بسم الله الرحمن الرحيم

Basic Principles and Perspectives in Medical Chemistry and Biochemistry

Amino Acids & Proteins

Part 1

1st Medical and Biochemistry (BIQC-101) Lecture

Second Semester

by

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Amino Acids

Learning Objectives

1. Describe the general structure of an amino acid.
2. Recognize amino acids and classify them based on the characteristics of their side chains.
3. List the twenty common amino acids found in living organisms.
4. Describe how a peptide bond forms.
5. Understand the biologic activities of peptides

Introduction

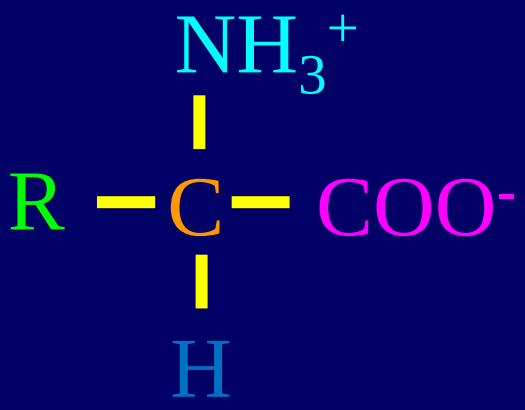
- Proteins are biopolymers built from monomeric units called amino acids.

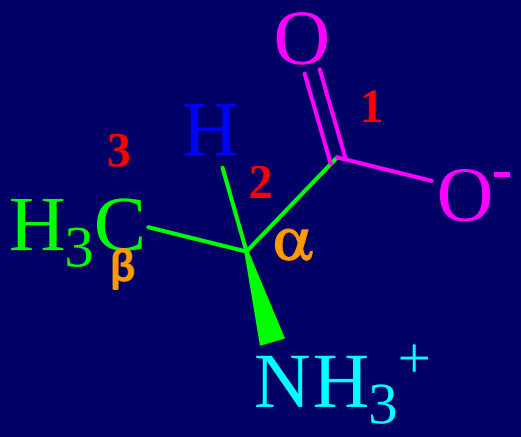
- More than 700 amino acids occur naturally, but 20 of them are commonly found in proteins.

- Protein function depends on both:-
  1. Amino acid content
  2. Amino acid sequence.

To understand protein function, we must first understand the nature of amino acids.

Structure





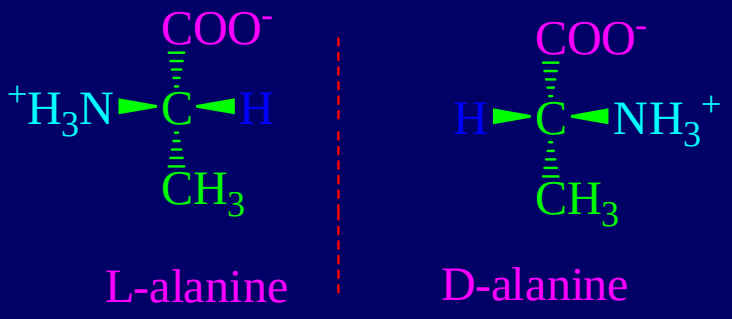
- **Amino acids** contain two functional groups, a protonated amine and carboxylic acid in the form of a carboxylate group.
- These functional groups are bonded to a central carbon atom known as the **alpha (α) carbon**, and are referred to as **alpha amino acids**.

- The α carbon is also bonded to a hydrogen atom and a larger side chain. The side chain is unique for each amino acid.
- The α carbon on all amino acids, except glycine, is a ***chiral carbon*** because it has four different groups bonded to it.
- An amino acid, with a chiral center, has two forms called ***enantiomers***, which are nonsuperimposable mirror images.

L and D forms

When drawing the Fischer projection, the carboxylate group is at the top of the structure and the side chain (R group) is at the bottom.

The protonated amine group can be on the left-hand side (L form) or right-hand side (D form) of the structure.



- The L-amino acids are the building blocks for proteins. Some D-amino acids occur in nature, but not in proteins.
- There are nine different families of organic compound represented in the structures of different amino acids. They are as follows:

1. Alkanes
2. Aromatics
3. Thioethers
4. Alcohols
5. Phenols
6. Thiols
7. Amides
8. Carboxylic acids
9. Amines

Classification of amino acids

The functional groups divide the amino acids into the following four categories:

Nonpolar, aliphatic (7)

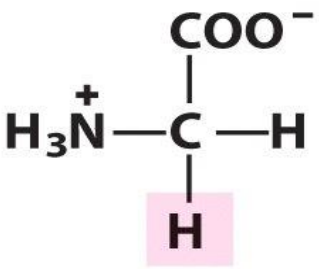
Aromatic (3)

Polar, uncharged (5)

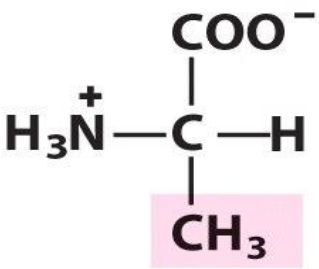
Positively charged (3)

Negatively charged (2)

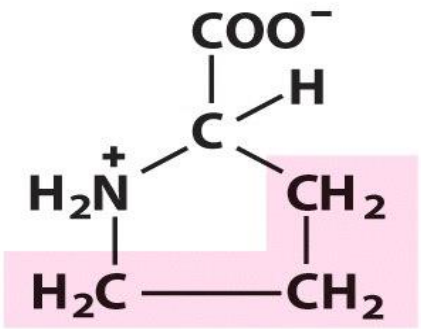
Nonpolar, aliphatic R groups



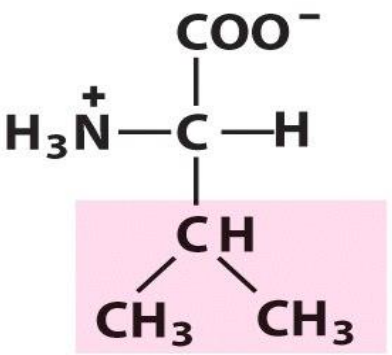
Glycine



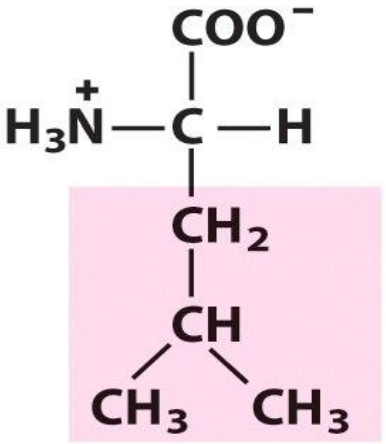
Alanine



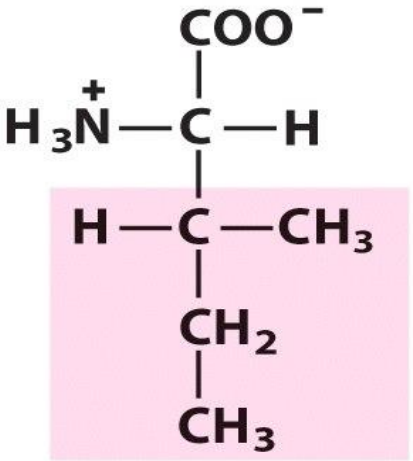
Proline



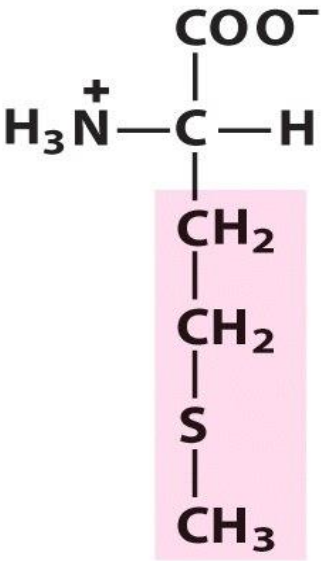
Valine



Leucine

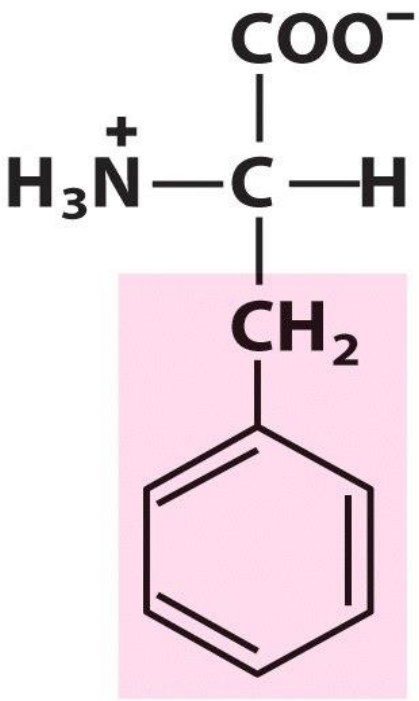


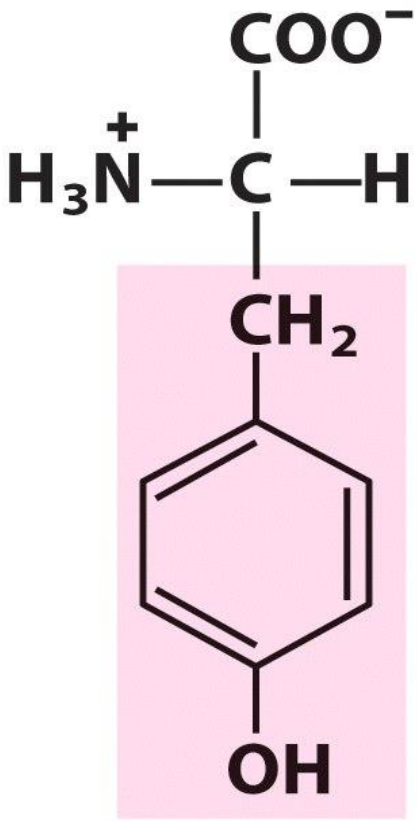
Isoleucine

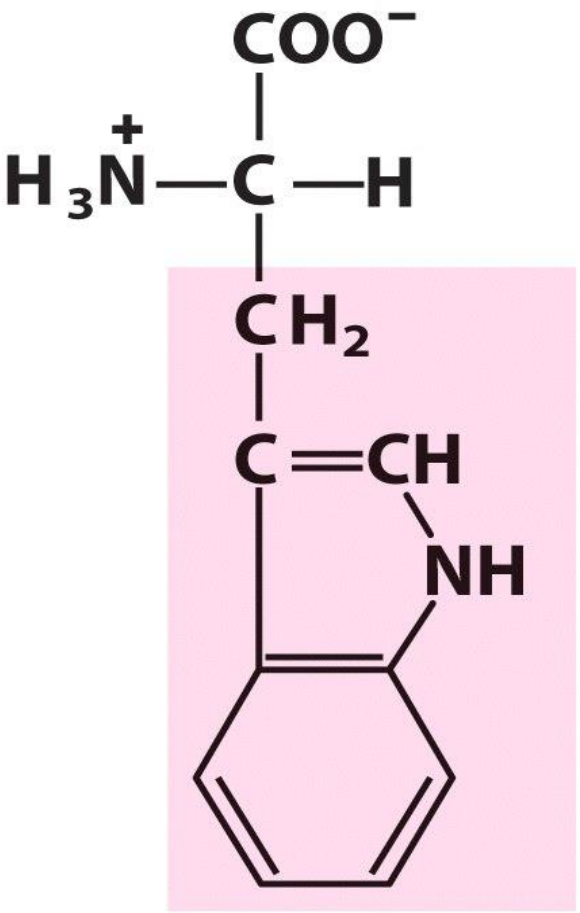


Methionine

Aromatic R groups

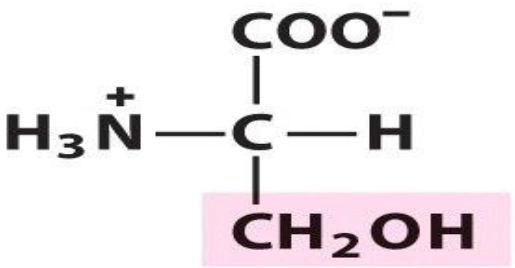




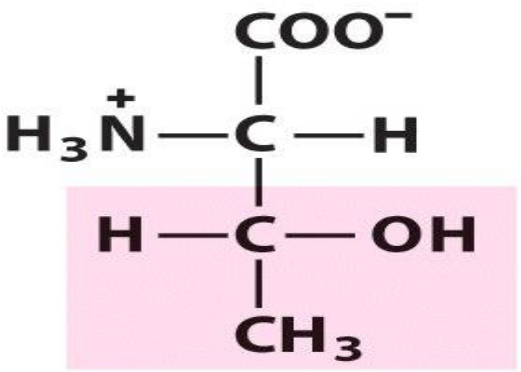


Phenylalanine Tyrosine Tryptophan

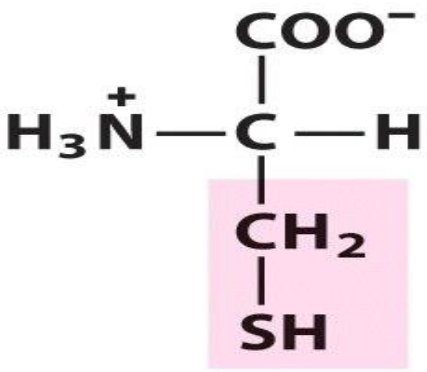
Polar, uncharged R groups



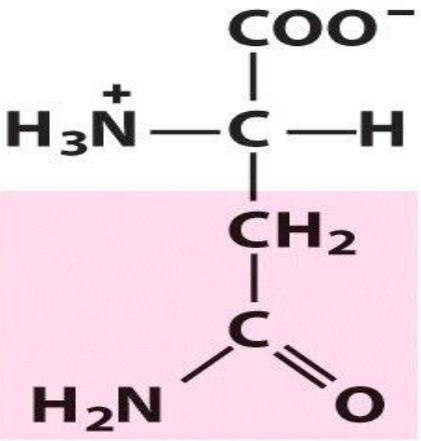
Serine



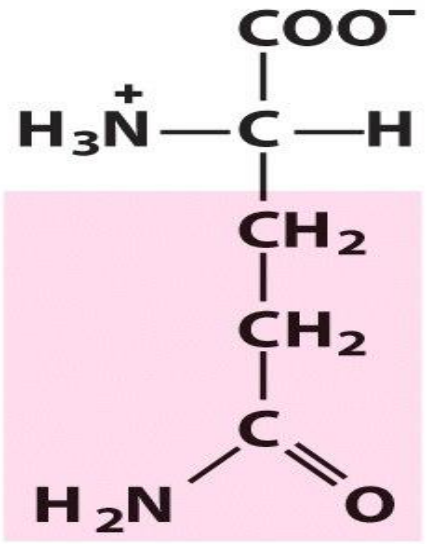
Threonine



Cysteine

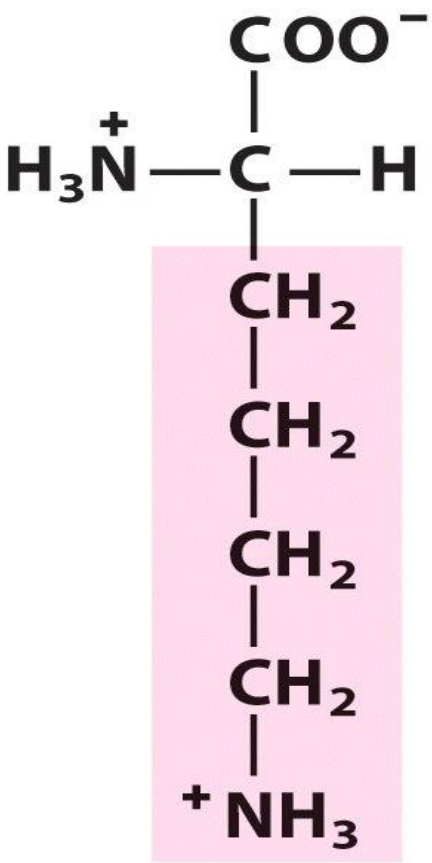


Asparagine

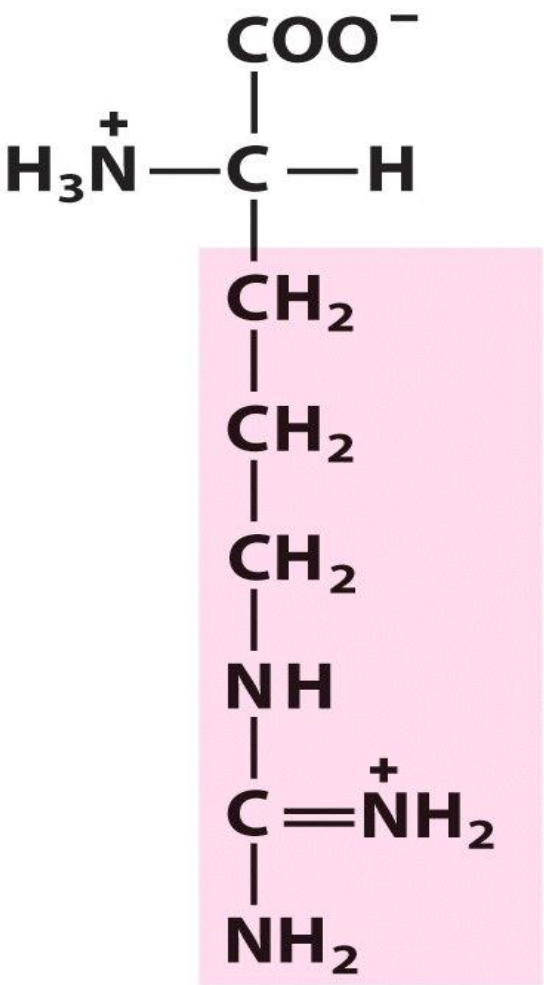


Glutamine

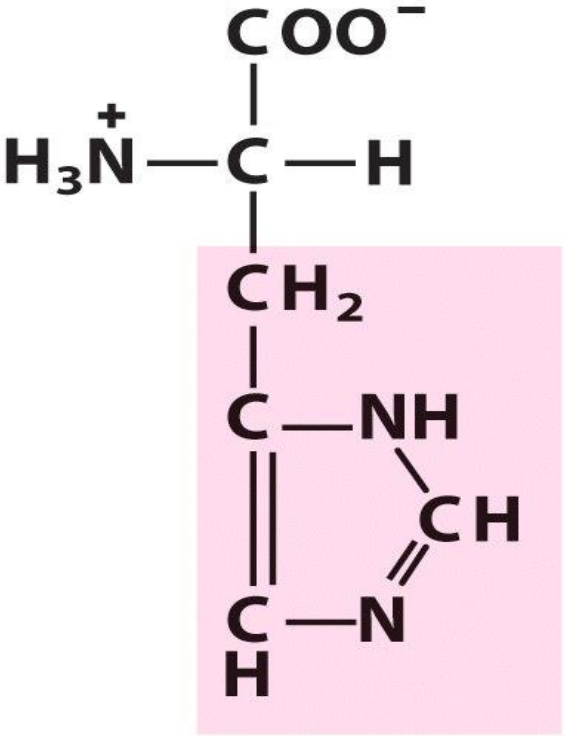
Positively charged R groups



Lysine

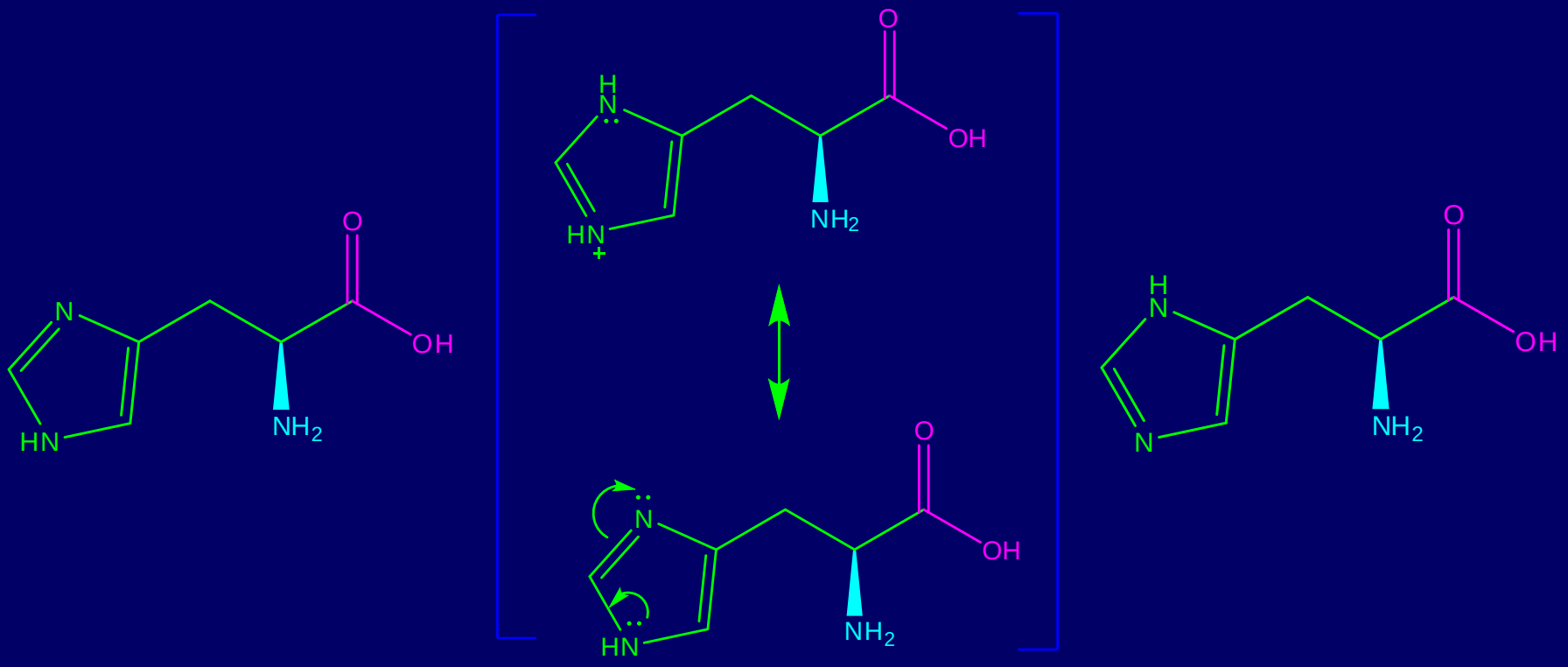


Arginine

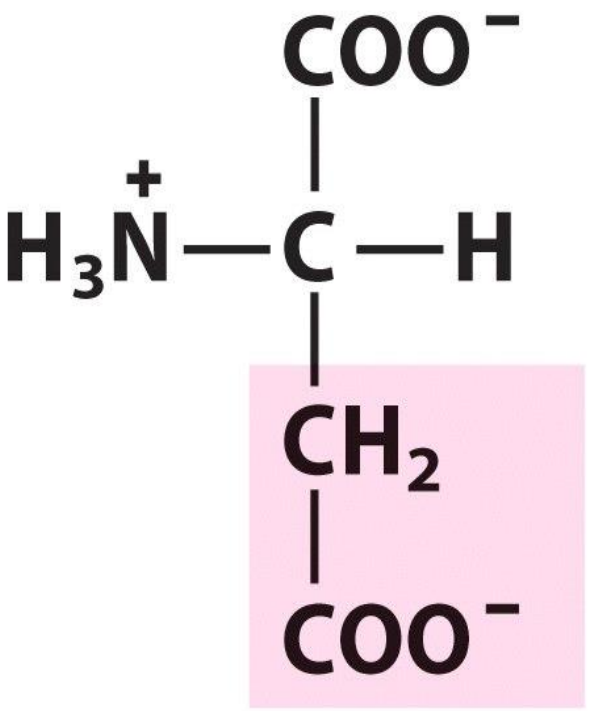


Histidine

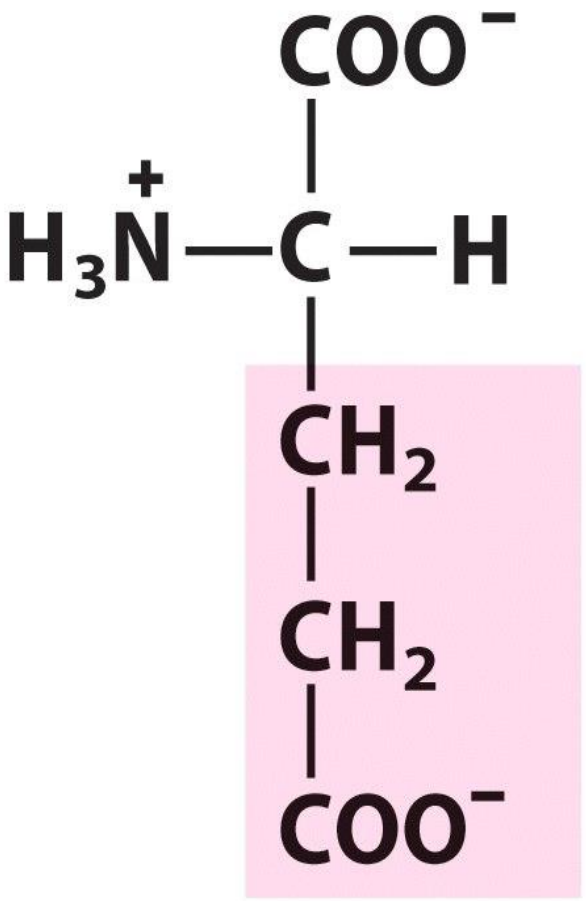
Ionic and Tautomeric States of the Histidine Side Chain



Negatively charged R groups



Aspartate



Glutamate

- There are 10 amino acids that are essential amino acids because they cannot be synthesized in the human body and must be obtained in the diet.
- The 10 essential amino acids are: valine, leucine, isoleucine, phenylalanine, methionine, tryptophan, threonine, histidine, lysine, and arginine.
- Two of these amino acids, arginine and histidine, are essential in children, but not adults.

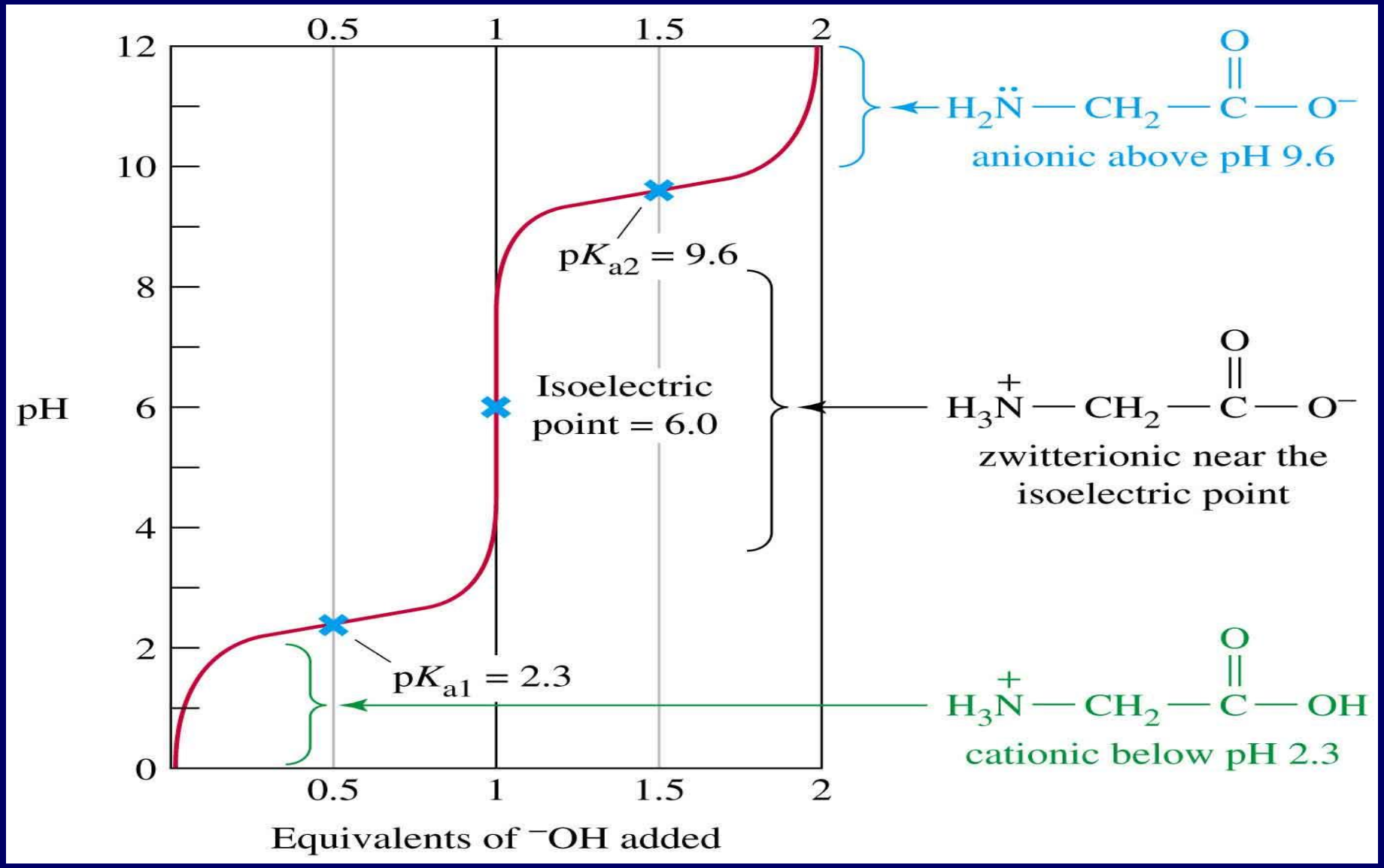
- Nonessential amino acids can be synthesized in the body from essential amino acids.
- Proteins that contain all the essential amino acids are called ***complete proteins***.

- Soybeans and most proteins found in animal products are complete proteins.

- Some plant proteins are incomplete proteins because they lack one or more essential amino acid.

- Complete proteins can be obtained by combining foods like rice and beans.

Structure and pH

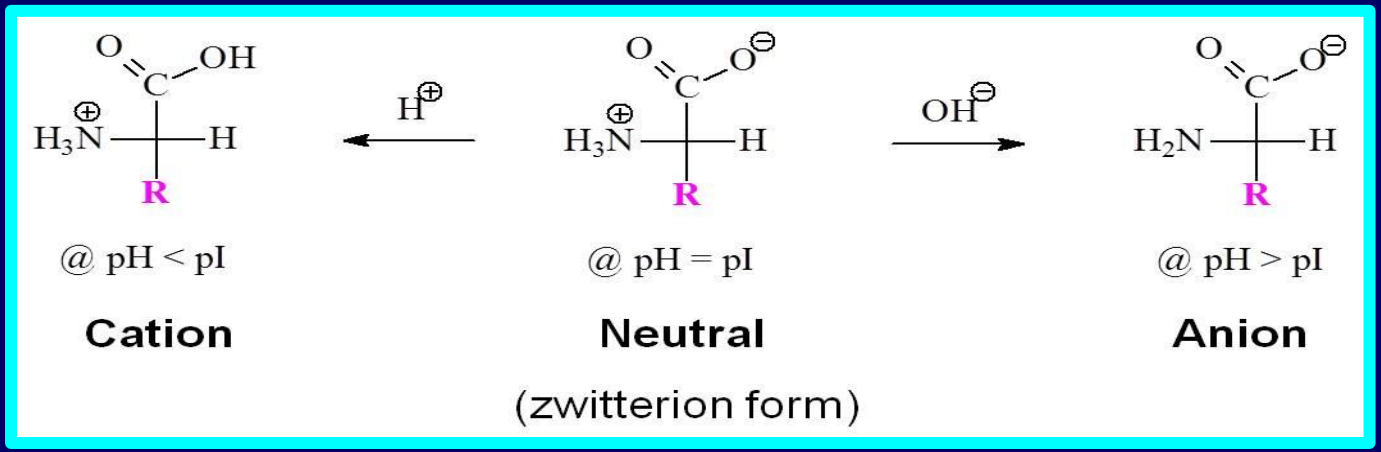


Isoelectric Point

Each amino acid has an **isoelectric point**, **(pI)** numerically equal to the pH at which the **zwitterion** concentration is at a maximum.

The amino acid has no NET charge at its pI; it has one positive and one negative charge.

At a pH less than the value of the isoelectric point, the amino acid is protonated and has a POSITIVE charge; at a pH greater than the pI the amino acid is deprotonated and has a NEGATIVE charge

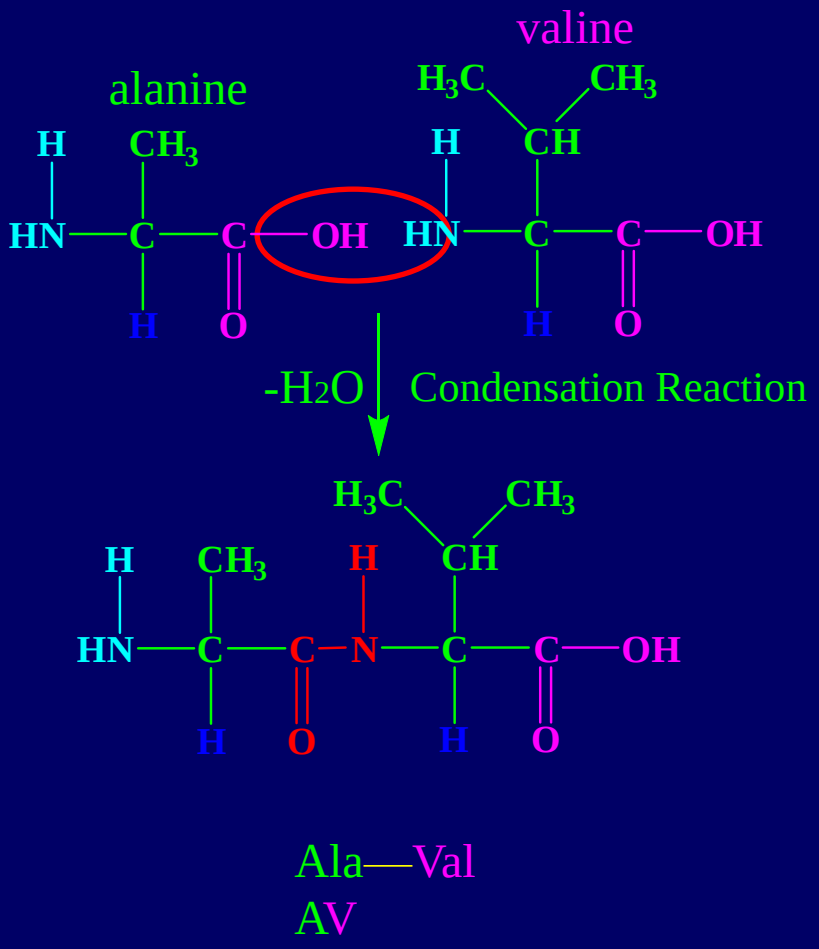


- Peptides are compounds in which an amide bond links the amino group of one a-amino acid and the carboxyl group of another.
- An amide bond of this type is often referred to as a peptide bond
- Polymerization of amino acids – form peptides and proteins
- A condensation reaction between the carboxyl of one amino acid and the amino group of another forms a Dipeptides (dimerization reaction) .
- Peptides are di, tri, tetra and oligopeptides. Oligopeptides – condensation of 2 – 10 AA units. Polypeptides – condensation of 11 – 100 AA units. Proteins – more than 100 AA units

Dipeptide Formation

The amino group of one molecule condenses with the acid group of another to form peptide bond.

- The product formed during the condensation of alanine and valine is known as a dipeptide, which is represented as Ala—Val or AV.
- In this dipeptide, alanine is called the ***N-terminus*** because it has an un reacted α-amino group.
- Valine is called the ***C-terminus*** because it has an unreacted α-carboxylate group.



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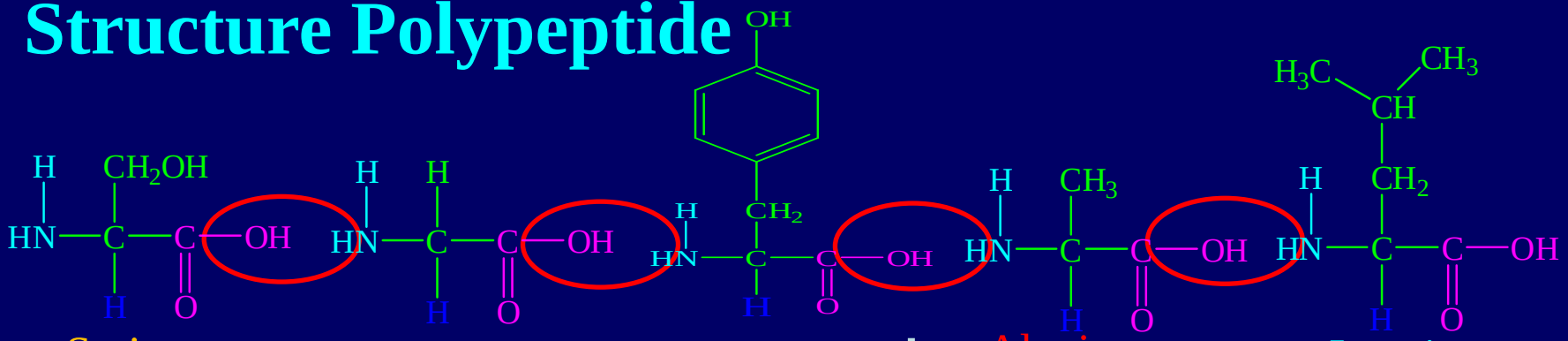
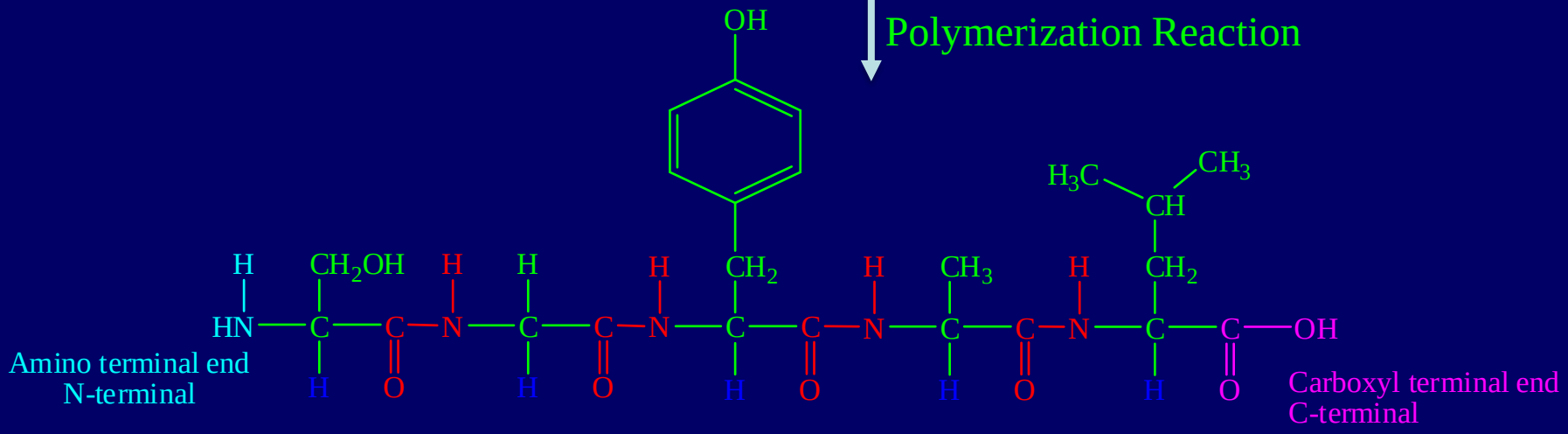
- Valine is called the ***C-terminus*** because it has an unreacted α-carboxylate group.
- Structures are always written from N-terminus to C-terminus.
- Two amino acids can combine in two ways forming two different dipeptides.
- The two dipeptides formed from condensation of Ala and Val are Ala—Val and Val—Ala.
- They are structural isomers, different compounds, and have different properties.

Structure Polypeptide



-4H2O Condensation Reaction or Polymerization Reaction



Naming peptides: Start at the N-terminus

1. Using full amino acid names Serylglycyltyyroslalanylleucine
2. Using the three-letter code abbreviation Ser-Gly-Tyr-Ala-Leu
3. For longer peptides (like proteins) the one- letter code can be used SGYAL

Functions of peptides

1. Precursor of protein
2. Antimicrobial agent eg. Penicillin G (valine-cystein-phenylacetic acid)
3. Hormones eg. insulin, somatostatin, vasopressin etc
4. Growth factors. eg. Ascorbic acid (vit. C)
5. Anti-oxidant they scavenge free radicals. eg. Carnosine
6. Clinical diagnosis: hyper secretion of peptide in urine is indicator for mental state of disturbance like depression, schizophrenia etc.
7. Structural component eg. Keratin, collagen
8. Slow down the aging process eg. collagen

Protein

- Proteins are large biomolecules or macromolecules that are comprised of one or more long chains of amino acid residues.
- Proteins are generally between 100 and 1000 residues in length.
- Proteins differ from one another primarily in their sequence of amino acids.
- Proteins perform a vast array of functions within organisms, including Catalyzing metabolic reactions.

1. DNA replication
2. Responding to stimuli
3. providing structure to cells and organisms
4. Transporting molecules from one location to another.


Thank you for your attention