

Summary: Carbohydrates and Lipids (IMAT 2026)

1. Organic Molecules Overview

The document outlines the four main classes of organic molecules and their elemental composition:

- **Carbohydrates**: C, H, O (Usually in a 1:2:1 ratio).
- **Lipids**: Mostly C, H, with a small amount of O (some contain P, N).
- **Proteins**: C, H, O, N (sometimes S).
- **Nucleic Acids**: C, H, O, N, P.

2. Carbohydrates

→ Functions:

- Energy Source: **Glucose**.
- Energy Storage: **Glycogen** (animals), **Starch** (plants).
- Structural: **Cellulose** (plant cell walls).
- Genetic Material: Monomers for genetic molecules (ribose/deoxyribose).

→ Classification by Sugar Units:

A. Monosaccharides (Simple Sugars)

Structure: Single sugar unit, usually 3-7 carbon atoms. Hydrophilic/polar (dissolve in water).

Functional Groups: Contains Hydroxyl (-OH) and Carbonyl (C=O) groups.

Aldehyde (Aldose): Carbonyl group at the end of the chain (e.g., Glucose, Galactose).

Ketone (Ketose): Carbonyl group in the middle of the chain (e.g., Fructose).

Examples by Carbon Count:

Triose (3C): Glyceraldehyde, Dihydroxyacetone.

Pentose (5C): Ribose (RNA), Deoxyribose (DNA) - difference is one oxygen atom.

Hexose (6C): Glucose, Fructose, Galactose ($C_6H_{12}O_6$).

3. Lipids

Functions:

- * **Energy Storage:** Long-term energy storage (triglycerides).
- * **Structural:** Component of cell membranes (phospholipids, cholesterol).
- * **Signaling:** Hormones (steroids).
- * **Insulation and Protection:** Padding for organs.

Structure: Mostly Hydrophobic (do not dissolve in water).
Nonpolar C-H bonds.

Classification:

A. Fatty Acids

Structure: Long hydrocarbon chains with a Carboxyl group (-COOH) at one end.

Types:

- * **Saturated Fatty Acids:** No double bonds between carbon atoms. Solid at room temperature (e.g., butter). High melting point.
- * **Unsaturated Fatty Acids:** Have one or more double bonds (C=C), creating kinks. Liquid at room temperature (e.g., oils). Lower melting point.

B. Triglycerides (Fats and Oils)

Structure: One glycerol molecule + three fatty acid chains.

Formation: Formed via Dehydration Synthesis (ester linkages).

Main storage form of fat.

C. Phospholipids

Structure: One glycerol + two fatty acids + one phosphate group.

Amphipathic: Hydrophilic head (phosphate) and Hydrophobic tails (fatty acids)

Function: Major component of cell membranes (forming a bilayer).

D. Steroids

Structure: Four fused carbon rings. No fatty acid chains.

Examples: Cholesterol (membrane stability), Testosterone, Estrogen (hormones).

Isomerism:

- **Glucose vs. Fructose:** Functional group difference (Aldose vs. Ketose).
- **Glucose vs. Galactose:** Positional difference of the -OH group on Carbon 4.
- **Alpha (α) vs. Beta (β) Glucose:** Position of the -OH group on Carbon 1.

B. Disaccharides

Structure: Two monosaccharides linked by a glycosidic bond.

Formation: formed via **Dehydration Synthesis** (removal of water); broken down by **Hydrolysis** (addition of water).

Common Examples:

- **Maltose:** Glucose + Glucose (α 1-4 linkage). Found in brewing.
- **Sucrose:** Glucose + Fructose (α 1-2 β linkage). Table sugar.
- **Lactose:** Glucose + Galactose (β 1-4 linkage). Milk sugar.

C. Oligosaccharides

Structure: 3-10 sugar units.

Function: Often found in cell membranes attached to proteins (**Glycoproteins**) or lipids (**Glycolipids**) for cell recognition and signaling.

D. Polysaccharides

Structure: Long chains (>10 units) of monosaccharides.

Key Types:

- **Starch** (Plants): Energy storage. Made of α -glucose.
 - **Amylose:** Unbranched, helical (α 1-4 bonds).
 - **Amylopectin:** Branched (α 1-4 and α 1-6 bonds).
- **Glycogen** (Animals): Energy storage (Liver and Muscles).
 - Highly branched structure (α 1-4 and α 1-6 bonds) allowing for rapid release of glucose.
- **Cellulose** (Plants): Structural component of cell walls.
 - Made of β -glucose (β 1-4 bonds).
 - Straight, unbranched chains connected by hydrogen bonds (forming microfibrils).
 - Indigestible by humans.