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Lipids



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Importance

- Heterogenous group of compounds that are insoluble in water but soluble in non-polar solvents such as chloroform
- Occur in plants and animals as storage and structural components
- Supply the essential fatty acids that are not synthesized in human beings
- Essential for the absorption of fat soluble vitamins A, D, E, and K
- Fats are deposited in the adipose tissue that serves as a reserve source of energy during starvation
- Improve the palatability of the diet



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Classification

- **Simple Lipids** – Esters of fatty acids with glycerol and monohydric alcohols
 - Fats are triglycerides that are esters of fatty acids with glycerol (vegetable oils, ghee, and butter)
 - Waxes are esters of fatty acids and alcohol (bees wax)
- **Compound Lipids** – Esters containing chemical groups in addition to alcohol and fatty acids
 - Phospholipids – contain phosphate group
 - Glycolipids contain hexose units preferably galactose
 - Plant Sulpholipids – contain sulfated hexose



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Simple Lipids

- Contain fatty acids and glycerol or long chain alcohols (fats, oils, waxes)
- Also referred to as oils, fats, or neutral fats
- Triacylglycerols are composed of three fatty acids esterified to the hydroxyl groups of glycerol
- Triacylglycerol that are solids at room temperature are called fats
- Liquid triacylglycerols are called as oils
- Waxes are esters of long-chain saturated and unsaturated fatty acids with long chain alcohol

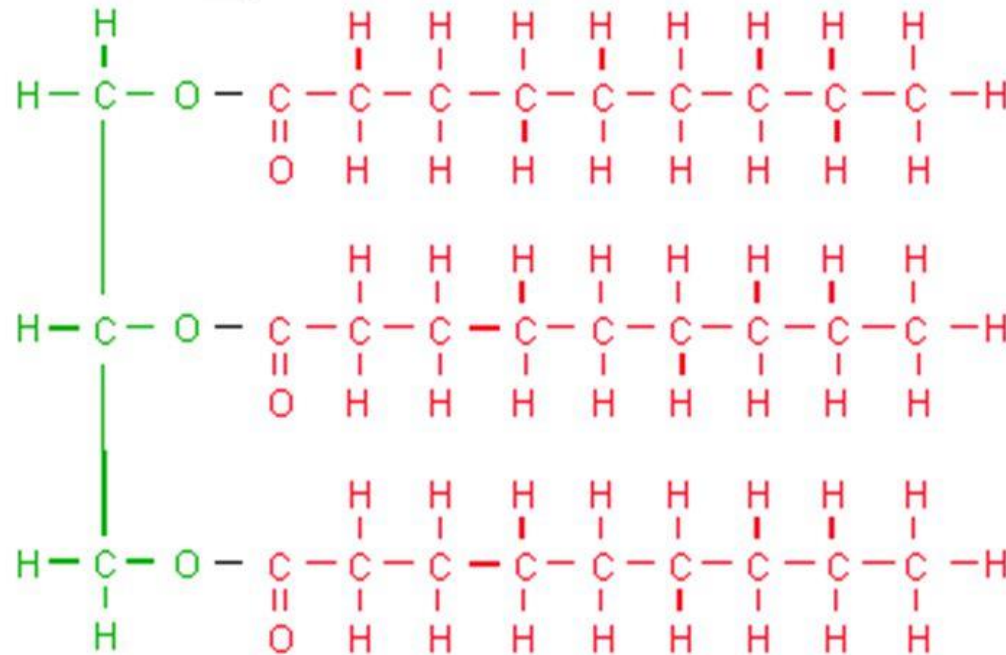


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Structure of Simple Lipids

One glycerol molecule and up to three fatty acids
(saturated or unsaturated)





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Compound Lipids

- Contain chemical groups in addition to alcohol and fatty acids:
 - Glycerophospholipids – glycerol, fatty acid, phosphoric acid, and a nitrogenous base and this is an important structural lipid in membranes
 - Phosphatidyl choline (lecithin) – contains nitrogenous base choline. Present in the membranes of cells having both metabolic and structural functions
 - Sphingophospholipids - phosphate and fatty acids are attached to the alcohol sphingosine instead of glycerol (linkage is by amide and not ester)



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Derived Lipids

- Derivatives of hydrolysis of simple and complex lipids
- Sterols – Possess a cyclic ring structure with one secondary alcoholic group. Occur in the free state as esters with fatty acids. Classified as:
 - Animal sterols – cholesterol – brain consists of 5.5% and blood of human being consists of 150-250 mg/100 ml
 - Plant sterols – phytosterol
 - Mycosterol - ergosterol



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Plant Fatty Acids

- Fatty acids are carboxylic acids with hydrocarbon chains of 2-36 carbons
- More than 200 fatty acids have been isolated from plants but only a few are present in large quantities (major fatty acids)
- Major fatty acids are saturated and unsaturated with an unbranched carbon chain
- Saturated fatty acids are: Lauric, Myristic, Palmitic, and Stearic



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Lipid Classification

- Unsaturated fatty acids are oleic, linoleic, and linolenic acid
- The double bonds of all naturally occurring unsaturated fatty acids are in cis configuration
- Non-polar hydrocarbon chain accounts for the poor solubility of fatty acids in water
- Minor fatty acids are characterized by a high content of short and medium chain saturated fatty acids (cow and goat milk)



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Lipid Classification

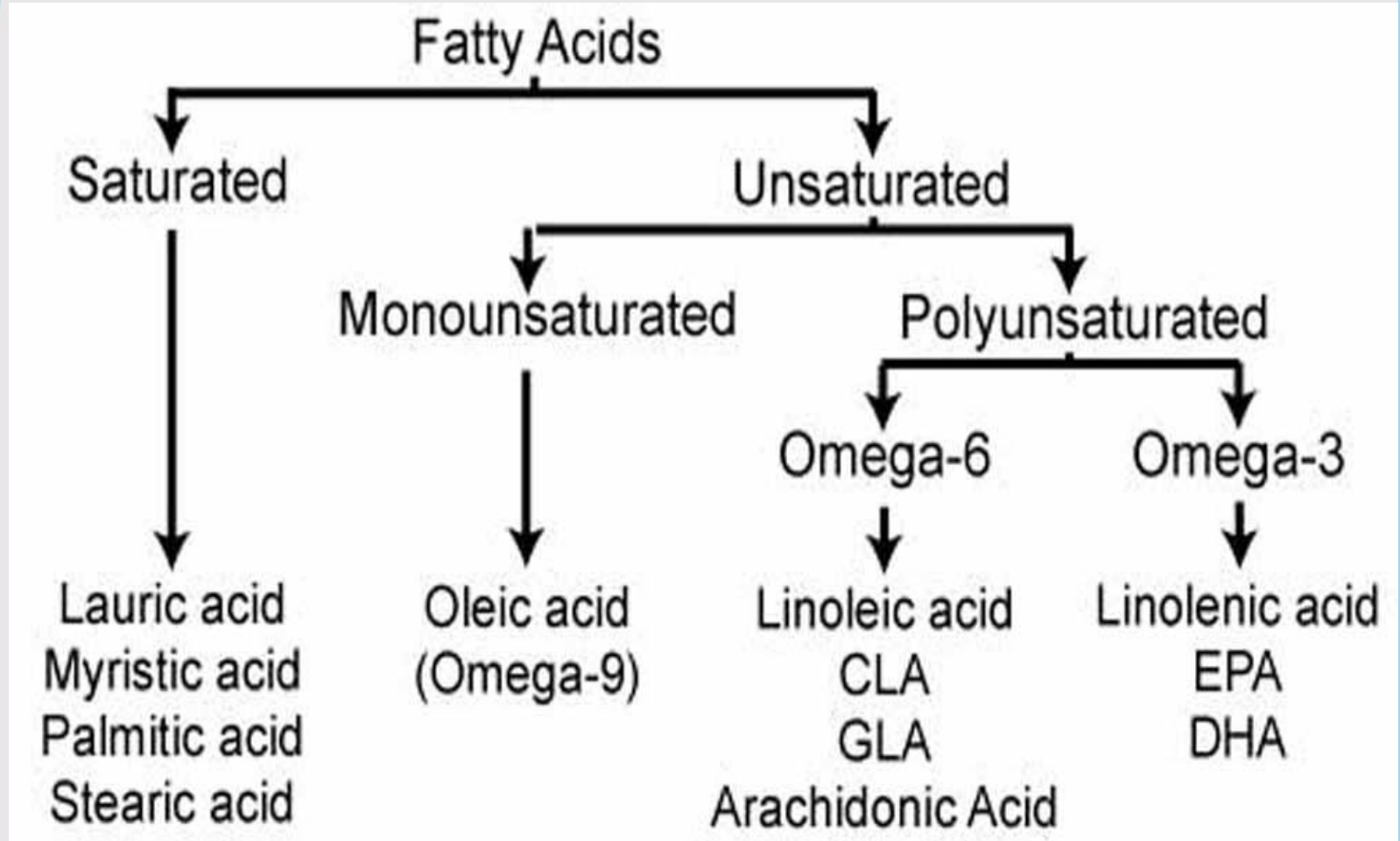
- **Unusual fatty acids** are found only in few individual species or genus
- Castor bean seed oil is rich in ricinoleic acid
- Hydnocarpic and chaulmoogric acids are found in chaulmoogra oil used in the treatment of leprosy
- **Essential Fatty Acids:** fatty acids that are not synthesized in the body but required for normal body growth are called essential fatty acids
- Linoleic and linolenic acids are essential fatty acids, arachidonic is synthesized from linolenic acid



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Fatty Acid Classification



Essential Fatty Acid Pathways

OMEGA-6 Family

LINOLEIC ACID (LA)
Eg. Soybean, Sunflower, Corn,
Canola + Rice Bran Oil

Your Body Converts LA to:

GAMMA-LINOLENIC ACID (GLA)
Eg. Evening Primrose Oil +
Borage Oils

EPA Inhibits this Conversion

ARACHIDONIC ACID (AA)
Eg. Meat

**PRO-INFLAMMATORY
PRODUCTS**

OMEGA-3 Family

ALPHA-LINOLENIC ACID (ALA)
Eg. Flaxseed, Hemp + Chia Seed Oil

Your Body Converts ALA to:

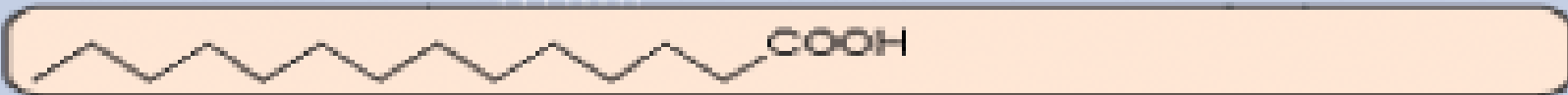
EICOSAPENTANOIC ACID (EPA)
Eg. Fish Oil

Your body converts EPA to:

DOCOSAHEXAENOIC ACID (DHA)
Eg. Fish Or Algae Oil

**ANTI-INFLAMMATORY
PRODUCTS**

Myristic acid
(14:0)



Palmitic acid
(16:0)



Stearic acid
(18:0)



Oleic acid
(18:1)



Linoleic acid
(18:2)



γ -Linolenic acid
(GLA) (18:3)



Arachidonic acid
(ARA) (20:4)



α -Linolenic acid
(ALA) (18:3)



Eicosapentaenoic acid
(EPA) (20:5)



Docosahexaenoic acid
(DHA) (22:6)





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Essential Fatty Acids

Essential Fatty Acids with Numeric Formula

COMMON NAME (Abbreviation)	NUMERIC FORMULA (chain length:double bonds)	LOCATION OF FIRST DOUBLE BOND (relative to omega end of chain)
Linoleic acid (LA)	18:2	Omega-6
Alpha-linolenic acid (ALA)	18:3	Omega-3
Arachidonic acid (AA)	20:4	Omega-6
Eicosapentaenoic acid (EPA)	20:5	Omega-3
Docosahexaenoic acid (DHA)	22:6	Omega-3



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Properties of Fats

- Sources of fats – butter, cooking oil, egg, meat, nuts, milk, cereals, pulses, fruits and vegetables
- Solubility – Soluble in acetone, benzene, hot alcohol
- Fats have sharp melting range for confectionary
- Specific heat increases with increasing unsaturation
- Viscosity decreases with increases unsaturation
- Hydrogenation – preparation of refined oil under optimal temperature and pressure in presence of nickel catalyst
 - Hydrogen is added to the unsaturated linkages



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Rancidity

- Development of off-flavors in fats is known as rancidity – hydrolytic and oxidative
 - **Hydrolytic** – fat is hydrolyzed by lipases, free fatty acids are formed that contribute to off odours
 - **Oxidative** – oxidation takes place at the unsaturated linkage resulting in the formation of peroxides which breakdown into aldehydes and ketones
 - Antioxidant is a substance that is added to fats to retard the oxidative breakdown of fat and prevent spoilage. They act by combining with free radicals and disrupting free radical chain mechanism (Tocopherol)



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Nutritional Aspect of Lipids

- Normal human plasma contains 500 mg/100 ml of which 120 mg are triglycerides, 180 mg cholesterol and 10-15 mg free fatty acids
- Adult human synthesizes about 2000 mg of cholesterol
- Blood cholesterol level of over 250 mg/100 ml increases the risk of coronary heart disease
- Consumption of essential fatty acids is reported to reduce cholesterol levels