Lipids

Definition of Lipids

- Lipids are a diverse group of naturally occurring organic compounds that are:
  - Insoluble in water (hydrophobic),
  - Soluble in organic solvents like chloroform, ether, and benzene.

Biochemical Nature

- Lipids are composed primarily of carbon (C), hydrogen (H), and oxygen (O), with some types containing phosphorus (P), nitrogen (N), or sulfur (S).

Functions

- Energy storage (more efficient than carbohydrates),
- Structural components of cell membranes (phospholipids, cholesterol),
- Hormonal roles (steroid hormones),
- Insulation and protection (subcutaneous fat),
- Carriers of fat-soluble vitamins (A, D, E, K).

Classification of Lipids with Examples

1. Simple Lipids

➢ Esters of fatty acids with alcohols.

A. Fats and oils (triglycerides):

- Esters of fatty acids with glycerol.
- **Example:** Tripalmitin, triolein.

B. Waxes:

- Esters of long-chain fatty acids with long-chain alcohols.
- **Example:** Beeswax (myricyl palmitate).

2. Compound (Complex) Lipids

➢ Contain additional functional groups besides fatty acids and alcohol.

A. Phospholipids:

- Contain phosphate group.

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- **Example:** Lecithin (phosphatidylcholine), cephalin (phosphatidylethanolamine).

B. Glycolipids:

- Contain carbohydrate moiety.
- **Example:** Cerebrosides, gangliosides.

C. Lipoproteins:

- Lipids combined with proteins.
- **Example:** HDL, LDL.

3. Derived Lipids

- Substances derived from simple and complex lipids.
  - Fatty acids, glycerol, steroids (e.g., cholesterol), fat-soluble vitamins.

4. Miscellaneous Lipids

- Include substances with lipid-like properties.
  - Examples: Squalene, carotenoids, hydrocarbons.

Biological Functions of Lipids

- **Energy Storage**: Provide 9 kcal/g, the most energy-dense macronutrient.
- **Structural Role**: Phospholipids and cholesterol are key components of cell membranes.
- **Insulation & Protection**: Adipose tissue insulates the body and cushions organs.
- **Vitamin Absorption**: Needed for absorption of fat-soluble vitamins (A, D, E, K).
- **Hormone Synthesis**: Cholesterol serves as a precursor for steroid hormones (e.g., estrogen, cortisol).
- **Nerve Function**: Lipids form the myelin sheath, essential for nerve conduction.
- **Fat Emulsification**: Bile salts emulsify dietary fats in the intestine for digestion.
- **Cell Signaling**: Lipid derivatives like prostaglandins regulate inflammation, blood pressure, and immunity.

Structure and Properties of Triglycerides (Fats and Oils)

Definition:

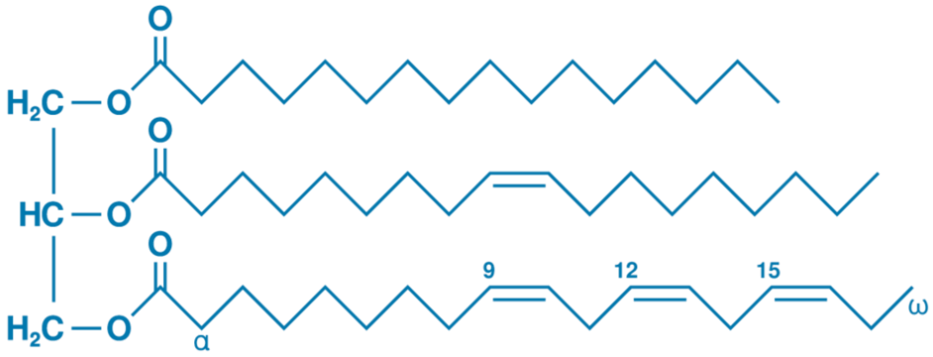
- Triglycerides (also known as triacylglycerols) are the most common type of fat found in food and in the human body.

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- They are esters formed by the reaction of one molecule of glycerol with three fatty acids.

Structure

- **Glycerol**: A 3-carbon alcohol with three hydroxyl (–OH) groups.
- **Fatty Acids**: Long-chain hydrocarbons with a carboxylic acid group (–COOH) at one end.
- **Ester Bonds**: Formed between the hydroxyl group of glycerol and the carboxyl group of each fatty acid.



General formula:

- Glycerol + 3 Fatty Acids → Triglyceride + 3 H_2O
- It can be simple (same fatty acids) or mixed (different fatty acids).

Types:

- **Fats (solid at room temp):** High in saturated fatty acids (e.g., butter, lard)
- **Oils (liquid at room temp):** High in unsaturated fatty acids (e.g., olive oil, sunflower oil)

Properties

1. **Physical State:**
   - Fats are solid at room temperature (more saturated fatty acids),
   - Oils are liquid (more unsaturated fatty acids).
2. **Hydrolysis:**
   - In the presence of enzymes (lipases) or alkali (saponification),
   - Yields glycerol and free fatty acids or soap.
3. **Rancidity:**
   - Oxidative degradation causes bad smell/taste in fats.
4. **Energy Content:**
   - 9 kcal/g (more than proteins and carbohydrates).

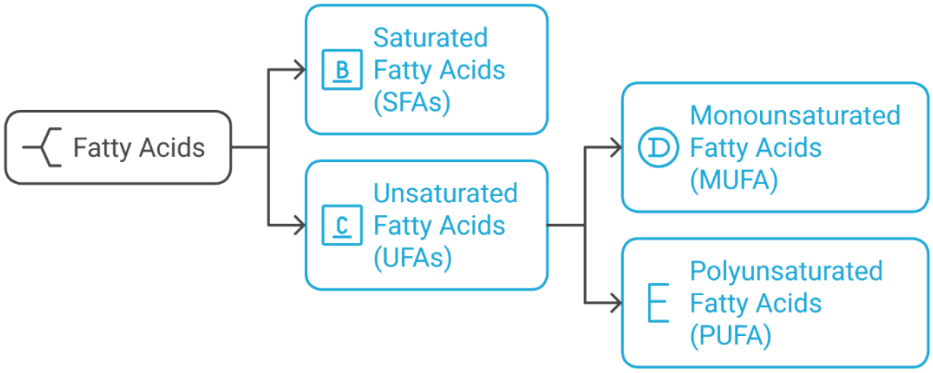
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Fatty Acid Classification

Definition

- Fatty acids are carboxylic acids with long hydrocarbon chains (even-numbered carbon atoms).
- Can be saturated or unsaturated, and essential or non-essential based on different criteria.

Classification Based on Chemical Structure



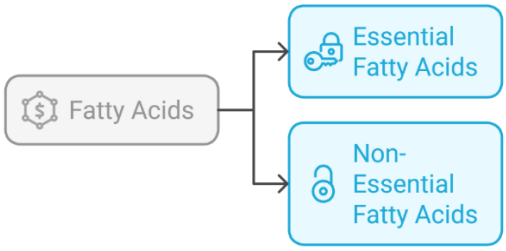
1. Saturated Fatty Acids (SFAs)

- No double bonds.
- Solid at room temperature.
- Mostly found in animal fats and some tropical oils.
- ***Example*:** Palmitic acid, Stearic acid.

2. Unsaturated Fatty Acids (UFAs)

- One or more double bonds,
- Liquid at room temperature,
- Subtypes:
  - **Monounsaturated (MUFA)**: One double bond (e.g., Oleic acid),
  - **Polyunsaturated (PUFA)**: Multiple double bonds, Essential for health. (e.g., Linoleic acid, Arachidonic acid).

Classification Based on Nutritional Requirement



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