Biological Macromolecules and lipids

First of all, terminology:

Synthesis: production.

Hydrolysis: a chemical reaction in which water breaks down the chemical bonds.

Hydro: relating to water

Lysis: breaking down

Mono: one

Poly…: more than 3

Macro: large

Saccharides: Sugars.

Exo: outside.

** the suffix of sugars is **ose**

- The fundamental structural units of **all** living beings are macromolecules + lipids, and they are:
  1. Carbohydrates
  2. Lipids
  3. Proteins
  4. Nucleic acids

The following **macro**molecules are synthesized within cells by joining **small organic** molecules (building units) called Monomers

For this, we can say that Macromolecules are chains of Monomers, in which these chains are made up by the Monomers joining together via covalent bonds.

MONOMERS ARE EITHER IDENTICAL OR SIMILAR

2/3 Monomers joining together makes a dimer/trimer

The joining of many monomers produces Polymers.

**Lipids are not polymers

Macromolecules are polymers. Therefore, we are going to focus on how polymers are synthesized and broken down.

- The Synthesis and Breakdown of Polymers:

Polymers are made (with the help of an enzyme) when monomers bond together through the loss of a water molecule. For this reason, it is called a **<u>Dehydration Reaction.</u>** (It can also be called a condensation reaction). The water molecule is made up collectively from the 2 monomers linked.

In a dehydration reaction, when presented in a chemical reaction formula, always include water in the results;

glucose

$C_6H_{12}O_6 + C_6H_{12}O_6 = C_{12}H_{22}O_{11} + H_2O$ (Notice, 1 water molecule for 2 monomers joining)

However, the disassembly of a polymer to monomers is done by hydrolysis: the addition of HOH to break down bonds. In this reaction, water breaks down the bonds and then adds H to one of the monomers, and HO to the other.

1. Carbohydrates (CH_2O) (1:2:1) → General Rule of Sugars

Carbohydrates include sugars or polymers of sugars. They serve as Fuel and Building material (energy storage and release).

Carbohydrate macromolecules (they have a chain like structure) are polymers called polysaccharides, composed of many sugar-building blocks.

- Monosaccharides

Monosaccharides are classified (not named) into 2 main groups:

1. Their carbonyl group location; in which if they are Aldehydes, they are Aldoses, and if they are ketones, they are ketoses
2. The number of carbons in the carbon skeleton

- Monosaccharides Isomers: Monosaccharides that have the same number of atoms (carbon, oxygen and hydrogen), but differ in their structural organization of their atoms (each one has a different arrangement). For e.g.: Glucose with Galactose with Fructose.

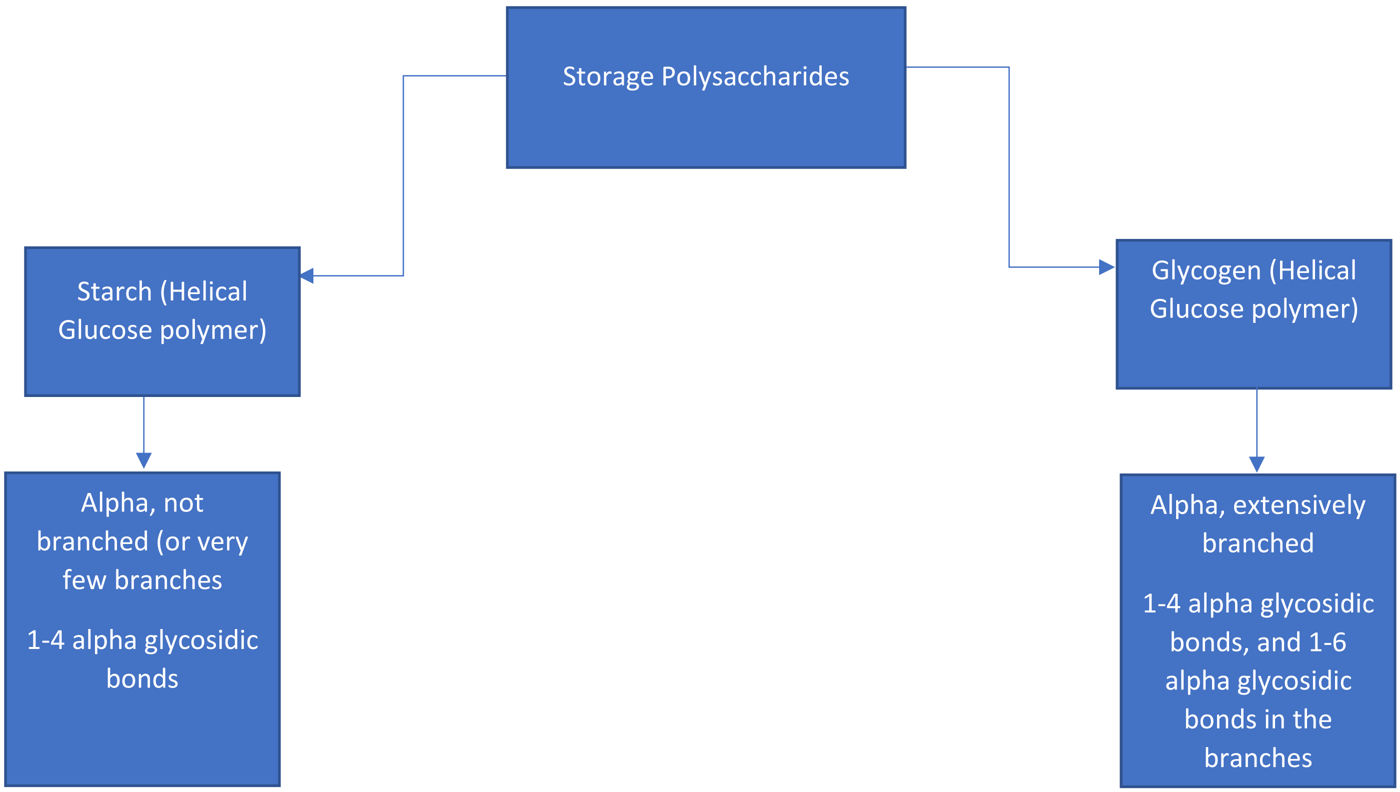
Carbon chains/skeletons have 2 general shapes: linear and ring shape. And most of these carbon chains are in a ring shape especially when transforming from linear to ring form in an aqueous solution.

In the transformation to a carbon chain, in aldoses, the first carbon links with the second to last one, in which the hydrogen from the second to last carbon links with the first's oxygen, and the 2 carbons bond together via the 5^{th}'s oxygen.

Glycosidic linkage: it's the covalent bonds that joins sugars together.

Polysaccharides, the polymers of sugars, are either used for storage (like Starch and Glycogen), or structures (Cellulose and Chitin)

A polysaccharide that has 100 Glucoses produces **99 (yes) water molecules.



Cellulose is an unbranched structural polysaccharide that is made up of many beta glucoses linked together via beta 1-4 glycosidic bonds.

Cellulose is seen as a line-shaped macromolecule, and many celluloses gather up and bond via hydrogen bonds to form a bundle, thus constructing a plant's cell wall.

Chitins are structural polysaccharides that differ from all polysaccharides from the Presence of Nitrogen in their sugar monomers, and they are called astelglucoseamen. They also bond together via beta 1-4 glycosidic bonds.

Notes:

I. Examples of disaccharides:
    a. Maltose
    b. Sucrose
    c. Lactose

2. Lipids: the hydrophobic group

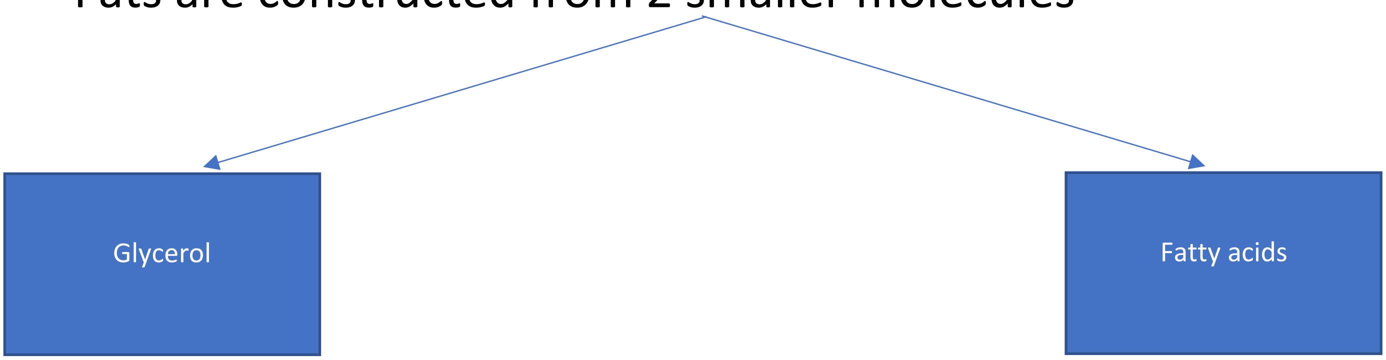
Firstly, Lipids are not made of true polymers. But in general, they are largely made up of hydrocarbon regions.

The most biologically important lipids are:

a. Fats
b. Phospholipids
c. Steroids

a) Fats:

Fats are constructed from 2 smaller molecules



Glycerol: is an alcohol that has 3 possible linkages to the opposing fatty acids

Fatty acids are categorized within the carboxyl groups

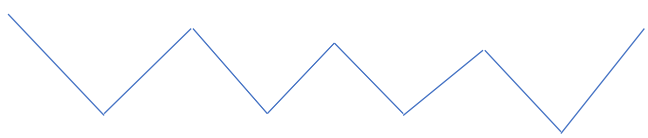
The Synthesis of Fats:

The Synthesis of Fats is another example of a dehydration reaction: When the H of the glycerol (the alcohol) and the OH of the fatty acid are linked together, forming a water molecule, and after that a covalent bond, called an ester linkage, is formed between them, forming an ester……. A fat.

- The Types of Fats:

Saturated fats: Fats that have no double bonds (they have the maximum number of hydrogen bonds)

Saturated fats' carbons are more compacted with each other, thus having a stronger and a more solid fat in the overview. For this reason, saturated fats in room temperature are found in solid property.



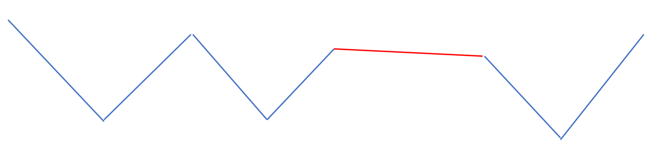
no straight lines

Unsaturated fats: Fats that have one or more double bonds.

The presence of double bonds in the fatty acids results in kinks (bendings) in the fats, and they are either cis kinks or trans kinks:

Cis kinks: the hydrogens that are linked to the doubled bonded carbons are next to each other

Trans kinks: the hydrogens that are linked to the doubled bonded carbons are in opposite sides of each other (in cross direction).



These bendings cause the carbon molecules to be less compacted. For this reason, we find unsaturated fats in liquid state in room temperature, and they are also called oils.

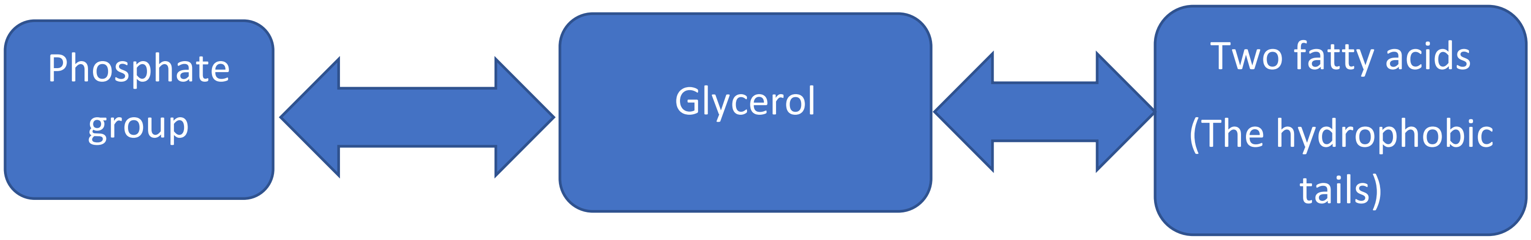
Notes:

i. For a fat to be constructed, 3 fatty acids should be joined, not less. Forming a Triacylglycerol.
ii. The fatty acids are all carboxyl compounds (COOH); what they differ from is their carbon skeleton, from the number of carbons and the position of the double bonds (if present).
iii. When fats are introduced to water, the hydrophobic relationship between them is demonstrated when hydrogen bonds are formed only between the water molecules, and excluding the fats.
iv. Notice the bends in the fats to differentiate between saturated and unsaturated fats.
v. The full body of the fat is made up of the fatty acid. But, notice the head-liked shape in one of the edges: that's the glycerol.
vi. Most animal fats are saturated.
vii. Plant and fish oils fats are normally unsaturated.
viii. Fats' function is to store energy.
ix. It's called a saturated fat, not a poly-saturated fat.
x. Triacylglycerols are predominantly non-polar

Revise slides 55, 56 and 57

b) Phospholipids

Lipids that are made up of 3 main parts:



Notes:

I. The glycerol links the phosphate group with the two fatty acids
II. One of the fatty acids has a cis double bond, thus making it bent.
III. The phosphate group with its attachment (the choline) is the hydrophilic part of the structure. (Go see the full structure in slide 59)
IV. Some waxes and pigments are lipids
V. Steroids are also found in cell membrane.
VI. From the phospholipids bilayer is the structure of the cell membrane.

c) Proteins/polymers of amino acids/Polypeptides:

The fundamental element of all proteins is the amino acids. And better said, it is the linear chains of amino acids linked together by covalent bonds called peptide bonds.

Each polypeptide chain has 2 ends: a carboxyl end, called **The C terminus,** and an amino end called **The N terminus.**

- The types of proteins:

1. Enzymatic proteins: catalyze
2. Structural proteins: keratin, silk fibers, collagen, elastin
3. Storage proteins: Casein, ovalbumin
4. Transport proteins: hemoglobin
5. Hormonal proteins: insulin
6. Receptor proteins:
7. Contractile and motor proteins: motor proteins are responsible for flagella and cilia
8. Defensive proteins: antibodies

- ## The structure of amino acids

Amino acids are structured of 2 main parts:

- ✓ The backbone: it is the common part for all amino acids

The backbone is made up of a carbon molecule in the heart which is linked to 4 main groups: a hydrogen, a carboxyl group (…. COOH) and the amino group (NH_2….).

- ✓ The fourth link that the carbon makes is with an R group - the side chain. It is in fact the differences of the R group that makes a protein unique to another.

Notes:

I. A protein's 3-D shape that is essentially structured from the bonds made up in the secondary and tertiary structure (especially the tertiary structure) is fundamental for a protein's functionality.
II. Hemoglobin is a globular protein
III. Insulin is a protein
IV. Globular proteins hydrophilic acids can be found at the surface. And its hydrophobic amino acids can be found in the core.
V. Enzymes carry out catalysis in biological systems
VI. Proteins is the most diverse macromolecule in the cell
VII. The simplest amino acid is Glycine.
VIII. The tertiary structure represents the 3D shape of protein that is stabilized by interaction between side chains.
IX. When presented a tertiary structure, the inner parts of the folds are the ones that have the disulfide bridge and the hydrophobic interactions (an OH with an H make a hydrogen bond)

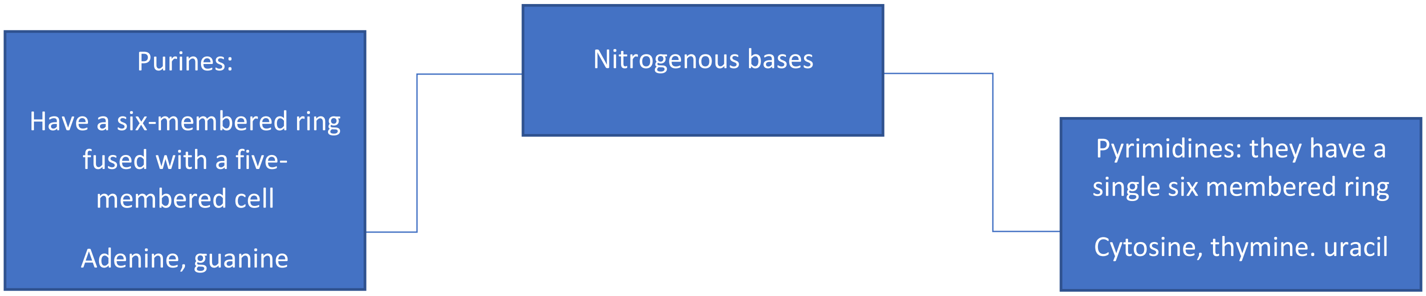
d) Nucleic Acids

The DNA (Deoxyribonucleic acid) and the RNA (Ribonucleic acid) are the 2 types of nucleic acids.

The monomers (subsets) of the DNA and the RNA are called nucleotides.

Nucleotides are made up of 3 main elements:

1. A five-carbon sugar (a pentose)
2. A phosphate group
3. A nitrogen group



The deoxyribose sugar (the pentose sugar) is linked with the phosphate group with its 5^{th} carbon, and with the nitrogenous base with its first carbon. And it is linked with the following nucleotide's phosphate with its 3^{rd} carbon via ester bonds called phosphodiester bonds (the bonds between 2 nucleotides of a nucleic acid)

- ## The DNA

The DNA's main function is to make the genetic material of the cell (It has a specific sequence of code to build proteins)

It is special from the RNA from having the thymine nitrogen base

The DNA is made of 2 strands of polynucleotides wrapped around each other forming double helix.

- ## The RNA

The RNA's main function is seen in the code that it caries to make proteins (it executes that code to build proteins)

It is special from the DNA form having the uracil nitrogen base.

It is single-stranded (it is not a helix)

Notes:

i. The 5'C end of a DNA contains the phosphate group
ii. The 3'C end of a DNA contains the OH group.
iii. Notice the omission of the O in the DNA ribose sugar, and the presence of it in RNA.
iv. The carbon that houses the differentiating OH^- or the H of the pentose sugar is the second carbon.
v. A phosphate is the linkage between 2 nucleotides; it makes to phosphoester bonds: one with the upper sugar via its 3rd carbon, and the second with the bellow sugar via its 5th carbon. And from this we call it a phosphodiester bond (another example of a dehydration reaction; the upper OH + the lower H)
vi. A gene is a part of a whole DNA that encodes a functional product (a protein)
vii. The gene is the fundamental part of the genetic material of a cell
viii. The 2 strands of polynucleotides are linked with each other via hydrogen bonds.