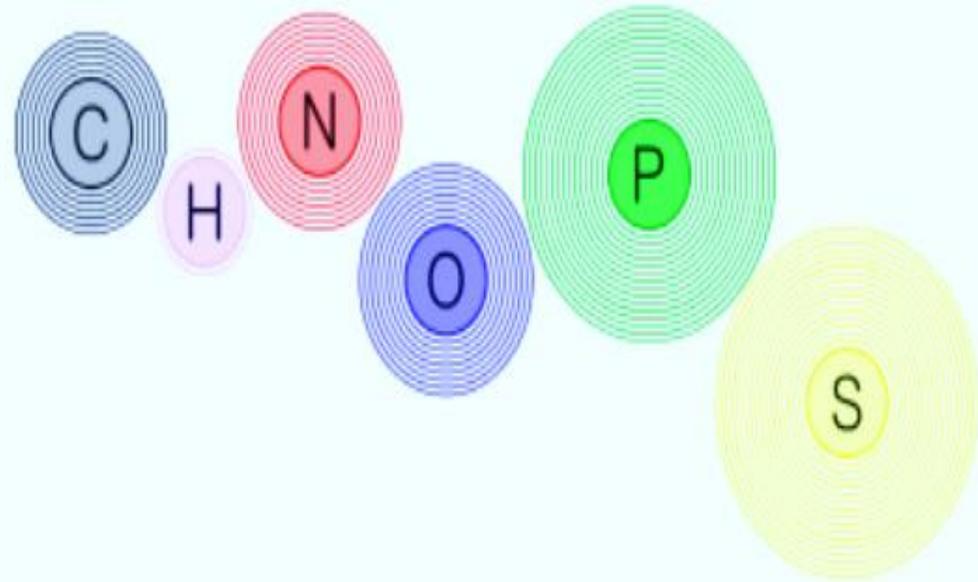


Biological Macromolecules



**Prepared by:
Dr/ Aya El-Hanafy**

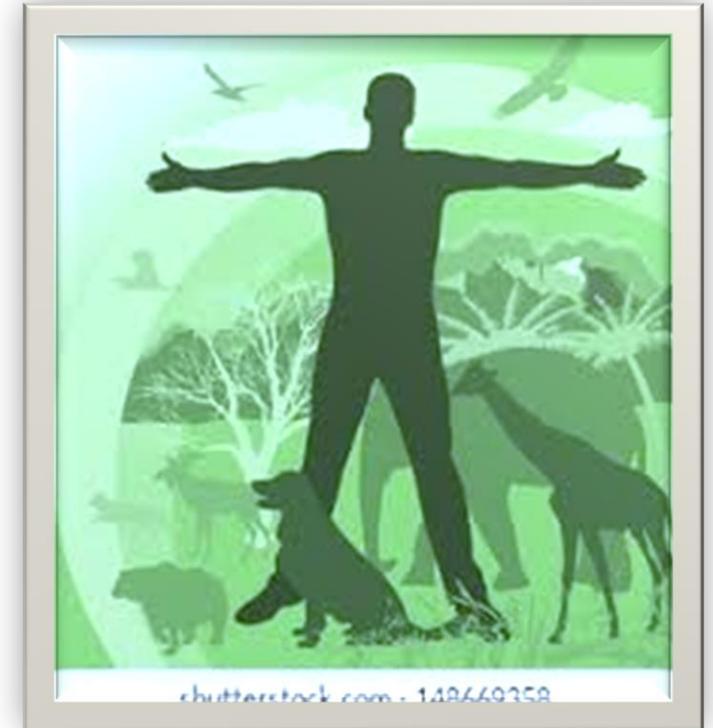
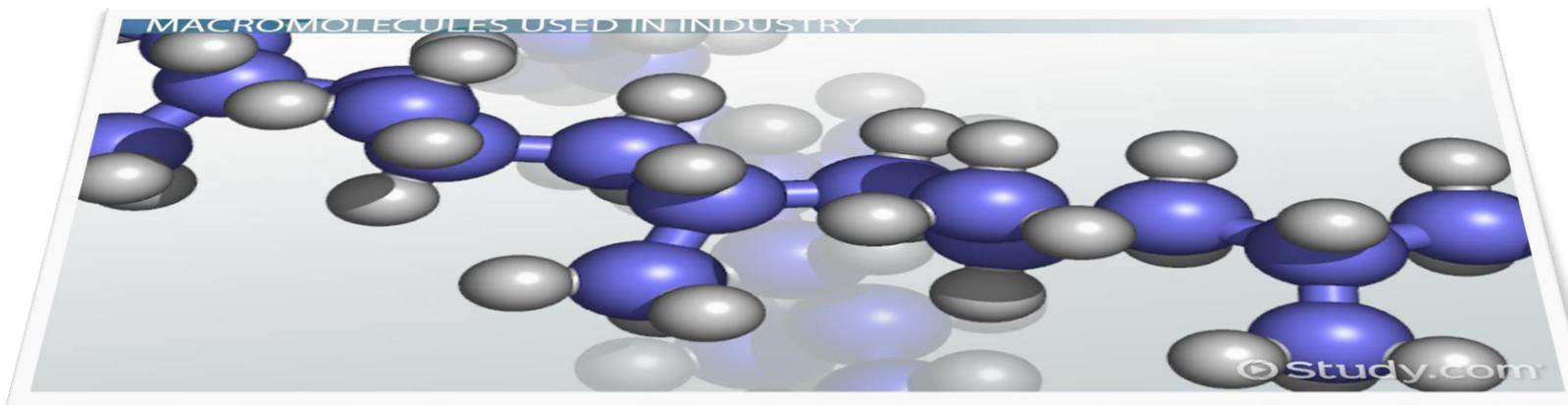
Students Learning Outcomes

❖ **By the end of this lecture, the students should be able to:**

- 1. Classify Macromolecules.**
- 2. Differentiate between Carbohydrates, lipids , proteins and Nucleic acid.**
- 3. Summarize the general characteristics and biological function of each biomolecule.**

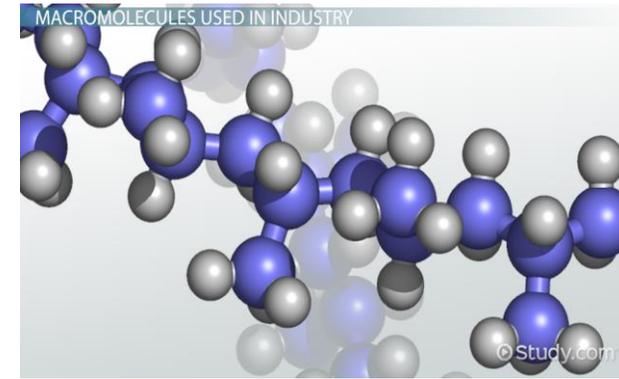
Overview: The Molecules of Life

- Organisms contain a wide variety of **organic molecules** with numerous functions which depend on the **chemical structures** and **properties** of these molecules.



Overview: The Molecules of Life

- All living things are made up of four classes of large molecules (**Macromolecules**):
carbohydrates, lipids, proteins, and nucleic acids.



Carbohydrates

Lipids

Proteins

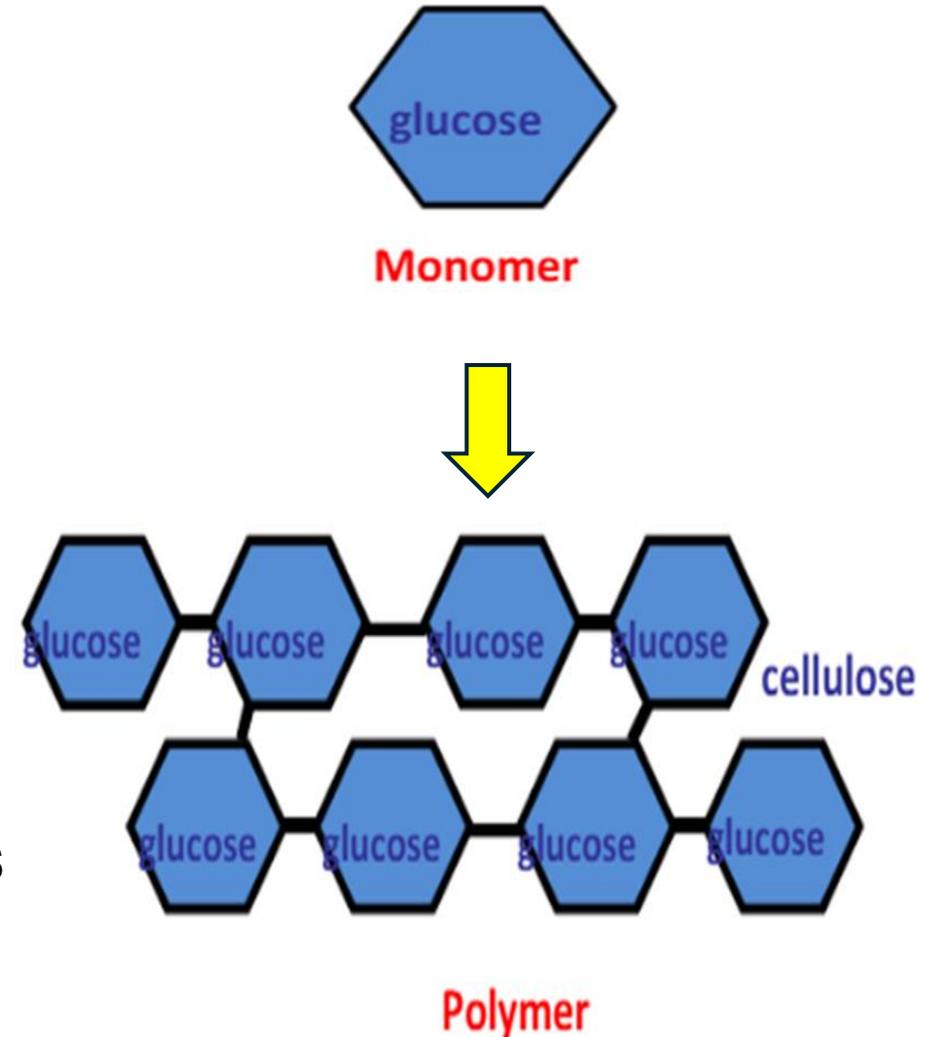
Nucleic Acids

Macromolecules are polymers, built from monomers

❑ **Macromolecules** are large biological molecules that are formed by joining small organic molecules together

❑ Macro = “Large”

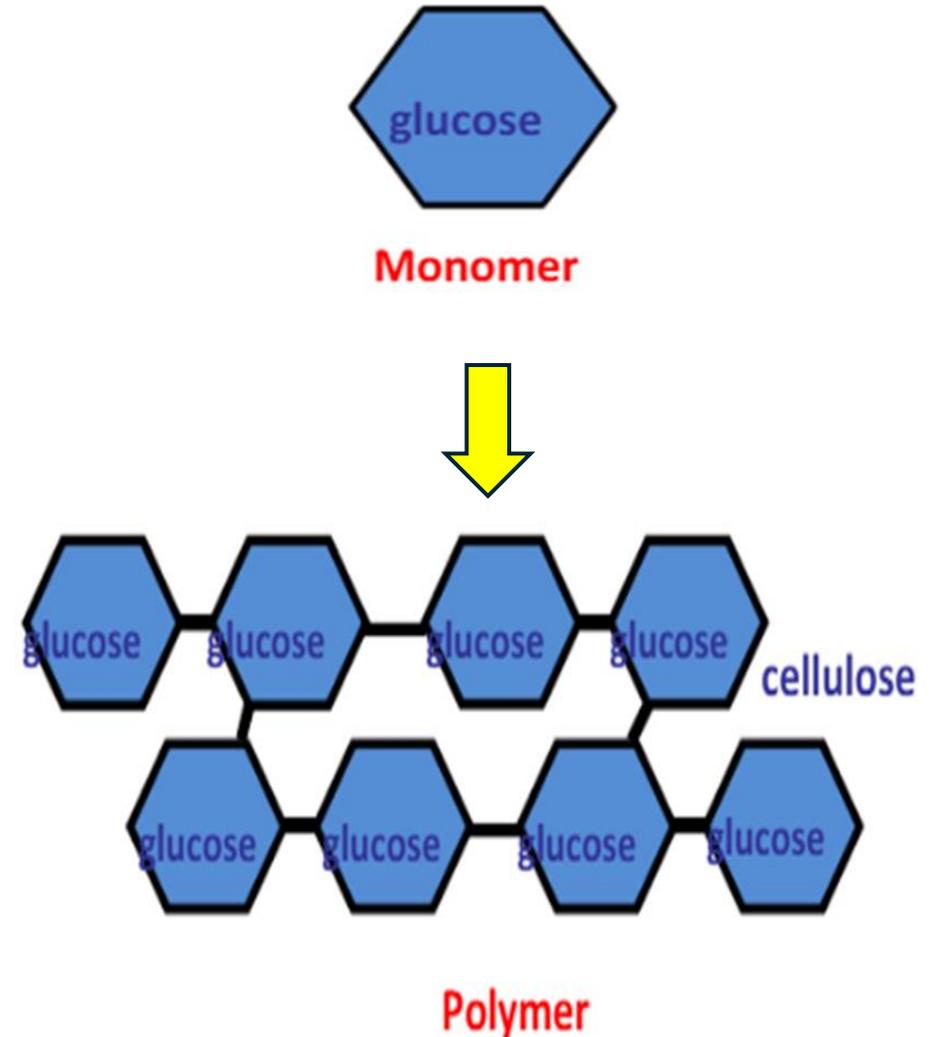
- Also known as **polymers**. Poly = “Many”
 - Many what? Many **Monomers**.
 - Monomers are smaller repeating subunits that make up polymers.



Macromolecules are polymers, built from monomers

SO:

- ❑ **Monomers** are small molecules or **building blocks** that **joined together** to form more complex molecules called polymers.
- ❑ **A polymer:** may be a natural or synthetic macromolecule comprised of **repeating units** of a smaller molecule (**monomers**).

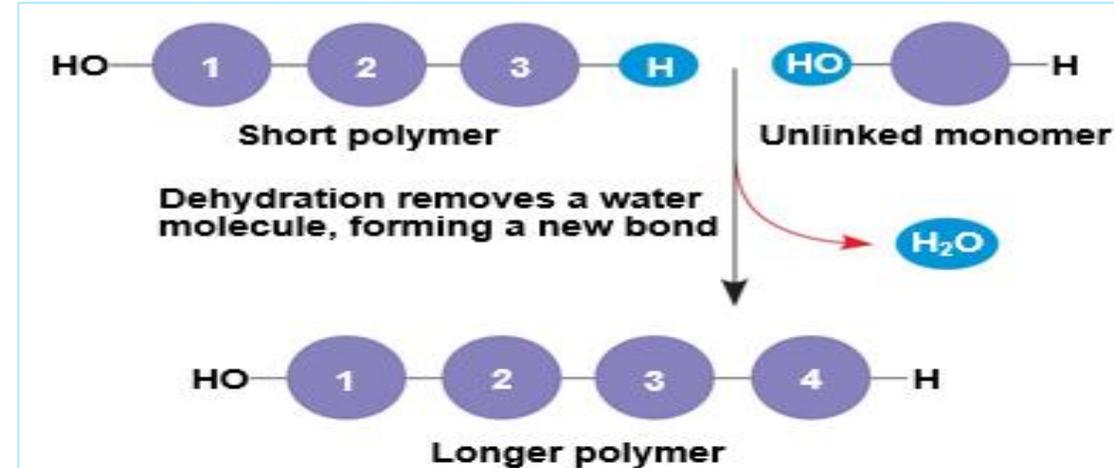


The Synthesis and Breakdown of Polymers

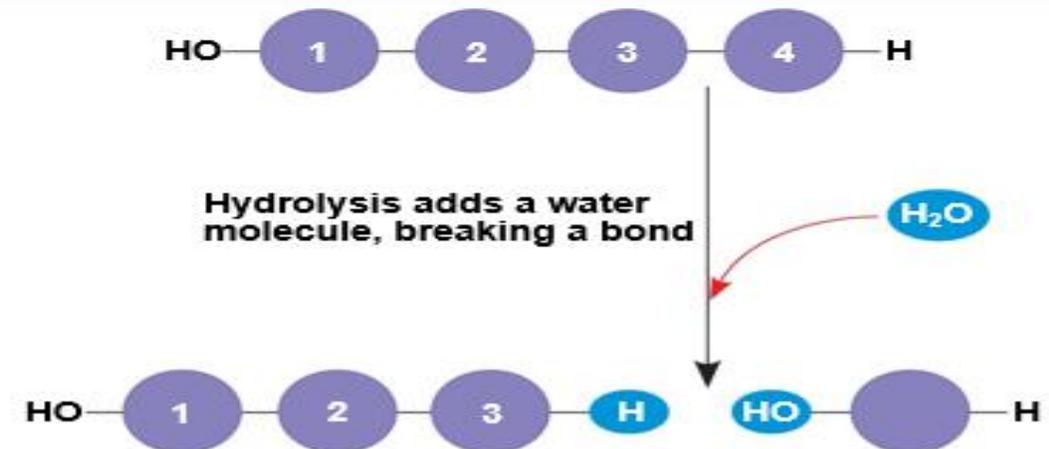
□ A **condensation (Polymerization) reaction** or more specifically a **dehydration reaction**:

occurs when two monomers bond together through the loss of a water molecule, linking the two monomers with a covalent bond.

□ Polymers are break down to monomers by **hydrolysis**, the **reverse of the dehydration reaction**



(a) Dehydration reaction in the synthesis of a polymer

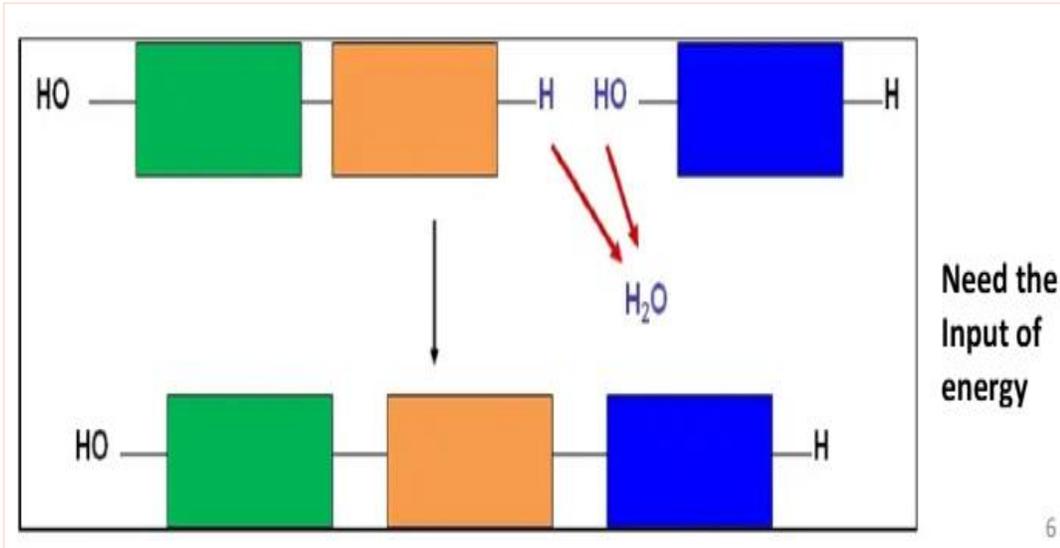


(b) Hydrolysis of a polymer

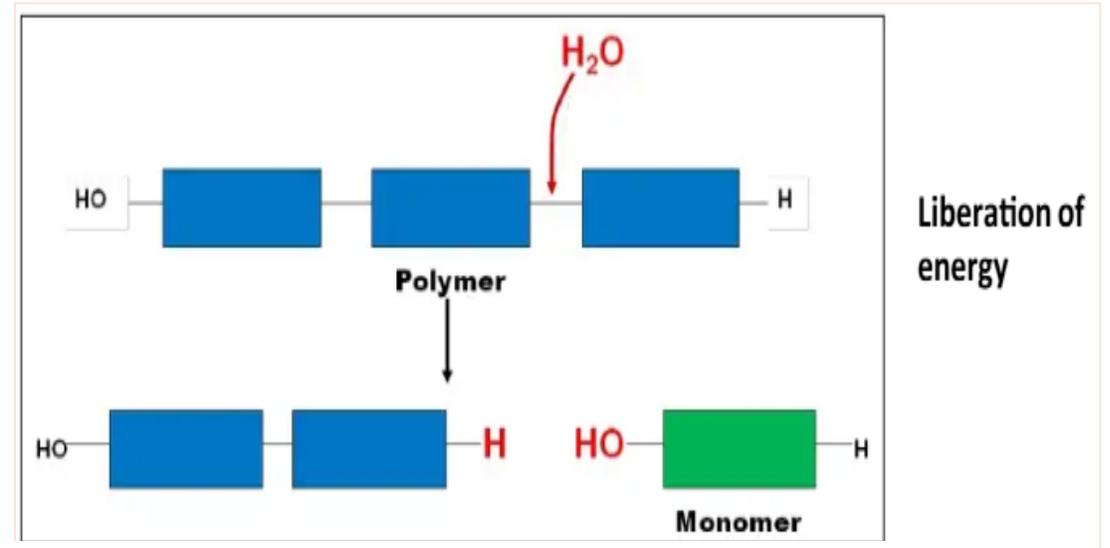
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The Synthesis and Breakdown of Polymers

Polymerization (Condensation)



Hydrolysis (Reverse of Condensation)

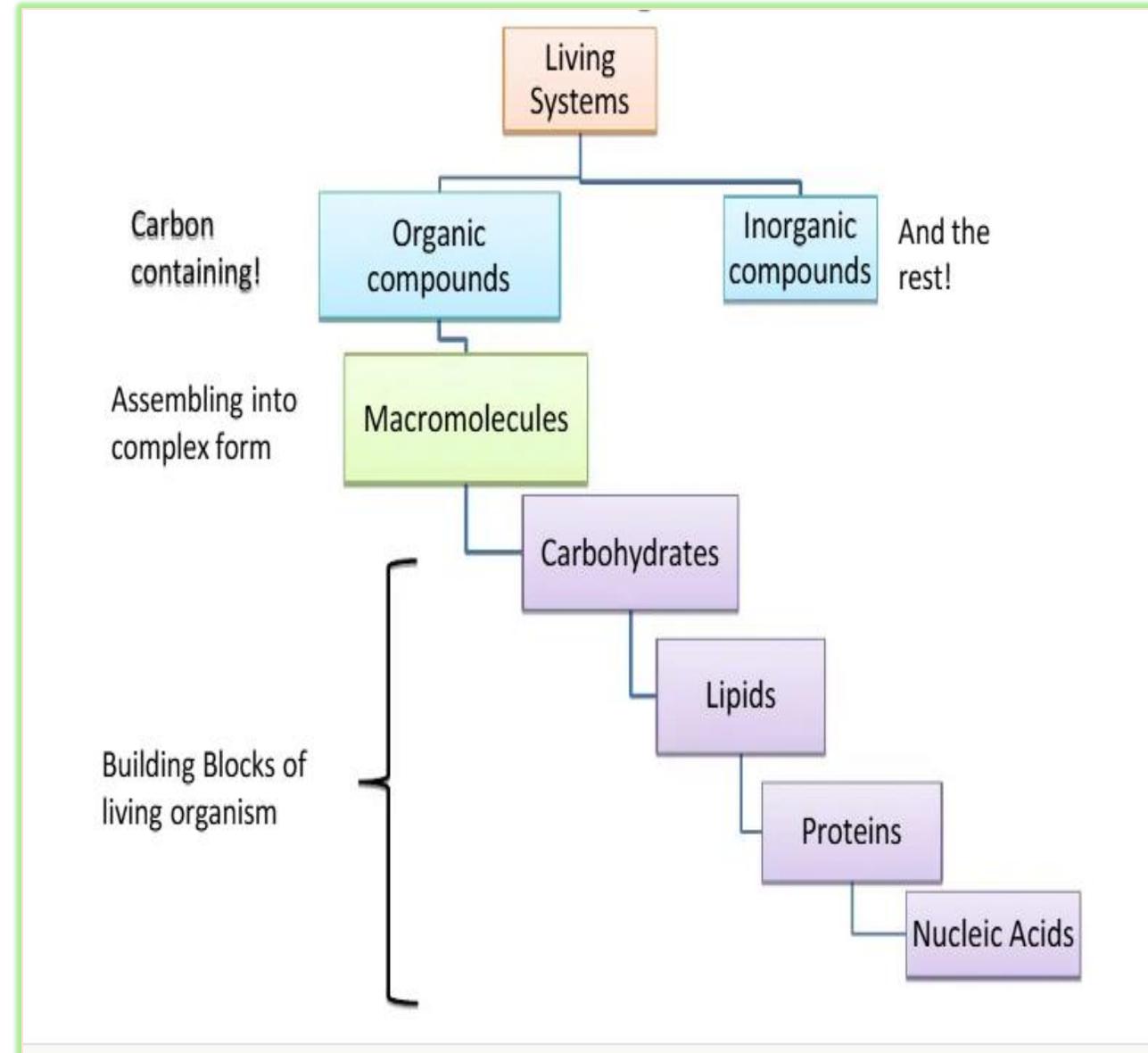


By breaking the bonds between monomers, Hydrolysis **liberates the energy** that polymers contained during condensation; thus, some of the energy required to polymerize is returned upon hydrolysis.

Classification of Different Macromolecules

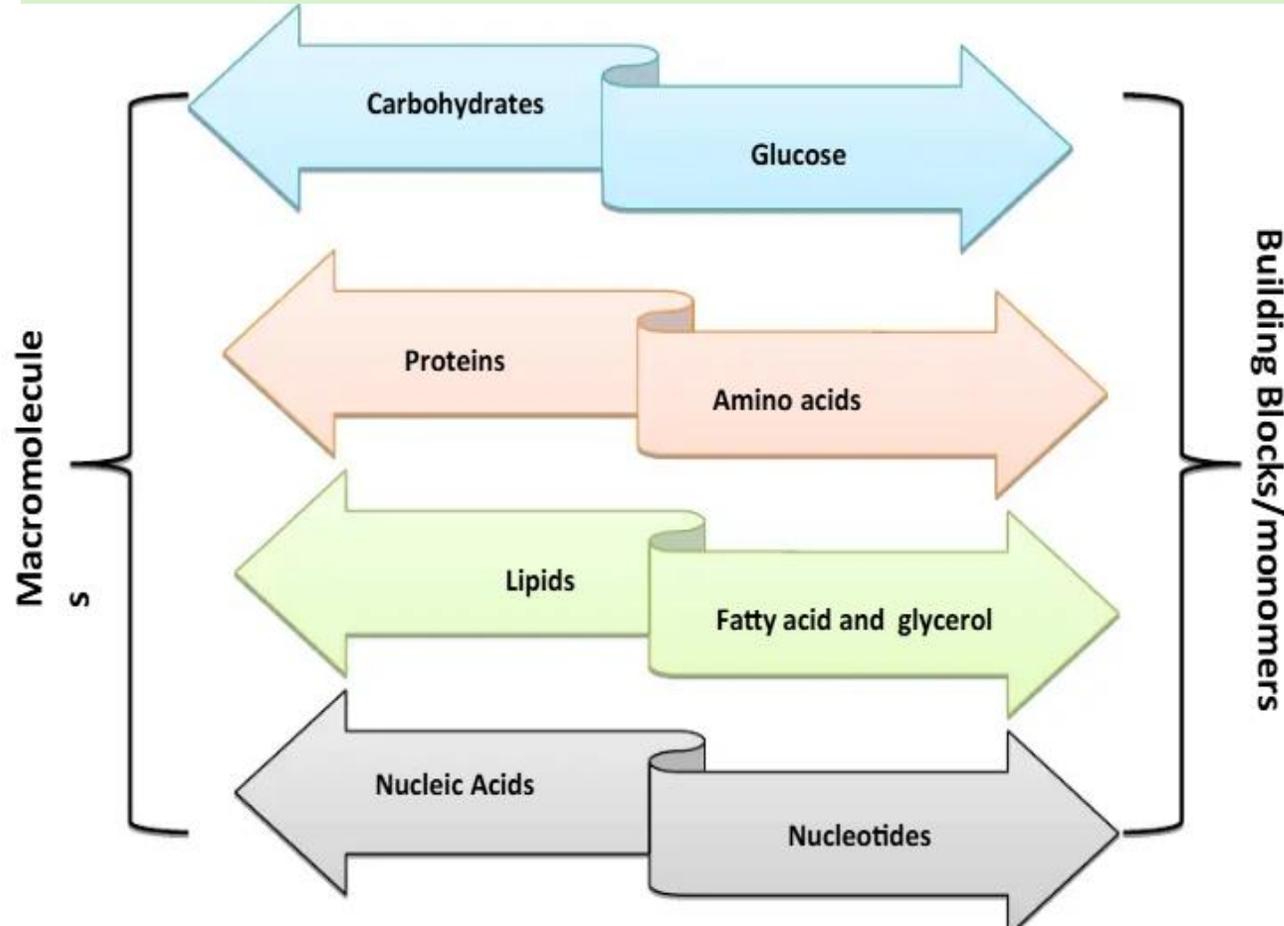
- Biological macromolecules are **classified** based on their structure and function inside living organisms into:

1. **Carbohydrates,**
2. **Lipids,**
3. **Proteins, and**
4. **Nucleic acids.**



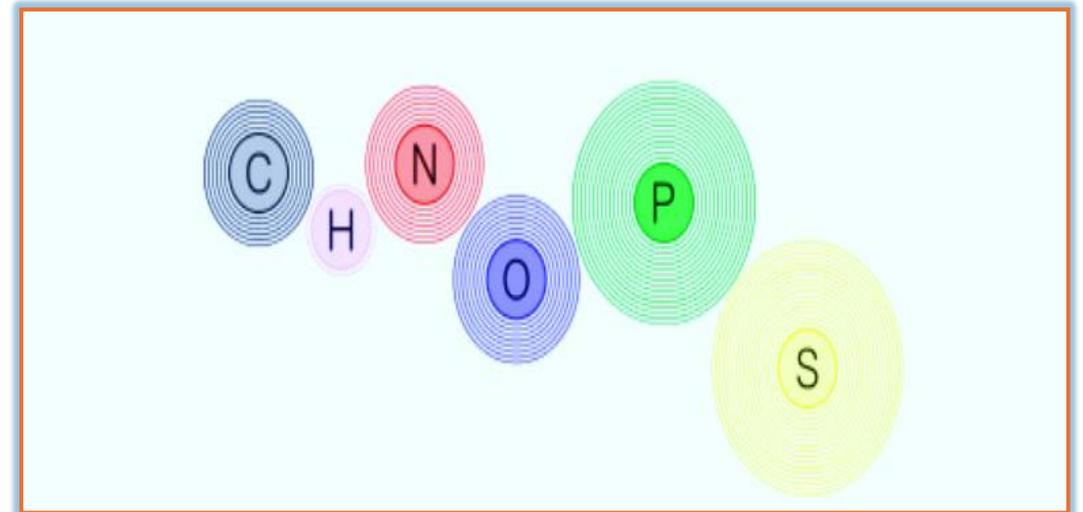
Structures of the Different Macromolecules

➤ Each macromolecule (polymer) composed of different monomers:

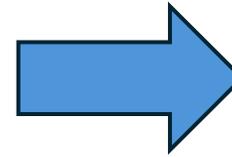
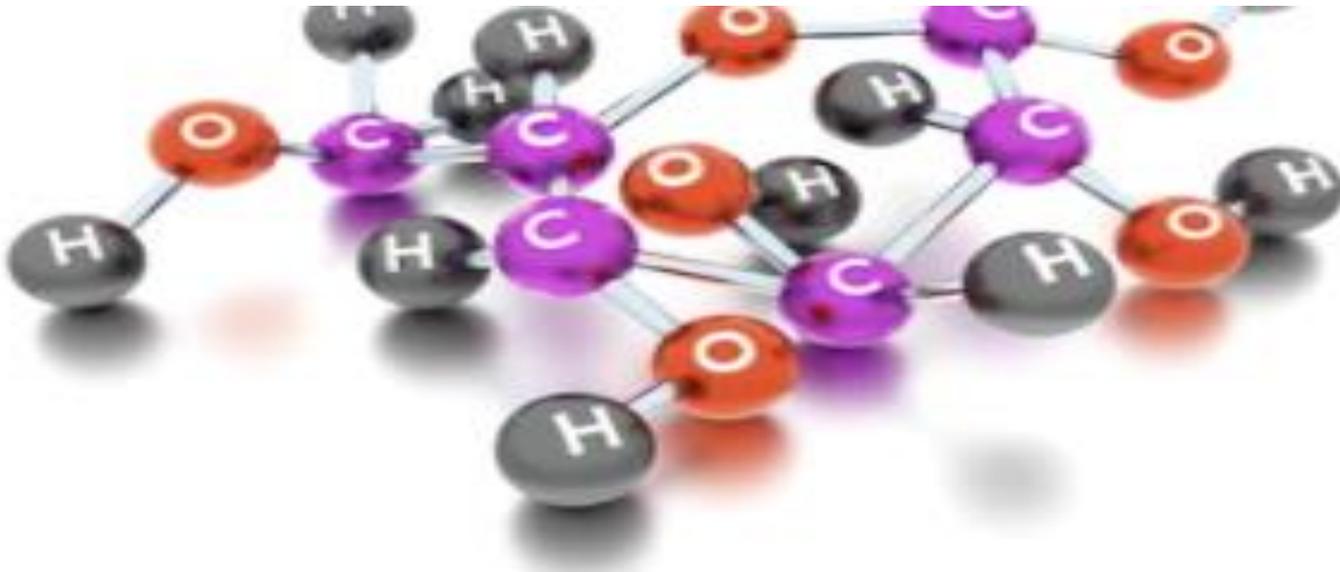


➤ Each monomer composed of different elements:

- **C** stands for the element **Carbon**
- **H** stands for the element **Hydrogen**
- **O** stands for the element **Oxygen**
- **N** stands for the element **Nitrogen**
- **P** stands for the element **Phosphorus**



I. Carbohydrate



Carbohydrates

Lipids

Proteins

Nucleic Acids

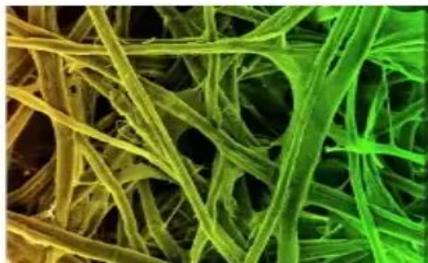
Carbohydrates

- Carbohydrates are **the most abundant organic molecules in nature.**
- They are present in **human, animal** tissue, **plant** and in **microorganisms.** Carbohydrates are also present in tissue fluids, blood, milk, secretion, and excretions of animals.

- **Dietary sources:**

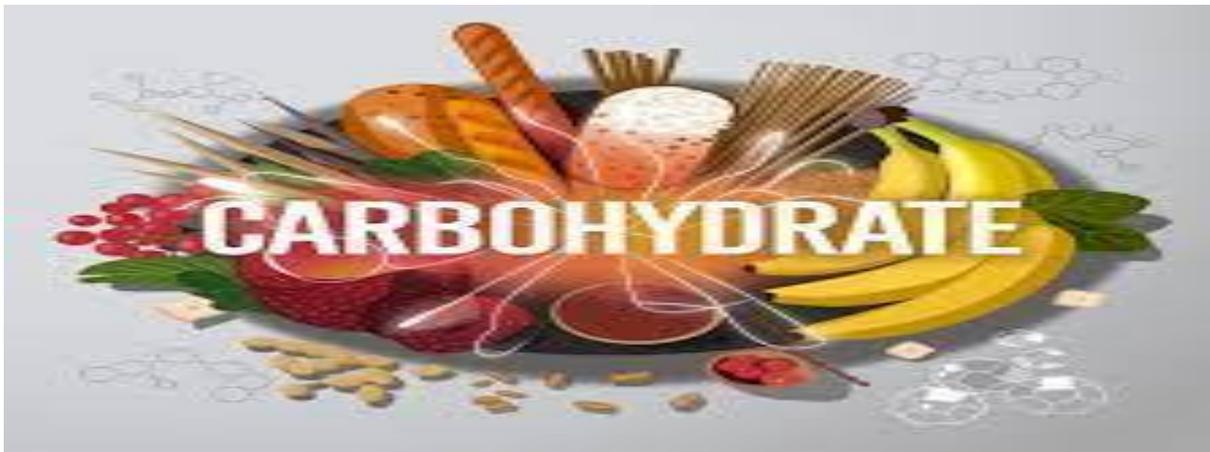
- Grains, Pastas, Fruits, Vegetables, Sugar, Honey, Potatoes

- Cellulose



Carbohydrates

- The word **carbohydrate** may be broken down to carbon and hydrate, and this is due to the fact that most carbohydrates follow the formula $C_n(H_2O)_n$.
- Another term for carbohydrate is **saccharide**.



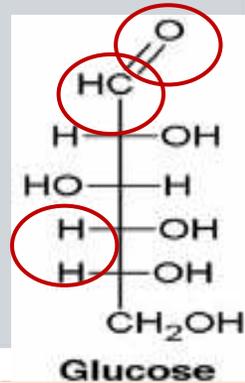
Carbohydrates

Guide questions:
1. What elements do you see in the structure/ formula?
2. What do you notice with the chemical formula of glucose?

- Common symbol: $(\text{CH}_2\text{O})_n$
- Carbohydrates are Organic compounds characterized by 3 features:

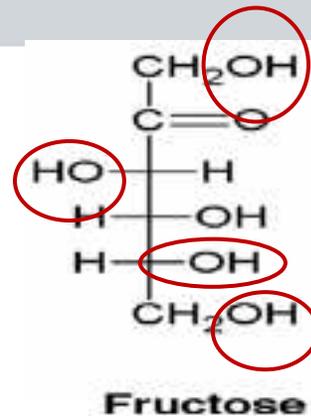
Containing :
(C, H & O).

- Carbon
- Hydrogen,
- Oxygen



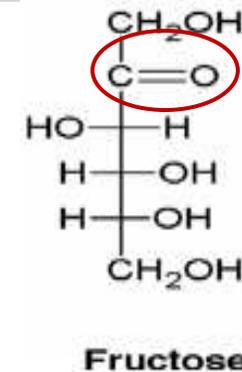
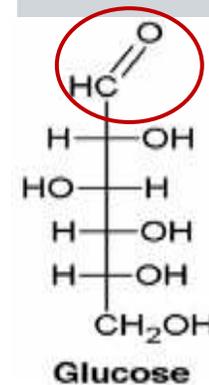
Containing more than one "OH" group

- (Poly-hydroxyl)



Containing free active **carbonyl group**

- Either aldehyde (**HC=O**) or ketone (**C=O**) group



- In glucose, Carbon, Hydrogen and Oxygen makes a molecule of glucose in 1:2:1 ratio.
- Chemical formula: $\text{C}_6\text{H}_{12}\text{O}_6$. or $(\text{CH}_2\text{O})_6$

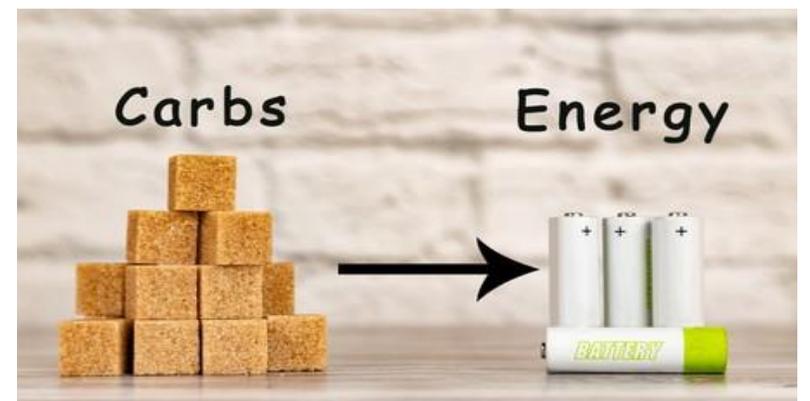
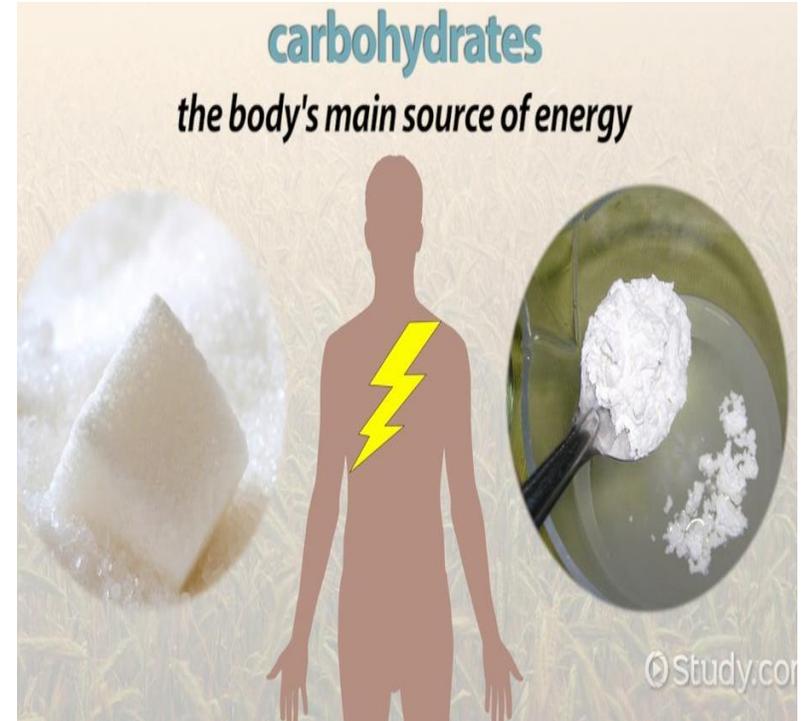
Biological Functions of CHO:

1. CHO is the **primary source for production of energy** for tissues e.g. brain, muscles and erythrocytes.

❑ **Simple CHO:** Provides fast acting energy

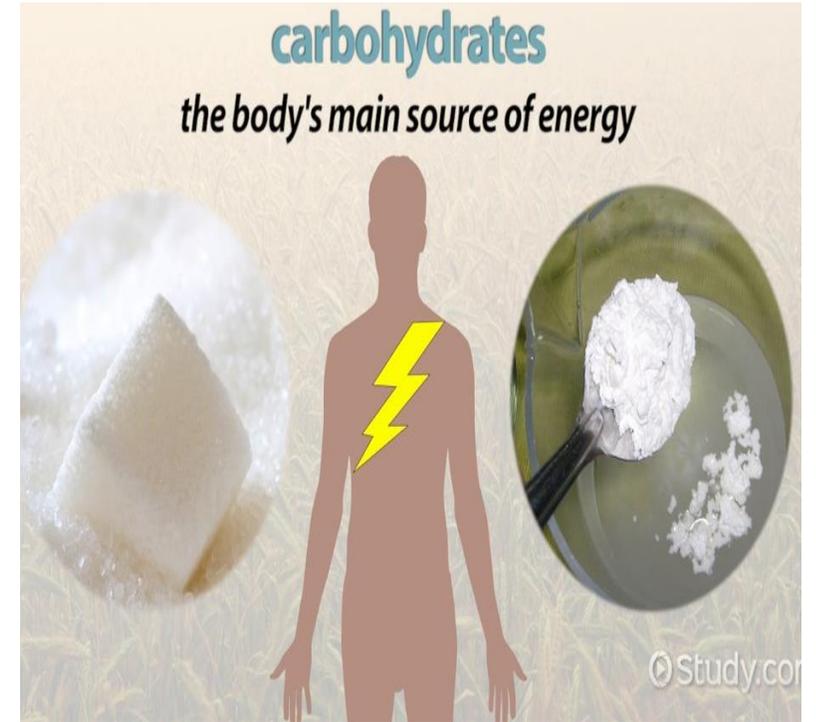
❑ **Complex CHO:** Provides long-lasting energy

2. Excess CHO taken into the body is **converted to glycogen** that is **stored in liver & muscle** (Storage energy to meet immediate demand).



Other functions of CHO:

- ❑ **Sparing the use of proteins for energy**
- ❑ **Flavor and Sweeteners**
- ❑ **Dietary fiber**, which is also a form of carbohydrate, is **essential for elimination of waste materials from the body.**
- ❑ **Structural components** (cell membrane “as glycoproteins & glycolipids” & cell wall in plants, exoskeleton in insects etc)



Classification of Carbohydrates

THEY ARE CLASSIFIED ACCORDING TO THE NUMBER OF **SUGAR UNITS** INTO:

1) Simple carbohydrates

2) Complex carbohydrate

Monosaccharides

Disaccharides

Oligosaccharides

Polysaccharides

1 sugar unit

2 sugar unit

3-10 sugar units

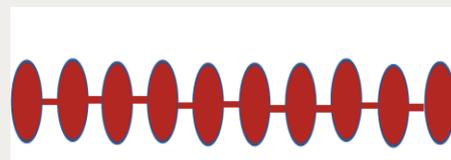
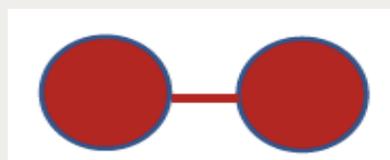
> 10 sugar units

Glucose, fructose,
galactose

Maltose,
sucrose, lactose

Raffinose, sesamose

Starch, glycogen,
fibers



A. Definition of monosaccharides

They are the simplest sugar :

1. Formed of **one sugar unit**
2. **cannot be hydrolyzed** into smaller units

Classification of monosaccharides

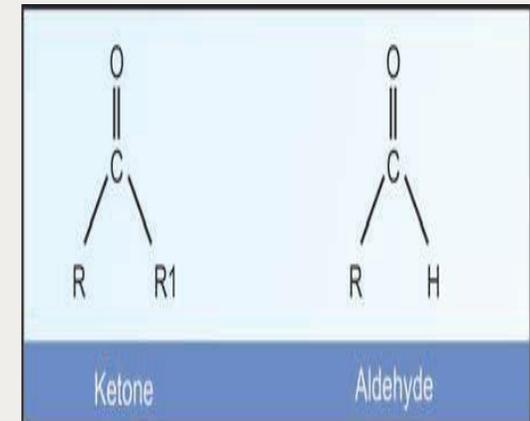
Monosaccharides are further classified according to:

Number of C atom

- **Trioses:** 3 carbon atoms.
- **Tetroses:** 4 carbon atoms.
- **Pentoses:** 5 carbon atoms.
- **Hexoses:** 6 carbon atoms

Active sugar gp

- **Aldehyde:** (aldoses)
(H-C=O)
- **Ketone:** (Ketoses).
(C=O)

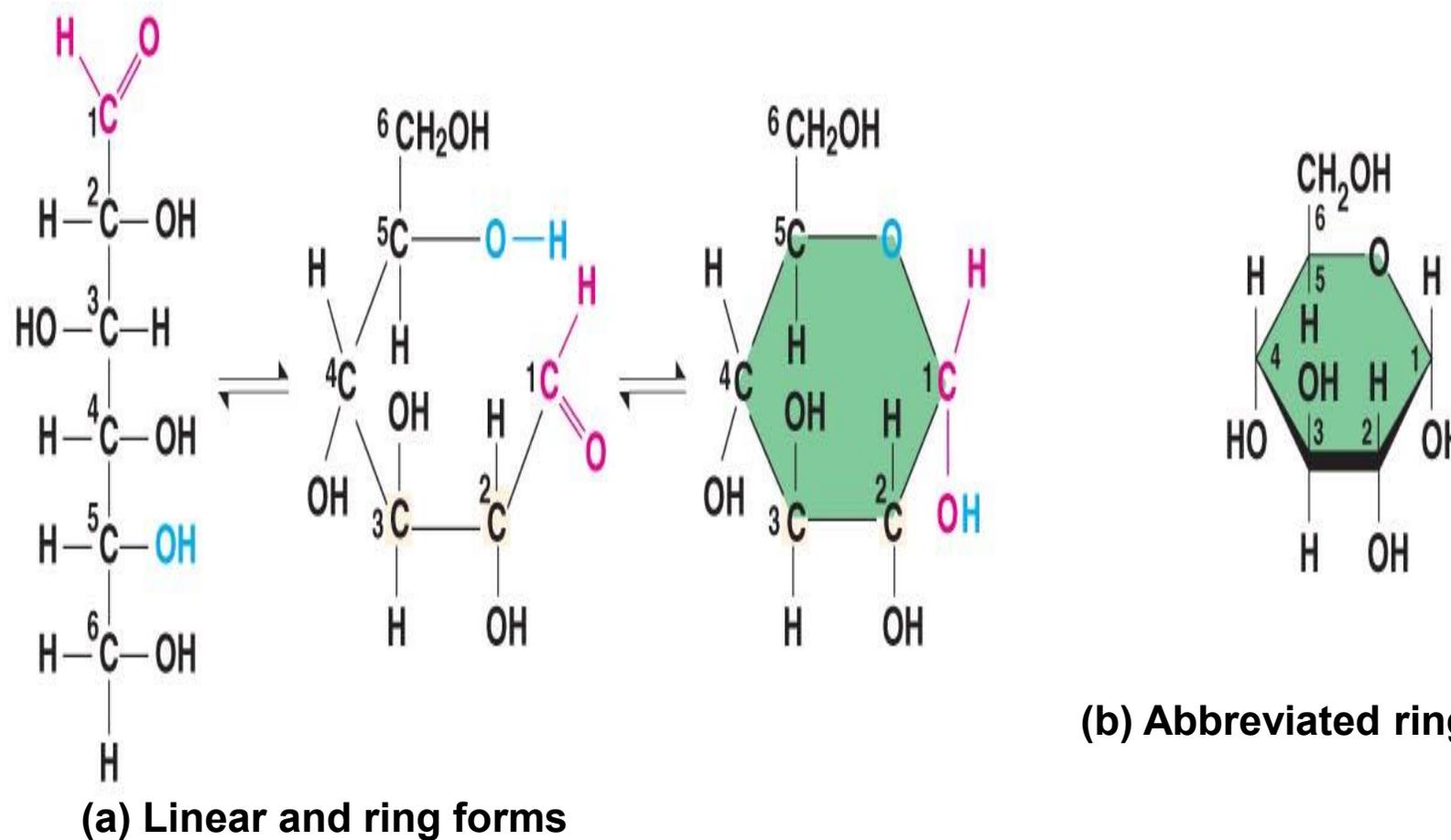


Structure and classification of some monosaccharides

	Trioses (C ₃ H ₆ O ₃)	Pentoses (C ₅ H ₁₀ O ₅)	Hexoses (C ₆ H ₁₂ O ₆)	
Aldoses	$ \begin{array}{c} \text{H} \\ \diagdown \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $ <p>Glyceraldehyde</p>	$ \begin{array}{c} \text{H} \\ \diagdown \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $ <p>Ribose</p>	$ \begin{array}{c} \text{H} \\ \diagdown \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{HO}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $ <p>Glucose</p>	$ \begin{array}{c} \text{H} \\ \diagdown \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{HO}-\text{C}-\text{H} \\ \\ \text{HO}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $ <p>Galactose</p>
Ketoses	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $ <p>Dihydroxyacetone</p>	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $ <p>Ribulose</p>	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{C}=\text{O} \\ \\ \text{HO}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $ <p>Fructose</p>	

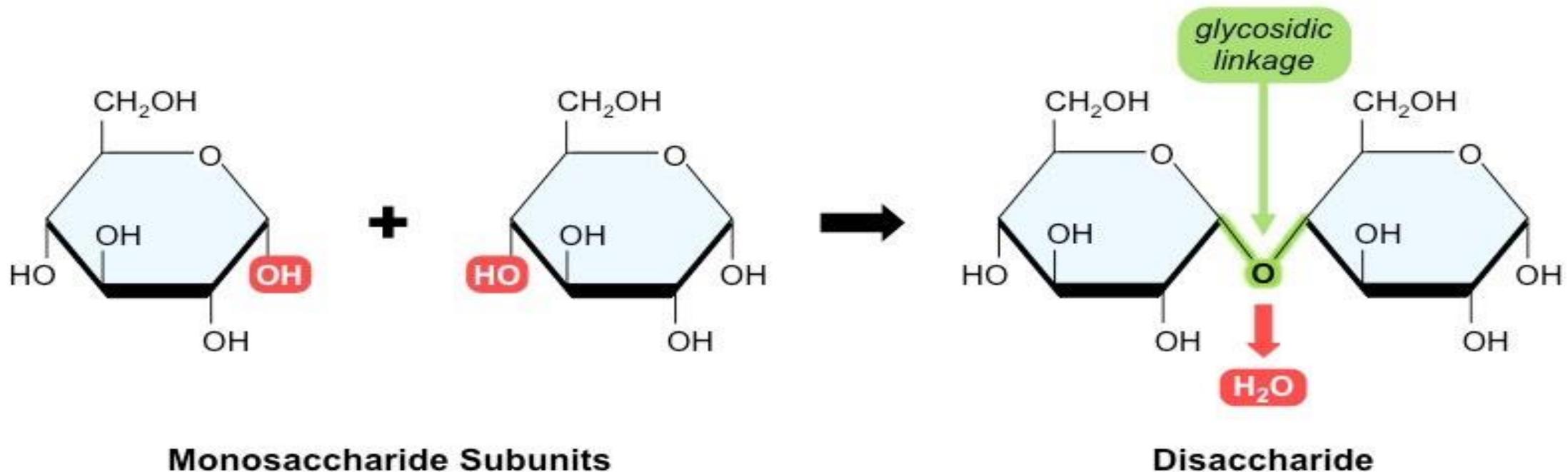


- Though often drawn as linear skeletons, in aqueous solutions many sugars form rings



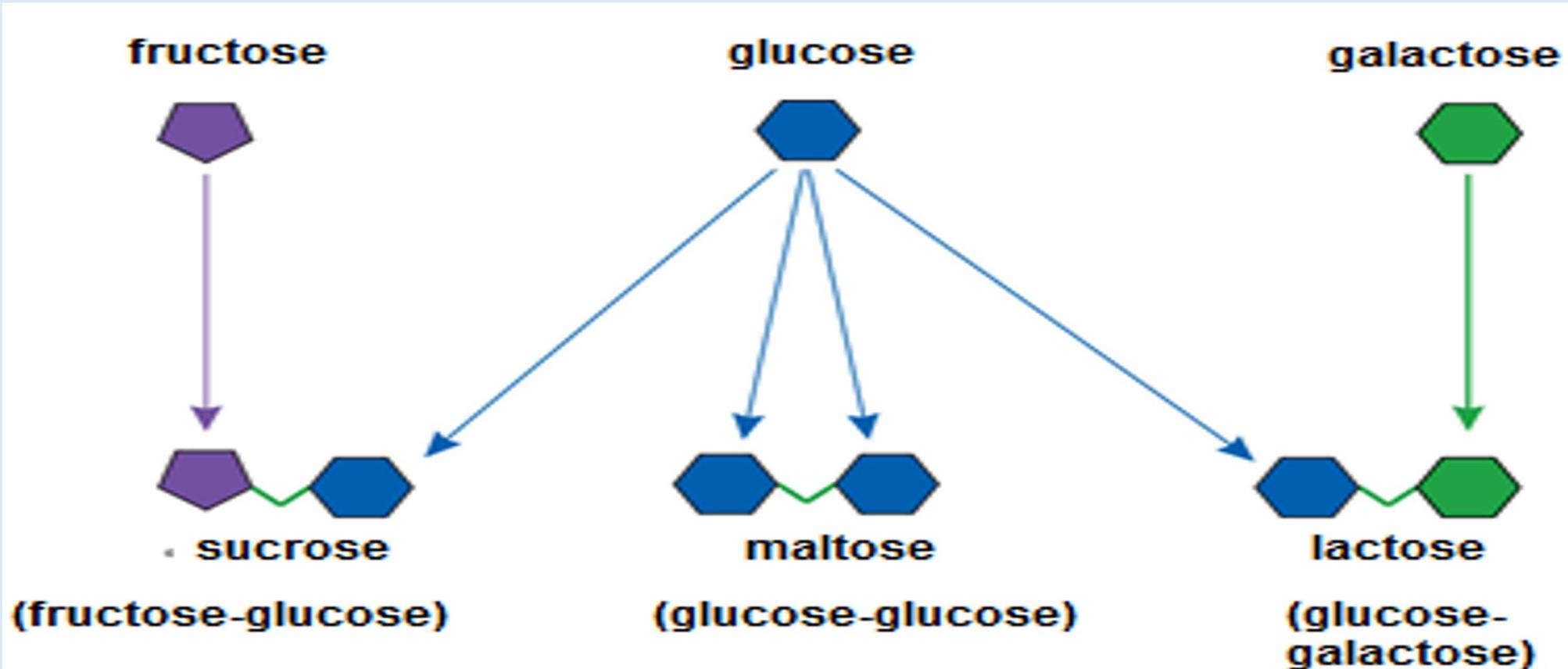
B. Definition of Disaccharides

- **Disaccharides consist of 2 monosaccharide units** formed when a dehydration reaction joins two monosaccharides
- **joined by** covalent bond called an **O-glycosidic bond**.



Classification of Disaccharides

The most abundant disaccharides are sucrose, maltose, and lactose

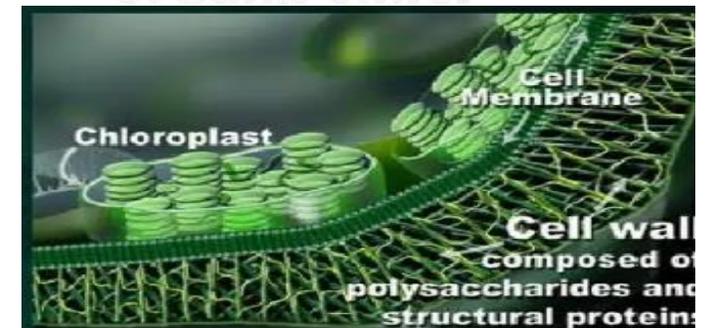
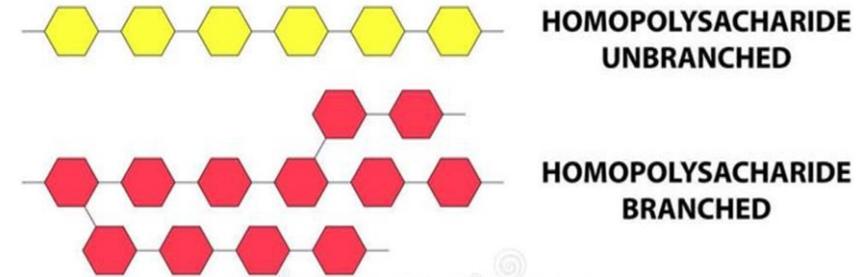


C. Definition of polysaccharides

Polysaccharides, also called **glycans**, consist of **more than 10** monosaccharide units joined together by **glycosidic linkage**.

Examples of polysaccharide

- **Starch**: Used for energy storage in plants (Potatoes, pasta and rice are starch)
- **Glycogen**: Used for energy storage in animals (Liver and muscle).
- **Cellulose**: Provides structural support in plants (found in the cell wall)
- **Chitin**: Found in exoskeletons of arthropods (insects, spiders) and in cell wall of some fungi



Activity : Bio Word Hunting



To explore the lesson more, the students are task to answer the activity called “

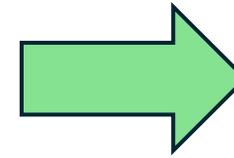
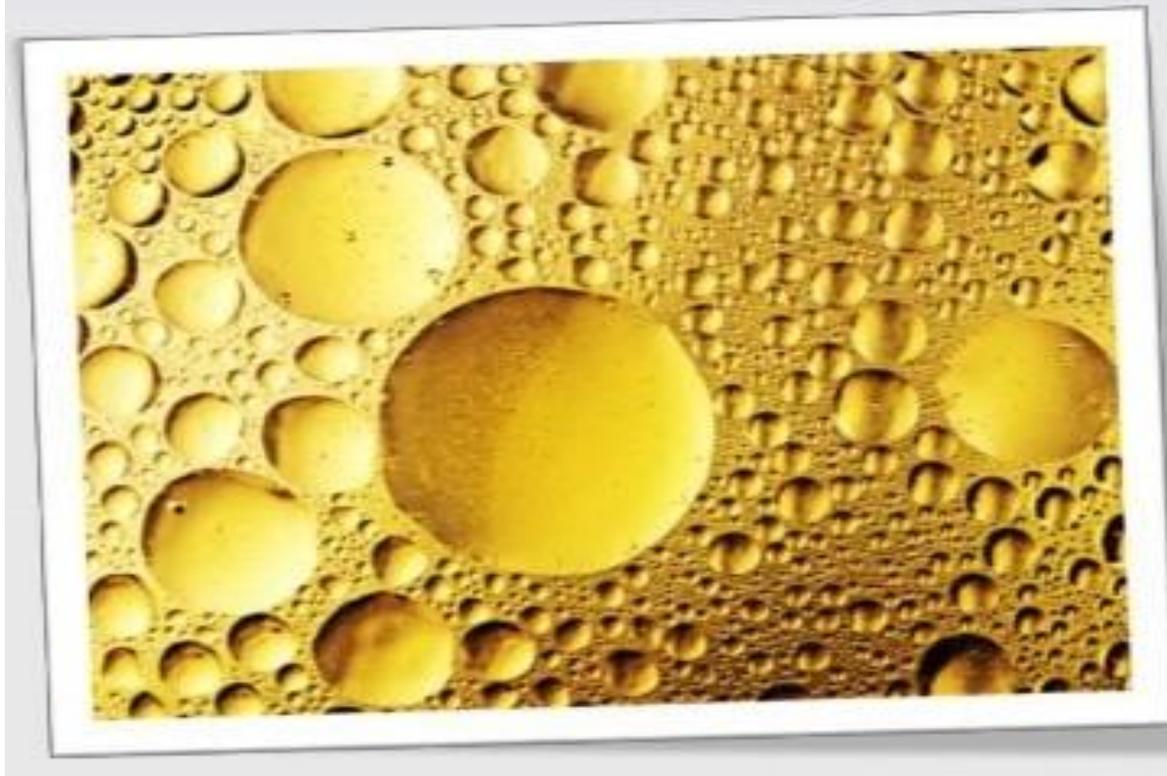
Bio Word Hunting

- Food is a source of molecules that are needed for life. These are biological molecules. What you eat belongs to biomolecules. There are four biological molecules that make up all of life.

F	A	T	S	H	Y	L	I	P	I	D	P
U	P	I	A	T	E	P	R	O	T	E	R
N	U	C	L	E	I	C	A	C	I	D	O
Y	Y	K	T	L	P	D	G	O	G	O	T
C	A	R	B	O	H	Y	D	R	A	T	E
A	R	O	A	A	H	L	E	W	W	W	I
B	I	O	M	O	L	E	C	U	L	E	N



II. Lipids



Carbohydrates

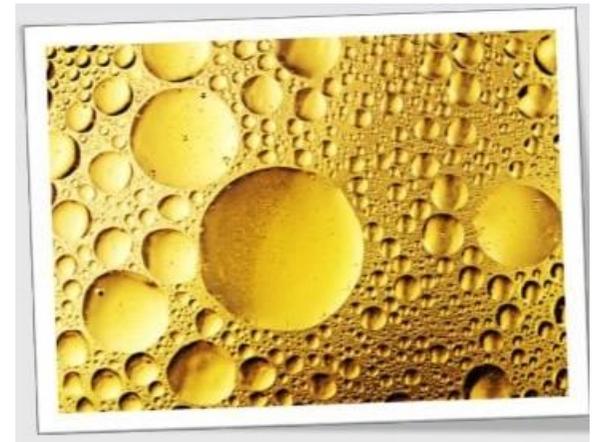
Lipids

Proteins

Nucleic Acids

Definition of lipid

- ❑ Lipids are biological compounds consisting of **carbon, hydrogen** and **oxygen**.
- ❑ Lipids are the one class of large biological molecules that **do not form polymers**.
- ❑ The unifying feature of lipids is having little or no affinity for water (relatively insoluble in water) (**hydrophobic**).
- ❑ Lipids are hydrophobic because water molecules form hydrogen bonds with each other and exclude the fats.
- ❑ The most biologically important lipids are **fats & oils** , **phospholipids**, and **steroids**.

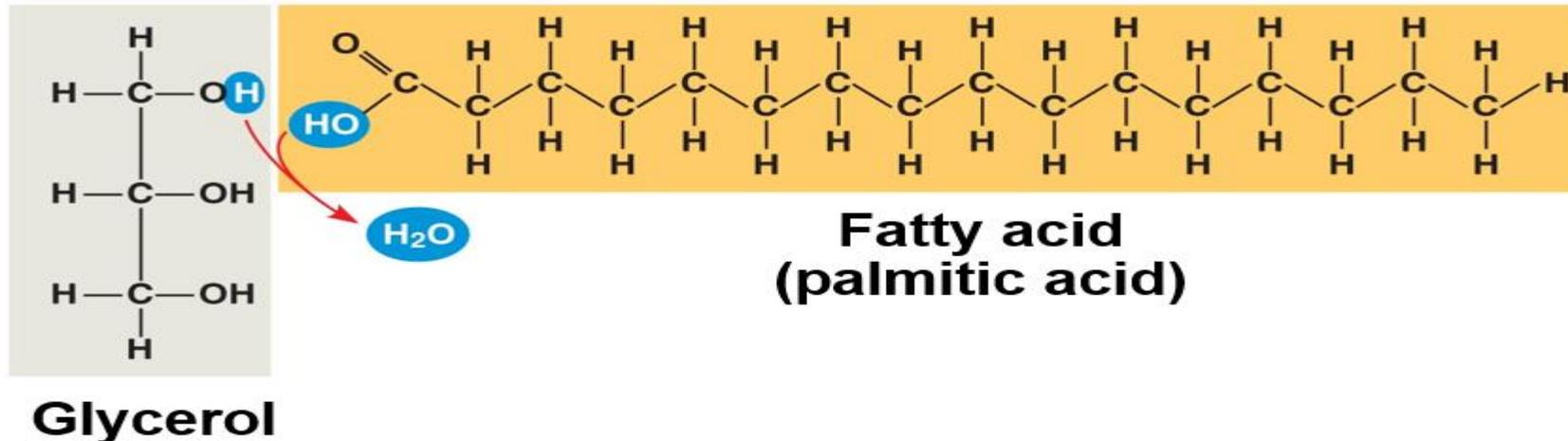


Biological Functions of Lipids:

- 1- Source of energy:** they yield twice the energy produced by the same weight of carbohydrates or protein
- 2- Serve as **Energy store** in adipose tissue.
- 3- They are the natural **solvent for fat-soluble vitamins.**
- 4- Lipids have a role in **protection and fixation of internal organs** as kidneys.
- 5- Lipids in myelin sheath of nerve fibers serve as **electrical insulator.**
- 6- Lipids under the skin serve as **thermal insulator.**
- 7- **Lipoproteins:** important for **lipid transport** in the blood.

Fats and oils

- **Fats** are constructed from two types of smaller molecules: **glycerol and fatty acids**
- **Glycerol** is a three-carbon alcohol with a hydroxyl group attached to each carbon
- A **fatty acid** consists of a carboxyl group attached to a long carbon skeleton

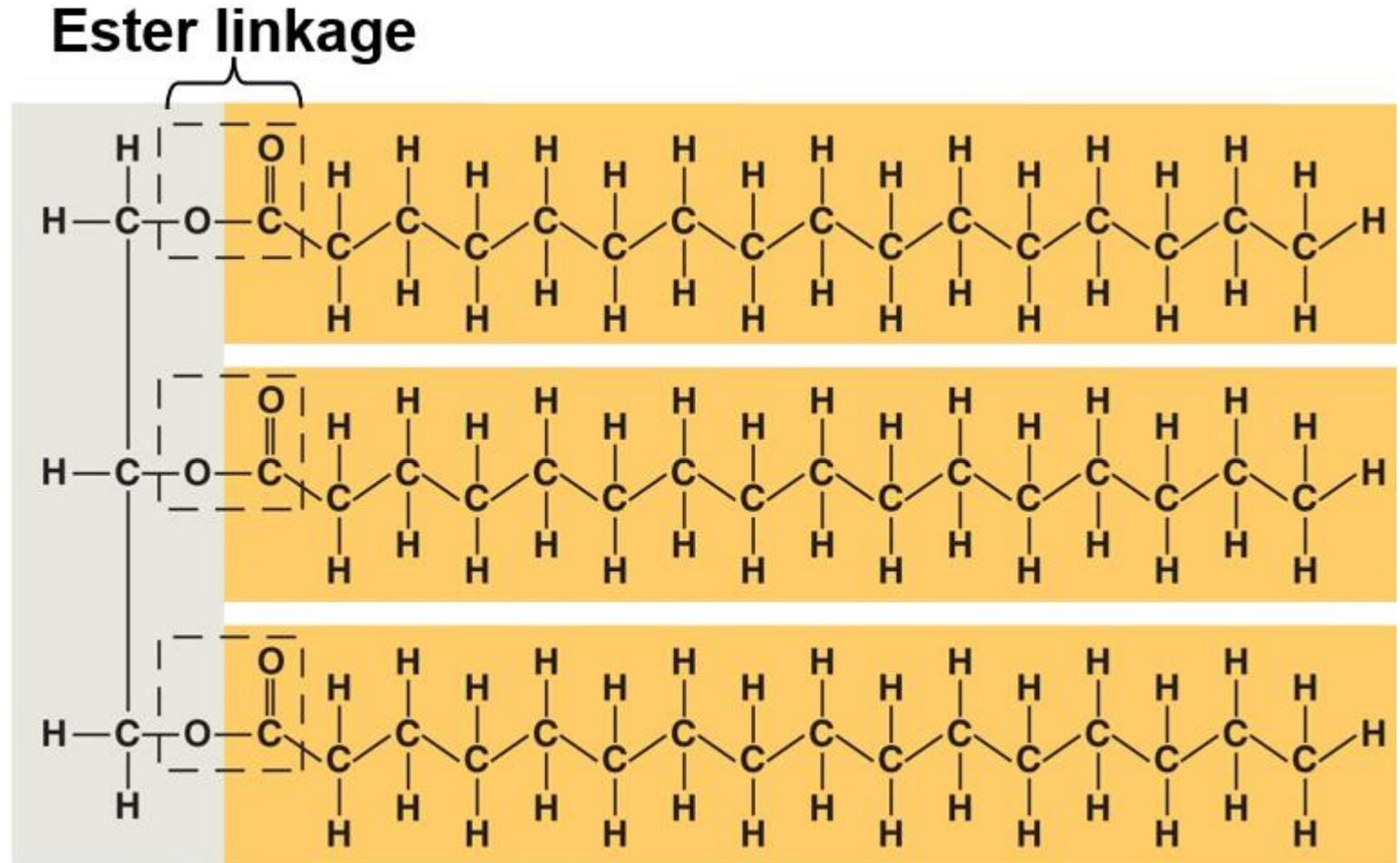


(a) Dehydration reaction in the synthesis of a fat

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Fats and oils

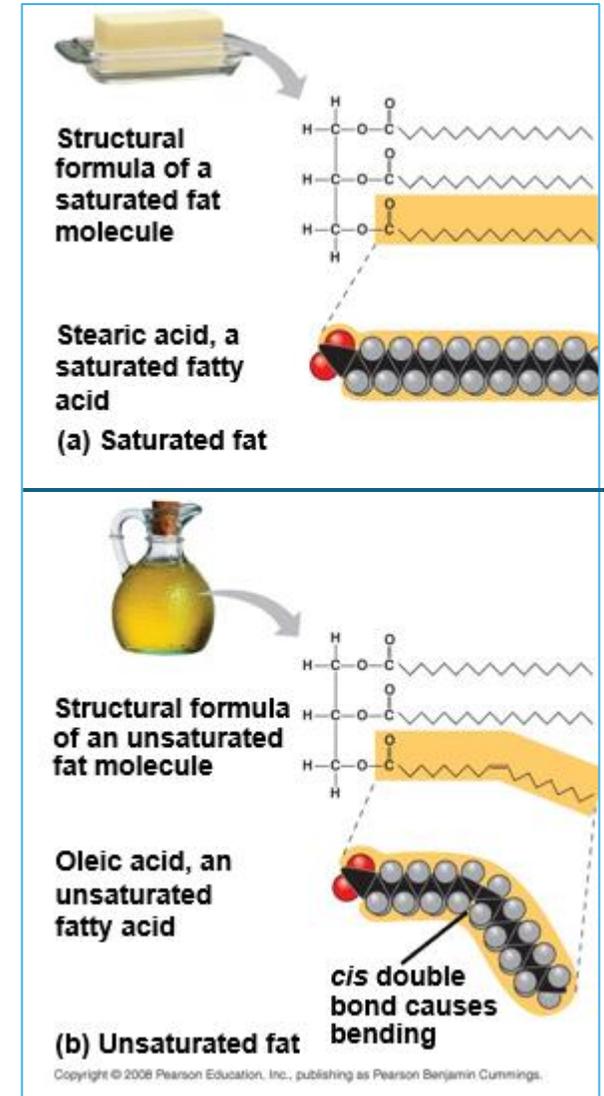
- In a fat, **three fatty acids** are joined to glycerol by an **ester linkage**, creating a **triacylglycerol**, or triglyceride



(b) Fat molecule (triacylglycerol)

Fats and oils

- Fatty acids vary in length (number of carbons) and in the number and locations of double bonds
- According to absence or presence of double bonds fatty acids are classified into:
 - ❑ **Saturated fatty acids:** have no double bonds, eg: Stearic acid.
 - ❑ **Unsaturated fatty acids:** have one or more double bonds, eg: oleic acid.



Fats and oils

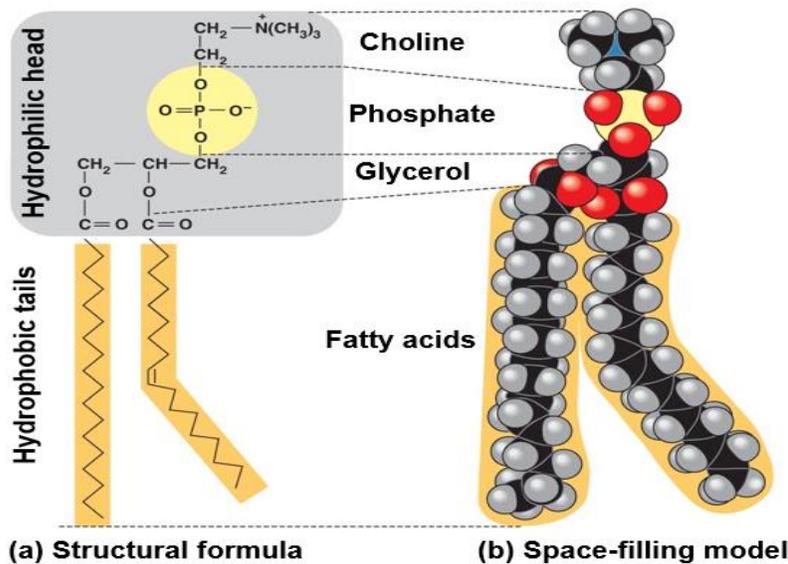
- Fats made from saturated fatty acids are called **saturated fats**, (**Most animal fats**) and are solid at room temperature
- Fats made from unsaturated fatty acids are called **unsaturated fats or oils**, and are liquid at room temperature (**Most of Plant fats and fish fats**)
- A diet rich in **saturated fats** may contribute to **cardiovascular disease** through plaque deposits

Fats and oils

- **Hydrogenation** is the process of converting unsaturated fats to saturated fats by adding hydrogen
- Hydrogenating vegetable oils also creates unsaturated fats (*trans fats*).
- These *trans* fats may contribute more than saturated fats to **cardiovascular disease**

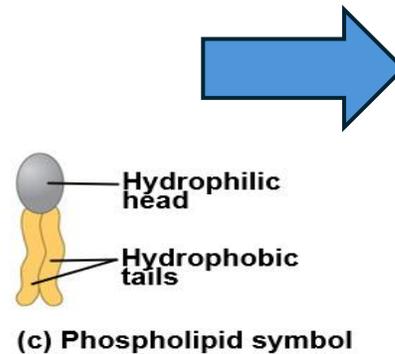
Phospholipids

- In a **phospholipid**, two fatty acids and a phosphate group are attached to glycerol
- The two fatty acid tails are hydrophobic, but the phosphate group and its attachments form a hydrophilic head
- Phospholipids are the major component of all cell membranes

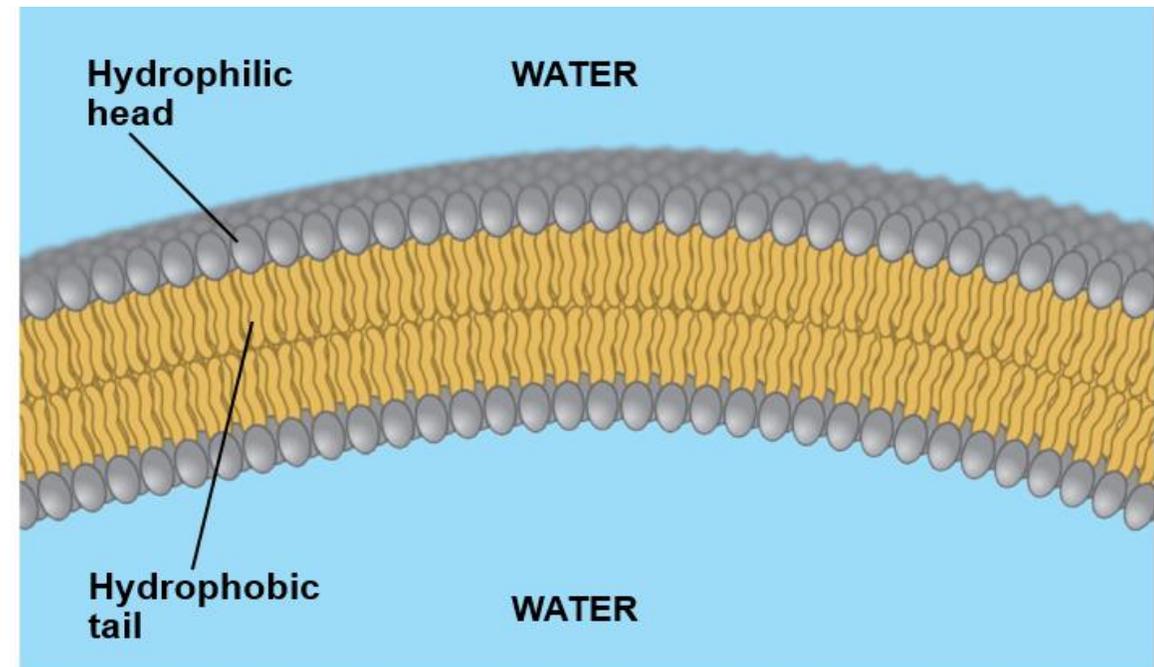


(a) Structural formula

(b) Space-filling model

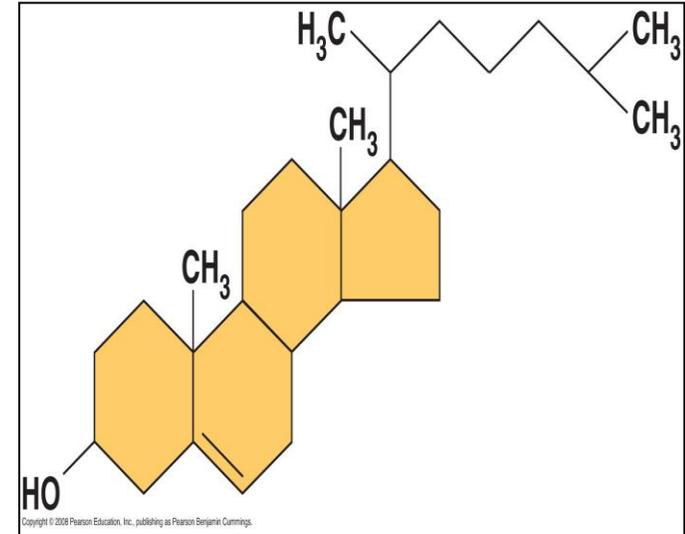


(c) Phospholipid symbol



Steroids

- **Steroids** are lipids characterized by a carbon skeleton consisting of **four fused rings**
- **Cholesterol**, an important steroid, is a component in animal cell membranes
- Although cholesterol is essential in animals, high levels in the blood may contribute to **cardiovascular disease**



Activity

- **Direction:** On a clean sheet of paper, answer the following questions.

Carbohydrates

What elements are they composed of?

What is the monomer?

What is its function for the body?

Write two examples:

Lipids

What elements are they composed of?

What is the monomer?

What is its function for the body?

Write two examples:

BELIEVE IN
YOURSELF

