Tishk International University
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GENERAL AND SYSTEMIC BIOCHEMISTRY

Lipids

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LEC4

Lectures outline

- Introduction to lipids
- Classification of lipids
- Function of lipids

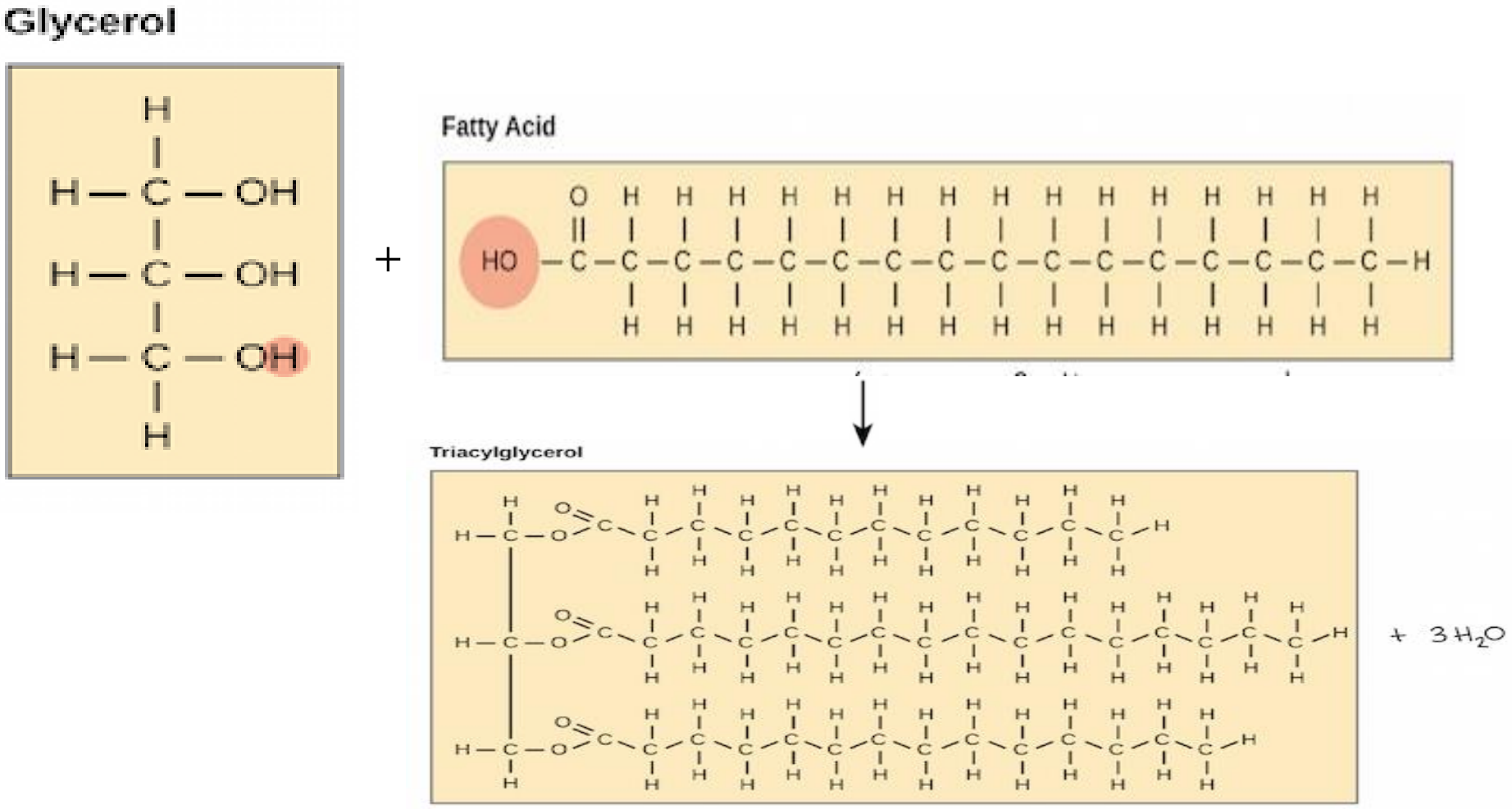
Fats and oils

•A **fat** molecule consists of two kinds of parts: a glycerol backbone and three fatty acid tails. Glycerol is a small organic molecule with three hydroxyl (OH) groups, while a fatty acid consists of a long hydrocarbon chain attached to a carboxyl group.

•A typical fatty acid contains 12–18 carbons, though some may have as few as 4 or as many as 36.

•To make a fat molecule, the hydroxyl groups on the glycerol backbone react with the carboxyl groups of fatty acids in a dehydration synthesis reaction. This yields a fat molecule with three fatty acid tails bound to the glycerol backbone via ester linkages (linkages containing an oxygen atom next to a carbonyl, or C=O, group).

Triglycerides may contain **three identical fatty acid tails**, or **three different fatty acid tails** (with different lengths or patterns of double bonds).



Fat molecules are also called **triacylglycerols**, or **triglycerides**. In the human body, triglycerides are primarily stored in specialized fat cells, called **adipocytes**, which make up a tissue known as adipose tissue. While many fatty acids are found in fat molecules, some are also free in the body.

Classification of lipids

Triglyceride (simple)

composed of glycerol as a backbone and three fatty acids.

Waxes (simple)

Structurally speaking, waxes typically contain long fatty acid chains connected to alcohols by ester linkages, waxes produced by plants.

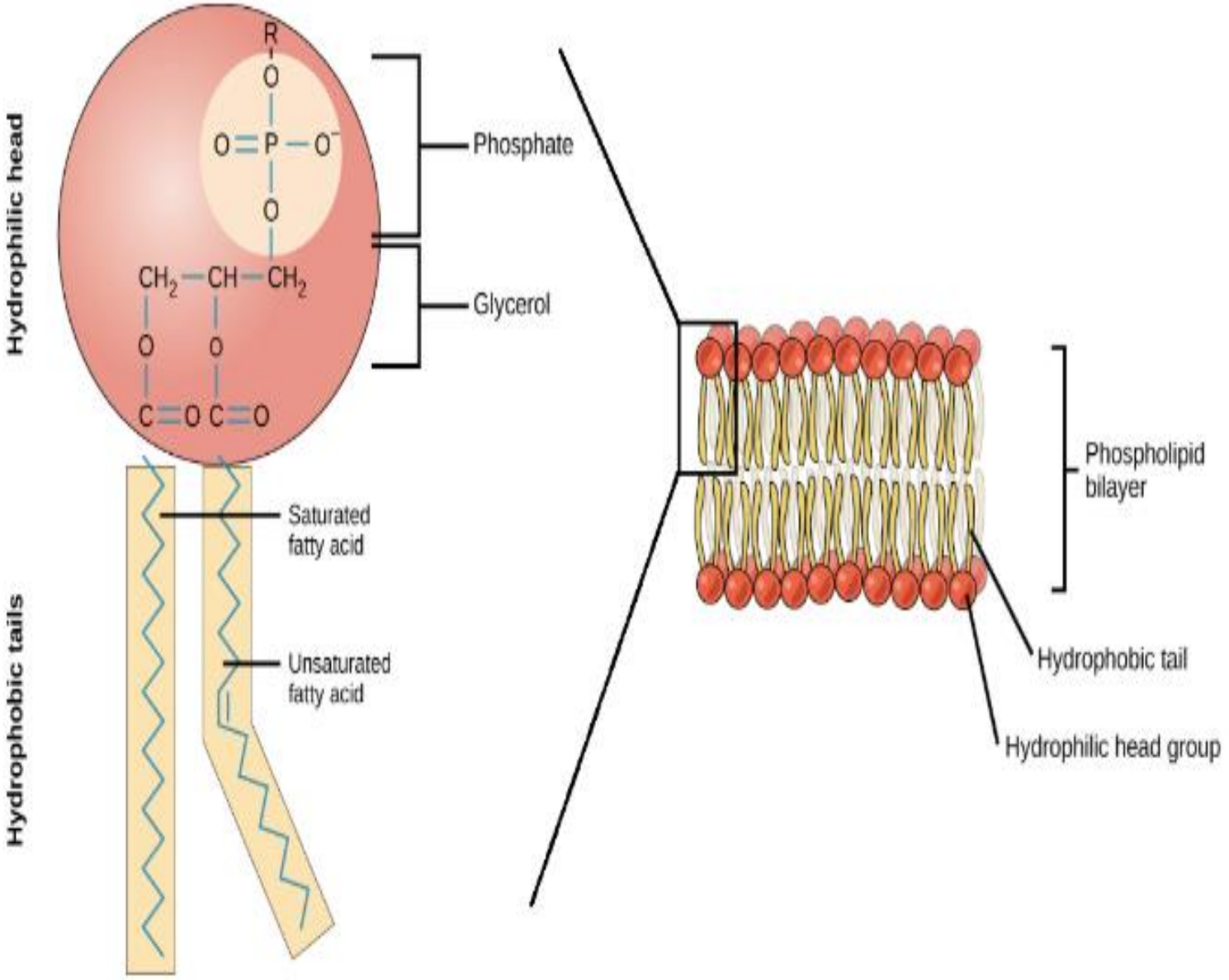
Waxes are biologically important category of lipids. Wax covers the feathers of some aquatic birds, where its hydrophobic (water-repelling)

Phospholipids (complex)

Cells are surrounded by a structure called the plasma membrane, which serves as a barrier between the inside of the cell and its surroundings.

Specialized lipids called **phospholipids** are major components of the plasma membrane.

Like fats, they are typically composed of fatty acid chains attached to a backbone of glycerol. Instead having three fatty acid tails, phospholipids generally have just two, and the third carbon of the glycerol backbone is occupied by a modified phosphate group.

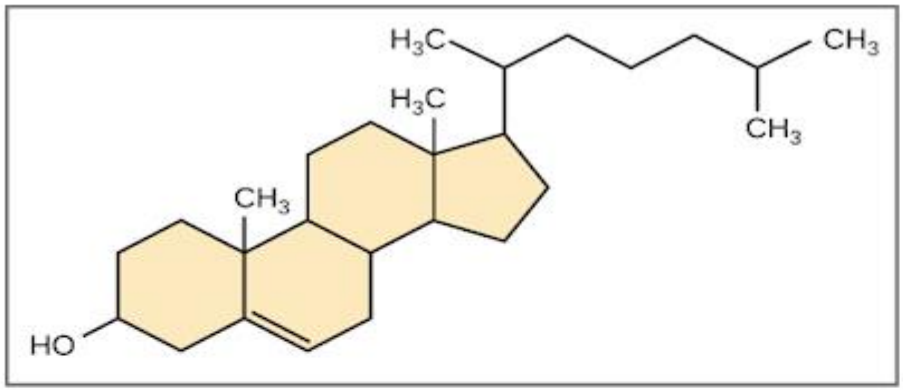

Hydrophilic head
Hydrophobic tails
R
O
O = P — O⁻
O
CH2 — CH — CH2
O O
C = O C = O
Phosphate
Glycerol
Saturated fatty acid
Unsaturated fatty acid
Phospholipid bilayer
Hydrophobic tail
Hydrophilic head group

A phospholipid is an **amphipathic** molecule, meaning it has a **hydrophobic** part and a **hydrophilic** part. The fatty acid chains are hydrophobic and do not interact with water, whereas the phosphate-containing group is hydrophilic (because of its charge) and interacts with water. In a membrane, phospholipids are arranged into a structure called a bilayer, with their phosphate heads facing the water and their tails pointing towards the inside

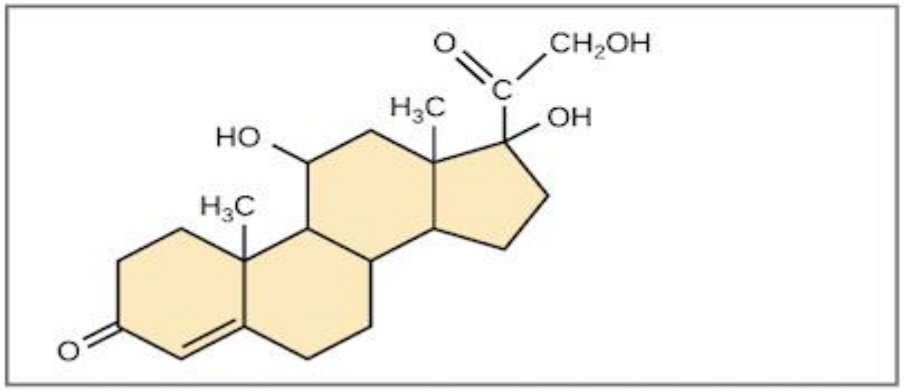
Steroids (derived)

Are another class of lipid molecules, identifiable by their structure of four fused rings.

Steroids are included in lipid category because they are also hydrophobic and insoluble in water. All steroids have four linked carbon rings and several of them, like cholesterol, also have a short tail. Many steroids also have an –OH functional group attached at a particular site, as shown for cholesterol below; such steroids are also classified as alcohols, and are thus called sterols.



Cholesterol



Cortisol

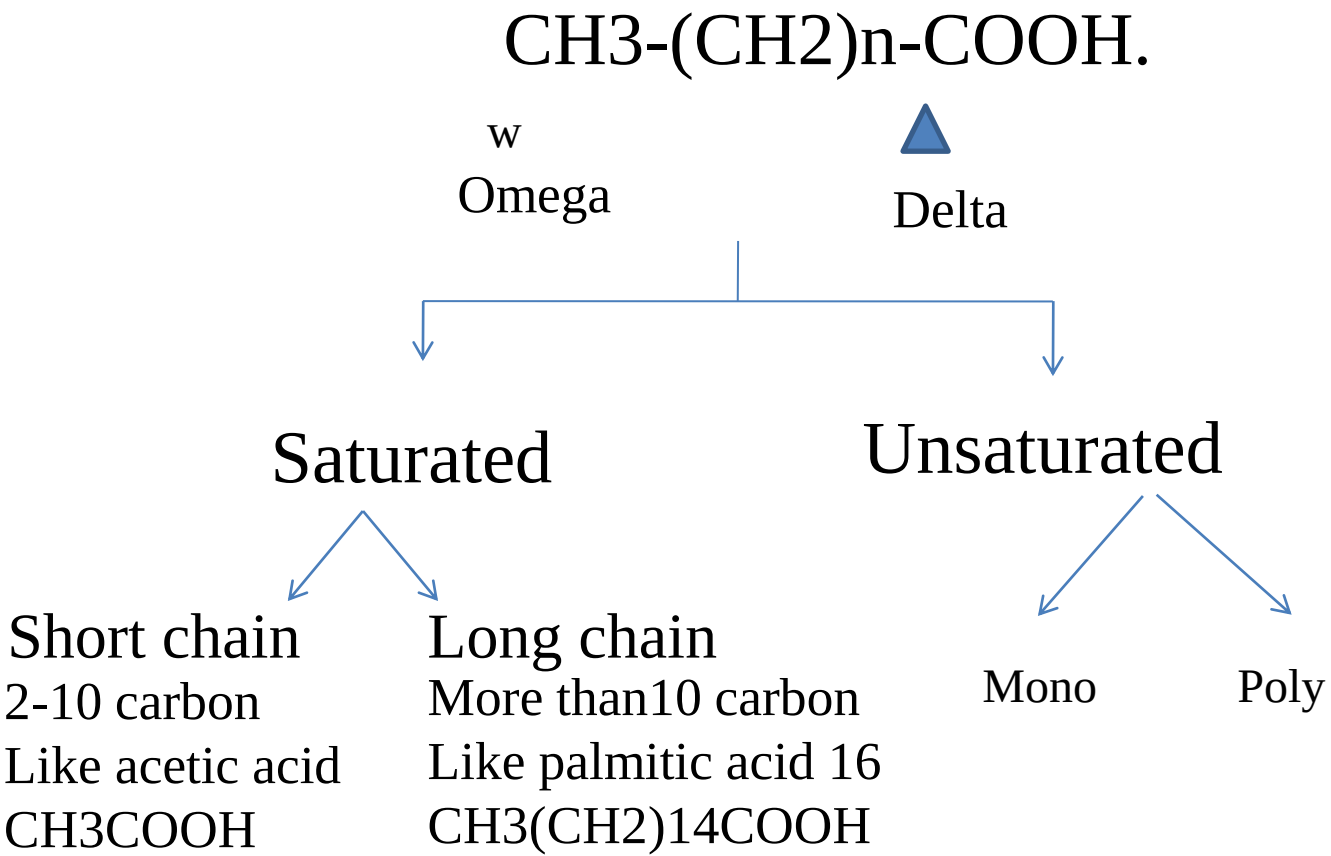
•**Cholesterol**, the most common steroid, is mainly synthesized in the **liver** and is the precursor to many **steroid hormones**.

•Cholesterol also serves as the starting material for other important molecules in the body, including vitamin D and bile acids

•Cholesterol in the blood can have both protective effects and negative effects

Fatty acids:

Long chain hydrocarbon. General formula one end is methyl (CH3) and another end is COOH.



Mono unsaturated: are not essential

Oleic acid

CH3-(CH2)7-HC=CH-(CH2)7-COOH

C18:1: ▲9

W9

Palmitoleic acid

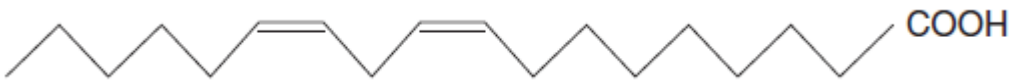
CH3-(CH2)5-HC=CH-(CH2)7COOH

C16:1: ▲9

W7

Poly unsaturated fatty acids: are essential, can not be synthesized in the body.

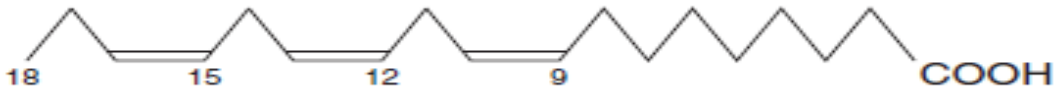
Linoleic acid



C18:2: ▲9,12

W6

Arachadonic acid C20/4double bonds



Linolenic

C18:3: ▲9,12,15

W3

Docosahexaenoic acid DHA

Eicosapentaenoic acid EPA

Importance of fat

Diet: to get energy, essential fatty acids, important for fat soluble vitamins A,D,E,K.

Variable fat (depot): storage of energy, protect against trauma, insulator against heat loss, and support internal organs.

Constant fat: cell membrane.

Signaling: Hormones.

COMPOUND LIPIDS

Compounds lipids contain lipids part + non lipids part.

It includes:

1-Phospholipids

2- Glycolipids

3- Lipoproteins

I-PHOSPHOLIPIDS

Phospholipids are lipids conjugated with phosphoric acid

Functions of phospholipids :

1-Structural component of cell membrane and nervous system.

2-Formation of surface layer of lipoproteins.

3-Dipalmityl lecithin acts as lung surfactant.

4-Signal transduction of hormones.

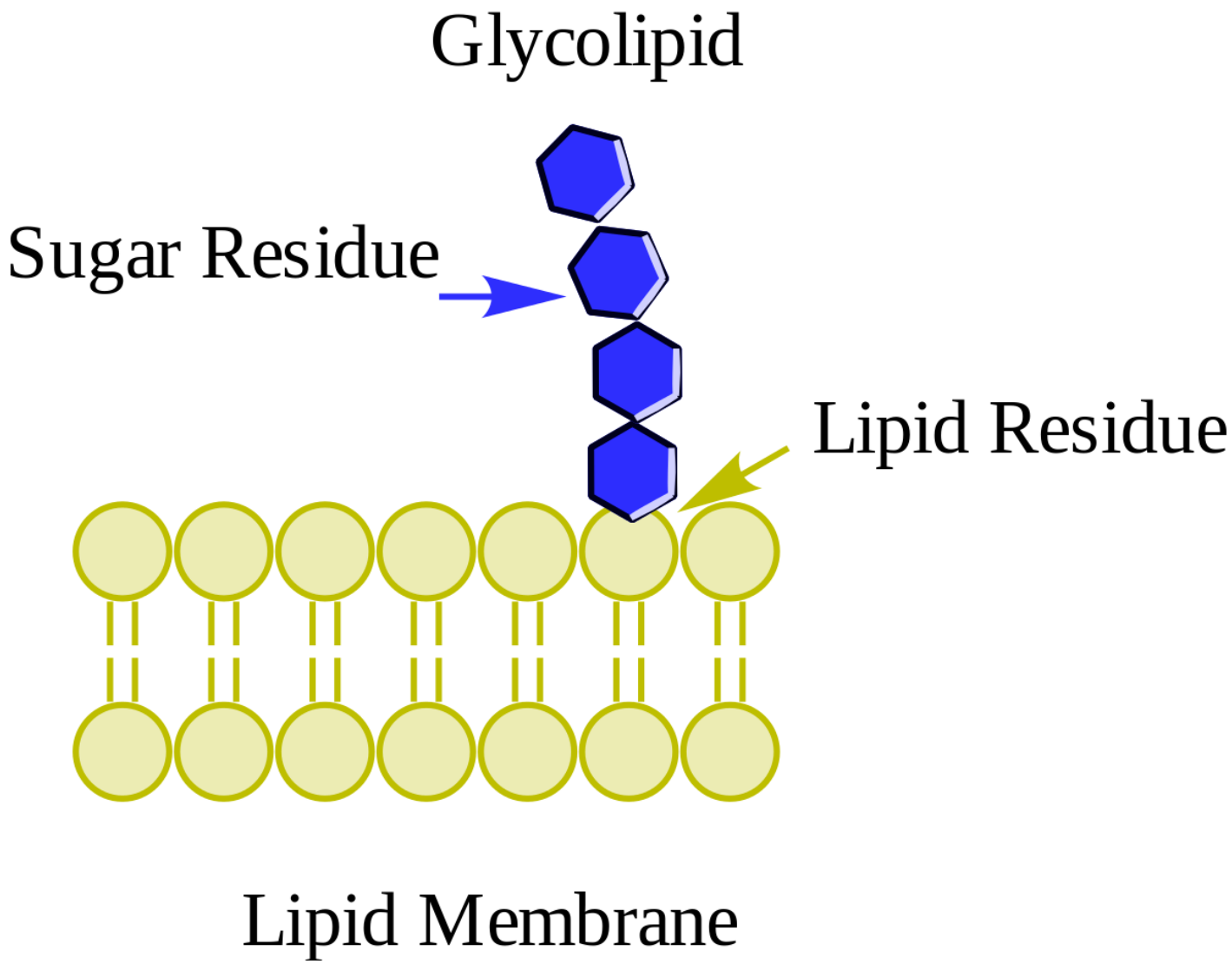
II-GLYCOLIPIDS

Distribution :

1- Nervous system.

2- Outer layer of cell membrane ,where they play a role in the regulation of cellular interaction (adhesion and recognition).

The basic **structure** of a **glycolipid** consists of a mono- or oligosaccharide group attached to a glycerol group with one or two fatty acids.


Glycolipid
Sugar Residue
Lipid Residue
Lipid Membrane

III-LIPOPROTEINS

Lipoproteins→ lipids + proteins

-Lipids component of lipoproteins includes phospholipids, cholesterol, cholesterol ester, fatty acids and triacylglycerols.

Classification of lipoproteins

INCREASING DENSITY AND A DECREASE IN THE SIZE OF THE PARTICLES
CM: chylomicrons
VLDL: very low density lipoprotein
IDL: intermediate density lipoprotein
LDL: low density lipoprotein
HDL: high density lipoprotein

Chylomicrons are lipoprotein particles that consist of triglycerides, phospholipids, cholesterol, and proteins. Due to their density relative to lipoproteins, they are also commonly known as ultra low density lipoproteins

VLDL stands for very low density lipoprotein. Lipoproteins are made up of cholesterol, triglycerides, and proteins. They move cholesterol, triglycerides, and other lipids (fats) to around the body. **VLDL** is one of the three main types of lipoproteins. **VLDL** contains the high amount of triglycerides.

Intermediate-density **lipoproteins** (**IDL**) are intermediate between VLDL and LDL. They are not usually detectable in the blood when fasting. Low-density **lipoproteins** (LDL) carry 3,000 to 6,000 fat molecules (phospholipids, cholesterol, triglycerides, etc.) around the body.

LDL, Low density lipoproteins

LDL particles, average 22 nm in diameter with roughly 3000 lipid molecules in total, and they contain a hydrophobic core of approximately 170 **triglycerides**, 1600 **cholesterol** ester and 200 **unesterified cholesterol** molecules.

The **function of LDL** is to deliver cholesterol to cells, where it is used in membranes, or for the synthesis of steroid hormones.

HDL stands for high-density lipoproteins. It is sometimes called the "good" cholesterol because it carries cholesterol from other parts of your body back to your liver. Your liver then removes the cholesterol from your body.

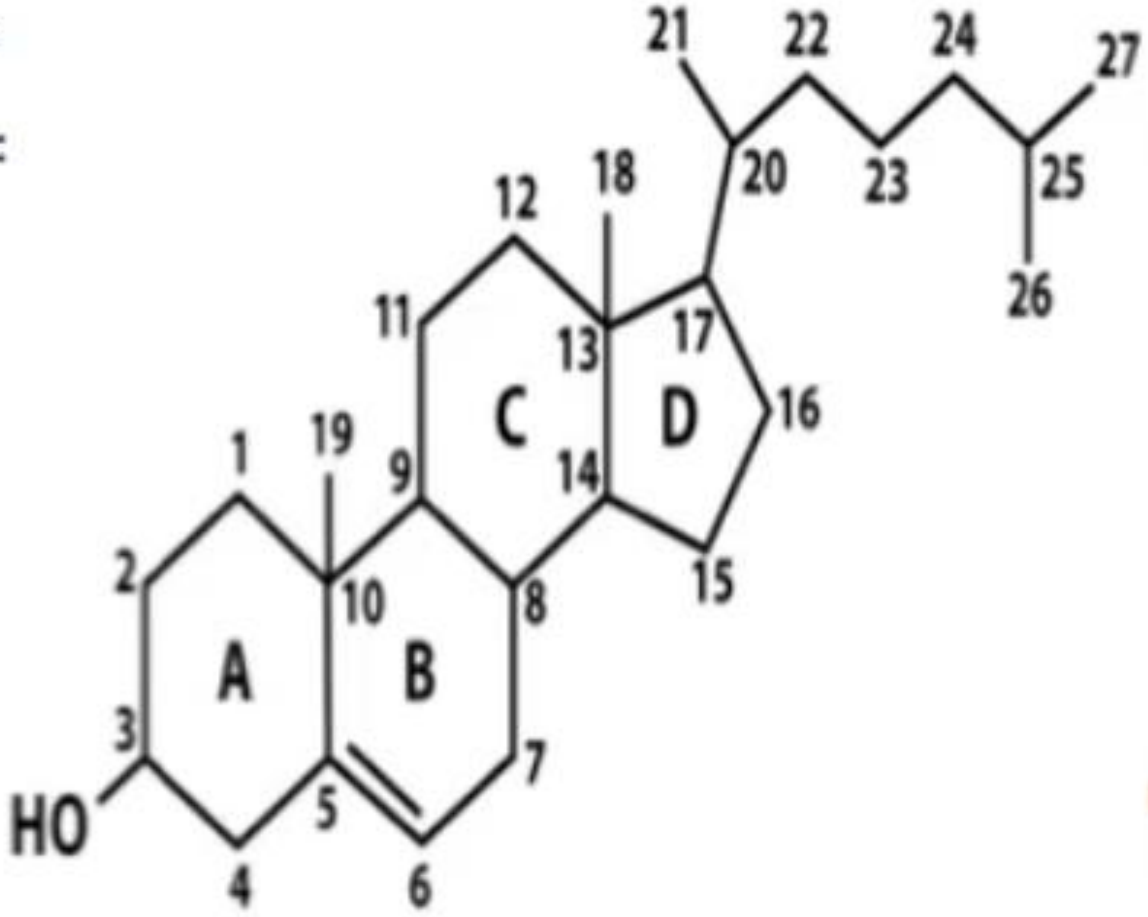
CHOLESTEROL

- **Sources of cholesterol:**

1-Exogenous sources: egg yolk, liver, and brain are dietary sources

2-Endogenous sources:

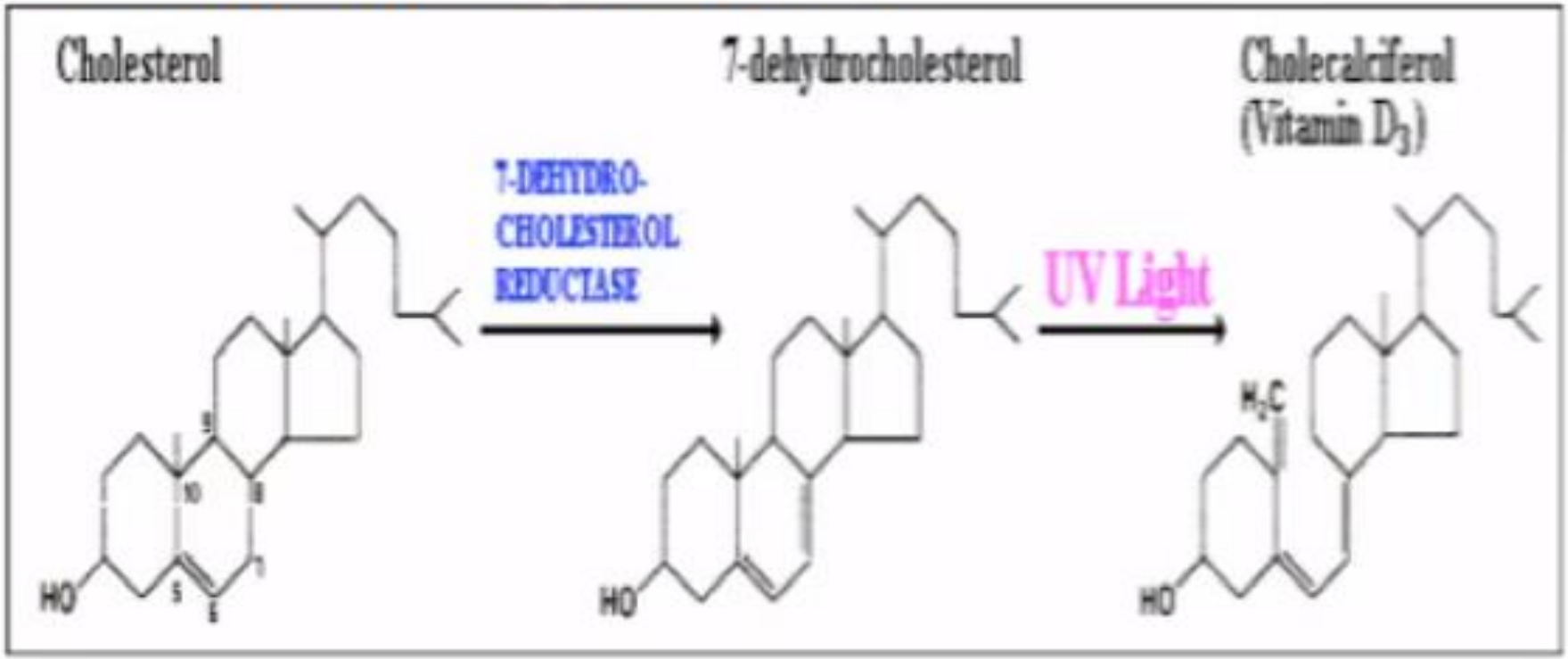
Every cell in the body can synthesize its own cholesterol but blood cholesterol is formed by the liver.



FUNCTIONS OF CHOLESTEROL :

1-Enters in the formation of cell membrane.

2-Formation of vitamin D



3-FORMATION OF BILE ACIDS :

- Cholesterol is oxidised in the liver to form bile acids.

Importance of bile salts :

1. - Emulsification of lipids so help in digestion of lipids.
2. - Activation of pancreatic lipase enzyme.
3. - Absorption of lipids and fat soluble vitamins (A,D,E,K

4-STEROID HORMONES:

Cholesterol is the precursor of steroid hormones

A. Corticoids:

Secreted by supra-renal cortex

Corticoids are classified into:

- **Glucocorticoids** regulate carbohydrates, lipids and proteins metabolism e.g. cortisol, cortisone and corticosterone.
- **Mineralocorticoids** regulate water and mineral metabolism e.g. aldosterone, 11-deoxycorticosterone.

B.Sex hormones

- **Male sex hormones** (Androgens)

The most important is testosterone.

- **Female sex hormones:** e.g.estrogen and progesterone.