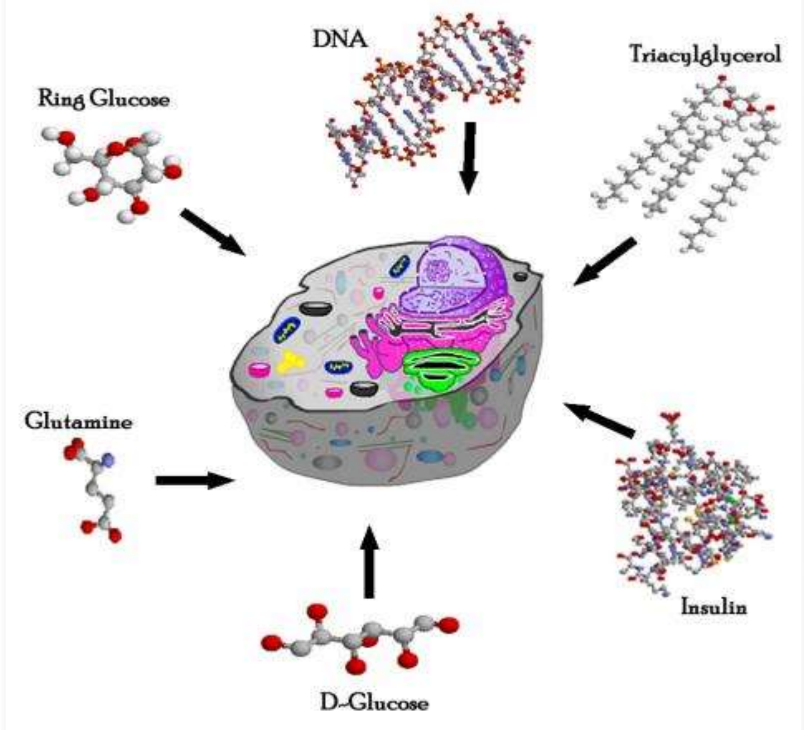
SBI4U
UNIT #1: BIOCHEMISTRY
LECTURE #2 (CHEM. OF LIFE)



CARBOHYDRATES, LIPIDS AND PROTEINS

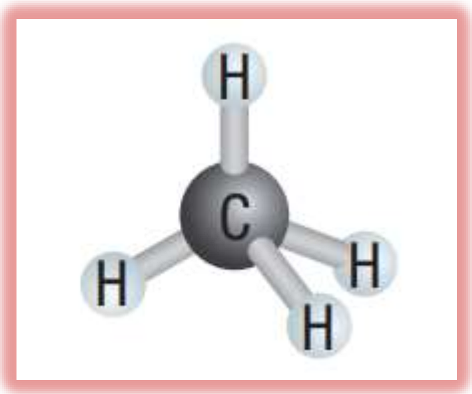
FAUZIA AKHTER, MEnvSc, MSc, BEd

CARBON: AN ORGANIC MOLECULE

Carbon atoms make up the base of every organic molecules.

Why Carbon atom is so unique and important to living world?

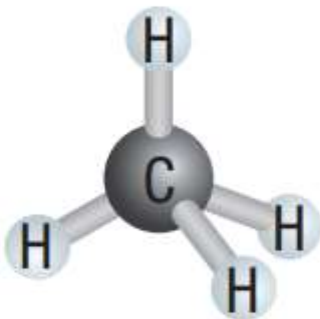
The unique role of carbon bonding properties:



- ❑ Variety of **chain** and **ring** structure
- ❑ Carbon's four valance electrons can form four **covalent bonds** with other atoms. (Methane CH_4)
- ❑ Capable to form substances as multi ringed molecules; diamonds, and nanotubes.
- ❑From each carbon atom is connecting points for other molecules to **branch in** or **branch out** in four direction
- ❑ Combination of **Single, Double, and Triple bonds**, an almost limitless array of molecules is possible!!!

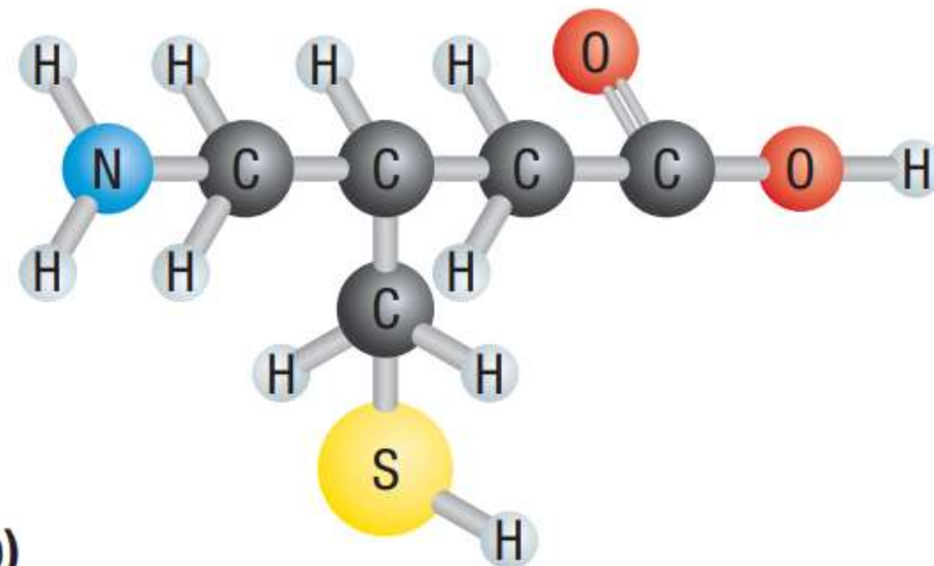
Carbon Chains: The backbone of Biochemistry

In Chain structure



(a)

Single chain

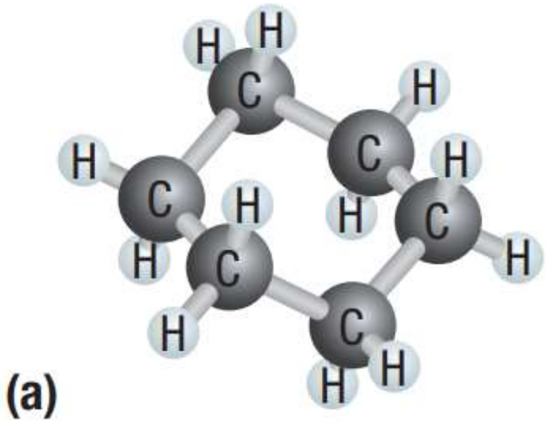


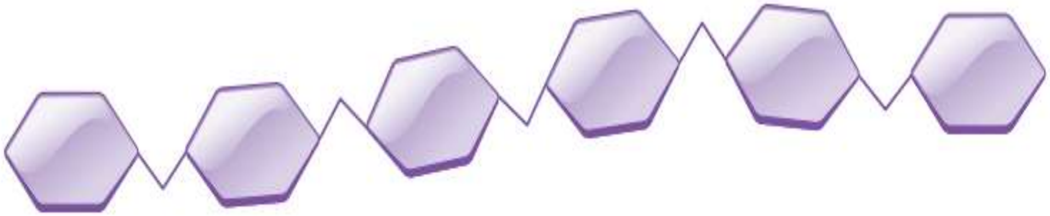
(b)

Long chain and branches

Carbon Chains: The backbone of Biochemistry

In Ring structure



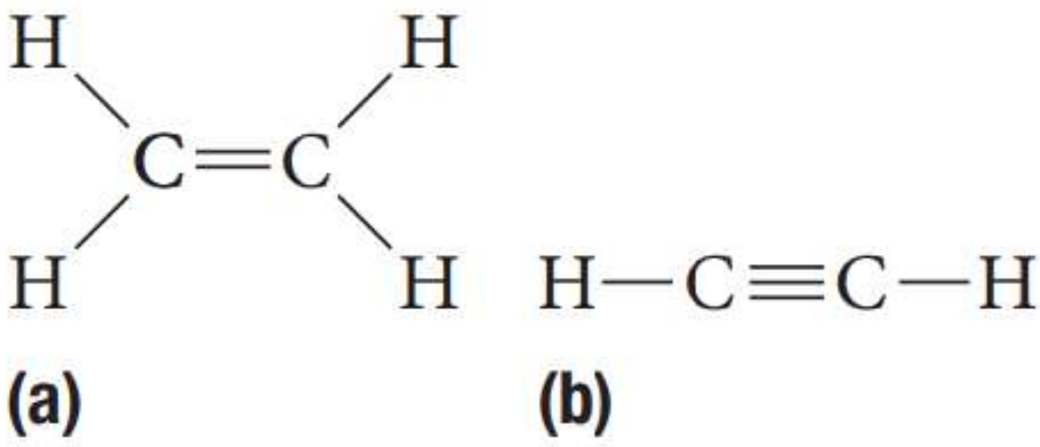


Long chain of rings and branches

Single Ring

Carbon Chains: The backbone of Biochemistry

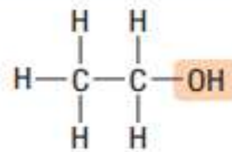
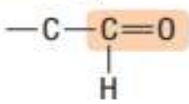
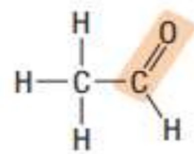
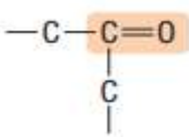
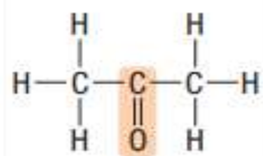
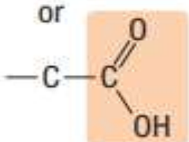
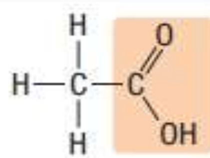
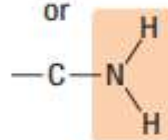
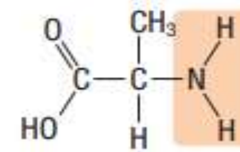
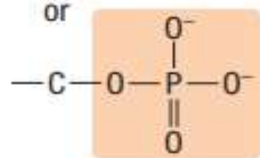
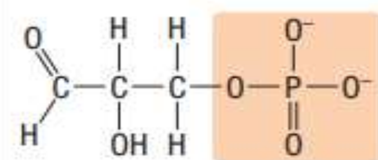
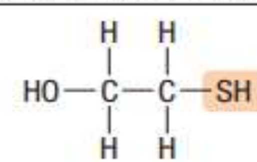
In Double or Triple bonding structure



a) Double bond; b) Triple bond

FUNCTIONAL GROUPS

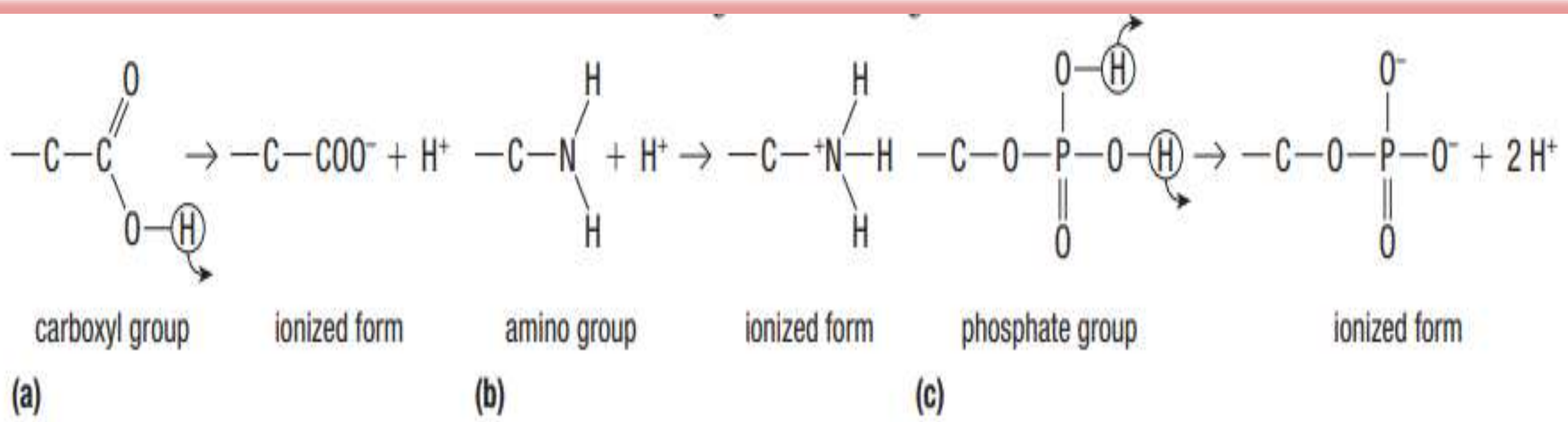
Definition: A group of atoms that affects the function of a molecule by participating in chemical reactions.

Functional group	Major classes of molecule	Example
hydroxyl $—C—OH$	alcohols	 ethyl alcohol (in alcoholic beverages)
carbonyl 	aldehydes	 acetaldehyde
	ketones	 acetone (a solvent)
carboxyl $—C—COOH$ or 	organic acids	 acetic acid (in vinegar)
amino $—C—NH_2$ or 	amino acids	 alanine (an amino acid)
phosphate $—C—PO_4^{2-}$ or 	nucleotides, nucleic acids, many other cellular molecules	 glyceraldehyde-3-phosphate (product of photosynthesis)
sulfhydryl $—C—SH$	many cellular molecules	 mercaptoethanol

FUNCTIONAL GROUPS

Characteristics of Functional groups:

- Either ionic or Strongly Polar
- Influences chemical and physical properties of a large portion of biological molecules.
- Assists in 'dehydration' and 'hydrolysis' reactions to determine he length of molecules (large or small)



DEHYDRATION AND HYDROLYSIS REACTIONS

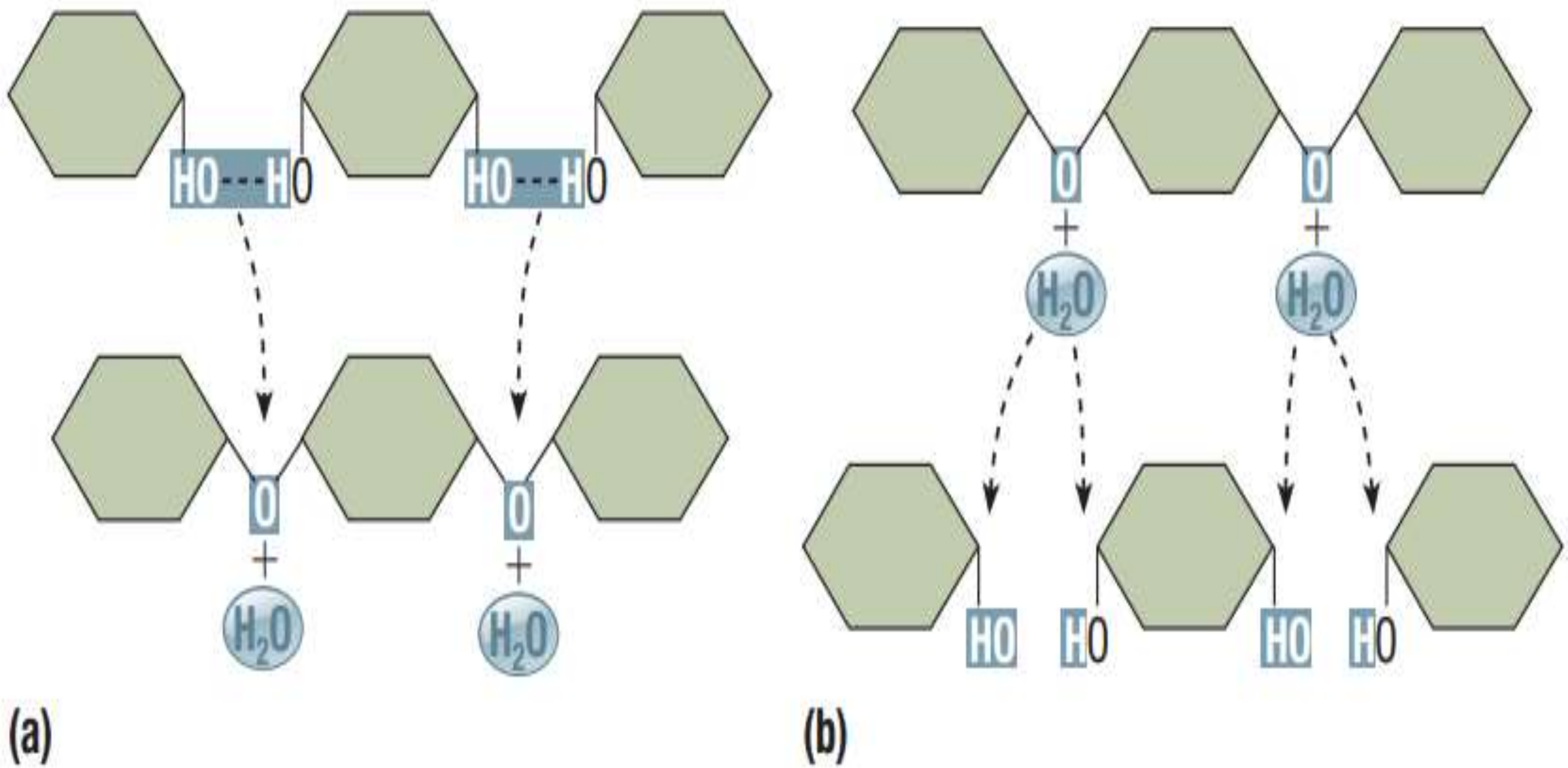


Figure (a) During dehydration, water is produced as subunits join to form larger molecules.
(b) During hydrolysis, water is used as a reactant to split larger molecules into smaller subunits.

2 MIN. BREAK!!!

CARBOHYDRATES AND LIPIDS

Carbohydrates ***(Carbo: Carbon; Hydrate: Water):*** A biomolecule that consists of Carbon, Hydrogen, and Oxygen. (Tips: CHO)

Sources: Sugary/Sweet foods; fruits; Vegetables; and Grains

Functions: Delivers energy to cells.

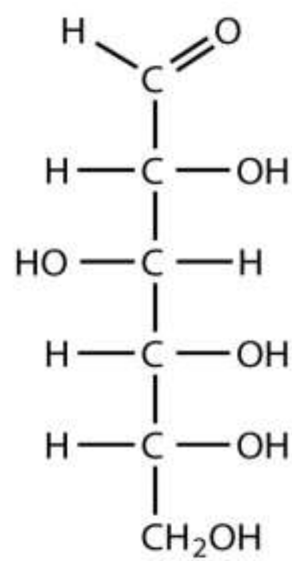
Chemical formula: CH_2O

Ratio: 1: 2: 1

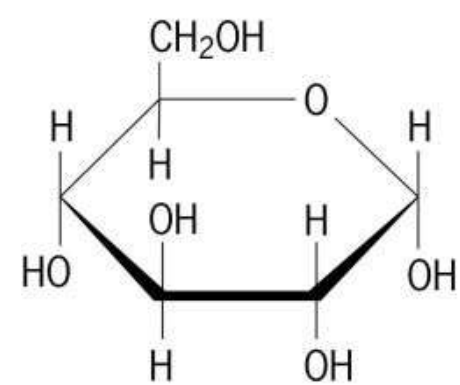
Or, its derivatives:

$C_nH_{2n}O_n$

e.g. Glucose **($C_6H_{12}O_6$)**



Chain structure of Glucose

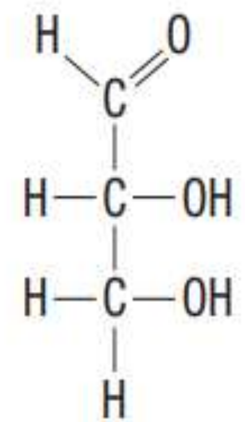


Ring structure of Glucose

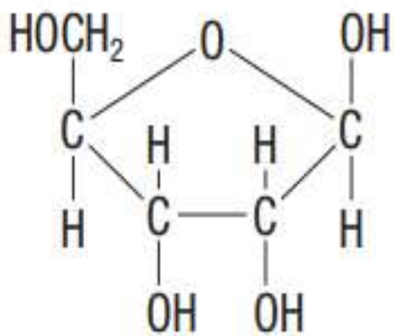
TYPES OF CARBOHYDRATES

Carbohydrates (also called ***saccharides****)*

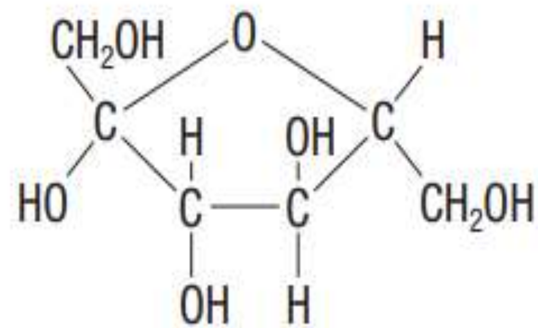
i) Monosaccharides: the simplest carbohydrates and are often called single **sugars**. They are the building blocks from which all bigger carbohydrates are made. e.g.Glyceraldehyde; Ribose; Glucose; Fructose



glyceraldehyde

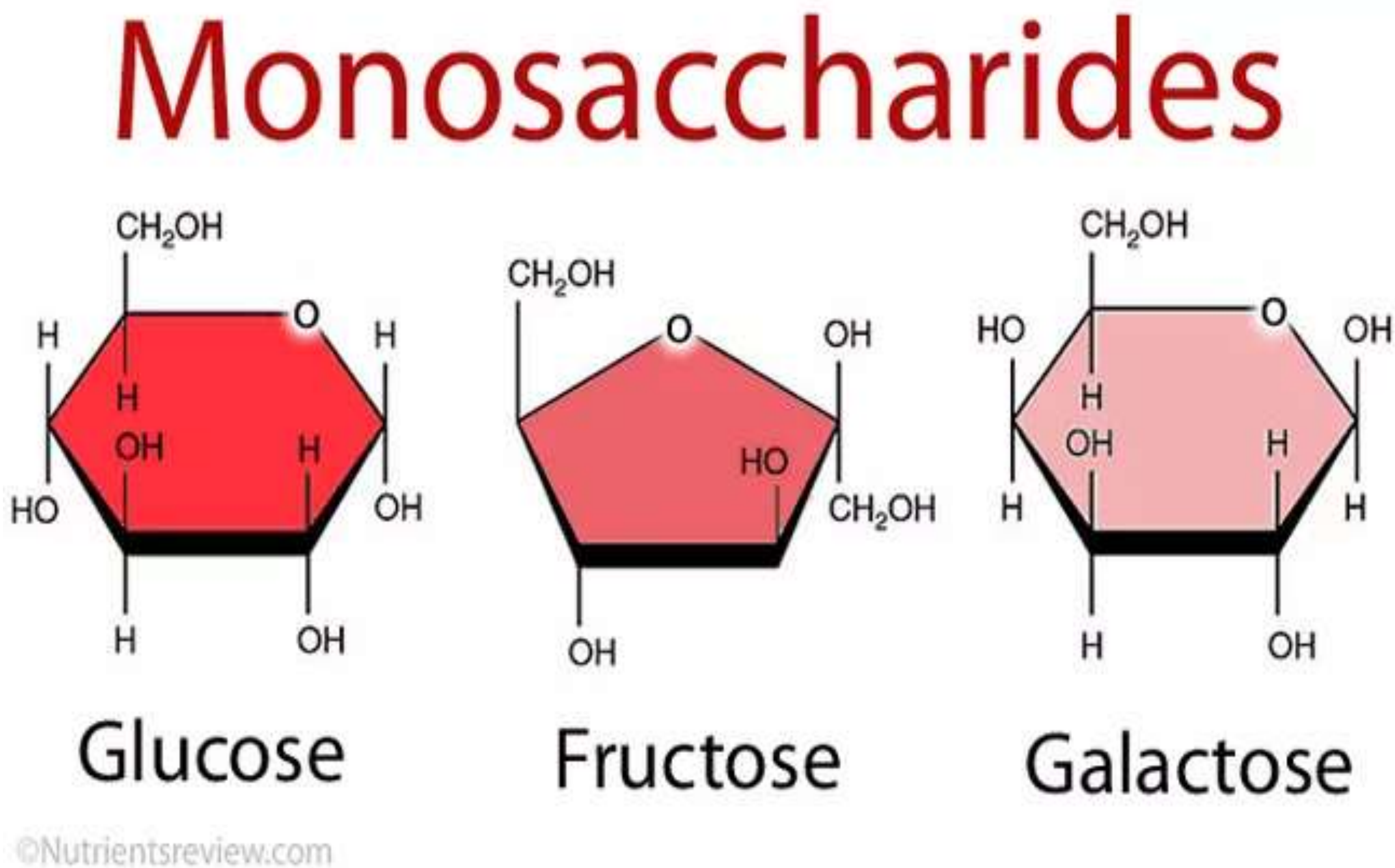


ribose



fructose

TYPES OF CARBOHYDRATES

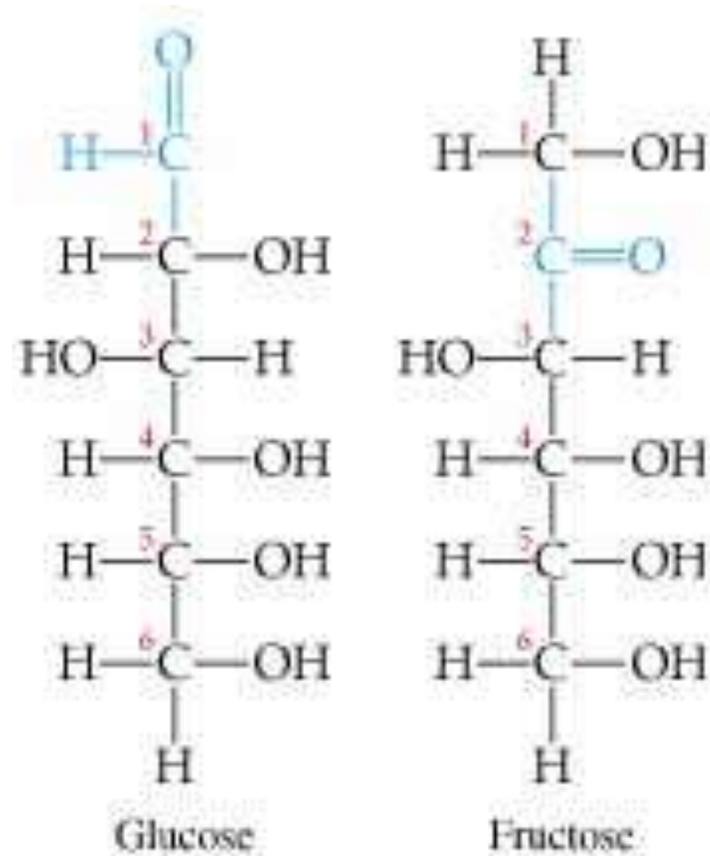


TYPES OF CARBOHYDRATES

Isomer: A molecule that has the same composition as another, but a different arrangement of atoms.

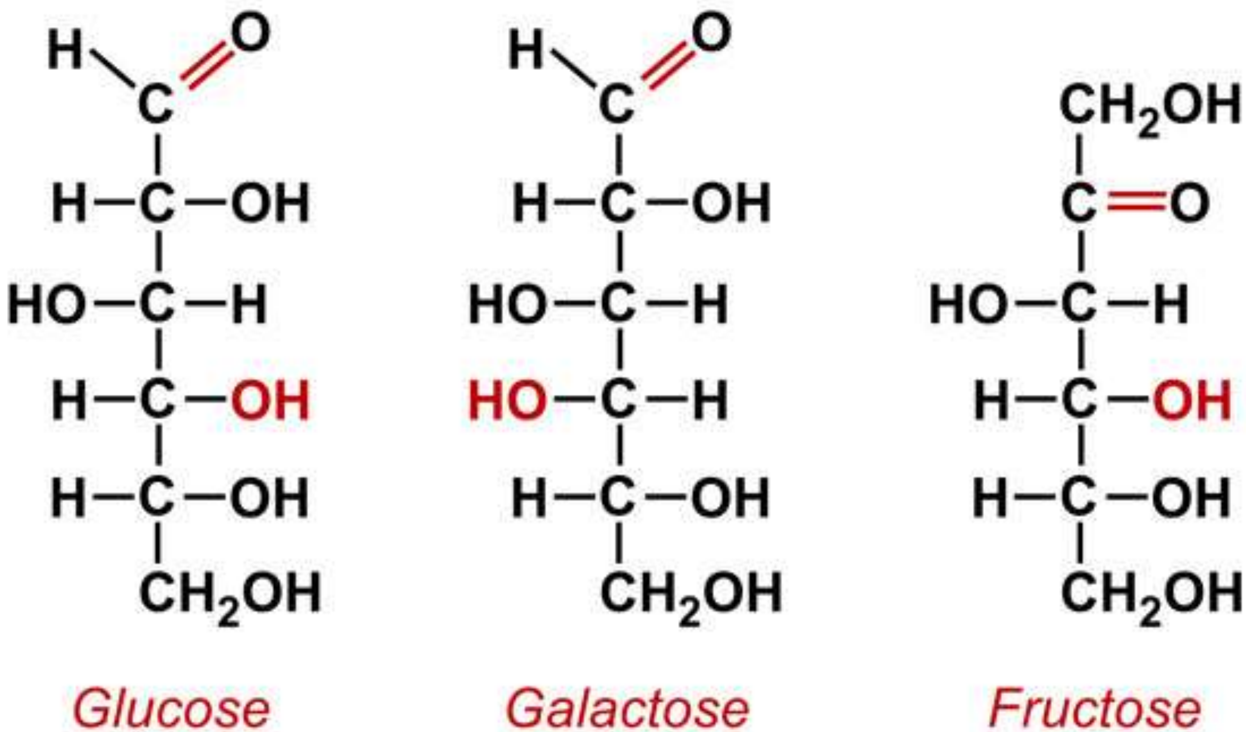
e.g. Glucose and Fructose
(both chemical formula is **($C_6H_{12}O_6$)**

Q. Where do they differ????



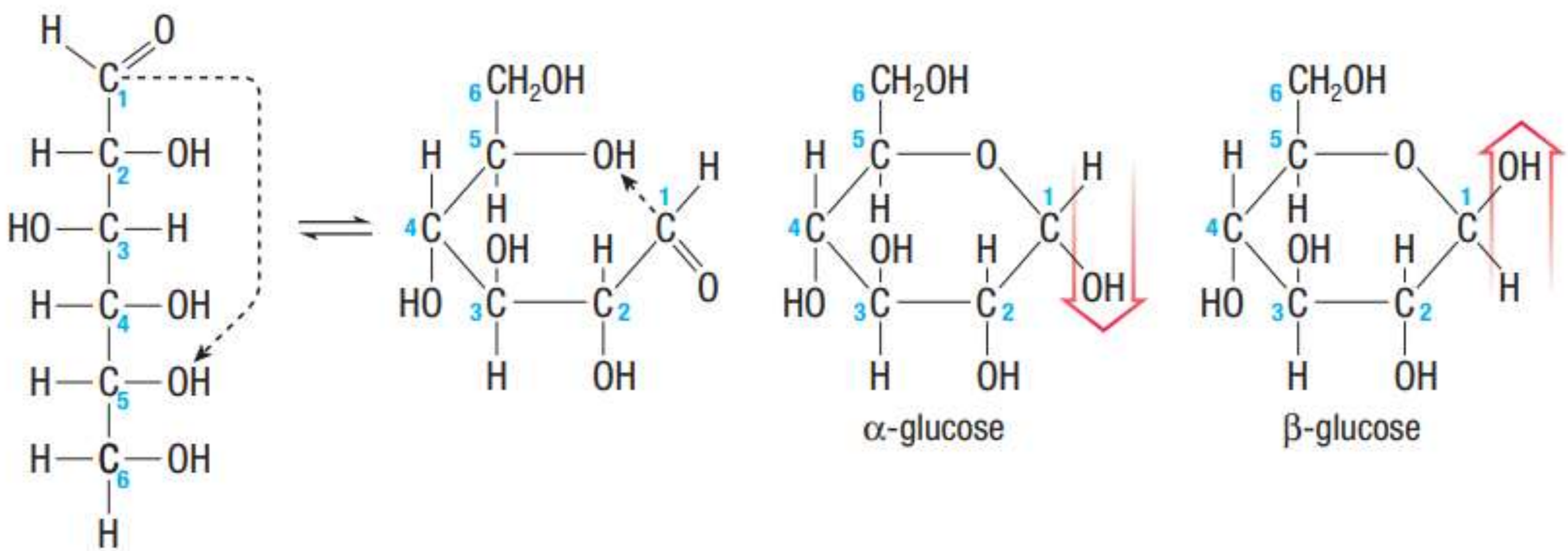
TYPES OF CARBOHYDRATES

Carbohydrate Isomers

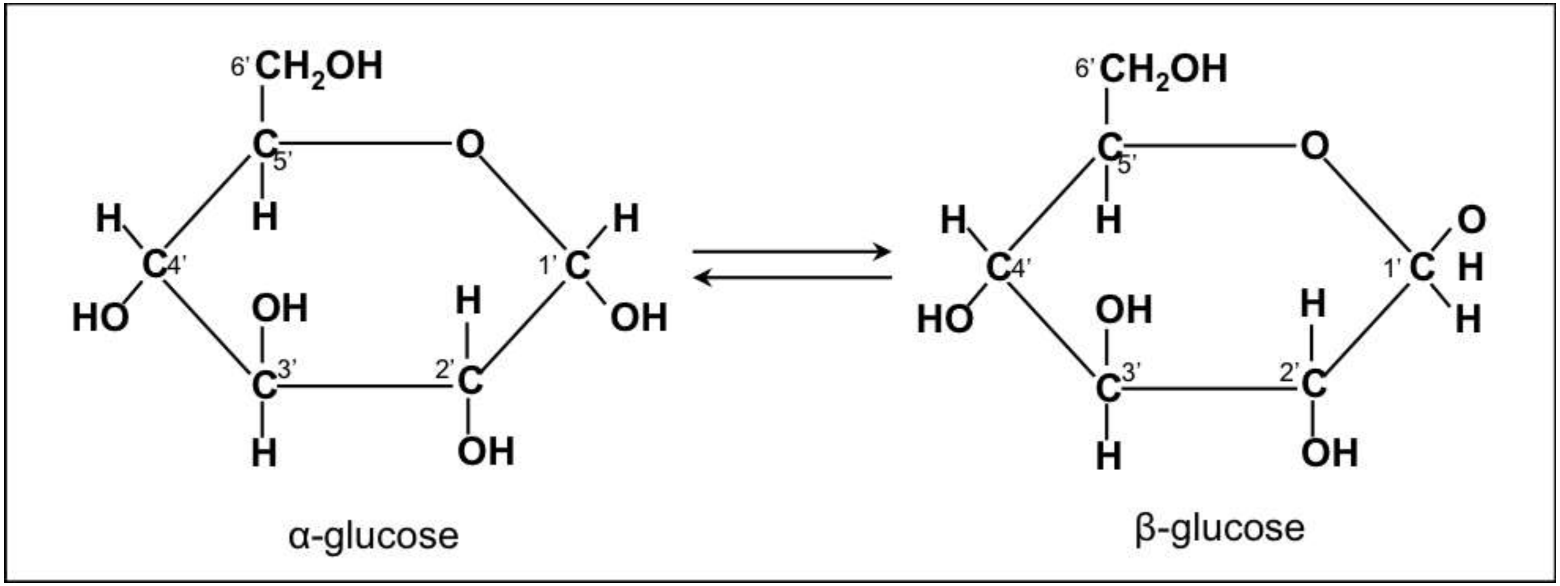


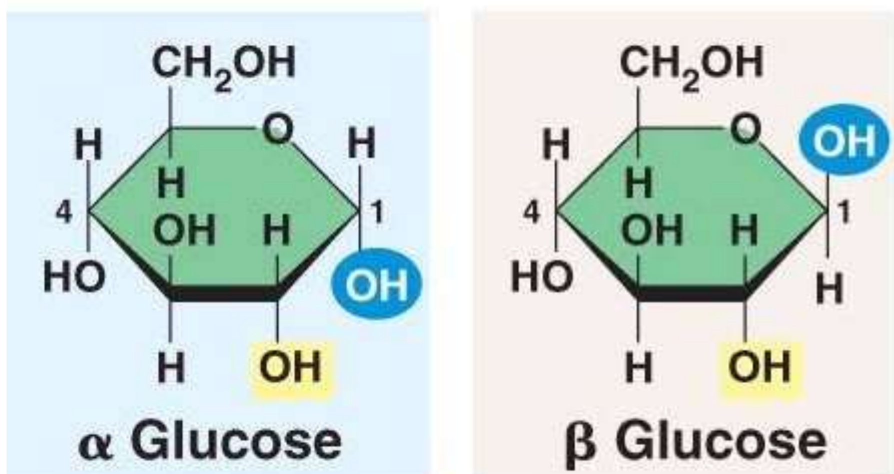
TYPES OF CARBOHYDRATES

Isomers formation



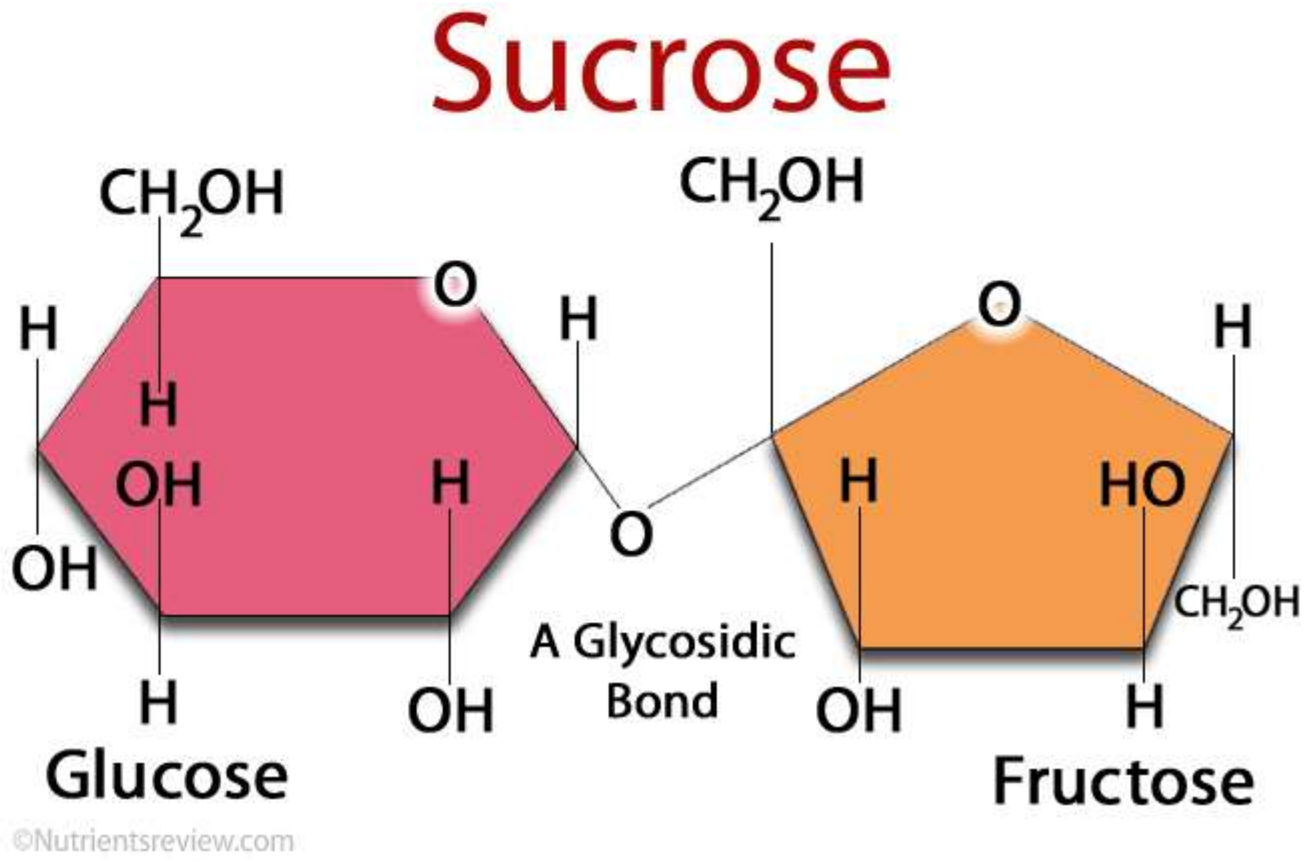
TYPES OF CARBOHYDRATES





TYPES OF CARBOHYDRATES

ii) Disaccharides: Monosaccharides are rare in nature. Most sugars found in nature are disaccharides. These form when two monosaccharides react and the bond is **glycosidic bond.**



TYPES OF CARBOHYDRATES

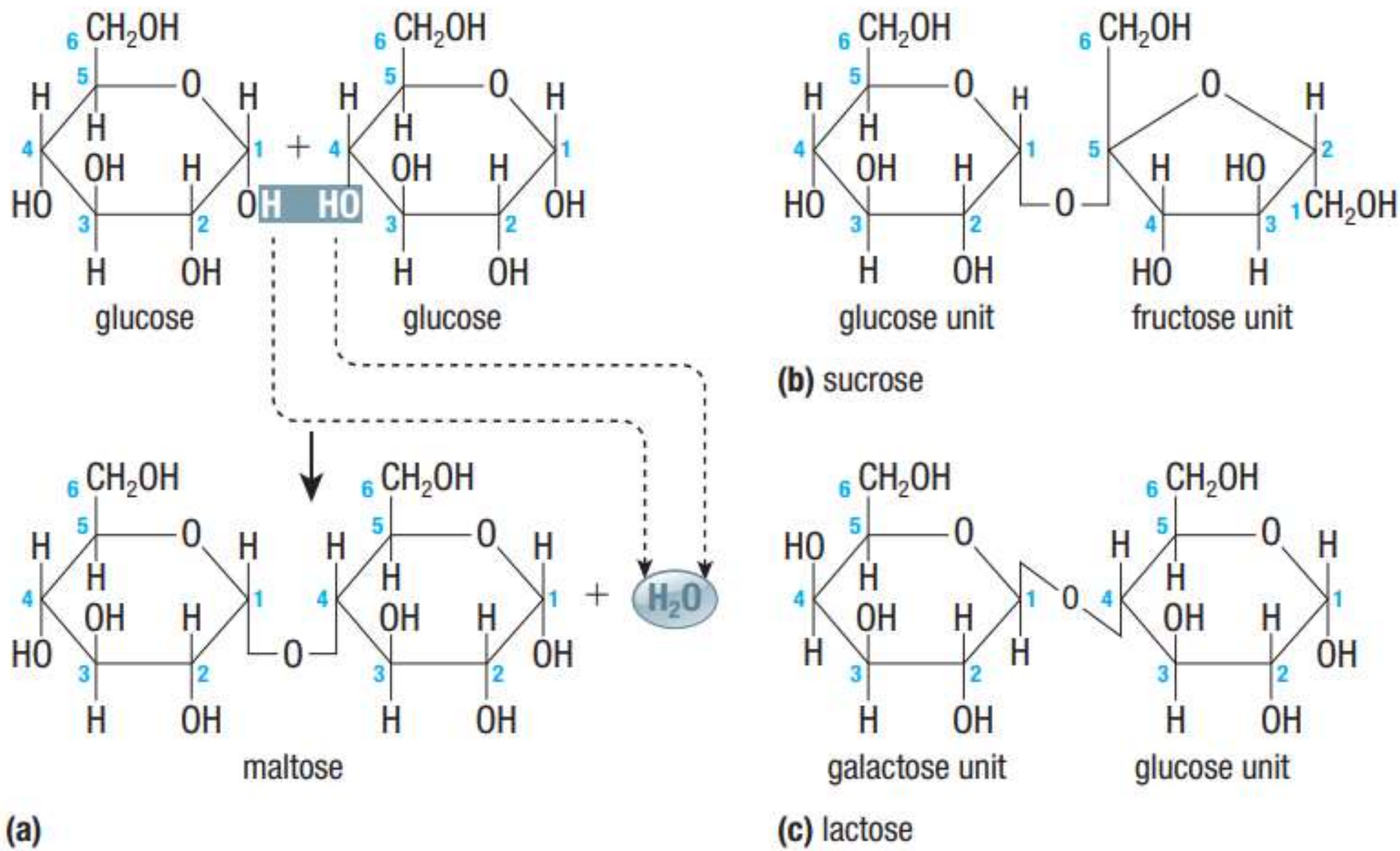
Origin and examples of disaccharides:

Disaccharide		Monosaccharides
sucrose	from	α-glucose + α-fructose
maltose	from	α-glucose + α-glucose
α-lactose *	from	α-glucose + β-galactose

TYPES OF CARBOHYDRATES

Formation of disacchrides:

.



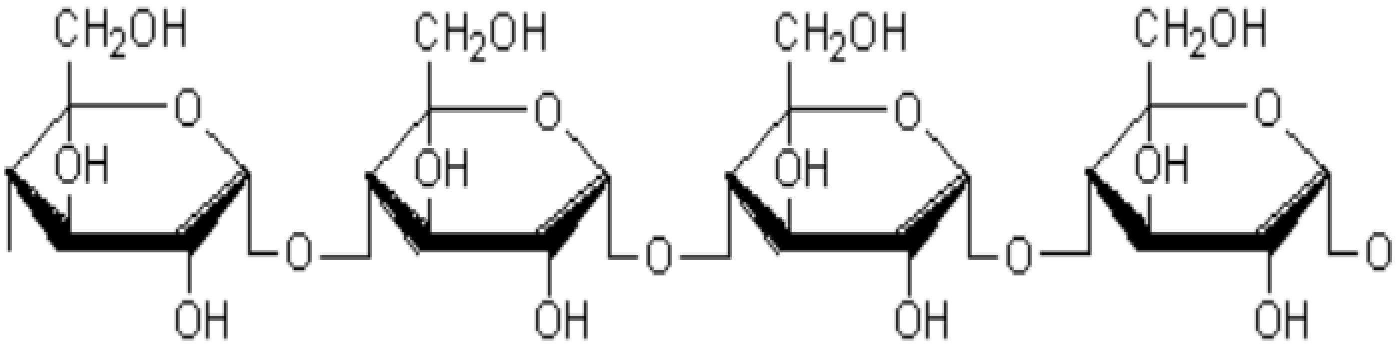
TYPES OF CARBOHYDRATES

iii) Polysaccharides (Complex Carbohydrates): a molecule that is composed of hundreds to thousands of monosaccharides linked together through a series of condensation reactions, adding one unit after another to the chain until very large molecules (polysaccharides) are formed. E.g. Starch (grains carbohydrates); Cellulose; Chitin; Gycogen. The linking reaction is called **condensation polymerisation**, and the building blocks are called **monomers**.

The properties of a polysaccharide molecule depend on:

- Its length (though they are usually very long)
- The extent of any branching (addition of units to the side of the chain rather than one of its ends)
- Any folding which results in a more compact molecule
- Whether the chain is 'straight' or 'coiled'

POLYSACCHARIDES



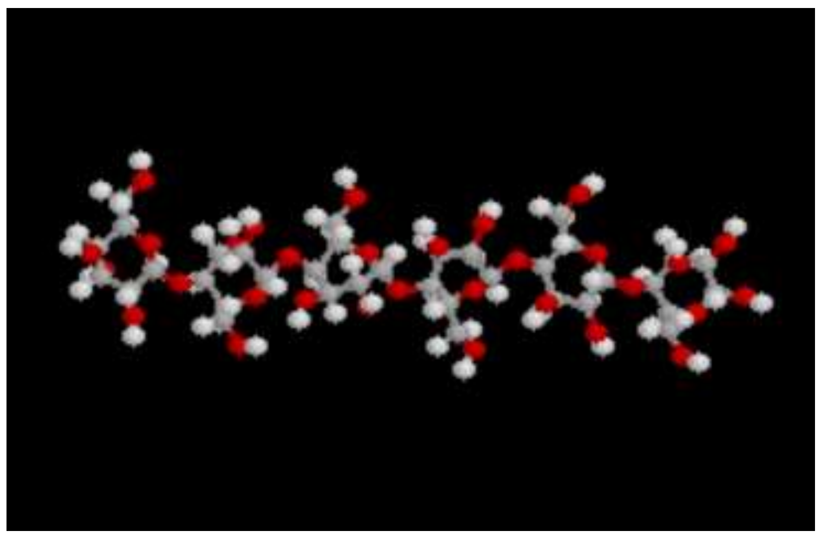
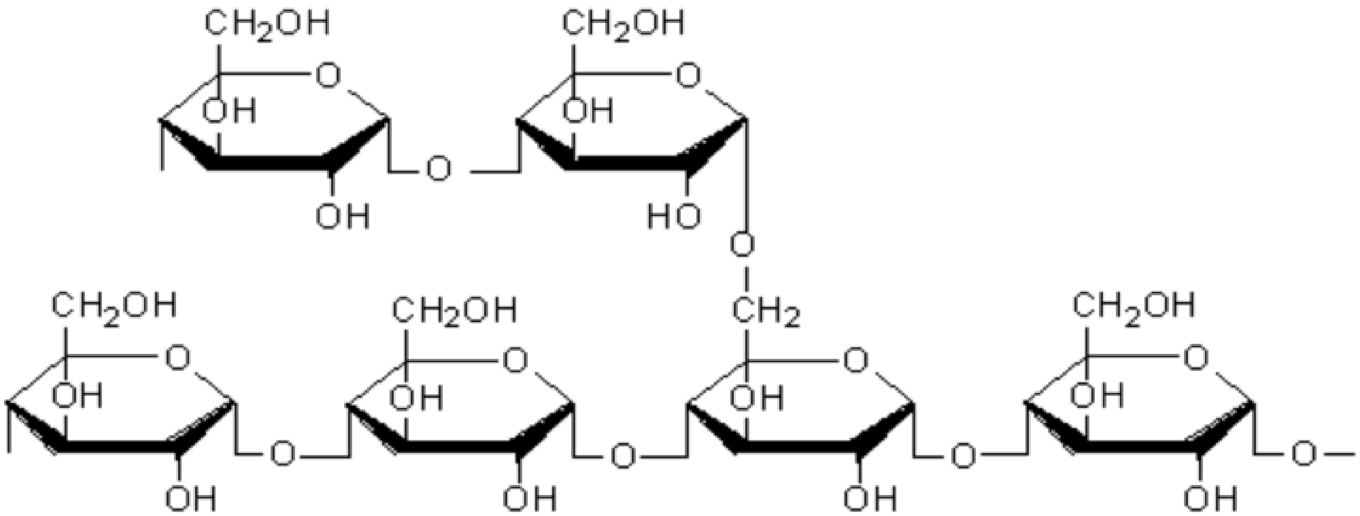


Figure: Starch

POLYSACCHARIDES



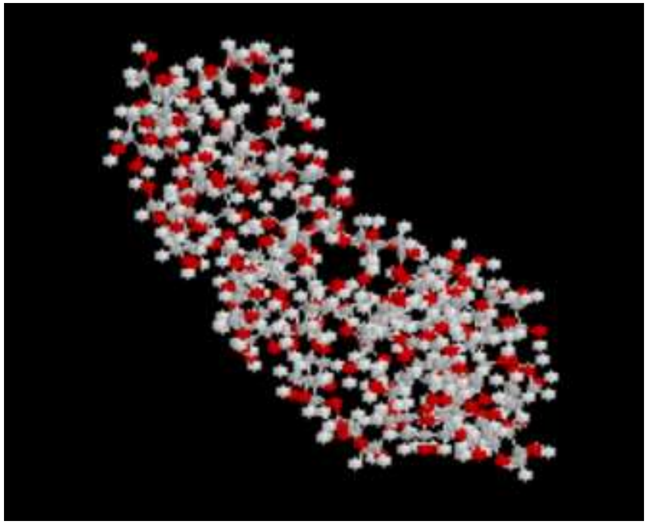
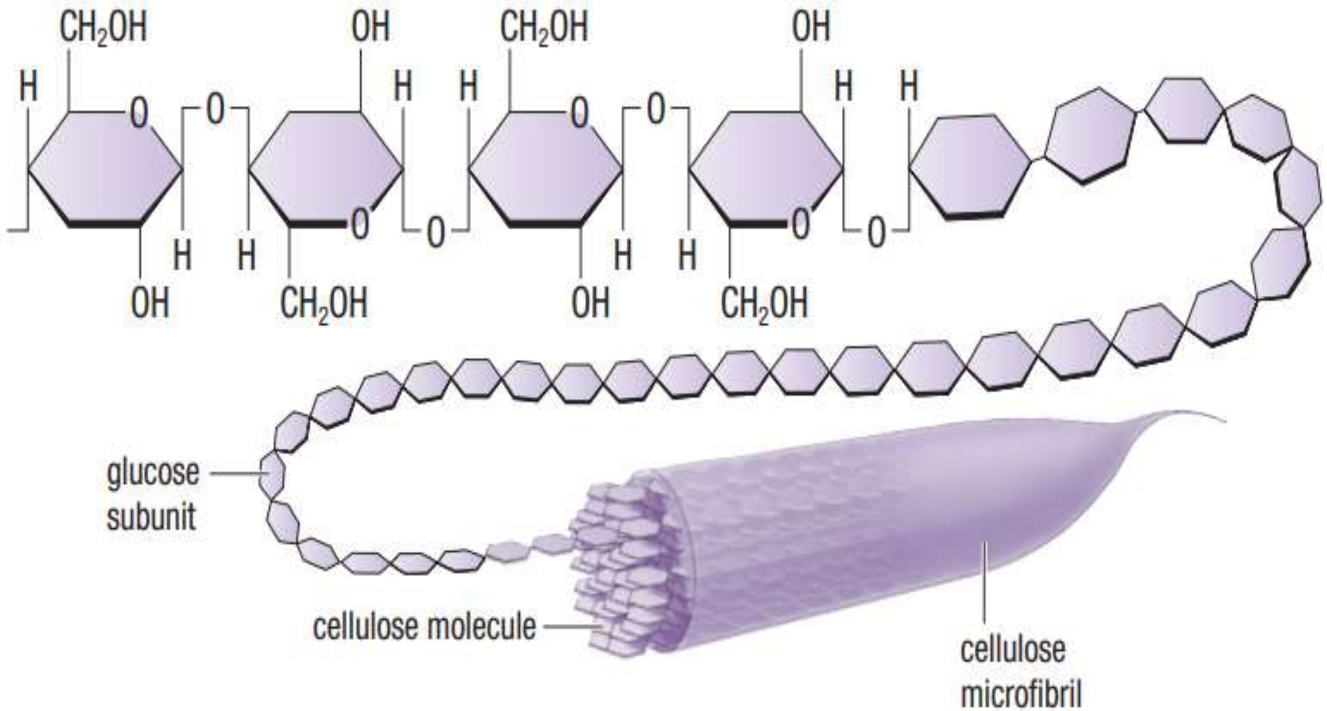


Figure: Glycogen

POLYSACCHARIDES



Cellulose microfibrils in plant cell wall

Figure: Cellulose

CARBOHYDRATES

Table Structures and Functions of Carbohydrates

Type	Structure	Function	Example
monosaccharide	chain, α-ring, or β-ring	energy source, building blocks	glucose, ribose, and deoxyribose
disaccharide	two monomer subunits, with α or β linkage	energy source	sucrose, maltose, and lactose
polysaccharide	very long chain or branching chain with α or β linkages	energy storage, structural support, and cell-to-cell communication	starch and cellulose

LET'S WATCH A VIDEO:

Hydrolysis and Dehydration Synthesis: https://www.youtube.com/watch?v=ZMTeqZLXBSo

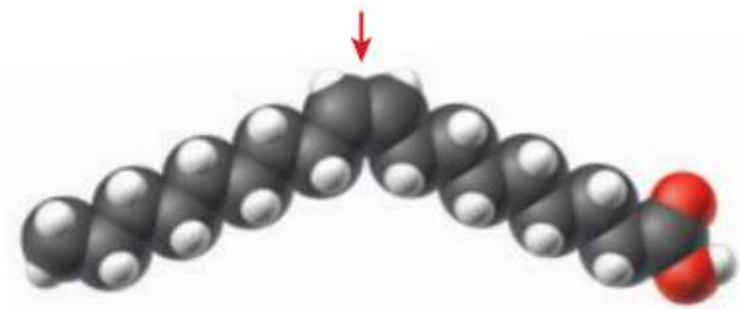
LIPIDS

Lipids are naturally occurring (organic) compounds that are insoluble in polar solvents such as water. They also composed of **Carbon, Hydrogen,** but fewer **Oxygen.**

Their **insolubilit**y can be attributed solely to their long **hydrophobic** hydrocarbon chains. These hydrophobic chains may be saturated (e.g. Stearic acid) or unsaturated (e.g. Oleic acid).

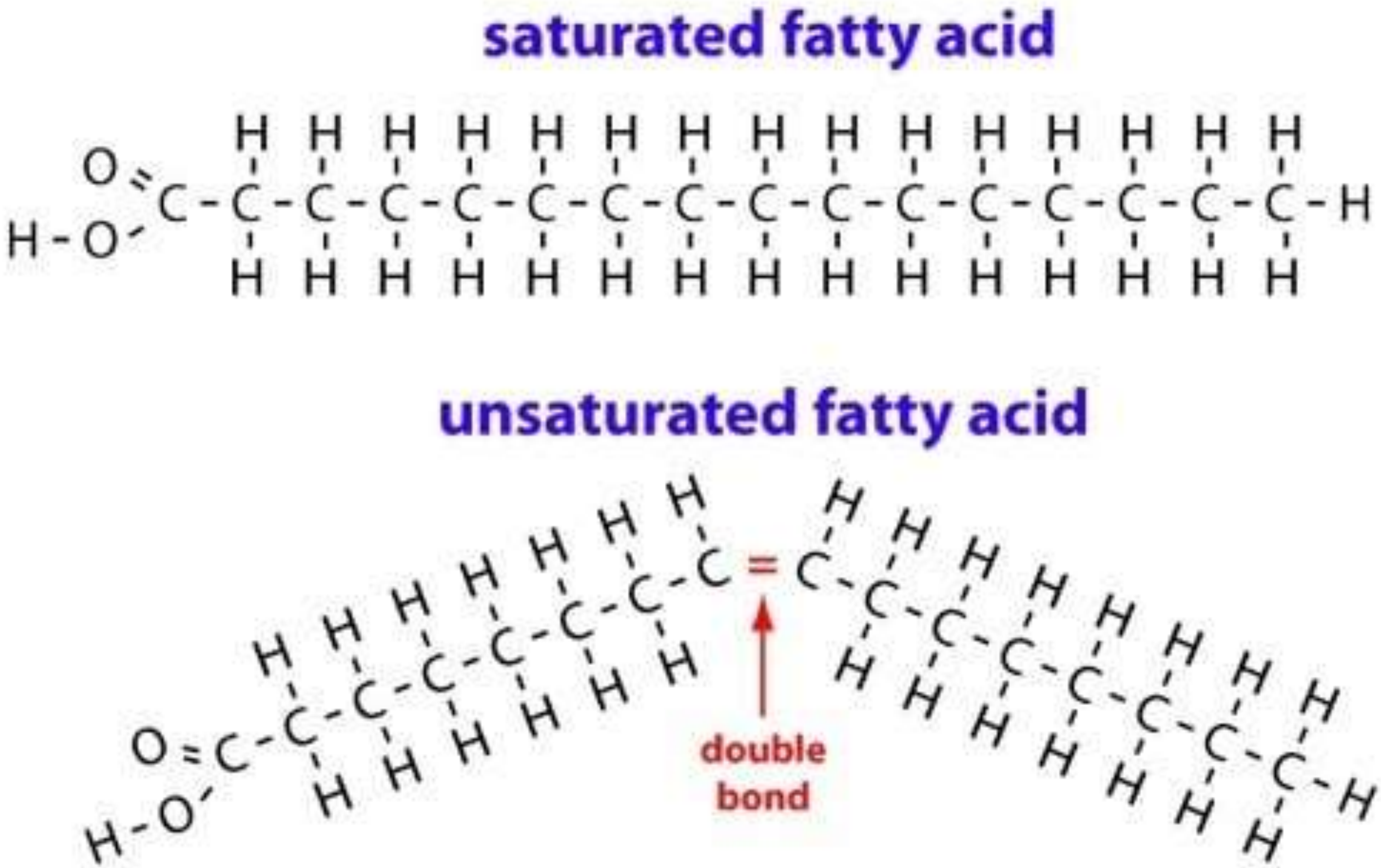
Unsaturated chains contain double or triple **covalent bonds** between adjacent carbons while saturated chains consist of all single bonds.

(b) stearic acid, $CH_3(CH_2)_{16}COOH$



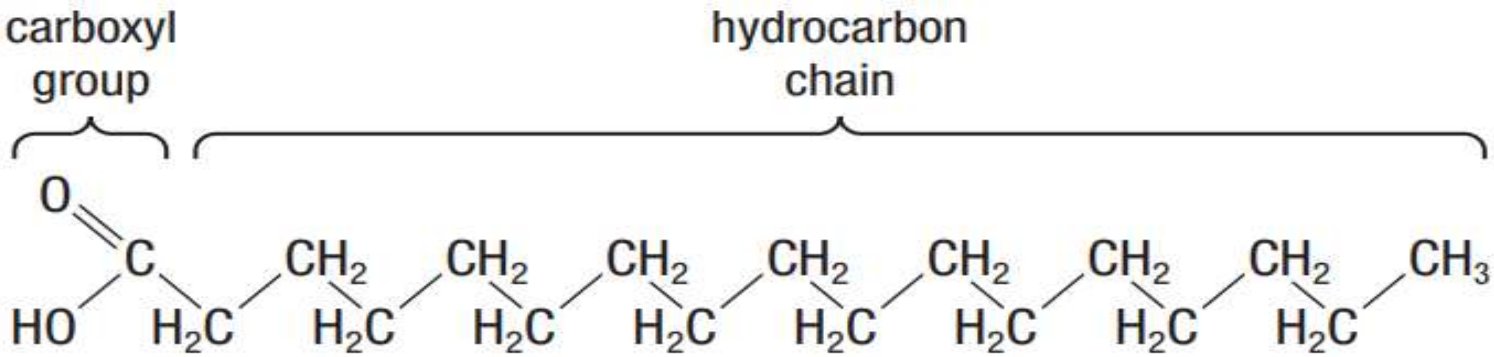
(c) oleic acid, $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$

LIPIDS

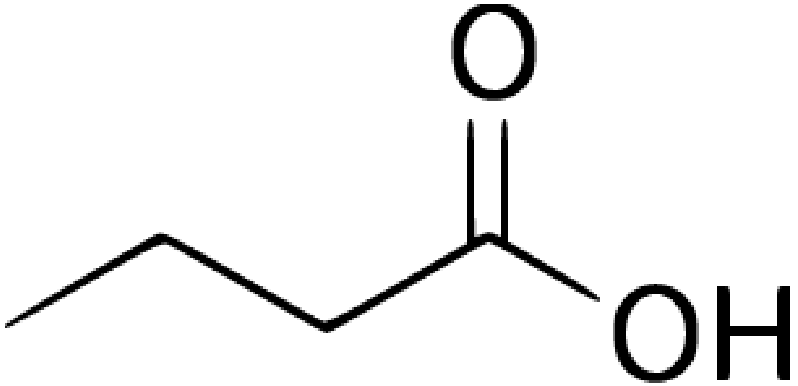


LIPIDS

Fatty Acid: A molecule that consists of a carboxyl group and a hydrocarbon chain. The is the building block of most lipids.

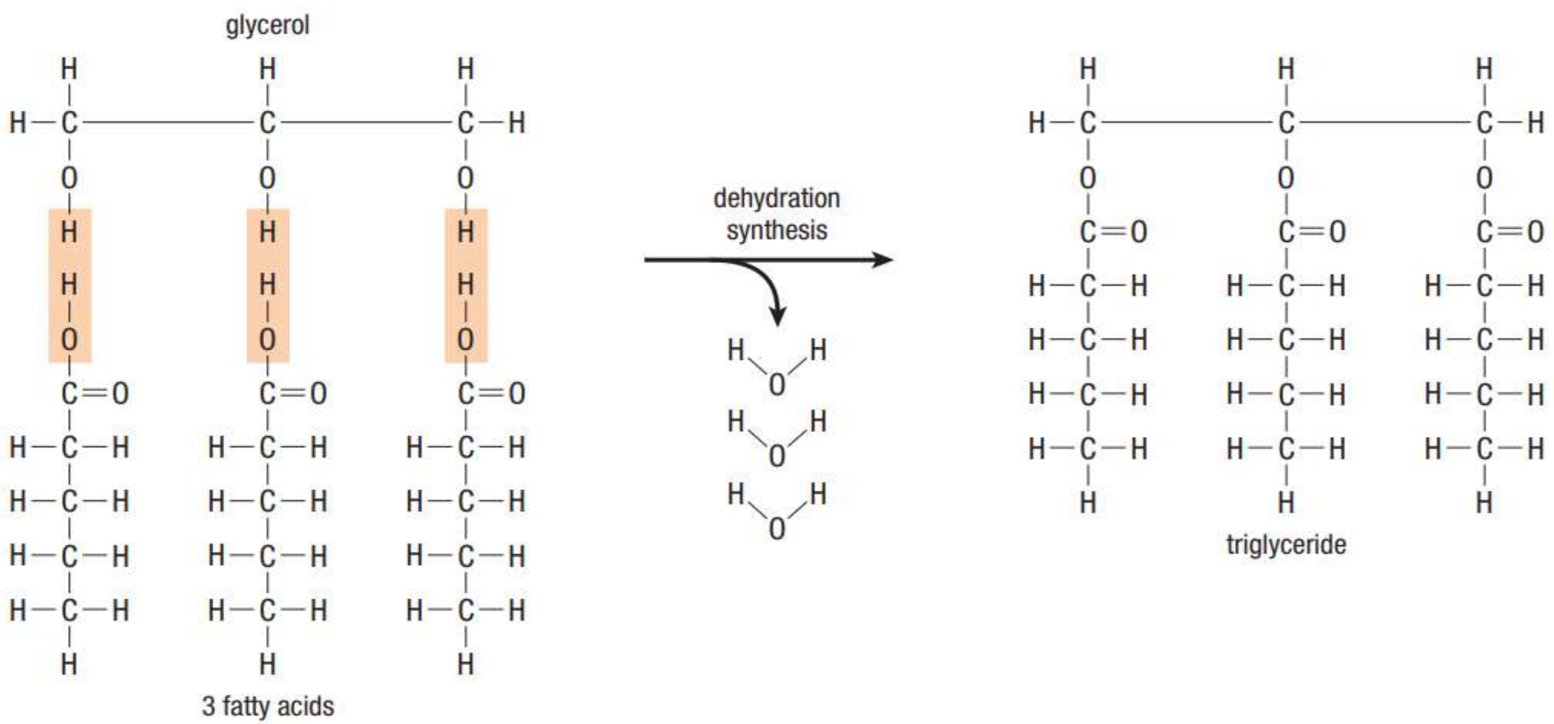


(a) fatty acid



LIPIDS

Fats: A lipid made up of **two types** of molecules**: Fatty acid** and a **Glycerol molecule.** e.g. Triglycerides



LIPIDS

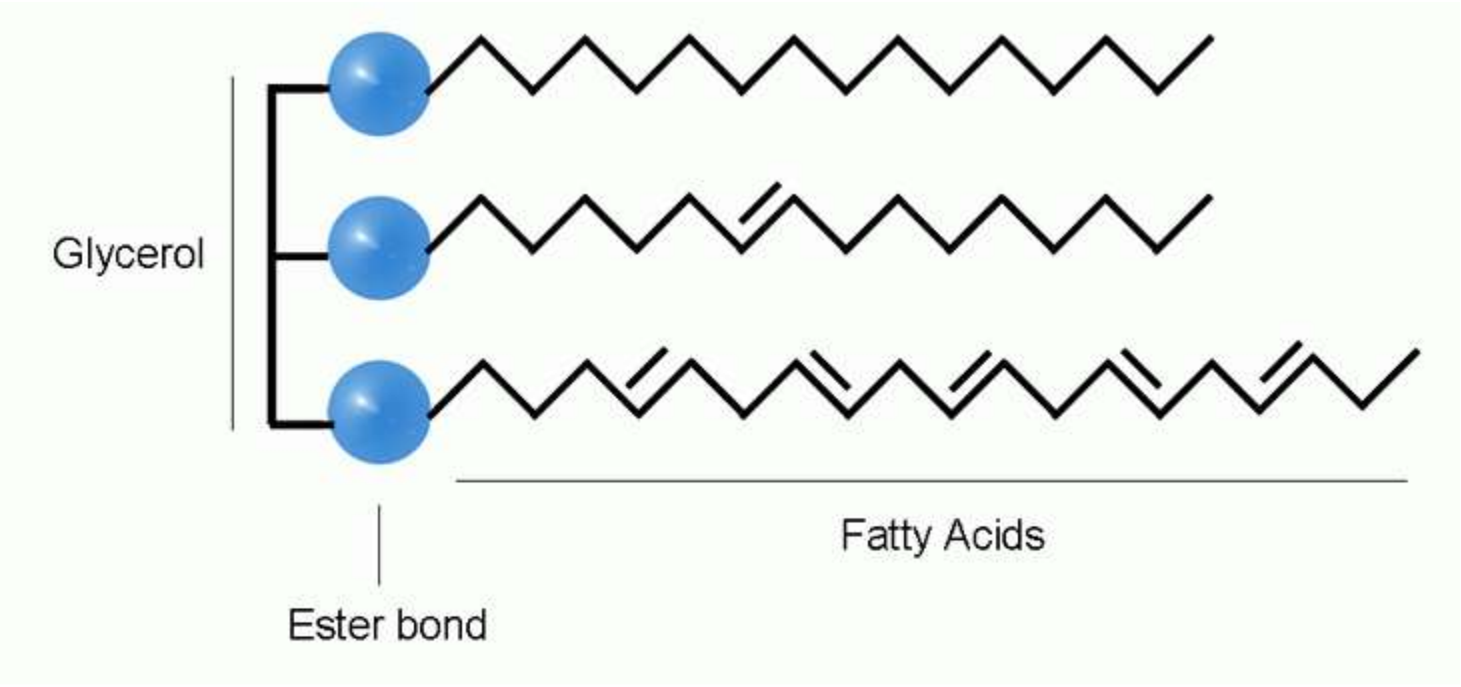
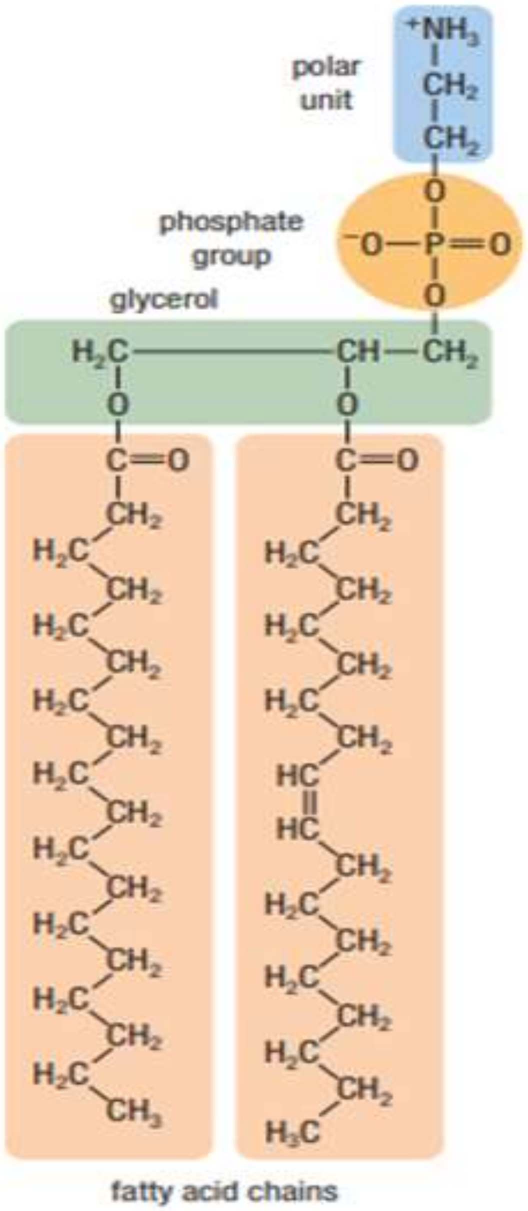


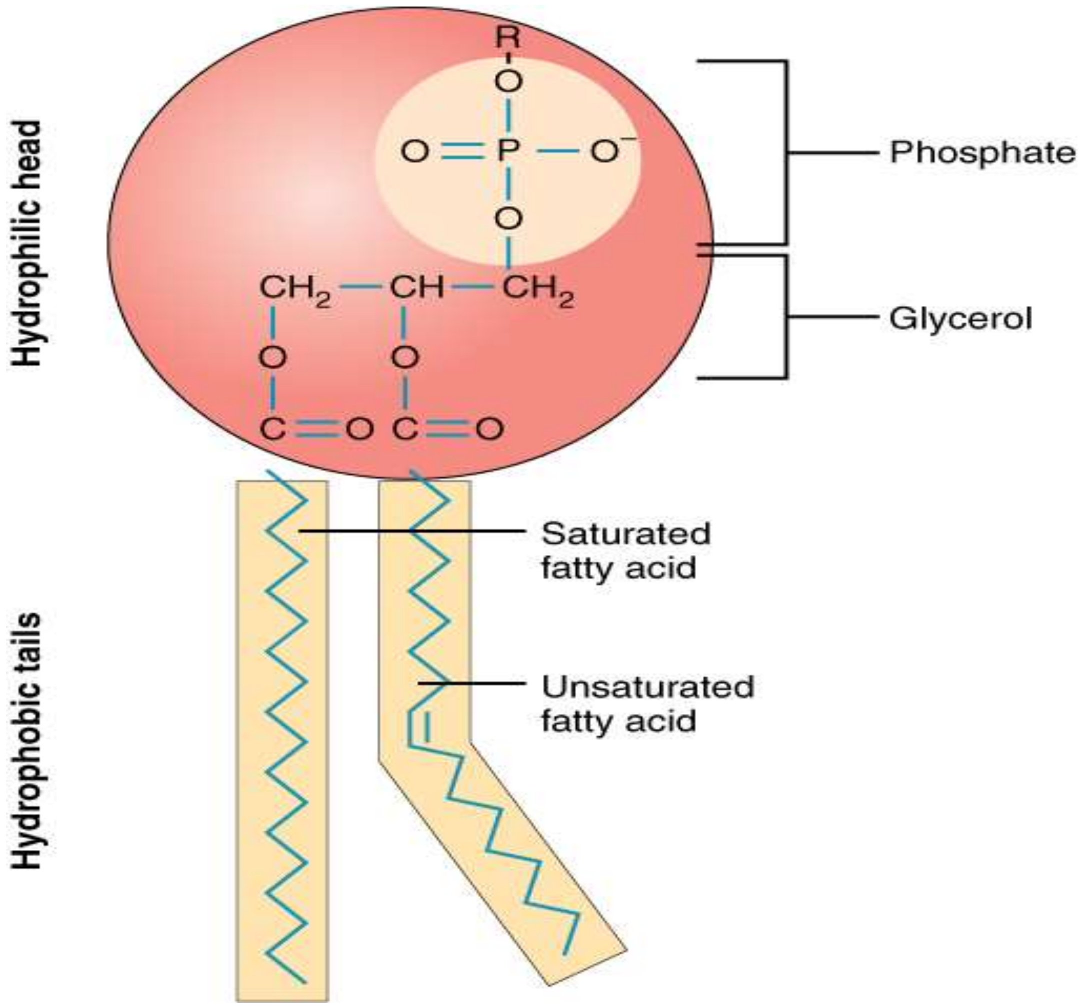
Figure: **Triglycerides**

LIPIDS

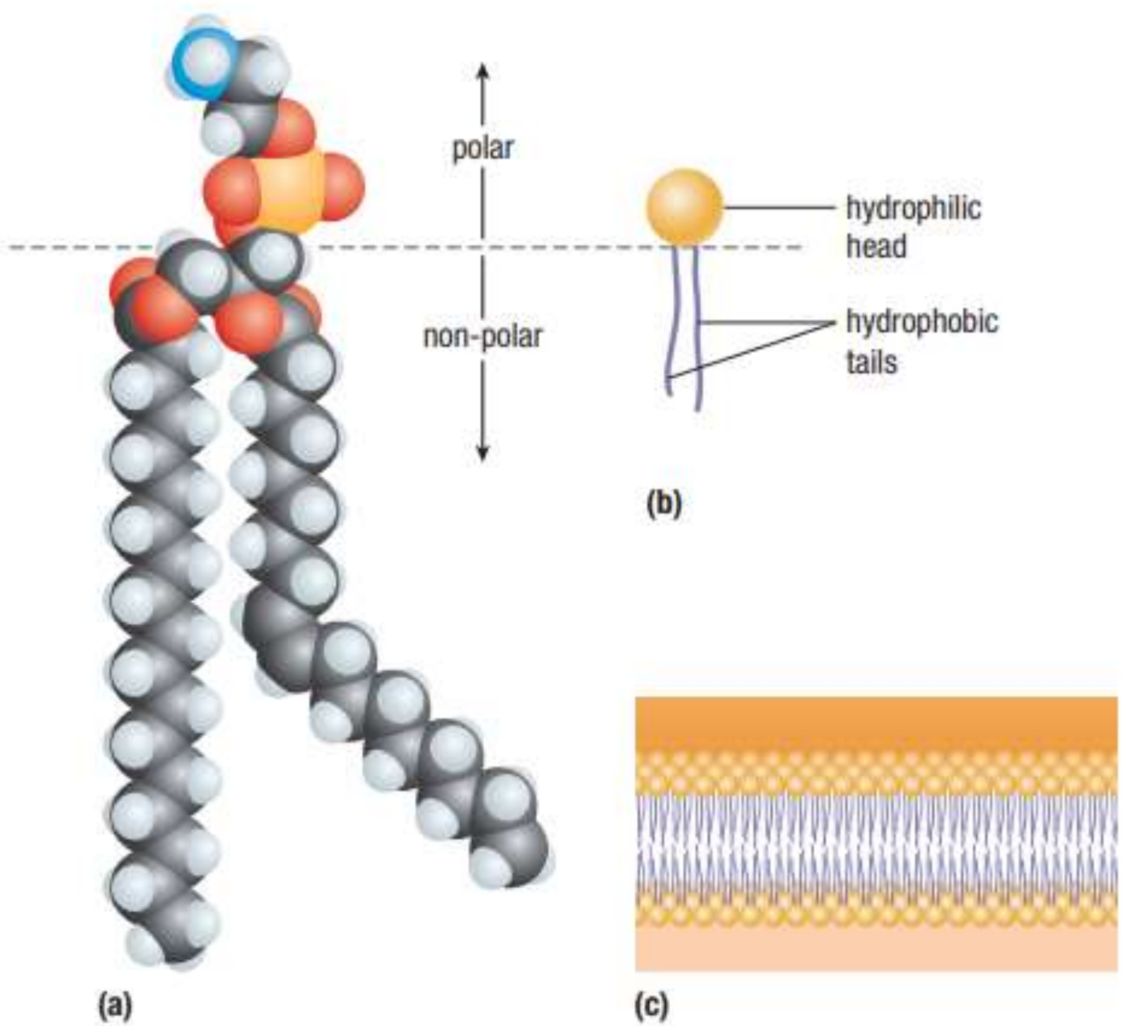
Phospholipids: A lipid that consists of two fatty acids and a phosphate group bound to glycerol. Phospholipids are the primary lipids of cell membranes.



Phospholipids

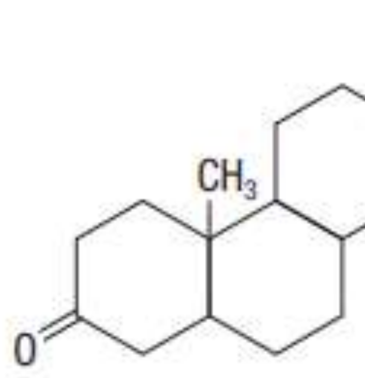


Polar and non-polar ends of Phospholipids

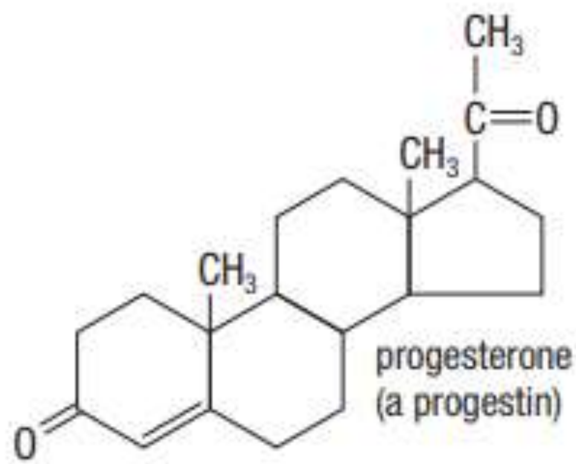


LIPIDS

Steroids: A lipid that is composed of four carbon rings. e.g. Hormones (Testosterone; Progesterone)

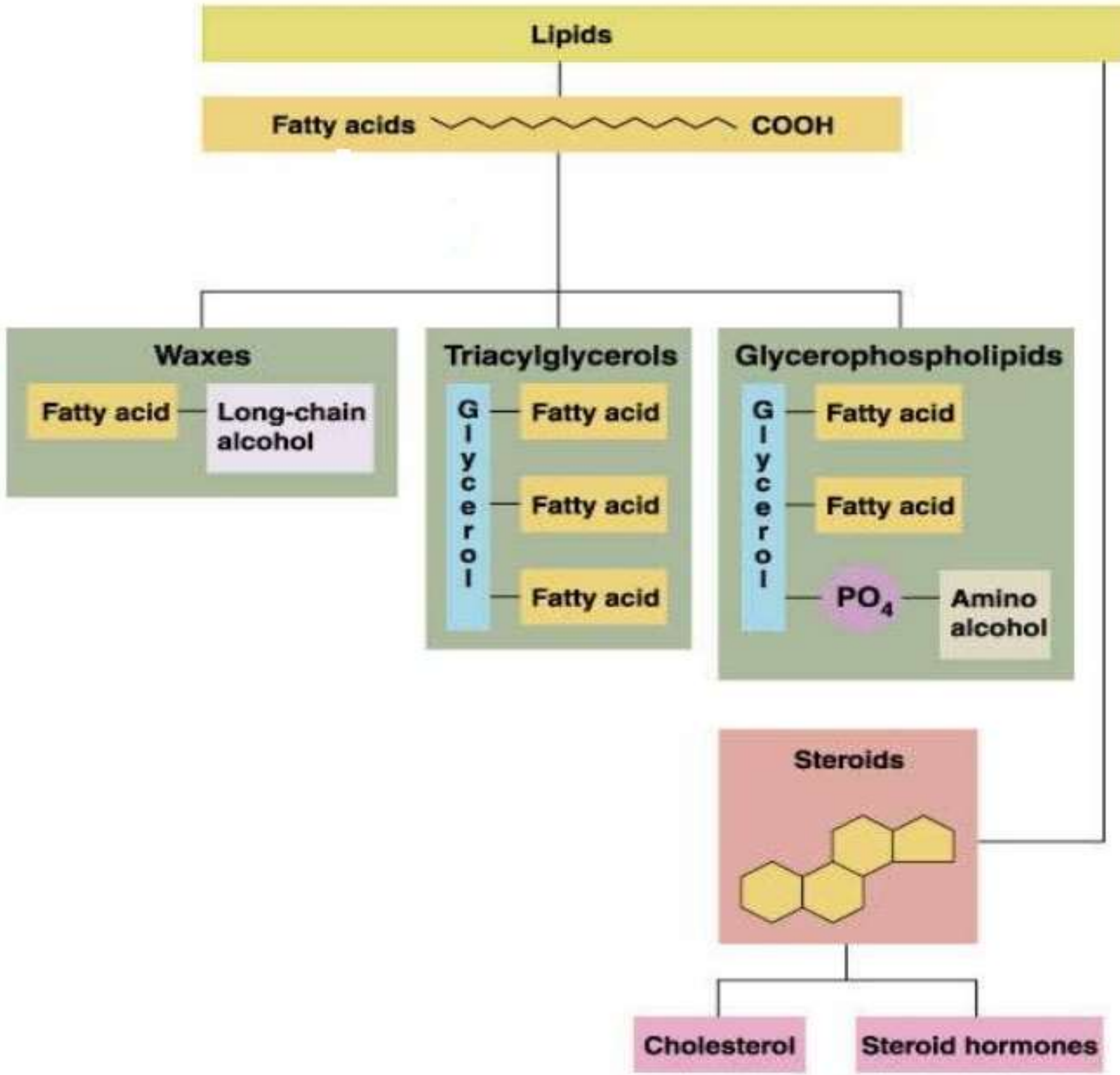


testosterone
(an androgen)



progesterone
(a progestin)

Summary of Lipids composition



LIPIDS

Table Structure and Function of Lipids

Type	Structure	Function	Example
fatty acid	carboxyl group linked to a hydrocarbon chain	cellular functions and energy storage	stearic acid
fat	three fatty acid chains linked to glycerol	energy storage and insulation	butter and olive oil
phospholipid	two fatty acid chains and one phosphate group linked to glycerol	cell membrane	lipid bilayer
steroid	four carbon rings	hormonal signalling, cell response to the environment, and growth	testosterone and cholesterol
wax	long fatty acid chains linked to alcohol or carbon rings	water resistance and protection	wax coating on fruits, leaves, and stems

THE END