Biochemistry

Amino acids

Proteins: {structure and function}

Proteins are macromolecules found in the cells and they makeup over half of the dry weight of most organisms.

All proteins in all species are built from the same basic set of 20 amino acids, proteins differ from each other by their sequence of amino acid units; there are thousands of different proteins in each species of organism and there are perhaps 10 million species so:

Q_1: How can only 20 amino acids de assembled? (Mathematics can tell us the answer for this question).

Answer: the number of possible sequences of a set of object is: -

$$ {}_nN_r^{tot} = n^r $$

N: Total number of different linear arrangement

n: Object taker

r: time

For example: 3 amino acids

So we have: $3^3 = 27 \rightarrow N$

Different linear peptides

When the amino acid used only one time: -

N = 3 x 2 x 1 = 6

abc bac cab

acb bca cba

Example: -

$N = 20^{12} = 4.096 \times 10^{15}$ different linear peptides when amino acids used only one time so that ($n \neq r$)

$$ {}_nN_r = n\,(n-1)(n-2)\,\ldots\,(n-r+1) $$

$20 \times 19 \times 18 \times 17 \times 16 \times 15 \times 14 \times 13 \times 12 \times 11 \times 10 \times 9 = 6.034 \times 10^{13}$

If ($n = r$): -

$ {}_nN_r = n! $ Equal to 2.433×10^{18} different peptides

So the twenty 20 amino acid can thus be arranged in enough sequence to account for not only thousands of proteins in organism but for all proteins in all species of organisms.

Biomedical importance of proteins: -

Analysis of certain protein or enzyme of the blood is used in diagnosis of many diseases like: -

A. Diagnosis of liver disease by measurement of ***Got, Gpt*** enzymes and electrophoresis analysis of ***Alb, globulin***.
B. Diagnosis of heart disease like ***myocardial infarction*** but not angina by measurement and analysis of ***LDH – isoenzyme, ck***, and ***Alp***.
C. Measurement of Alp & γ – glutamyl use in diagnosis of cholestasis and bone disease.
D. Analysis of plasma lipoprotein and plasma immunoglobulin by electrophoresis and other methods are use in diagnosis of specific type of ***hyperlipoproteinemia*** and in ***immunodisorders***.
E. Detection of protein in urine (***proteinurea***) is important indicator of ***renal disease***.
F. ***PSA {prostate specific antigen}***: is an enzyme occurs in prostatic tissue and used as tumor marker in prostate cancer.
G. Amylase is produced by the pancreas and salivary glands and its main diagnostic application is in the investigation of acute pancreatitis.

Note: The ck enzyme (creatine kinase enzyme) used for diagnosis of the muscular dystrophies.

Classification of proteins: -

Proteins are classified according to: -

1. On the basis of shape and size.
2. On the basis of functional properties.
3. On the basis of solubility and physical properties.

On the basis of shape and size: -

The proteins can classify to: -

a. Globular proteins (in plasma).
b. Fibrous proteins (in hair, skin).

On the basis of functional properties: -

The proteins classify to: -

a. Defense proteins.
b. Contraction proteins.
c. Respiration proteins.
d. Structural proteins.
e. Enzymes.
f. Hormones.

Both the above classification schemes have many overlapping features; there for a third most acceptable scheme of the classification of protein is based on their ***solubility and physical properties***.

This scheme is divided in three different classes: -

A. **<u>Simple proteins:</u>** these are proteins which on complete hydrolysis yield only amino acids and these are further subclassified based on their solubility's and heat coagulability. Major subclasses of simple proteins are: -

1. **Protamines:** these simple, small molecules, soluble in water, acids, alkalines and the dilute ammonia, these do not coagulate by heat. They are rich in Arg and exist as basic proteins in the body.
2. **Histones:** they from conjugated proteins with the nucleic acid (DNA) and porphyrins. They are rich in Arg & His.
3. **Albumins:** these proteins are soluble in water and diluted salt solutions and are coagulable by heat and changed to insoluble in water. Like: lactalbumin in milk and ovatalbumin in egg.
4. **Globulins:** these are insoluble in water and heat coagulable, bind with heme, for example: hemopexin in liquid and VLDL (very low density lipoproteins) also found in transferrin and cerucoplasma in which the protein bind to metals.
5. **Gliadin (prolamines):** these proteins are alcohol soluble plants proteins also this type of proteins are insoluble in water and they are rich in Proline (Pro).
6. **Glutelins:** these are plant proteins, soluble in water and rich in Glutamic acid (Glu).
7. **Scleroproteins (Albuminoids):** these are fibrous proteins with great stability and very lower solubility and form structure of animals. E.g. keratins, collagens and elastin.

B. **<u>Conjugated proteins:</u>** are simple proteins combined with a non – protein group called ***prosthetic group***, protein part is known ***apo – protein***.

- The entire molecule is called Haloproteins.
- Conjugated proteins divided into: -
  1. **Nucleoproteins:** basic protein + nucleic acid (such as: Histone & protamine.
  2. **Mucoproteins:** protein + mucopolysaccharide (such as: some hormones like FSH & HCG)
     Note: 30% carbohydrate of its molecular weight.
  3. **Glycoproteins:** protein + carbohydrates moiety bounded more strongly more strongly.
  4. **Chromoprotins:** protein that contain colored substance like: hemoglobins, cytochromes.
  5. **Phosphoproteins:** protein + phosphoric acid as the organic phosphate, like: casein, ovovitellin (found in milk).
  6. **Lipoproteins:** proteins + lipids (like: cephalin, fatty acid).
  7. **Metalloproteins:** protein + metal ion (some enzyme contain metallic elements such as: Fe, Co, Mn, Zn, Cu, Mg), like: ferritin contain Fe, ceruloprotein which contain the Cu.

C. **<u>Derived proteins:</u>** this class of proteins formed from the native protein (simple and conjugated proteins) by the action of heat, physical forces or chemical factors like: coagulated proteins and denatured protein by heat or X – ray or UV – ray or vigorous shaking or acid or alkali or progressive hydrolysis of protein.

Note: in coagulated protein there is intramolecular rearrangement leading to changes in their properties like the fibrin from fibrinogen.

There is another kind of derived protein is formed by progressive hydrolysis of protein.

Classification according to their functional properties: -

A. Defense proteins (for protection): immunoglobulins involved in defense mechanisms like antibodies which involved on the destruction of foreign cells.

B. Contractile proteins (for movement):

- Proteins of muscle involve in muscle contraction and relaxation like: actin and myosin.
- Muscle contraction is cameol on by the interaction between these two proteins.
- Myosin also possesses an enzymatic activity for facilitation the conversion of the chemical energy of ATP to chemical energy.

C. Structural protein: like protein of skin, cartilage, nail, Collagen; which provides strength in teeth and bone.

D. Transport and storage: many molecules are transported in the blood and within cell by being bound to carrier protein like: myoglobin, hemoglobin.

E. Enzymes: protein enhancing rates of the reaction.

F. Regulatory proteins: like hormones.

Classification of protein on shape and size: -

A. **Globular proteins:** where polypeptide chain or chains are tightly folded into compact spherical or globular shapes. *For example:* almost all enzymes are globular proteins where soluble in aqueous system and most of them have mobile or dynamic function.
B. **Fibrous protein:** are water insoluble, long, stringy molecules with the polypeptide chains, extended along one axis rather than folding into globular shape. Most fibrous proteins serve in a structural or protective rule, like: α – keratin of hair and wool. Fibrin of silk and collagen of tendons and myosin also included to this class, where these proteins participate in contractile events in both muscle and non – muscle cells.