LIPIDS

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B1.1.10	Difference between saturated, monounsaturated and polyunsaturated fatty acids
B1.1.11	Triglycerides in adipose tissues for energy storage and thermal insulation
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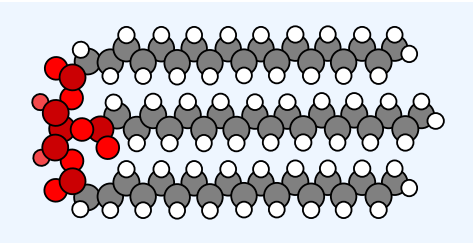
LIPIDS

Lipids are a class of **non-polar** organic molecules that serve a variety of functions within cells. Unlike other classes of organic molecules, they are not composed of recurring monomers – although they may possess discrete subunits. Lipids are commonly composed of hydrocarbons arranged into either chains *(fatty acids)* or fused rings *(steroids)*. All lipids possess **hydrophobic** properties, meaning they will have low solubility in aqueous solvents (but will dissolve in non-polar solvents). This makes a lipid an effective water-repellent.

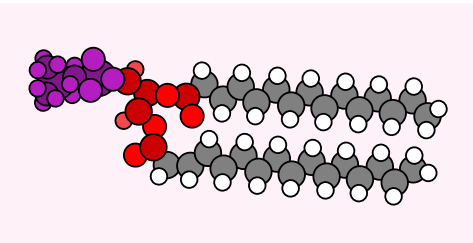
TYPES OF LIPIDS

Lipids can be categorised into three groups based on their chemical composition and physical properties:

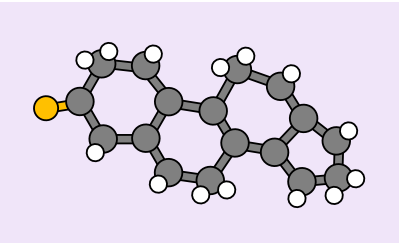
- **Simple lipids** include esters of fatty acids and alcohol (waxes and triglycerides are common examples)
- **Compound lipids** are simple lipids that have been linked to an additional group (such as phospholipids)
- **Derived lipids** consist of hydrocarbon rings produced from the hydrolysis of simple lipids (e.g. steroids)



SIMPLE: TRIGLYCERIDE



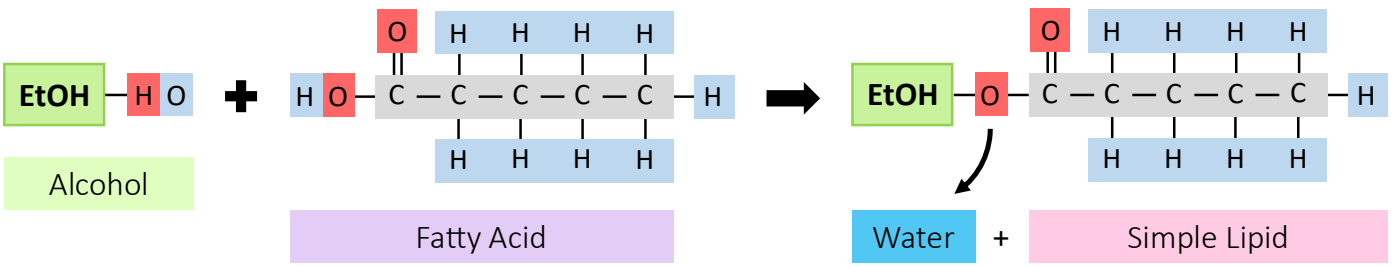
COMPOUND: PHOSPHOLIPID



DERIVED: STEROID

ESTER LINKAGES

Simple and compound lipids contain fatty acids within their structure, which are covalently attached to an alcohol (such as glycerol) via an ester bond. This linkage involves a **condensation reaction** (water released).

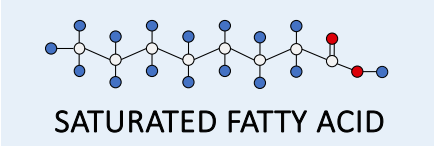


FATTY ACIDS

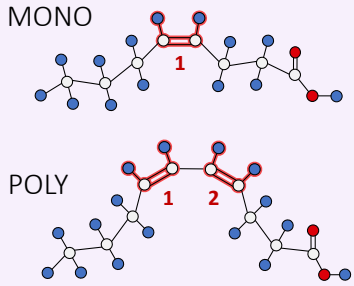
Lipids will possess different properties according to the type of fatty acid they possess. Triglycerides can differ in their physical state (solid fats or liquid oils), while phospholipids will possess different levels of fluidity. Fatty acids are primarily classified according to the presence or absence of double bonds between the carbon atoms in the chain.

- **Saturated** fatty acids possess no double bonds (saturated with H)
- **Unsaturated** fatty acids have double bonds (either one or many)

Saturated fatty acids will form straight (linear) hydrocarbon chains, while unsaturated fatty acids will have a **kinked chain**. Unsaturated fatty acids may be either *monounsaturated* (has one double bond) or *polyunsaturated* (multiple double bonds). Polyunsaturated fatty acids will possess an even greater kink in their hydrocarbon chain.



SATURATED FATTY ACID



UNSATURATED FATTY ACIDS

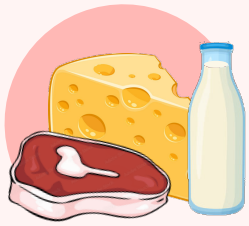
FATS AND OILS

Triglycerides can be stored by organisms as either solid fats or liquid oils depending on the type of fatty acid they possess. As saturated fatty acids have straight chains, they can be packed more tightly together, which means more intermolecular forces can form between the chains. This increases the melting temperature of the triglyceride, meaning triglycerides with saturated fatty acids will exist as **solid fat** at room temperature. Unsaturated fatty acids have kinked chains and are packed more loosely, with fewer intermolecular forces between the chains. This results in a lower melting point, so they exist as **liquid oil** at room temperatures.

The storage of triglycerides as fats or oils is determined by an organism's physiology and environment. Fatty acids need to be as a liquid within tissues to allow them to be utilised by cells, but should also be packed as tightly as possible to maximise storage. Warm-blooded mammals (**endotherms**) will tend to produce more *saturated fatty acids* – as their higher core body temperatures can keep these fatty acids liquid. However, cold-blood animals (or those living in colder climates) will tend to produce a relatively higher proportion of unsaturated fatty acids – as saturated fats would likely solidify. This is why cold-water fish are an excellent source of polyunsaturated fats that are essential to human diets (omega-3 and omega-6 oils). **Plants** cannot control their internal temperatures and so predominantly produce *unsaturated fatty acids*. However, plants found in warmer climates (tropical plants) will produce more saturated fatty acids than temperate plants.

COMPARISON: FATS VERSUS OILS

FATS	OILS
Found in animals (endotherms)	Found in plants (and fish oils)
Saturated fatty acids	Unsaturated fatty acids
Chains are straight and tightly packed	Chains are kinked and loosely packed
Solid at room temperatures	Liquid at room temperatures
Higher melting point than oils	Lower melting point than fats

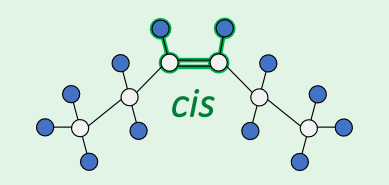


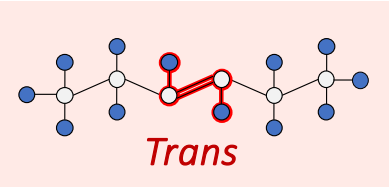
Dietary Fats:
Meats
Cheese
Milk
Eggs

Dietary Oils:
Canola Oil
Avocados
Nuts
Fatty fish

TRANS FATS

Unsaturated fatty acids can exist in two isomeric forms. Most unsaturated fatty acids produced by organisms are ***cis*-isomers**, whereby the hydrogen atoms attached to the carbon double bond are on the same side (causing a kink). However, unsaturated fatty acids can also be ***trans*-isomers**, when the hydrogen atoms attached to the carbon double bond are on different sides. This will not cause the hydrocarbon chain to kink, meaning that the *trans*-fatty acids have similar properties to saturated fats. These *trans*-fats are not typically produced by living organisms (except ruminants) and are instead produced by industrial cooking practices to improve the shelf life.





LIPID FUNCTIONS

The different types of lipids serve different functions within cells, due to the differences in their properties:

1. Triglycerides function as a long-term energy storage molecule and also are effective thermal insulators
2. Phospholipids play a structural role in cells by forming a primary component of all cellular membranes
3. Steroids may function as signalling molecules by binding to intracellular receptors (e.g. sex hormones)

1. TRIGLYCERIDES

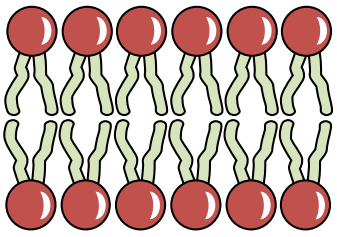
In animals, triglycerides are stored within a subcutaneous layer of tissue known as **adipose tissue**. This tissue layer functions as both a means for thermal insulation and a source of energy (long-term). Fats have a very low level of thermal conductivity and so have a very limited capacity to conduct heat. Consequently, they are very effective insulators. Many marine mammals will possess an especially thick layer of adipose tissue (blubber) in order to reduce the amount of heat lost to the water and also to increase its buoyancy.

Triglycerides can also be utilised as an energy storage option *instead* of carbohydrates. These lipids have key properties that make them better at storing the energy long term:

- **Solubility:** Triglycerides are non-polar and insoluble in water (harder to transport)
- **Osmosis:** Triglycerides will create less osmotic pressure in cells (better for storage)
- **Digestion:** Triglycerides are harder to digest than carbohydrates (less accessible)
- **ATP Production:** Triglycerides will produce roughly twice as much energy per gram

2. PHOSPHOLIPIDS

Phospholipids are the primary component of cell membranes because they are **amphipathic** (have hydrophilic and hydrophobic regions). Phospholipids consist of a phosphate group connected to two fatty acid chains by a central glycerol molecule. As a phosphate group is polar, it forms a head region that orientates away from the fatty acid tails. In cells, phospholipids form **bilayers**, with phosphate heads facing out into the aqueous solutions, whilst the fatty acid tails face in to hold the bilayer together (via hydrophobic associations).



Lipid Bilayer

3. STEROIDS

Steroids are derived lipids composed of four fused carbon rings. Because they are non-polar, they can pass through the phospholipid bilayer and will commonly be utilised as signalling molecules (**hormones**). Some examples of steroids include the sex hormones – *oestradiol* (released by ovaries) and *testosterone* (testes).