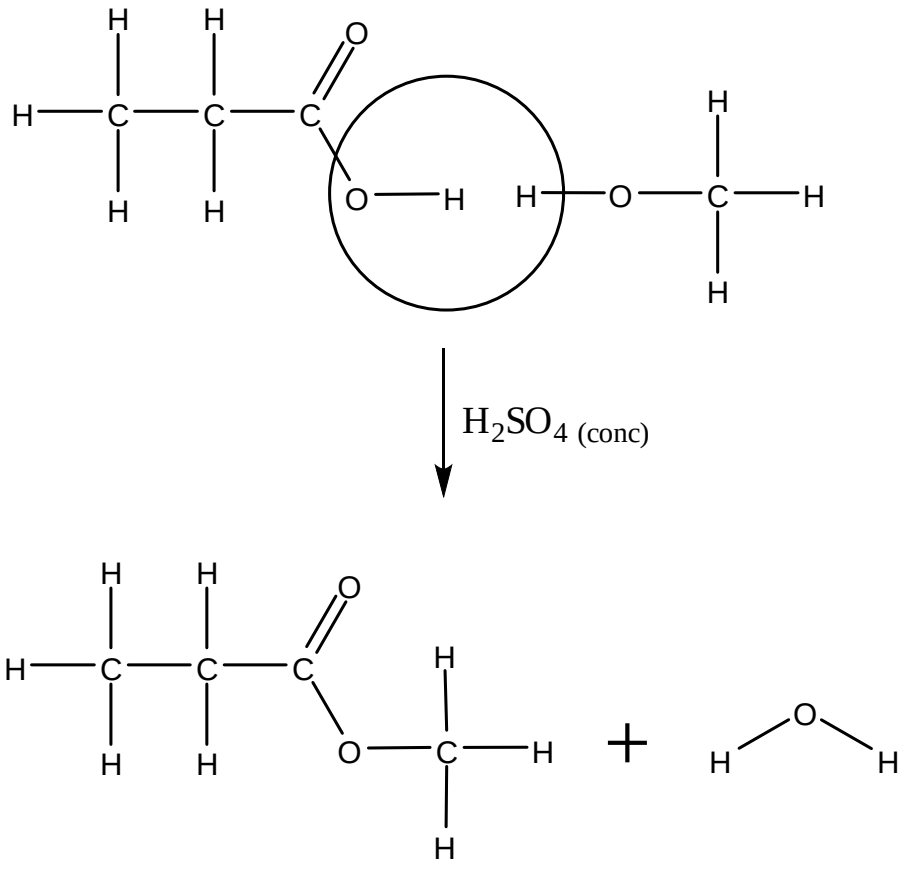
Chemistry 3.5
Advanced Organic Chemistry

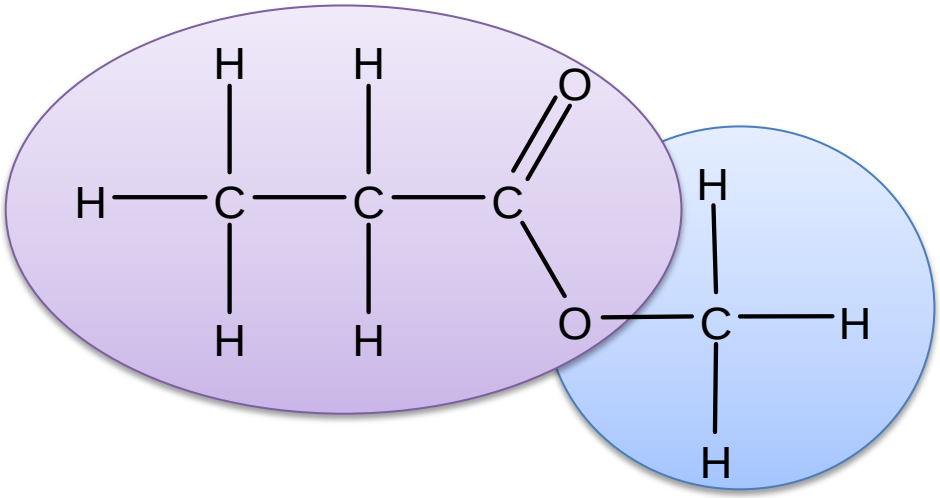
Esters

Condensation reaction

- **Condensation reactions** are reactions which **two molecules are joint** together by **removing** a **smaller molecule** (e.g. H_20)
- **Esters** are **formed** by reacting **carboxylic acid** with **alcohol** and **water is removed**



Naming Esters



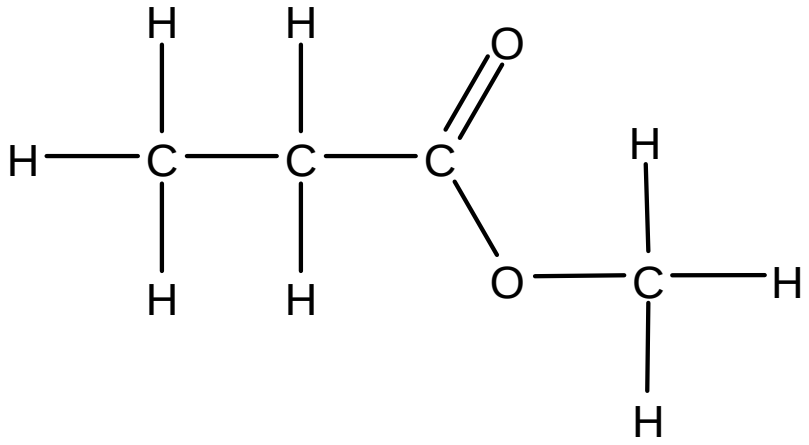
- The alcohol side is the side with oxygen

- The acid side is the side with C=O

(Alcohol)yl (acid)oate

Methyl propanoate

An easier way



- There is a “methyl” attached to the “propanoate”

Laboratory preparation for Esters

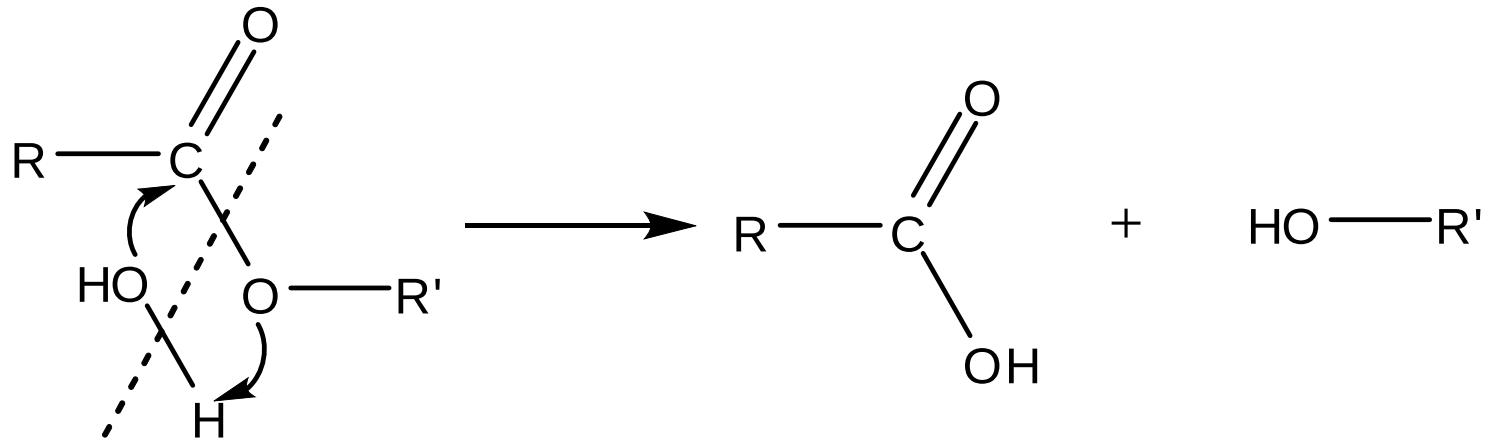
- Esters can be prepared by **refluxing** the reactant (alcohol and carboxylic acid) with small amount of **H_2SO_4 conc**.
  - H_2SO_4 conc. is a **dehydrating agent**
- After refluxing, there should be a **layer of oily** substance on top of the reaction vessel, this is because **esters are not soluble** in water
- The **excess acid** is **neutralised** by adding **K_2CO_3**

$$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$$

- The **Ester** can be **extracted** by **distillation**

Hydrolysis of Esters

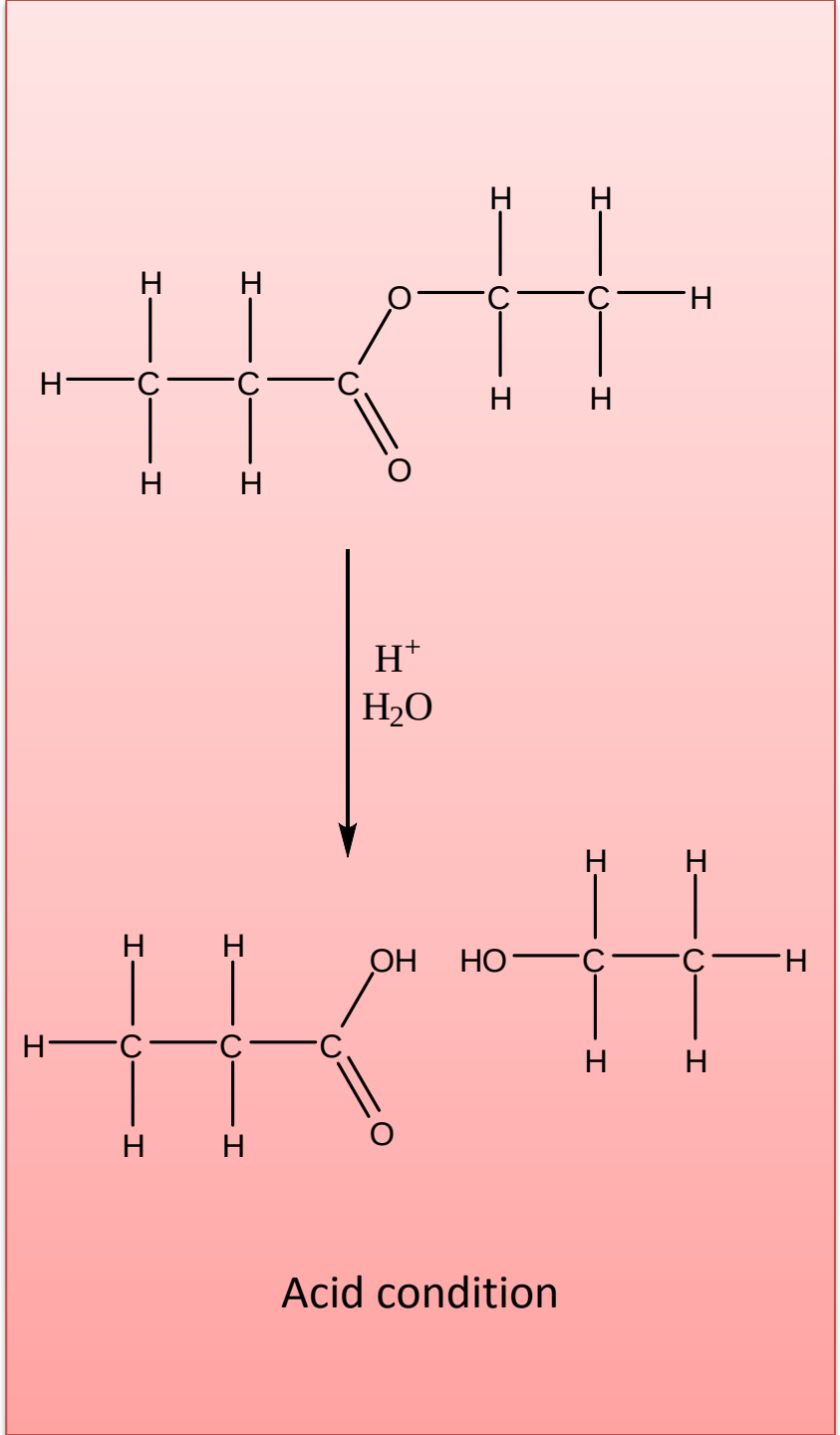
- *Hydro-* water *-lysis* break
- The ester bond is broken by addition of water

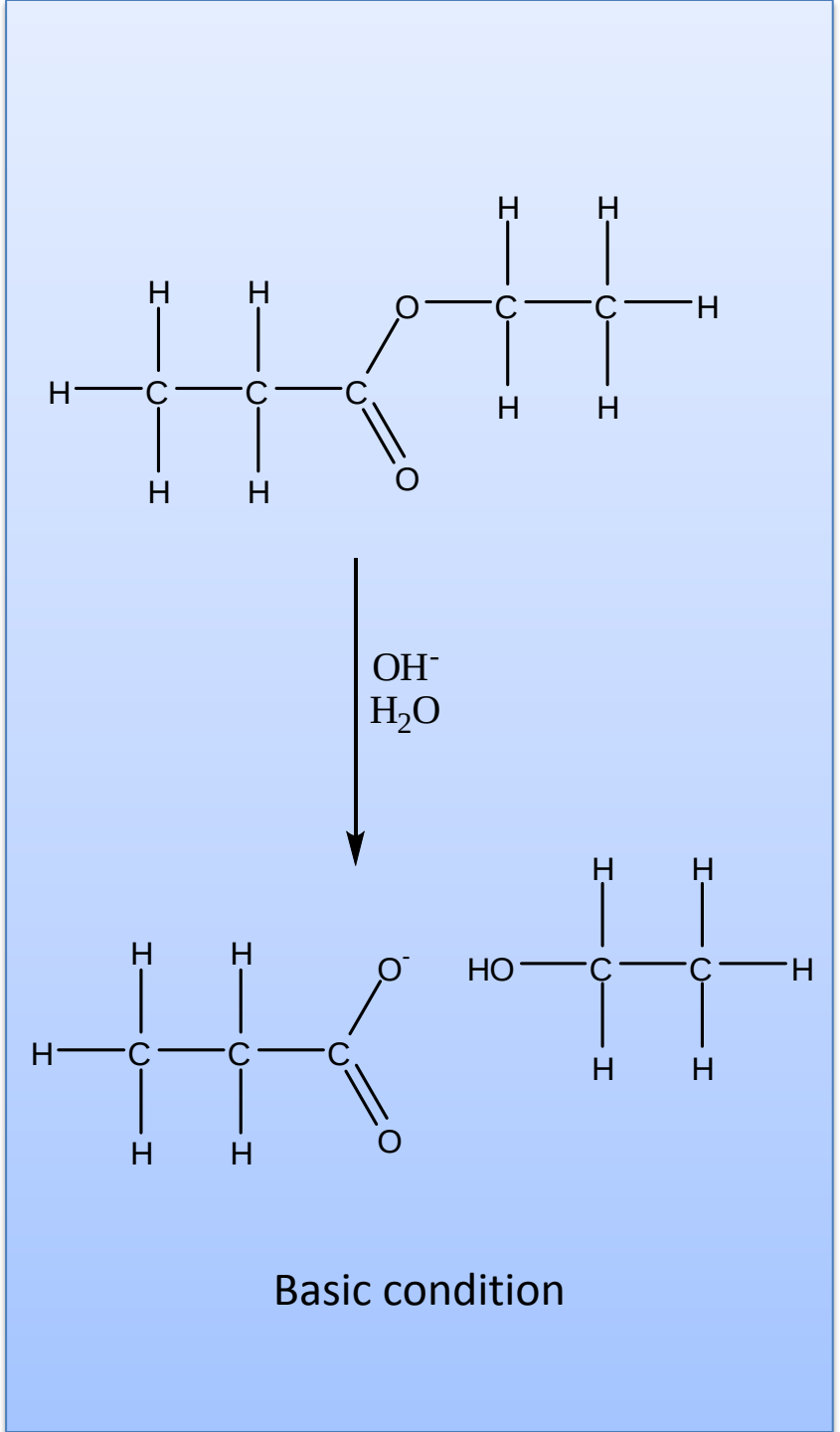


- It will form carboxylic acid and alcohol

Hydrolysis conditions

- In acidic condition
  - pH < 7 More H^+ than OH^-
  - Carboxylic acid (COOH) and an alcohol will be formed.
- In basic condition
  - pH > 7 More OH^- than H^+
  - Carboxylic acids will lose a proton to OH^- therefore
  - Carboxylate ion (COO^-) and an alcohol will be formed

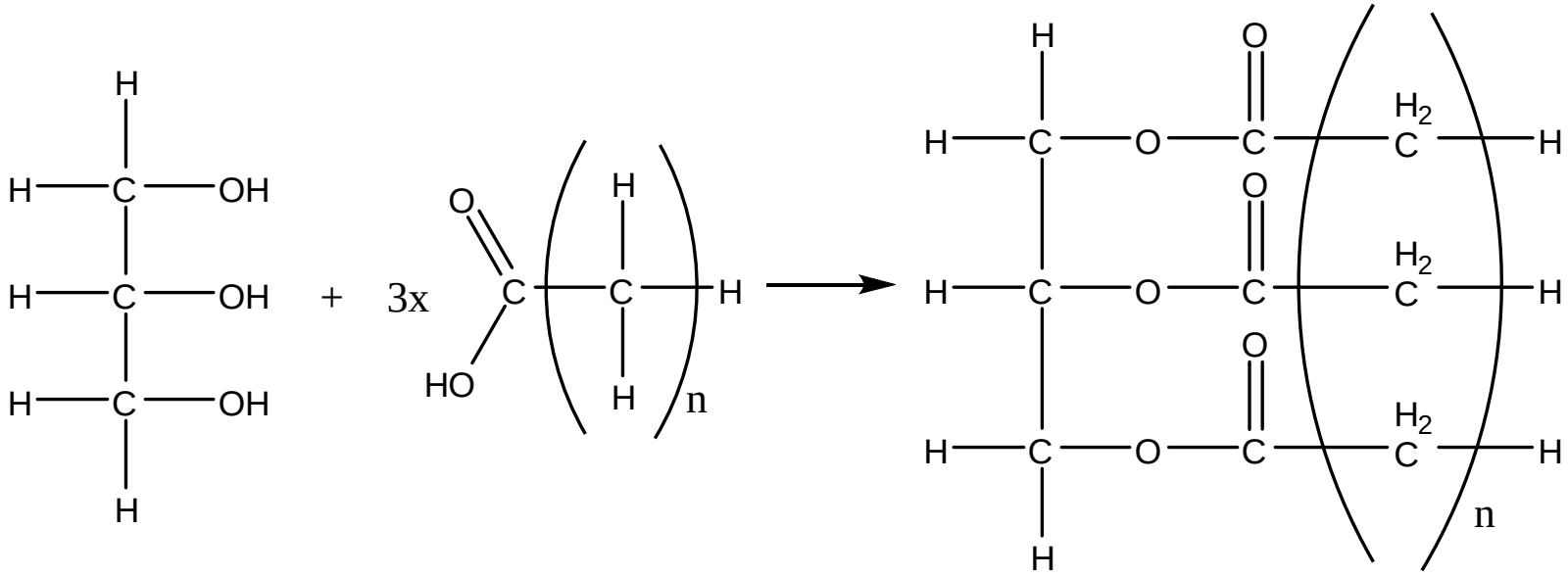

H+
H2O
OH
HO
Acid condition


OH-
H2O
O-
HO
Basic condition

Triglycerides and fat

- Triglycerides are naturally occurring esters found in fats and oils.
- It is formed by condensation of glycerol (propan-1,2,3-triol) and carboxylic acids called fatty acids.
- Fatty acids are carboxylic acids with long hydrocarbon chains containing even number of carbon atoms (usually between 12 and 20 carbon atoms)

Condensation of triglycerides



Glycerols

Fatty acids

Triglycerides
Fats or oils

Saturated and unsaturated fats

- Unsaturated fatty acids (fatty acid with one or more double bonds) have a lower melting point compared to saturated fatty acid.
- In nature, the *cis* isomers are much more common than the trans form
- Each *cis* double bond puts a “C” shaped kink in the carbon chain making the molecules much more “awkward” to fit into a regular pattern of solid.
- Hence lower m.p. and less viscous

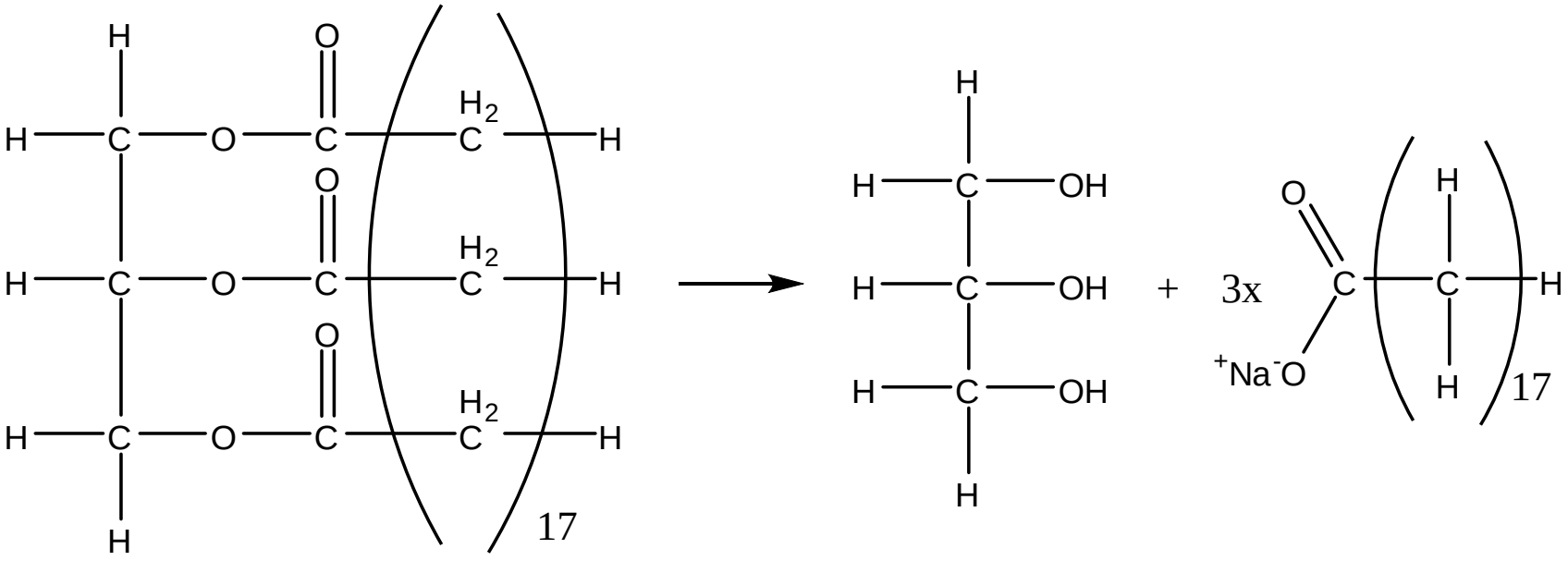
Table spread

- Vegetable oils such as peanut or olive oil are hardened by hydrogenation (additional reaction with hydrogen)
- The oils are heated to 150 – 200 ^{o}C with hydrogen and Ni catalyst
- Some of the double bonds are broken and the level of saturation increases.
- As level of saturation increases, viscosity also increases.

Saponification

- Saponification = soap making
- Soap is the sodium salt of the fatty acid.
- It is made by reacting a triglyceride (fat or oil) with sodium hydroxide

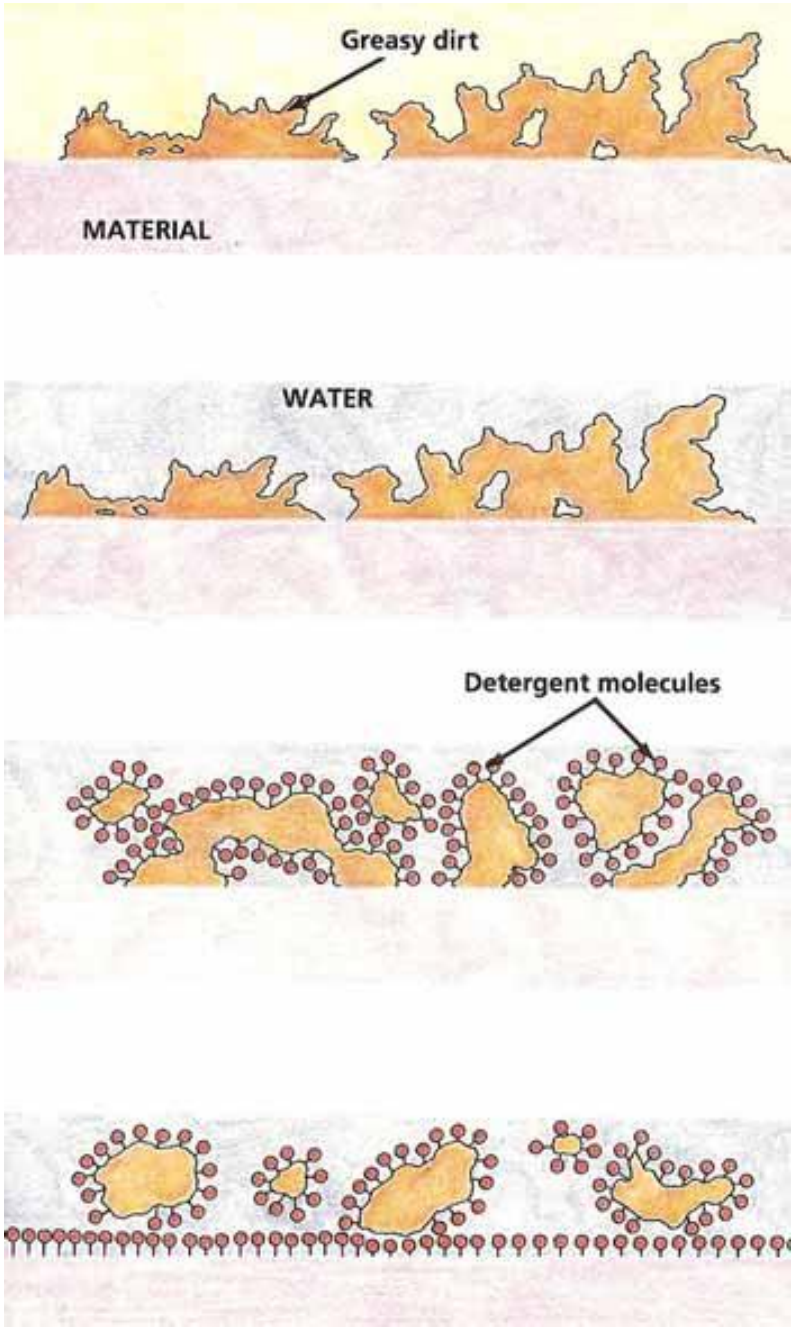
Hydrolysis of triglycerides



+ 3 NaOH

How soap works

- The soap molecule has a long nonpolar hydrocarbon chain which is soluble in grease (also nonpolar)
  - This “tail” is hydrophobic (water hating)
- It also has a polar carboxyl group (COO^-) which is soluble in water
  - This “head” is hydrophilic (water loving)
- The hydrocarbon chain dissolves in grease deposits while the carboxyl groups dissolve in water, lifting the grease from the object being clean and dispersing it in water


Greasy dirt
MATERIAL
WATER
Detergent molecules

Reaction with amine and ammonia

- Ester preform substitution with amine or alcoholic ammonia
- The alcohol group is replaced with the amine group (or ammonia) forming an **amide**