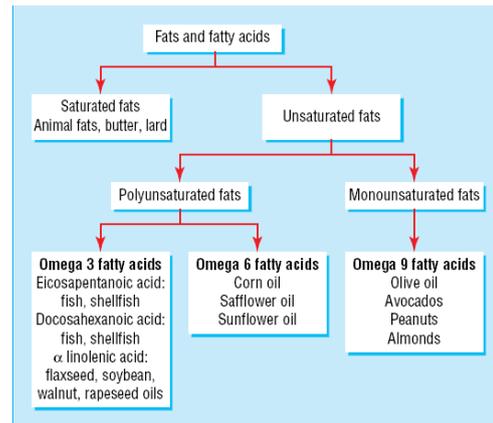


# Lipids

- High energy density: 1g=9kcal
- Sources in food:
  - Visible fat: meat, oil, margarine, butter, mayonaise
  - Invisible fat: cookies, cheese, milk, fries, chips, snacks
- Types
  - Fatty acids
  - Triglycerides
  - Phospholipids
  - Sterols



## Fatty acids

A fatty acid is an organic acid – a chain of carbon atoms with hydrogens attached, it has an acid group (COOH) at one end and a methyl group (CH<sub>3</sub>) at the other. There are over forty different fatty acids (saturated and unsaturated).

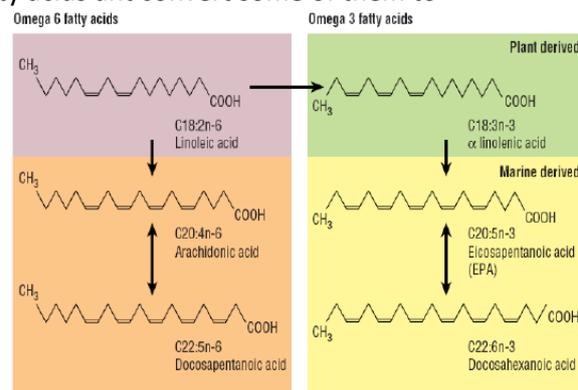
**Chain Length:** Most fatty acids contain an even number of carbons in the chains, up to 24 carbons in length. The chain length determines solubility and absorption.

- Very long-chain (VLCFA – 20 to 22 C's)
- Long-chain (LCFA – 14 to 18 C's; fatty acids in meats, fish and vegetable oils are most common in the diet)
- Medium-chain (MCFA – 6 to 12 C's; less common)
- Short-chain (SCFA – 2 to 4 C's; fatty acids occur mostly in dairy products)

**Degree of Saturation:** A saturated fatty acid has all the carbons in the chain filled with hydrogens. Unsaturated fatty acids are missing hydrogens and as a result the carbons form double bonds → monounsaturated vs. polyunsaturated.

**Location of Double Bonds:** Fatty acids are identified by the position of the double bond nearest the methyl end. A polyunsaturated fatty acid with its first double bond three carbons away from the methyl end is an omega-3 fatty acid. The same holds for omega-6 fatty acids.

**Essential Fatty Acids:** The body can make saturated fatty acids and convert some of them to monounsaturated fatty acids. The body cannot produce two polyunsaturated fatty acids, linoleic acid (omega-6) and linolenic acid (omega-3) and therefore these are essential and must be provided from the diet.



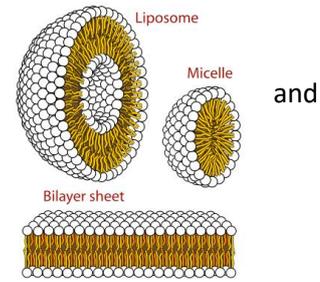
## Triglycerides

Fats in our body and in food are made up of fatty acids and glycerol called triglycerides. Glycerol is a water soluble compound that can bind to three fatty acids (→ mono- / di- / triglycerides) via condensation.

## Compound Lipids: Phospholipids

- Compound lipids: triacylglycerol + other chemical
- Phospholipids: diacylglycerol + phosphate group in combination with inositol / serine / ethanolamine / choline

- Because phospholipids can dissolve both fat and water they...
  - ...are an important structural part of cell membranes
  - ...help fats and fat like compounds such as fat soluble vitamins hormones to move across cell membranes
  - ...act like emulsifier and help keep fat and fat like compounds dispersed in the blood, with is water based



**Phospholipids in Food:** Phospholipids are present in both animal as plant food sources. Lecithin is one of the best known phospholipids. In foods lecithin keeps fat particles dispersed in water, such as salad dressings and mayonnaise. Lecithin is an emulsifier found naturally in many foods: eggs, soybeans, peanuts.

**Phospholipids in the Body:** Phospholipids are in cell membranes to help fats and fat like compounds such as fat soluble vitamins and hormones move across cell walls. The body can make lecithin in the liver.

### Sterols (=Steroids)

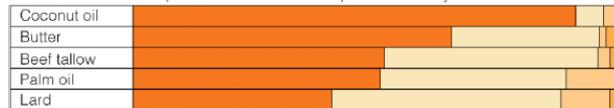
Polycyclic alcohol: 4 rings with diverse chains. Cholesterol is found only in animal tissue and animal nutrition – often bound to LCFA (absorbed as an ester). Cholesterol serves as the starting material for many important body compounds (bile acids, hormones (testosterone, cortisone), vitamin D, cell membranes, myelin sheath around nerve fibres). Phytosterols (vegetable origin) is member, too.

**Solid or Liquid Fats:** The relative amounts of different fatty acids effects whether a fat is solid or liquid. Unsaturated fats tend to be liquid at room temperature and contain more unsaturated fatty acids. Saturated fats tend to be solid at RT and contain more saturated fatty acids. Exceptions are tropical oils, such as palm oil, palm kernel oil, cocoa butter and coconut oil. Even though these fats are liquid at RT they are very saturated.

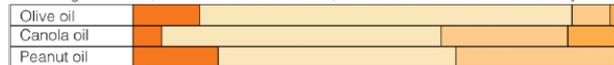
**Fats in Food:** Foods contain combinations of the three types of fatty acids. Completely saturated fats and completely polyunsaturated fats are rare in nature! The dominate fatty acid in a food determines whether the fat is referred to saturated or unsaturated.



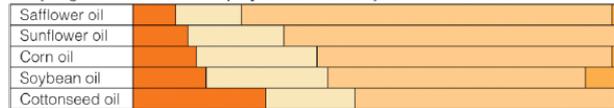
Animal fats and the tropical oils of coconut and palm are mostly **saturated**.



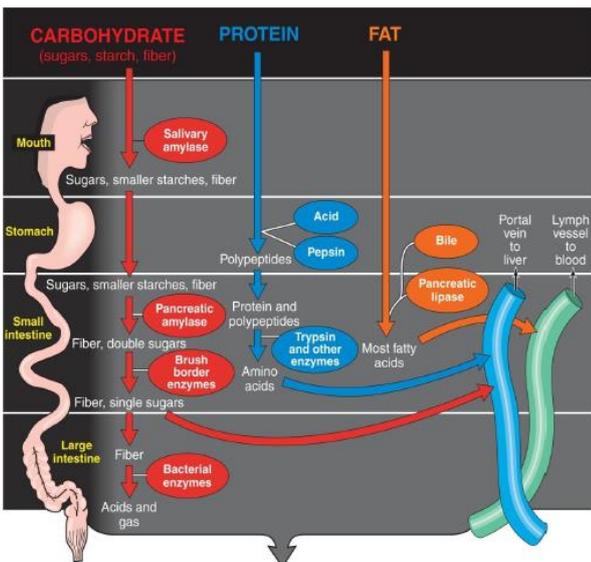
Some vegetable oils, such as olive and canola, are rich in **monounsaturated** fatty acids.



Many vegetable oils are rich in **polyunsaturated** fatty acids.



### Lipid digestion



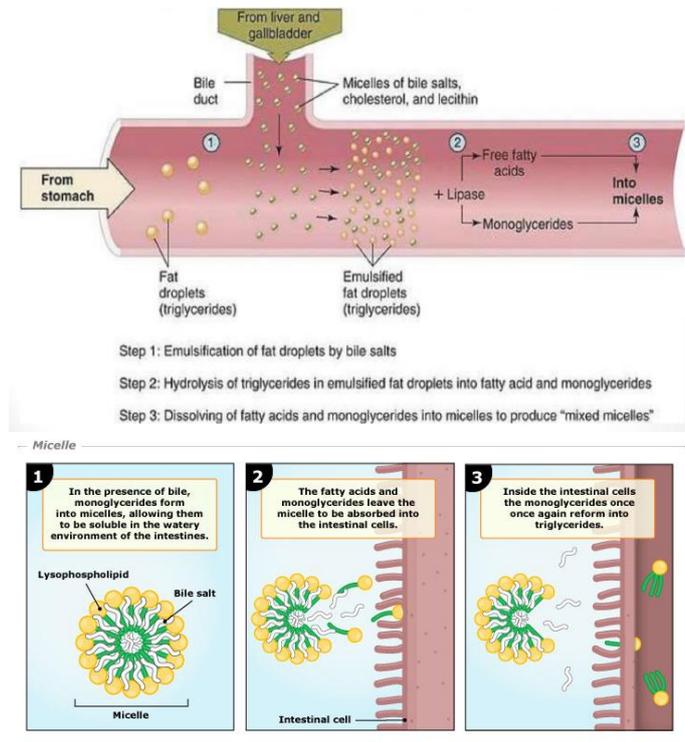
Feces contain bacteria, undigested fiber, dead cells, and undigested food products

- Mouth: initiation of triglyceride hydrolysis via lingual lipases
- Stomach: Gastric lipase (less effective in stomach due to low pH, not effective for LCFA, most effective for SCFA and MCFA). Lipids delay gastric emptying: high satiety!
- Intestines: emulsification. Lipids are hydrophobic and thus are poorly soluble in the aqueous environment of the digestive tract. Lipases are water soluble. Digestion is improved by emulsification, whereby breaking up fat globules into small emulsion droplets (peristaltic movements of intestines, bile salts).
- Digestion in small intestines
  - Pancreatic lipase: digestion of triglycerides (position 1 & 3)
  - Phospholipase A2: digestion of phospholipids (removes FA from carbon 2)

- Cholesterol esterase: digestion of cholesteryl esters (cholesterol + fatty acids)
- Bile salts (derivatives of cholesterol: both hydrophilic and hydrophobic)
- Inhibition of gastric and pancreatic lipases by Orlistat (decreasing fat digestion and absorption, resulting into weigh loss)

## Lipid absorption

- Glycerol, SCFA, MCFA are directly absorbed into portal vein
- LCFA, free cholesterol, phospholipids and monoglycerides retain their association with bile salts to form mixed micelles
- These micelles are absorbed:
  - Monoglycerides and fatty acids via diffusion
  - Some fatty acids via active transport
- Resynthesis of triglyceride in ER of enterocyte – inside Golgi, triglyceride is packed with cholesterol, apipoproteins and phospholipids into chylomicrons – release in lymphatic duct – release in blood
- Lipids – Recommendations
  - Reducing the amount of total fat intake to less than 30% of total energy intake helps prevent unhealthy weigh gain in the adult population (WHO)
  - $n6/n3 < 5$  ( $n3$  1-5% vs  $n6$  4-8%)
  - $\leq 10\%$  EN from SFA: Prefer products that are low in saturated fatty acids (WHO)
  - palmitic acid (C16:0), myristic acid (C14:0) and lauric acid (C12:0) intake should be limited to  $<8\%$
  - PUFA: 5-10%: Necessity for essential fatty acids
  - MUFA:  $>10$  (difference between total lipid intake and sum of PUFA and SFA)
  - As little as possible trans fatty acids ( $<1\%$ )(WHO)
- Possible mechanisms of action of omega-3 fatty acids: antiarrhythmic, antithrombotic, antiatherosclerotic, anti-inflammatory, improves endothelial function, lowers blood pressure, lowers triglyceride concentrations



Fish n-3: Moderate evidence shows that consumption of two servings of seafood per week, which provide an average of 250 mg per day of long-chain n-3 fatty acids, is associated with reduced cardiac mortality from coronary heart disease or sudden death in persons with or without cardiovascular disease.

Vegetable n- 3: Alpha-linolenic acid (ALA) intake of 0.6-1.2 percent of total calories will meet current recommendations and may lower cardiovascular disease (CVD) risk, but new evidence is insufficient to warrant greater intake beyond this level. Limited, but supportive evidence suggests that higher intake of n-3 from plant sources may reduce mortality among persons with existing CVD.

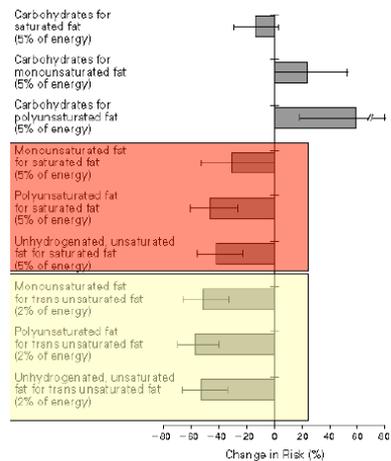
Calling a fat / oil "healthy" like omega-3/6 fats is not the same as their energy density or ability to promote obesity. Nevertheless, polyunsaturated fatty acids are shown to improve brain functions and neuronal plasticity.

Nurses' health study (REVIEW!). Estimated percent changes in the risk of coronary heart disease associated with isocaloric substitutions of one dietary component for another: see figure.

Removing statistically the positive effect of unsaturated fatty acids no significant negative effect of saturated fatty acids can be shown!

## Trans fatty acids

- In food processing polyunsaturated fats may be modified.
  - Hydrogenation makes liquid polyunsaturated fats more solid and more saturated.
  - CAVE: trans unsaturated fatty acids
  - Results into increased LDL and reduced HDL cholesterol. Also cardiac risks!!!
  - 'cheap' margarines
  - Manufactured products: cakes, pasteries,...
  - Some cooking oils
  - Nowadays <1%
- "Compared to saturated fat, TFAs are, gram to gram, associated with a considerably (2.5- to > 10-fold) higher risk increment for ischemic heart disease".
- Recommendations:
  - No intake of cholesterol required, synthesized in liver
    - The liver makes 800 to 1500 mg of cholesterol every day, much more cholesterol than in food.
    - In healthy people the body makes less cholesterol if dietary intake is high, and it more cholesterol if dietary intake is low.
    - Dietary saturated fat intake effects cholesterol synthesis more than dietary cholesterol.
  - Previous recommendations: 300mg/day (1egg)
  - Now: no limitation for intake



## Functions of Fat

Fats have many functions in our body: Part of cell membranes and component of many body compounds, body fat protects internal organs and provides insulation from heat loss, source of fat-soluble vitamins and essential fatty acids, concentrated source of stored energy, increases satiety, increases palatability: taste!

## Health Effects of Lipids

- Although fat is important, too much fat increases the risk for chronic disease.
- High saturated fat and trans fat intakes are associated with increasing blood cholesterol and heart disease. CAVE!
- High fat diets have also been associated with increased risk of certain types of cancer
- Relationship between fat intake and cancer is not clear and may be related to calorie intake and obesity.
- Fat provide more than twice as many calories as carbohydrate or protein. As a result, people who consume high fat diets may exceed their calorie needs resulting in weight gain / obesity
- By increasing the risk of obesity, high fat diets may indirectly increase risk of diabetes and high blood pressure
- + Replacing saturated and trans fats with monounsaturated and polyunsaturated fats can help lower heart disease risk
- + Consuming fish on a regular basis as a source of omega-3 polyunsaturated fatty acids may also lower the risk of heart disease by helping to prevent blood clots and protect against irregular heartbeats and lower blood pressure.