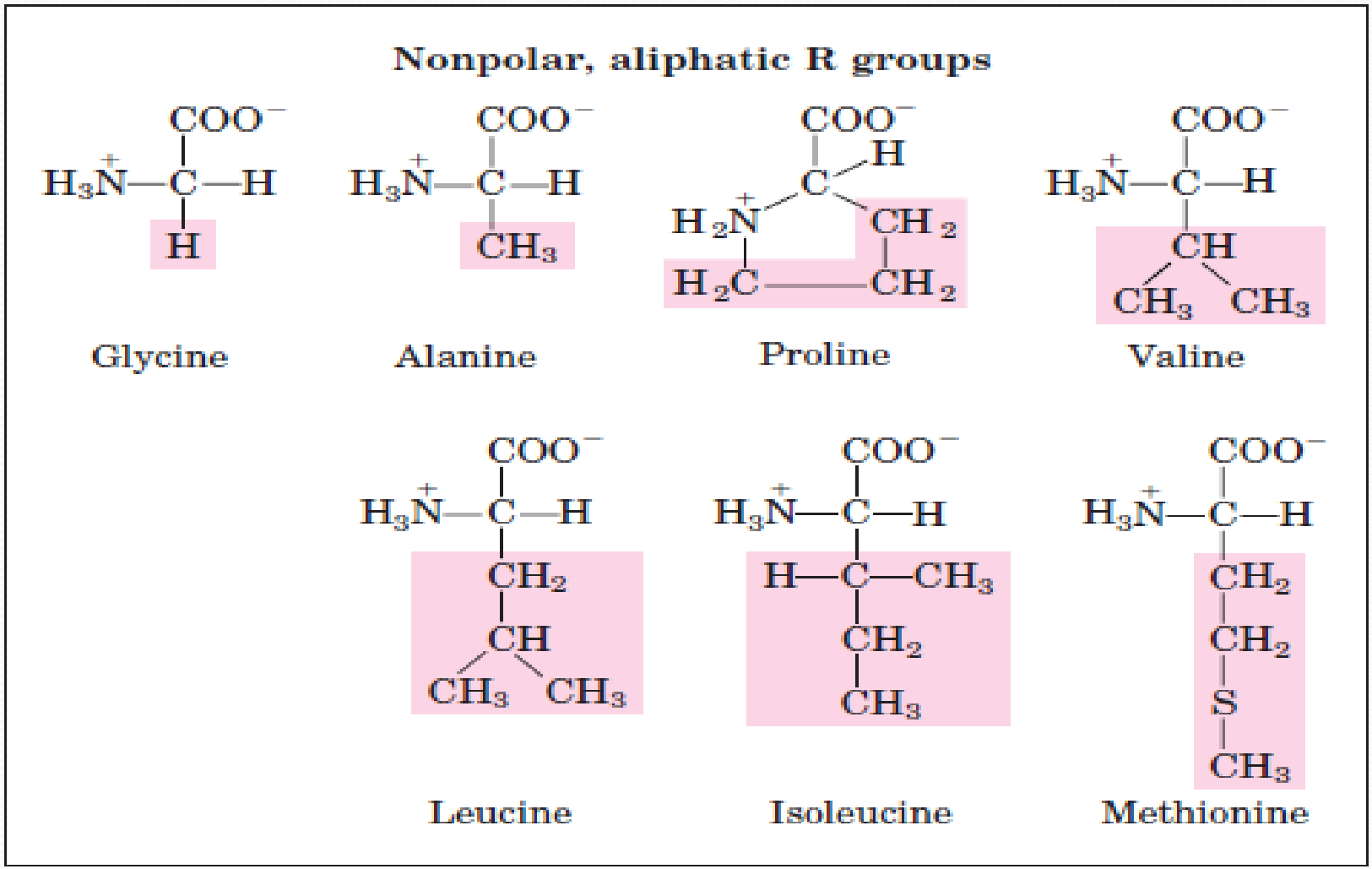
A. Amino acid classification based on the chemical structure

1-Nonpolar, Aliphatic R Groups

- The R groups in this class of amino acids are nonpolar and hydrophobic

- **Alanine** (Ala), **Glycine** (Gly) , **Valine** (Val) , **Leucine** (Leu) , **Isoleucine** (Ile) , **Methionine** (Met) , and **Proline** (pro) are nonpolar aliphatic R group amino acids

Nonpolar, Aliphatic R Groups



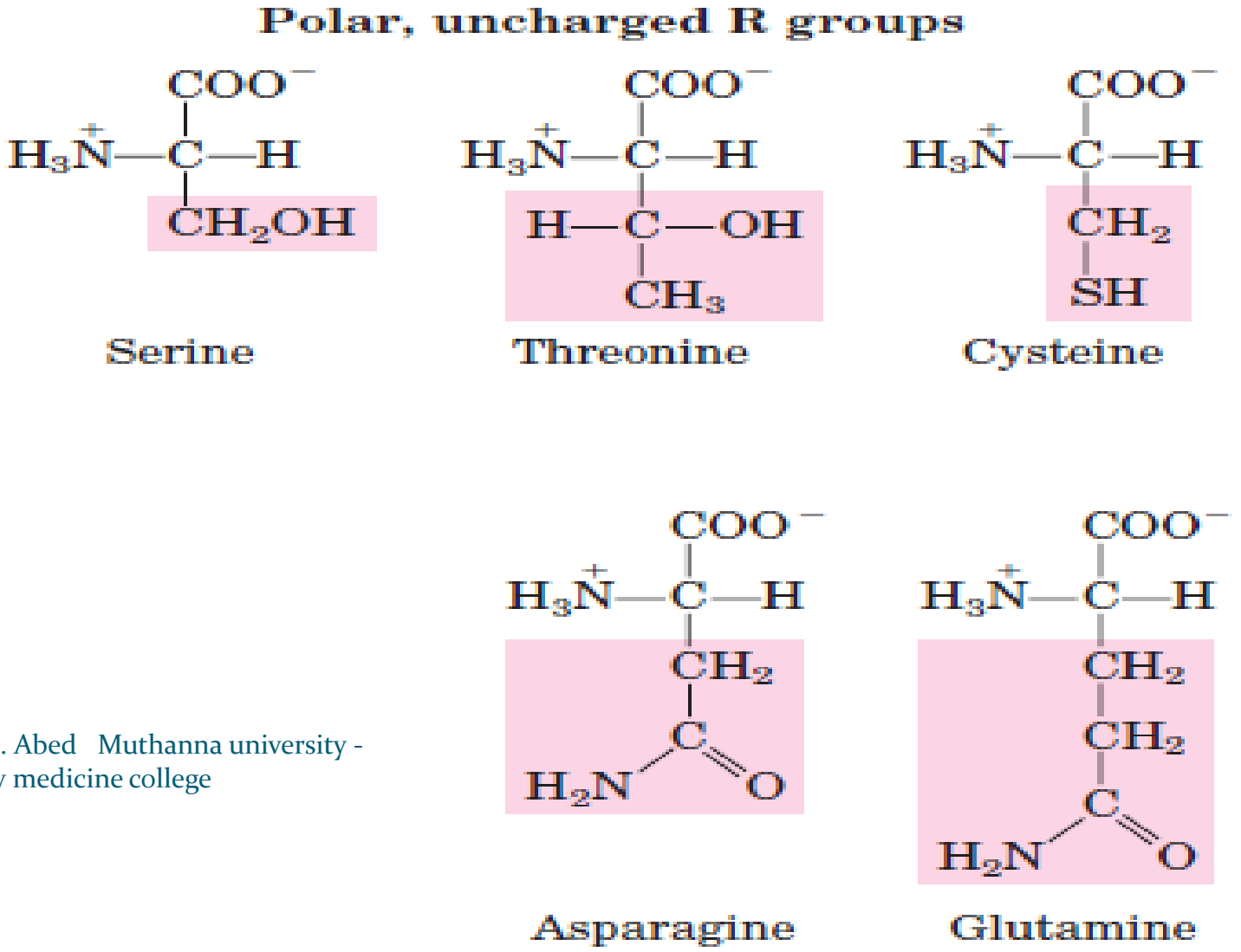
2-*Polar, Uncharged R Groups*

2-Polar, Uncharged R Groups

- The R groups of these amino acids are more soluble in water, or more hydrophilic, than those of the nonpolar amino acids, because they contain functional groups that form hydrogen bonds with water.

- This class of amino acids includes **Serine** (Ser) , **Threonine** (Thr), **Cysteine** (Cys) , **Asparagine** (Asn) , and **Glutamine** (Gln) .

2- Polar, Uncharged R Groups



3- Aromatic R Groups

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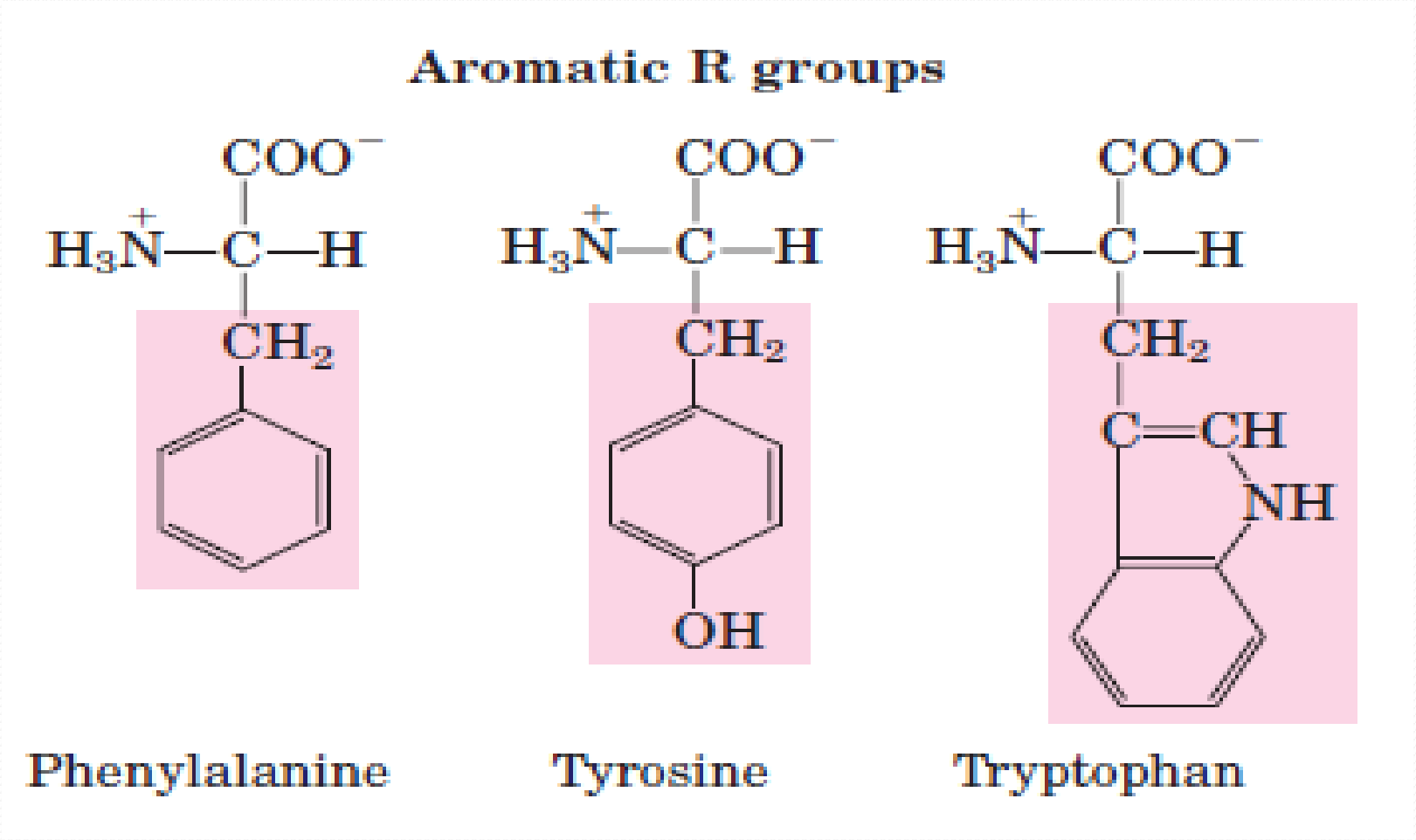
- Include **Phenylalanine** (Phe), **Tyrosine** (Tyr) , and **Tryptophan** (Trp) ,
- with their aromatic side chains, are relatively nonpolar (hydrophobic).
- All can participate in hydrophobic interactions.

3- Aromatic R Groups

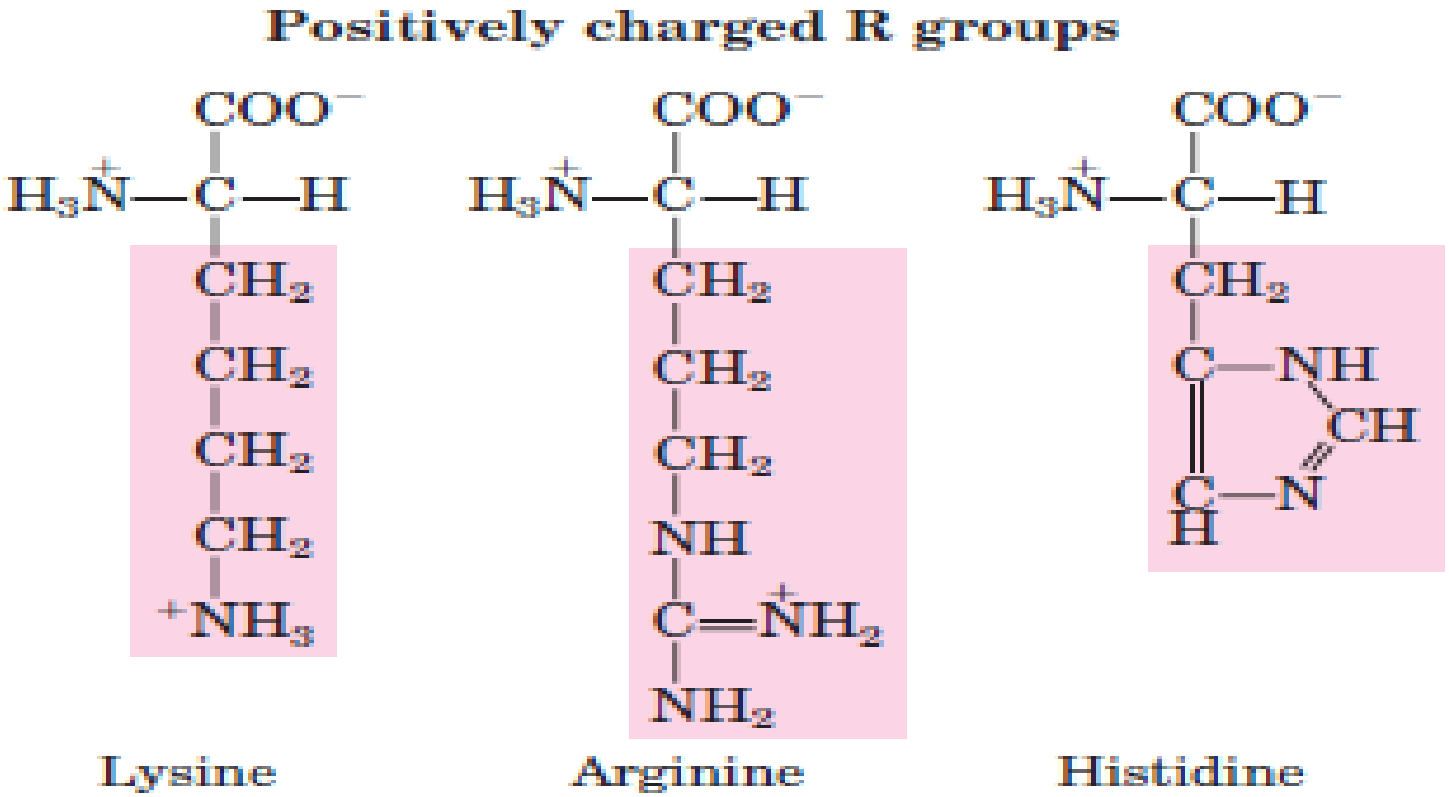


4- Positively Charged (Basic) R Groups

4-*Positively Charged (Basic) R Groups*

- The amino acids in which the R groups have significant positive charge at pH 7.0 are **Lysine** (Lys) , **Arginine** (Arg) , **Histidine** (His),

4- Positively Charged (Basic) R Groups



5- Negatively Charged (Acidic) R Groups

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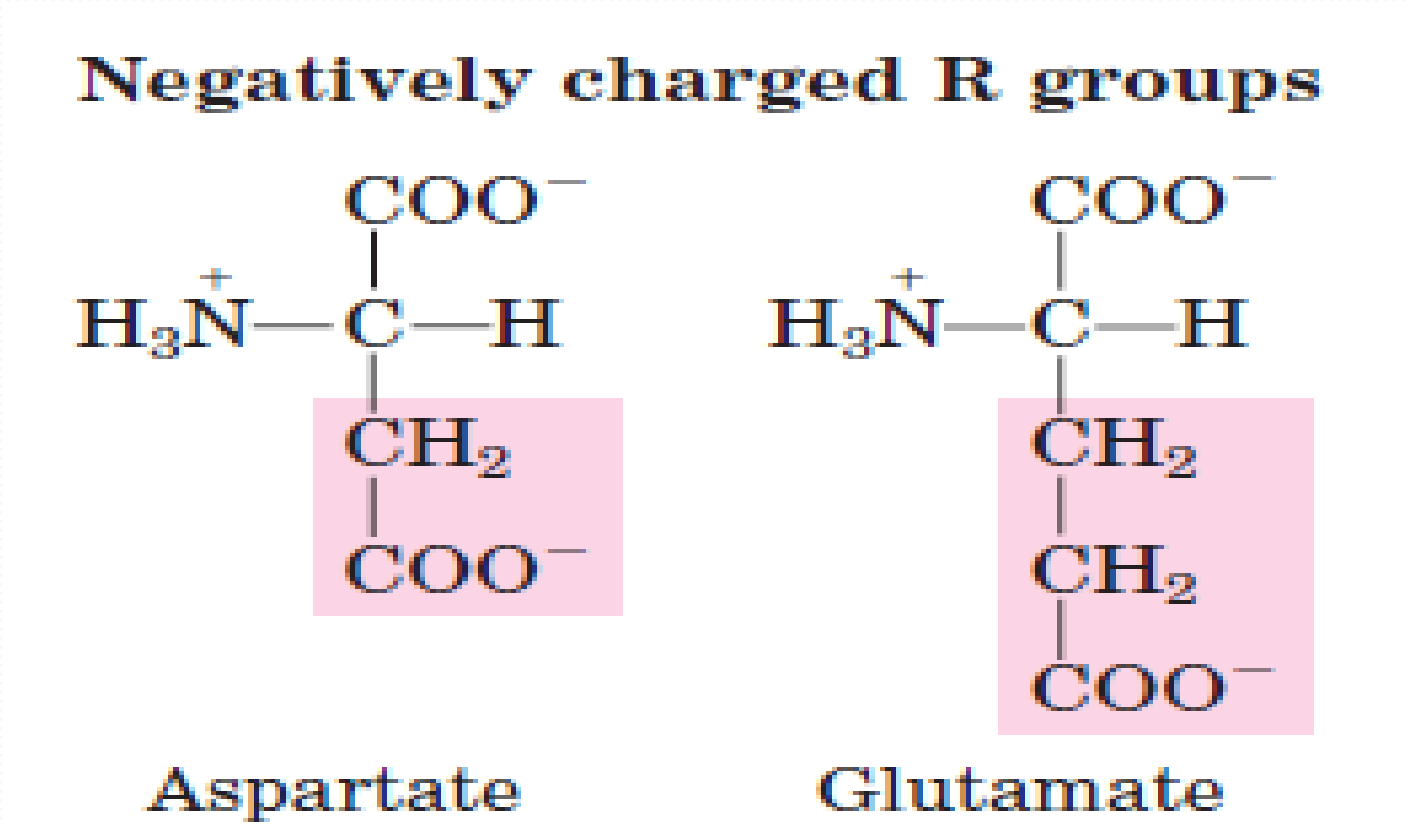
- The two amino acids having R groups with a net negative charge at pH 7.0 are **Aspartate** (Asp) and Glutamate (Glu) , each of which has a second carboxyl group.

Negatively Charged (Acidic) R Groups



B-classification depend on nutritional requirement

1- Essential amino acids cannot be made by the body. As a result, they must come from food.

- The essential amino acids are:
- histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

2- Nonessential amino acids means that our bodies produce an amino acid, even if we don't get it from the food we eat.

- They include: alanine, asparagine, aspartic acid, glutamic acid , arginine, cysteine, glutamine, tyrosine, glycine,, proline, and serine

Uncommon amino acids also have important functions

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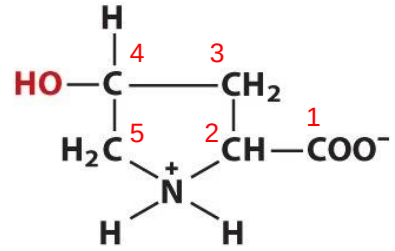
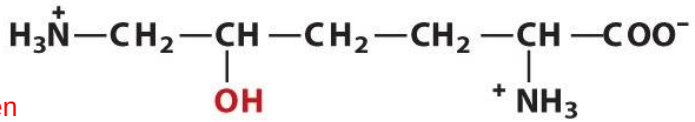
plant cell wall, collagen



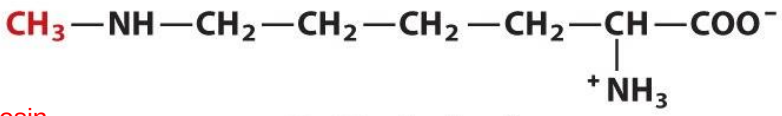
4-Hydroxyproline

collagen



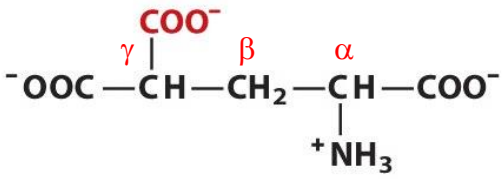
5-Hydroxylysine

myosin



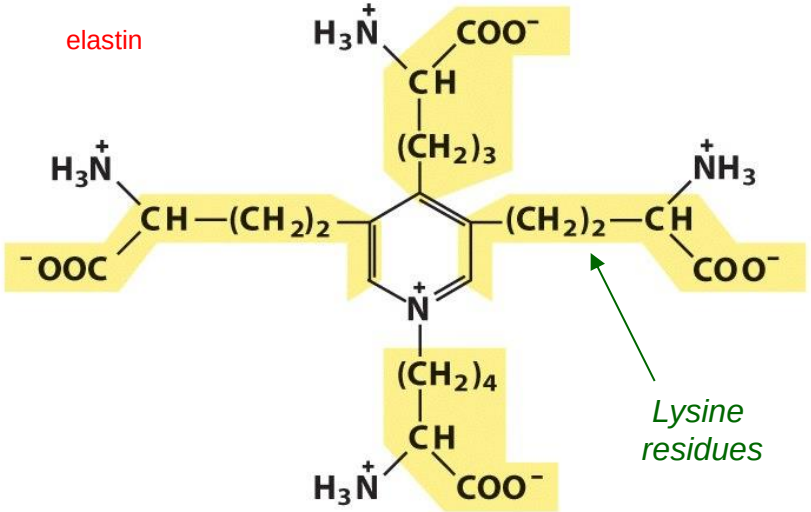
6-*N*-Methyllysine

prothrombim, a # of Ca^{+} binding proteins



γ-Carboxyglutamate

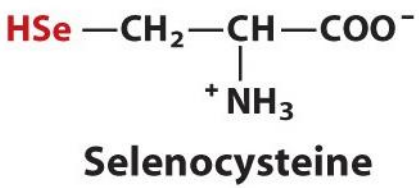
elastin



Desmosine

Lysine residues

Residues created by modification of common residues already incorporated into a polypeptide



Selenocysteine

rare, introduced during protein synthesis rather than created through a postsynthetic modification

~ 300 additional amino acids have been found in cells

Properties of amino acids

- physical properties :

1. **Solubility** : Most of the amino acids are **usually soluble in water** and insoluble in organic solvents.

2. **Melting points** : Amino acids generally melt at higher temperatures, often above 200°C.

3- **Optical properties** : All the amino acids **except glycine** possess optical isomers due to the presence of asymmetric carbon atom.

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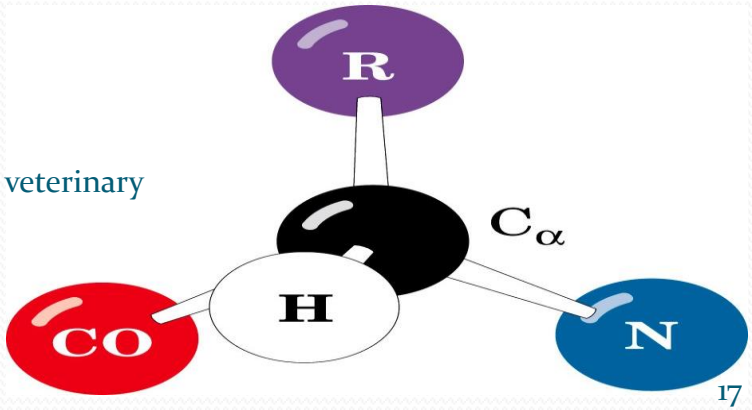
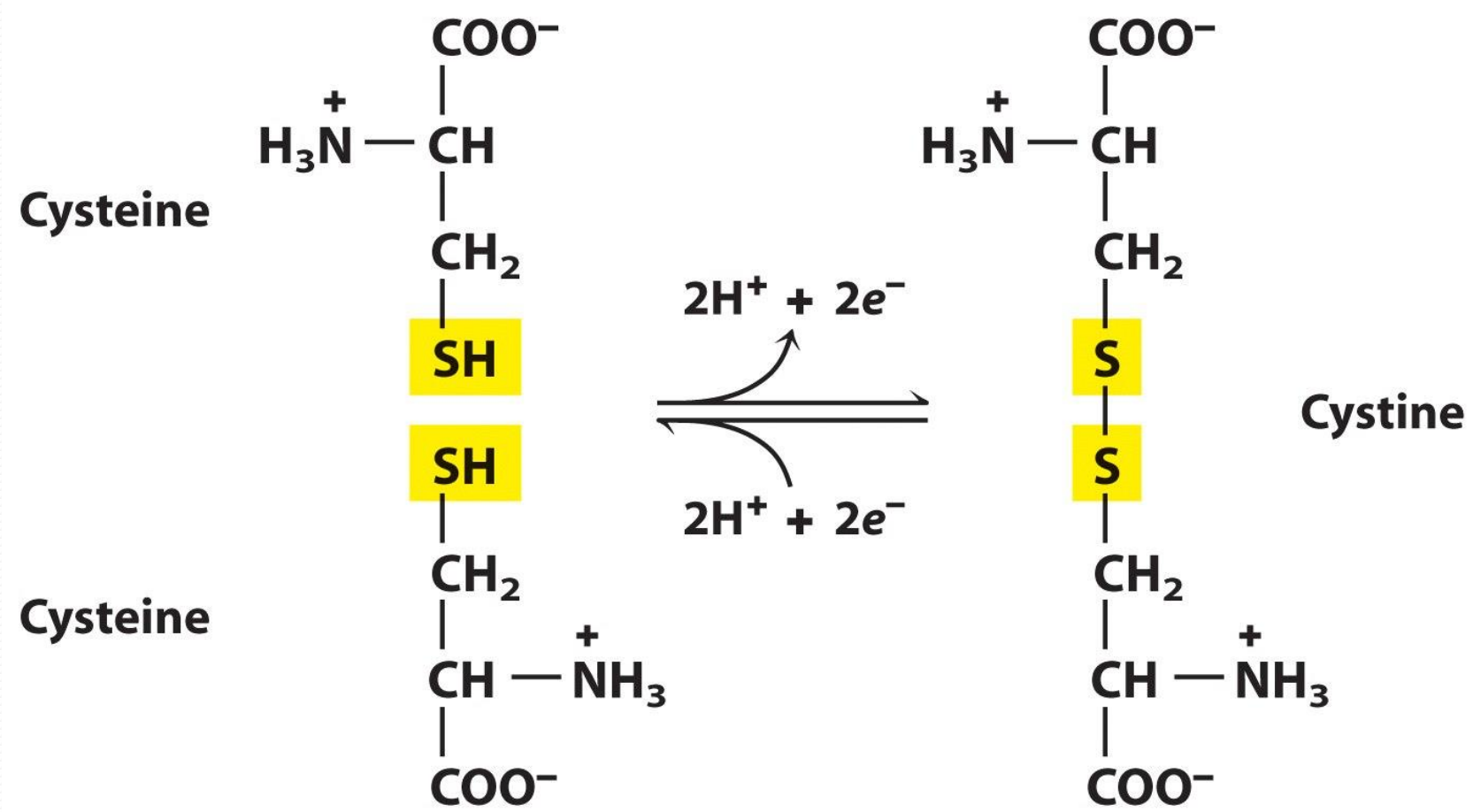


Reversible formation of disulfide bond by the oxidation of two molecules of cysteine



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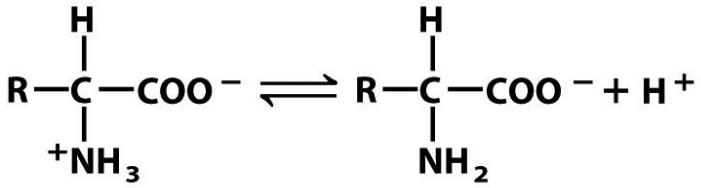
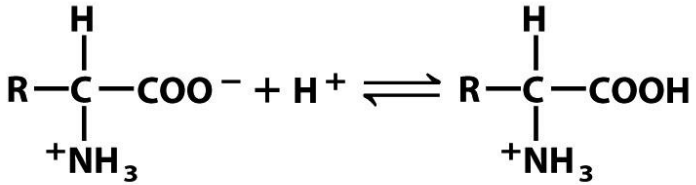
e.g. two polypeptide chains of insuline

Amino acids can act as acids and bases

Nonionic and
zwitterionic forms

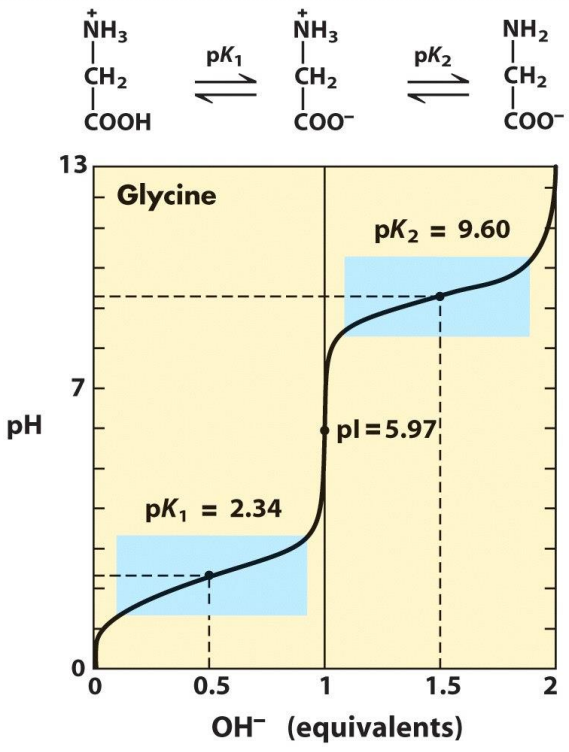




amphoteric

(*ampholytes* - amphoteric electrolytes)

Titration of glycine



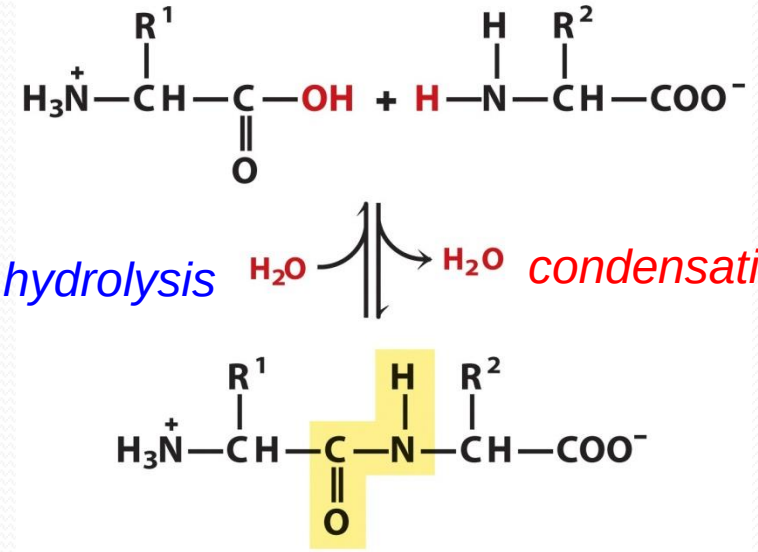
Titration curves predict the electric charge of amino acids

Isoelectric point (or isoelectric pH)

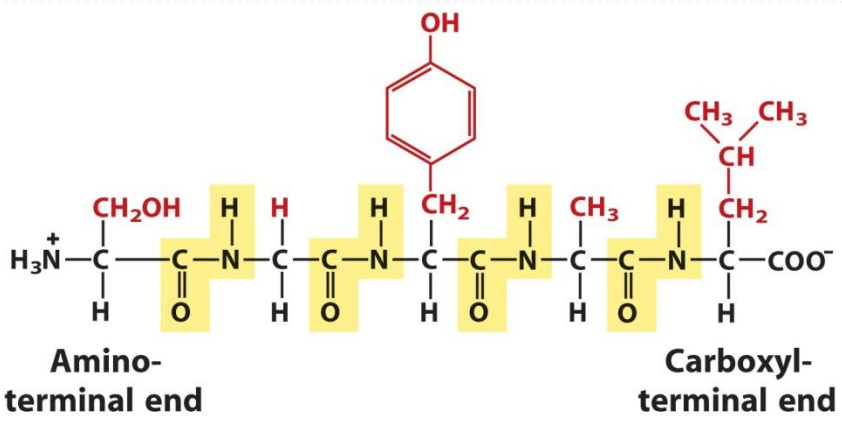
pI = ½ (pk_1 + pk_2) = ½ (2.34 + 9.60) = 5.97

Peptides bond and protein

Peptides are chains of amino acids



Pentapeptide



Serylglyciltyrosylalanylleucine
or
Ser-Gly-Tyr-Ala-Leu
or
SGYAL

Peptides are named beginning with the amino-terminal residue, which by convention is placed at the left.

just a few residues → oligopeptide
many residues → polypeptide

Protein function

Biological Roles of Proteins (examples):

1. **Catalysis (enzymes)**
2. **Transport (e.g., hemoglobin - O2 transport in blood; transport of ions across cell membranes)**
3. **Storage (e.g., myoglobin - oxygen storage in muscle; seed proteins - storage of nutrients)**
4. **Coordinated motion (e.g., in muscle, cilia, flagella)**
5. **Mechanical support (e.g., collagen)**

Protein functions

6. Protection (e.g., immune system - antibodies; blood clotting proteins)
7. Regulation and communication (e.g., hormones, receptors, gene activation and repression, control of enzyme activity)
8. Generation and transmission of nerve impulses
9. Toxins (bacterial, plant, snake, insect)

Levels of Protein Structure

1.Primary structure (1° structure):

- **–Defined sequence of AAs**
- –linked by **peptide bonds (amide linkages)**

2. Secondary structure (2° structure):

- **–local, regular/recognizable conformations observed for parts of peptide backbone of a protein**
- –e.g, α-helix, β conformation, collagen helix

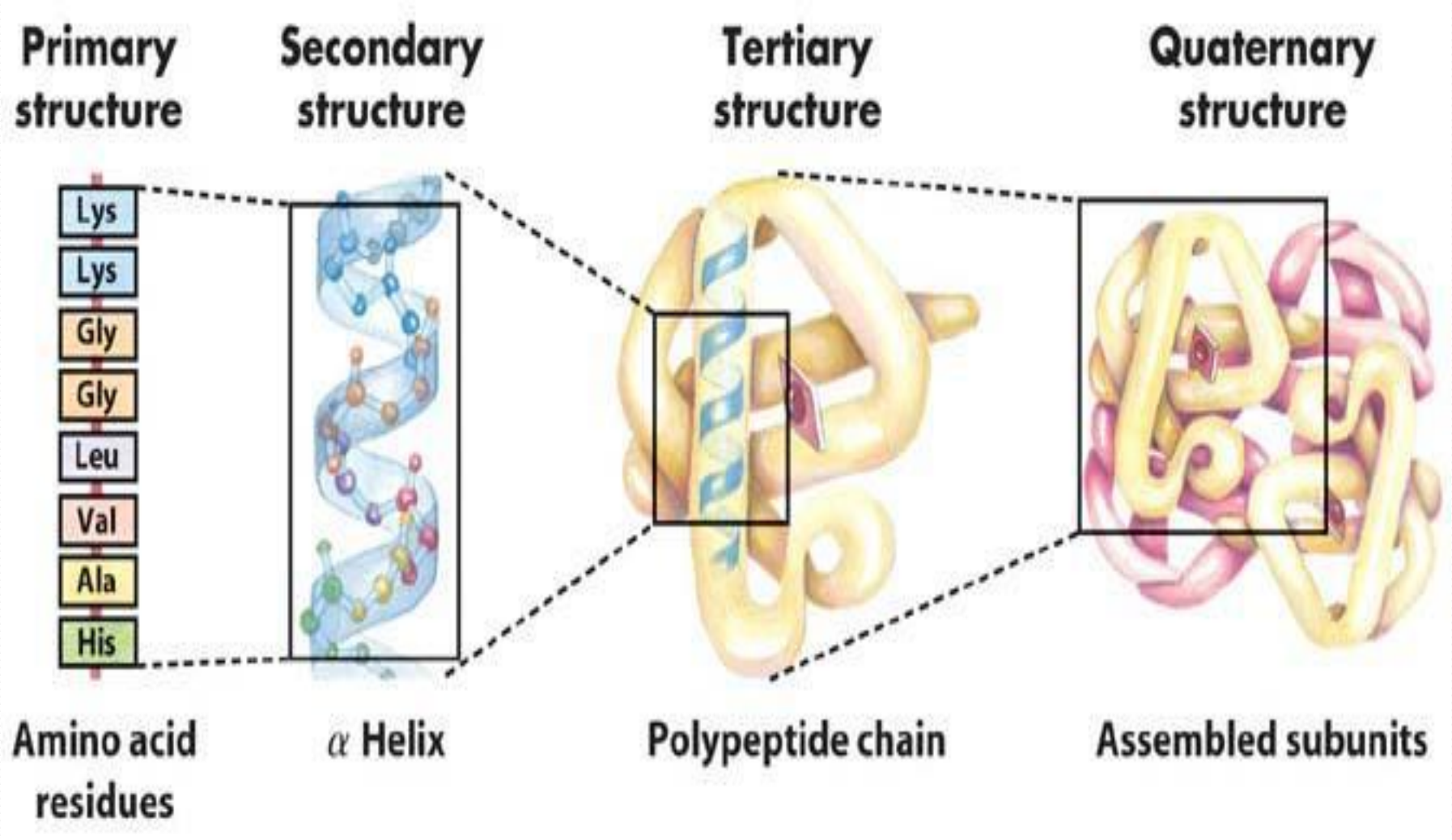
3. Tertiary structure (3° structure):

- **–3-dimensional conformation of whole folded polypeptide chain**

4. Quaternary structure (4° structure):

- Three-dimensional relationship of ***different polypeptide chains (subunits)***
- how the subunits fit together and their symmetry relationships
- only in proteins with ***more than 1 polypeptide chain***

Levels of Protein Structure



Thank you for listening