Carbohydrates

1. Introduction

- Carbohydrates are **polyhydroxy aldehydes or ketones** or substances that yield such compounds on hydrolysis.
- They contain **C, H, O** atoms, generally with the empirical formula $\mathbf{C_n(H_2O)_n}$.
- They are called **saccharides** (Greek: sakkharon = sugar).
- Roles in biology:
    - **Energy source** (e.g., glucose).
    - **Energy storage** (e.g., starch in plants, glycogen in animals).
    - **Structural components** (e.g., cellulose in plant cell walls, chitin in exoskeleton of insects).
    - **Cell recognition and signaling** (glycoproteins, glycolipids).

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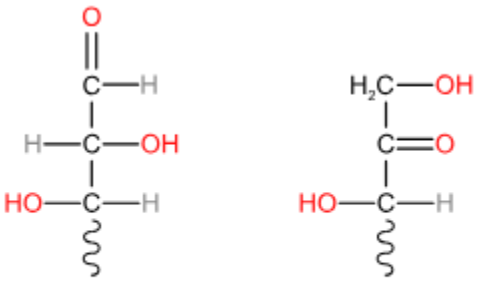
2. Nomenclature of Carbohydrates

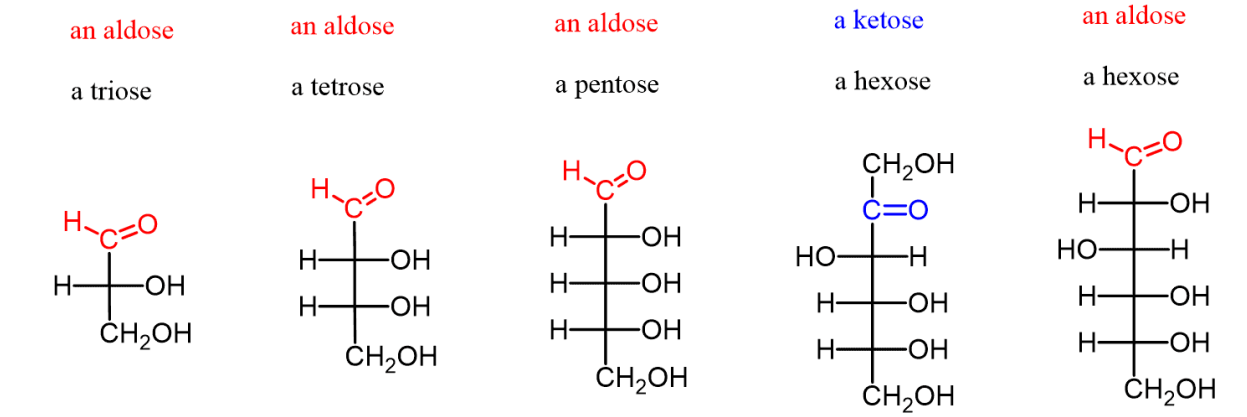
1. **Based on functional group**
   - **Aldoses** → contain an aldehyde group (–CHO).
   - **Ketoses** → contain a keto group (C=O).



Aldoses Ketoses

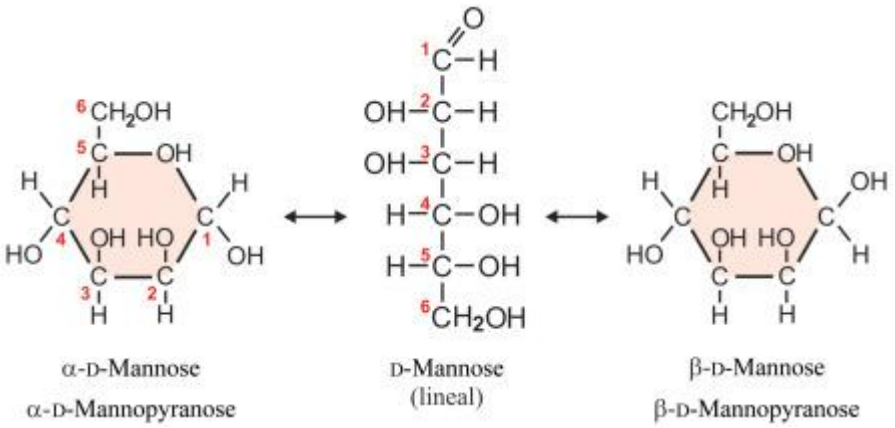
Monosaccharide units

2. **Based on number of carbon atoms**
   - 3 C → **Triose** (e.g., Glyceraldehyde, Dihydroxyacetone).
   - 4 C → **Tetrose** (e.g., Erythrose, Erythrulose).
   - 5 C → **Pentose** (e.g., Ribose, Ribulose).
   - 6 C → **Hexose** (e.g., Glucose, Fructose, Galactose).
   - 7 C → **Heptose** (e.g., Sedoheptulose).



3. **Stereochemistry**
   - Carbohydrates show **isomerism** (optical isomers, epimers, anomers).
   - **D and L series** are based on configuration of the asymmetric carbon farthest from the carbonyl group, relative to glyceraldehyde.

- **α and β anomers** occur due to different orientations of the OH group at the anomeric carbon (C1 in aldoses, C2 in ketoses).



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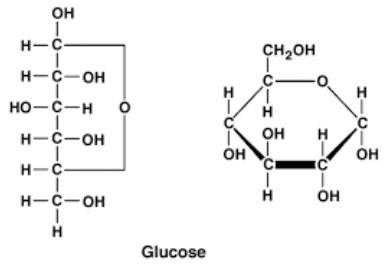
3. Classification of Carbohydrates

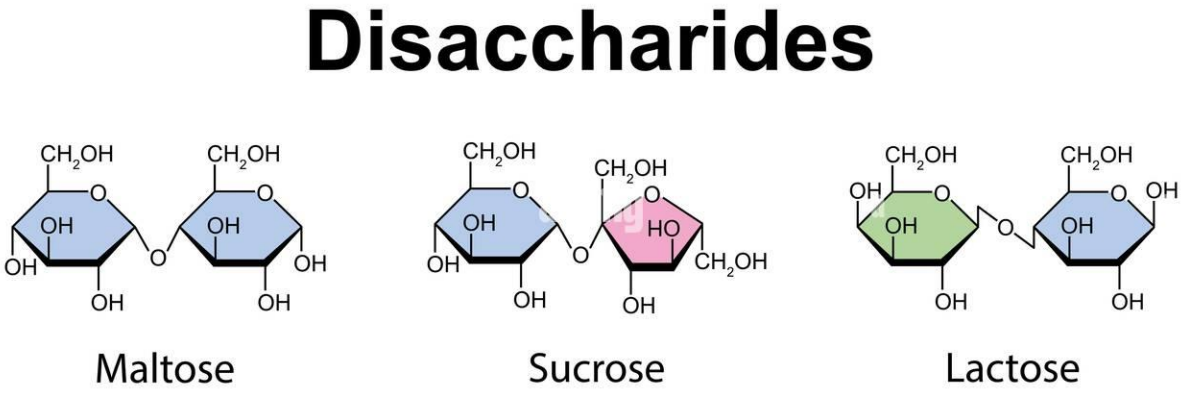
(A) Monosaccharides

- **Definition**: Simple sugars that cannot be hydrolyzed further into smaller carbohydrate units.
- **Properties**:
  - Colorless, crystalline solids.
  - Soluble in water, sweet in taste.
  - Reducing sugars (due to free carbonyl group).
- **Examples**:
  - **Glucose** (aldohexose, blood sugar).
  - **Fructose** (ketohexose, fruit sugar).
  - **Ribose** (aldopentose, RNA component).
- **Structure Example – Glucose**:
  - Exists in straight chain (open) and cyclic forms (α-D-glucopyranose, β-D-glucopyranose).
  - Six-membered pyranose ring predominates.



(B) Disaccharides

- **Definition**: Sugars formed by condensation of two monosaccharides via **glycosidic linkage**.
- **Properties**:
  - May be reducing or non-reducing depending on free anomeric carbon.
- **Examples**:
  1. **Maltose** = Glucose + Glucose (α-1,4 linkage) → reducing sugar.
  2. **Lactose** = Glucose + Galactose (β-1,4 linkage) → reducing sugar.
  3. **Sucrose** = Glucose + Fructose (α-1,2 linkage) → non-reducing sugar.
- **Structure Example – Sucrose**:
  - Both anomeric carbons are involved in glycosidic bond, hence no free carbonyl → non-reducing.



(C) Oligosaccharides

- **Definition**: Carbohydrates containing **3–10 monosaccharide residues** linked by glycosidic bonds.
- **Properties**:
  - Often occur as components of glycoproteins, glycolipids.
  - Important in **cell recognition and immune response**.
- **Examples**:
  - **Raffinose** (Galactose + Glucose + Fructose).
  - **Stachyose**, **Verbascose** in legumes.

(D) Polysaccharides

- **Definition**: Long chains of monosaccharide units (≥10, often hundreds to thousands).
- **Types**:
    1. **Homopolysaccharides** – only one type of monosaccharide.
        - **Starch** (plant storage, glucose units).
            - Two components: **Amylose** (linear α-1,4) and **Amylopectin** (branched α-1,4 and α-1,6).
        - **Glycogen** (animal storage, highly branched α-1,4 and α-1,6).
        - **Cellulose** (plant cell wall, linear β-1,4 glucose chains).
        - **Chitin** (exoskeleton of arthropods, β-1,4 N-acetylglucosamine).
    2. **Heteropolysaccharides** – more than one type of monosaccharide.
        - **Hyaluronic acid**, **Heparin**.
- **Properties**:
    - Generally tasteless, insoluble in water.
    - Provide storage or structural support.

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4. Representative Structures (to show students)

1. **Monosaccharide – Glucose (α and β forms)**.
2. **Disaccharide – Maltose with α-1,4 bond**.
3. **Polysaccharide – Amylose (linear helix), Amylopectin (branched), Cellulose (straight chain).**

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5. Summary Table

Class	Definition	Units	Bond type	Example	Function
Monosaccharides	Simple sugars, basic units	1	–	Glucose, Fructose, Ribose	Energy source, nucleic acids
Disaccharides	Two monosaccharides linked	2	Glycosidic bond	Maltose, Sucrose, Lactose	Transport/storage
Oligosaccharides	Short chains of sugars	3–10	Glycosidic	Raffinose, Stachyose	Cell recognition
Polysaccharides	Large polymers	100–1000s	Glycosidic (α or β)	Starch, Glycogen, Cellulose	Storage, structure