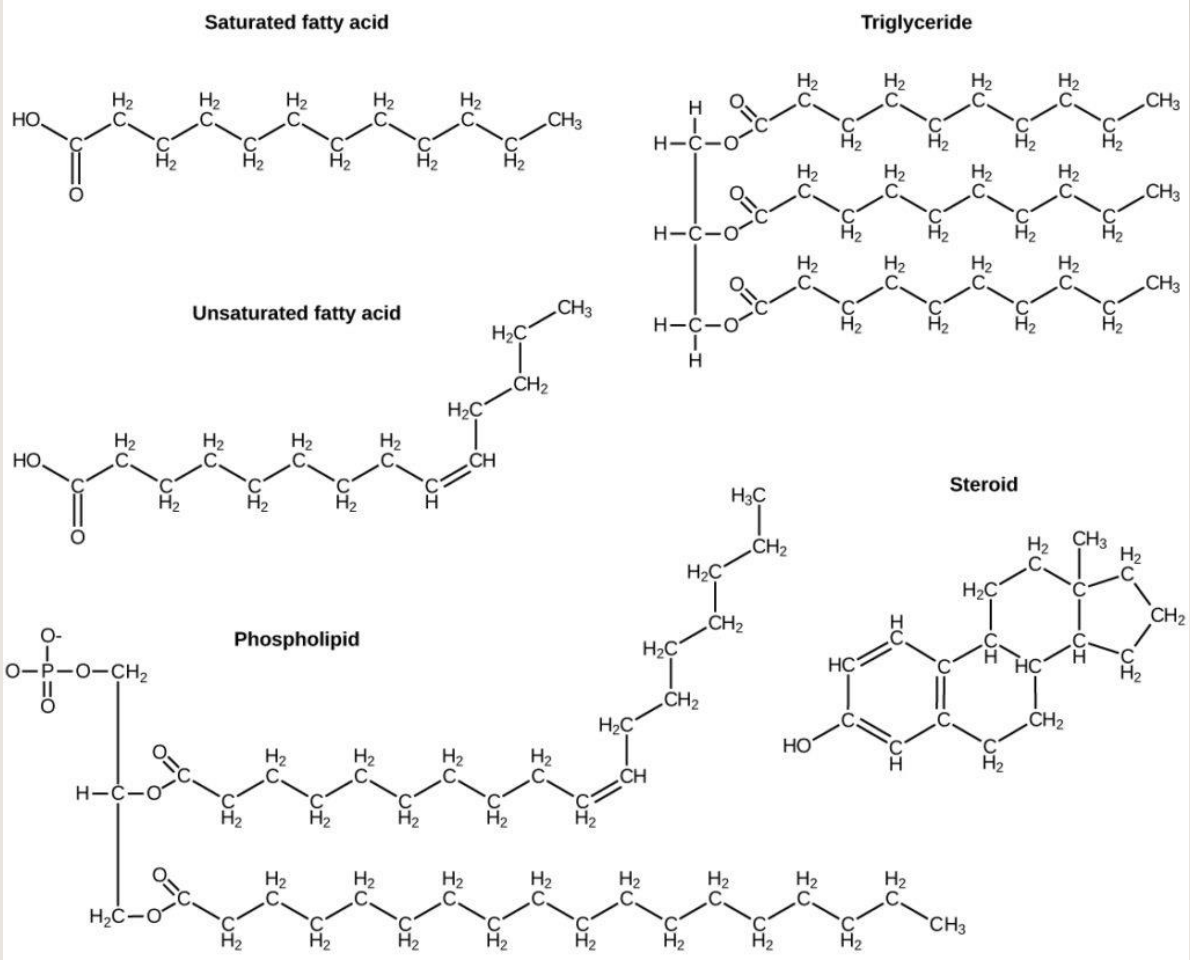
LIPIDS

Fundamentals of Biotechnology I

Module II - Biomolecules

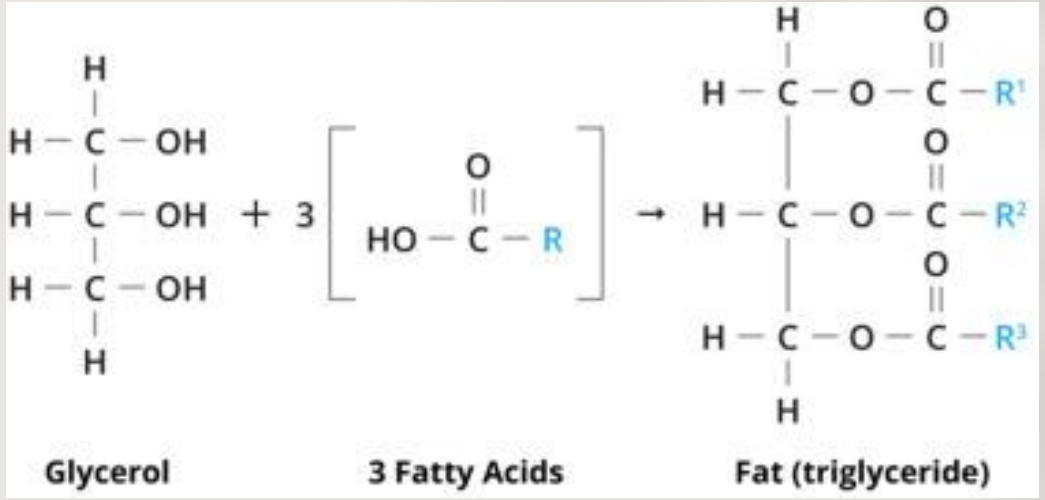
Introduction to Lipid Chemistry

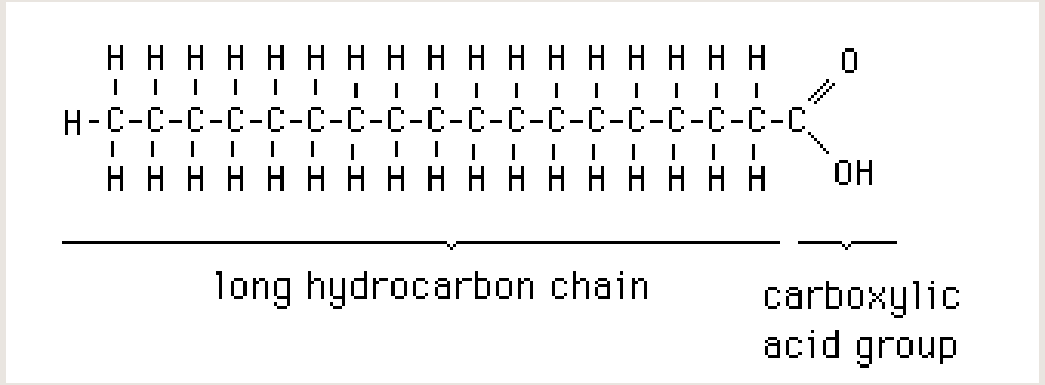
- Definition of lipids
- Biological functions of fats & lipids
- Definition of fatty acids
- Classification of fatty acids



Definitions

- Lipids are a heterogeneous group of compounds, including fats, oils, steroids, waxes, and related compounds
- Lipids are made up of carbon, hydrogen, and oxygen
- **Lipids** – Organic molecules generally that are largely or wholly hydrophobic and therefore tend to be insoluble in water but soluble in organic solvents such as hexane
- **Fatty acids** - carboxylic acid with a long-chain hydrocarbon side group





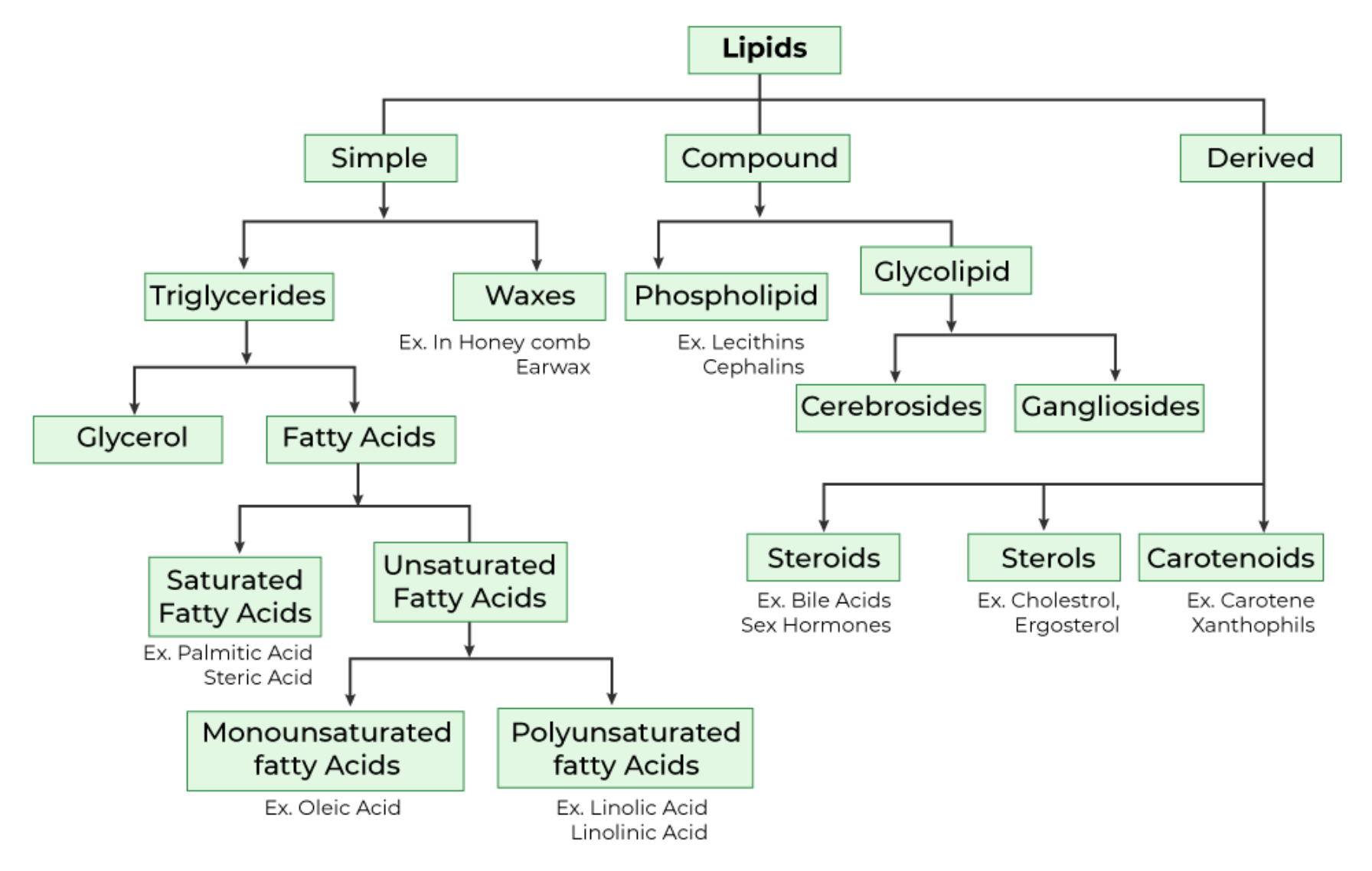
Biological functions of fats & lipids

- **Energy source** – high calorific value (twice the energy produced by the same weight of carbohydrates or proteins)
- **Energy storage** – triglycerides stored in adipose tissue
- **Nutritional value** – contain essential fatty acids and act as natural solvent for fat-soluble vitamins (A, E, D, K)
- **Membrane structure** - lipid molecules in the form of lipid bilayers are essential components of biological membranes
- **Increases bioavailability** – lipids help in digestion, absorption and transport of hydrophobic molecules

Biological functions of fats & lipids

- **Signaling & Regulation** – steroid hormones are critical intracellular messengers
- **Thermal insulation** – fats deposited under the subcutaneous layer of skin serve as thermal insulator
- **Electrical insulation** – lipids in myelin sheath serve as electrical insulator and rapid propagation of nerve impulse
- **Shock absorption** – fats around the vital organs act as padding against mechanical shock

Classification of fats & lipids



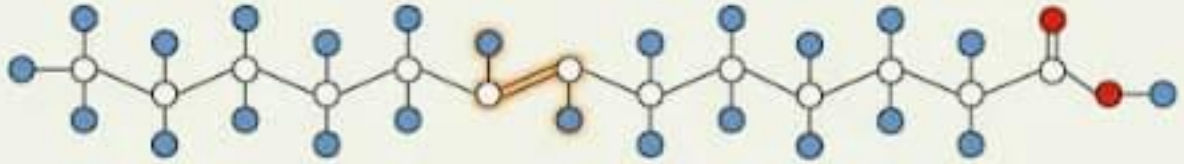
Simple lipids

- **Simple lipids** – esters of fatty acids with alcohols
- Mainly of two types:
  1. **Triglycerides** – esters of fatty acids with glycerol
  2. **Waxes** – ester of fatty acids with alcohols other than glycerol

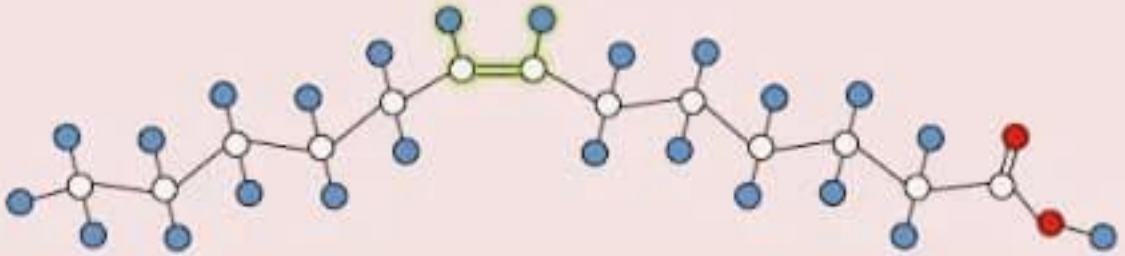
Differences Between Saturated and Unsaturated fatty acids

Saturated fatty acid
(***no*** double bonds)

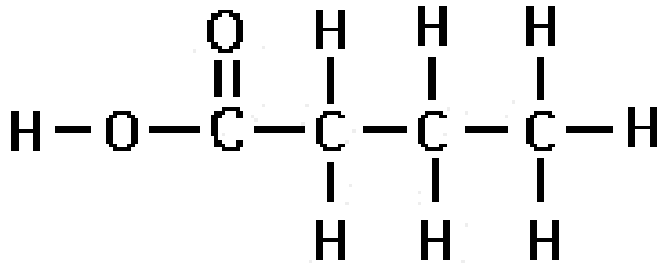
Unsaturated – ***trans***
(H atoms opposite)



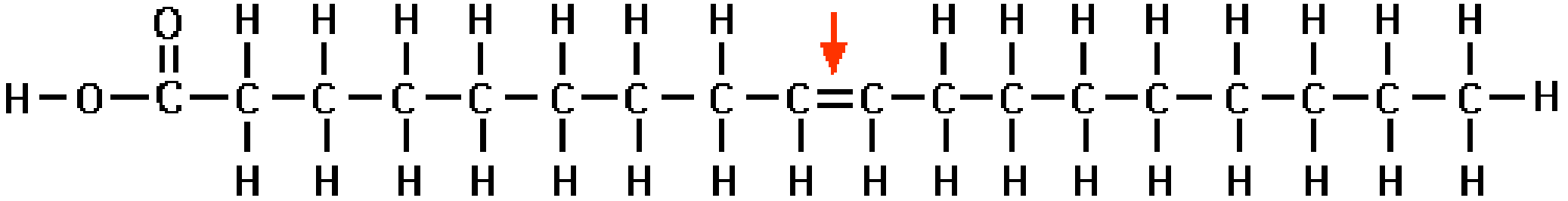
Unsaturated – ***cis***
(H atoms same side)
→ *bent configuration*



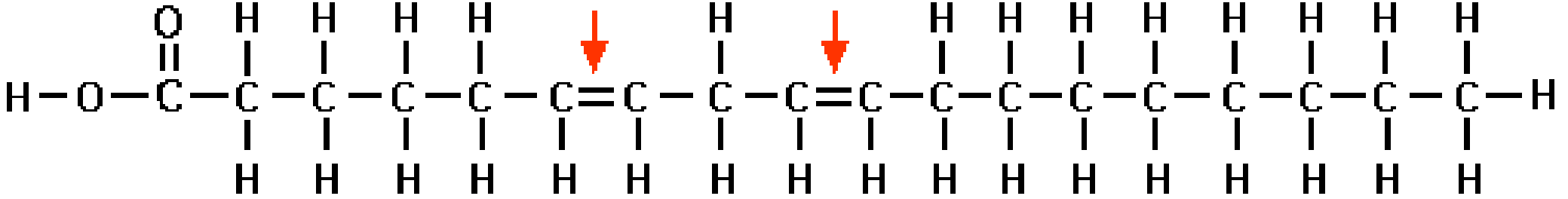
○ = C ● = O ● = H



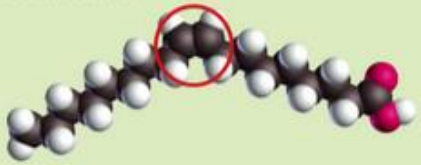
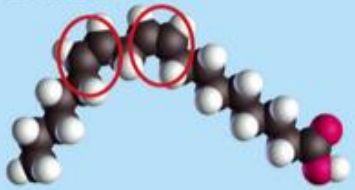
Butyric Acid-Saturated Fatty Acid



Oleic Acid- Monounsaturated Fatty Acid



Linoleic Acid- Polyunsaturated Fatty Acid

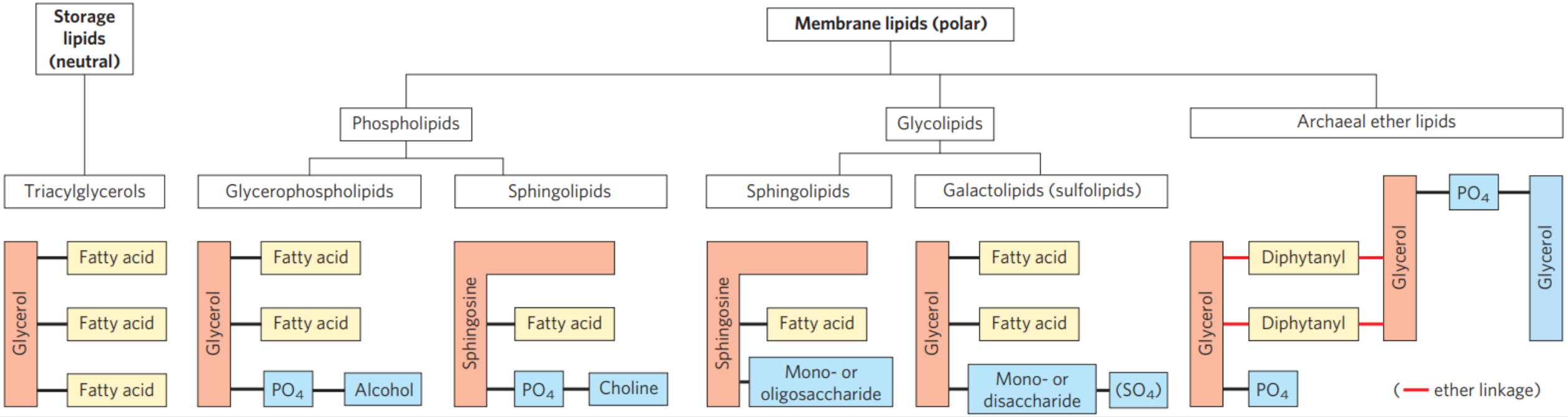
Types of Fatty Acids	Examples of Sources	Health Impacts and Intake Recommendations
Saturated  • No double bond • Straight structure • Solid at room temperature	 Beef  Butter  Coconut oil	• Increase risk of heart disease • Less than 20g of saturated fats per day (for a 2000 kcal diet)
Trans  • One or more double bonds in trans configuration • Straight structure • Semi-solid/Solid at room temperature	 Margarine  Cream soup with puff pastry  Chicken pie	• Increase risk of heart disease • Less than 2.2g of trans fats per day (for a 2000 kcal diet)
Monounsaturated  • One double bond in cis configuration • Bent structure • Liquid at room temperature	 Olive oil  Canola oil  Peanut oil	• May reduce risk of heart disease • Moderate intake of monounsaturated fats
Polyunsaturated  • Multiple double bonds in cis configuration • Even more "bent" in structure • Liquid at room temperature	 Soybean oil  Corn oil  Fatty fish	• May reduce risk of heart disease • Moderate intake of polyunsaturated fats

Complex/Compound lipids

- **Complex lipids** – esters of fatty acids with alcohols containing additional groups such as phosphate, nitrogenous base, carbohydrate, protein, etc.
- Divided into following types:

1. **Phospholipids** – contains additional phosphoric acid and frequently a nitrogenous base
2. **Glycolipids** – contains additional carbohydrate and a nitrogenous base
3. **Lipoproteins** – macromolecular complexes of lipids with proteins
4. **Other complex lipids** – sulfolipids, aminolipids, lipopolysaccahrides, etc.

Complex/Compound lipids



Derived lipids

- **Derived lipids** – derivatives obtained on hydrolysis of lipids from the previous groups
- Possess characteristics of lipids
- Include glycerol and other alcohols, fatty acids, mono- and diacylglycerols, lipid (fat) soluble vitamins, steroid hormones, hydrocarbons, ketone bodies

TABLE 2.7 Lipid Functions

Type	Function
Bile acids	Steroids that aid in fat digestion and nutrient absorption
Cholesterol	Component of cell membranes; precursor of other steroids
Eicosanoids	Chemical messengers between cells
Fat-soluble vitamins (A, D, E, and K)	Involved in a variety of functions including blood clotting, wound healing, vision, and calcium absorption
Fatty acids	Precursor of triglycerides; source of energy
Phospholipids	Major component of cell membranes; aid in fat digestion
Steroid hormones	Chemical messengers between cells
Triglycerides	Energy storage; thermal insulation; filling space; binding organs together; cushioning organs

Based on Chemical Composition

Simple Lipids
1. Fatty Acids
2. Triglycerides
3. Waxes

Compound Lipids
1. Phospholipids
2. Glycolipids
3. Lipoproteins

Derived lipids

Based on Fatty Acids
1. Saturated Fatty Acids
2. Unsaturated fatty acids

Based on Requirement
1. Essential Fatty Acids
2. Non essential Fatty Acids

Based on Source
1. Visible Fat
2. Invisible Fat

Classification of lipids

IMPORTANT

Hydrocarbons

- Compounds that contain only carbon and hydrogen
- Two classes: Aliphatic and aromatic