Carbohydrates

Tishk International University,

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Biochemistry, 1st Semester

Carbohydrates

- Carbohydrates are the main source of energy for the living cells.
- Glucose is the central molecule in carbohydrate metabolism, actively participating in a number of metabolic pathway.
- The word ‘carbohydrate’ is derived from the Greek word ‘**sakcharon**’ meaning ‘**sugar**’.
- Their general formula is $(C.H_2O)_n$

Biological Significance/functions of carbohydrates

1) **source of energy;** carbohydrates are the primary source of energy. They are the food reserve (energy store molecules) in microbes, animals and plants.

2) Structural framework of genetic material: The sugars **ribose and deoxyribose** are a part of the structural framework of genetic material **RNA and DNA.**

3) Structural element of cell wall: Polysaccharides are the structural elements of the cell wall of bacteria and plants.

- **Cellulose**, a polysaccharide and a principal component of the cell wall of pants, is one of the most abundant organic compounds in the biosphere.

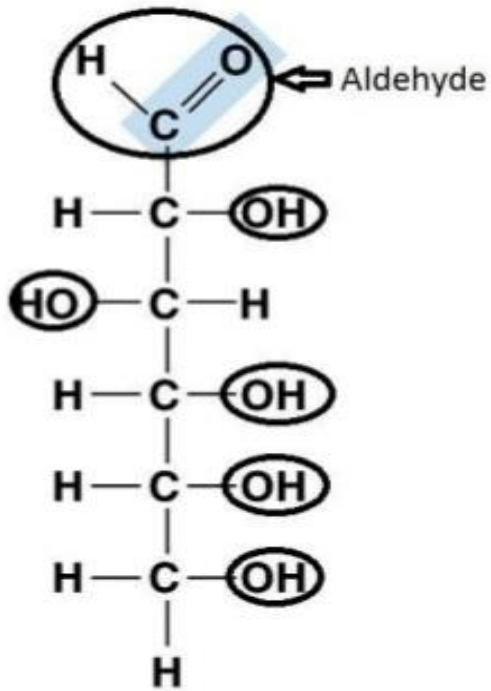
4) Conjugate with lipids and proteins: Carbohydrates are extensively linked protein and lipid molecules. These glycoprotein and glycolipids are critical in choreographing interactions between cells and other biological elements.

- For carbohydrates, the functional group is the carbonyl group which may be either

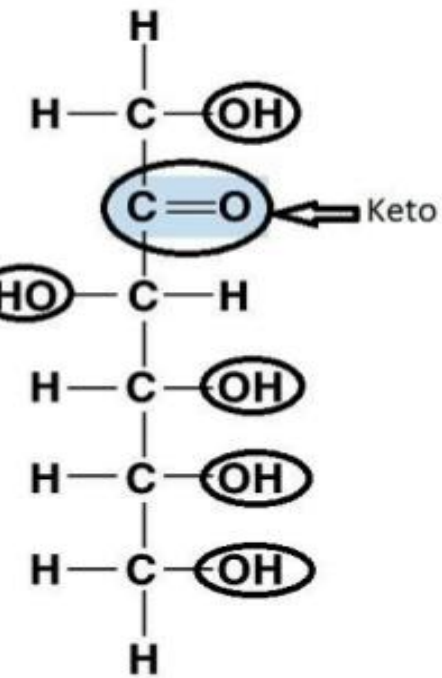
Aldehyde Group (H-C=O)

Or

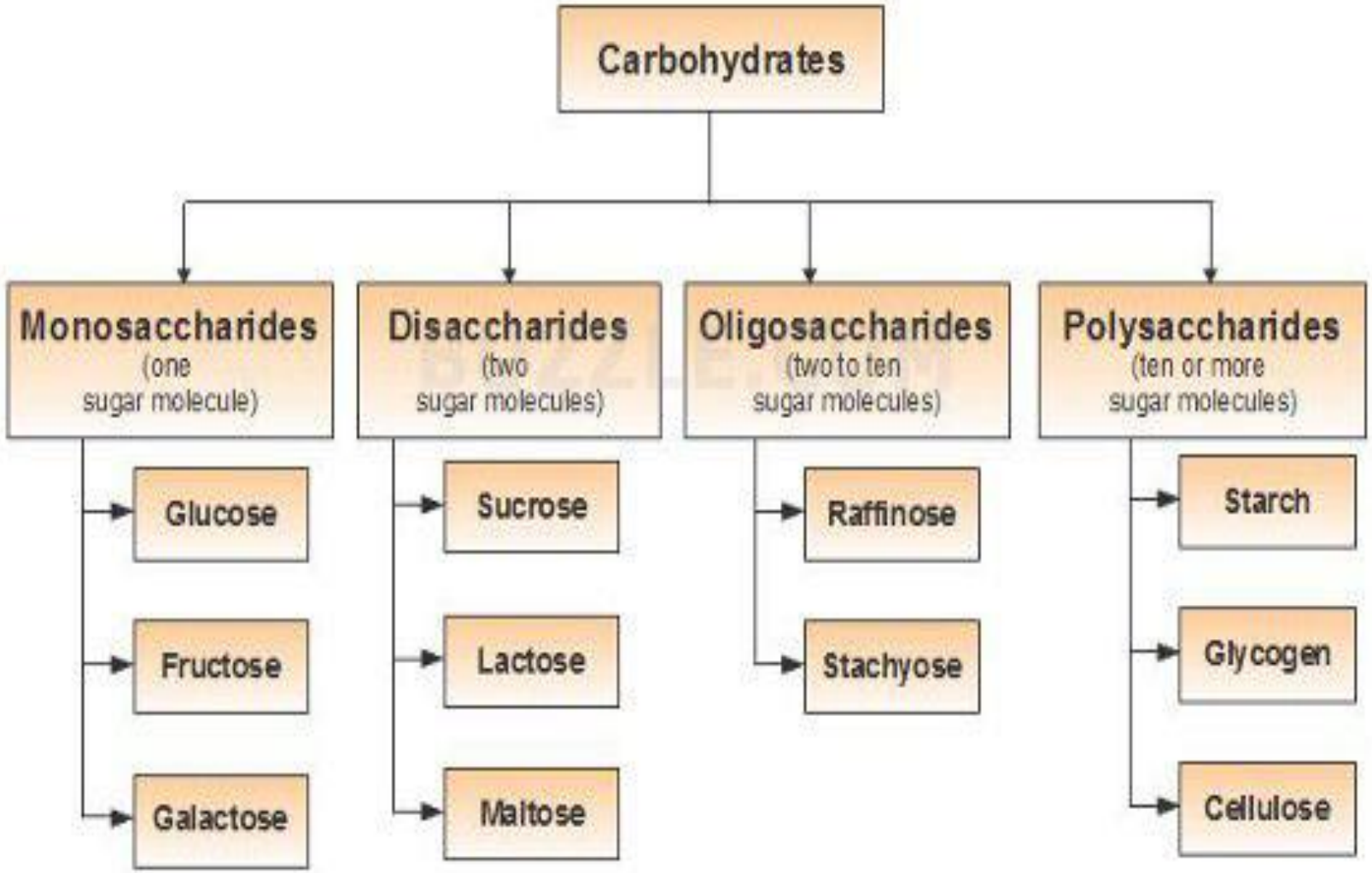
Keto Group (C=O)



Glucose



Fructose


Carbohydrates
Monosaccharides
(one
sugar molecule)
Disaccharides
(two
sugar molecules)
Oligosaccharides
(two to ten
sugar molecules)
Polysaccharides
(ten or more
sugar molecules)
Glucose
Fructose
Galactose
Sucrose
Lactose
Maltose
Raffinose
Stachyose
Starch
Glycogen
Cellulose

Monosaccharides

- (*mono*– = “one”; *sacchar*– = “sweet”) are simple sugars, the most common of which is glucose.

- In monosaccharides, the number of carbons usually ranges from three to seven.

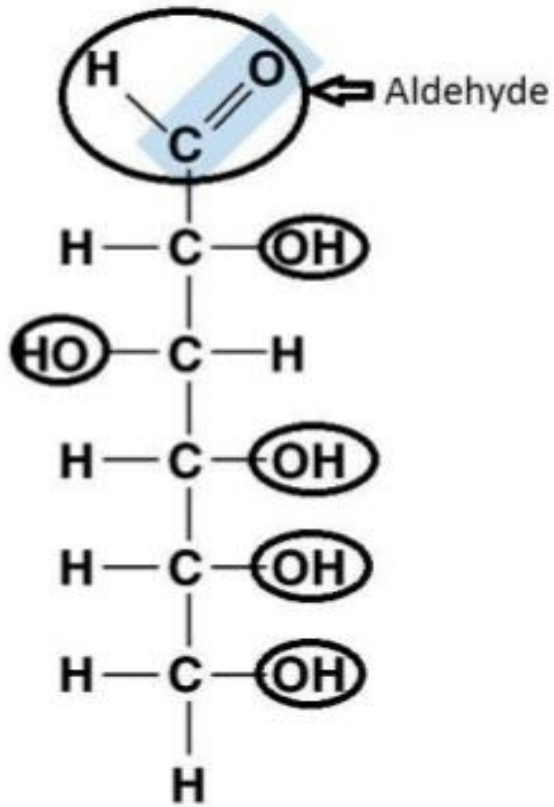
- Monosaccharides are further classified into two subgroups depending upon the;
  1) **Number of carbon atoms present**
  2) **Chemical nature of their carbonyl group or presence of aldehyde or ketone unit**

1) Number of carbon atoms present*:*

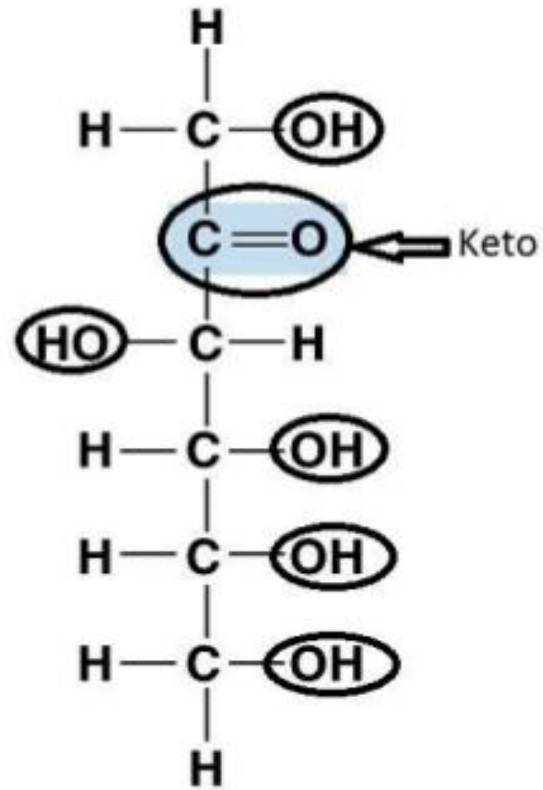
- the smallest monosaccharide is the one with three carbon atoms, known as **trioses**.
- Therefore, the monosaccharide with four, five, six or seven carbon atoms are called **tetroses, pentoses, hexoses and heptoses.**

2) Chemical nature of their carbonyl group or presence of aldehyde or ketone unit:

- if the carbonyl group is **aldehyde** in nature, the monosaccharide is called **aldose**.
- If the carbonyl group is **ketone**, then the monosaccharide is called **ketose**.



Glucose



Fructose

Monosaccharide

Cannot further Hydrolyzed

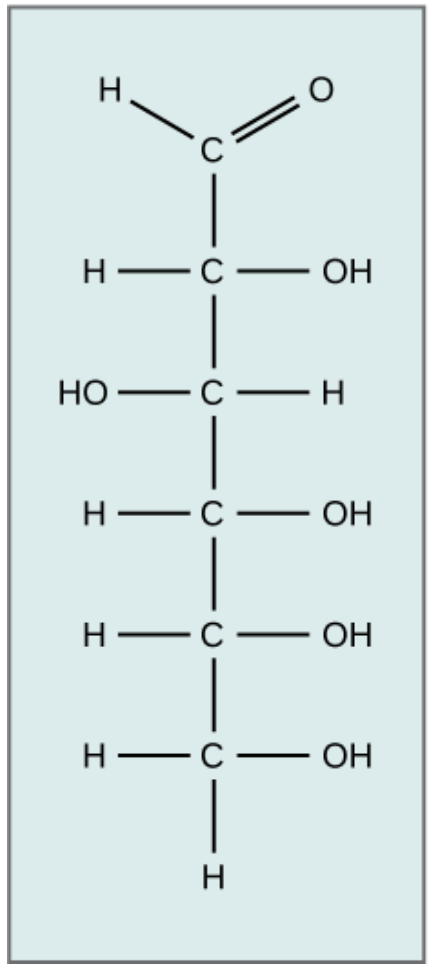
No. of Carbon	Type of sugar	Aldoses	Ketoses
3	TRIOSES	Glyceraldehydes	Dihydroxyacetone
4	TETROSES	Erythrose	Erythrulose
5	PENTOSES	Ribose, Xylose	Ribulose, xylulose
6	HEXOSES	Glucose, Galactose	Fructose
7	HEPTOSES	Glucoheptose	Sedoheptulose

TYPES	EXAMPLE	IMPORTANCE
Trioses	Glyceraldehyde, Dihydroxyacetone	✔ Intermediates of glycolysis, ✔ Precursor of glycerol (for lipid synth)
Tetroses	D-Erythrose	✔ Intermediates of carbohydrate metabolism
Pentoses	D-Ribose	✔ Structural element of nucleic acid, RNA, co-enzymes.
Hexoses	D-Glucose	✔ Main sugar of the body.
	D-Fructose	✔ Converted to glucose & utilized by the body.
	D-Galactose	✔ Synthesized in mammary gland to make the lactose of milk.
	D-Mannose	✔ Constituent of glycoprotein, glycolipids

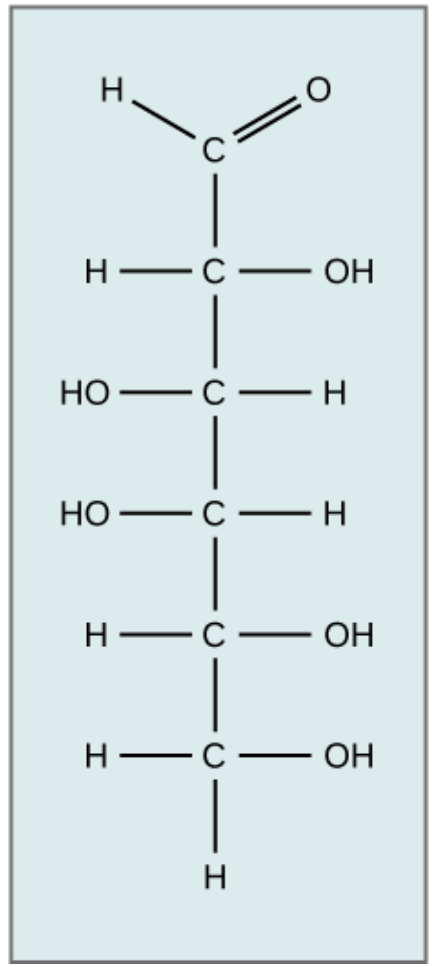
- The chemical formula for glucose is $C_6H_{12}O_6$.
- In humans, glucose is an important source of energy.
- During cellular respiration, energy is released from glucose, and that energy is used to help make adenosine triphosphate (ATP).
- Plants synthesize glucose using carbon dioxide and water, and glucose in turn is used for energy requirements for the plant.

- Galactose and fructose are other common monosaccharides — galactose is found in milk sugars
- fructose is found in fruit sugars.
- Although **glucose, galactose, and fructose** all have the same chemical formula ($C_6H_{12}O_6$),
- they differ structurally and chemically (and are known as isomers) because of the different arrangement of functional groups around the asymmetric carbon.

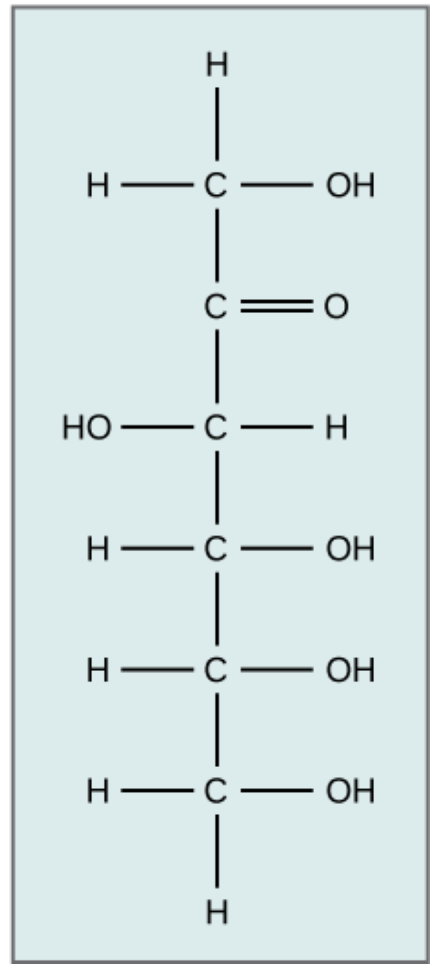
Glucose



Galactose



Fructose



Disaccharides

- **Disaccharides** (*di*– = “two”) form when two monosaccharides undergo a dehydration reaction (also known as a condensation reaction or dehydration synthesis).

- During this process, the hydroxyl group of one monosaccharide combines with the hydrogen of another monosaccharide, releasing a molecule of water and forming a covalent bond.

- A covalent bond formed between a carbohydrate molecule and another molecule (in this case, between two monosaccharides) is known as a **glycosidic bond.**

Disaccharides

- Three common disaccharides:
- **sucrose** — common table sugar = glucose + fructose
- **lactose** — major sugar in milk = glucose + galactose
- **maltose** — product of starch digestion = glucose + glucose

Oligosaccharides

- An **oligosaccharide** is a saccharide polymer containing a small number (typically three to ten) of monosaccharides (simple sugars).
- Oligosaccharides can have many functions including cell recognition and cell binding. For example, glycolipids have an important role in the immune response.
- Not all natural oligosaccharides occur as components of glycoproteins or glycolipids.
- Some, such as the raffinose series, occur as storage or transport carbohydrates in plants.

Polysaccharides

- A long chain of monosaccharides linked by glycosidic bonds is known as a **polysaccharide**

(*poly*– = “many”).

- The chain may be branched or unbranched, and it may contain different types of monosaccharides.
- Starch, glycogen, cellulose, and chitin are primary examples of polysaccharides.
- Starch is the stored form of sugars in plants and is made up of a mixture of amylose and amylopectin (both polymers of glucose).
- Plants are able to synthesize glucose, and the excess glucose, beyond the plant’s immediate energy needs, is stored as starch in different plant parts, including roots and seeds.

- **Glycogen** is the storage form of glucose in humans and other vertebrates and is made up of monomers of glucose.

- Glycogen is the animal equivalent of starch and is a highly branched molecule usually stored in liver and muscle cells.

- **Cellulose** is the most abundant natural biopolymer. Cellulose is the main substance found in **plant cell** walls and helps the plant to remain **stiff and strong**.
- Humans **cannot** digest cellulose, but it is used to make clothes and paper.
- Chitin is also a major component of fungal cell walls; fungi are neither animals nor plants and form a kingdom of their own in the domain Eukarya.