بسم الله الرحمن الرحيم

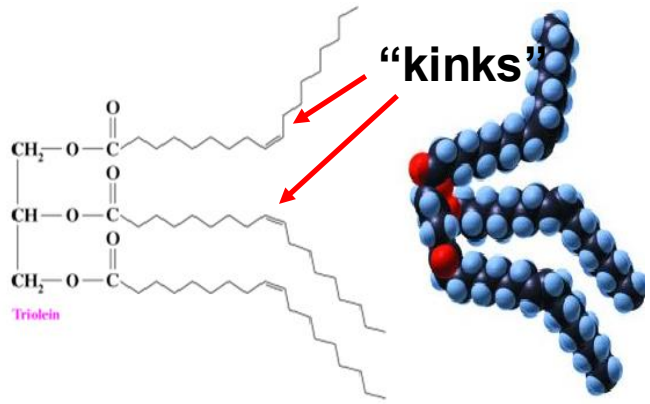
BioChemistry | Lecture #10

Lipids Pt.2

Written by : Abdallah Al-Abdallat
Hashem Alhalalmeh

Reviewed by : Jannat Nasri

Classification (unsaturated)



- Monounsaturated: Palmitoleic acid, Oleic acid
- Polyunsaturated:
  - More than one double bond
  - Essential fatty acids
  - Linoleic, Linolenic, and Arachidonic
  - $C18:2\Delta^{9,12}$
  - $C18:3\Delta 9, 12, 15$
  - $C20:4\Delta 5, 8, 11, 14$
- Do not pack closely (Cis)

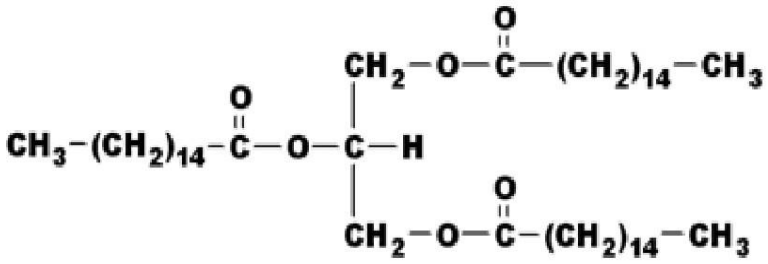
They are called essential because there is no metabolism in the body that can synthesize them, but we can obtain them from the diet and the bacteria in our body.

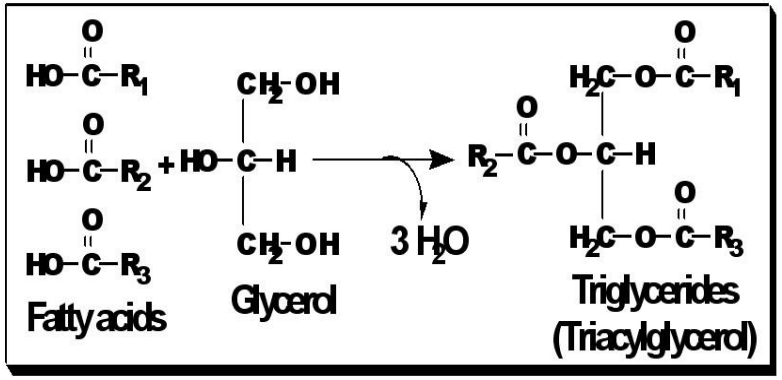
$$CH_3\text{-}(CH_2)_5CH=CH\text{-}(CH_2)_7\text{–}COOH$$

$$CH_3\text{-}(CH_2)_7\text{-}CH=CH\text{–}(CH_2)_7\text{-}COOH$$

Naturally occurring unsaturated fats are in the cis configuration. The cis double bond introduces a kink that prevents tight packing. In contrast, trans unsaturated fats are more linear, pack tightly like saturated fats, have higher melting points.

Simple lipids
Neutral - TAGs

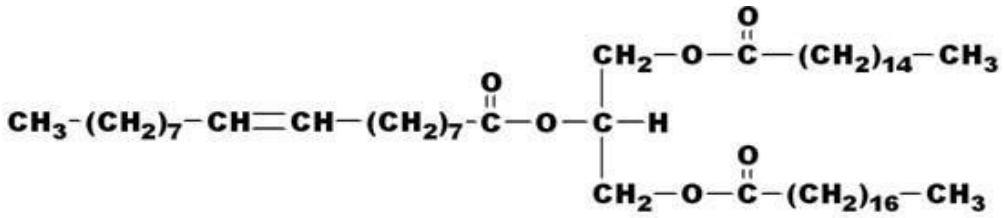


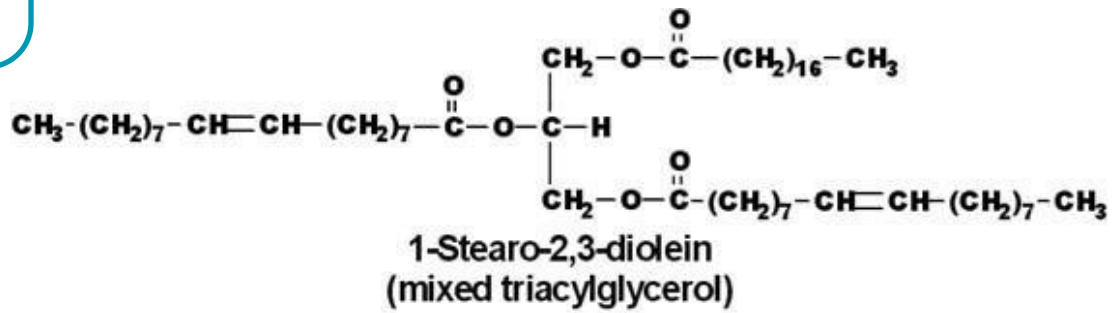


Uncharged (neutral) due to absence of ionizable groups in it which means they are not reactive

In lipids, glycerol can bind one, two, or three fatty acids, forming mono-, di-, or triglycerides. All are simple lipids, but only the fully esterified form with three fatty acids (a triglyceride) is considered a **neutral fat**.

the body store lipids in a non-reactive form for energy storage - the fat stored in our bodies is chemically stable (like triglycerides) to prevent unwanted reactions.



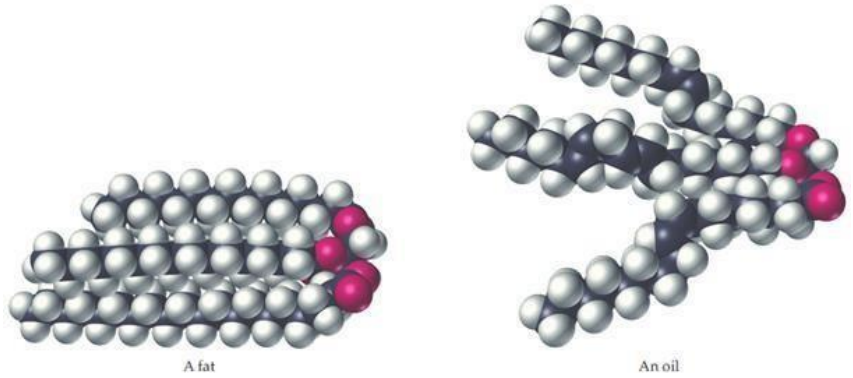


Most abundant (common) lipids in nature

Either **simple or mixed**

Physical:

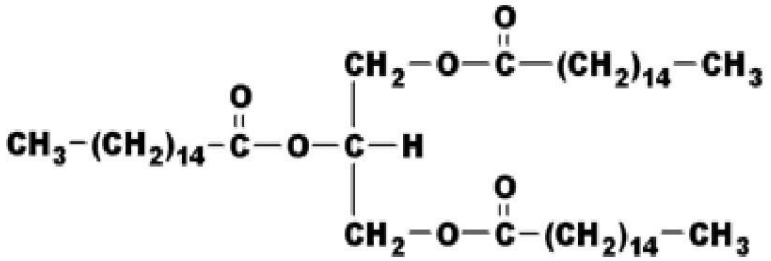
- Colorless, odorless & tasteless like water
- Specific gravity less than 1 Insoluble
- At room temp. (oils or fat)



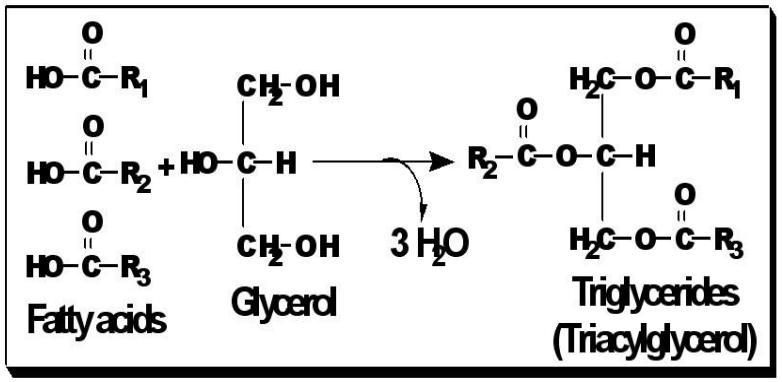
Simple lipids
Neutral - TAGs

They're called neutral fats or neutral oils depending on the fatty acids. The fatty acid **chain length**, **saturation**, and **number of double bonds** affect the **melting point**. Since glycerol is the same, the fatty acids decide whether the lipid is solid, semi-solid, or liquid.

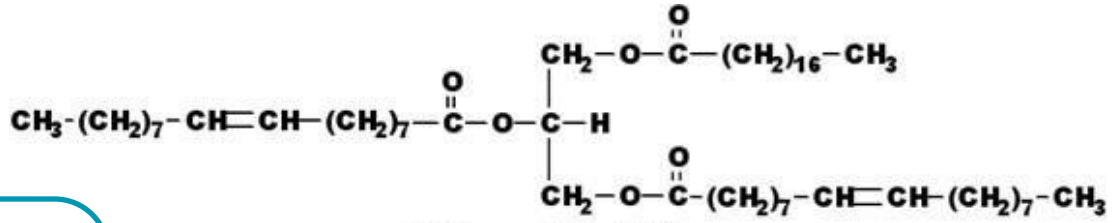
Glycerol can bind three fatty acids. If all three are the same, it's a **simple triacylglycerol** (named *tri...*+ acid name) e.g., **tripalmitin**



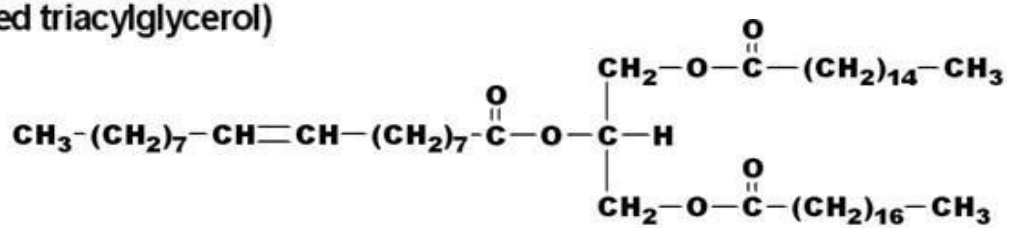
Tripalmitin
(simple triacylglycerol)



If the fatty acids are different, it's a **mixed triacylglycerol** – naming depends on the combination, often listing the fatty acids in order e.g., 1-palmitoyl-2-oleoyl-3-stearoyl-glycerol



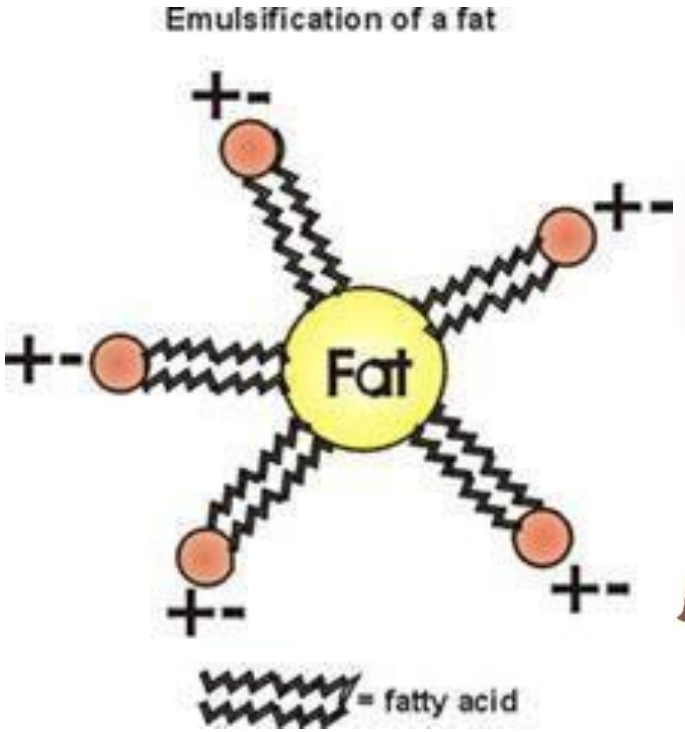
1-Stearo-2,3-diolein
(mixed triacylglycerol)

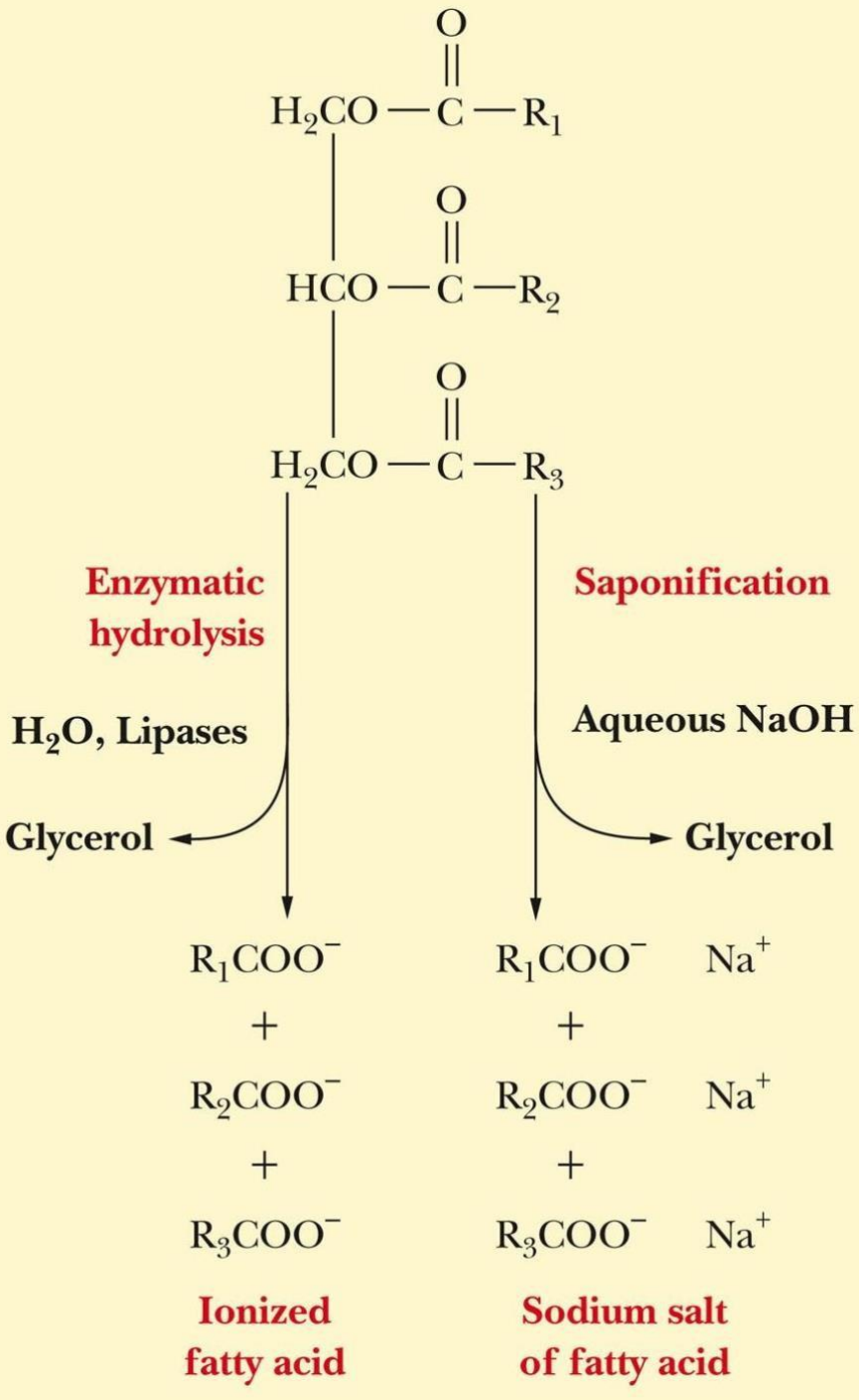


1-palmito-2-oleo-3-stearin
(mixed triacylglycerol)

Chemical reactions

Hydrolysis and saponification (emulsification)





- Hydrolysis of TAGs: the ester bond is broken by adding H_2O, with the help of enzymes (lipases).
- Triglycerides are hydrolyzed into 3 fatty acids and glycerol.
- When the body needs energy, it hydrolyzes TAGs. Why? Because this gives glycerol and 3 fatty acids, and the body uses the fatty acids to make energy.

- Saponification: a type of hydrolysis that happens in the presence of an alkaline medium.

- During saponification, triglycerides (Neutral Fats & Oils) are broken down into glycerol and three fatty acids. But because of the alkaline environment, the fatty acids react with the cations, forming salts – which are soaps.

- Soap alone does nothing on greasy hands, but with water, the cation dissolves and gets surrounded, leaving the negatively charged fatty acid. The carboxyl group (hydrophilic) attaches to water, while the hydrocarbon tail (hydrophobic) embeds into grease. This allows water flow to pull off fat gradually, forming small fat droplets and breaking down the large greasy mass.

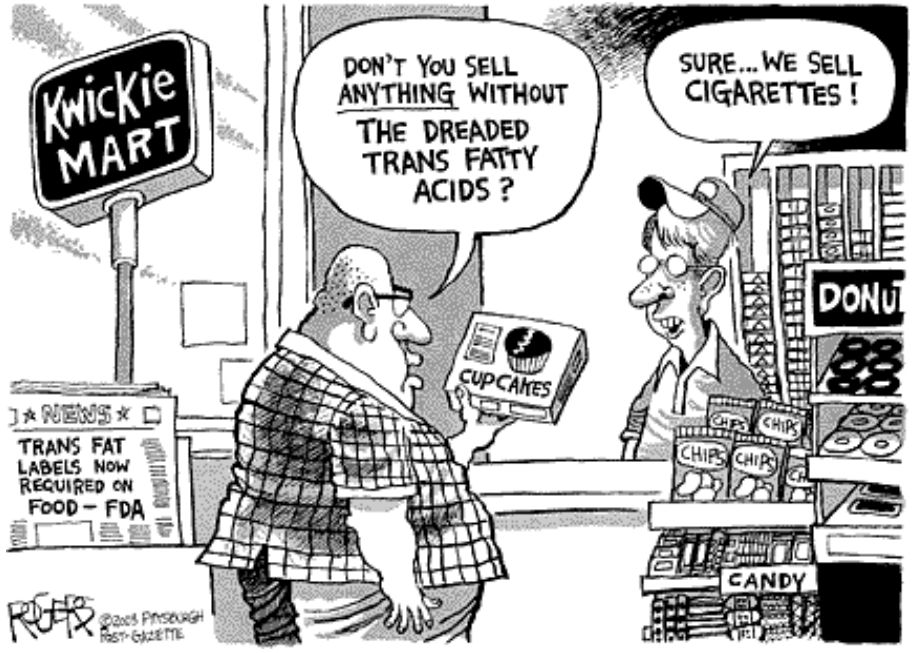
- Emulsification is the process where one part of the fatty acid attaches to fat and the other part to water. It's the basis of fat digestion.
- The gallbladder releases bile salts, which are fat-like molecules with a negatively charged acidic part and a positively charged ion.
- In the watery intestine, water solubilizes the ion, and the hydrocarbon tail (from cholesterol) embeds in the fat, causing emulsification. This makes fat soluble in water, allowing digestion.
- So, to mix fat and water, we just add an emulsifier, like in Mayonnaise, Chocolate & Icecream.

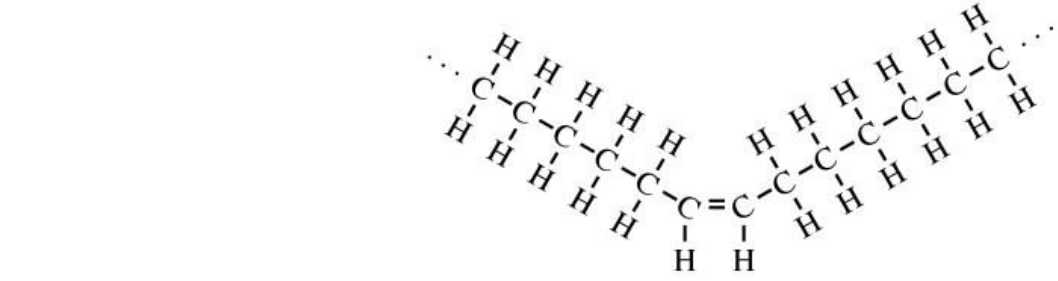
Chemical reactions

Oils (liquid) (with unsaturated fatty acids, e.g., oleic) —*Hydrogen, high pressure, nickel*→ Hard fat (margarine, solid) (with saturated fatty acids, e.g., stearic)

Hydrogenation: margarine manufacturing

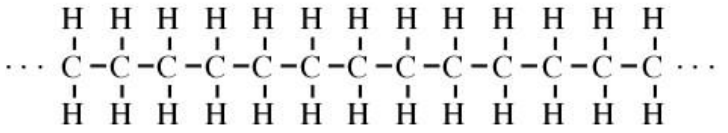
Adding H_2 under high pressure to double bonds. It only affects unsaturated fatty acids—mainly in oils, not fats, because oils have many double bonds, fats mostly don't. Hydrogenation turns liquid oils into more solid forms.

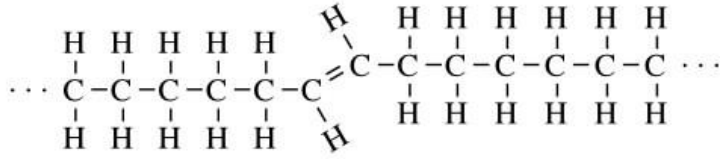




Complete chemical hydrogenation

side-effect of chemical hydrogenation





Double bond in the ***trans*** configuration

- Why is converting oil to butter (hydrogenation) favorable?

Because they are better for storage, double bonds are more reactive than single bonds. So, fats without double bonds are more stable.

- But why do we still make hydrogenated fats (like margarine) even though storage is easier now?

Because saturated fats taste better, but they are dangerous for human's health, why?

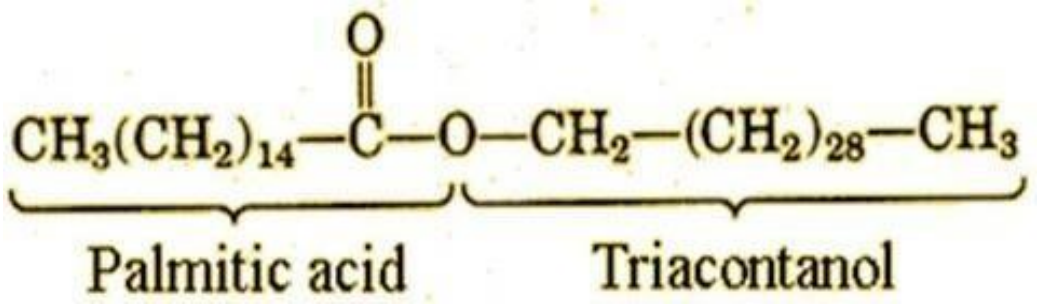
1. Saturated fats are harmful, because they can pack tightly in the human body.

2. Not all double bonds become single bonds during hydrogenation; some cis double bonds turn into trans double bonds, which are also harmful because they also pack tightly.

3. Hydrogenation of oils reduces the amount of essential polyunsaturated fatty acids, so we lose the nutritional benefits.

4. Hydrogenation reduces fat-soluble vitamins (like vitamins A, D, E, K), which are important for health.

Simple lipids
Neutral - waxes → They are hydrophobic



A monohydric alcohol (C16 ~ C30, higher molecular weight than glycerol) esterified to long-chain fatty acids (C14 ~ C36)

Insoluble, indigestible, coatings

Type	Structural Formula	Source	Uses
Beeswax	$CH_3(CH_2)_{14}-C(=O)-O-(CH_2)_{29}CH_3$	Honeycomb	Candles, shoe polish, wax paper
Carnauba wax	$CH_3(CH_2)_{24}-C(=O)-O-(CH_2)_{29}CH_3$	Brazilian palm tree	Waxes for furniture, cars, floors, shoes
Jojoba wax	$CH_3(CH_2)_{18}-C(=O)-O-(CH_2)_{19}CH_3$	Jojoba	Candles, soaps, cosmetics

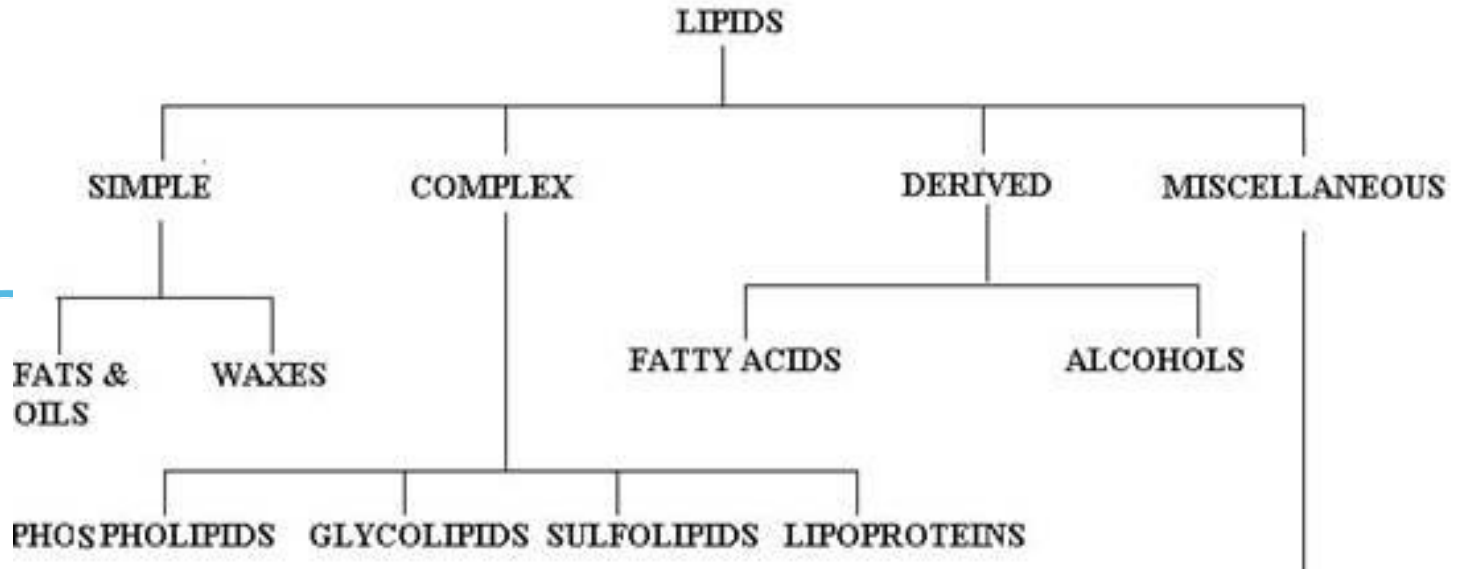
- Waxes are hydrophobic and made by combining long-chain fatty acids with long-chain monohydric alcohols.
- They are insoluble, indigestible, and leave the body unchanged.
- Bees produce waxes, and plants use them to coat fruits and surfaces to reduce water loss and keep their form longer.
- Honey may contain wax, but wax has no nutritional value and just takes up space.
- Waxes may help skin but are useless in the GI tract.

Differences between neutral lipids & waxes

Property	Waxes	Neutral lipids
1.Digestibility	Indigestible (not hydrolyzed by lipase)	Digestible (hydrolyzed by lipase)
2-Type of alcohol	Long-chain monohydric alcohol + one fatty acid	Glycerol (trihydric) + 3 F.A
3-Type of F.A	Mainly palmitic or stearic acid	Long & short chain F.A
4-Acrolein test	Negative (Aren't glycerol-based)	Positive (Glycerol-based)
5-Nature at room temperature	Hard solid	Soft solid or liquid
6-Saponification	Nonsaponifiable Doesn't break down in alkaline media	Saponifiable
7-Nutritive value	No nutritive value	Nutritive
8-Example:	Bees wax	Butter & vegetable oils

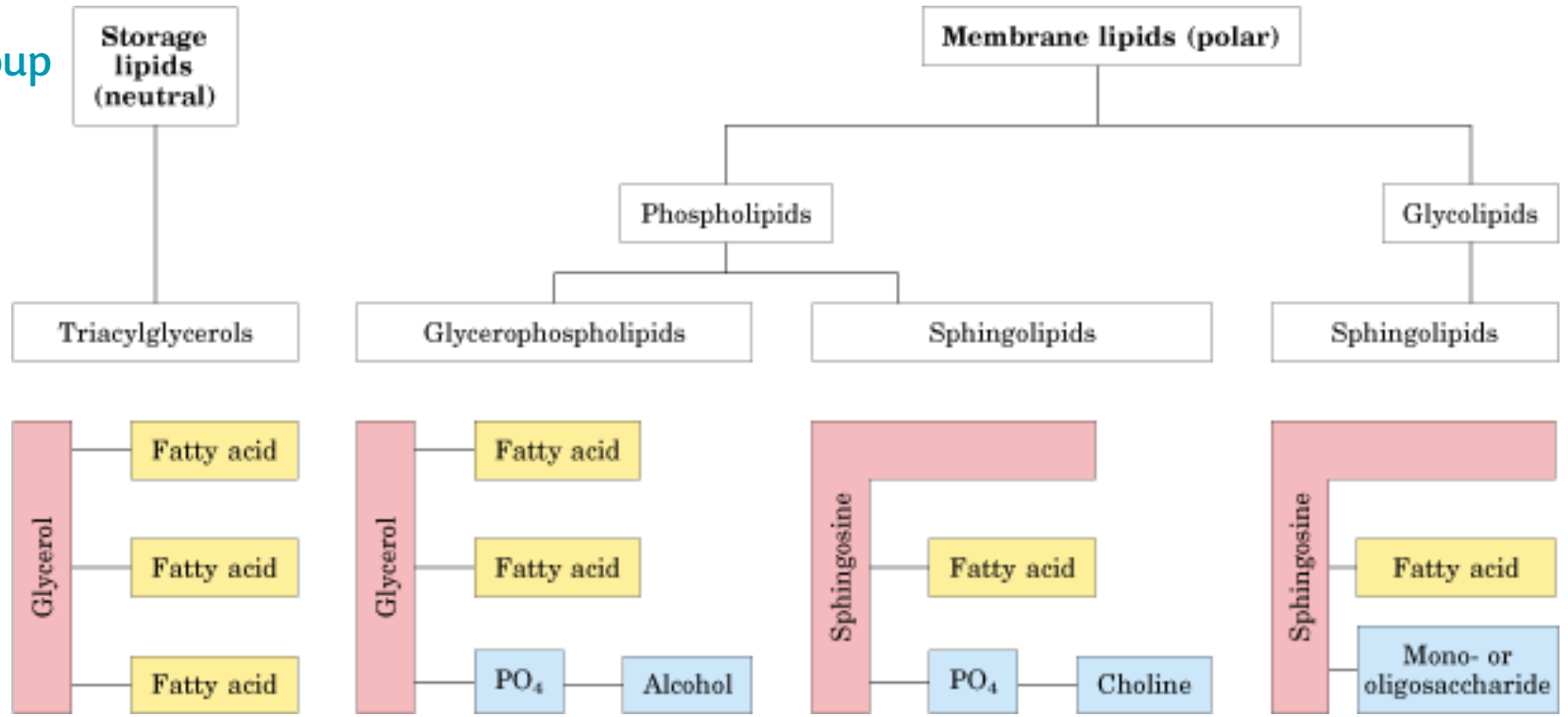
Complex lipids

Conjugated/compound
Non lipidic structure is bound to it



e.g.
Phosphate + Lipid Group

Lipid isn't neutral anymore, so now it's reactive and has a function other than storage.



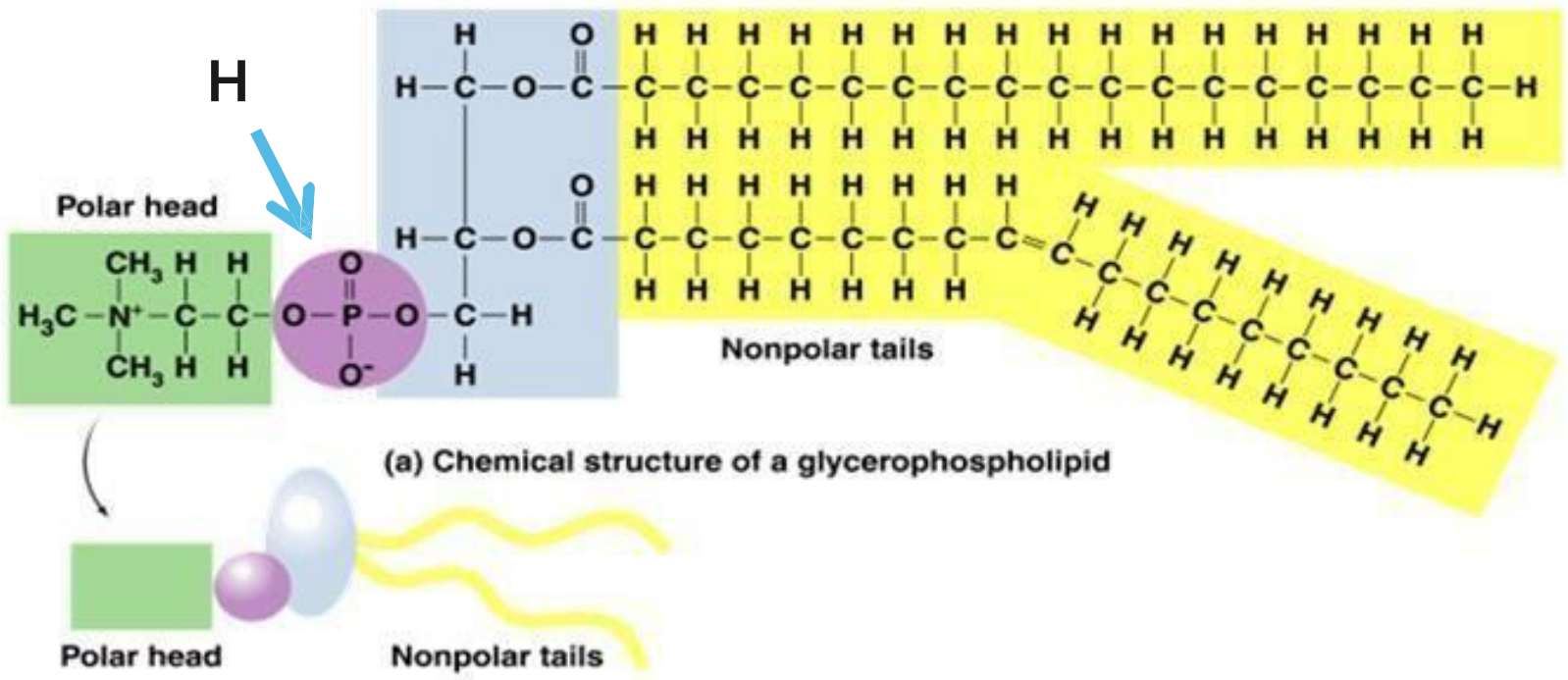
Glycero-phospholipids

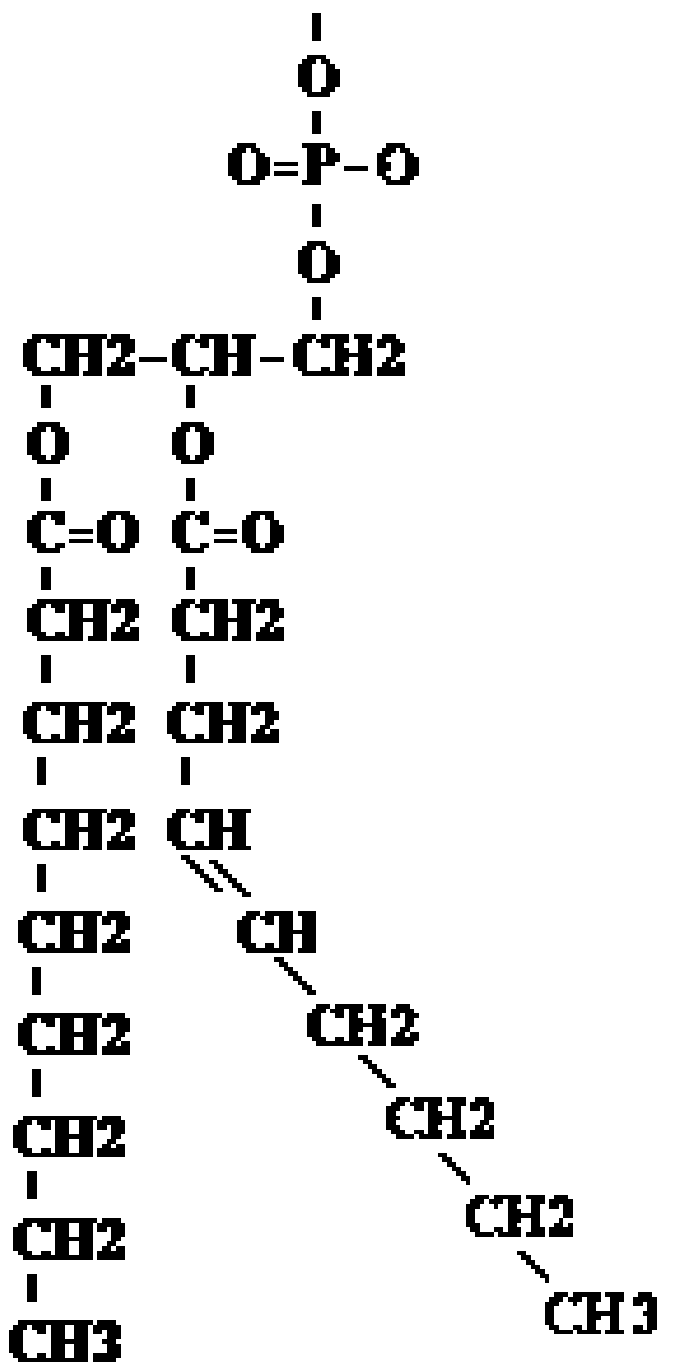
2 fatty acids (any type can bind to glycerol)

Phosphate

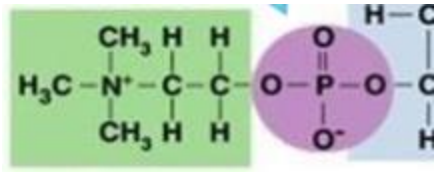
Simplest is phosphatidic acid or phosphatidate (suffix -ate is for acids)

Nothing is bound to phosphate, the original H on it wasn't replaced



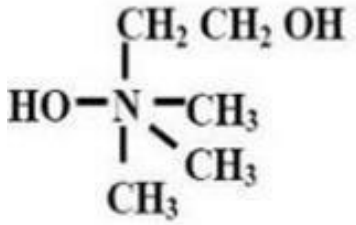


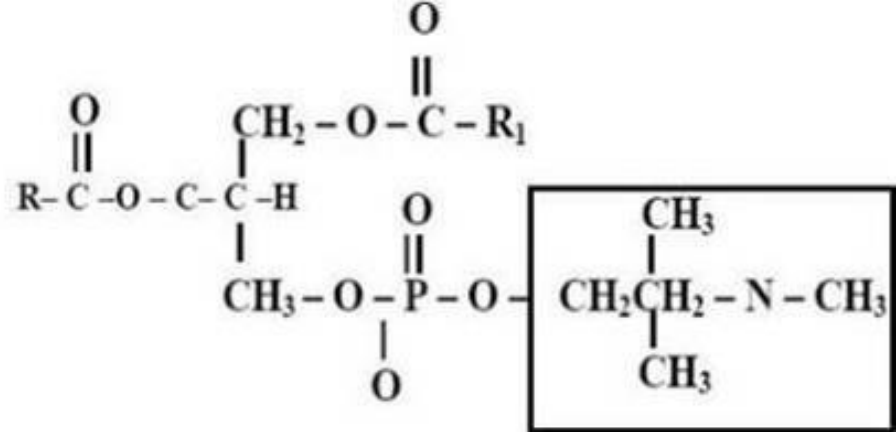
- Phospholipids are subclassified based on what is attached to the phosphate group.
- In phosphatidic acid, nothing is added to the phosphate – it's just glycerol + two fatty acids + one phosphate group.
- But when something is added to the phosphate, the name changes to phosphatidyl + [added group].
- For example, phosphatidylcholine: here, choline is attached to the phosphate.
- Choline is a quaternary amine(N is bound to 3 methyl groups and another carbon).



Choline structure

Lecithins = Phosphatidyl choline



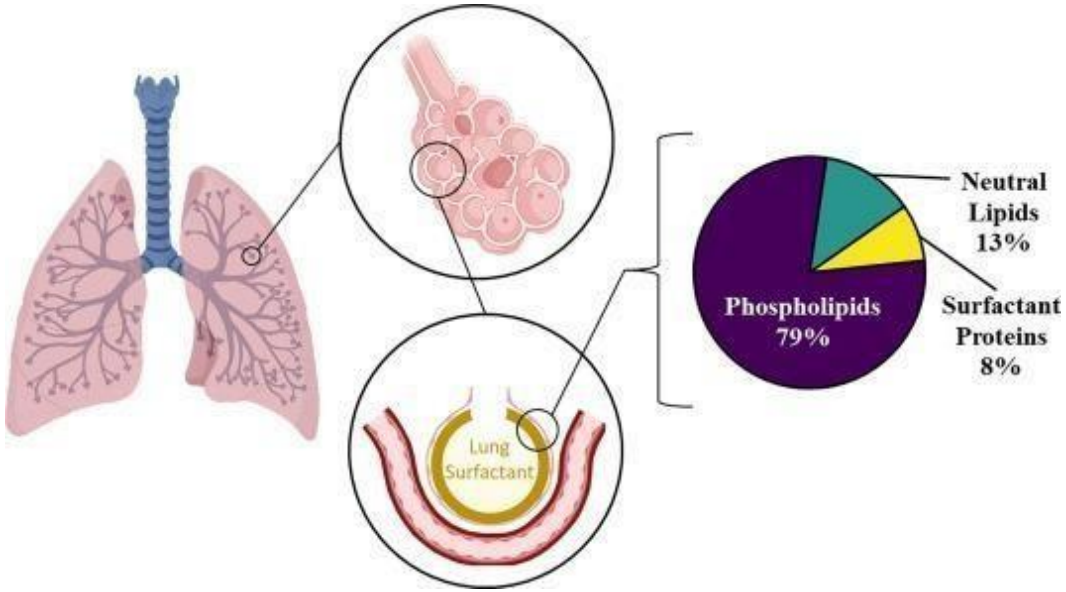


Choline as a nitrogenous base

Most abundant membrane lipid Snake venom

Lung surfactant & RBC's

Choline $-CH_2-CH_2-\overset{+}{N}(CH_3)_3$



Snake venom contains an enzyme called lecithinase, which breaks down lecithin in cell membranes and converts it into lysolecithin.
This damages the RBC membrane, leading to rupture (hemolysis).

- Lung surfactant creates negative pressure, helping pull the lungs outward to allow breathing. It's found in babies, but premature babies (born before 9 months) often lack it, leading to respiratory problems.
- To make surfactant, cell membranes must fully develop.
- A major component is lecithin (dipalmitoyl lecithin), which contains two palmitic acids.
- Doctors give steroids to premature babies to support their respiratory function until their lungs are fully developed.

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			

رسالة من الفريق العلمي:

رَبّ أعني ، ولا تعن علي ، وانصرني ولا تنصر علي ، وامكر لي ولا تمكر علي ، واهدني ويسر الهدى لي ، وانصرني على من بغى علي ، رب اجعلني لك شكارا لك ، ذكارا لك ، رهابا لك ، مطواعا لك ، مخبتا إليك ، أواها منيبا ، تقبل توبتي ، وأجب دعوتي ، واهد قلبي ، وثبت حجتي ، وسدد لساني ، واسلل سخيمة قلبي