CHAPTER 21
BIOCHEMISTRY

CARBOHYDRATES

→ Plants are major sources of carbohydrates which comprise upto 80% of their dry weight

→ Animals contain very small amount of carbohydrates e.g about 1%.

→ Plants use carbohydrates both as energy sources and supporting materials while animals use them for production of energy.

→ General Formula : $C_n(H_2O)_n$

→ 2-deoxyribose having molecular formula $C_5H_{10}O_4$ cannot be represented by $C_n(H_2O)_n$ formula

→ Carbohydrates are poly hydroxy aldehydes or poly hydroxy ketones or molecules which yield these compounds on hydrolysis.

1. Monosaccharides

→ Simple sugars

→ One sugar unit per molecule

→ Examples : Glucose, Fructose etc

→ Monosaccharides may be aldoses or ketoses.

Aldoses : having aldehyde functional group e.g Glucose

Ketose : having ketone functional group e.g Fructose

→ Monosaccharides may be trioses, tetroses, pentoses, hexoses

2. OLIGOSACCHARIDES

→ 2 - 10 units of monosaccharides
→ hydrolysable carbohydrates
→ Disaccharides (2 units), Tri saccharides (3 units) and so on.
→ Maltose : Glucose + Glucose
→ Sucrose : Glucose + Fructose
→ Lactose : Glucose + Galactose

3. POLYSACCHARIDES

→ more than 10 units of monosaccharide
→ hydrolysable
→ e.g starch, cellulose, glycogen

FUNCTIONS OF CARBOHYDRATES

→ They produce energy by the process of oxidation

$$\text{Carbohydrate} + O_2 \longrightarrow CO_2 + H_2O + \text{Energy}$$

→ Glucose is used as an immediate source of energy for the sick and sportsmen
→ Cellulose is used for manufacture of paper
→ Oligo saccharides are involved in the formation of secreted proteins like antibodies and blood clotting factors
→ The derivatives of carbohydrates such as protein glycol heparin sulfate are involved in the attachment or adhesion of neurons to one another during development of nervous system.

1. SUCROSE

→ Sucrose is used in the preparation of sucrose octa acetate which is used for denaturation of alcohols and for making anhydrous adhesives.

→ The material known as "plaque" which sticks to our teeth is caused by sucrose

2. LACTOSE

→ Also called milk sugar

→ Human milk contains about 6.8 % while cow milk contains about 4.8 % lactose.

→ Enzyme lactase digest lactose. Lactase is secreted by intestinal mucosal cells of young mammals.

→ Lactase Intolerance: Digestive disorder caused by inability to digest lactose.

Symptoms: Abdominal bloating, cramps, flatulence, colic pains, abnormal intestinal flow, nausea, watery diarrhea. The symptoms appear within 30-90 min after the ingestion of milk

3. Glucose

→ Grapes contain 20-30 % glucose

→ Human blood contains normally about 65-110 mg of glucose per 100ml

→ Glycogen is stored in liver and muscles

→ The consequences of unchecked diabetes include hardening of blood vessels, dysfunction of kidneys, diabetic coma which cause pre-mature death.

4. FRUCTOSE

→ as sweetening agent in confectionary
→ in medicinal syrup
→ to prevent sandiness in ice-creams
→ used as substitute of sucrose for the obese and diabetic

PROTEINS

* Chemical Composition : C, H, O, N
Small quantities of sulphur and phosphorus.
Percentage of nitrogen is fairly constant and is about 16% of the molecular weight of protein

* TYPES OF PROTEINS:

E.coli : 3000 different types
Human : 100,000 " "

None of the proteins of E.coli is identical with any of the human proteins

* FUNCTIONS OF PROTEINS:

→ constitute more than 50% of the dry weight of most organisms
→ Ferritin : for iron storage in blood
→ Pheromones : chemical signals released by an organism that influence the behaviour of another.

CLASSIFICATION OF PROTEINS

1. SIMPLE PROTEINS
   → Upon hydrolysis produce only simple amino acids or their derivatives.
   → Examples : Albumins, Globulins, Legumin, Collagen, Globins, Histones

2. CONJUGATED PROTEINS
   → Proteins bonded or conjugated to some non proteins known as prosthetic group
   → Examples : Nucleoprotens, Phosphoproteins, Lipoproteins, Glycoproteins, Chromoprotein, Metalloprotein

3. DERIVED PROTEINS
   → proteins by partial digestion of simple or conjugated proteins.

STRUCTURE OF PROTEINS

1. PRIMARY STRUCTURE
   → shows sequence and number of different amino acid units along polypeptide chain.
   → also shows whether polypeptide chain is open, branched or cyclic

2. SECONDARY STRUCTURE

→ May assume any of the following two forms:

a) Alpha - helix form

b) Beta - pleated sheets

3. TERTIARY STRUCTURE

→ Three dimentional structure

4. QUATERNARY STRUCTURE

→ This structure shows the association of many individual protein sub-units, each with its own tertiary structure into a complex functional unit.

→ Examples : myoglobin, haemoglobin

PROPERTIES OF PROTEINS

→ Proteins are amphoteric in nature bcz they contain both acidic (-COOH) and basic (amino) group. They react with both acids and bases.

→ They can be precipitated from their solution by salts of heavy metals, heat and alcohols etc

→ When proteins are strongly heated or treated with certain reagents they lose their structural organization and their biological functions. This is known as coagulation of proteins.

* Ceruloplasmin act as carrier of copper in blood plasma

ENZYMES

→ Enzymes are soluble, colloidal organic catalysts produced by living cells but they are capable of acting independently of the cells.

→ They are non-hydrolysable with nitrogen content of about 16%.

→ The lingual lipase enzyme secreted by Ebner's glands on the dorsum of the tongue remains active in stomach and can hydrolyse or digest about 30% of ingested fats.

→ Pancreatic lipase enzyme also known as steapsin.

→ The first enzyme that acts upon the proteins of the ingested food is called pepsin present in gastric juice of stomach.

→ Pepsin also have milk curdling properties

→ Inactive trypsinogen is activated to active trypsin by the action of enzyme enterokinase.

→ Pancreatic Juice contains : Trypsin, chymotrypsin, elastase, carboxy peptidase's A and B, collagenase etc

→ Enzymes can be stored for years in frozen state

→ Some plant enzymes such as urease has optimum temp even upto 60°C.

→ Optimum pH : Pepsin → 2, Trypsin → 8-9

IRREVERSIBLE INHIBITION:

When inhibitor reacts and form a strong covalent bond with the active site of enzyme, it is termed as irreversible inhibition.

REVERSIBLE INHIBITION

may be competitive or non-competitive

i) Competitive Inhibition

inhibitor competes for active site

ii) Non-competitive Inhibition:

binds to allosteric site.

iii) Uncompetitive Inhibition:

inhibitor binds to enzyme-substrate complex

INDUSTRIAL APPLICATION OF ENZYMES

1. FRUIT JUICE PRODUCTION

→ To extract fruit juice, plant cell wall must be broken

→ Plant cell wall is build of cellulose fibres which are held together by pectins and hemicelluloses and they are extremely tough

→ Cellulases and hemicullales are added to break cell wall and extract fruit juice.

2. PRODUCTION OF ETHANOL

Cellulase are used to break down cellulose into sugar and which can then be fermented to produce ethanol.

3 HIGH FRUCTOSE SYRUP

→ High fructose corn syrup is a sweetner which is manufactured from starch in corn fruit.

→ Enzymes amylase and glucose isomerase are used

4. PAPER INDUSTRY

Amylase → degrade starch to lower viscosity, aiding sizing and coating of paper.

Xylanase → produce bleach required for decolourizing.

Cellulase → smoothen fibers, enhance water drainage, promote ink removal

Lipase → reduce pitch

Lignin Degrading Enzymes → remove lignin to soften paper

LIPIDS

Saponifiable Lipids → Fats, oils and waxes

Unsaponifiable Lipids → Terpenes and steroids

CLASSIFICATION OF LIPIDS

1. Simple Lipids
2. Compound Lipids
3. Derived Lipids

1. SIMPLE LIPIDS

esters of fatty acids with different types of alcohols.

(i) FATS AND OILS

→ esters of fatty acids with trihydroxy alcohol called glycerol.

→ also known as triglycerides or triglycerols

→ Fatty acids are long chain carboxylic acids containing usually 12-18 carbon atoms per molecule.

(ii) Waxes

→ esters of fatty acids with high molecular weight monohydroxy alcohol

2. COMPOUND LIPIDS

These are esters of fatty acids ↑ containing some additional groups as well. They include: with alcohols

(i) Phospholipids

→ contain fatty acids, phosphoric acid, nitrogenous bases

→ also called phosphatide

(ii) Glycolipids

→ contain fatty acid, alcohol and carbohydrate

→ present in white matter of brain and in myelin sheath of nerves

(iii) Sulpholipids

→ fatty acids, alcohol, carbohydrate and sulphate group

(iv) Lipoproteins

→ complexes of lipids with proteins

3. DERIVED LIPIDS

→ derived by the hydrolysis of simple and compound lipids

→ include fatty acids, alcohols, mono and triglycerides, steroids, terpenes and arytenoids.

The most common occuring lipids are triglycerides (fats, oils) and phospholipids.

Lipids have low specific gravity and float on the surface of water.

HYDROLYSIS:

Natural fats undergo hydrolysis with acids or bases in boiling water where they produce fatty acids and glycerol

In case of base hydrolysis, the base reacts with the free fatty acids and produce salts of fatty acids called soaps. This process is called saponification.

ADDITION REACTIONS:

Unsaturated fatty acids of fats and oils undergo addition reactions at the points of unsaturation and produce addition products.

→ The oils which contain more unsaturation are hydrogenated to produce solid ghee.

OXIDATION

Fats rich in unsaturated fatty acids (linseed oil) undergo spontaneous oxidation at their double bonds and produce aldehydes, ketones and resins. They form a thin transparent coating on the surface to which the oil is applied. These are known as drying oils. They are used in manufacture of paints and varnishes.

→ A drying oil is an oil that hardens to a tough, solid film after a period of exposure to air.

RANCIDIFICATION

Natural and specially animal fats contain lipase enzyme. By the action of atmospheric oxygen, in the presence of lipase the fats undergo partial hydrolysis and oxidation at their double bonds. This produces volatile carboxylic acids of sour taste and unpleasant smell. This process is called rancidification and the fat is said to have become rancid.

→ Cholesterol is the precursor of five major classes of steroid hormones; progesterone, glucocortecoids, mineralocortecoid androgen and progesterone.

→ Amino acid derivatives hormones are commonly derived from tyrosine and tryptophan. The tyrosine derived hormones are thyroid hormones and catecholamines.

→ 1g of lipid on complete oxidation produce 9.3 kcal of heat

→ Fat-Soluble Vitamines : A, D, E

→ Squealing, a steroid present in the blood of shark has antibiotic and antifungal properties. This explains why sharks rarely contract infections and almost never get cancer.

NUCLEIC ACIDS

* Nucleotide : Nitrogenous base, sugar, phosphate group
* Nitrogenous base : Purine, Pyramidine
* Purine : double ring
  ↳ Adenine, Guanine
* Pyrimidine : single ring
  ↳ Cytosine, Thymine, Uracil

IRON

→ An adult man requires about 10 mg of iron in daily diet.
→ Good sources: Liver, heart, kidney, egg yolk, green leafy vegetables, wheats etc
→ Daily synthesis of haemoglobin requires about 27mg of iron
→ About 300mg of iron is transferred to the fetus in uterus.
→ Deficiency of iron produces a disease called anemia
→ Excess of iron is stored in the form of hemosiderin in the skin, pancreas, liver, spleen etc. This leads to bronzed appearance of the skin, diabetes mellitus and cirrhosis. This state is called hemochromatosis or hemosideros's.

CALCIUM

→ present in largest quantity in body
→ About 1kg of calcium is present in man
→ 99% of calcium is present in bones in the form of hydroxyapatite crystals.
→ Small amount is also present in blood
→ Sources: milk, milk products, egg yolk, legumes, nuts, green leafy vegetables

→ Functions of Calcium : Regulation of large number of cellular activities, muscle and nerve functions, hormonal action, blood coagulation, cell motility
→ Increase in concentration of calcium in plasma leads to hyperparathyroidism.
→ Decrease in plasma calcium level leads to hypocalcaemia.

PHOSPHORUS

→ major constituent of bones and teeth
→ An adult require 800mg/day of phosphorus
→ An increase in the plasma phosphate level due to decrease in its excretion leads to kidney dysfunction.
→ Decrease in plasma phosphate level due to an increase in its excretion leads to renal rickets.

ZINC

→ for normal growth, reproduction and longevity of animals
→ constituent of several enzymes e.g alkaline phosphatase, carbonic anhydrase etc
→ forms a complex with insulin and helps in its storage and release according to body needs.
→ required for maintaining plasma concentration of Vitamin A
→ Sources : meat, liver, eggs, fish, milk, cereals
→ Deficiency : delayed wound healing, Impairment of acuity of taste.