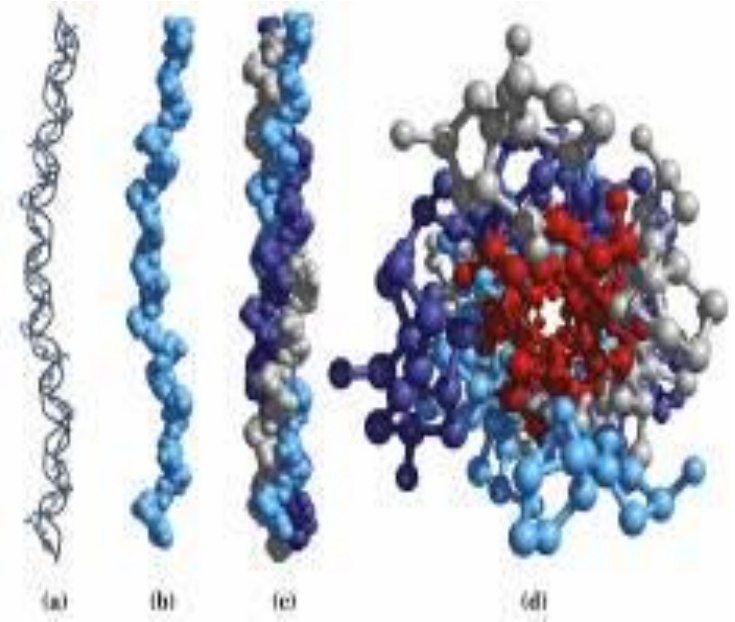
PROTEIN



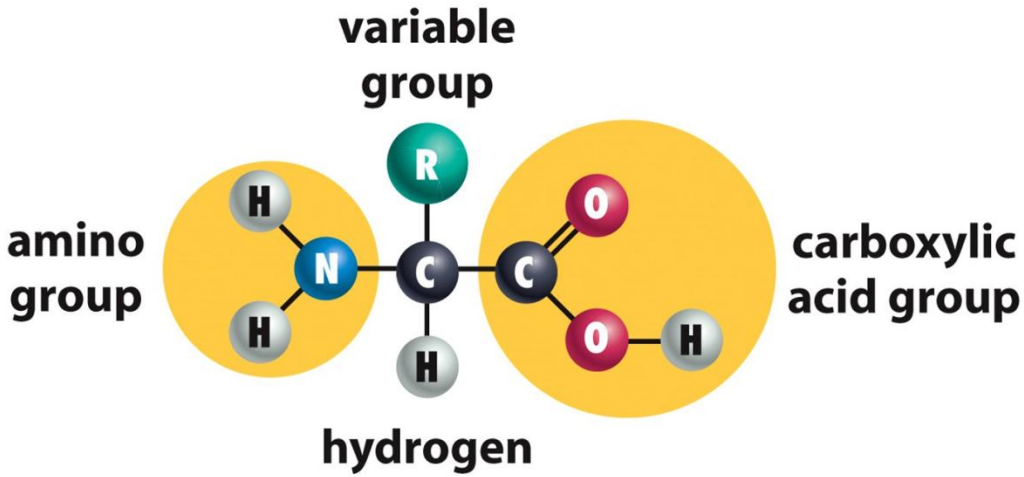


Figure 3-18 Biology: Life on Earth, 8/e

Proteins …… What are proteins?

Proteins are present in every cell of humans, animals, plant tissues, tissue fluids and in micro organisms. They account for about 50% of the dry weight of a cell. meaning holding first The term protein is derived from the Greek word *proteios* place or rank in living matter .

Proteins are macromolecules composed of amino acids linked together through peptide bonds. Proteins are made up of the 4 elements: carbon, hydrogen , nitrogen , oxygen , and sometimes sulphur. The sub-units for proteins are amino acids. Amino acids are joined together by strong chemical bonds called peptide bonds. A chain of hundreds of amino acids linked together is called a polypeptide.

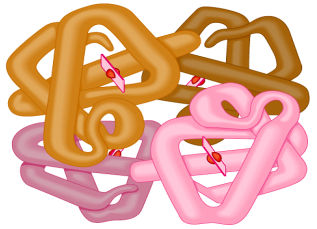
Protein function

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

CHEMICAL NATURE OF PROTEINS

All proteins are polymers of amino acids. The amino acids in proteins are united through “Peptide” linkage. Sometimes proteins are also called as polypeptides because they contain many peptide bonds.



PROPERTIES OF PROTEINS

1. Proteins have high molecular weight, *e.g.,* the lactalbumin of milk molecular weight is 17000 D and pyruvate dehydrogenase molecular weight is 7 ×106 D .

2. Proteins are colloidal in nature.

3. Proteins have large particle size.

4. Different kinds of proteins are soluble in different solvents.

5. Proteins differ in their shape.

6. Some proteins yield amino acids only on hydrolysis where as others produce amino acids plus other types of molecules.

7. **Charge properties:** Charge of a protein depends on the surroundings like amino acids. So, by changing the pH of surroundings the charge of protein can be altered. This property is used for separation of proteins.

Isoelectric point: Proteins have characteristic isoelectric points. At the isoelectric point its net charge is zero because the number of positive charges are equal to number of negative charges.

Amino acid

Amino acids and peptides are present in humans, animals, tissues, blood, microorganisms and plants. **Amino acids are the building blocks of proteins, which have structural and functional properties in our bodies.**

Proteins are polymers of amino acids covalently bonded in specific sequences.

There are 20 commonly occurring amino acids that make up proteins, and the order of amino acids in proteins determines its structure and biological function.

MEDICAL AND BIOLOGICAL IMPORTANCE

1. Amino acids serve as building blocks of proteins. Some amino acids are found in free form in human blood.

2. They also serve as precursors of hormones, purines, pyrimidine's, porphyries, vitamins and biologically important amines like histamine.

3. Peptides have many important biological functions. Some of them are hormones. They are used as anti-biotics and antitumor agents.

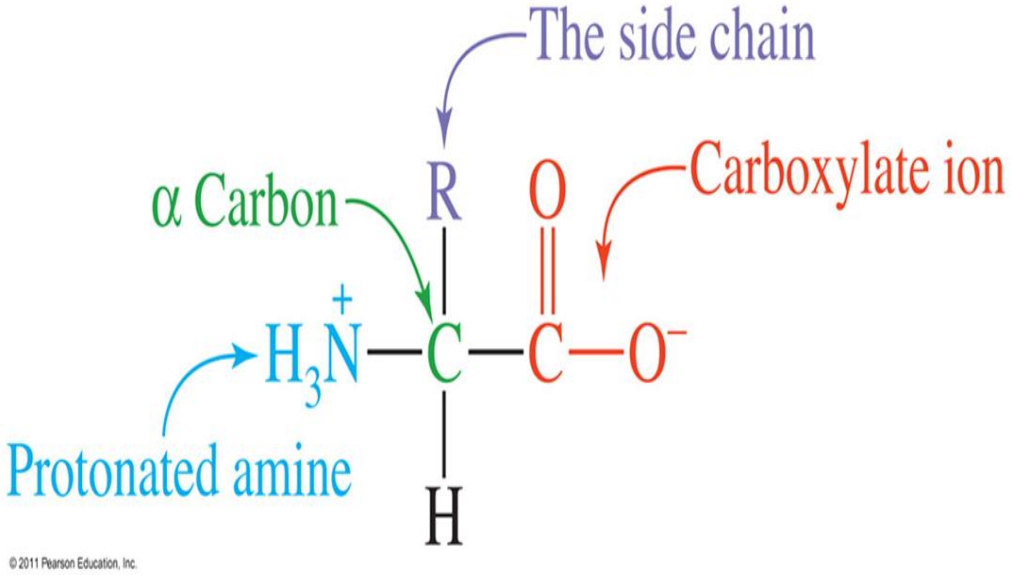
4. Some peptides are required for detoxification reactions. Some peptides serve as neurotransmitters.

5. Amino acid prolin protects living organisms against free radical induced damage.

6. Some peptides are involved in regulation of cell cycle and apoptosis.

Amino acid

- **Structure**
  - **central carbon**
  - **amino group**
  - **carboxyl group (aci**
  - **R group (side chain)**
    - **variable group**
    - **different for each amino acid**
    - **confers unique chemical properties to each amino acid**
      - **like 20 different letters of an alphabet**



Amino Acid 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 .

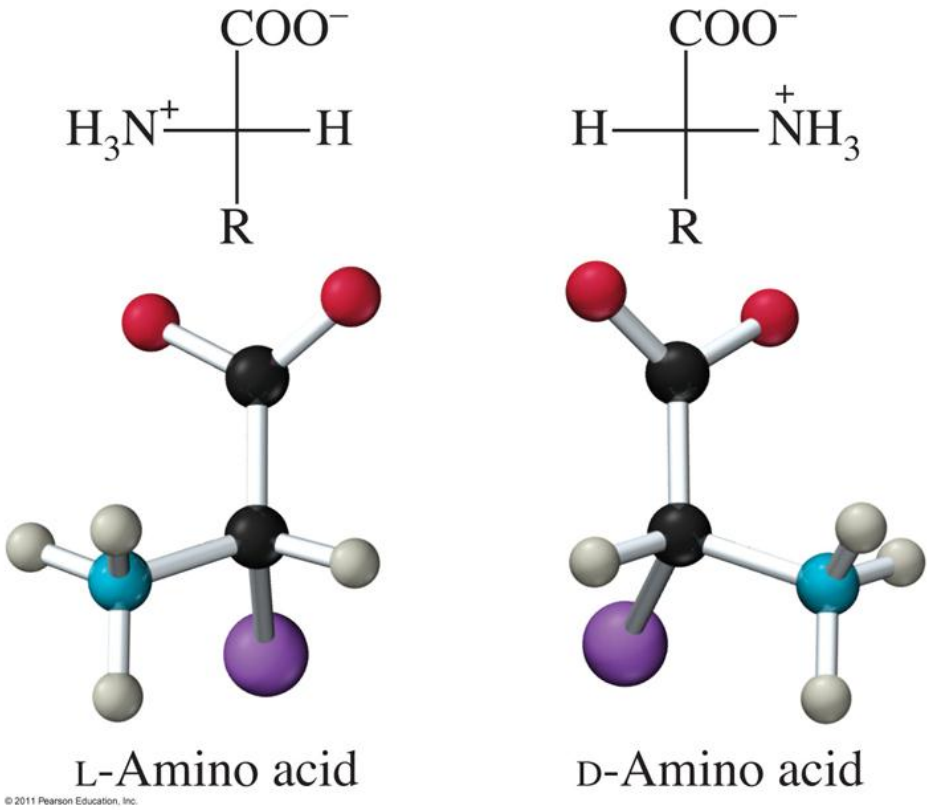
The (α) carbon is also bonded to a hydrogen atom and a larger side chain. The side chain is unique for each amino acid.

The α carbon on all amino acids, except glycine, is a chiral because it has four different groups bonded to it

An amino acid, with a chiral center, has two forms called enantiomers.

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.



AMINO ACIDS

- Only 20 types of amino acids are used for protein synthesis in biological systems.
- 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:
- **Tryptophan, Valine, leucine, isoleucine, phenylalanine, methionine, 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.

- The 10 nonessential amino acids are
- Glycine , alanine , serine , cysteine , aspartic acid , asparagine , glutamic acid , glutamine , tyrosine, proline

- Proteins that contain all the essential amino acids are called complete proteins.
- Soybeans and most proteins found in animal
- 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.

Classification of Amino Acids (AA)

The R group creates unique characteristics for each amino acid so they differ in: shape, size, composition, electrical charge, and PH .
The R groups, also called side chains, make each A.A unique and distinctive

R groups are different in their, hydrogen bonding capability and chemical reactivity.

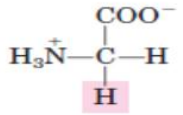
I. Based on side chain and ring structure present, amino acids are classified into 7 major classes.

1. Amino acids with aliphatic side chain. They are also called as aliphatic amino acids. They are glycine, alanine, valine, leucine and isoleucine. Valine, leucine and isoleucine are called as branched chain amino acids.

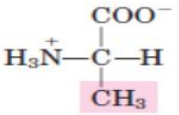
2. Amino acids with side chain containing hydroxyl groups. They are also called as hydroxy amino acids. They are serine and threonine .

3. Amino acids with side chain containing sulfur atoms. They are also called as sulfur containing amino acids. They are cysteine, methionine and cysteine.

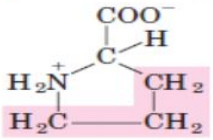
Nonpolar, aliphatic R groups



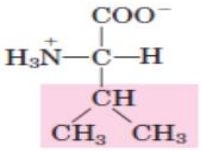
Glycine



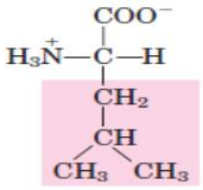
Alanine



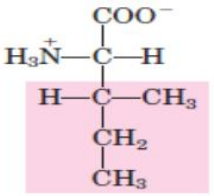
Proline



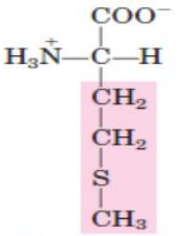
Valine



Leucine

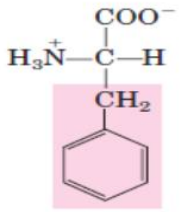


Isoleucine

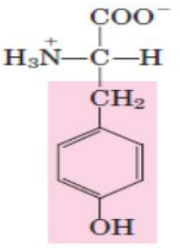


Methionine

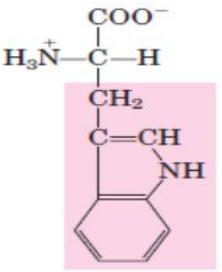
Aromatic R groups



Phenylalanine

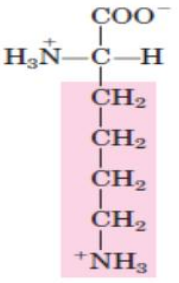


Tyrosine

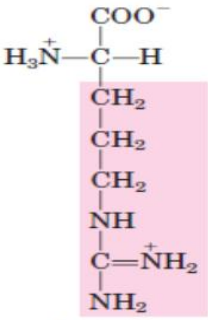


Tryptophan

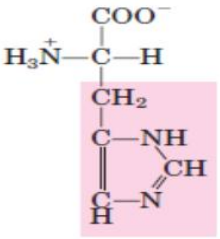
Positively charged R groups



Lysine

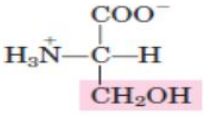


Arginine

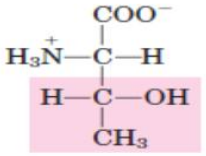


Histidine

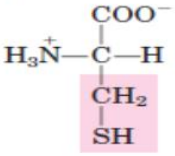
Polar, uncharged R groups



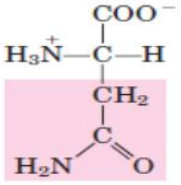
Serine



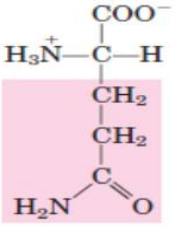
Threonine



Cysteine

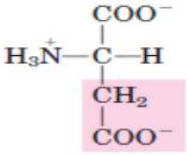


Asparagine

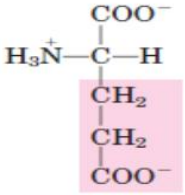


Glutamine

Negatively charged R groups



Aspartate



Glutamate

5. Amino acids with side chain containing basic groups. They are also called as *basic amino acids*. They are arginine, lysine, hydroxy lysine and histidine.

6. Amino acids containing aromatic rings. They are also called as *aromatic amino acids*. They are phenylalanine, tyrosine and tryptophan.
7. Imino acids. They are proline and hydroxy proline .

II. Amino acids are also classified according to the reaction in solution or charge. They are categorized in 3 classes, acidic, basic and neutral amino acids. Acidic amino acids are aspartic acid, glutamic acid. Basic amino acids are arginine, lysine and histidine. **Rest of the amino acids are neutral amino acids.**

III. Another classification of amino acids is based on the number of amino and carboxyl groups present in the molecule.
Example. Mono-amino -mono-carboxylic acid (Glycine), Mono-amino dicarboxylic acid (Glutamate).

IV. Amino acids are also classified according to their nutritional importance. Nutritionally amino acids are classified into

(a) Essential amino acids: These amino acids are not synthesized in the body and hence they have to be obtained from the diet. Sometimes histidine and arginine are referred as semi-essential because body synthesizes these amino acids to some extent. Lack of essential amino acids in the diet gives rise to growth failure.

(b) Non-essential amino acids: These amino acids are synthesized in the body. They are alanine, glycine, serine, tyrosine, glutamate, glutamine, aspartate, aspargine, cysteine and proline. They need not be present in the diet.

Rare Amino Acids or Unusual Amino Acids

These are the amino acids that are not found in proteins but play important roles in metabolism. Examples

1. Ornithine, citrulline and arginino succinic acid of urea cycle.
2. β-alanine is part of co-enzyme A .

3. Taurine is part of bile acids .

4. γ-aminobutyric acid is a neurotransmitter .

5. Mono- and di-iodotyrosine are precursors of thyroxine.

6. Pantothenic acid is a water-soluble vitamin.

7. Homoserine is an intermediate of methionine catabolism.

8. Homocysteine. It is also an intermediate of methionine catabolism. It is a atherothrombogenic agent. It triggers platelet adhesion. Hence, it is considered as **a risk factor for development of coronary artery disease (CAD).**

9. S-allylcysteine sulfoxide. It is an amino acid obtained from garlic. It has many therapeutic effects. It is commonly called as alliin.

Formation peptide bond

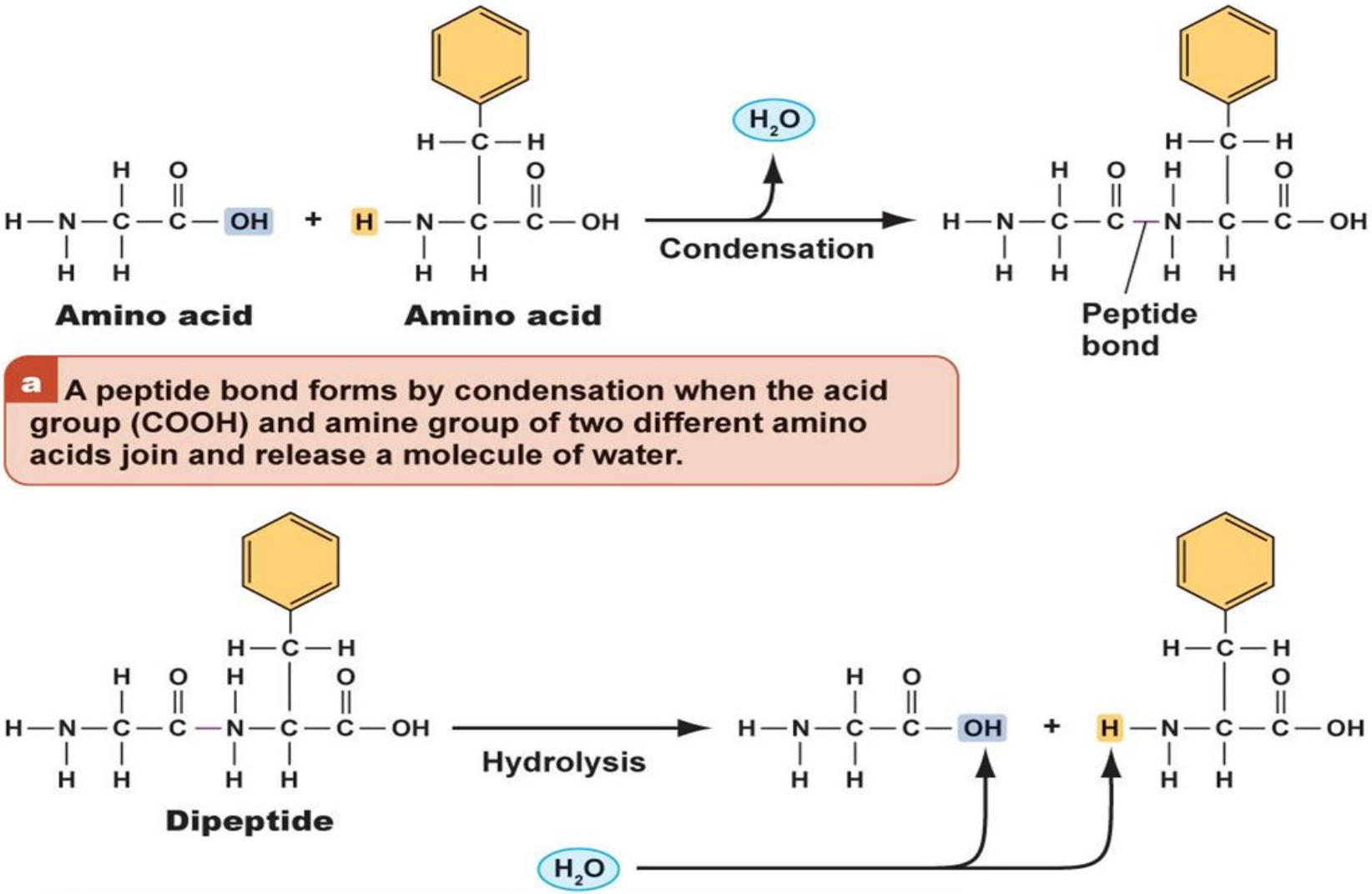
When two amino acids condense, a dipeptide is formed.

The carboxylate ion (COOH) of one amino acid reacts with the protonated amine (NH_2) of a second amino acid.

A water molecule is lost and an amide functional group is formed.

An amide bond is formed between the two amino acids.

When amino acids combine in a condensation reaction, the amide bond that is formed between them is called a peptide bond



a A peptide bond forms by condensation when the acid group (COOH) and amine group of two different amino acids join and release a molecule of water.

b When peptide bonds are broken by hydrolysis, the hydroxyl group (OH) and hydrogen (H) from water are added.

In this dipeptide, first A.A is called the N-terminus because it has an unreacted α-amino group.
Second A.A is called the C-terminus because it has an unreacted α-carboxylate group.
Structures are always written from N-terminus to C-terminus.

A dipeptide consist of two amino acid residues and one peptide bond.

- **Carnosine and Anserine** are two peptides present in muscle and brain.

- **Aspartame :** It is present in African berry. It is a sweetening agent.

Tripeptides

A tripeptide consist of three amino acid residues and two peptide bonds. **Glutathione** it act as reducing agent in all cells.

Penta Peptides

They consist of five amino acids and four peptide bonds. Example **Enkaphalin**, it is present in brain.

Other noteworthy peptides are

- **Angiotensin II**. It is an octa peptide, found in lungs and other cells. It is a powerful vaso constrictor and raises blood pressure.
- **Bradykinin.** It consist of nine amino acid residues. It is a powerful vasodilator and anti inflammatory.
- **Oxytocin I.** It is also a nona peptide. It stimulates uterus contraction.
- **Vasopressin**. A nona peptide produced by pituitary gland. It has a disulfide bridge. It is also known as antidiuretic hormone (ADH).

Polypeptide Structure

A polypeptide is a compound that is formed when the number of amino acids increases.

A biologically active polypeptide consisting of 50 or more amino acids is referred to as a protein.