Lipids

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Lipids

1. General introduction
2. Nomenclature of fatty acids
3. Degradation of fatty acids and triacylglycerols
4. Biosynthesis of fatty acids and triacylglycerols

Lipids - definition

- **Heterogenous family of substances that are hydrophobic, i.e. insoluble, or only sparingly soluble in water, soluble in organic solvents such as chloroform and methanol**
- **Mostly derivatives of fatty acids with a long chain: their esters, amides with (phospho)alcoholes, amines, etc.**
- **Fats and oils (TAGs), certain vitamines (A, D), steroid hormones, eicosanoids incl. prostaglandins, and most nonprotein membrane components (phospholipids, glycolipids, cholesterol)**

Lipids and membranes

- Membranes function to organize biological processes by compartmentalizing them. The cell, the basic unit of life, is essentially defined by its enveloping plasma membrane. **Biological membranes** are organized assemblies of LIPIDS and PROTEINS with small amounts of CARBOHYDRATES.
- Many fundamental biochemical processes occur on or in a membrane scaffolding.

  Electron transport; oxidative phosphorylation; photosynthesis; communication via hormones, growth factors and nutrients, virus entry (all require membrane receptors); nerve impulses.

LIPID CLASSIFICATION (1)

1. Simple lipids

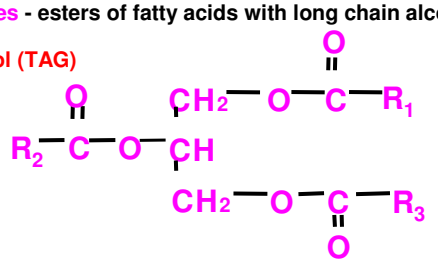
- Fatty acids (FA) – carboxylic acids with long-chain hydrocarbon side group
- Neutral fats/triacylglycerols/triglycerides (TAGs) - esters of fatty acids with glycerol

  simple: contain only one type of FA residue

  mixed: contain two or three different types of FA residues

  = fats (solid at RT) and oils (liquid at RT); otherwise complex mixtures of simple and mixed triacylglycerols whose fatty acid compositions vary with the organism that produces them. Plant oils are usually richer in unsaturated FA residues than are animal fats
- Waxes - esters of fatty acids with long chain alcohols

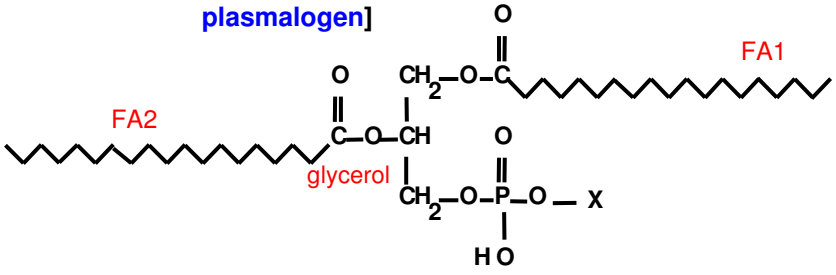
Triacylglycerol (TAG)



LIPID CLASSIFICATION (2)

2. Composed lipids (1)

PHOSPHOLIPIDS – composed of an alcohol (glycerol or sphingosine; polar "head" groups), C1, 2: FAs, C3: phosphoryl group and a group X (choline, ethanol-amine, serine, inositol; phosphatidyl-X), [X=H: phosphatidic acid; X=choline: 3-Phosphatidylcholine, lecithin; C2:OH: lysolecithin; X=ethanolamine +: plasmalogen]

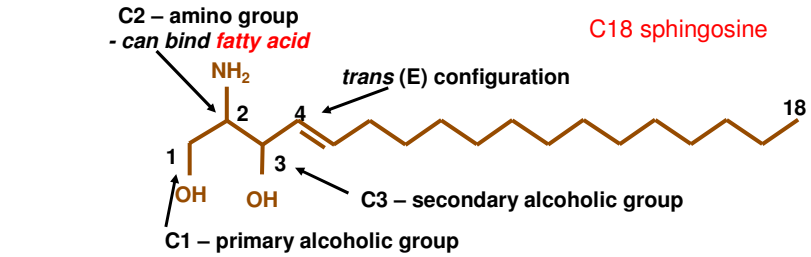


(**Diphosphatidylglycerol** = cardiolipin, a major lipid of mitochondrial membranes)

2. Composed lipids (2)

CERAMIDES: N-acyl fatty acid derivatives of amino alcohols
sphingosines (sphingenines) (C16-C20, C18 amino-alcohol)

(i) Sphingophospholipids - (e.g. sphingomyelin) composed of sphingosine or dihydrosphingosine, FA and phosphocholine



-can bind phosphoryl group + choline (= sphingomyelin) or a saccharide (galactose = galactocerebroside)

2. Composed lipids (3)

(ii) Glycosphingolipids / Sphingoglycolipids –
composed of alcohol sphingosine, FAs and a saccharide

- Globosides
- Cerebrosides
  - » (i) Galactocerebrosides
  - » (ii) Glucocerebrosides
- Gangliosides (+ N-Acetylneuraminidate = sialic acid)

LIPID CLASSIFICATION (3)

3. Others

- **Sterols, steroids (e.g. cholesterol, bile acids, steroid hormons)**
- **Lipophilic vitamines A, D, E, K**
- **Eicosanoids (C20)- local hormone-like mediators**

Lipids – significance (1)

Fats are a highly efficient form of fuel in which to store metabolic energy.

- **fats are less oxidized than carbohydrates or proteins and hence yield more than twice more energy on oxidation: triacylglycerols= TAGs [9,3 kcal (38,9 kJ)/g ; saccharides: 4,1 kcal (17,2 kJ)/g]**

  In animals: TAGs are synthesized and stored in adipocytes, adipose tissue. The fat content: 21% men, 26% women. Allows survival for 2-3 months x body glycogen can supply energy for less than 1 day.

(b) being nonpolar substances, they are stored in anhydrous form, whereas glycogen binds about twice its weight of water

In summary:

TAGs store about six times more energy (by weight) than does glycogen

FUEL RESERVES IN THE HUMAN BODY

- *70-kg man*:
- **1,600 kcal/6,693 kJ in glycogen** (liver ~ 400 kcal, muscles ~ 1,200 kcal)
- **24,000 kcal/100,800 kJ in mobilizable protein** (muscles)
- **135,000 kcal/567,000 kJ in TAGs** (adipose tissue)

- *The energy need for a 24-hour period is between 1,600-6,000 kcal depending on the extent of activity*

Lipids – significance (2)

Thermal insulator – subcutaneous layer

Promote absorption of certain vitamines soluble in fats

The source of essential fatty acids

An integral part of cellular membranes

Intracellular regulatory (signalling) molecules (Phosphatidylinositol tris phosphate, PIP_3; diacylglycerol, DAG; eicosanoids, PG)

Hormones (steroids)