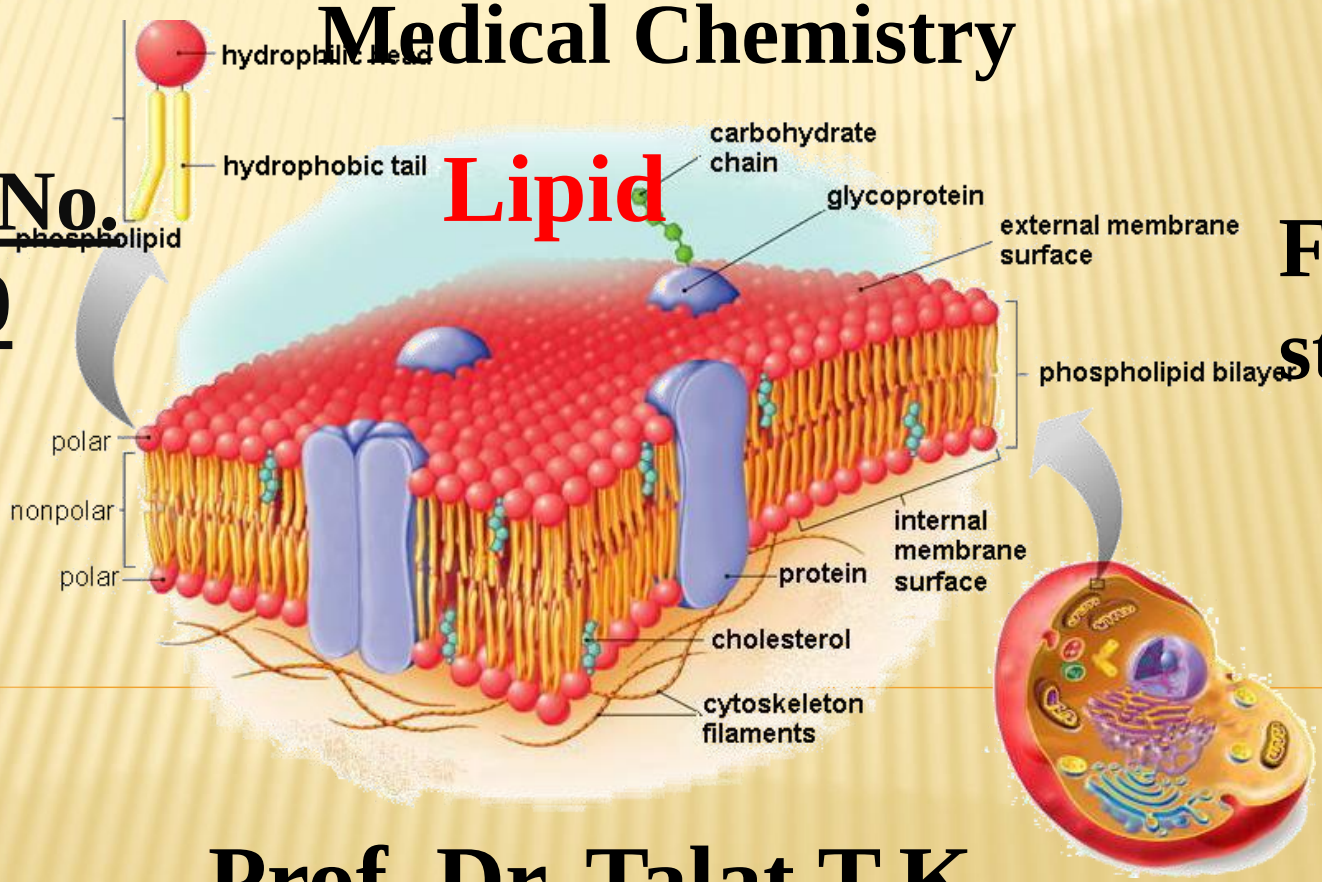
College of Medicine

Medical Chemistry

Lecture No. 8,9,10

Lipid

First stage

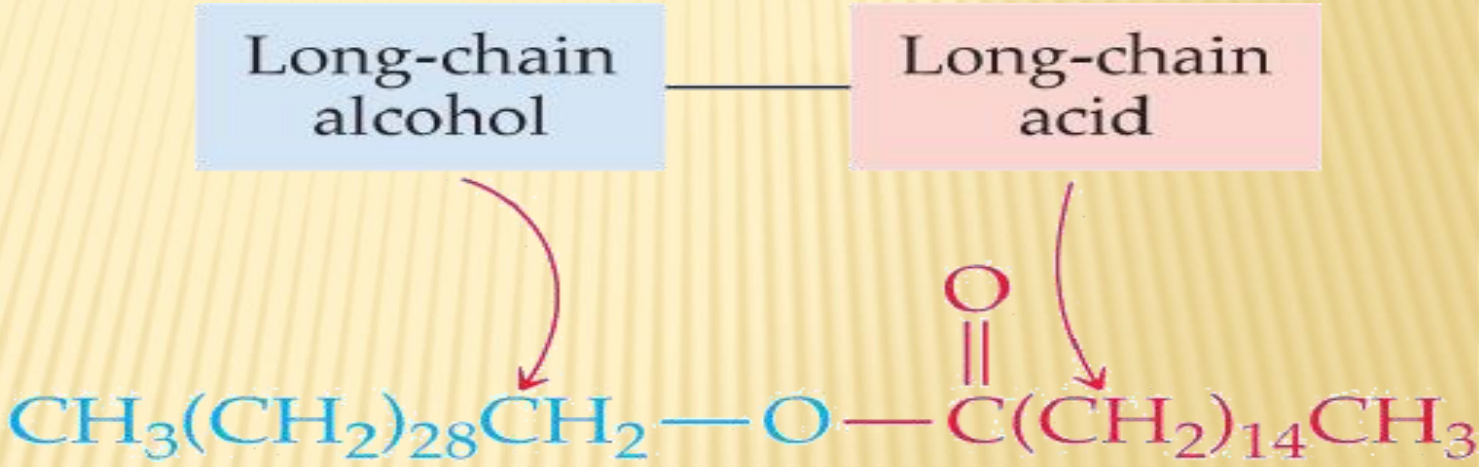


Prof. Dr. Talat T.K.

Lipids are one of the four major classes of biologically essential organic molecules found in all living organisms and together with carbohydrates, proteins and nucleic acids

Unlike carbohydrates, proteins and nucleic acids they aren't polymers but small molecules (M.wt between 100 and 5000)

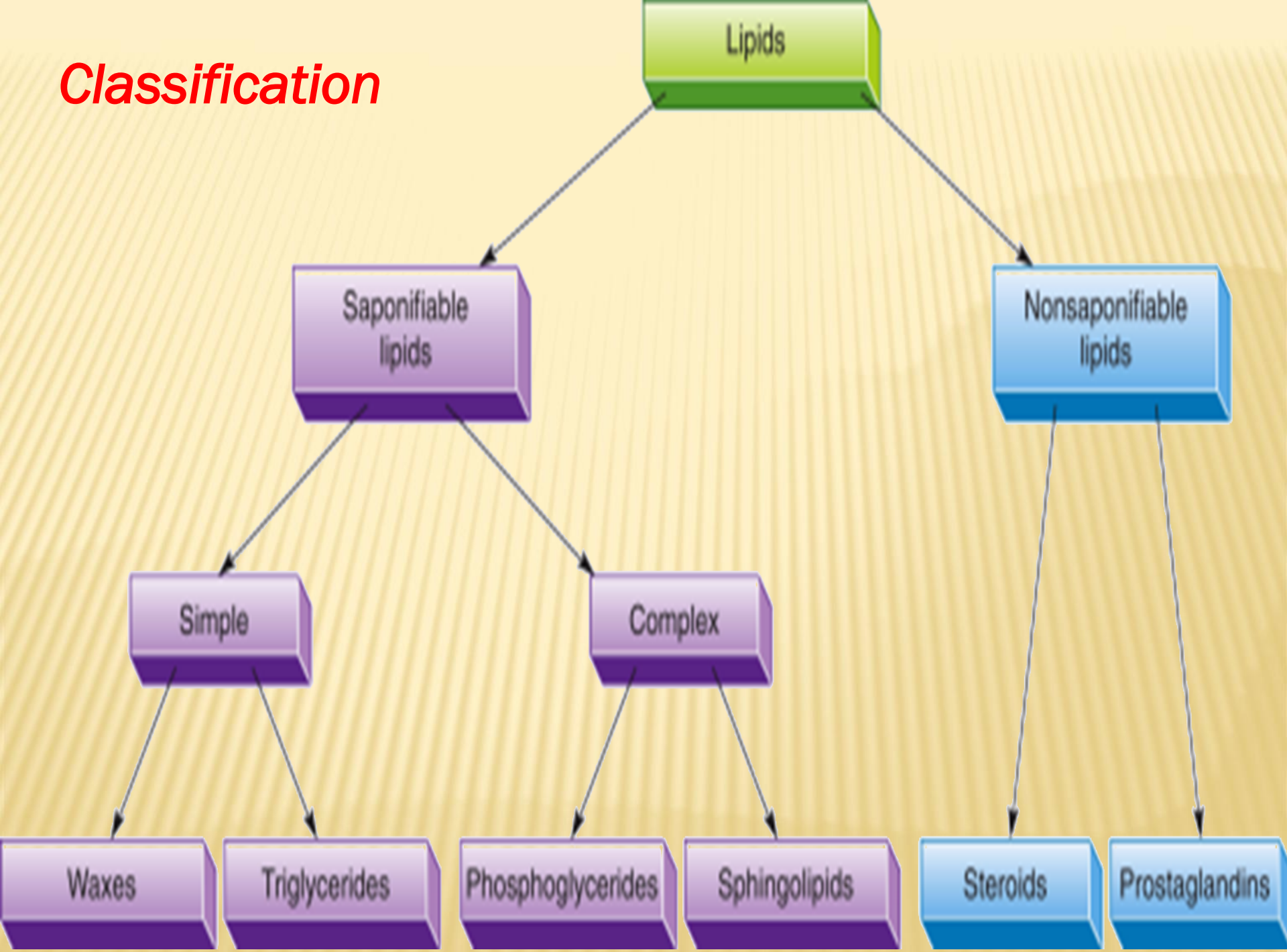
Wax



the lipid are soluble in organic solvents because a major portion of their structure is like a hydrocarbon.

Lipids or fats are macronutrients that are important in human nutrition. They are found mainly in dairy foods and meats, as well as other foods

Classification



The Role of lipid in body

a-As an energy source, lipids provide 9 kcal of energy per gram while Protein and carbohydrates both contain 4 Kcal per gram.

b-Triglycerides provide energy storage in adipose cell

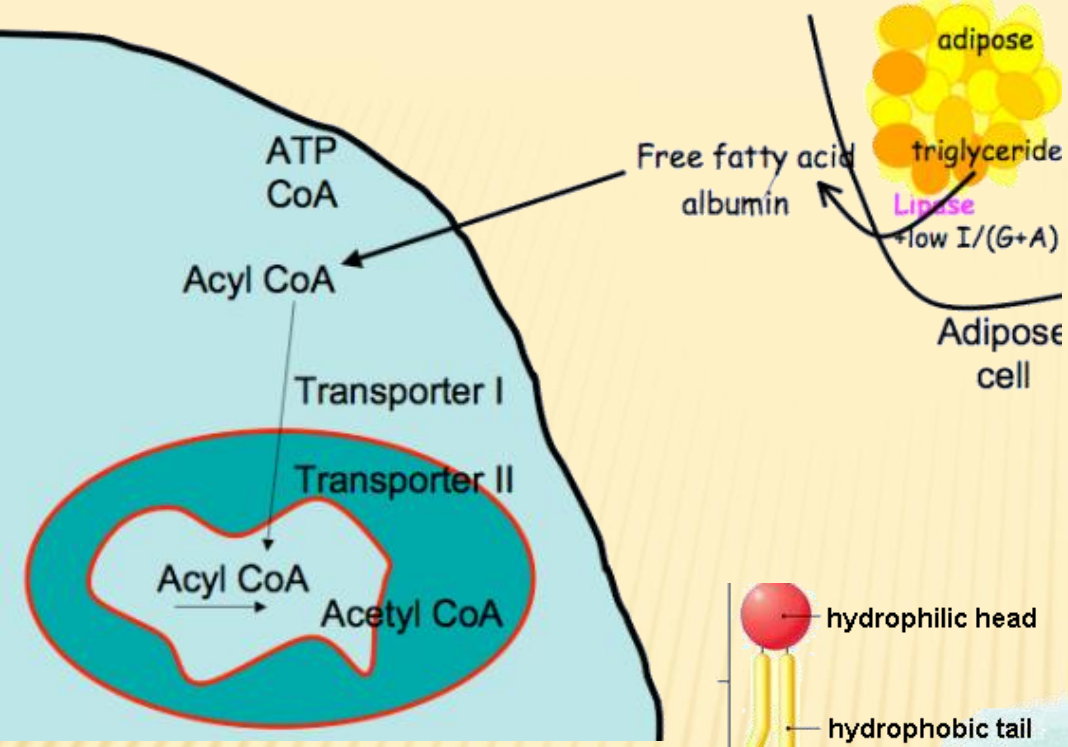
c- Phosphoglycerides, sphingolipids, and steroids are structural components of cell membranes

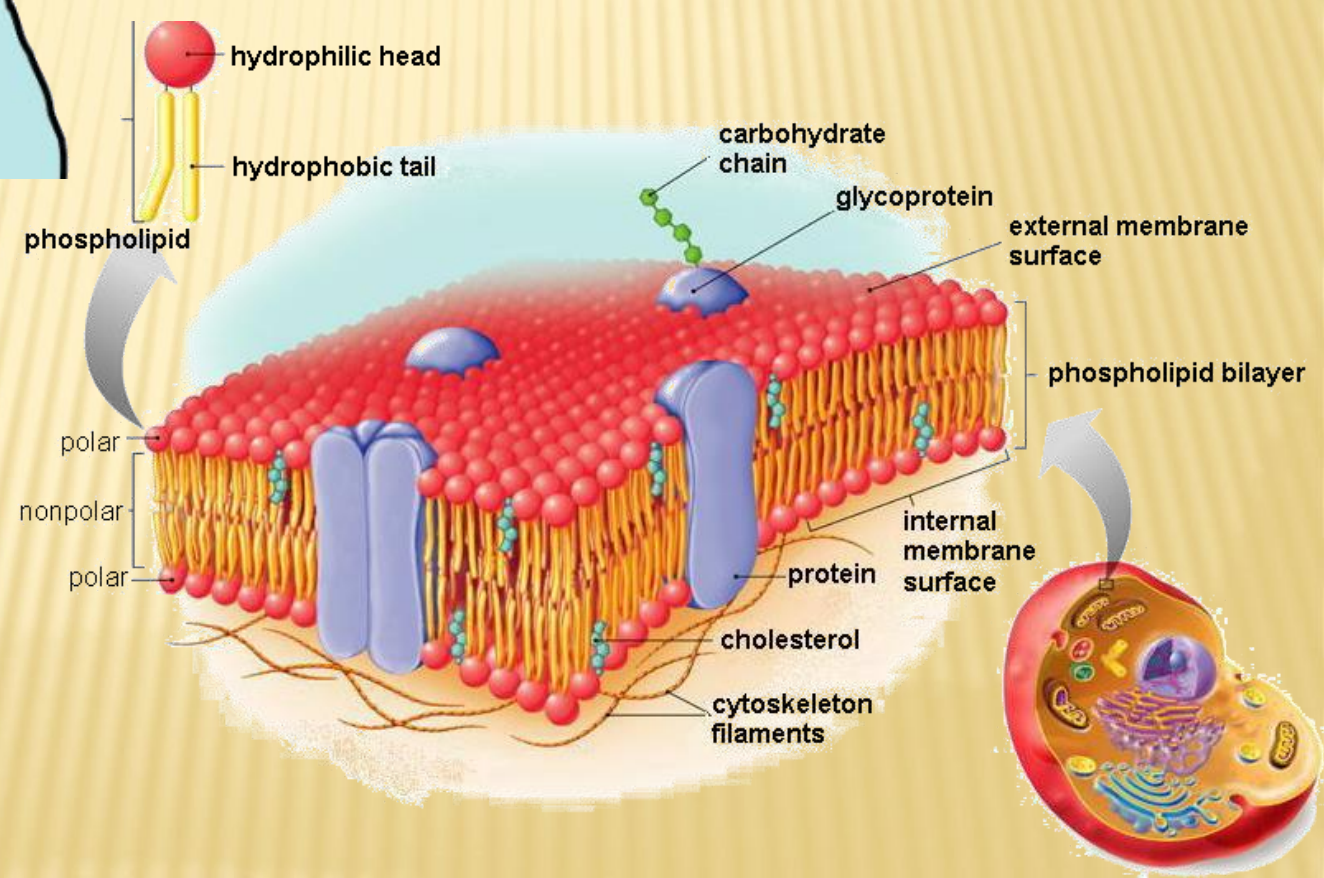
d- Steroid hormones are critical intercellular messengers

f- Essential nutrients such as Lipid-soluble vitamins (A, E, D, K)

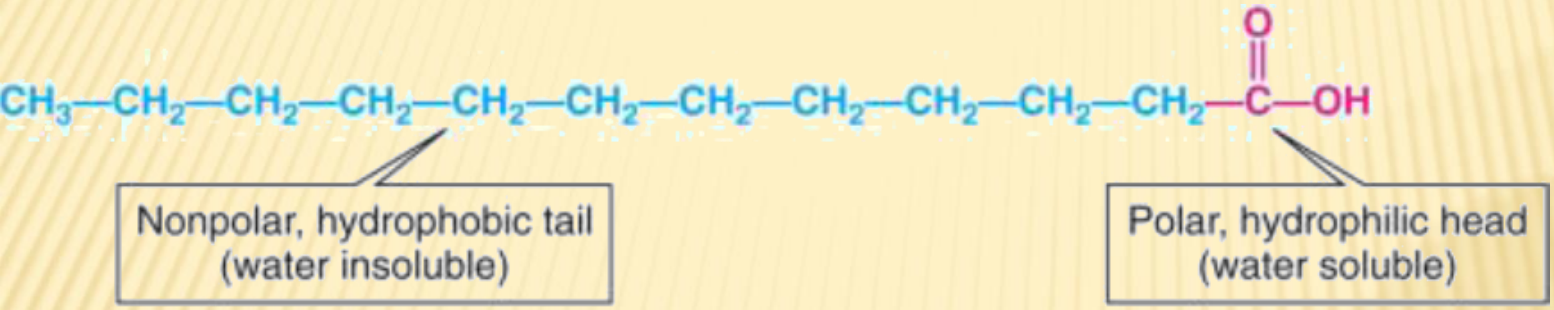
e- Dietary fat acts as a carrier of lipid-soluble vitamins into cells of small intestine

g- Provide shock absorption and insulation


ATP
CoA
Acyl CoA
Transporter I
Transporter II
Acyl CoA
Acetyl CoA
Free fatty acid
albumin
adipose
triglyceride
Lipase
+low I/(G+A)
Adipose
cell


hydrophilic head
hydrophobic tail
phospholipid
carbohydrate
chain
glycoprotein
external membrane
surface
phospholipid bilayer
polar
nonpolar
polar
internal
membrane
surface
protein
cholesterol
cytoskeleton
filaments

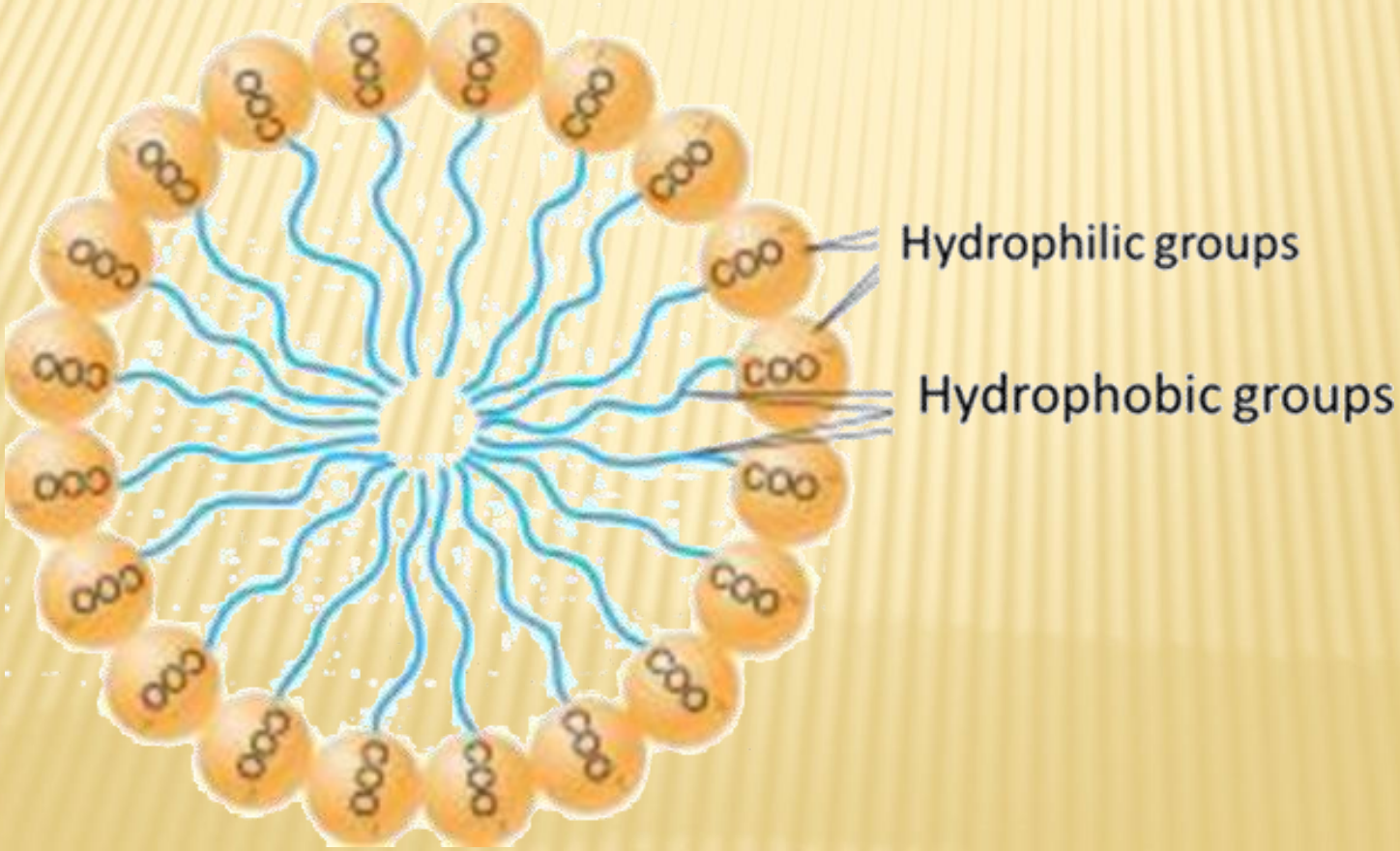
Fatty Acids are long-chain carboxylic acids:

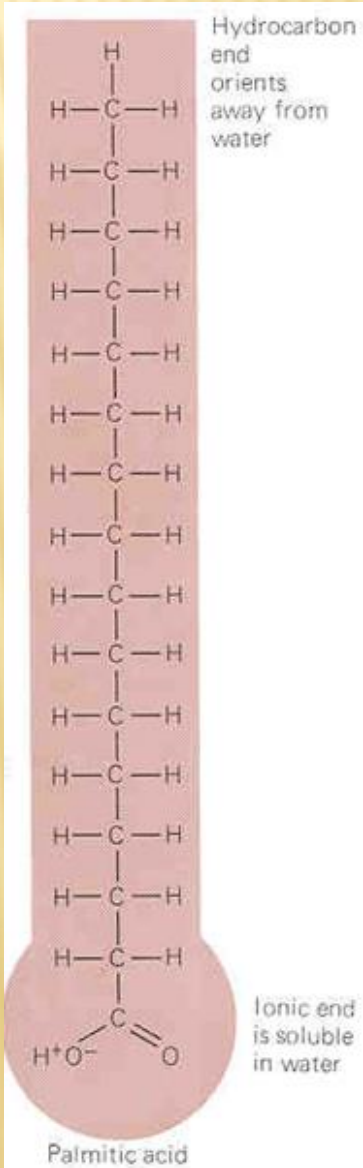


Nonpolar molecules that repel the water molecules are said to be **hydrophobic**; molecules forming ionic or a hydrogen bond with the water molecule are said to be **hydrophilic**

fatty acids have nonpolar hydrocarbon tails that are responsible for most of the fatty or oily and have The carboxyl (COOH) group is hydrophilic

In **aqueous solutions**, fatty acids associate with each other in spherical clusters called **micelles**

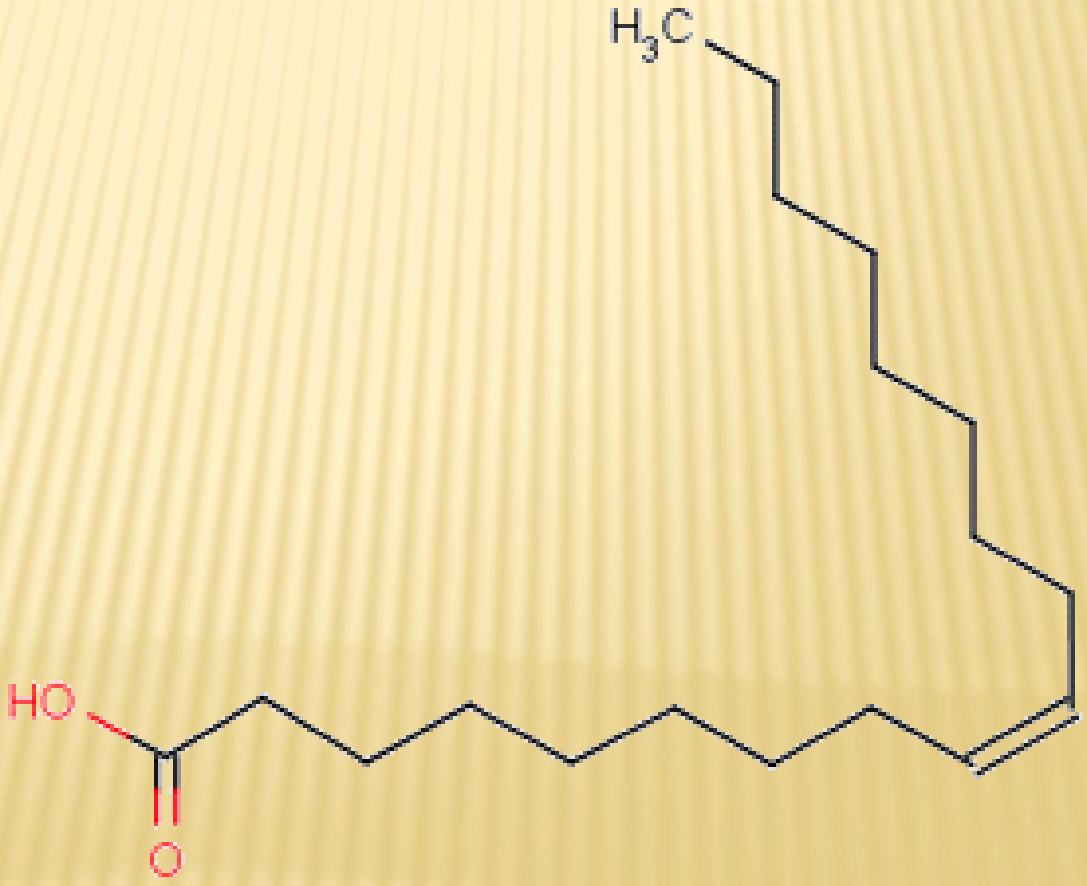




Classification of fatty acids

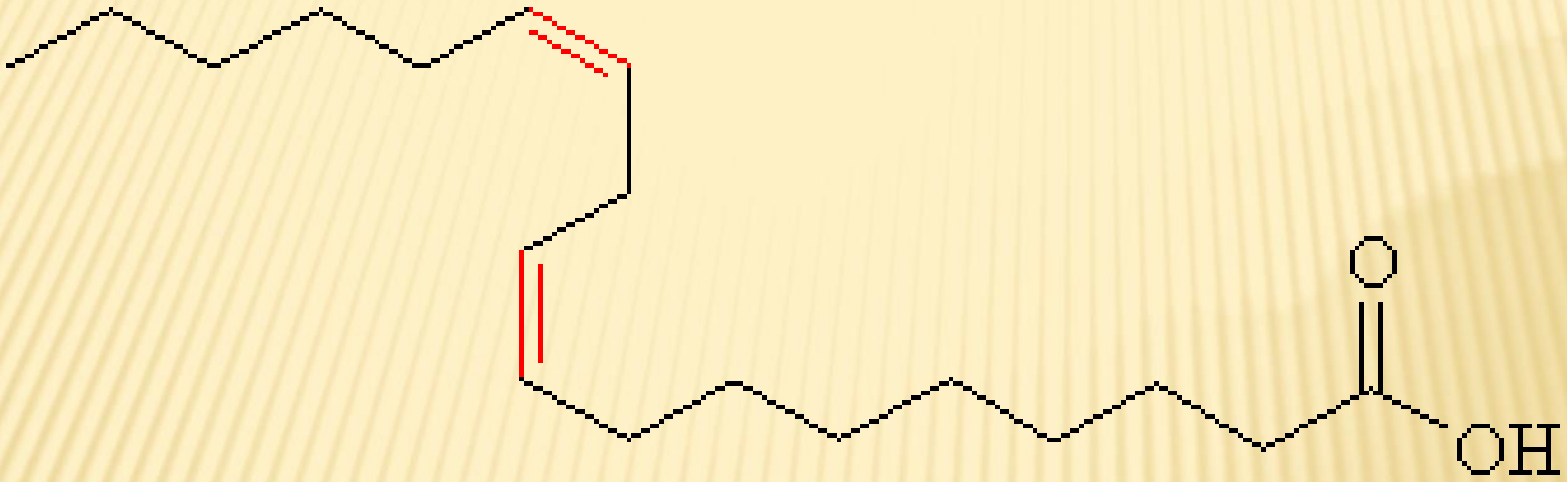
1- 0 double bonds: saturated fatty acids

2- 1 double bond: monounsaturated fatty acids



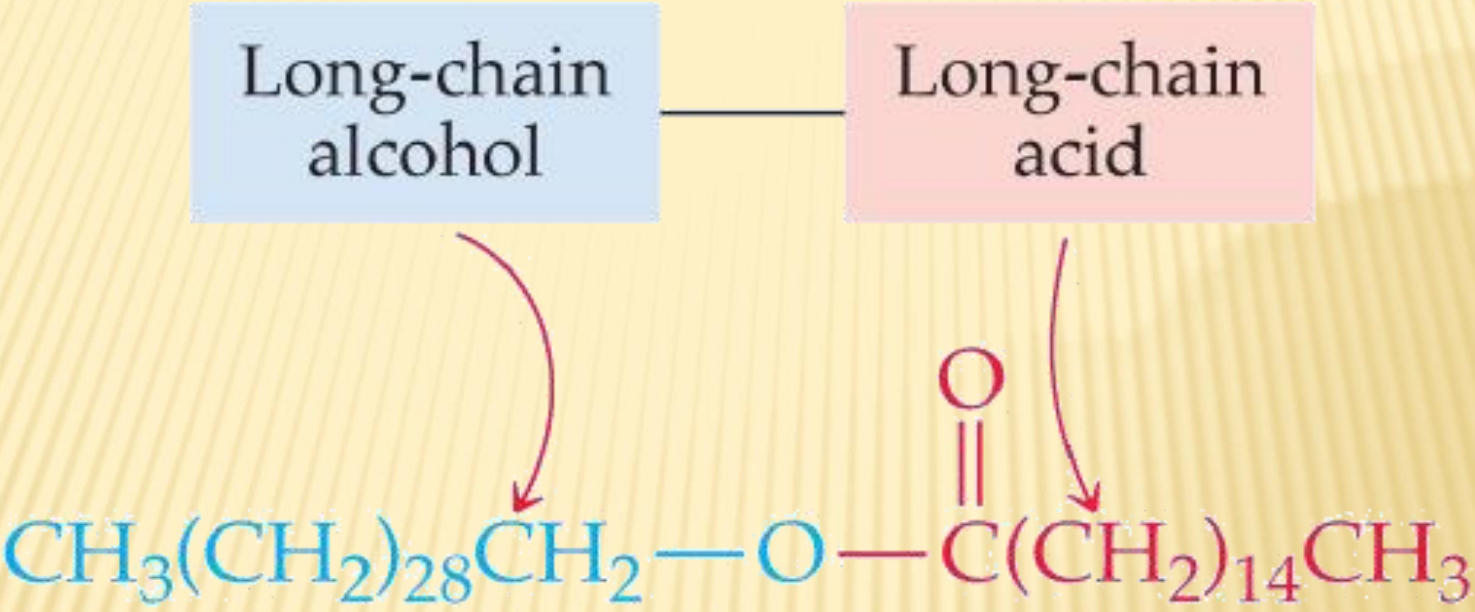
Oleic acid

3- 2 or more double bonds: polyunsaturated fatty acids



Linoleic acid

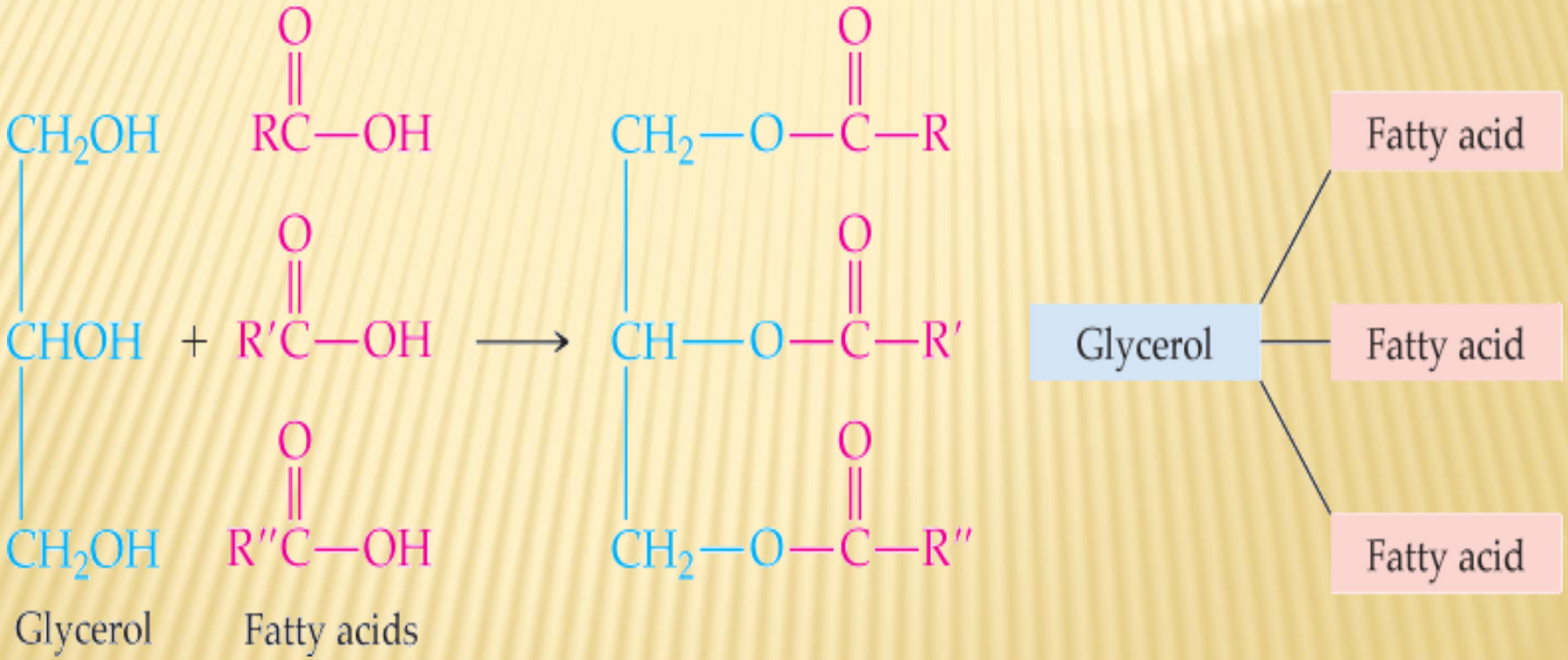
Waxes: They are simple lipids contain esters of saturated fatty acids and long-chain (26-34 carbon) alcohols



Plant waxes help to prevent water loss, and protect plants from bacterial as well as minimizing damage by UV radiation

These include the liquid waxes used for lubricants, cosmetics, and printing inks, and the solid waxes used for candles, polishes etc.

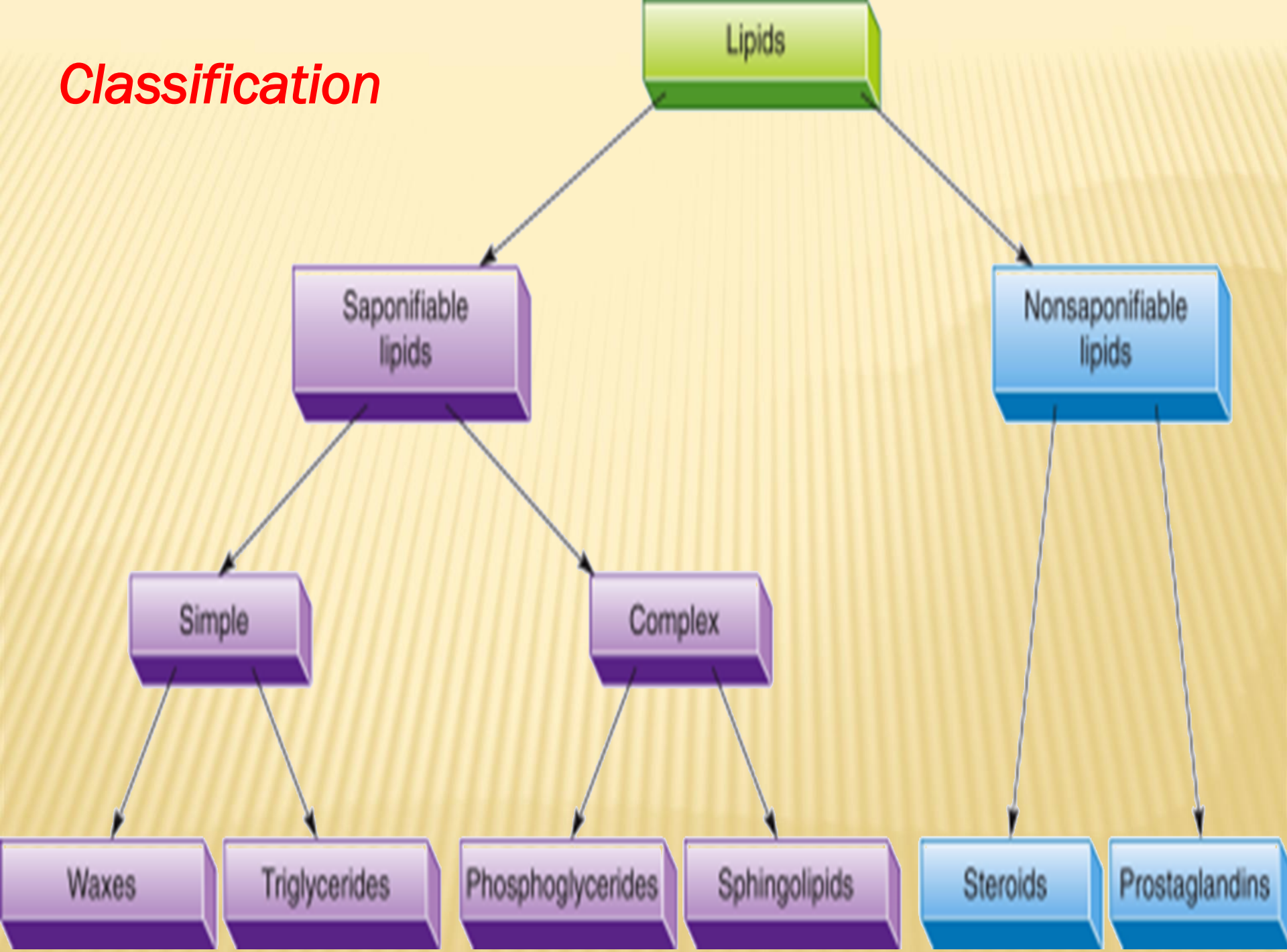
Fats and oils are esters composed the hydroxyl groups of glycerol react with the carboxyl groups of fatty acids. producing a structure called a triglyceride or a triacylglycerol



The fatty acids in a triglyceride molecule are usually not all the same

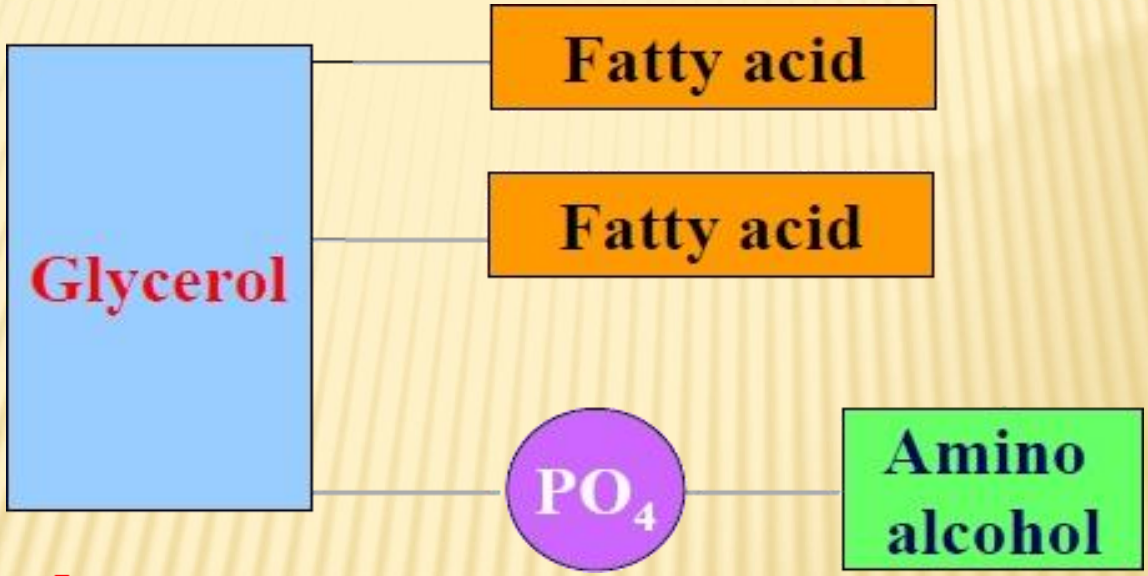
Fats are triglycerides that are solids at room temp, usually derived from animals, mostly saturated fatty acids while oils are triglycerides that are liquids at room temp, usually derived from plants or fish, mostly unsaturated fatty acids

Classification

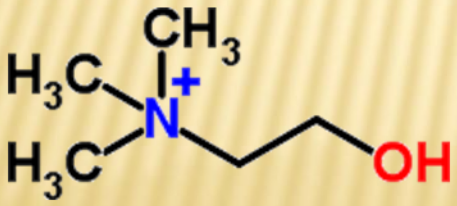


phosphoglycerides

Glycerophospholipids are complex lipids that are major components of cell membranes, phosphoglycerides contain **aminoalcohols**(choline, ethanolamine, or serine)attached to the **phosphate group**.

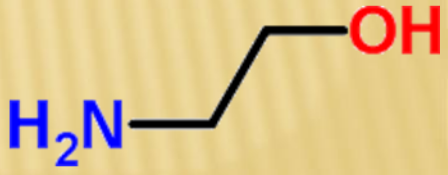


aminoalcohols



choline

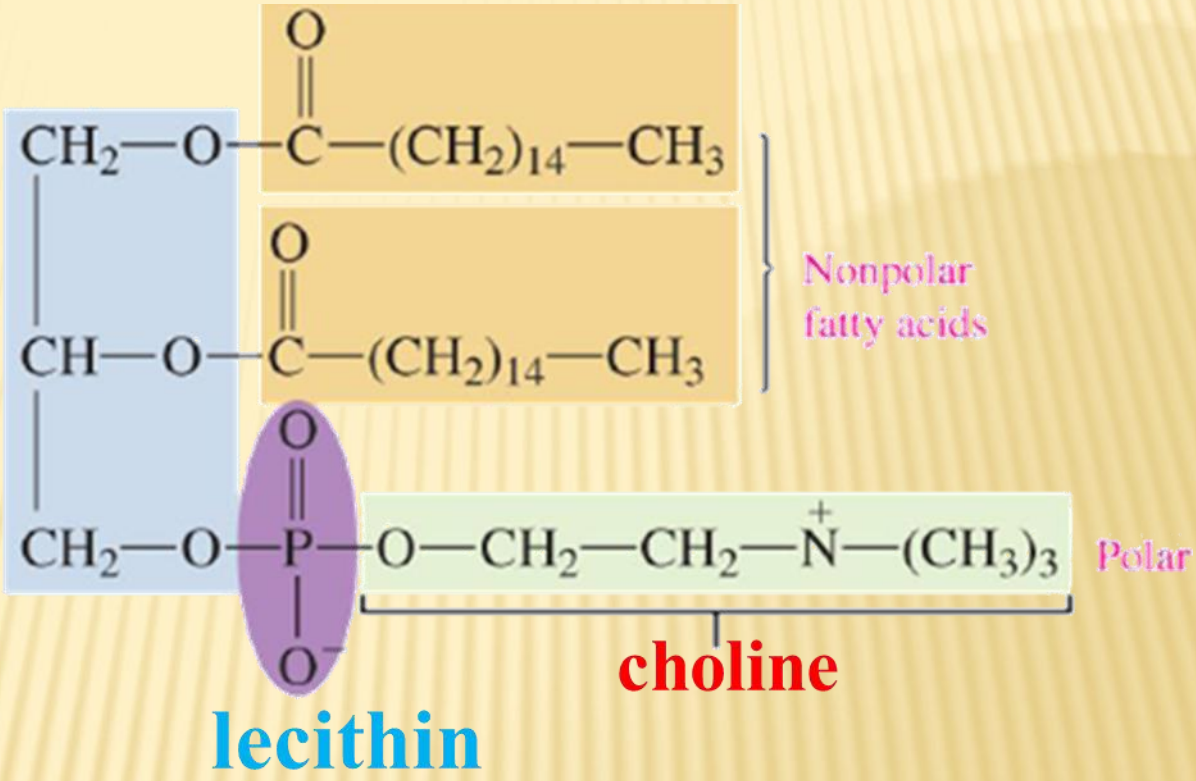
serine



ethanolamine

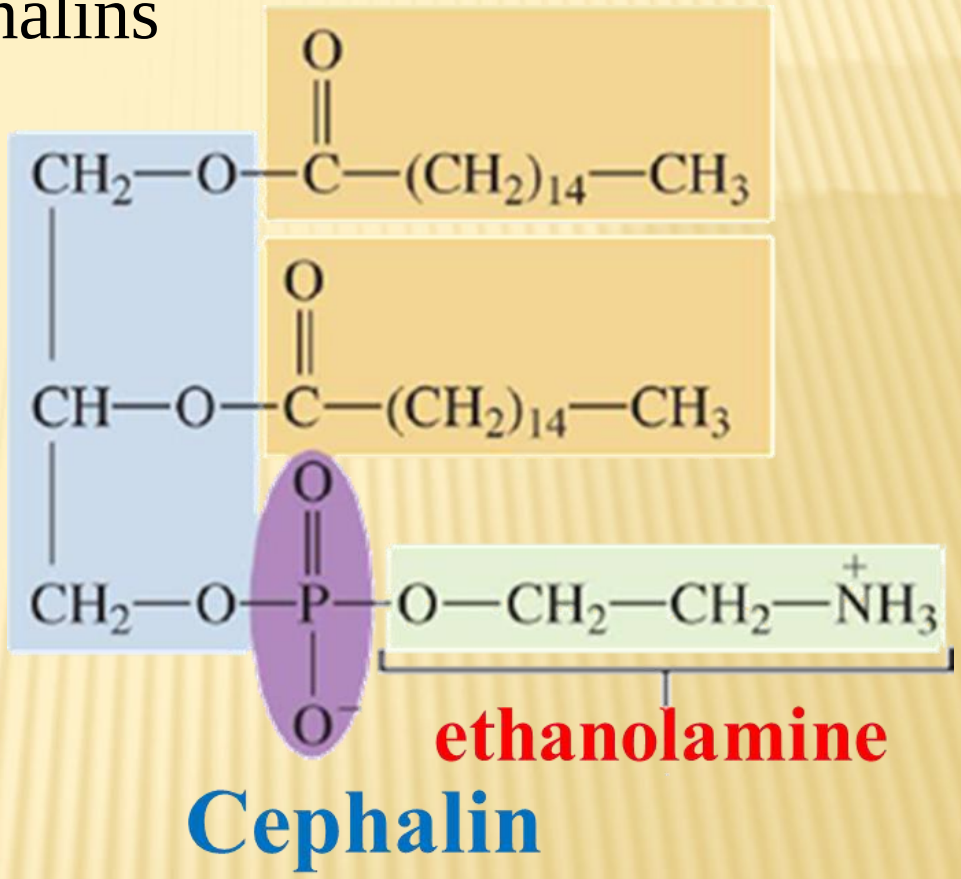
lecithins

Phosphoglycerides that contain the aminoalcohol choline are called **lecithins**.

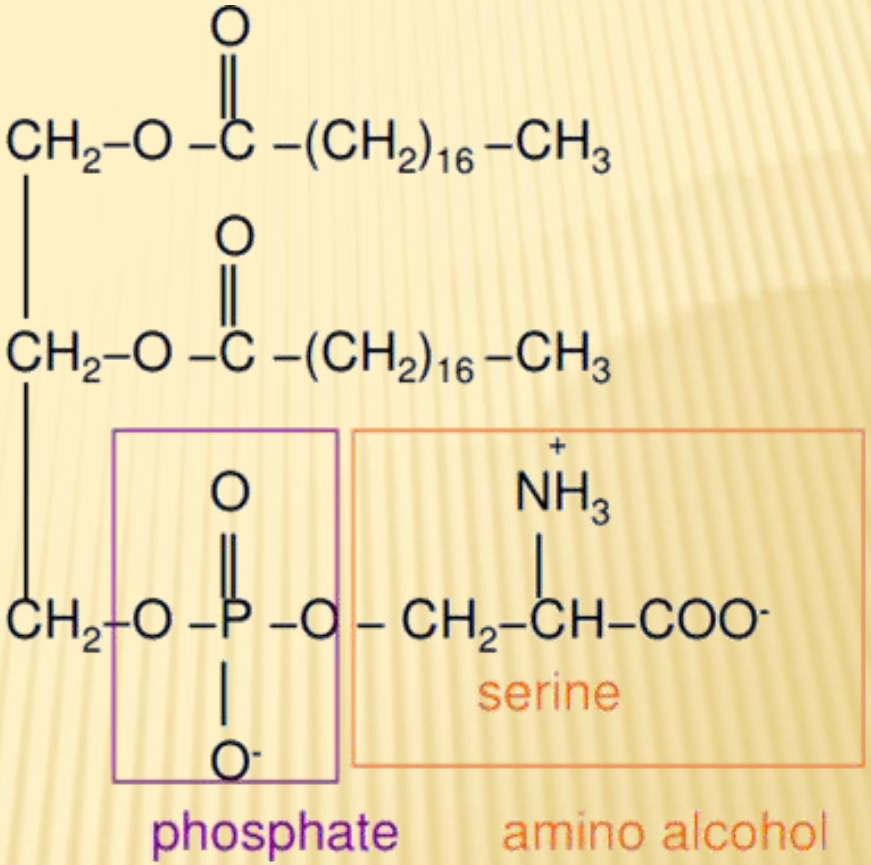


Cephalin

Phosphoglycerides that contains the aminoalcohols ethanolamine are called cephalins

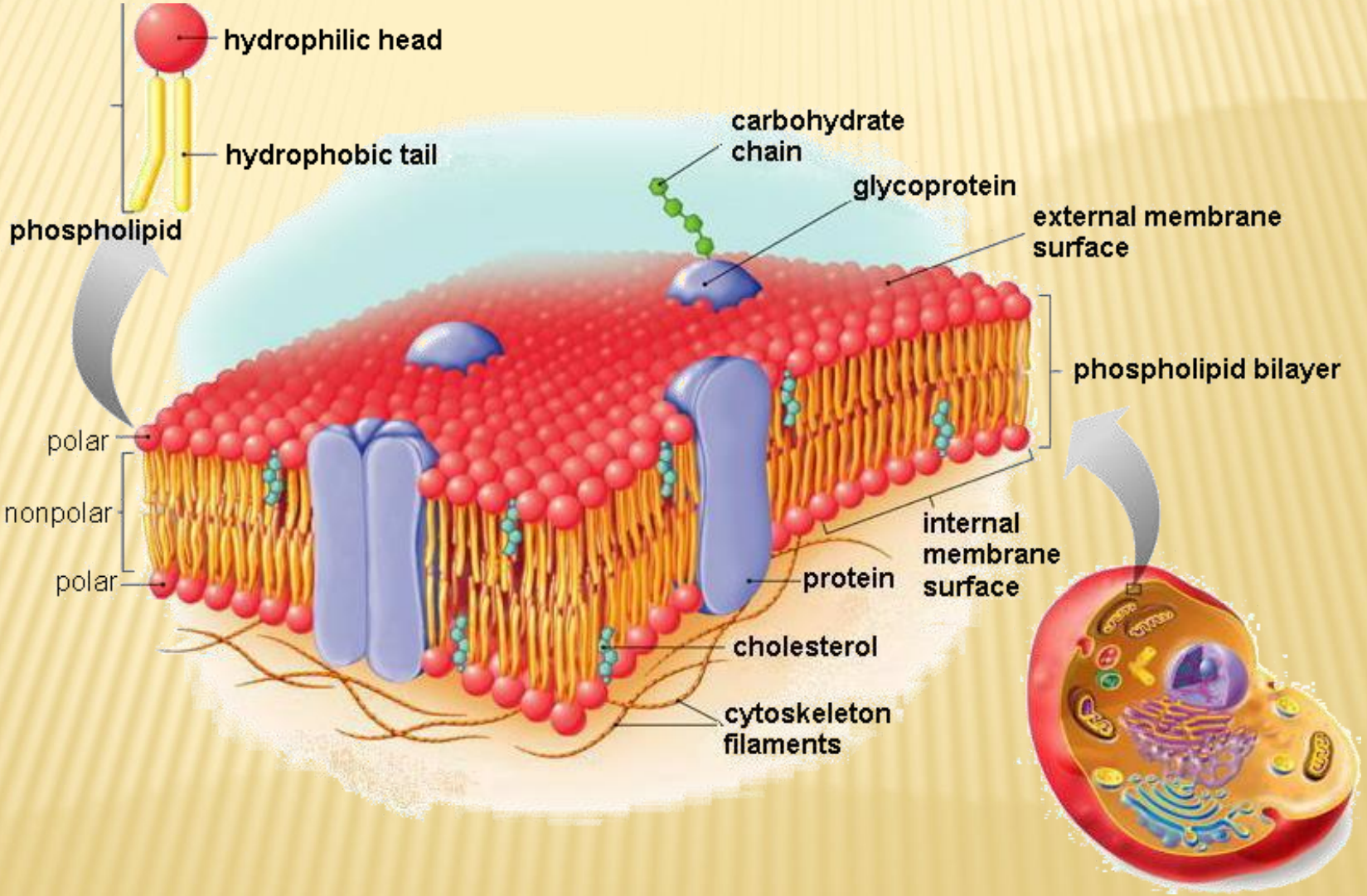


Phosphoglycerides that contains serine are called Phosphatidylserine



Phosphatidylserine (PS)

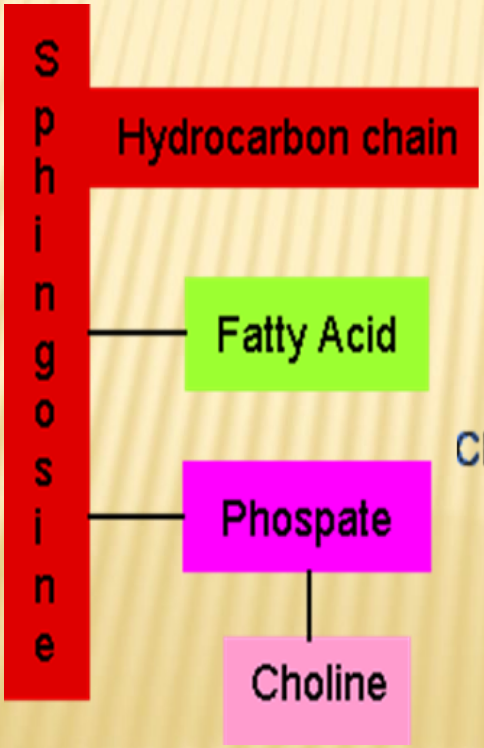
phospholipids make up the basic structural components of the cell membrane

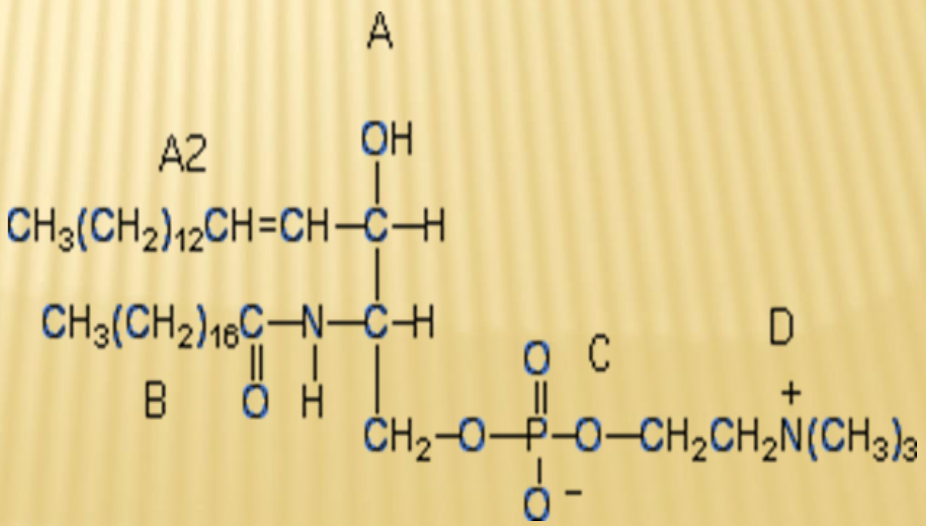


Sphingolipids : are complex lipids that contain sphingosine instead of glycerol and play the role in protects nerves

Sphingosine

One important type of sphingolipds are the sphingomyelins:

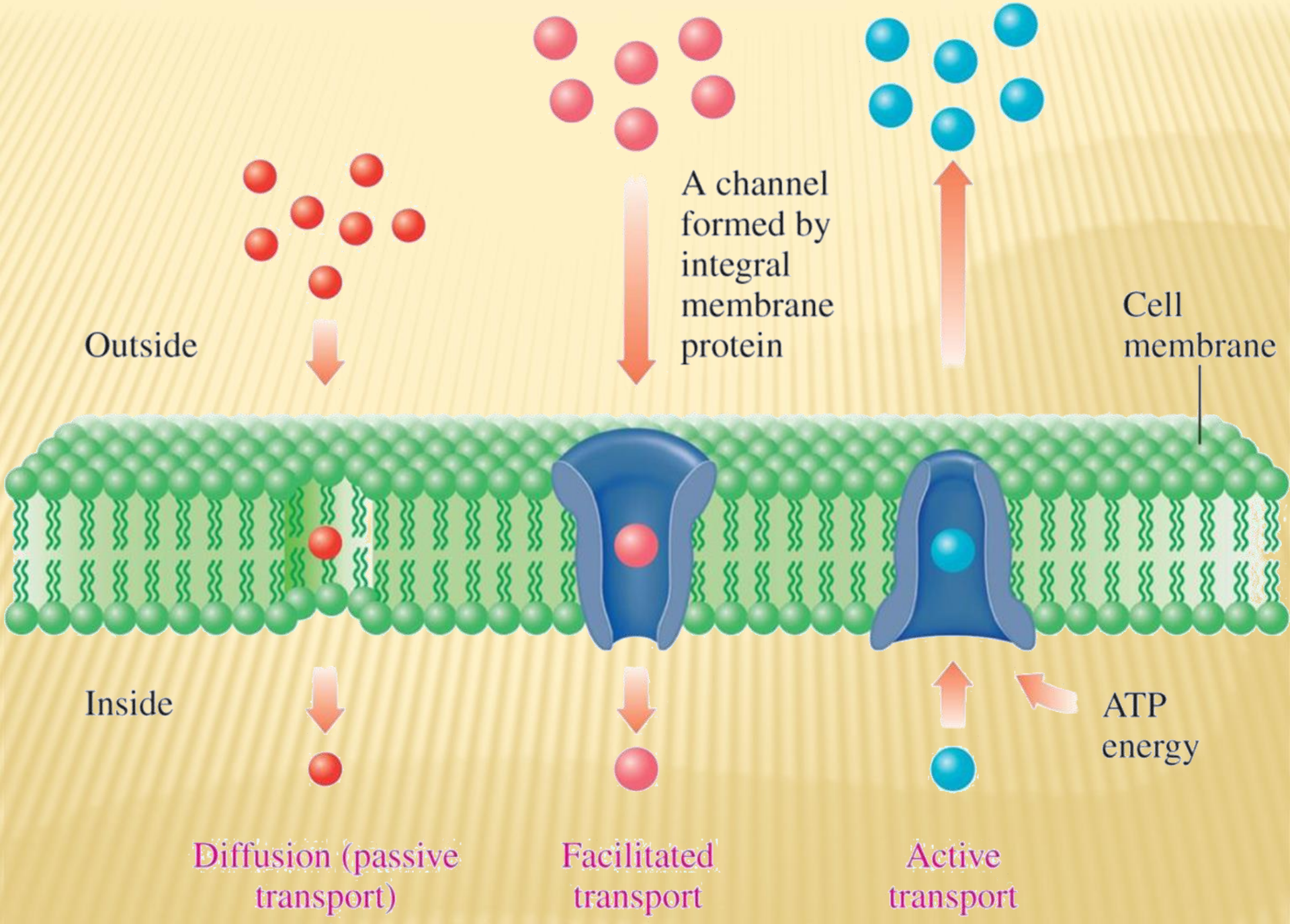




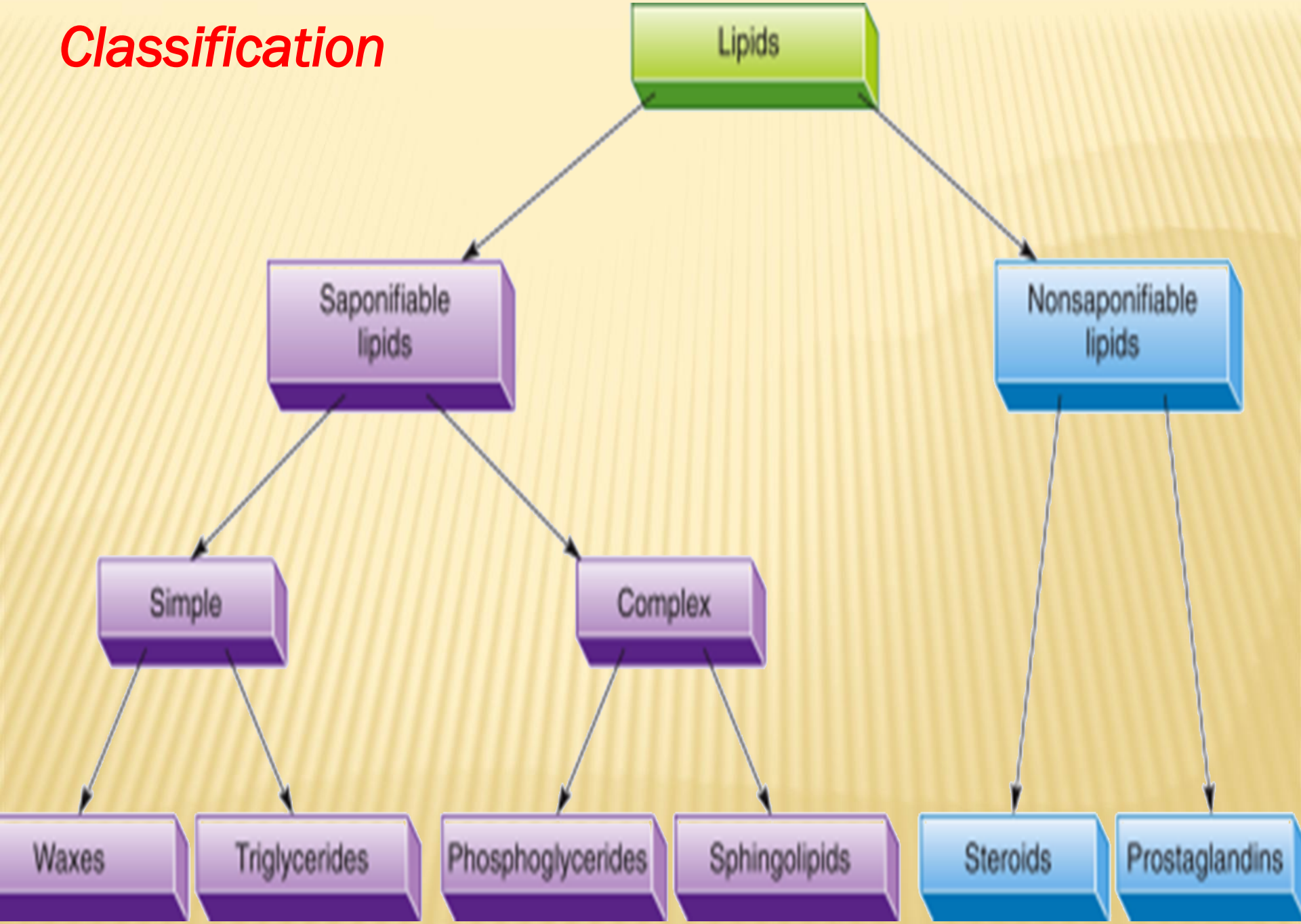
Transport through Cell Membranes

The transport of substances through cell membranes involves

- **diffusion (passive transport), which moves particles from a higher to a lower concentration**
- **facilitated transport, which uses protein channels to increase the rate of diffusion**
- **active transport, which moves particles from a lower to a higher concentration by using ATP**

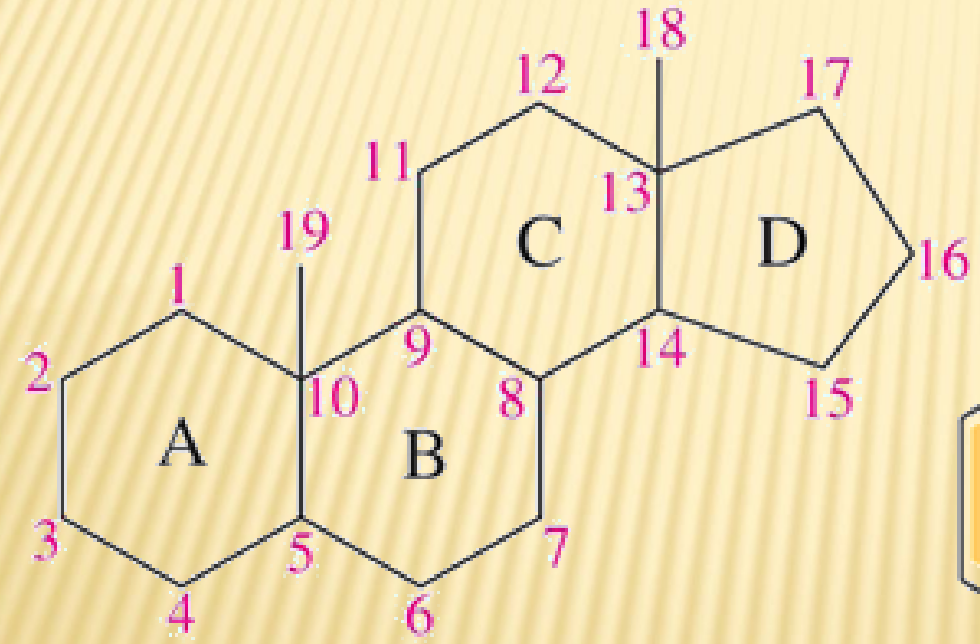

A channel formed by integral membrane protein
Outside
Cell membrane
Inside
ATP energy
Diffusion (passive transport)
Facilitated transport
Active transport

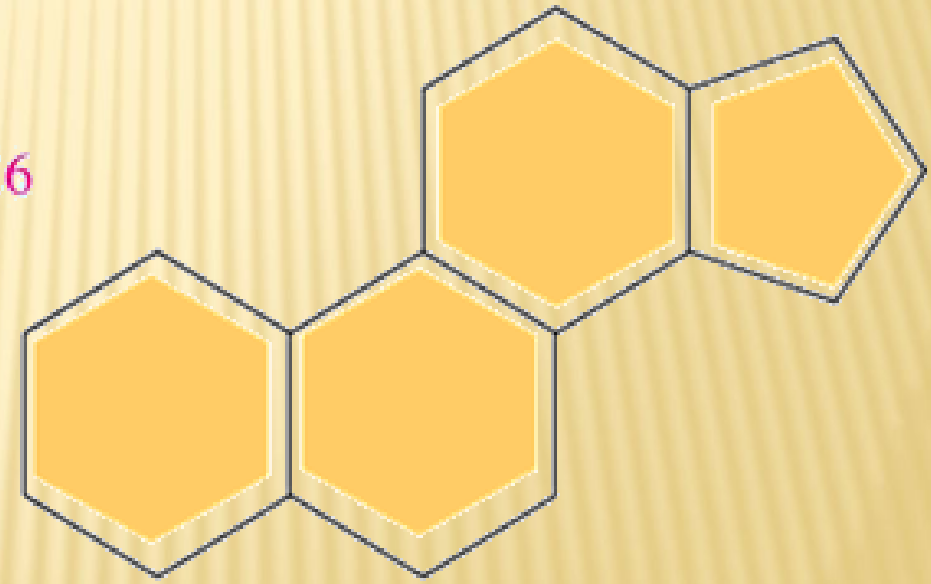
Classification



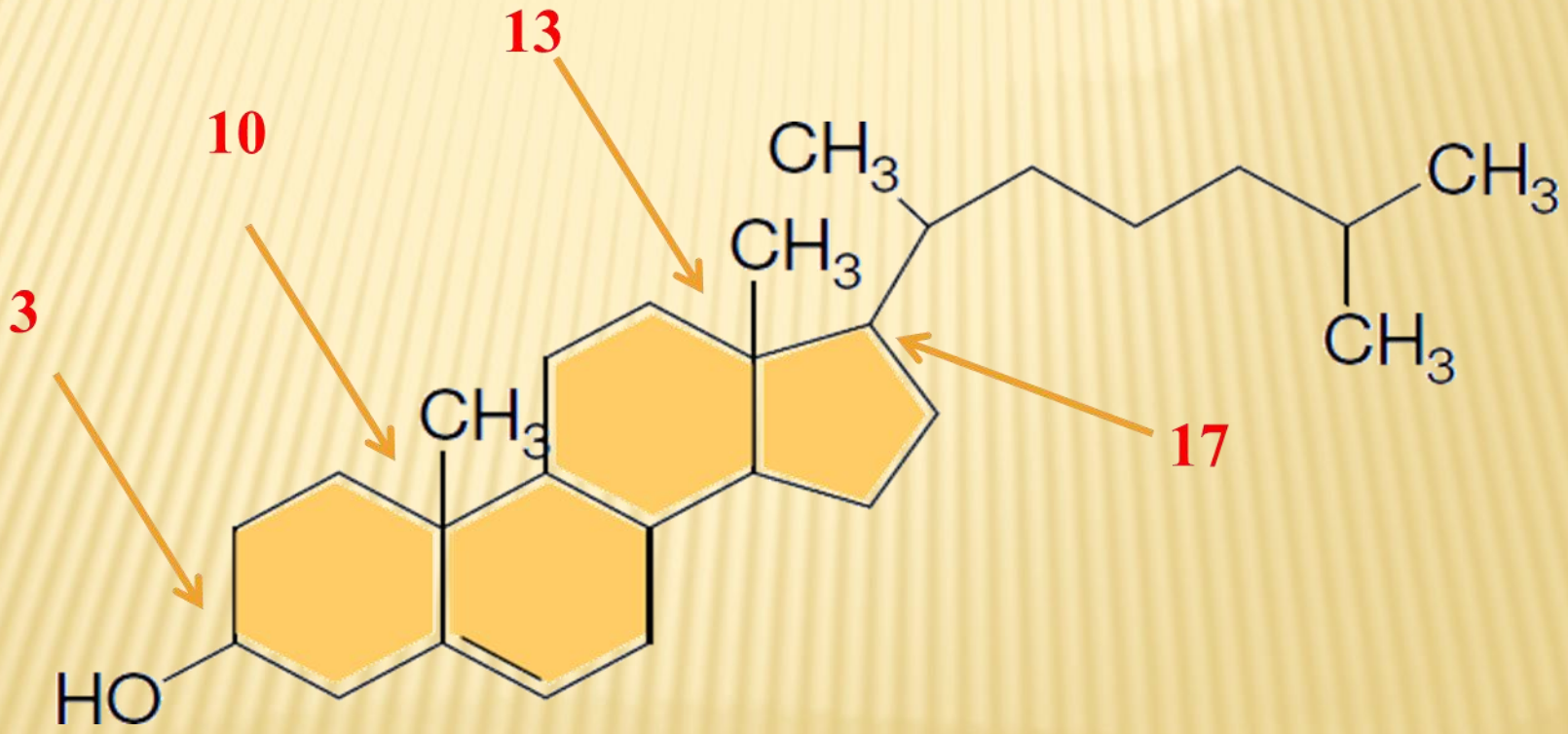
non-saponifiable

A steroid nucleus consists of three cyclohexane rings and one cyclopentane ring fused together.





Cholesterol is the most abundant steroid in the body, the characteristic steroid alcohol of animal tissues, is a very hydrophobic compound, and is synthesized in the liver.



It is an essential component of cell membranes, and is a precursor for other steroids, such as the bile salts, sex hormones, vitamin D, and the adrenocorticoid hormones.

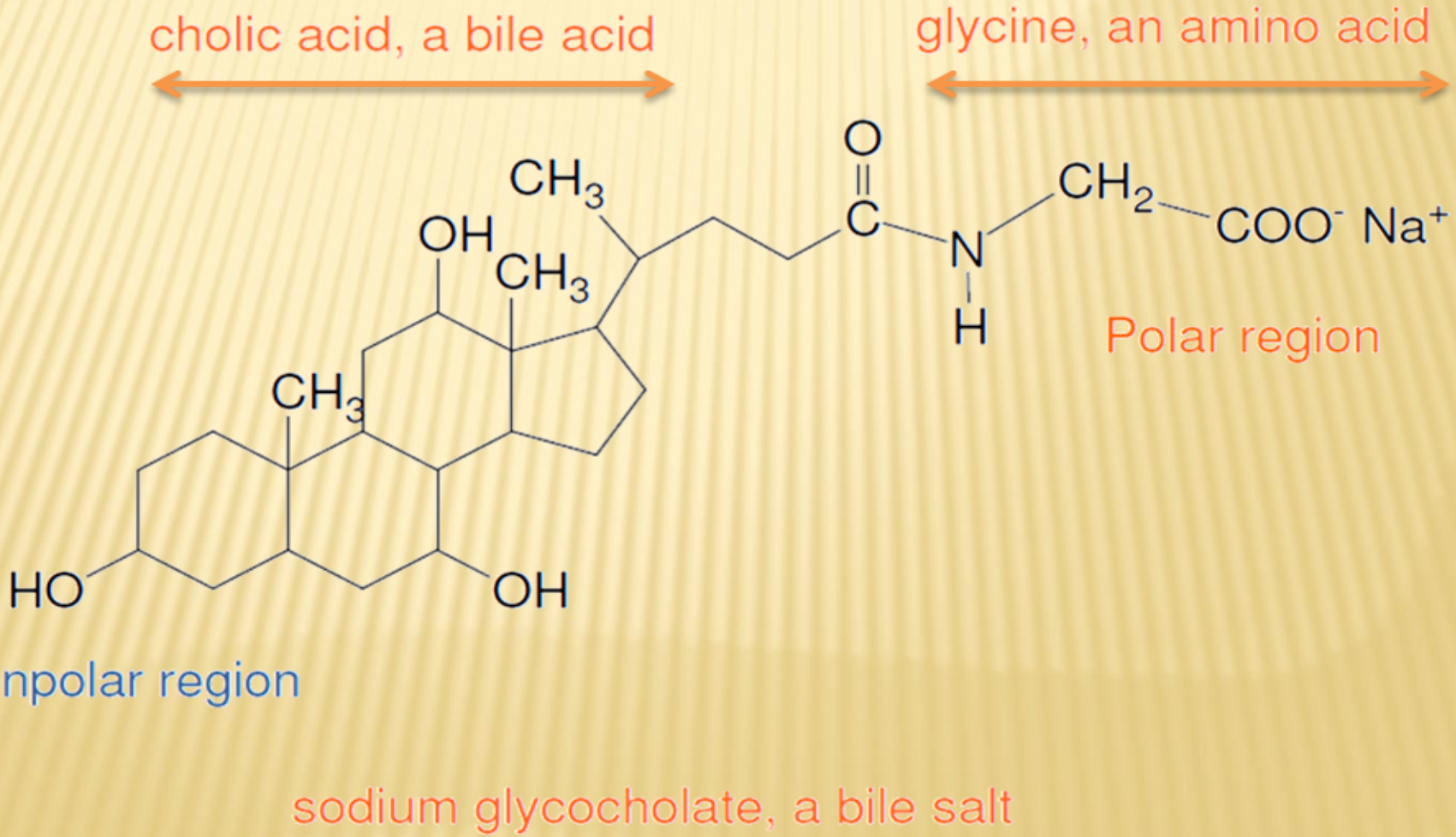
There is a correlation between high levels of cholesterol in the blood and atherosclerosis.

Normal open artery

An artery clogged by cholesterol plaque

Bile Salts

Bile is a yellowish brown or green fluid produced in the liver and stored in the gall bladder . They are synthesized in the liver from cholesterol, have polar and nonpolar regions that act like soaps to make fat soluble in water , help in absorption of cholesterol



If cholesterol levels are too high or the levels of bile salts is too low, the cholesterol precipitates lead to forms gallstones.

Gallstones can block the duct that allows bile pigments absorbed into the blood causes the skin to become yellow and the stool to become gray

Adrenocorticoid Hormones

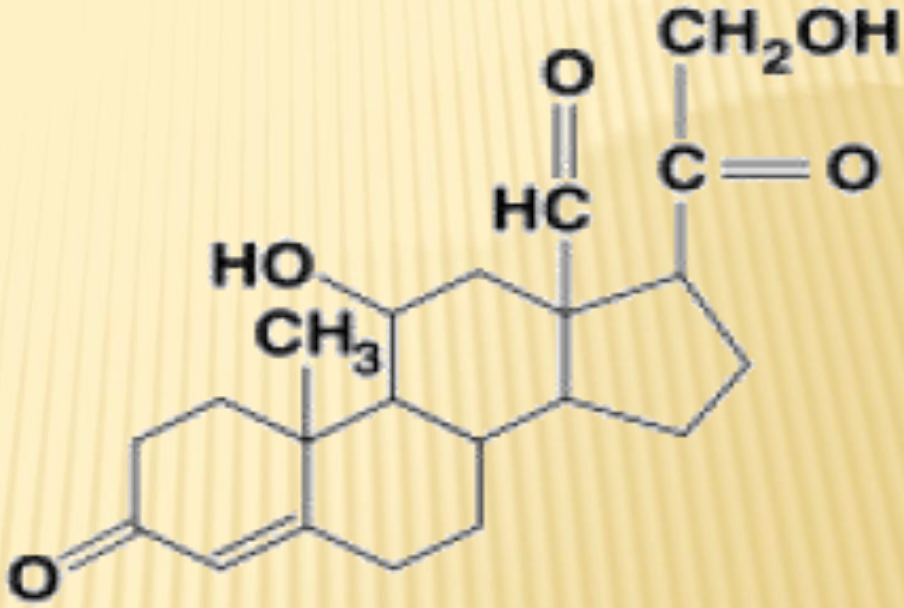
Hormones are chemicals released by cells or glands in one part of the body that send out messages that affect cells in other parts of the body. Many hormones are based on steroids.

The adrenocorticoid hormones are produced in the adrenal glands (located on the top of the kidney). They include

(1) aldosterone, which regulates electrolytes and water balance by the kidneys

(2)cortisone, a glucocorticoid, which increases blood glucose level and stimulates the synthesis of glycogen in the liver ,and serve as anti-inflammatory agents

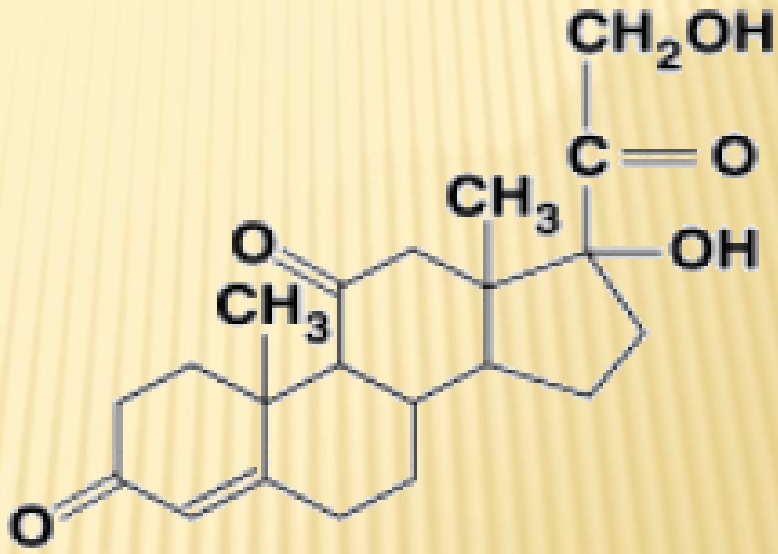
1) aldosterone, which regulates electrolytes and water balance by the kidneys



Aldosterone (mineralocorticoid)
(produced in adrenal gland)

Increases the reabsorption of Na^+ in kidneys; retention of water

2)cortisone, a glucocorticoid, which increases blood glucose level and stimulates the synthesis of glycogen in the liver ,and serve as anti-inflammatory



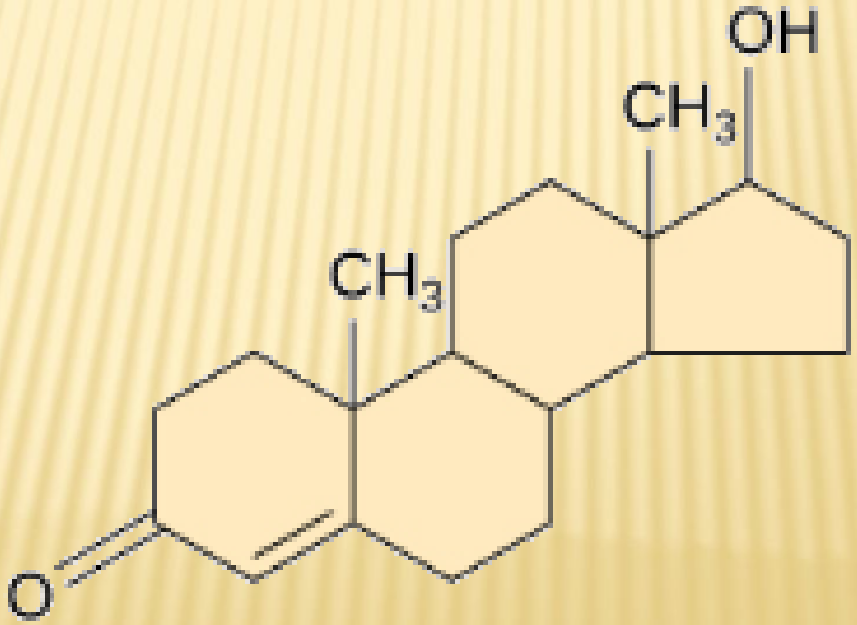
Cortisone
(produced in adrenal gland)

Increases the blood glucose and glycogen levels from fatty acids and amino acids

Sex Hormones(testosterone, estrogen and progesterone)

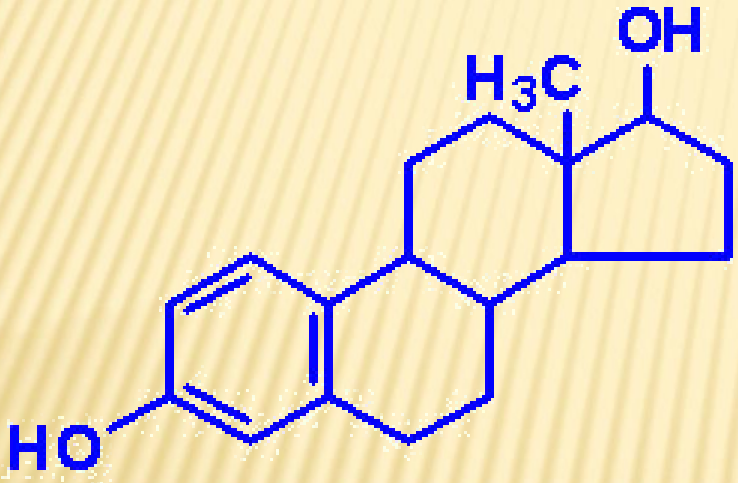
Sex hormones produced in the testes and ovaries regulate the production of sperm and eggs and aid in the development of secondary sex characteristics.

1-androgens (testosterone) : These hormones are secreted mainly by the testes, are called as androgens (andro = male).

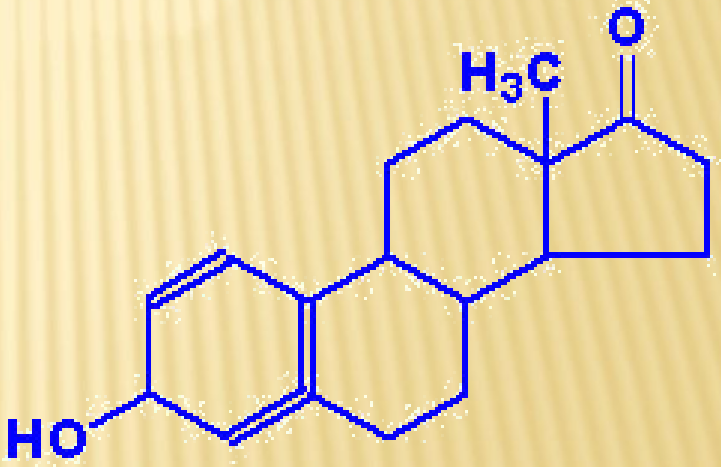


Estrogens (Female Sex Hormones):

The estrogens **estradiol** and **estrone** control development of secondary sex characteristics, regulate the menstrual cycle.



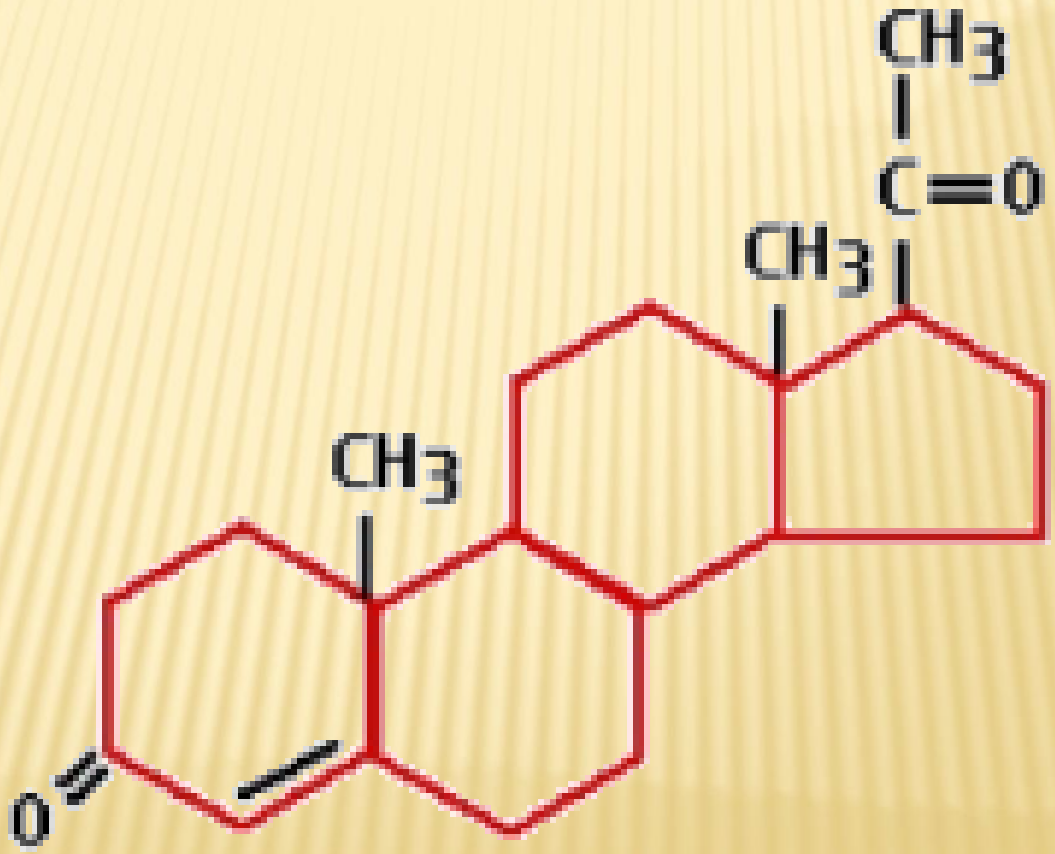
estradiol



estrone

Progestins (Female Sex Hormones):

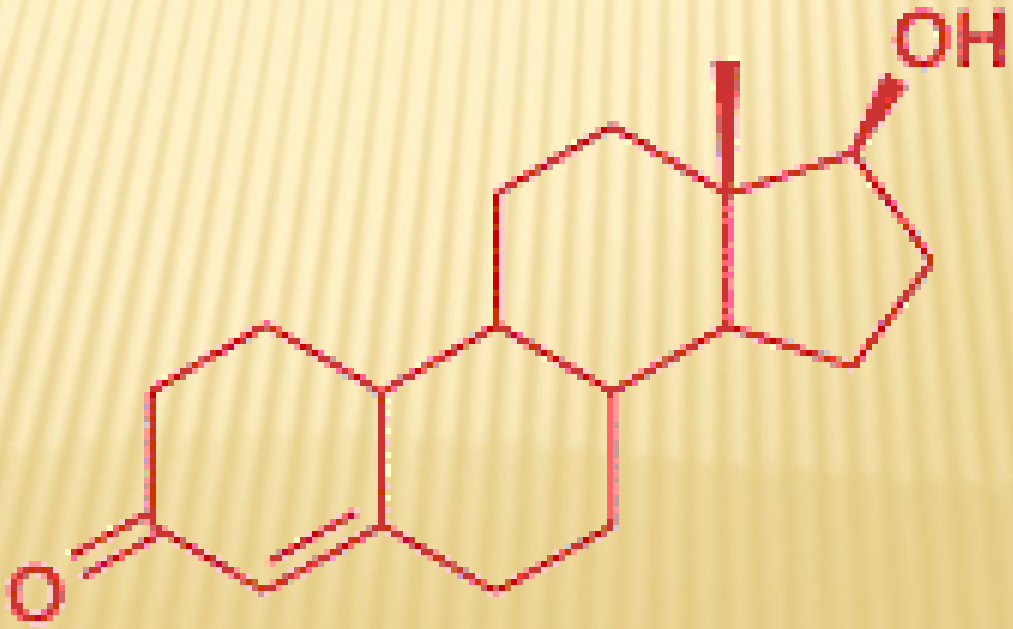
The progestin progesterone is called the “pregnancy hormone”; it is responsible for implantation of a fertilized egg.



Anabolic steroids

- Synthetic androgen analogues, called anabolic steroids, promote muscle growth. They have the same effect as testosterone, but are more stable, have come to be used by body builders

Prolonged use of anabolic steroids can cause physical and psychological problems.



Vitamins

the four fat-soluble vitamins have diverse biologic functions((A, D2, E and K1). They act

as coenzymes(vitamins A and K),

as antioxidant (vitamins A and E),

as hormones that regulate DNA transcription(vitamins A and D)..

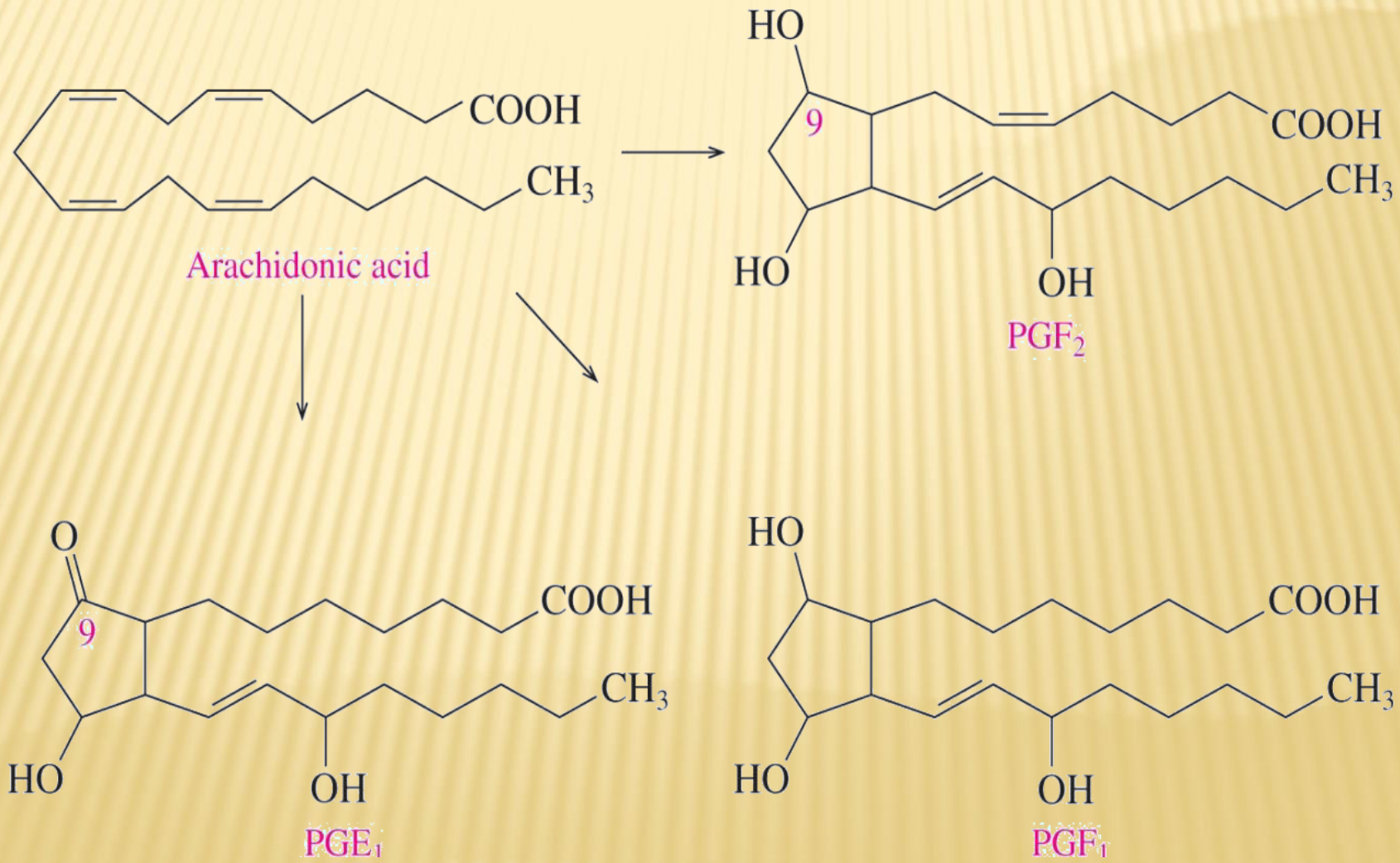
The fat-soluble vitamins are present in plant and animal source, and they are absorbed from the intestine along with other dietary lipid

PROSTAGLANDINS (PGs) PGs were originally isolated from prostate tissue and hence the name.

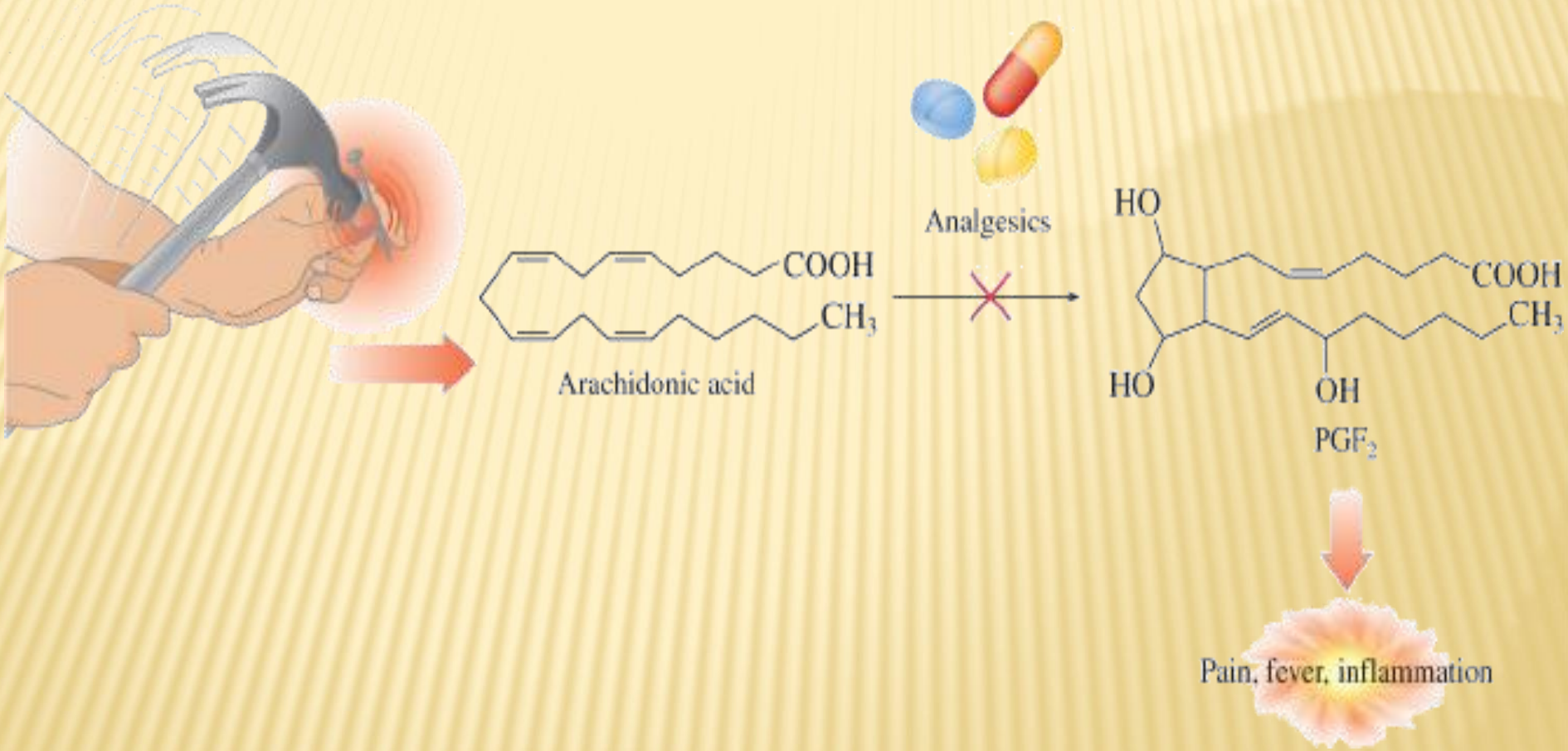
They formed from arachidonic acid, the polyunsaturated fatty acid with 20 carbon atoms, from which they take their general name (Greek *eicos*, twenty) but differ by the substituents attached to the five-carbon ring.

Prostaglandins have many functions, such as lower or raising blood pressure and stimulating contraction and relaxation of uterine smooth muscle.

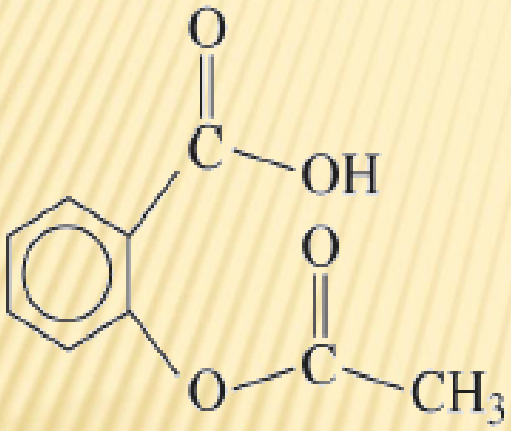
When tissues are injured, arachidonic acid is converted to prostaglandins such as PGE(for ether-soluble) and PGF(fosfat in Swedish) buffer–soluble that produce inflammation and pain in the area



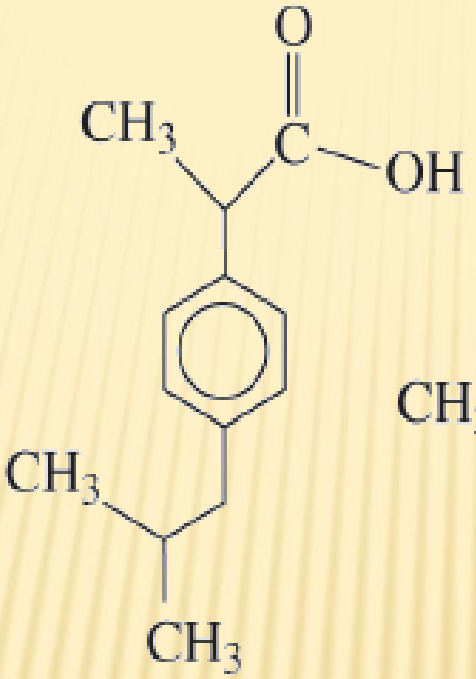
The treatment of pain, fever, and inflammation is based on inhibiting the enzymes that convert arachidonic acid to prostaglandins.



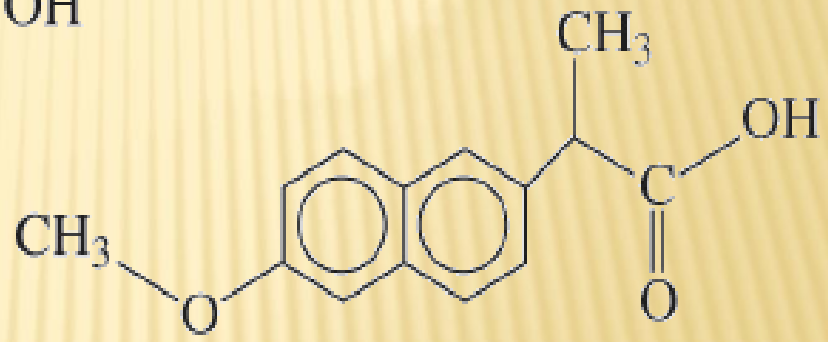
Nonsteroidal anti-inflammatory drugs (NSAIDs) block production of prostaglandins, decreasing pain and inflammation.



Aspirin (acetylsalicylic acid)



Ibuprofen (Advil, Motrin)



Naproxen (Aleve, Naprosyn)

lipoproteins

The lipids transport in the body by plasma lipoproteins which are complex between lipid and protein

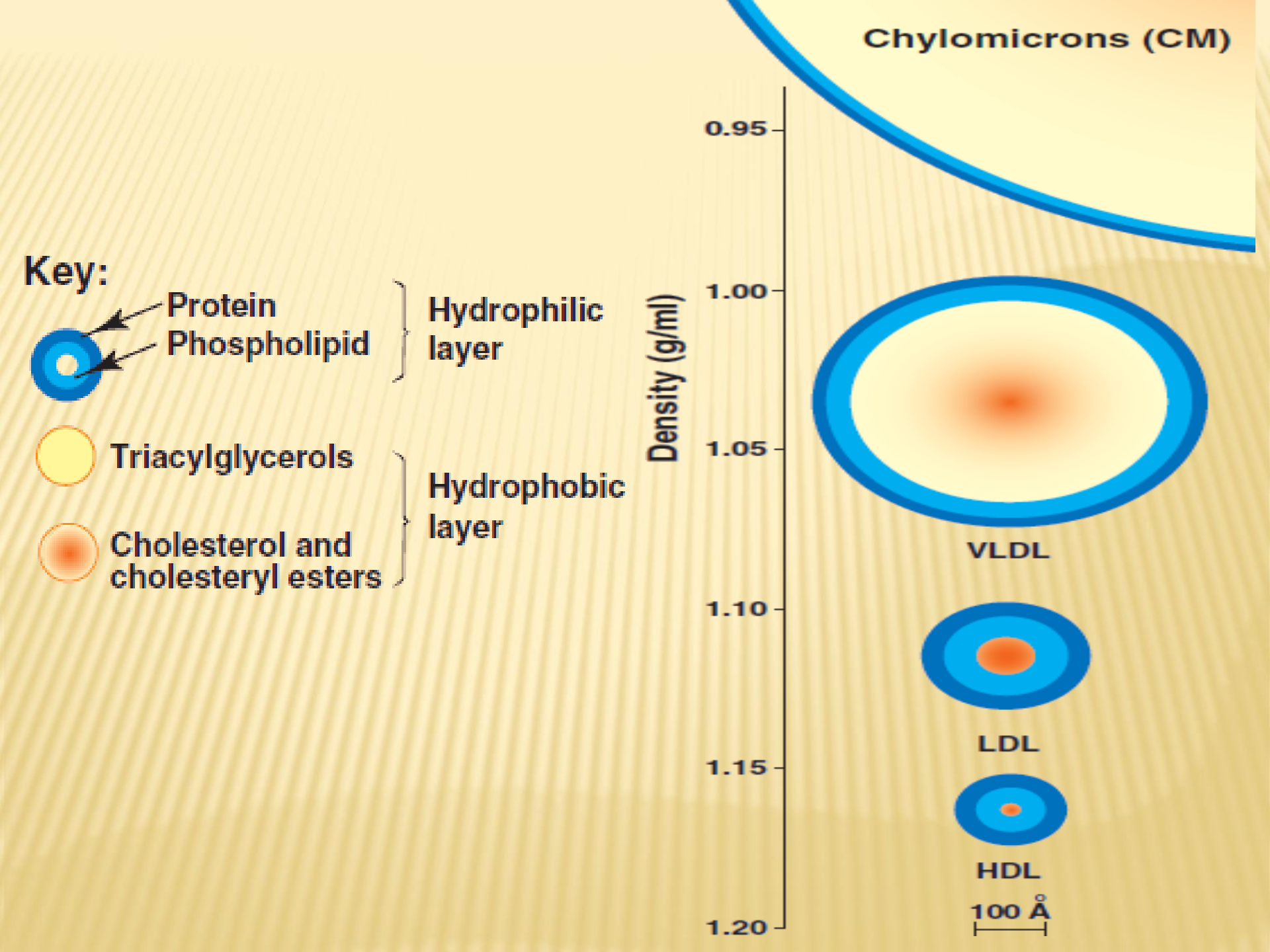
Four major classes of lipoproteins

Chylomicrons transport lipids resulting from digestion and absorption.

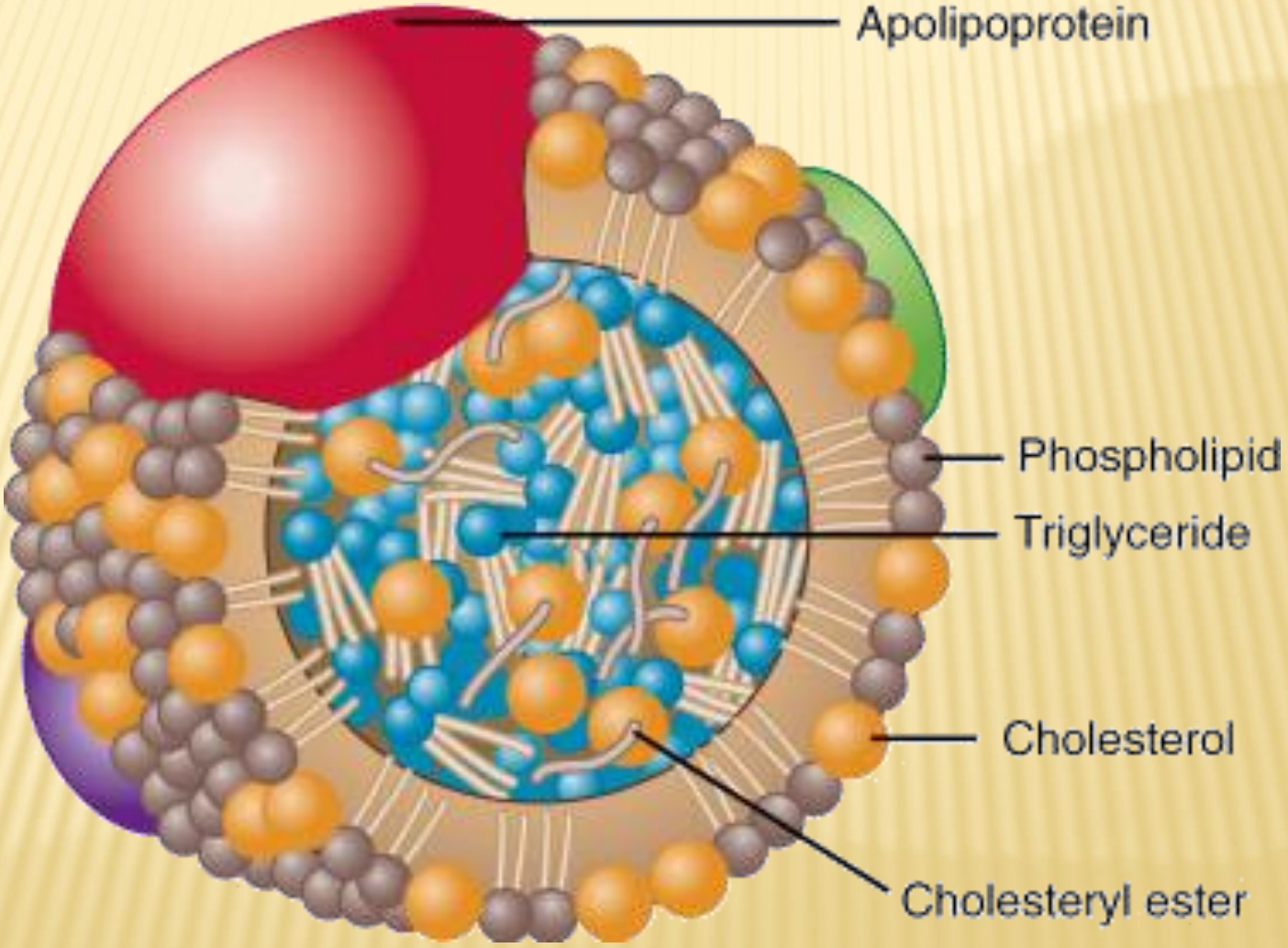
Very low density lipoproteins (VLDL) transport triglycerides from the liver.

Low-density lipoproteins (LDL) deliver cholesterol to the tissues

high-density lipoproteins (HDL) remove cholesterol from the tissues and return it to the liver for excretion.


Chylomicrons (CM)
Key:
Protein
Phospholipid
Hydrophilic layer
Triacylglycerols
Cholesterol and cholesteryl esters
Hydrophobic layer
Density (g/ml)
0.95
1.00
1.05
1.10
1.15
1.20
VLDL
LDL
HDL
100 Å

lipoproteins



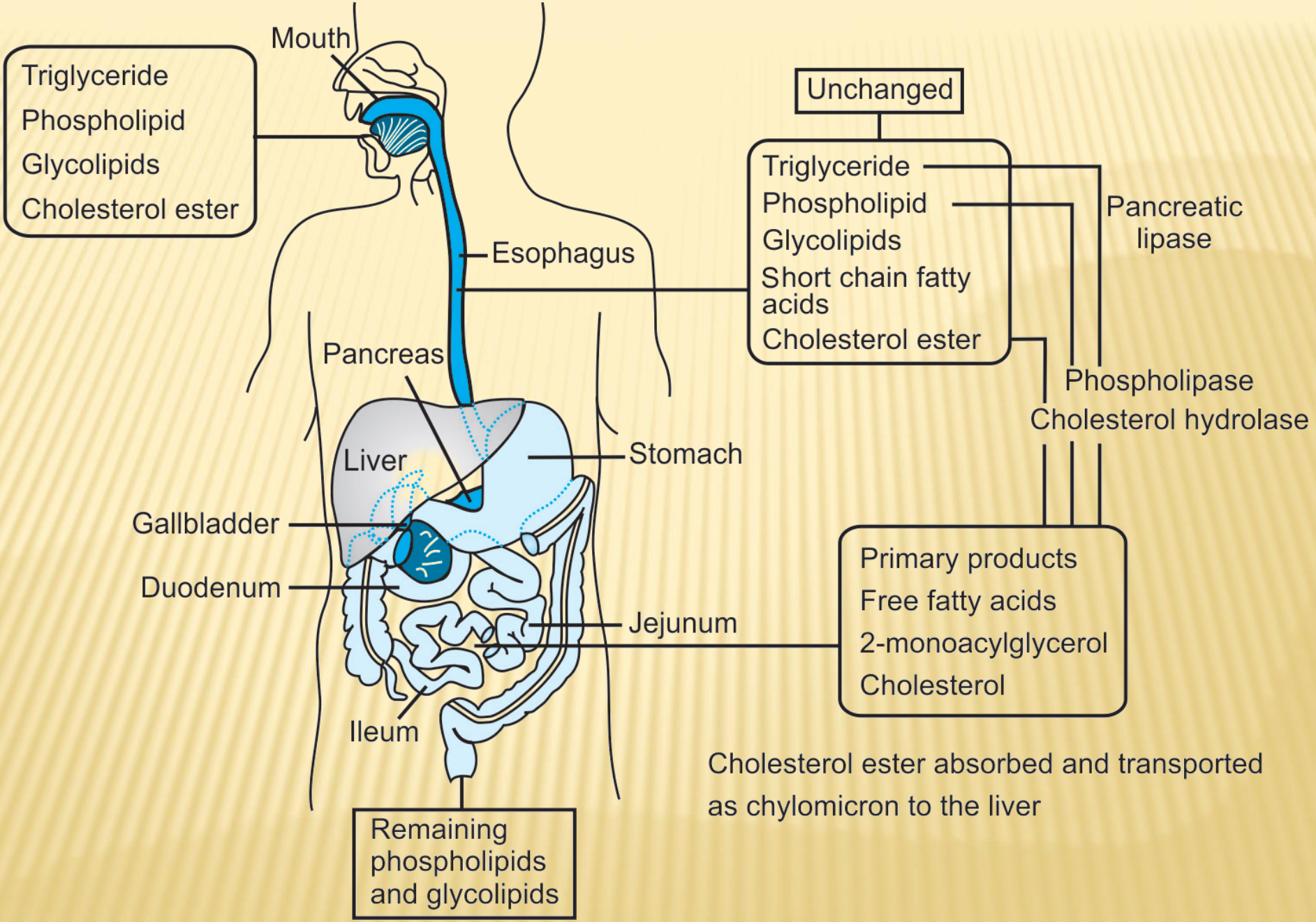
DIGESTION OF FAT

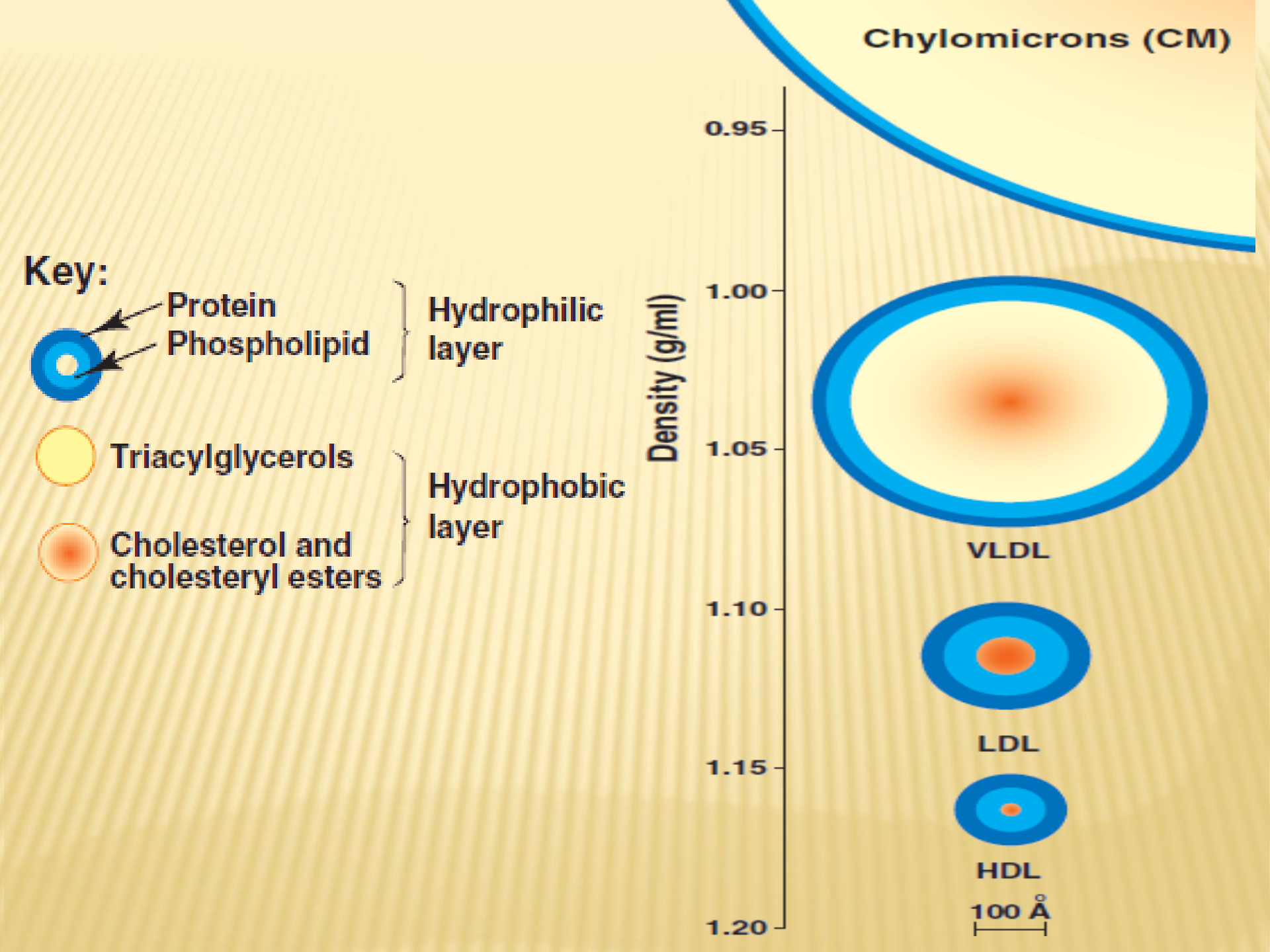
End products of digestion: fatty acids and glycerol

- Digestion of lipids is initiated in the stomach, catalysed by gastric lipase is called an acid lipase because its activity is highest in an acidic medium(30% of TG may be digested)
- Small Intestine: Digestion of fat mainly occurs in the small intestine.

o Liver produces bile salts, stores it in gall bladder. These bile salts are secreted into small intestine, to make fat soluble in water and break up fat into small fat globules, The aim of the bile is to increase the surface area of the fat for enhanced activity of enzymes.

o The pancreas secretes the enzyme lipase into the small intestine. Lipase transforms the triglycerides into fatty acids and glycerol


Mouth
Triglyceride
Phospholipid
Glycolipids
Cholesterol ester
Esophagus
Unchanged
Triglyceride
Phospholipid
Glycolipids
Short chain fatty acids
Cholesterol ester
Pancreatic lipase
Phospholipase
Cholesterol hydrolase
Pancreas
Liver
Stomach
Gallbladder
Duodenum
Jejunum
Ileum
Primary products
Free fatty acids
2-monoacylglycerol
Cholesterol
Remaining phospholipids and glycolipids
Cholesterol ester absorbed and transported as chylomicron to the liver


Chylomicrons (CM)
Key:
Protein
Phospholipid
Hydrophilic layer
Triacylglycerols
Cholesterol and cholesteryl esters
Hydrophobic layer
Density (g/ml)
0.95
1.00
1.05
1.10
1.15
1.20
VLDL
LDL
HDL
100 Å

lipoproteins

The lipids transport in the body by plasma lipoproteins which are complex between lipid and protein

Four major classes of lipoproteins

Chylomicrons transport lipids resulting from digestion and absorption.

Very low density lipoproteins (VLDL) transport triglycerides from the liver.

Low-density lipoproteins (LDL) deliver cholesterol to the tissues

high-density lipoproteins (HDL) remove cholesterol from the tissues and return it to the liver for excretion.

Malabsorption of lipids(steatorrhea); causes loss of lipids include fat soluble vitamins and essential FAs in feces..