بسم أللہ الرحمن الرحیم

Basic Principles and Perspectives in Medical Chemistry and Biochemistry

Chemistry of Lipids

Part-2- Glyceride , Non-glyceride & Complex lipids

Medical and Biochemistry (BIQC-101) Lecture

by

Prof. Dr. Salih Mahdi Salman

Chemistry of lipids

Learning objectives

After this unit you should be able to:

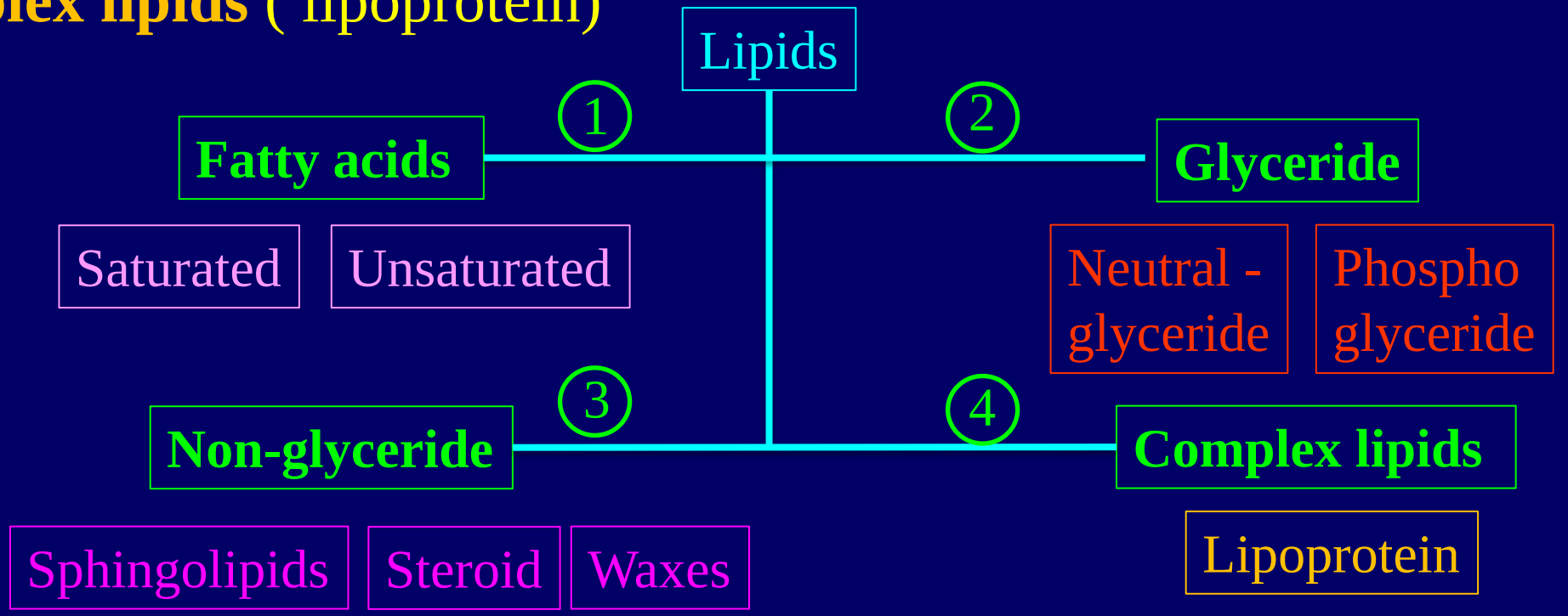
1. Classify lipids.
2. Know the mean class of lipids
3. Have an idea about the structure of each class.
4. Understand the physical and chemical of the classes.
5. List the biological function of all classes.
6. Relate the structure and properties with the diseases come as a result of this lipids.

List of Content

Classification of Lipids

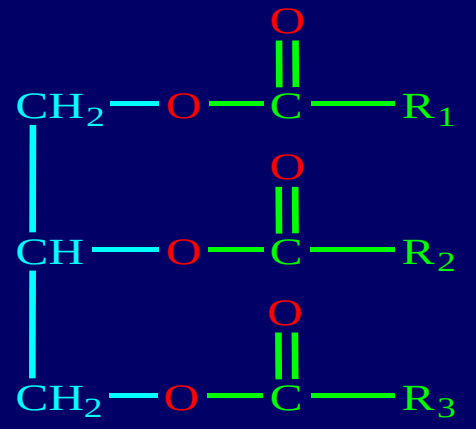
Lipids are subdivided to four mean groups:-

1. **Fatty acids** (saturated & unsaturated)
2. **Glyceride** (neutral glyceride, phosphoglyceride)
3. **Non-glyceride** (sphingolipids, steroid, waxes)
4. **Complex lipids** (lipoprotein)



Triglycerides

- **Glycerides** or **acylglycerols**, are esters formed from glycerol and fatty acids that are very hydrophobic.
- These structures vary in their fatty acid as they can contain different carbon numbers, and degrees of unsaturation, and different configurations and positions of olefins.
- Vegetable oils and animal fats contain mostly triglycerides, but are broken down by natural enzymes (lipases) into mono and diglycerides and free fatty acids and glycerol.
- The body converts any calories it doesn't need into triglycerides. Triglycerides are stored in fat cells.
- A lipid profile. can reveal whether triglycerides fall into a healthy range:



1. Normal : Less than 150 (mg/dL), or less than 1.7 (mmol/L)
2. Borderline high : 150 to 199 mg/dL (1.8 to 2.2 mmol/L)
3. High: 200 to 499 mg/dL (2.3 to 5.6 mmol/L)
4. Very high :500 mg/dL or above (5.7 mmol/L or above)

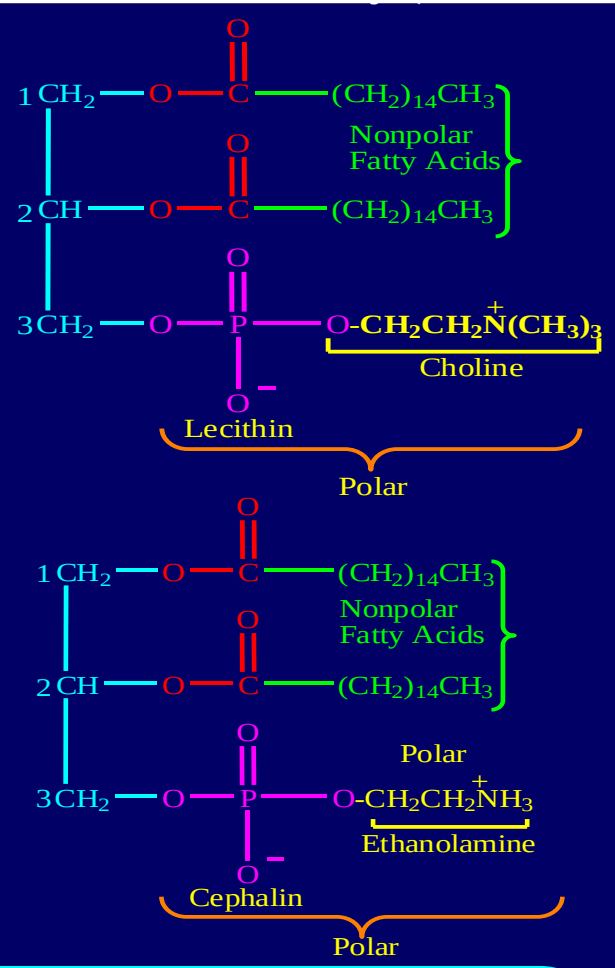
- High triglycerides may contribute to hardening of the arteries or thickening of the artery walls (arteriosclerosis), which increases the risk of stroke, heart attack and heart disease. Extremely high triglycerides can also cause acute inflammation of the pancreas (pancreatitis).

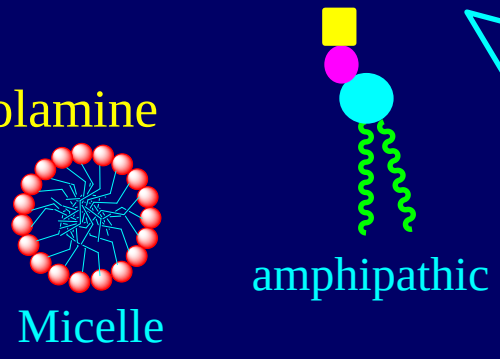
Phosphoglycerides

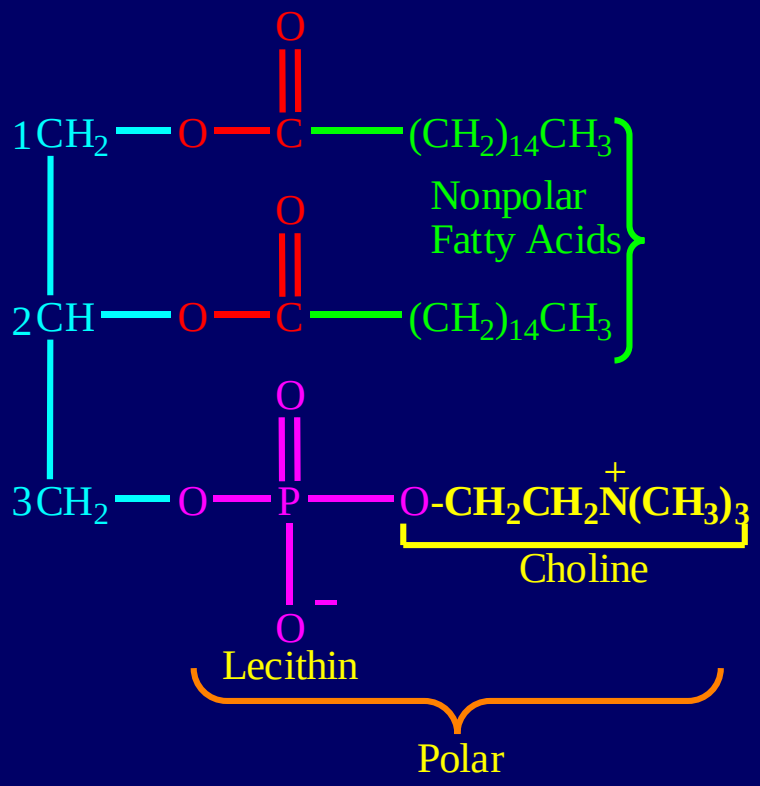
- Phospholglycerides are esters of only two fatty acids, phosphoric acid and a trifunctional alcohol – glycerol.
- The fatty acids are attached to the glycerol at the 1 and 2 positions on glycerol through ester bonds.
- The third oxygen on glycerol is bonded to phosphoric acid through a **phosphate ester bond**
- There is usually a complex amino alcohol also attached to the phosphate through a second phosphate ester bond. The complex amino alcohols include **choline**, **ethanolamine**, and the **amino acid-serine**.
- The long chains of the fatty acids are non-polar. The phosphate group has a negatively charged oxygen and a positively charged nitrogen to make this group ionic. There are other oxygen of the ester groups, which make on whole end of the molecule strongly ionic and polar.
- There are two common phospholipids:

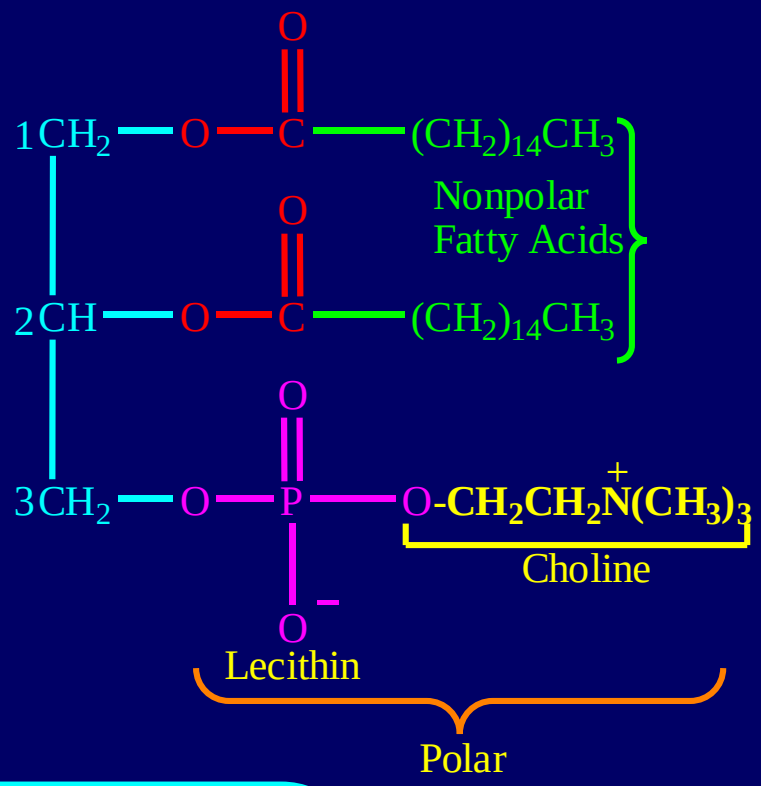
1. Lecithin contains the amino alcohol, choline.
2. Cephalins contain the amino alcohols serine or ethanolamine

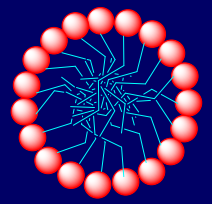
- They are used in: 1. Cell membranes 2. Emulsifying 3. Micelle-forming agents in the blood

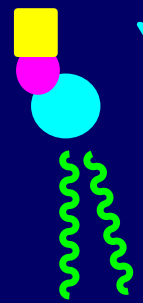


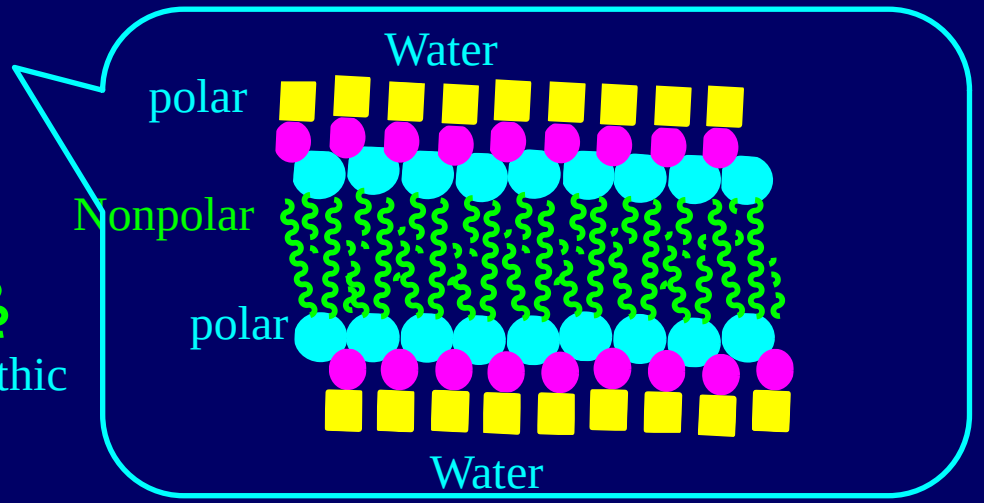







Micelle


amphipathic



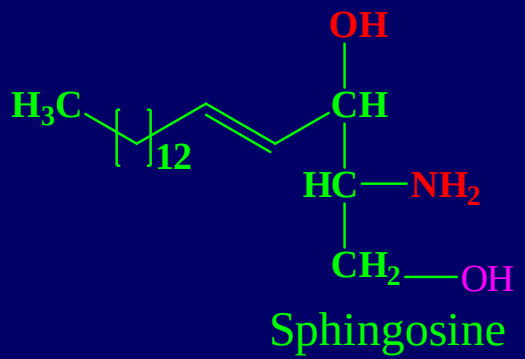
No glyceride Lipids (Sphingolipids)

- Sphingolipids based on the 18-carbon amino alcohol sphingosine.
- A fatty acid is linked to the amine group by an amide bond, and an amino alcohol phosphate ester (Sphingomyelins) or sugar (Glycosphingolipids) is linked to the bottom hydroxyl group.
- **Sphingolipids:** Two types:-

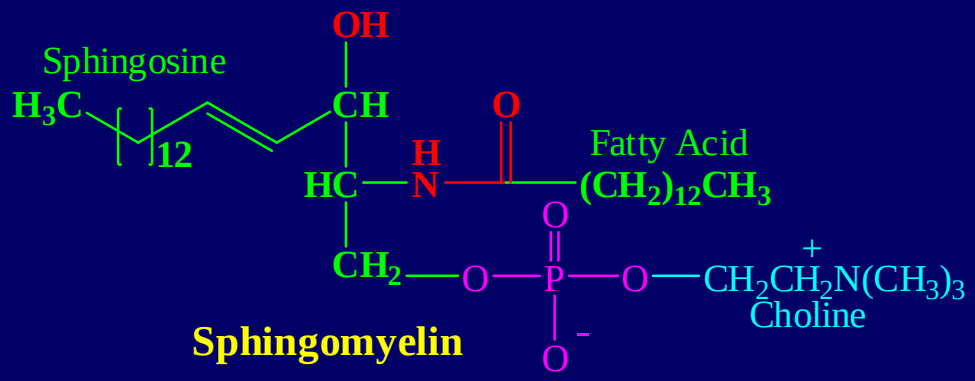
1. **Glycosphingolipids:-** Monosaccharides linked sphingosine by glycosidic bonds, two types:

1) Cerebrosides: One monosaccharide usually galactose or glucose connected to sphingosine by glycosidic linkage, and are involved in cellular recognition and immunity.
2) Gangliosides: Two more sugar unit, usually glucose and galactose, they are abundant in the cell membranes of neurons they act at the cell surface as receptors for hormones.

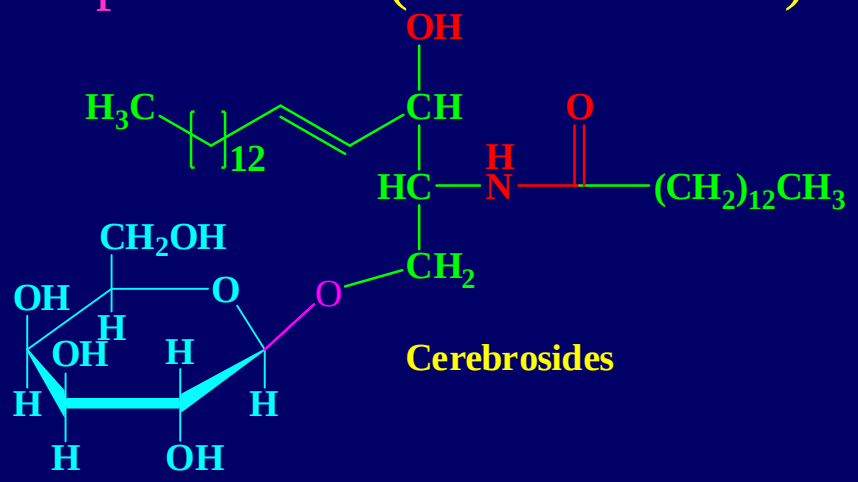
2. **Sphingomyelins** :-is sphingosine linked to amino alcohol phosphate ester (ethanol amine).



Sphingosine



Sphingomyelin



Cerebrosides

Sphingolipid Storage Diseases

Disease	Symptom	Sph. Lip	Enzyme
Tay-Sachs	Blindness, muscles weak	Ganglioside GM_2	β-hexose-aminidase A
Gaucher's	Liver & spleen enlarge, MR	Gluco-cerebroside	β-glucosidase
Krabbe's	demyelation, MR	Galacto-cerebroside	β-galactosidase
Nieman-Pick	MR	Sphingomyelin	Sphingomyelinase

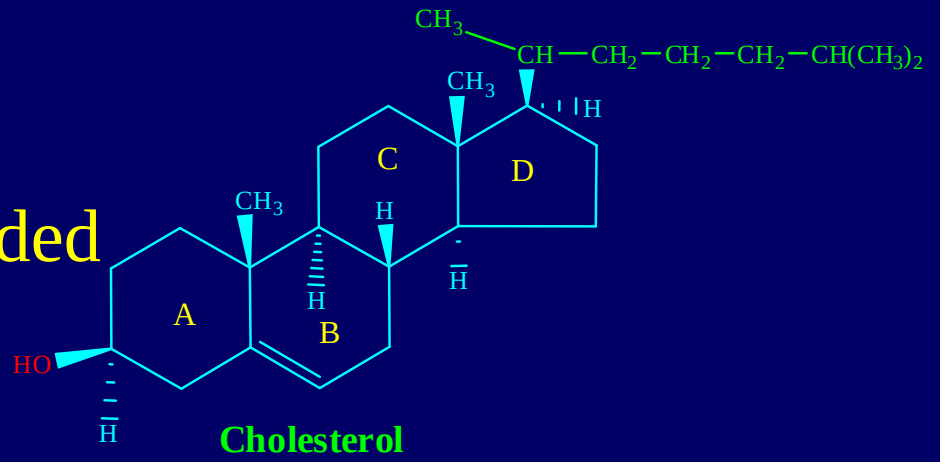
MR=Mitral regurgitation

Steroid

- Steroids are lipids containing a steroid nucleus (core structure)
- The steroid nucleus is a fused ring system consisting of three cyclohexane rings and one cyclopentane ring. The rings are designated A, B, C and D
- Attachment of different groups to the core steroid structure leads to a wide variety of steroid compounds, including cholesterol, bile salts and steroid hormones

Cholesterol

- A major component of cell membranes
- Liver can also synthesize all the cholesterol needed
- Animal products is a source of cholesterol
- Excessive blood cholesterol is associated with atherosclerosis and formation of gallstones

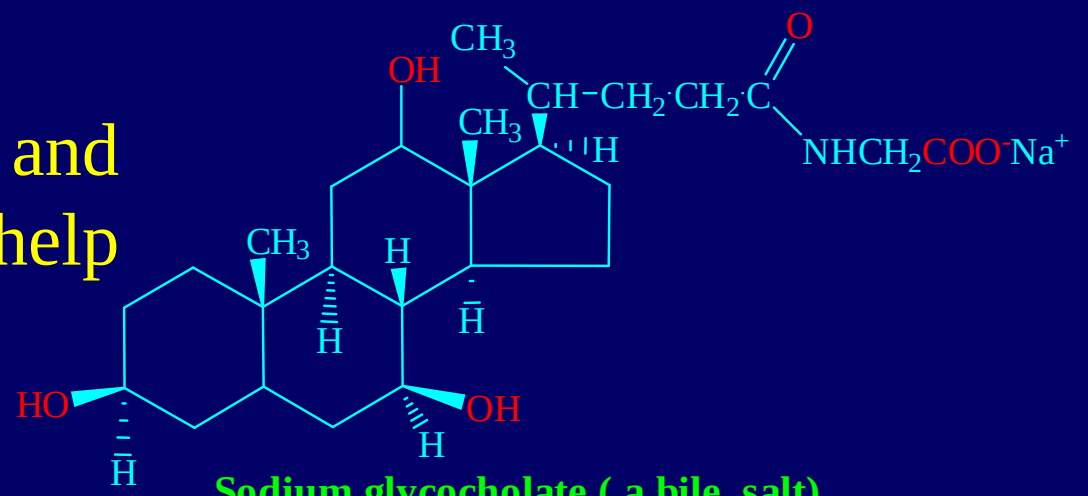


Cholesterol

- A precursor for biosynthesis of many other steroids such as bile salts, male and female sex hormones, vitamin D, and the adrenocortical hormones.

2. Bile Salts

- Bile salts are synthesized from cholesterol in the liver.
- They are stored in the gall bladder and released into the upper small intestine to help break down fats and oils (like soaps)



Sodium glycocholate (a bile salt)

3. Steroid Hormones

- Steroid hormones are biosynthesized from cholesterol.
- These hormones often are classified according to the organs that synthesize them

1. Adrenal steroids.
2. Sex hormones

Adrenal steroids.

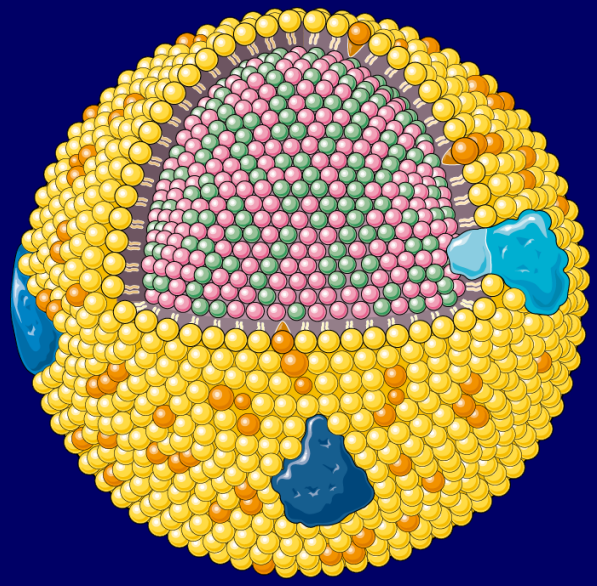
1. **Glucocorticoids:** such as **cortisol** control or influence many metabolic processes, including the formation of glucose from amino acids and fatty acids and the deposition of glycogen in the liver.
2. **Mineralocorticoids:** such as **aldosterone** help maintain the balance between water and salts in the body

Sex hormones.

1. **Androgen (testosterone):** Responsible for reproductive function and the secondary sex characteristics in the male
2. **Estrogen (estradiol):** Promote the development of the primary and secondary female sex characteristics
3. **Progesterone**: Play a role in maintaining pregnancy
4. **Norethindrone**: Synthetic form of progesterone is used for birth control (contraception) to prevent pregnancy.

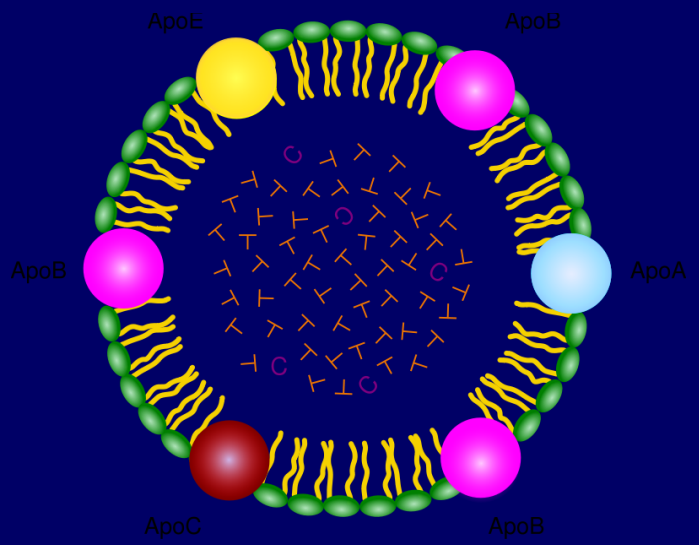
Complex lipids

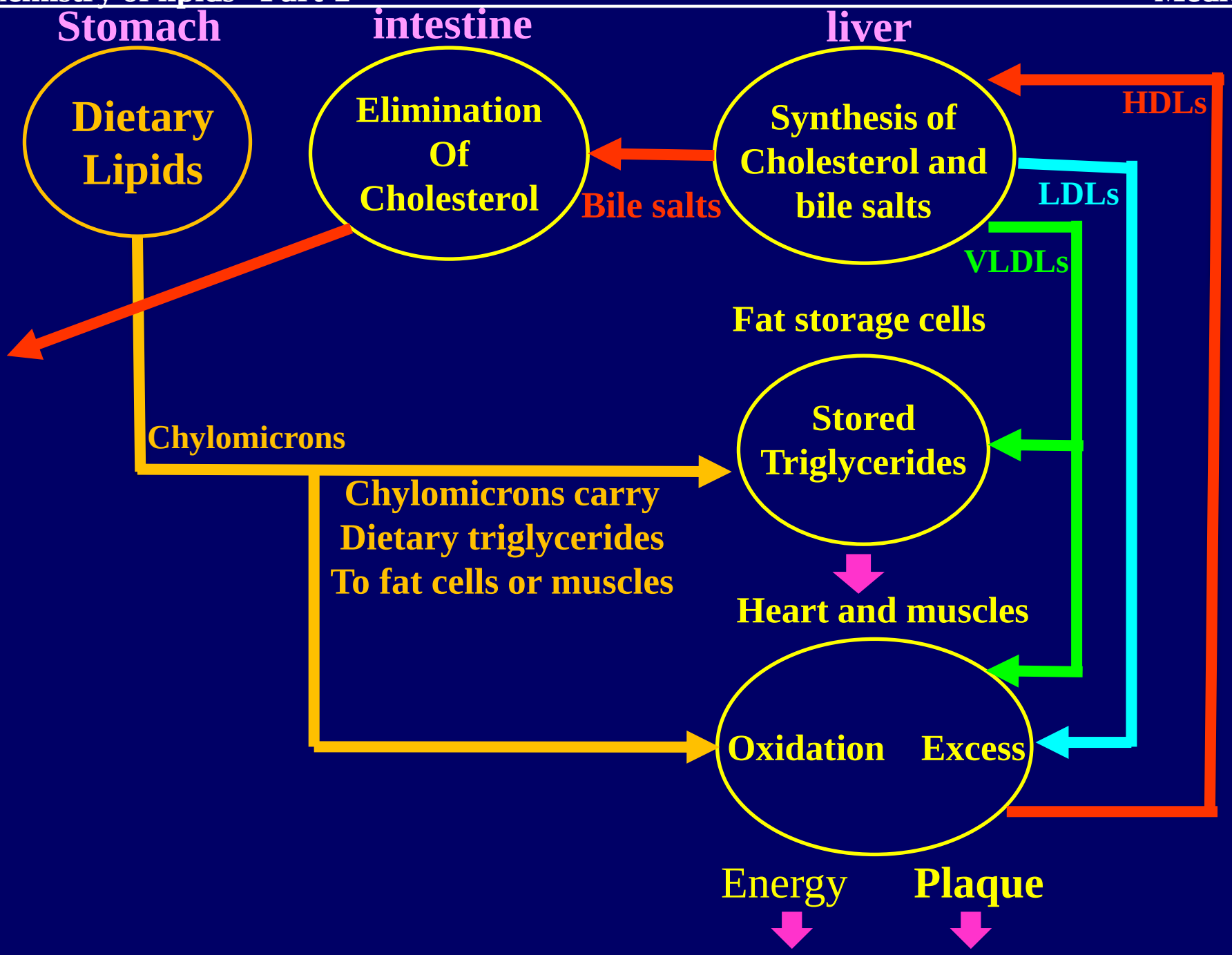
Lipoprotein



- A lipoprotein is a biochemical assembly whose primary function is to transport hydrophobic lipid molecules in water, as in blood plasma or other extracellular fluids.
- They consist of a Triglyceride and Cholesterol center, surrounded by a phospholipid outer shell.
- A special kind of protein, called **apolipoprotein**, is embedded in the outer shell.
- Lipoproteins differ by density, composition and function.
- Examples include plasma lipoprotein particles:-

1. High-density lipoprotein HDL
2. Low-density lipoprotein LDL
3. Very-low-density lipoprotein VLDL
4. Chylomicrons .





VLDLs and LDLs Carry triglycerides from liver to fat storage cells and muscle

HDLs move cholesterol to liver

LDLs carry cholesterol to cells and deposit excess cholesterol in arteries

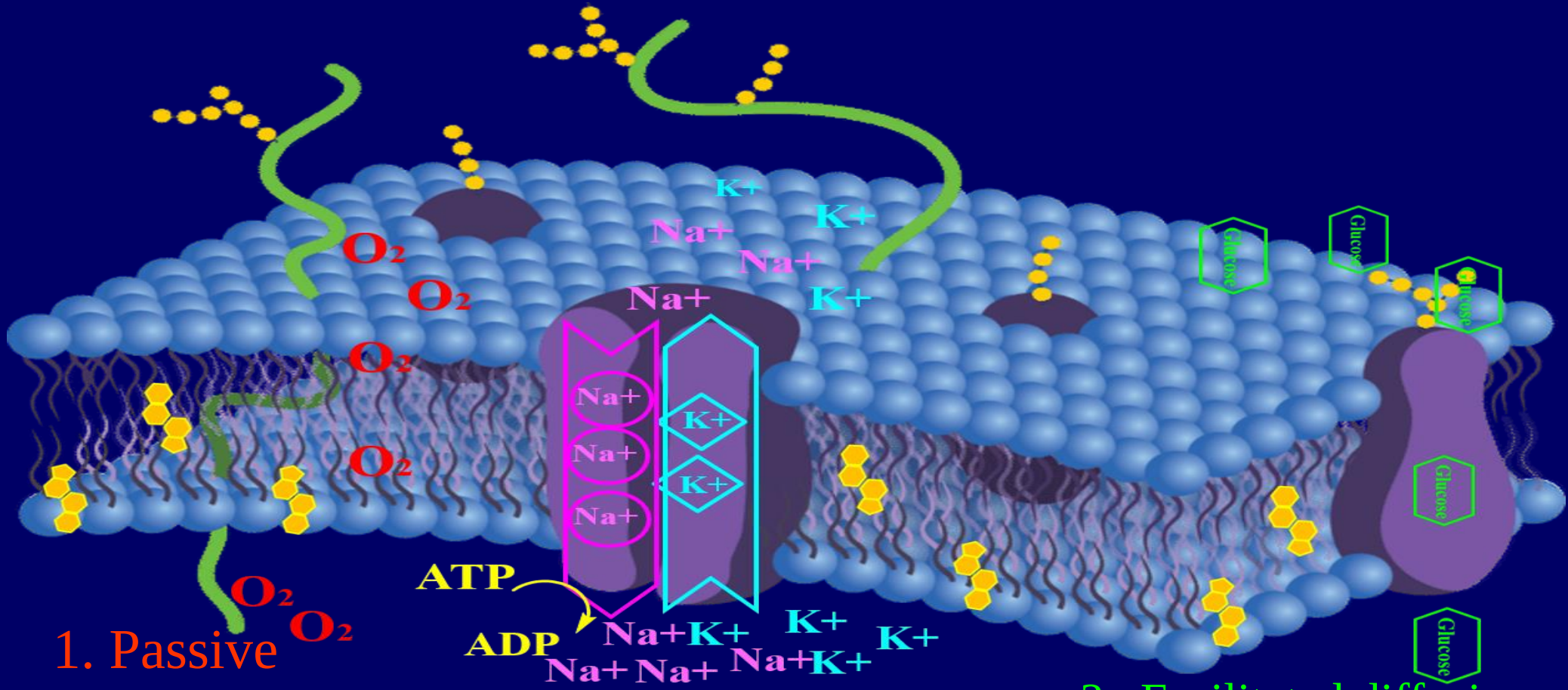
Transport Across Cell Membranes

- There is a very strong tendency for molecules to move from higher concentration to low, just based on thermal energy.
- There are times when membranes are impermeable to some molecules because of their size, polarity, etc. and only the smaller solvent molecules like water molecules will move across the membrane. This is called **osmosis**, and the tendency to transport the solvent molecules is quantified in terms of **osmotic pressure.**
- If a molecule is to be transported from an area of low concentration to an area of high concentration (**active transport**), work must be done to overcome the influences of diffusion and osmosis.
- Many crucial processes in the life of cells depend upon active transport. the sodium-potassium pump which is a vital cell process. Active transport mechanisms may draw their energy from the hydrolysis of ATP.

Transport Across Cell Membranes

1. **Diffusion**: Diffusion is the movement of molecules from a region of higher concentration to one of lower concentration just based on thermal energy.
2. **Osmosis:** Osmosis is the movement of water from a region of higher concentration to one of lower concentration
3. **Facilitated diffusion:** Certain proteins in the membrane assist facilitated diffusion by permitting only certain molecules to pass across the membrane. The proteins encourage movement in the direction that diffusion would normally take place, from a region with a higher concentration of molecules to a region of lower concentration.
4. **Active transport:** a protein moves a certain material across the membrane from a region of lower concentration to a region of higher concentration. Because this movement is happening against the concentration gradient, the cell must expend energy that is usually derived from a substance called adenosine triphosphate, or ATP i.e :the sodium-potassium pump which is a vital cell process.

Type of Transport through the cell membrane



1. Passive diffusion

2. Active transport against concentration gradient with input of energy

3. Facilitated diffusion with carrier protein (large molecule i.e. glucose)

thank you!