2·10. Proteins. Proteins are highly complex, natural compounds, composed of a large number of different α-amino-acids *i. e.* they are naturally occurring polypeptides*. Proteins are the chief constituent of protoplasm in all the living cells, but on the whole animals have relatively much more proteins than plants (in seeds) in which cellulose predominates. Among animals the mammals are constituted largely of proteins (*e. g.* skin. hair, nails, haemoglobin, muscles, etc). Antibodies, enzymes, some hormones, *viz.* insulin are proteinous in nature. It is very important to note that the tissue proteins of any two of the individuals are not identical, except for two twins. Due to this characteristic, proteins help in protecting the body by the attack of foreign toxic proteins and viruses ; the latter are partially proteins.

The biological importance of proteins can be judged by the fact that the animals can live for a long time without fat or carbohydrate, but not without protein. Proteins mainly supply new tissues, repair working parts and make up the loss (*e. g.* as gland secretions) in the vital processes. Only the plants can built up proteins from inorganic materials, like nitrates, ammonium sulphate, carbondioxide and water, while most of the animals derive them mainly plants and some other animals.

2·11. Characteristics of proteins : Since proteins are composed exclusively of α-amino-acids, the properties of the latter will also constitute the properties of the former. Some of the important properties are given below.

(i) Most of the proteins are hydrophilic, higher polymer colloids ; a few such as insulin, tobacco mosaic virus, etc. are crystalline. All the proteins are leavorotatory, this property is due to the presence of α-amino-acids which are the building blocks of the proteins. Except chromoproteins, other proteins have no characteristic colour. They have no melting points or decomposition temperature.

(ii) Because of the presence of free acidic or basic groups on the protein chain, the protein molecules also have some definite isoelectric point at which they exhibit minimum solubility and no migration in an electric field. The isoelectric points of the proteins are given below.

Protein	Isoelectric point
Casein	4·60
Gelatin	4·80—4·85
Insulin	4·30—5·35
Haemoglobin	6·79—6·83

(*iii*) *Denaturation* (*see also* 2·150,). Proteins are cations at pH values lower than the P isoelectric pH and anions at pH values higher than the isoelectric pH. On heating, exposing to ulteraviolet radiations or treating with a number of solvents or reagents (*i. e.* alcohol, acetone, aqueous potassium iodide) the proteins are precipitated out and thus undergo remarkable changes in their solubility, optical rotation and biological properties; *e. g.* enzymes (proteins) become inactive when denatured. These changes may be irreversible or reversible and generally referred as **denaturation**. Denaturation occurs most readily near the isoelectric point. The common example of irreversible denaturation is the familiar change which occurs during the boiling of an egg. The denatured protein samples may contain an intact primary structure, their three-dimensional structure is destroyed.

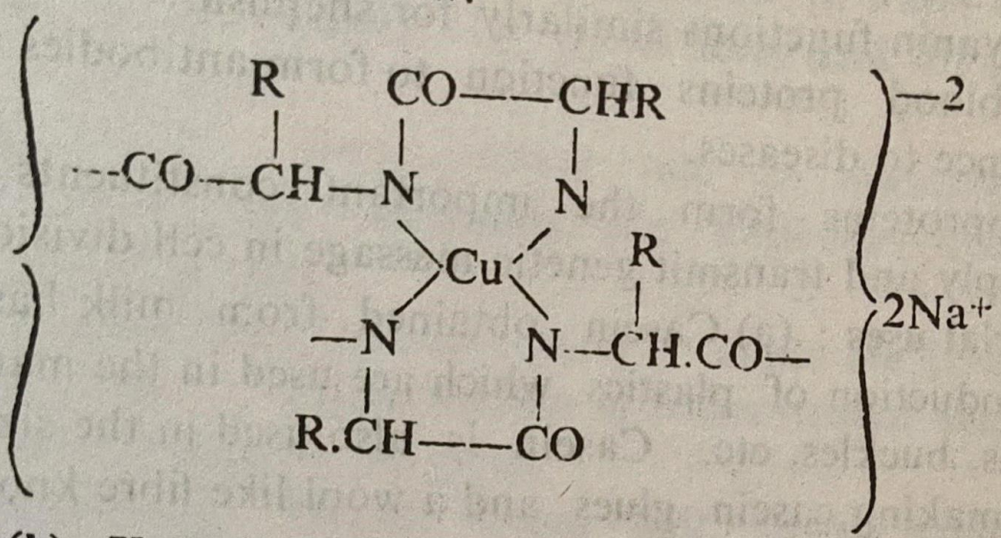
The reversal of denaturation is known as **renaturation** or **refolding**. In case denaturation is effected by heat, renaturation (reversible denaturation) may be carried out by very slow cooling (not rapid cooling) ; the process of this type of renaturation is known as **annealing**.

(*iv*) Peptides and proteins undergo hydrolysis by means of diluted hydrochloric or sulphuric acid, alkali or enzymes into their constituent amino-acids.

(v) *Colour reactions*. Proteins give characteristic colour on treatment with some specific reagents and hence these colour reactions constitute the **test of proteins**. However, it must be noted that these tests are specific for certain groups present in the protein molecule and therefore it should not be expected that all proteins will give all tests.

(**a**) **Biuret test**. The protein is warmed gently with 10% solution of sodium hydroxide and then a drop of very dilute copper sulphate solution is added, the formation of reddish—violent colour indicates the presence of the grouping, —CO—NH—CHR—CO—NH—, *i. e.* a dipeptide linkage. The test is given

by all proteins, peptones, and peptides; Except dipeptides which do not contain two peptide linkages. Its name is derived from the fact that the test is also positive for the compound **biuret**, $H_2N.CONH\ CONH_2$, obtained from urea by heating. The structure of the coloured product formed at a section of the protein chain is as below.



(b) Xanthoproteic reaction : On treatment with concentrated nitric acid certain proteins give yellow colour which becomes orange on the addition of alkali. This yellow colour is the same that is formed on the skin when the latter comes in contact with the concentrated nitric acid. The test is given only by the proteins having at least one mole of aromatic amino-acids, such as tryptophan and tyrosine which are actually nitrated during treatment with concentrated nitric acid.

(c) Millon reaction : Proteins on adding Milion's reagent (a solution of mercuric and mercurous nitrates in nitric acid containing a little nitrous acid) gives a white precipitate which turns red on heating. This reaction is characteristic of phenols, and so the test is given by proteins containing tyrosine.* Moreover, the non-proteinous material having phenolic group also responds the test.

(d) Ninhydrin reaction : Proteins and peptides give this test, but the colours are different from that of the amino-acids.

The test is also given by ammonia, ammonium salts, and certains amines.

2 12. Uses of Proteins : *In* addition to the use of proteins as food, they are of great importance. Some of the important uses of proteins may be discussed under the following headings.

1. Biological functions : The biological functions of proteins are extremely diverse, described below.

(a) Some proteins act as hormones and hence regulate various

metabolic processes *e.g.* insulin is responsible for maintaining blood sugar levels.

(b) Some proteins (enzymes) function as catalysts for biological reactions.

(c) Some proteins function as biological structural materials. *viz.* collagen in connective tissue and keratin in hair.

(d) Haemoglobin (a protein) acts as oxygen-carrier in mammals. Haemocyanin functions similarly for shellfish.

(e) Some blood proteins function to form antibodies which provide resistance to diseases.

(f) Nucleoproteins form the important constituents of the genes that supply and transmit genetic message in cell division.

2. Industrial uses : (a) Casein obtained from milk has been used in the production of plastics which are used in the manufacture of buttons, buckles, etc. Casein is also used in the sizing of paper and in making casein glues and a wool like fibre known as lanital.

(b) Gelatin is used to relieve futigue and to increase energy.

(c) Soyabean proteins are used in the manufacture of plastics, synthetic fibres and paints.

(d) Blood plasma (obtained after removal of the blood cells by centrifugal action) is essentially a solution of proteins in water and is used for the treatment of shock produced by serious injuries and operations.

2.13. Classification of proteins. Proteins are generally classified on the basis of increasing complexity in their structure into simple, conjugated and derived proteins

(i) **Simple proteins.** The simple proteins are those which yield only α-amino-acids on hydrolysis. They are further classified into following classes on the basis of the decreasing solubility.

(*i*) *Albumins* : These are soluble in water, acids and alkalies. These are coagulated by heat and precipitated by saturating their solutions with ammonium sulphate. These are usually deficient in glucine common examples are serum albumin, egg albumin and lactalbumin.

(*ii*) *Globulins* : These are insoluble in water, but are soluble in dilute solutions of salt strong inorganic acids and alkalies. These are coagulate by heat and precipitated by half saturating their solutions with ammonium sulphate. They generally contain glycine; common examples are serum globulin, vegetable globulin and tissue globulin.