

1. Carbohydrates

Biomolecules primarily produced by plants, often with the general formula $C_x(H_2O)_y$. Chemically, they are defined as optically active polyhydroxy aldehydes or ketones, or compounds that produce such units on hydrolysis.

Classification

1. Based on Hydrolysis:

- **Monosaccharides:** Cannot be hydrolyzed further into simpler units (e.g., Glucose, Fructose, Ribose).
- **Oligosaccharides:** Yield 2 to 10 monosaccharide units on hydrolysis (e.g., Sucrose, Maltose, Lactose).
- **Polysaccharides:** Yield a large number of monosaccharide units on hydrolysis (e.g., Starch, Cellulose, Glycogen). Not sweet, hence called non-sugars.

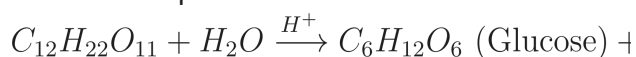
2. Based on Reducing Power:

- **Reducing Sugars:** Carbohydrates that reduce Fehling's solution and Tollens' reagent. All monosaccharides (aldoses and ketoses) and disaccharides (except sucrose) are reducing sugars.
- **Non-Reducing Sugars:** Do not reduce these reagents. The reducing groups (aldehyde/ketone) are bonded in the glycosidic linkage (e.g., Sucrose).

2. Glucose (Aldohexose)

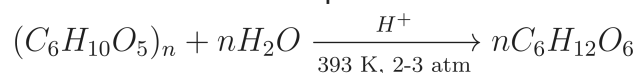
Methods of Preparation

1. **From Sucrose (Cane Sugar):** Boiling sucrose with dilute HCl or H_2SO_4 in alcoholic solution yields glucose and fructose in equal amounts.



2. **From Starch (Commercial Method):** Hydrolysis of starch by boiling with dilute

H_2SO_4 at 393 K under pressure.



Structure of Glucose

- **Open Chain Structure:** Prolonged heating with HI forms n-hexane (proving a straight chain of 6 carbons). Reaction with hydroxylamine (NH_2OH) forms an oxime (proving carbonyl group). Oxidation with bromine water yields gluconic acid (proving the carbonyl is an aldehyde). Acetylation with acetic anhydride gives glucose pentaacetate (proving 5 $-OH$ groups).
- **Cyclic Structure:** Glucose forms a six-membered ring (pyranose) by an intramolecular hemiacetal linkage between the $-OH$ on C-5 and the aldehyde group on C-1.
 - **Anomers:** The cyclic structure exists in two stereoisomeric forms (α -D-glucose and β -D-glucose) that differ only in the configuration of the hydroxyl group at C-1 (the anomeric carbon).

D and L Configuration

Refers to the spatial arrangement of the $-OH$ group on the lowest asymmetric carbon atom, relative to glyceraldehyde.

- **D-form:** $-OH$ group on the right side.
- **L-form:** $-OH$ group on the left side.
(Note: D/L has no relation to optical rotation direction (+/- or d/l)).

3. Fructose (Ketohehexose)

- **Preparation:** Obtained along with glucose by the hydrolysis of sucrose.
- **Structure:** Contains a ketone functional group at carbon number 2 and six carbons in a straight chain. It belongs to the D-series and is a laevorotatory compound ().

- **Cyclic Structure:** Forms a five-membered ring (furanose) by the intramolecular hemiketal linkage between C-5 and C-2. Exists as α -D-(-)-fructofuranose and β -D-(-)-fructofuranose.

between C-1 of galactose and C-4 of glucose. It is a reducing sugar.

Polysaccharides

1. **Starch:** Main storage polysaccharide of plants. A polymer of α -D-glucose consisting of two components:
 - *Amylose* (15-20%): Water-soluble, unbranched chain linked by C1-C4 glycosidic bonds.
 - *Amylopectin* (80-85%): Water-insoluble, branched chain linked by C1-C4 (linear) and C1-C6 (branching) bonds.
2. **Cellulose:** Predominant constituent of plant cell walls. A straight-chain polymer of β -D-glucose linked by C1-C4 glycosidic bonds.
3. **Glycogen (Animal Starch):** Carbohydrate stored in the animal body. Structure is highly branched, similar to amylopectin.



4. Disaccharides and Polysaccharides

Disaccharides are joined together by an oxide linkage formed by the loss of a water molecule, called a **glycosidic linkage**.

Disaccharides

1. **Sucrose (Invert Sugar):** Composed of α -D-glucose and β -D-fructose. The linkage is between C-1 of glucose and C-2 of fructose. Since both reducing groups are involved in bond formation, it is a **non-reducing sugar**. Hydrolysis of dextrorotatory sucrose yields a laevorotatory mixture, hence called "invert sugar."
2. **Maltose:** Composed of two α -D-glucose units linked at C-1 and C-4. It is a reducing sugar.
3. **Lactose (Milk Sugar):** Composed of β -D-galactose and β -D-glucose linked

5. Amino Acids and Proteins

Amino Acids

Contain both amino ($-NH_2$) and carboxyl ($-COOH$) functional groups. Proteins are polymers of α -amino acids.

- **Essential Amino Acids:** Cannot be synthesized in the body and must be obtained through diet (e.g., Valine, Leucine).
- **Non-Essential Amino Acids:** Can be synthesized in the body (e.g., Glycine, Alanine).
- **Zwitterion:** In aqueous solution, the $-COOH$ group can lose a proton and the $-NH_2$ group can accept a proton, forming a dipolar ion. It is electrically neutral but contains both positive and negative charges.

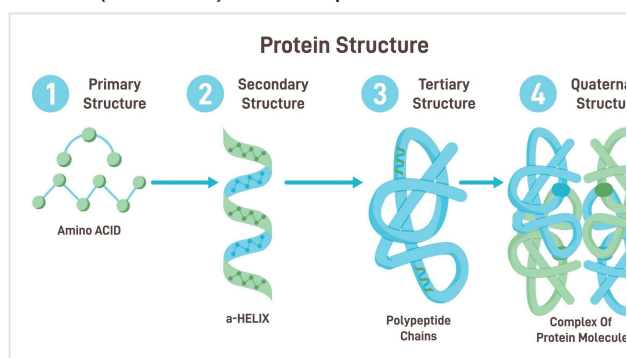
Structure and Types of Proteins

Amino acids are linked by **peptide bonds** ($-CO-NH-$) to form polypeptides.

1. **Fibrous Proteins:** Polypeptide chains run parallel, held together by hydrogen and disulfide bonds, forming fiber-like structures. Insoluble in water (e.g., Keratin in hair, Myosin in muscles).
2. **Globular Proteins:** Chains coil around to give a spherical shape. Soluble in water (e.g., Insulin, Albumins).

Levels of Protein Structure:

- **Primary Structure:** The specific sequence of amino acids in the polypeptide chain.
- **Secondary Structure:** The shape in which a long peptide chain can exist (α -helix or β -pleated sheet) due to hydrogen bonding between $-C=O$ and $-NH-$ groups.
- **Tertiary Structure:** Further folding of the secondary structure, giving a 3D shape. Stabilized by hydrogen bonds, disulfide linkages, van der Waals, and electrostatic forces.
- **Quaternary Structure:** Spatial arrangement of two or more polypeptide chains (subunits) with respect to each other.



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Denaturation of Proteins

When a protein in its native form is subjected to physical change (temperature) or chemical change (pH), the hydrogen bonds are disturbed. Globules unfold, helices uncoil, and the protein loses its biological activity. (Primary structure remains intact).

- *Example:* Coagulation of egg white on boiling; curdling of milk.



6. Enzymes

- Biocatalysts produced by living cells, almost all of which are globular proteins.
- They are highly specific (one enzyme catalyzes one specific reaction).
- **Mechanism (Lock and Key):** Enzymes lower the activation energy of a reaction. The substrate fits into the specific active site of the enzyme like a key fits into a lock, forming an Enzyme-Substrate complex, which then breaks down to yield products.

7. Vitamins

Organic compounds required in the diet in small amounts to perform specific biological functions for normal maintenance of optimum growth and health.

- **Fat-Soluble Vitamins:** Vitamins A, D, E, and K. Stored in liver and adipose tissues.
- **Water-Soluble Vitamins:** B group vitamins and Vitamin C. Must be supplied regularly in diet because they are readily excreted in

urine (except Vitamin B12, which is stored in the body).

Vitamin	Source	Deficiency Disease
A (Retinol)	Carrots, butter, milk, fish liver oil	Night blindness, Xerophthalmia
B1 (Thiamine)	Yeast, milk, green veggies	Beri-beri
B12	Meat, fish, egg, curd	Pernicious anaemia
C (Ascorbic Acid)	Citrus fruits, amla	Scurvy (bleeding gums)
D	Exposure to sunlight, egg yolk	Rickets (bone deformities in children)
K	Green leafy vegetables	Increased blood clotting time

8. Nucleic Acids (DNA and RNA)

Responsible for heredity and the synthesis of proteins in cells. They are polymers of nucleotides.

Composition

- Pentose Sugar:** β -D-ribose (in RNA) and β -D-2-deoxyribose (in DNA).
- Nitrogenous Base:**
 - Purines:* Adenine (A), Guanine (G).
 - Pyrimidines:* Cytosine (C), Thymine (T, only in DNA), Uracil (U, only in RNA).
- Phosphoric Acid Group.**
 - Nucleoside:* Sugar + Base.
 - Nucleotide:* Sugar + Base + Phosphate. Linked by phosphodiester linkages.

Structure

- DNA Double Helix (Watson-Crick Model):** Two nucleic acid chains are wound about each other and held together by hydrogen bonds between specific pairs of bases. Adenine pairs with Thymine (2 H-bonds); Cytosine pairs with Guanine (3 H-bonds).
- RNA Structure:** Usually a single strand. Three types: messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA (tRNA).

9. Hormones

Molecules that act as intercellular messengers. They are produced by endocrine glands and poured directly into the bloodstream.

- Classification:** Steroids (e.g., testosterone, estrogen), Polypeptides (e.g., insulin), Amino acid derivatives (e.g., epinephrine, thyroxine).
- Biological Importance & Deficiency:**
 - Insulin:* Regulates blood glucose levels. Deficiency causes Diabetes Mellitus.
 - Thyroxine:* Regulates metabolism. Low levels cause hypothyroidism (lethargy, obesity); high levels cause hyperthyroidism.

