

# 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.

- **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.

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## **Structure and Properties of Triglycerides (Fats and Oils)**

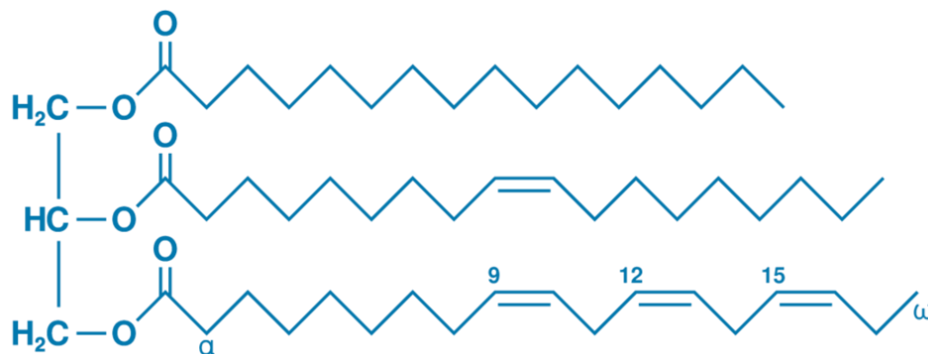
### **Definition:**

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

- 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<sub>2</sub>O
- 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:

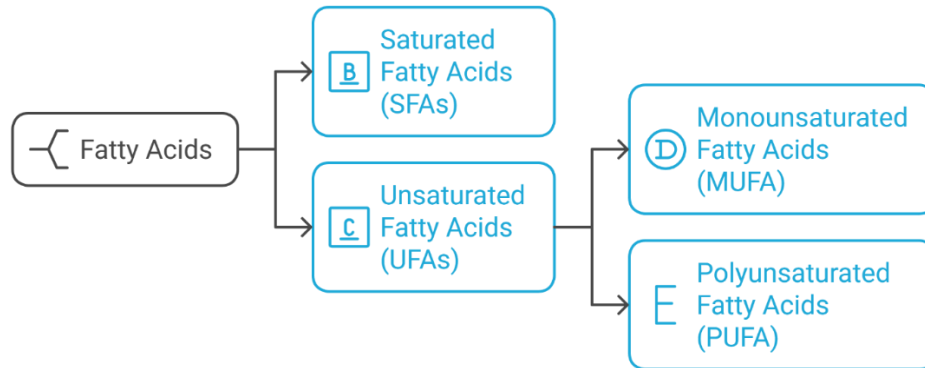
- 9 kcal/g (more than proteins and carbohydrates).

## 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



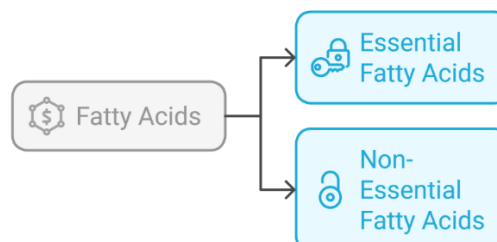
#### 1. Saturated Fatty Acids (SFAs)

- 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



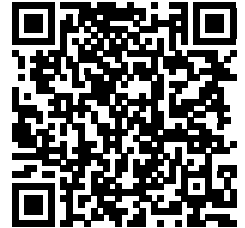


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