



University of Al-Ameed

Faculty of Nursing



# **Biochemistry**

## Lec.3

### **Chemistry of Lipids (part 1)**

**Assistant Lecture. Zainab Hashim Almosawi**

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# LIPIDS

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- organic molecules **insoluble** in water but soluble in organic solvents.
- Because of their insolubility in aqueous solutions, body lipids are generally found compartmentalized, as in the case of **membrane associated lipids** or droplets of **triacylglycerol in adipocytes** or **transported in plasma** in association with protein, as in lipoprotein particles or on albumin.

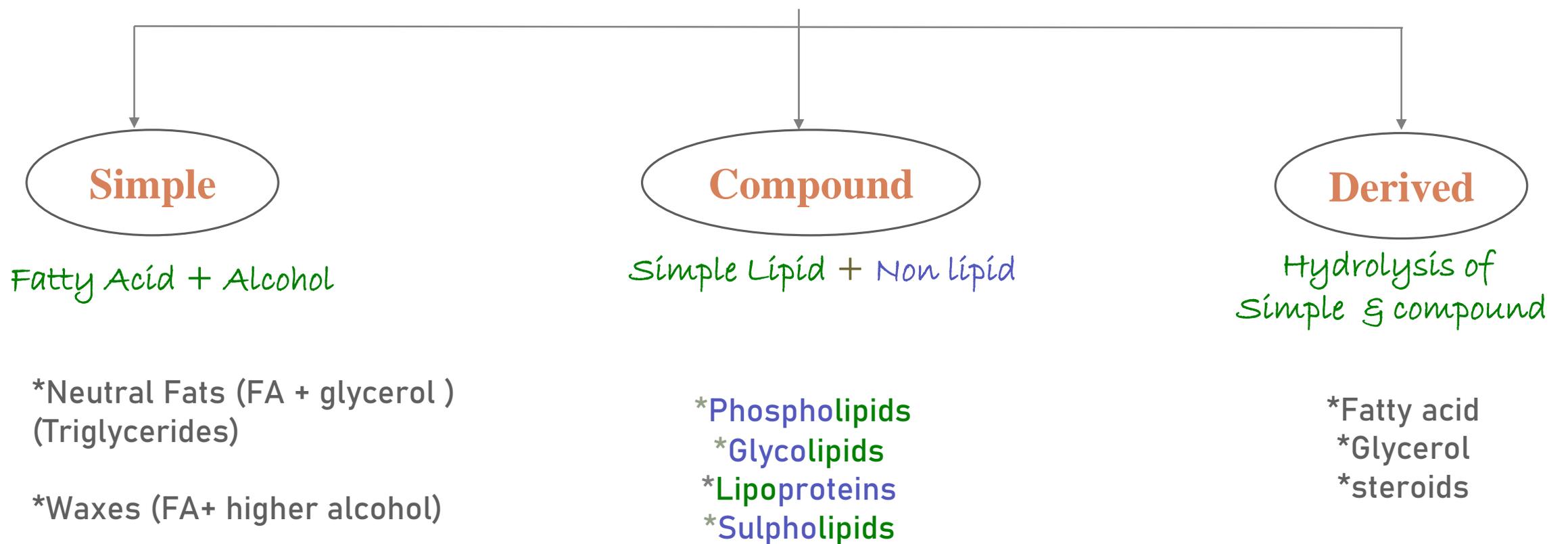
# LIPIDS

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- Lipids are a **major source of energy for the body**
- They also provide the hydrophobic barrier that permits the partitioning of the aqueous contents of cells and Subcellular structures.
- Lipids serve additional functions in the body, for example, **Some fat-soluble vitamins** have regulatory or coenzyme functions, and **steroid hormones** play major roles in the control of the body's homeostasis.

# Classification Of Lipids

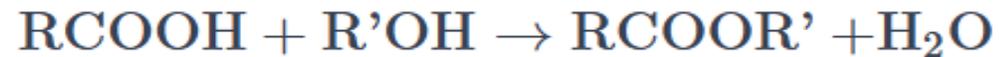
## Lipids



# Simple Lipids

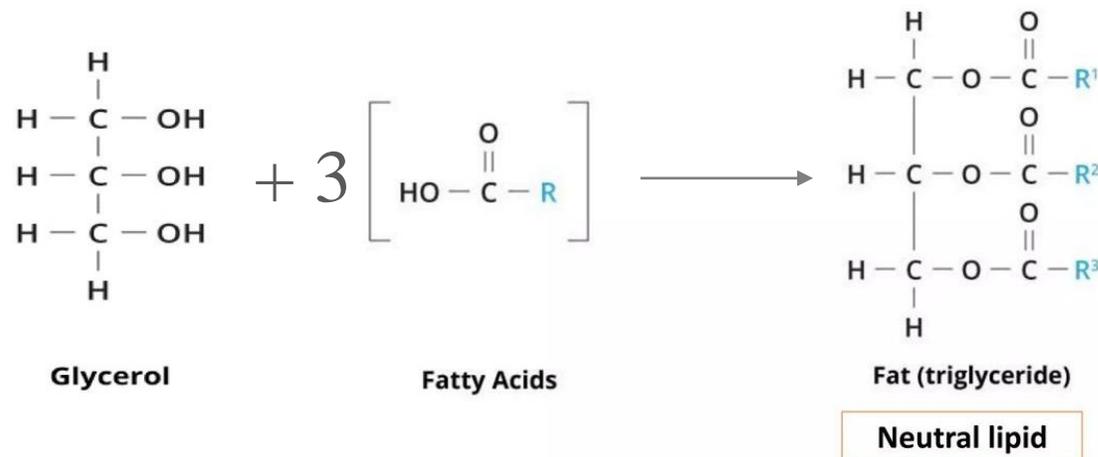
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Simple Lipids : **Esters** of fatty acids with various alcohols



## ➤ Triglycerides

These are triesters of fatty acids with glycerol (trihydroxy alcohol).



# Simple Lipids

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**\*Triglycerides** Most of the fatty acids in the body are components of triglyceride and are stored in the depots (adipose tissue). Adipose cells convert Fatty acids into triglyceride by esterification with glycerol-3-phosphate, compounds that arises from glucose metabolism

## ➤ Waxes

These are esters of fatty acids with long chain alcohols other than glycerol

Ex: True wax (Bee's wax): Esters of palmitic acid with mericyl alcohol



# Compound Lipids

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## ➤ Phospholipids

Phospholipids contain **fatty acids, glycerol, phosphoric acid, nitrogen bases** and other substituents. They are most abundant in cell membranes and serve as structural components, **Examples.** phosphatidyl choline (Lecithin), phosphatidyl ethanolamine (Cephalin), phosphatidyl serine, etc.

## ➤ Glycolipids

Glycolipids contain **fatty acids, a special alcohol (sphingosine or sphingol), carbohydrate and nitrogenous bases.** They do not contain phosphoric acid or glycerol. are important constituents of the brain and other tissues These are of two types: **Cerebrosides ,Gangliosides**

# Compound Lipids

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- **Sulpholipids:** are Compound Lipids characterized by have **sulphate groups**
- **Lipoprotein:** are Compound Lipids characterized by **conjugation with proteins**  
,These structures play a crucial role in transporting lipids through the bloodstream, as lipids are not soluble in water. Lipoproteins vary in size and density and are classified into several categories, including: (Chylomicron, VLDL, LDL,HDL).

# Derived lipids

➤ **Fatty acid (FA)** are straight-chain hydrocarbons with a terminal carboxyl Group

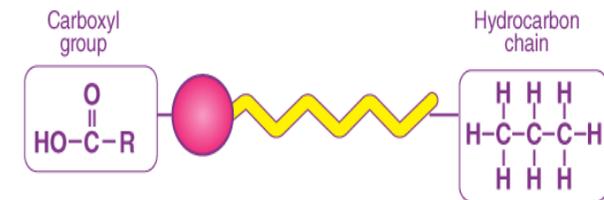
**Fatty acids are the main building blocks of fat.**

## Classification of fatty acids

- Saturated FA: Those which **contain no double bonds** (lauric acid )
- Unsaturated FA: Those which **contain one or more double bonds** (Palmitoleic acid).

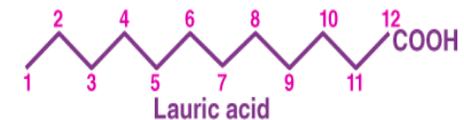
### Fatty Acid

Fatty acid made up from carboxylic group and hydrocarbon chain



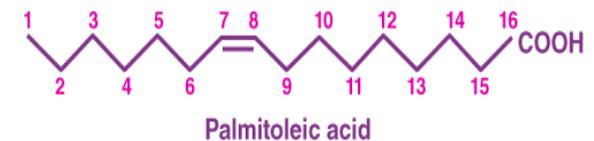
#### Saturated fatty acid

No double bond in structure



#### Unsaturated fatty acid

> 1 of double bond



They are classified further according to degree of unsaturation.

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- (1) **Mono unsaturated fatty acids:** They contain one double bond. Ex: palmitic acid
- (2) **Polyunsaturated fatty acids:** They contain more than one double bond

There are three polyunsaturated fatty acids of biological importance

\*Linoleic acid series It contains two double bonds

\*Linolenic acid series It contains three double bonds

\*Arachidonic acid series It contains four double bonds

# Classification of Fatty Acids: Essential vs Nonessential

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## A. Nonessential fatty acids:

1. These are fatty acids which **can be synthesized in the body**. Thus they are not necessary to be obtained from the diet.
2. They include **all saturated and monounsaturated fatty acids** as **palmitoleic and oleic acid**.
3. They can be synthesized from acetyl COA (active acetate) derived from glucose oxidation.

# Classification of Fatty Acids: Essential vs Nonessential

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## B. Essential fatty acids:

1. These are fatty acids that **cannot be synthesized in the body**. They must be obtained from the diet.
2. They include fatty acids that contain more than one double bond (**polyunsaturated fatty acids**) e.g. **linoleic, linolenic, Arachidonic acids**.
3. Lack of EFA in the diet can produce growth retardation and other deficiency symptoms

## Sources

- a) **Vegetable oils**: corn oil, soybean oil, sunflower, linseed oil and cottonseed oil.
- b) **Fish oils**

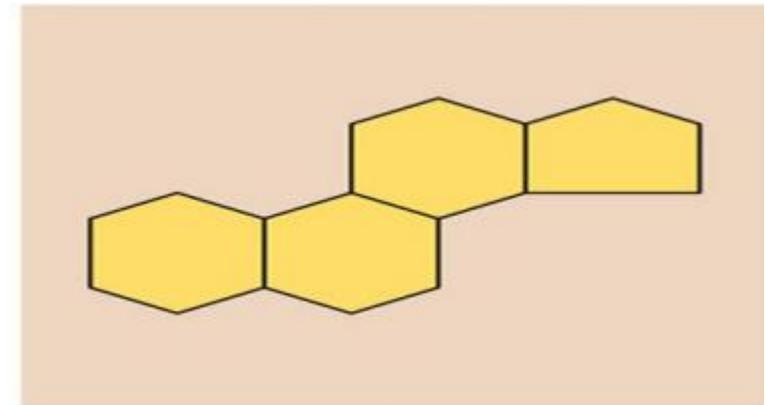
# Derived lipids

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➤ **Steroids** are derived lipids consists of four fused carbon rings. three fused cyclohexane (six-membered) rings and one fused cyclopentane (five-membered) ring.

- Examples: Steroid hormones, vitamin D
- Steroids containing one or more  
–OH group are often referred to sterols.
- \*Most important sterol in human body is

cholesterol



(a) General structure of a steroid

# Derived lipids

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**Cholesterol** is the most important sterol in human body

**Sources of cholesterol:**

1-Exogenous sources: egg yolk, liver, and dairy products

2-Endogenous sources: Synthesized in the body from acetyl CoA

**Functions:**

1. formation of cell membranes.
2. Cholesterol is a precursor for other important steroids including :

Bile salts, Hormones and Vitamin D

# *Digestion of dietary lipids*

# Digestion of dietary lipids

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The digestion of dietary lipids begins in the **stomach** and is completed in the **small intestine** .

The majority of dietary lipids are **triglycerides (TAGs)** that consists of three fatty acids (FA), whereas the remainder consists mainly of **cholesterol, cholesteryl esters, phospholipids**, and a small proportion of free fatty acids.

# Digestion in the stomach

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Lipid digestion in the stomach is **limited**. It is catalyzed by **lingual lipase** that originates from glands at the back of the tongue and **gastric lipase** that is secreted by the gastric mucosa. Both enzymes are relatively acid stable.

TAG molecules, particularly those containing fatty acids of short or medium-chain length (**fewer than 12 carbons, such as are found in milk fat**), are the primary target of this enzyme. these lipases play a particularly important role in lipid digestion in **infants** for whom milk fat is the primary source of calories.

# Emulsification of dietary lipid in the small intestine

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The critical process of emulsification of dietary lipids occurs in the **duodenum**. Emulsification **increases the surface area** of the hydrophobic lipid droplets so that the digestive enzymes which work at the interface of the droplet and the surrounding aqueous solution can act effectively.

Emulsification is accomplished by two complementary mechanisms

- 1- **Detergent properties of the bile salts,**
- 2- **Mechanical mixing due to peristalsis.**

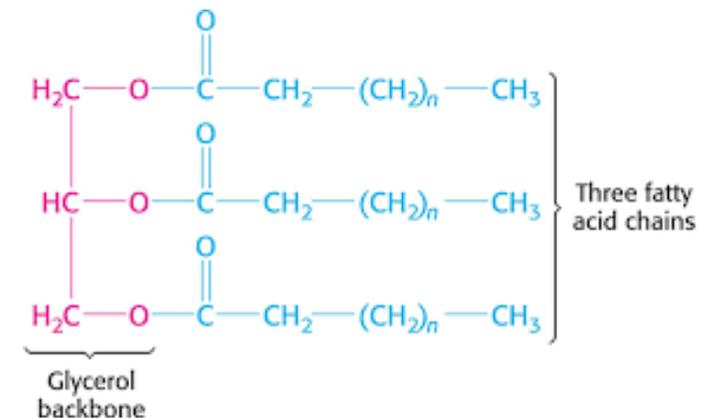
\***Bile salts, made in the liver and stored in the gallbladder, are derivatives of cholesterol**

# Degradation by pancreatic enzymes

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The **dietary TAG, cholesteryl esters,** and **phospholipids** are enzymatically degraded (“digested”) by **pancreatic enzymes**

- TAG degradation:** TAG molecules are too large to be taken up efficiently by the mucosal cells of the intestinal villi. Therefore, they are hydrolyzed by pancreatic lipase, which removes the FA at carbons **1 and 3**. **The primary products of hydrolysis are 2-monoacylglycerol (2-MAG) and FFA**



# Degradation by pancreatic enzymes

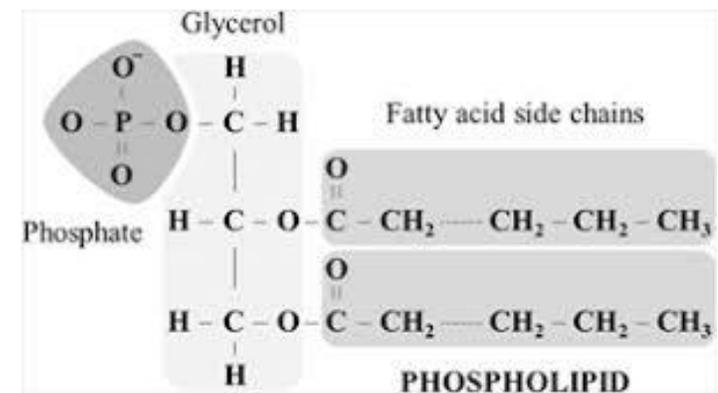
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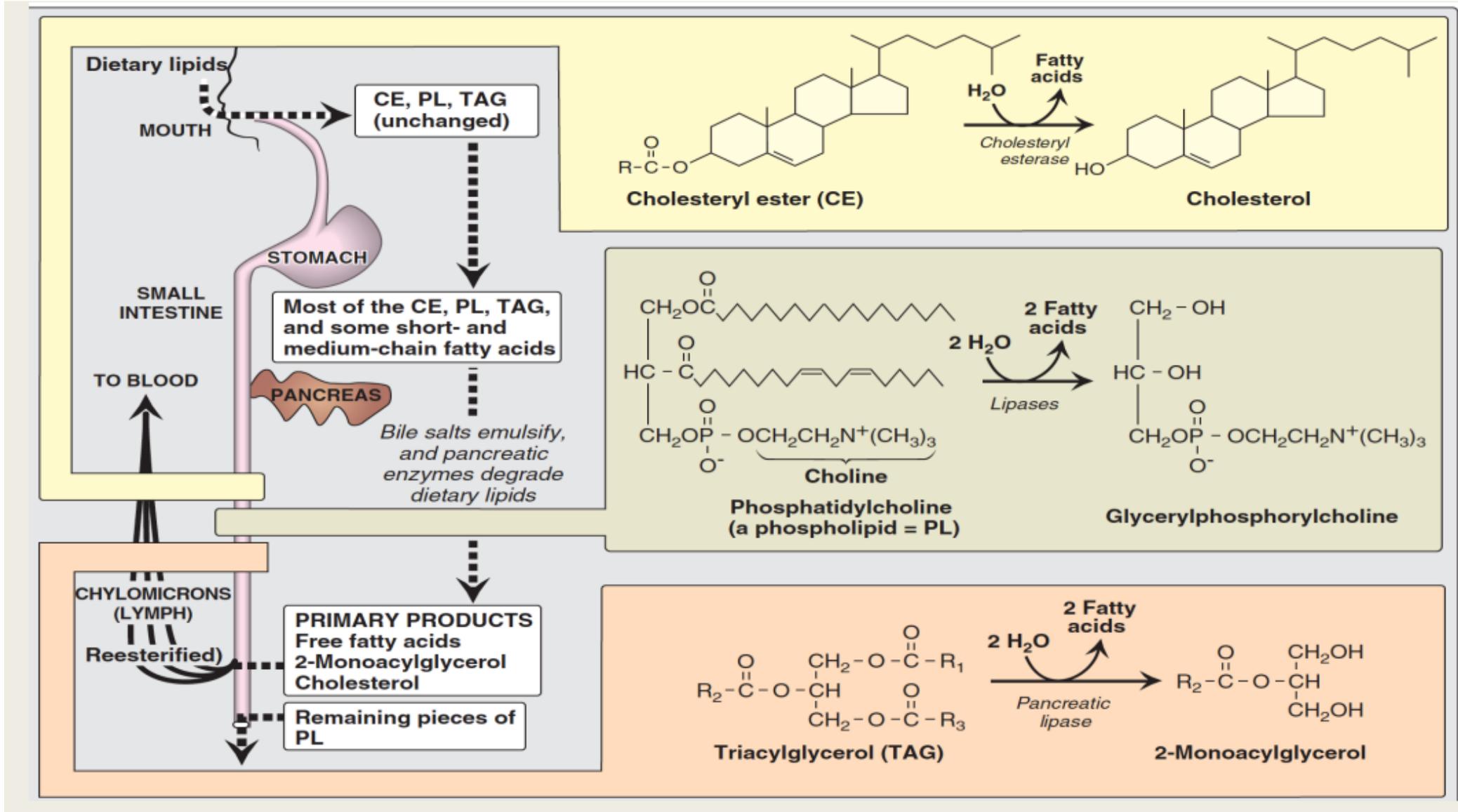
2. **Cholesteryl ester degradation:** Most dietary cholesterol is present in the free (non-esterified) form, with 10–15% in the esterified form. Cholesteryl esters are hydrolyzed by pancreatic cholesteryl ester hydrolase (**cholesterol esterase**), which produces **cholesterol plus free fatty acids**

# Degradation by pancreatic enzymes

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3. **Phospholipid degradation: Phospholipase A<sub>2</sub>**, secreted by the pancreas and activated in the presence of bile salts, **removes one fatty acid** from carbon 2 of a phospholipid, producing a lysophospholipid, the lysophospholipid is further hydrolyzed by **lysophospholipase**, removing the remaining fatty acid and forming glycerylphosphorylcholine.





## Overview of lipid digestion

*Thank You*