Lect.3.

Lipids

1-1:Introduction

Lipids are fatty compounds that perform a variety of functions in your body.

They're part of your cell membranes and help control what goes in and out of your cells.

They help with moving and storing energy, absorbing vitamins and making hormones.

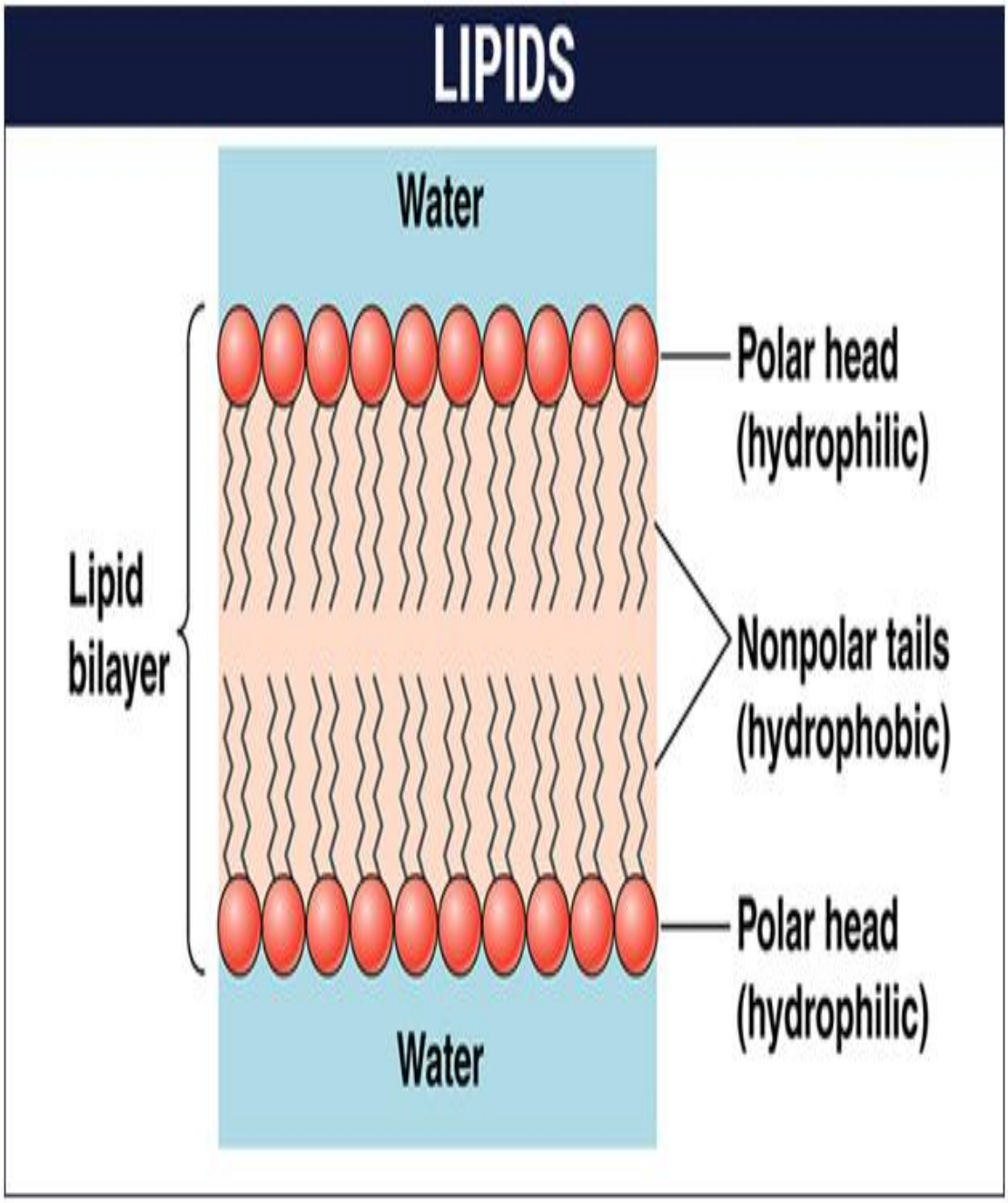
Having too much of some lipids is harmful. A lipid panel can tell you if you have normal levels.

What are lipids

Lipid is a general term for water- insoluble biological molecules, They are structurally and functionally diverse group of molecules.

The lipids include fatty acids, fats, oils, waxes and related compounds such as phospholipids, eicosanoids, terpenes and steroids.

Lect.3.


LIPIDS
Water
Polar head
(hydrophilic)
Lipid
bilayer
Nonpolar tails
(hydrophobic)
Polar head
(hydrophilic)
Water

Lect.3.

1- 2:Functions of lipids

[1]They are stored forms of energy in all living organisms. Fat molecules have maximum number of hydrogen atoms so, they have maximum of electrons, which produce more energy as ATP.

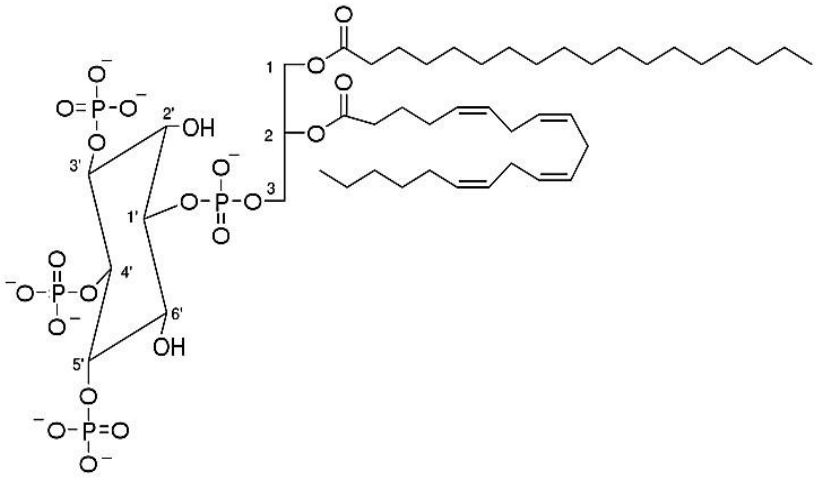
[2] They are structural components of the cell.

[3]The fatty acid, arachidonic acid is the precursor for all prostaglandins, leukotrienes and thromboxanes.

[4]The lipids are needed in the diet to solubilize the fat-soluble vitamins like A, D, E and K.

[5]The corticosteroids and sex hormones and Vitamin D, are synthesized from cholesterol.

[6] Phosphatidylinositol triphosphate serves as the key precursor in the formation of second messenge.



Lec.3.

[7]Lipids act as an insulating material, which prevents the dissipation of heat from the body.

[8]Lipids provide cushioning effect to the body which prevents the body against mechanical injuries.

[9]Because lipids are insoluble, they generate no osmotic pressure when stored in the cells.

1-3:Classification of lipids

Lipids can be classified according to simple or complex to:

[1]Simple lipids: Esters of fatty acids with various alcohols.

[2]Complex lipids: Esters of fatty acids containing groups in addition to an alcohol and a fatty acid.

[3]Derived lipids: These include fatty acids, glycerol, steroids, other alcohols, fatty aldehydes, and ketone bodies, hydrocarbons, lipid-soluble vitamins, and hormones. Because they are uncharged, acylglycerols (glycerides), cholesterol, and cholesteryl esters are termed neutral lipids.

Lec.3.

[1]Simple lipids

[a]Fats: Esters of fatty acids with glycerol.

Oils are fats in the liquid state.

[b]Waxes: Esters of fatty acids with higher molecular weight monohydric alcohols.

[2]Complex lipids

[a]Phospholipids: Lipids containing, in addition to fatty acids and an alcohol, a phosphoric acid residue.

They frequently have nitrogen containing bases and other substituents, eg, in glycerophospholipids the

alcohol is glycerol and in sphingophospholipids the alcohol is sphingosine.

[b]Glycolipids (glycolsphingolipids): Lipids containing a fatty acid, sphingosine, and carbohydrate. Other complex lipids: Lipids such as sulfolipids, and aminolipids. Lipoproteins may also be placed in this category.

Lect.3

1- 4:fatty acid

fatty acid, important component of lipids (fat-soluble components of living cells) in plants, animals, and microorganisms.

Generally, a fatty acid consists of a straight chain of an even number of carbon atoms, with hydrogen atoms along the length of the chain and at one end of the chain and a carboxyl group (—COOH) at the other end.

Fatty acids are straight aliphatic chains with a methyl group at one end and a carboxyl group at the other end. They can be represented by the formula RCOOH where R is the alkyl group {CH3 (CH2)n (hydrocarbon chain).

The hydrocarbon chain is hydrophobic and the carboxylate group is hydrophilic.

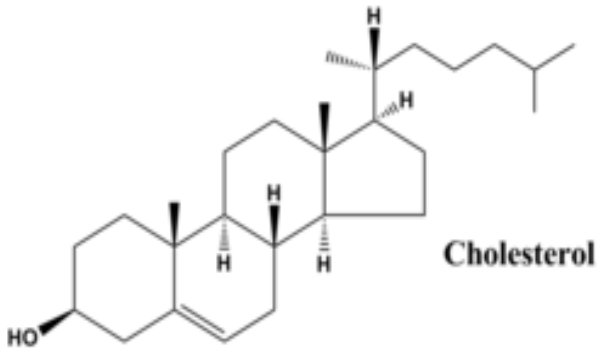
Fatty acids occur primarily as esters of glycerol.

It is that carboxyl group that makes it an acid (carboxylic acid).

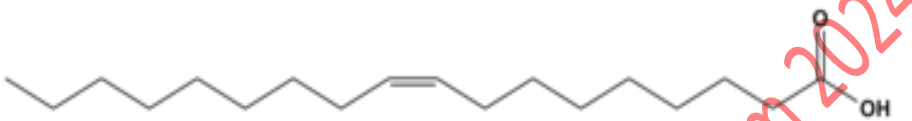
If the carbon-to-carbon bonds are all single, the acid is saturated; if any of the bonds is double or triple, the acid is unsaturated and is more reactive. A few fatty acids have branched chains; others contain ring (structures (e.g., prostaglandins).

Fatty acids are not found in a free state in nature; commonly they exist in combination with glycerol (an alcohol) in the form of triglyceride.

Lect.3

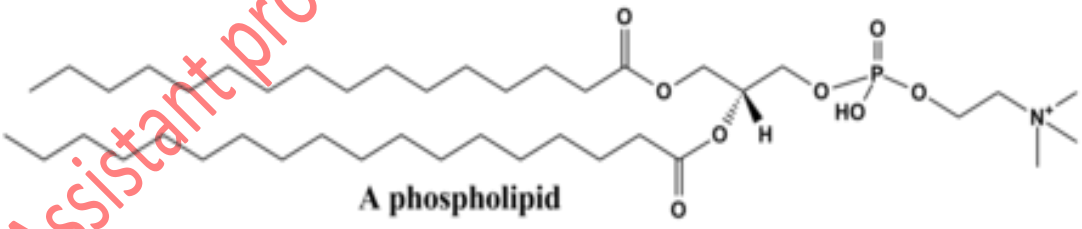


Cholesterol



A free fatty acid

A triglyceride



A phospholipid

Lect.3

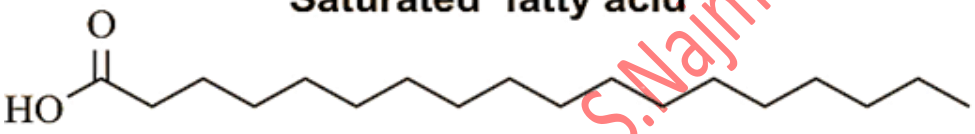
Fatty acids are divided into:

[1] (Short (2 to 4 carbon atoms)

[2] (Medium (6 to 10 carbon atoms)

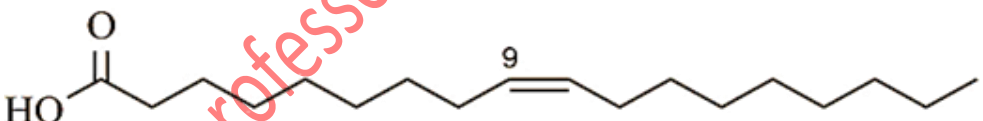
[3] (Long (12 to 26 or more carbon atoms)

Saturated fatty acid

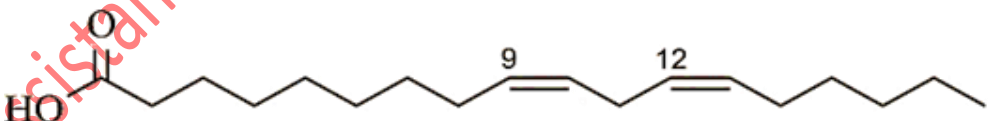


stearic acid (octadecanoic)

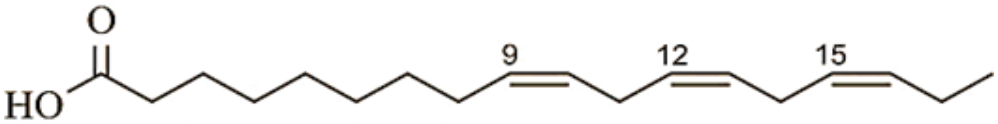
Unsaturated fatty acids



oleic acid (9-octadecenoic)



linoleic acid (9,12-octadecadienoic)



linolenic acid (9,12,15-octadecatrienoic)

Lect.3

Most fatty acids present in human cells have an ***even number of carbon atoms, usually between 16 and 20.***

Fatty acid may contain no double bond (saturated)

Fatty acid may contains one or more double bonds (unsaturated)

Monounsaturated fatty acids contain one double bond

polyunsaturated fatty acids contain two or more double bonds

1-5 Functions of fatty acids

[1]They are the constituents of phospholipids and glycolipids **(component of biological membranes).**

[2]Fatty acids are **fuel molecules** They are stored as triacylglycerols, which are uncharged esters of glycerol.

[3]**They provide physical protection for the organ of the body.**

[4]Fatty acid **derivatives such as prostaglandins, leukotriene**s and thromboxanes serve as local hormones and as a intracellular messenger in cell signaling mechanism.

Lect.3.

1-6 :Nomenclature and properties of fatty acids

In the naming of fatty acids:

Saturated acids end in - anoic acid e.g. octanoic acid.

Unsaturated fatty acids with double bonds end in – enoic acids, e.g. octadecenoic acid (oleic acid)

The fatty acids are generally designated as follows **(Δ, delta system of numbering).**

For example, **oleic acid is written as 18: 1, Δ 9. The number 18 indicates the number of carbon atoms, 1 indicates the number of double bond and the superscript 9 indicates the position of the double bonds** i.e. the double bond is between carbon atoms 9 and 10 of the fatty acid. Sometimes the Δ is omitted and oleic acid is indicated as **(18: 1; 9)**, **Linoleic acid (18: 3, Δ 9, 12, 15).**

18:indicates the number of carbon atoms.

3:Three of double bonds.

9,12,15 :position of double bonds.

The pKa of fatty acid carboxyl group is about 4.8. Hence, fatty acids are **ionized at physiologic pH and so it is appropriate to refer to them according to their carboxylate forms i.e. palmitate or hexadecanoate.**

The properties of fatty acids and the compounds that contain them are dependent on the **chain length and the degree of unsaturation.**

Non- polar hydrocarbon chain of fatty acids accounts for **the poor solubility of fatty acid in water.**

Lect.3.

Unsaturated fatty acids **have lower melting points t**han saturated fatty **.** acids of the same length. For eg. the melting point of stearic acid is 69.6^{o} C, whereas that of oleic acid is 13.4^{o}C.

The melting point of polyunsaturated fatty acids of the C18 series is even lower.

The melting point of arachidonic acid is - 49.5^{o} C.

The chain length also affects the melting point.

The melting temperature of palmitic acid (C16) is 62.8^{o} C.

The melting point of stearic acid (C18) is 69.68^{o} C.

Fatty acids with short chain length and unsaturation enhance the fluidity of membranes.

Lect.3.

1-7Nonessential and Essential Fatty Acids

Fatty acids are vital for the normal operation of all body systems.

The circulatory system, respiratory system, integumentary system, immune system, brain, and other organs require fatty acids for proper function.

The body is capable of synthesizing most of the fatty acids it needs from food.

These fatty acids are known as nonessential fatty acids.

However, there are some fatty acids that the body cannot synthesize and these are called essential fatty acids.

It is important to note that nonessential fatty acids doesn't mean unimportant; the classification is based solely on the ability of the body to synthesize the fatty acid.

Essential fatty acids must be obtained from food

It is important to note that nonessential fatty acids doesn't mean unimportant; the classification is based solely on the ability of the body to synthesize the fatty acid.

Essential fatty acids must be obtained from food.

Lect.3.

Essential fatty acids for many species including man are:

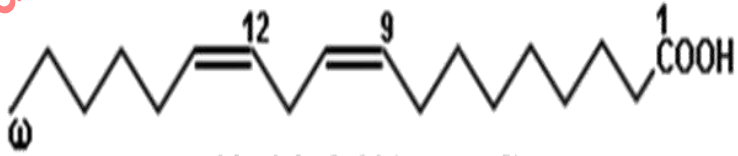
Linoleic (ω6) acid (Omega-3)

linolenic(ω3) acid (Omega-6).

The3and 6 refer to **the position of the first carbon double bond** and the omega refers to the methyl end of the chain.

Arachidonic acid is also an essential fatty acid and it can be formed from linoleic acid in most mammals but not in the cat family.

Alpha-Linolenic Acid (omega-3)



Linoleic Acid (omega-6)

Lect.3.

Deficiency causes

[1] Scaly dermatitis.

[2]Affects fluidity of membrane structure.

[3]Decreased availability of precursors for eicosanoid synthesis. (Eicosa is the Greek word for the number 20).

Eicosanoids are powerful hormones that control many other hormones and important body functions, such as the central nervous system and the immune system. Eicosanoids derived from omega-6 fatty acids are known to increase blood pressure, immune response, and inflammation. In contrast, eicosanoids derived from omega-3 fatty acids are known to have heart-healthy effects. Given the contrasting effects of the omega-3 and omega-6 fatty acids, a proper dietary balance between the two must be achieved to ensure optimal health benefits.

Essential fatty acids play an important role in the life and death of cardiac cells, immune system function, and blood pressure regulation. Docosahexaenoic acid (DHA) is an omega-3 essential fatty acid shown to play important roles in synaptic transmission in the brain during fetal development.

Some excellent sources of omega-3 and omega-6 essential fatty acids are fish, flaxseed oil, hemp, walnuts, and leafy vegetables.

Because these essential fatty acids are easily accessible, essential fatty acid deficiency is extremely rare.