

CHEMISTRY REVIEW

Chemical Components in The Cell-

Organic Components

Lipids



Learning Objectives:

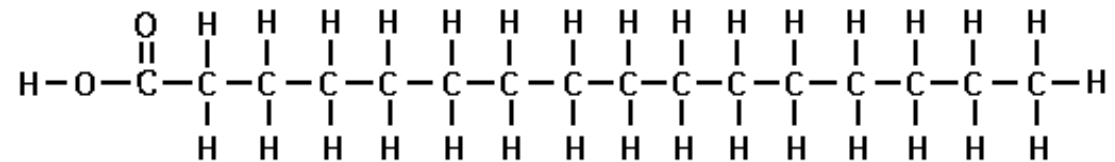
- ❖ Describe the structure of lipids and list the types of lipids.
- ❖ Describe fatty acids and give examples.
- ❖ Describe the structure of triglycerides, mention their function in human body and their correlation with coronary heart diseases.
- ❖ Describe the structure and properties of phospholipids.
- ❖ Describe how phospholipid bilayer is formed and mention its uses.
- ❖ List the types of steroid made in human body.
- ❖ Define the terms: “Apoproteins” and “Lipoproteins”.
- ❖ Explain the phrases “Good cholesterol” and “Bad cholesterol” and describe why we are concerned about high blood level of lipids.

Lipids:

- ❖ Lipids consist of *large number of carbon & hydrogen atoms*, with only *a very small amount of oxygen*. In addition, *phosphorus* is found in some of the more complex lipids. *Hydrocarbons with no oxygen cannot be processed by the body.*
- ❖ The lack of polarity makes most fats unable to mix with water, or *hydrophobic*.
- ❖ Lipids are *insoluble in water* but *dissolve readily in other lipids and in organic solvents* such as *alcohol, acetone and ether*.
- ❖ Lipids include *triglycerides, phospholipids, steroids*, and a number of other *lipoid substances*.

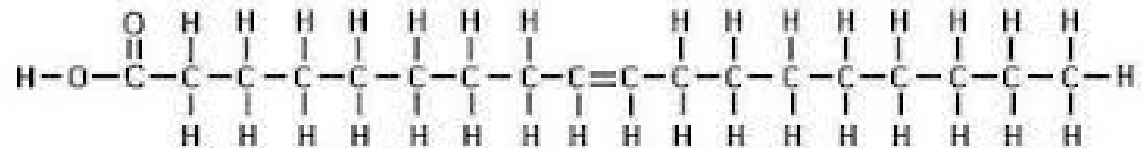
Lipids – Fatty Acids (FA):

- ❖ FA are *monocarboxylic acids* with variable lengths of carbon chain.
- ❖ **Saturated FA** have only *single covalent bonds* between carbon atoms. The general formula: **CH₃(CH₂)_nCOOH** “n” may equal any chain length up to about 26, with 16 and 18 being the most common. Saturated fats are usually *solid at room temperature*, found in *animal fats and coconut*.



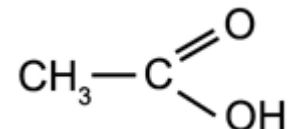
Palmitic Acid

- ❖ **Unsaturated FA** are similar, with **one or more double bonds between carbon atoms** in the chain. Unsaturated fats are *oils, liquid at room temperature*, found in *vegetable and fish oils*.



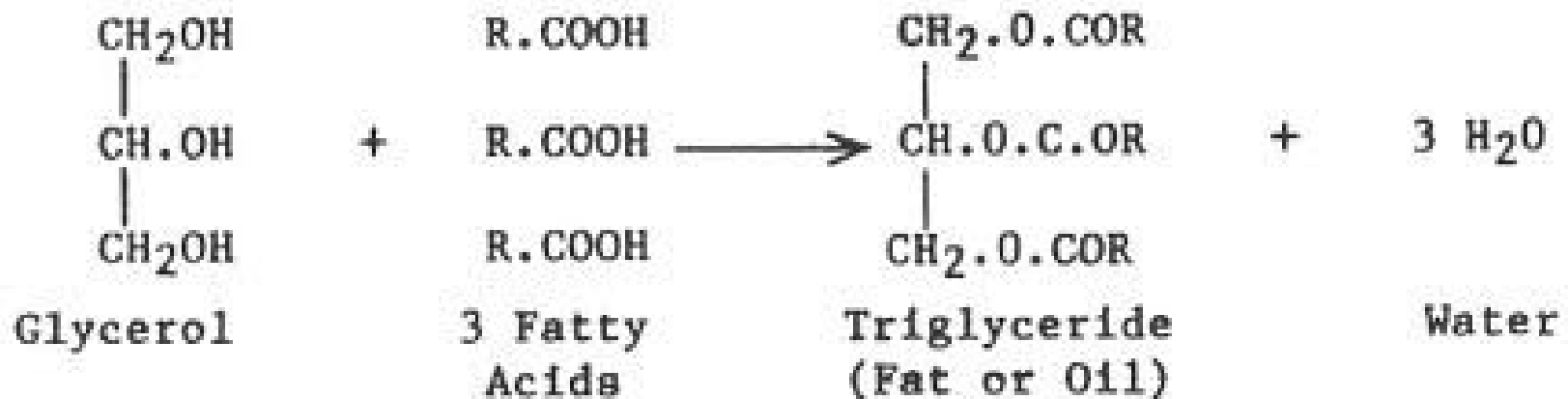
Oleic Acid- Monounsaturated Fatty Acid

- ❖ **Short chain FA** are not hydrophobic at all, e.g. **vinegar**, so we do not consider them to be fats. They are only called “FA” because they are in the same series.



Lipids – Triglycerides (TGs):

- ❖ TGs form >95% of the fats both in our diets and in our bodies.
- ❖ TGs , also called neutral fats, are commonly known as *fats when solid or oils when liquid*. A TG is composed of two types of building blocks, *fatty acids and glycerol*, in a *3:1 ratio of fatty acids to glycerol*.
- ❖ *Glycerol is a 3-carbon sugar alcohol* which can *form esters with FA*.
- ❖ The correct name for TGs is triacylglycerol because *3 FA groups are esterified on to the glycerol*. The 3 FA may/may not be different from each other.

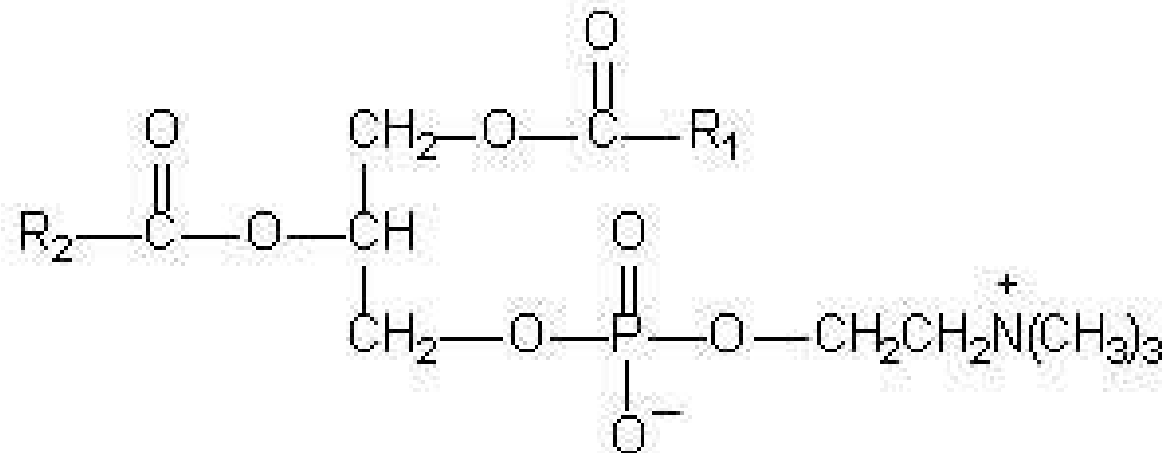


Lipids – Triglycerides (TGs):

- ❖ ***TGs made from saturated fats are solid at room temperature***, and usually come from animal sources, or from coconut oil. They often raise blood cholesterol and blood TG levels, so are considered to have a higher coronary risk. Animal fats are also associated with high cholesterol levels.
- ❖ ***TGs made from monounsaturated fats are liquid at room temperature***, found in olive oil, and are not associated with cholesterol or coronary risk.
- ❖ ***TGs made from polyunsaturated fats are also liquid, and are found in the majority of vegetable oils***. They are not associated with cholesterol, and they even lower our cholesterol levels. The problem with them, however, is that they are easily damaged in cooking, or just by being in a bottle.
- ❖ ***TGs are found mainly beneath the skin***, where they ***insulate the deeper body tissues from heat loss and protect them from mechanical trauma***. e.g. women are usually more successful English Channel swimmers than men (they have thicker subcutaneous fatty layer, which helps insulate them from the bitterly cold water of the Channel).

Lipids – Phospholipids:

- ❖ Phospholipids are **modified triglycerides**. Specifically, they are: *diglycerides with a phosphorus-containing group and two, rather than three, fatty acid chains.*
- ❖ A diglyceride (diacylglycerol) with a phosphate group and a basic group (e.g. choline) both covalently attached in sequence to the third reactive carbon of the glycerol.



Phosphatidylcholine

Lipids – Phospholipids – *Properties of Phospholipids:*

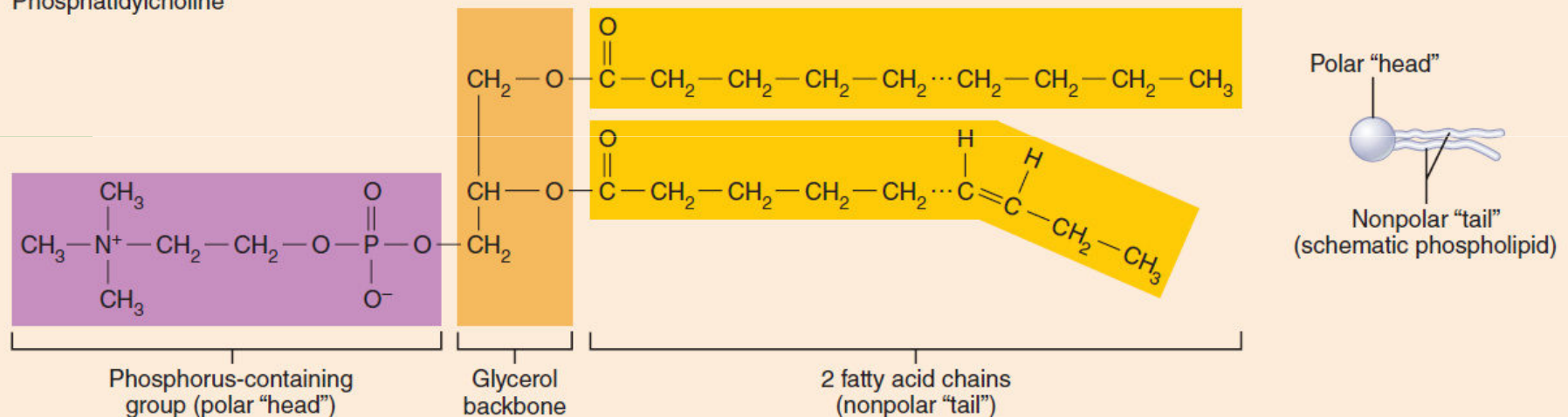
- ❖ They are both hydrophobic & hydrophilic (detergent or emulsifier).
- ❖ The *long-chain FA are hydrophobic*, i.e. won't mix with water.
- ❖ *The phosphate (-ve charge) and choline (+ve charge) are hydrophilic.*
- ❖ Phospholipids *allow continuity to exist between watery and fatty parts of biological structures.*
- ❖ The hydrophilic part is much smaller, forming a “*hydrophilic head*”.
- ❖ FA form **two** “*hydrophobic tails*” on the molecule.

Lipids – Phospholipids – *Properties of Phospholipids:*

“Typical” structure of a phospholipid molecule

Two fatty acid chains and a phosphorus-containing group are attached to the glycerol backbone.

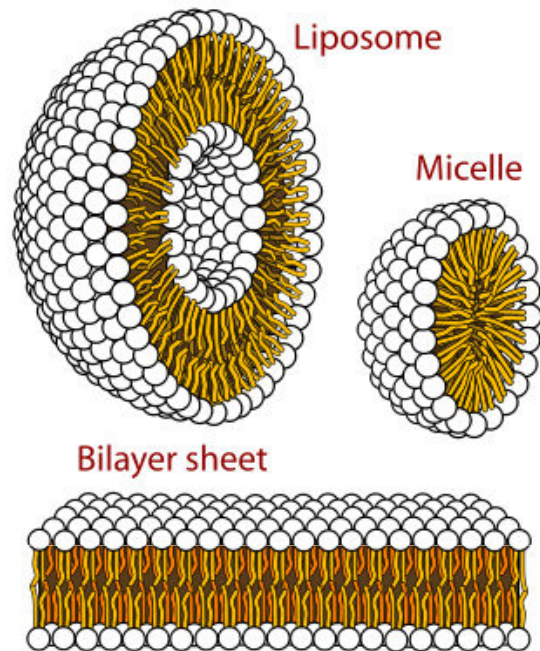
Example
Phosphatidylcholine



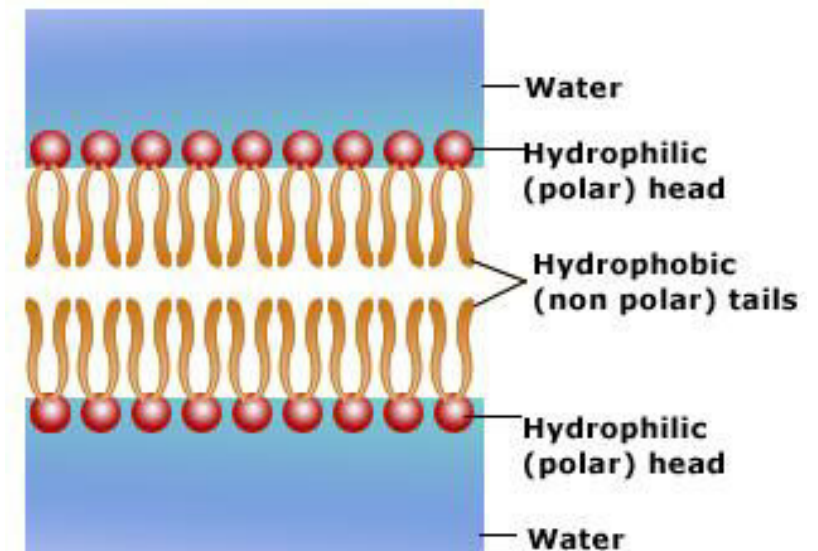
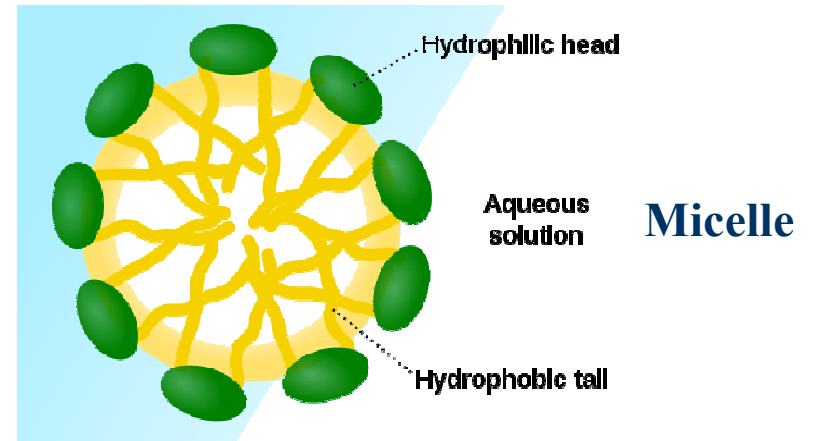
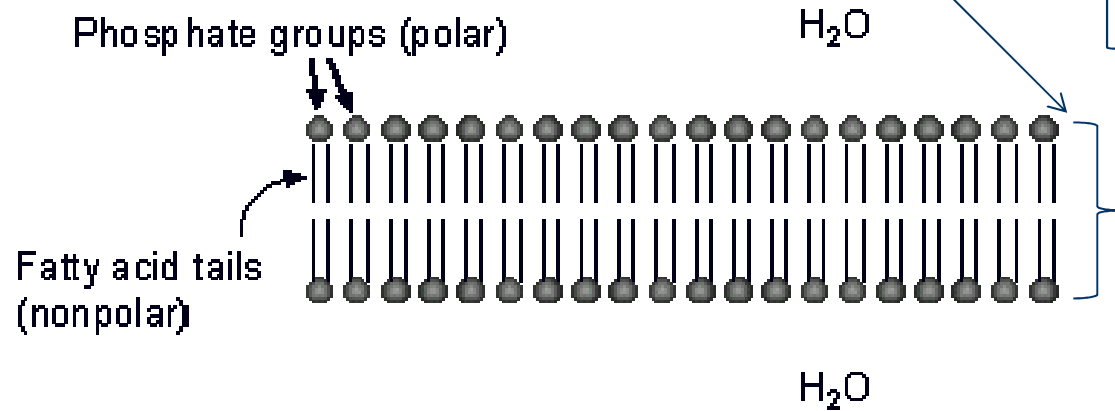
Phospholipid Bilayer Formation:

- ❖ When phospholipids are mixed with water, they form *micelles*, with hydrophobic interactions holding the hydrophobic tails together in the center of a sphere.
- ❖ When more phospholipids are added, they spread out to form a bilayer.
- ❖ The phospholipid bilayer cannot exist alone, because it needs some hydrophobic interactions at the ends, so it curves around to form *liposomes*.
- ❖ This structure forms spontaneously as direct result of phospholipid structure.
- ❖ *Biological membranes utilize this physical property of phospholipids.*

Phospholipid Bilayer Formation:



Phospholipid Bilayer



Phospholipid Bilayer Uses:

❖ Phospholipid bilayer uses in the body:

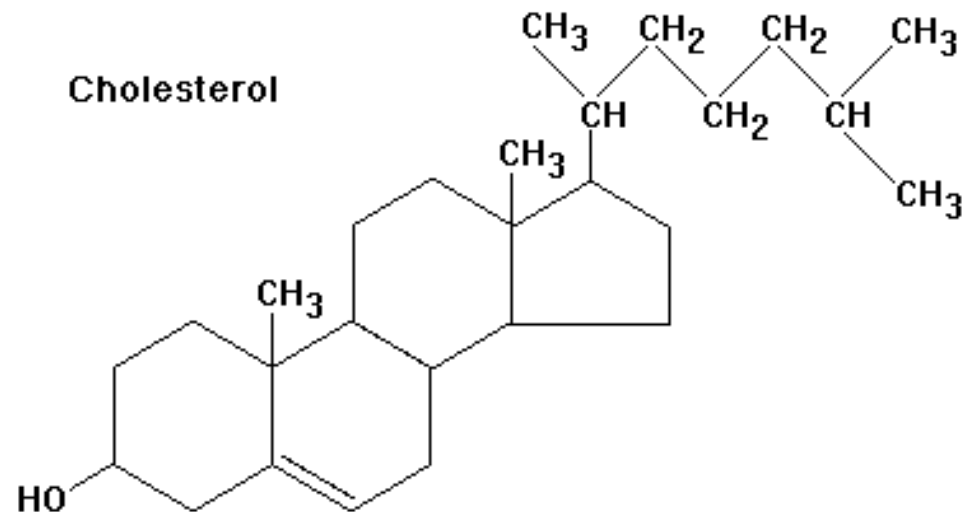
- All cell membranes consist of a large proportion of phospholipids.
- Myelin sheath is made up of many cell membranes layered on each other.
- Essential for conduction of nerve impulses.
- Involved in transporting fatty substances across membranes.
- A component of bile, to emulsify dietary fats in the GI tract

❖ Commercial uses:

- Lecithin is the familiar name for the most common phospholipid; its chemical name is phosphatidyl choline.
- It is used in food technology to emulsify foods to make a better texture.
- It is used as a health food supplement, but choline alone does a better job.

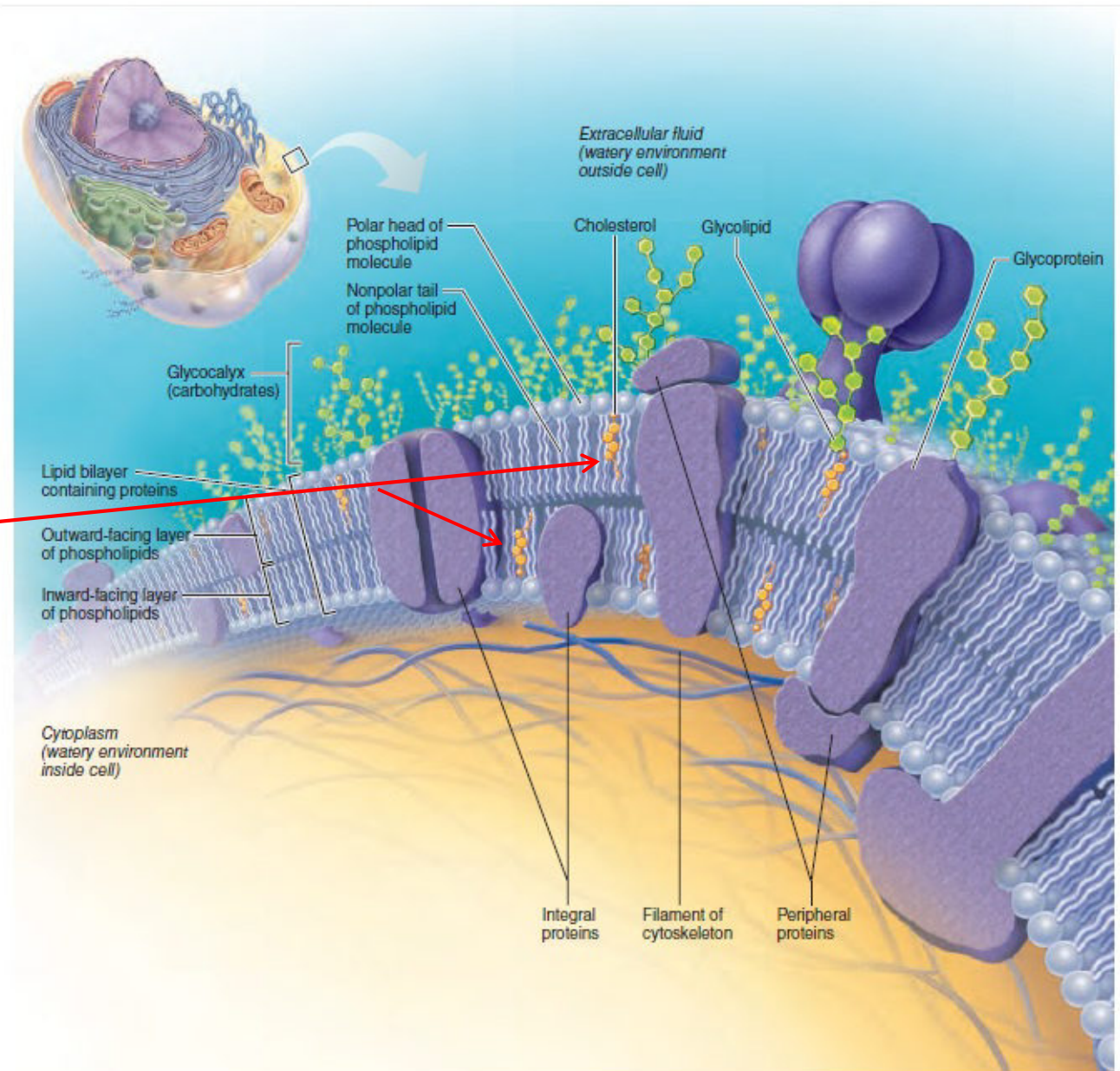
Lipids – Steroids:

- ❖ Structurally, steroids differ quite a bit from fats and oils. *Steroids are basically flat molecules made of four interlocking hydrocarbon rings.*
- ❖ Like triglycerides, steroids are *fat soluble and contain little oxygen.* The single most important molecule in our steroid chemistry is **cholesterol** (basic steroid made by animal cells).
- ❖ We ingest cholesterol in animal products such as *eggs, meat, and cheese, and our liver produces some.* Cholesterol is found embedded in animal cell membranes. *It helps stabilize them during temperature changes.*



Lipids – Steroids:

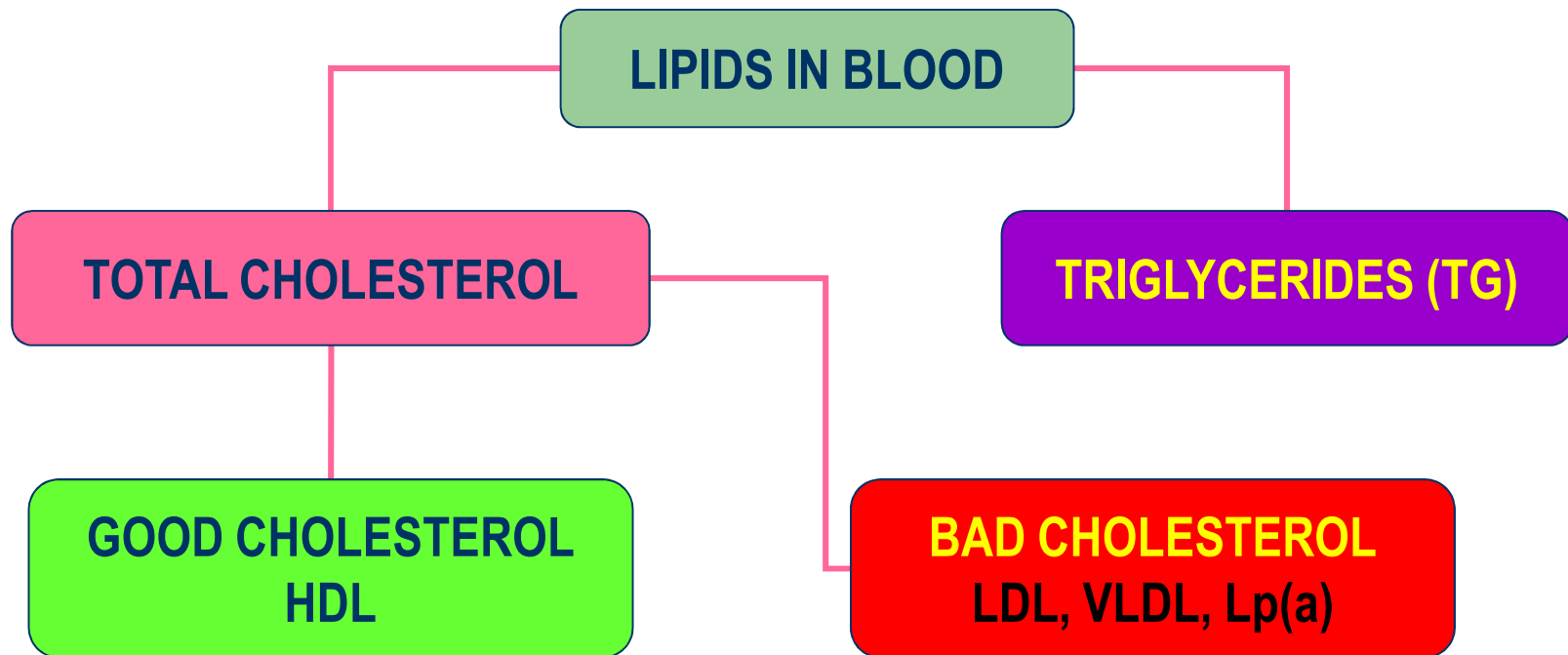
*Cholesterol is
embedded in animal
cell membrane*



Lipids – Steroids:

- ❖ *There is only one type of cholesterol molecule.* But some cholesterol is called “*good cholesterol*” and other called “*bad cholesterol*”, the reason is that some types of lipoprotein molecules, used for carrying fats (including cholesterol) in the blood, correlate with the incidence of heart disease more than others.
- ❖ The lipoprotein is of different densities (*LDL= Low Density Lipoprotein and HDL=High Density Lipoprotein*), but the cholesterol inside it is always the same.
- ❖ *HDL (good cholesterol) lowers the risk of coronary heart diseases by mobilizing cholesterol from blood vessel walls to the liver and excreting it through the bile*
- ❖ Other steroids made in the body are:
 - Vitamin D
 - Adrenal cortex hormones (involved in stress response)
 - Sex hormones.

Blood Lipids :



Cholesterol:

THE GOOD, BAD, & UGLY

Cholesterol:

- ❖ Cholesterol is one of the major lipids (steroids) in the body and is essential for cell growth and nourishment. The other major fats are called triglycerides.
- ❖ Cholesterol is classified into several categories. These categories include **HDL (Good)** **LDL (Bad)** and **VLDL (Ugly)**.
- ❖ HDL cholesterol helps to clear the LDL Cholesterol. ***VLDL cholesterol is the precursor to the LDL Cholesterol. LDL cholesterol & TGs (also ugly)*** are known for their stickiness and causing the blood to be thicker.

Cholesterol:

WHY BE CONCERNED ABOUT CHOLESTEROL?

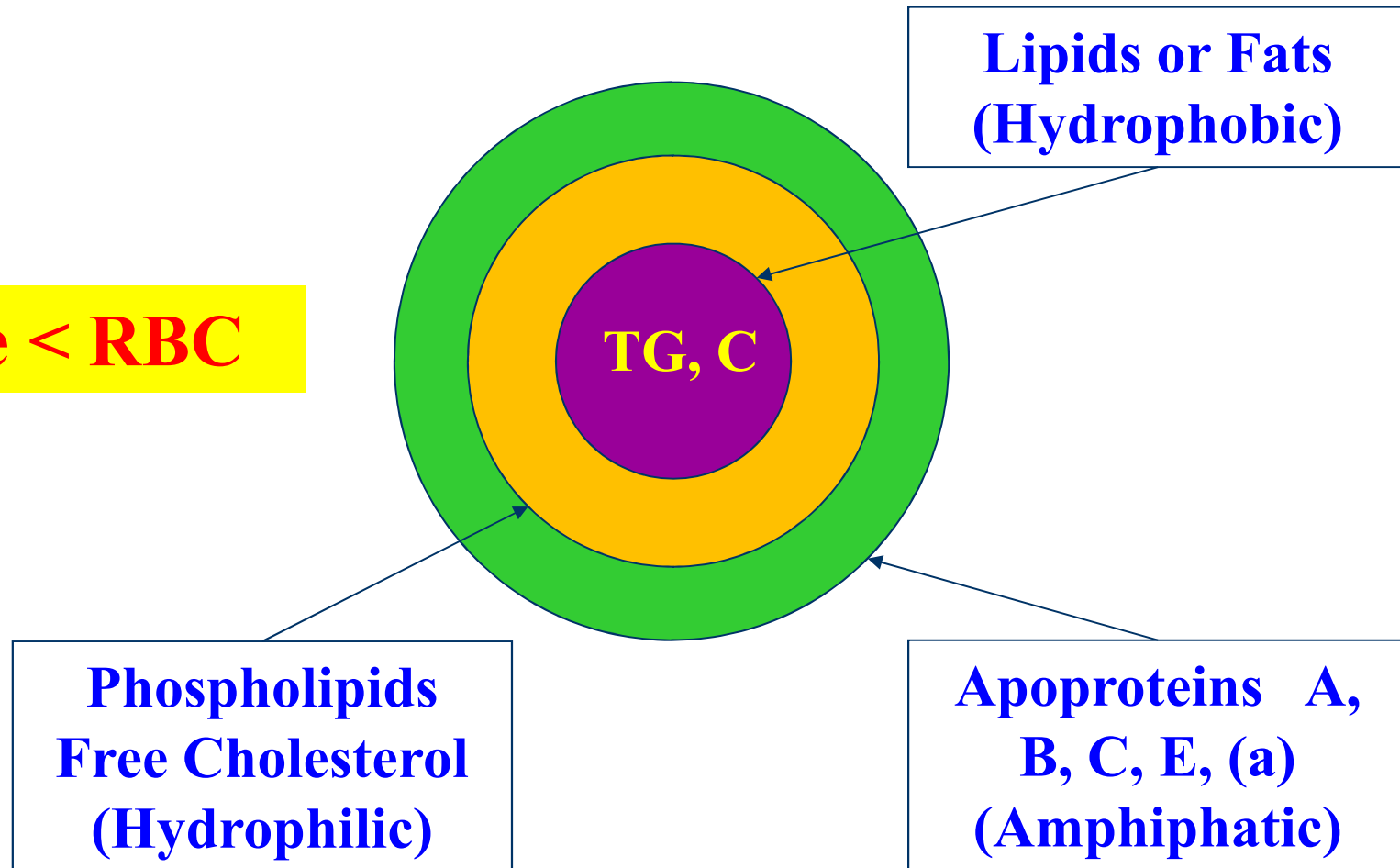
- ❖ High levels of **LDL and VLDL** cholesterol lead to the development of ***atherosclerosis*** (hardening of the arteries). This occurs as a result of cholesterol accumulating in the walls of blood vessels (arteries).
- ❖ These blood vessels become narrow and therefore limit the amount of blood that flows through them. If this blockage occurs in the blood vessels of the heart, coronary heart disease (CHD) will develop and a “***heart attack***” may occur.

Lipoproteins:

- ❖ A **lipoprotein** is a biochemical assembly that contains both proteins & lipids, bound to the proteins, which allow fats to move through the water inside and outside cells.
- ❖ The five major groups of lipoproteins (***chylomicrons, VLDL, IDL, LDL, HDL***) enable fats and cholesterol to move within water based solution of the blood stream.

Chemistry Review – Lipoproteins:

Size < RBC

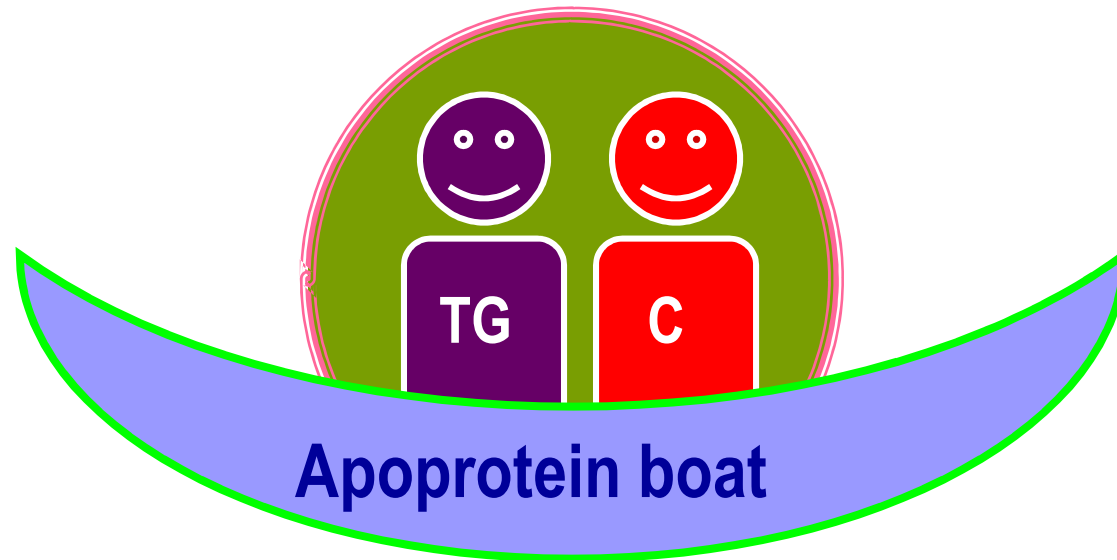


TG: Triglycerides
C: Cholesterol

Lipoproteins in Summary:

- ❖ Chylomicrons transport fats from the intestinal mucosa to the liver.
- ❖ In the liver, the chylomicrons release triglycerides and some cholesterol and become LDL.
- ❖ **LDL** then *carries fat and cholesterol to the body's cells.*
- ❖ **HDL** *carries fat and cholesterol back to the liver for excretion.*
- ❖ When oxidized LDL cholesterol gets high, atheroma formation in the walls of arteries occurs, which causes atherosclerosis.
- ❖ HDL cholesterol is able to go and remove cholesterol from the atheroma.
- ❖ Atherogenic cholesterol → **LDL, VLDL, IDL**

Chemistry Review – *Lipoproteins:*



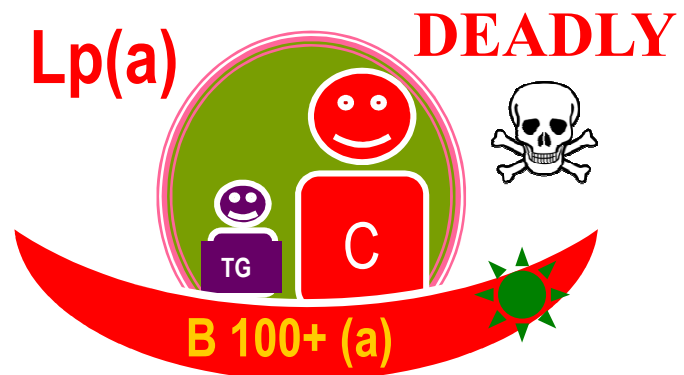
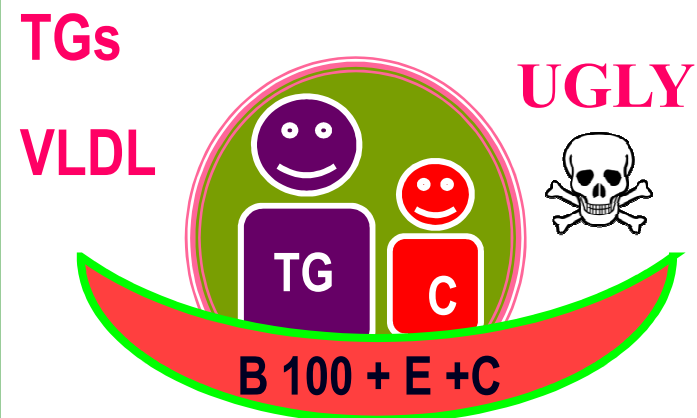
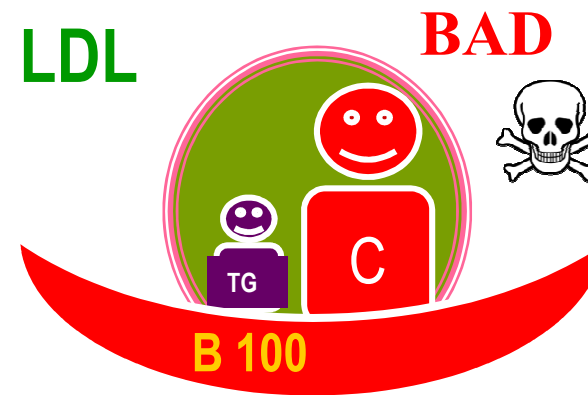
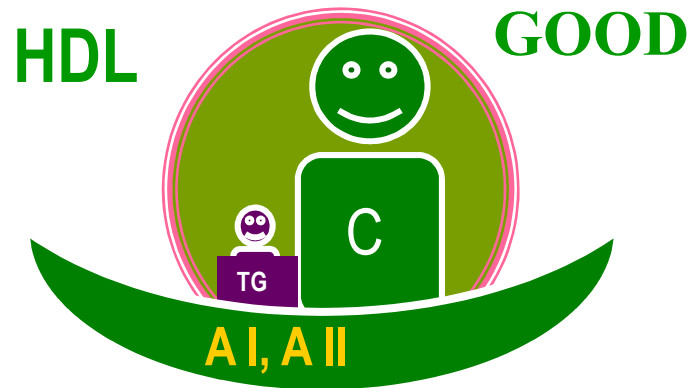
Apo A I and A II for HDL

Apo B100 for LDL

Apo B100+C+E for VLDL, IDL

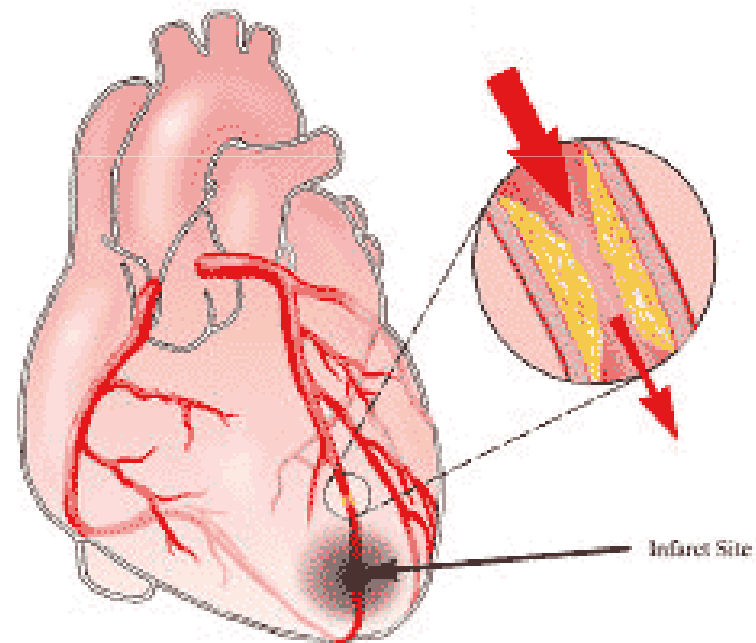
Apo B100+Apo(a) for Lp(a)

Chemistry Review – *Lipoproteins:*



Good, Bad, Ugly & Deadly

High cholesterol food will always
have a special place in my heart.



***A blocked coronary artery leads to a
heart attack (Myocardial Infarction)***