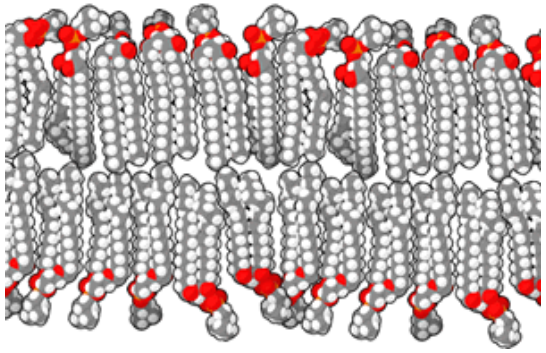
2302106 – Basic Organic Chemistry for ISE – Part II

Lecture 7-3

Biomolecules - Lipid



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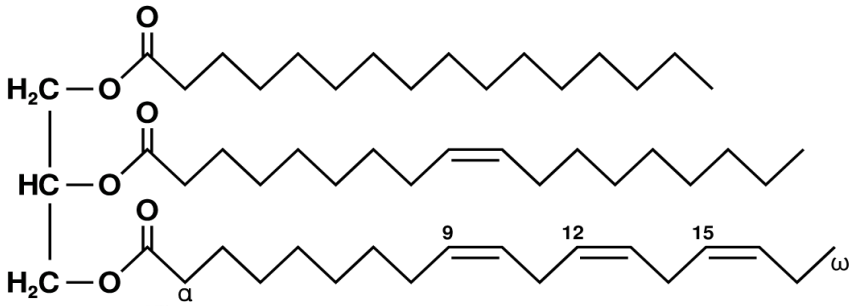
Recommended Textbook:

Chapter 23 and 25 in *Organic Chemistry*, 8th Edition, L. G. Wade, Jr., **2010**, Prentice Hall (Pearson Education)

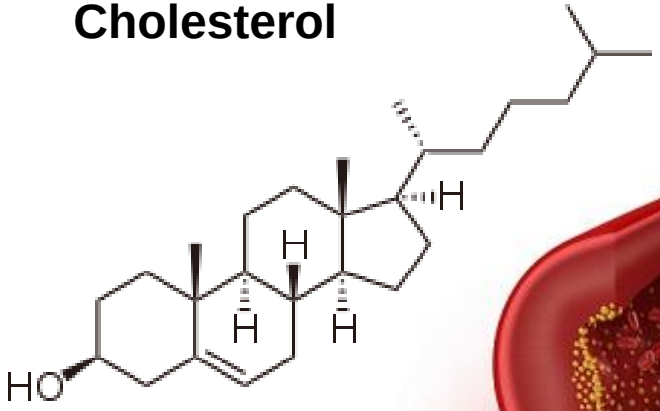
Lipids

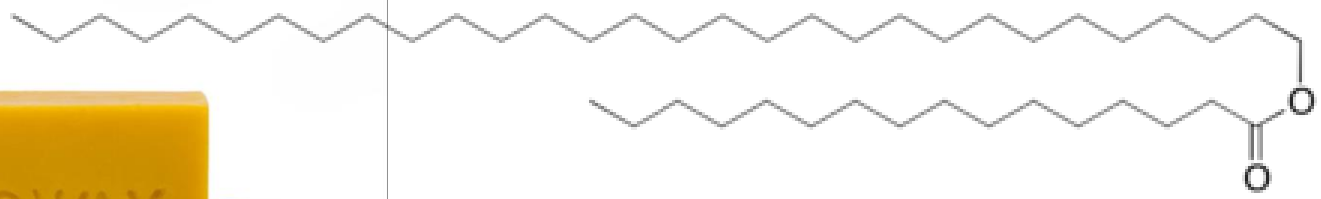
- Substances that can be **extracted** from cells and tissues by **nonpolar organic solvents**



Triglycerides

Cholesterol





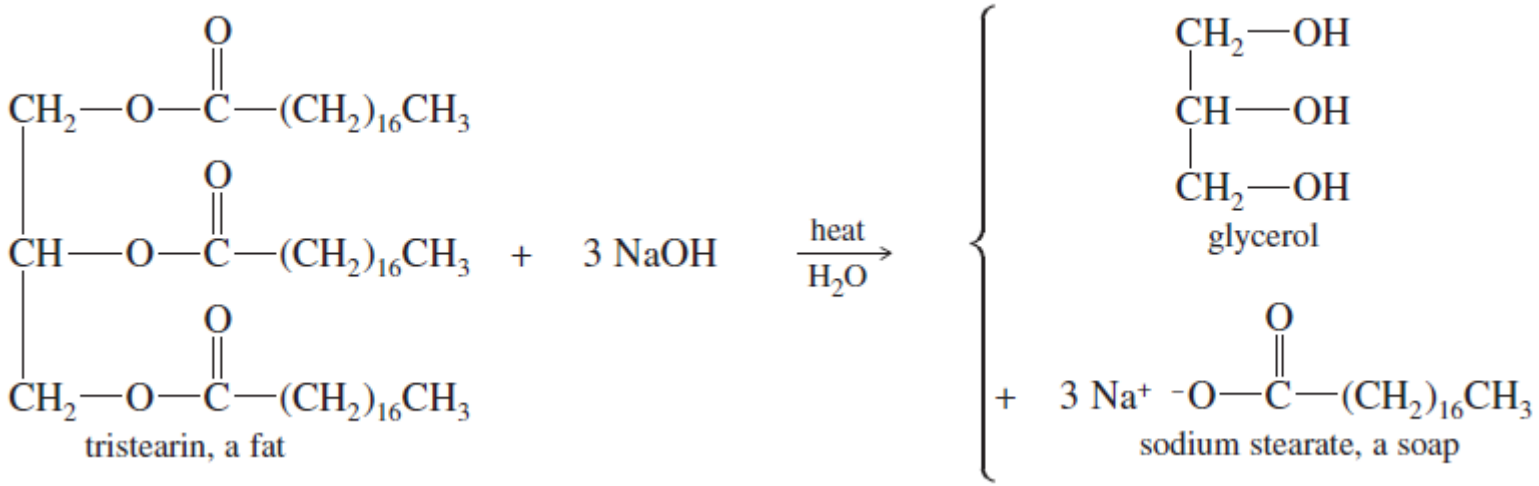
Beeswax

Hydrolysability of Lipids

1) Hydrolysable Lipids (Complex Lipids)

- Can be cleaved into smaller molecules by **hydrolysis with water**
- Many hydrolysable lipids contains an ester unit

1.1 Waxes 1.2 Triglycerides 1.3 Phospholipids



2) Nonhydrolysable Lipids (Simple Lipids)

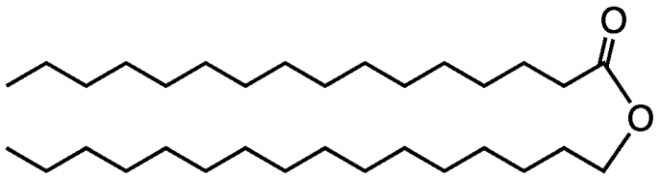
- Cannot be cleaved into smaller units by aqueous hydrolysis

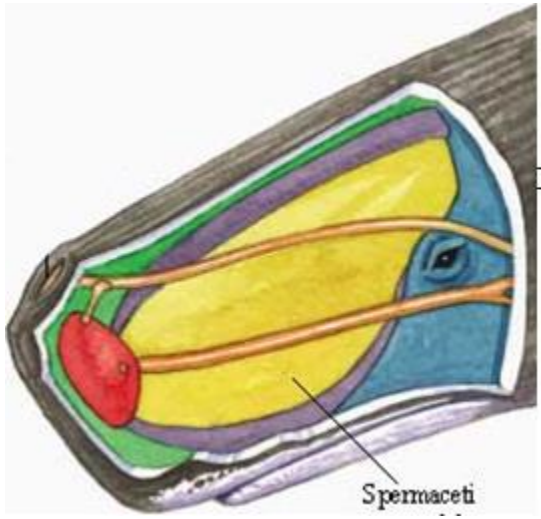
2.1 Steroids 2.2 Terpenes 2.3 Fat-soluble Vitamins

1.1 Waxes

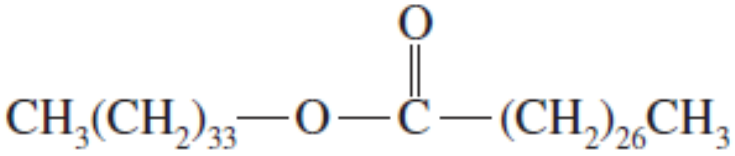
- **Esters** of **long-chain fatty acids** with **long-chain alcohols**

Spermaceti found in the head of the sperm whale, probably helps to regulate the animal's **buoyancy** for deep diving. It may also serve to **amplify high-frequency sounds** for locating prey





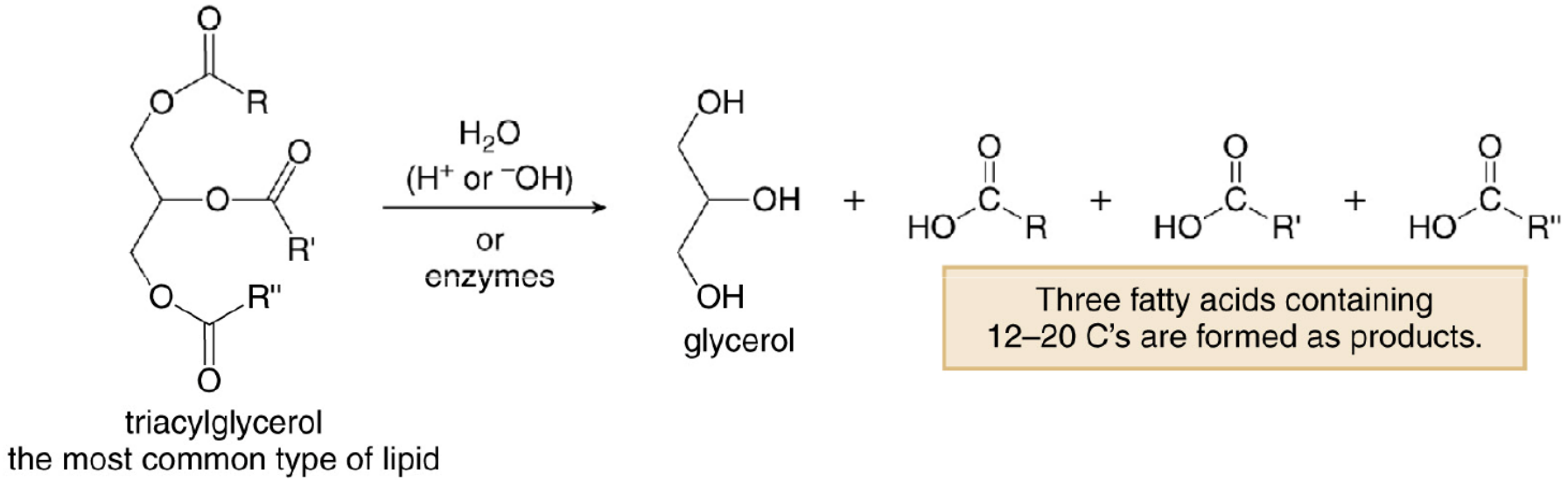
Carnauba wax
Plant leaves often have a wax coating to prevent excessive loss of water



a component of carnauba wax

1.2 Triglycerides

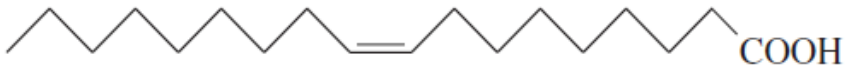
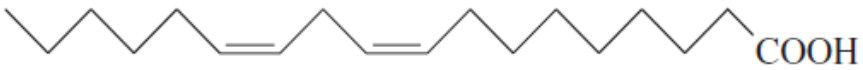
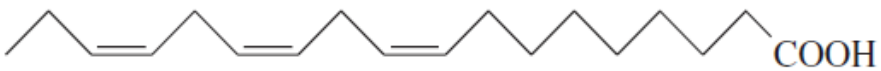
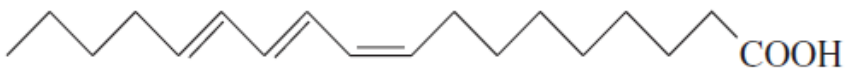
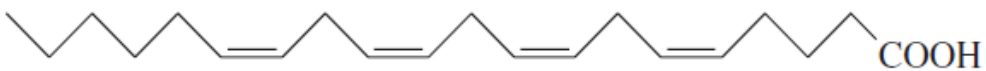
- **Esters** of **fatty acids** and the triol ***glycerol***



- **Simple triglycerides** are composed of **three identical fatty acid** side chains
- Most naturally occurring triglycerides are **mixed triglycerides**, containing two or three **different fatty acids**

1.2 Triglycerides – Examples of Fatty Acids

TABLE 25-1 Structures and Melting Points of Some Common Fatty Acids

Name	Carbons	Structure	Melting Point (°C)
Saturated acids			
lauric acid	12		44
myristic acid	14		59
palmitic acid	16		64
stearic acid	18		70
arachidic acid	20		76
Unsaturated acids			
oleic acid	18		4
linoleic acid	18		−5
linolenic acid	18		−11
eleostearic acid	18		49
arachidonic acid	20		−49

1.2 Triglycerides

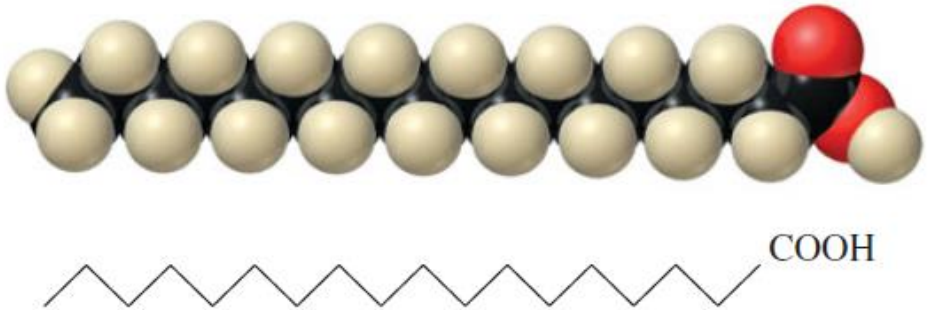
Features of Fatty Acids

- All fatty acid chains are **unbranched**, but they must be **saturated** (most common: palmitic acid and steric acid) or **unsaturated** (most common: oleic acid)
- Linoleic and linolenic acids are called **essential fatty acids** because we cannot synthesize them and must acquire them from our diets
- Naturally occurring fatty acids have an **even number** of carbon atoms
- All double bonds in naturally occurring fatty acids have the ***Z* configuration (*cis*)**

1.2 Triglycerides

Features of Fatty Acids

- Saturated fatty acids have melting points that increase gradually with their molecular weights
- The presence of a ***cis* double bond lowers the melting point**



stearic acid, mp 70 °C

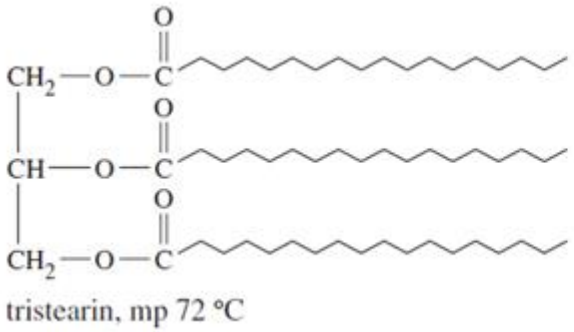
oleic acid, mp 4 °C

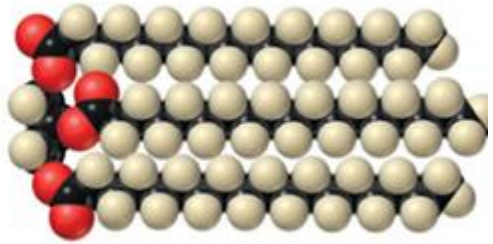
- **Kinked** molecules cannot pack as tightly together in a solid as the uniform zigzag chains of a saturated acid
- A second double bond lowers the melting point further (linoleic acid, mp –5 °C), and a third double bond lowers it still further (linolenic acid, mp –11 °C)

1.2 Triglycerides – Fats vs Oils

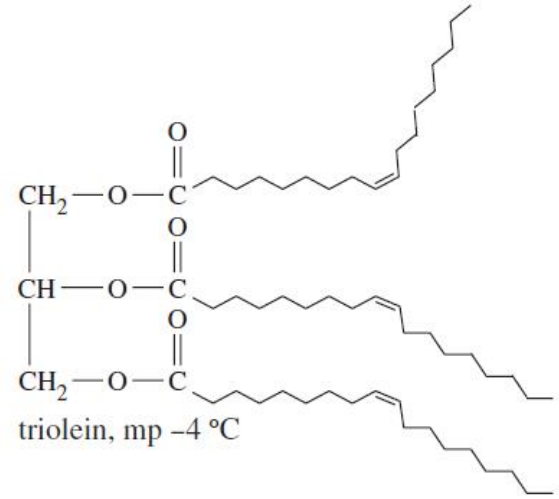
- The melting points of fats and oils also depend on the **degree of unsaturation** (especially *cis* double bonds) in their fatty acids

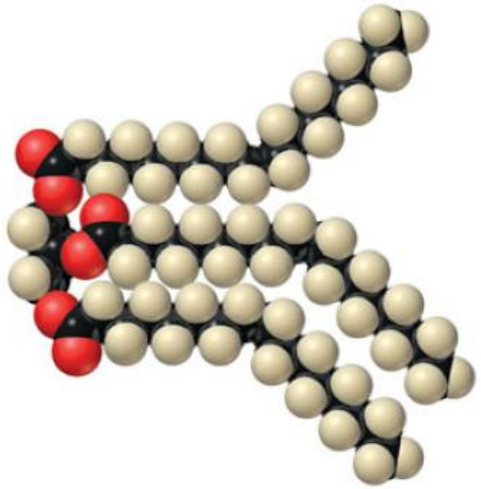
- Most ***saturated*** triglycerides are ***fats*** because they are solid at room temperature





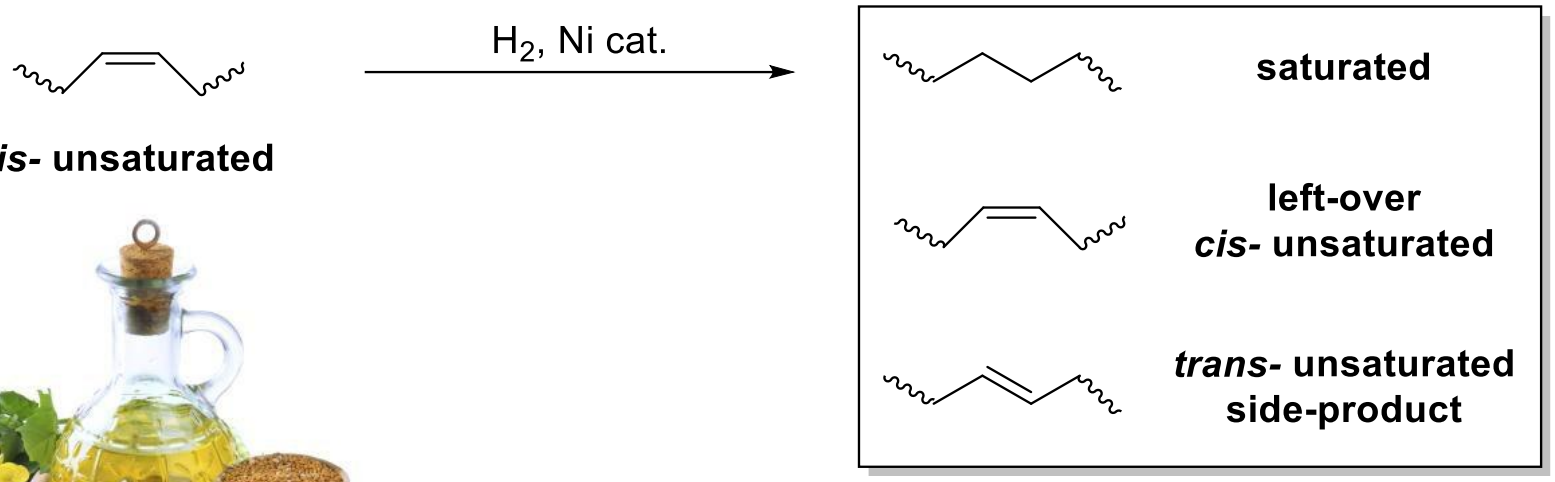
- Most ***unsaturated*** triglycerides are ***oils*** because they are liquid at room temperature





1.2 Triglycerides – Hydrogenation & Trans Fats

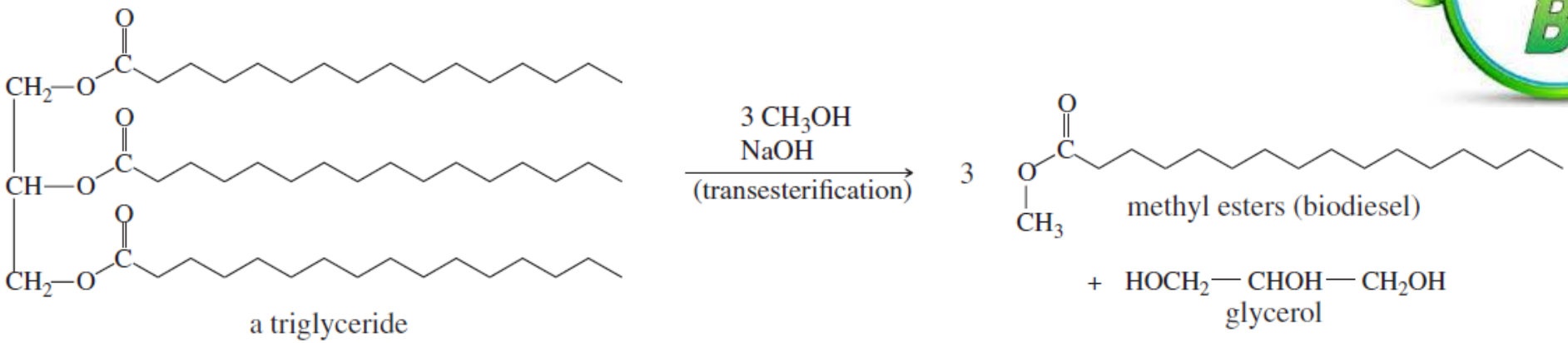
- Vegetable oils were treated with **hydrogen gas** and a **nickel catalyst**, reducing some of the double bonds to give a creamy, white vegetable shortening that resembles lard; (**Magarine**)



- Trans fat has been shown to consistently be associated, in an intake-dependent way, with increased **risk of coronary heart disease**

1.2 Triglycerides – Transesterification to Biodiesel

- Cooking oil is not sufficiently volatile to start a cold diesel engine
- A **base-catalysed** transesterification, using **methanol** as the alcohol and **NaOH** as the catalyst, converts fats and oils to the **methyl esters** of the three individual fatty acids
- The mixture of fatty acid methyl esters is called **biodiesel**

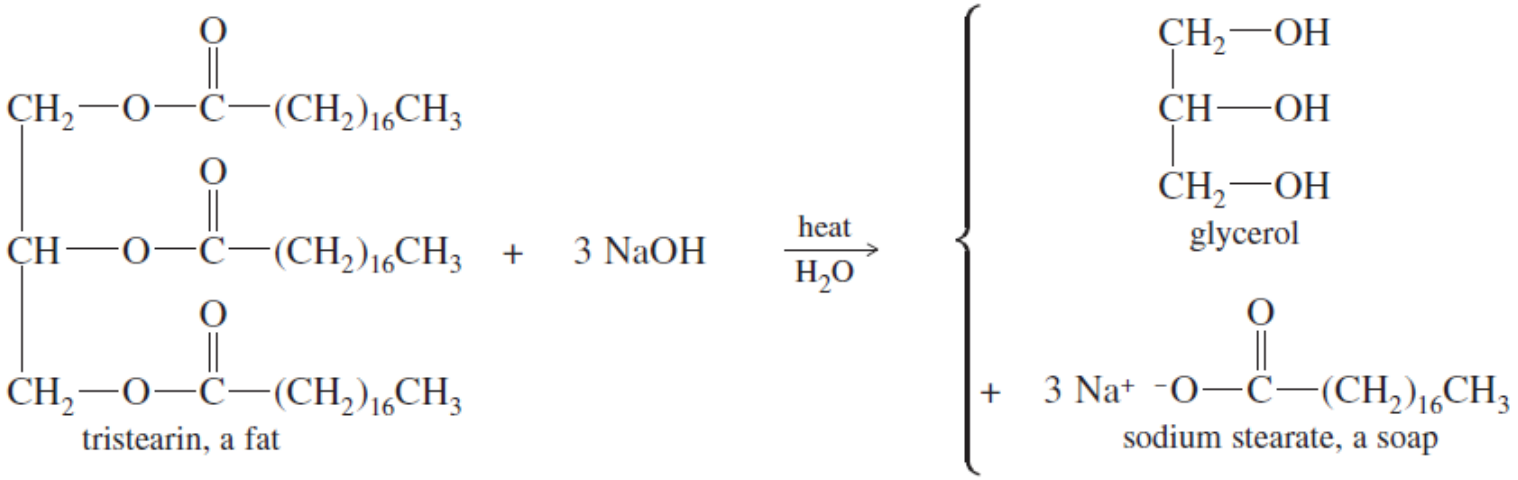


a triglyceride

- **Environmental advantages**: It converts waste cooking oil into a useful product, reducing the amount of waste going into landfills and replacing some of the petroleum that must be burnt

1.2 Triglycerides – Saponification to Soaps

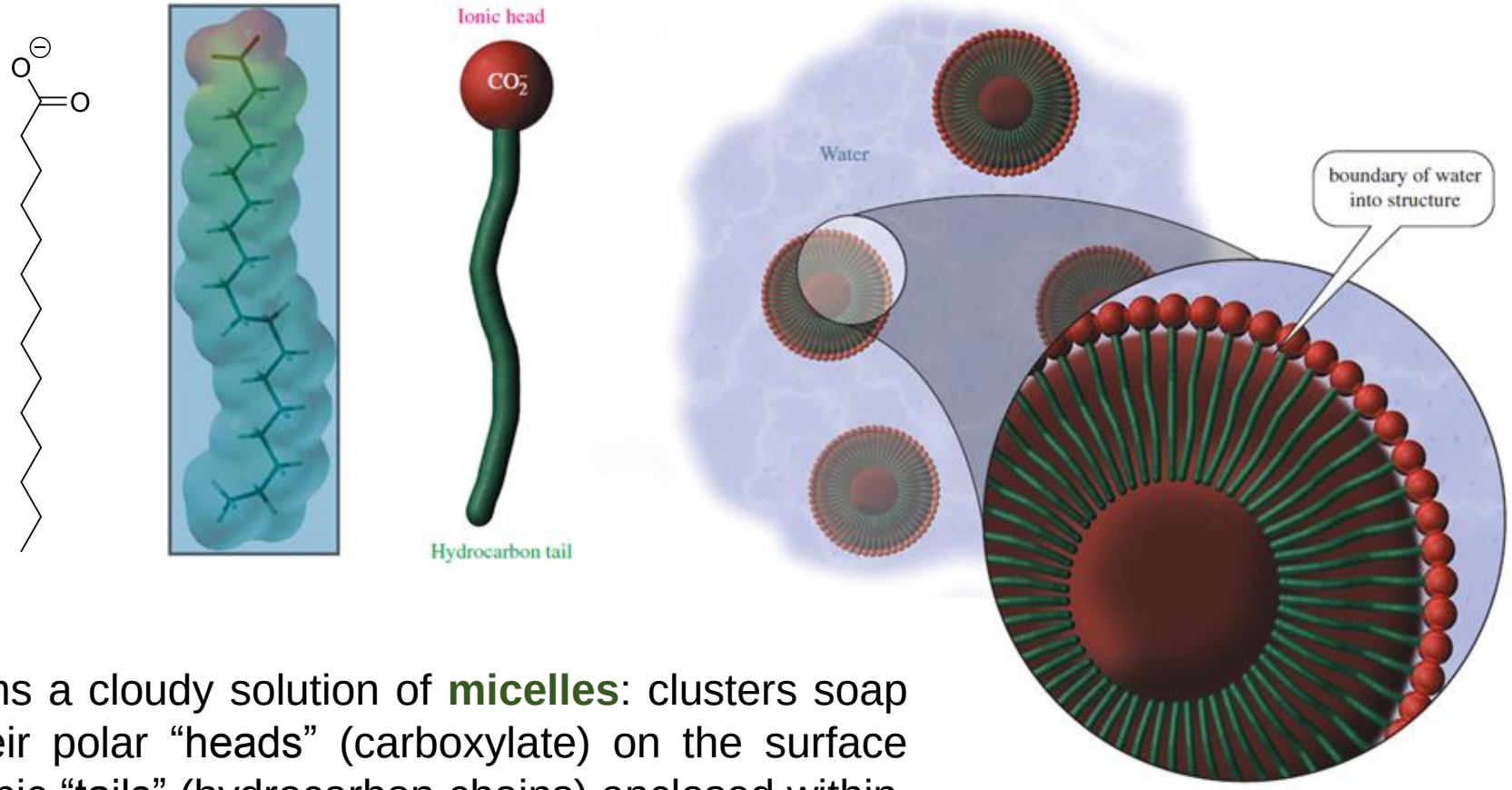
- **Saponification**: base-promoted **hydrolysis** of the ester linkages in fats and oils



- Soap is currently made by **boiling** animal fat or vegetable oil with a solution of **sodium hydroxide**

1.2 Triglycerides – Saponification to Soaps

- Chemically, a **soap** is the **sodium or potassium salt of a fatty acid**
- The negatively charged **carboxylate** group is **hydrophilic** (“attracted to water”), and the long **hydrocarbon chain** is **hydrophobic** (“repelled by water”) and **lipophilic** (“attracted to oils”).

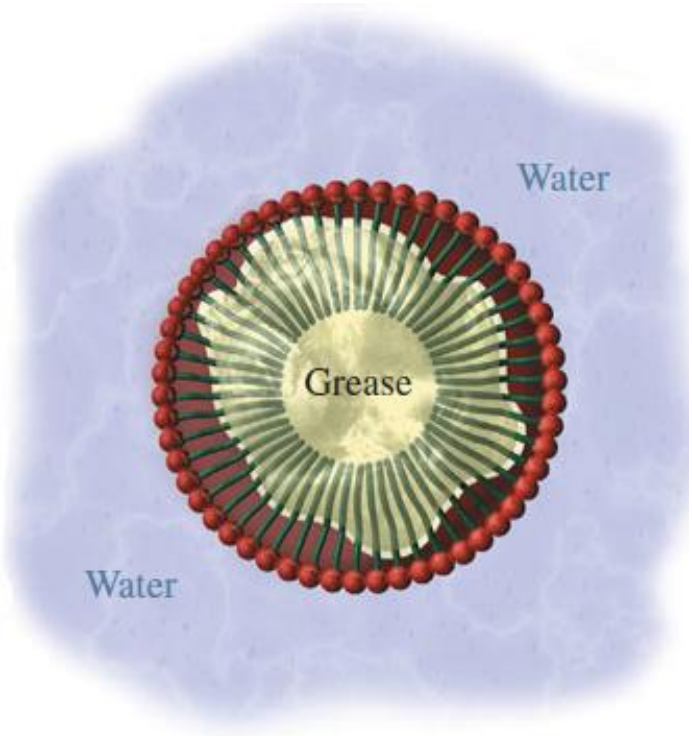


- In water, soap forms a cloudy solution of **micelles**: clusters soap molecules with their polar “heads” (carboxylate) on the surface and their hydrophobic “tails” (hydrocarbon chains) enclosed within

1.2 Triglycerides – Saponification to Soaps

- Greasy dirt is not easily removed by pure water because grease is hydrophobic and **insoluble in water**

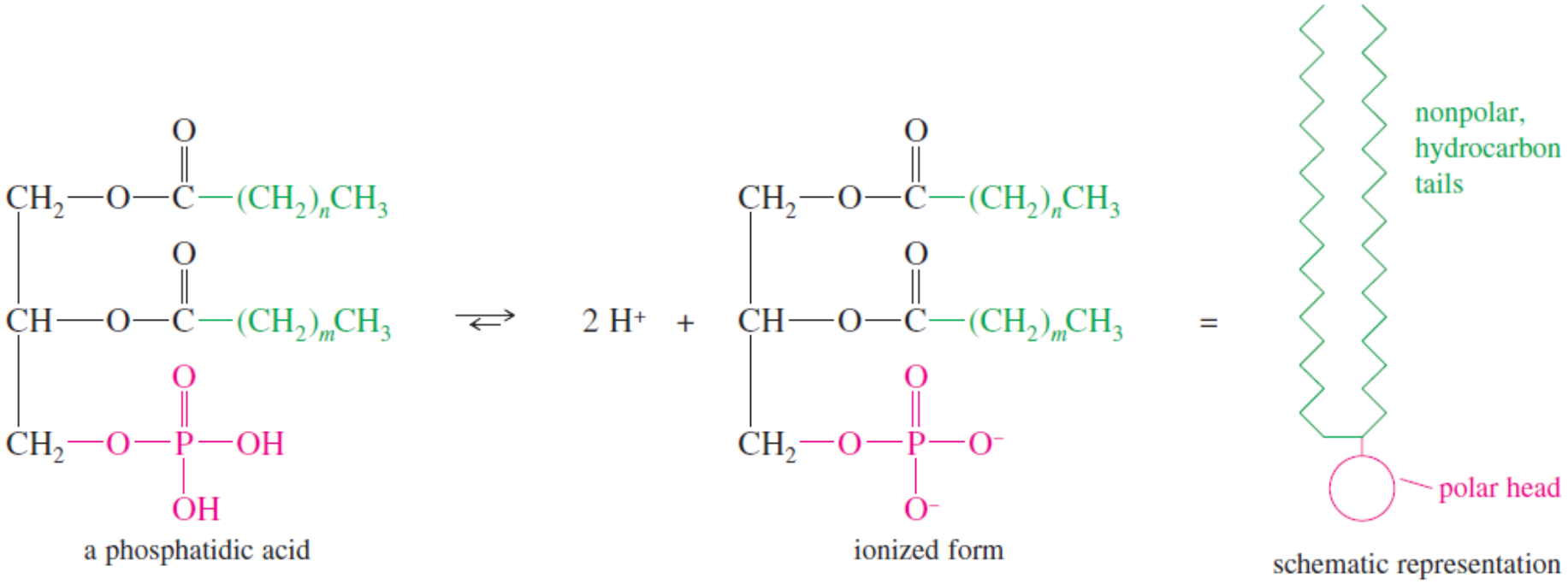
- Soaps are useful cleaning agents; the long hydrocarbon chain of a soap molecule dissolves in the grease, with the hydrophilic head at the surface of the grease droplet



- This grease droplet is easily suspended in water (hydrophilic carboxylate). The resulting **mixture of two insoluble phases** (grease and water), with one phase **dispersed throughout** the other in small droplets, is called an **emulsion**

1.3 Phospholipids

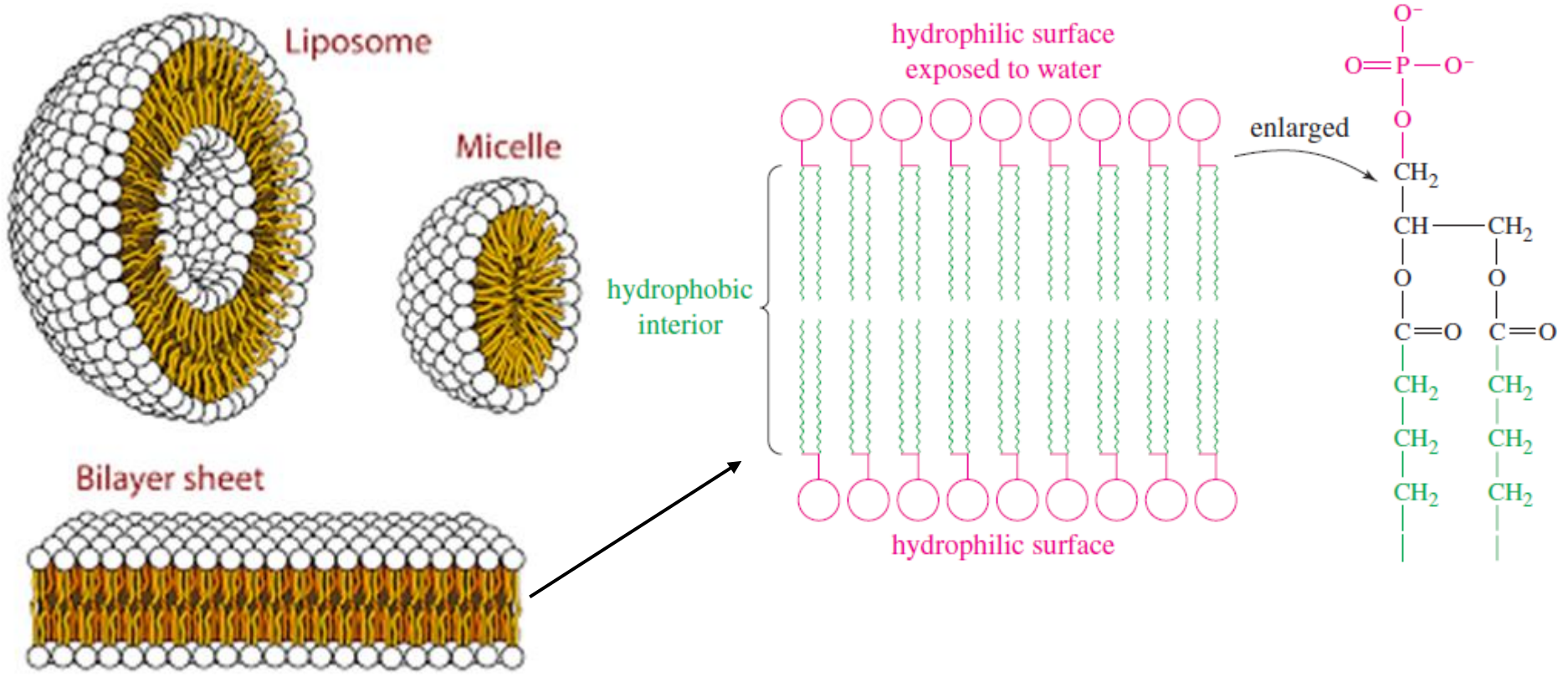
- Lipids that contain groups derived from **phosphoric acid**
- The most common phospholipids are **phosphoglycerides**, which are closely related to common triglycerides; (phosphoric acid group in place of one of the fatty acids)
- The simplest class of phosphoglycerides are **phosphatidic acids**; it is in the **deprotonated** form at neutral pH



1.3 Phospholipids

- Like soaps, **phosphoglycerides** form **micelles** and other aggregations with their polar heads on the outside and their nonpolar tails protected on the inside

- Another stable form of aggregation is a **lipid bilayer**, which forms animal **cell membranes**. In a lipid bilayer, the hydrophilic heads coat the two surfaces of a membrane, and the hydrophobic tails are protected within



Keywords:

Lipids

- Hydrolysibility (ester)
- Wax
- Triglyceride
  - Glycerol / Fatty acids
  - Saturated / Unsaturated + Fat / Oil
  - Margarine / Biodiesel / Soap
- Phospholipid