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Biochemistry

Carbohydrates 1

❖ Carbohydrates

- Carbohydrates consists of 1 or more sugars and their name ends by -ose
  - ➢ Sugars are polyhydroxy (2 or more OH) aldehydes or ketones (carbonyl group C=O)
  - ➢ The chemical formula of a sugar is **$(CH_2O)_n$**
- They can function as a source of energy, structural support and cells interactions and recognition
- Carbohydrates can be classified according to:

♦ The number of sugars that constitute the molecule

1) Monosaccharides

- They consist of 1 sugar (single saccharide), such as:
  - ➢ Glucose: It is the **essential energy source**, mild sweet flavor and it is known as **blood sugar**
  - ➢ Galactose: Hardly tastes sweet
  - ➢ Fructose: It is the **sweetest** sugar (found in fruits, honey, soft drinks, cereals, desserts)
- Mostly monosaccharides are not found free naturally, instead they are bound to other sugars or macromolecules forming polysaccharides, Glycoproteins (hormones), proteoglycans, Glycolipids (cerebrosides, gangliosides), glycosides, Mucopolysaccharides (hyaluronic acid) and Nucleic acids

2) Disaccharides

- Consist of 2 sugars

3) Oligosaccharides

- Consist of a short chain of monomers (3-10 sugars)

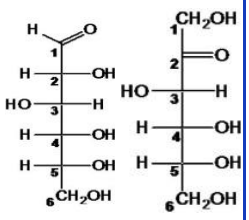
4) Polysaccharides

- Consist of a long chain of monomers (possibly hundreds and thousands) such as starch, cellulose, inulin

♦ The position of the functional group (carbonyl)

1) Aldoses

- The carbonyl group is **peripheral**, such as Ribose, Glucose, Mannose & Galactose



2) Ketoses

- The carbonyl group is **located within** the chain (in the middle), such as Fructose

♦ The number of carbons a sugar contains:

1) Triose (3-Carbons)

- They are the smallest possible sugars such as Dihydroxyacetone (**ketose**), Glyceraldehyde (**aldose**)

2) Tetrose (4-Carbons)

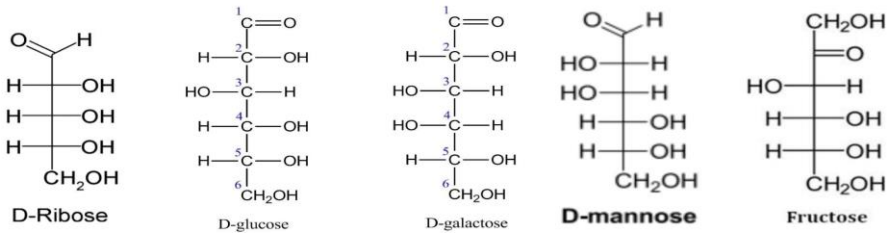
3) Pentose (5-Carbons)

- Such as Ribose

4) Hexose (6- Carbons)

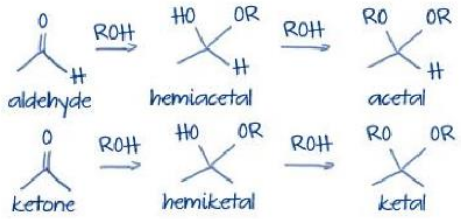
- such as fructose (**ketose**), glucose, galactose and mannose (**aldose**)

5) Heptose (7- Carbons)

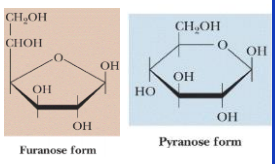


❖ Acetal, Ketal, Hemiacetal, Hemiketal

- Sugars have open and ring structures (mostly in the ring structure)
  - ➢ Rings are formed by the reaction between the functional carbonyl group with a hydroxyl group in the sugar chain
  - ➢ Rings are considered as hemi-acetals or hemi-ketals



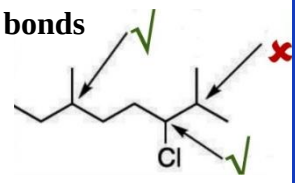
- Aldehyde + Alcohol → form **Ether** group → Hemiacetal
- Ketone + Alcohol → form **Ether** group → Hemiketal
- Acetal & Ketal are molecules having 2 ether (R-O-R) groups on the same carbon



- If the ring is 5 membered (consists of 4 C & 1 O atom) → it is called **Furanose**
- If the ring is 6 membered (consists of 5 C & 1 O atom) → it is called **Pyranose**

❖ Chirality

- Chirality is the ability of a molecule to rotate clockwise or counterclockwise producing different forms of the molecule (isomers)
  - ➢ **Chiral center:** It is a carbon bound to **4 different** groups and forms **only single bonds**
  - ➢ In sugars the first & last carbons are Achiral (not chiral)
  - ➢ Chiral molecules when rotated forms **non-superimposable** molecules

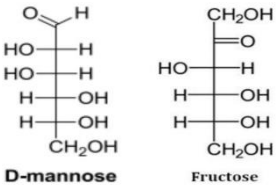


❖ Isomerism

- **Isomers:** They are molecules with the same molecular formula but different chemical structure and atoms arrangement and they can also differ in their properties
- The number of isomers of a molecule = 2^n (n is the number of chiral carbons)
- We have 2 types of isomers:

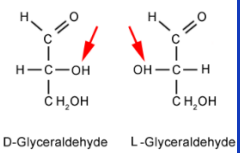
A. Constitutional isomers

- Molecules with the same molecular formula but **different Constitution** (bonding patterns and atomic organization)
- Such as: Fructose – Glucose, Fructose – Mannose, Fructose – Galactose



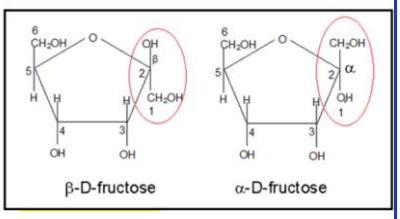
B. Stereoisomers

- Isomers with the same molecular formula & sequence of atoms but **different 3D orientation** of their atoms in the space. They have 2 types:
  - ➢ **Enantiomers:** Two stereoisomers where **all their chiral carbons** are different in their orientation
    - ✓ They are **mirror images** of each other and **non-superimposable**
    - ✓ They form L, D-isomers
      - If the OH on the **last chiral** (**penultimate**) carbon is on the **right**: **D-isomer**
      - If the OH on the **last chiral** (**penultimate**) carbon is on the **left**: **L-isomer**
    - ✓ Our body only uses D-isomers



  - ➢ **Diastereomers:** Two or more stereoisomers of a compound having different configurations at **one or more (but not all) of the chiral carbons**
    - ✓ They **not mirror images** of each other and **non-superimposable**
    - ✓ **Epimers:** A type of diastereomers, in which they differ in **only one chiral carbon**
      - Every epimer is a diastereomer, but not every diastereomer)

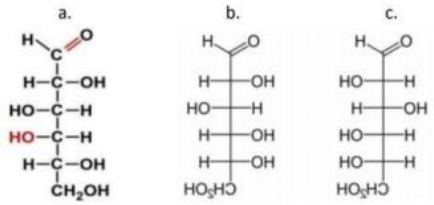
- **Anomers:** Isomers that differ only in their anomeric carbon
  - Anomeric carbon: it is the carbon of the carbonyl group when the ring structure is formed (carbon 1 in aldose and 2 in ketose)
  - **Beta (β):** OH of the anomeric carbon is in the **same orientation** as the last carbon (usually upward)
  - **Alpha (α):** OH of the anomeric carbon is in an opposite orientation as the last carbon (usually downward)



- **Beta** configuration is stronger and more stable, so it is found in the **structural** molecules (such as cellulose and chitin)
  - We don't have enzymes to digest beta sugars so we can't use them for energy utilization
- **Alpha** configuration is much weaker than beta so it is found in the **storage** molecules (such as starch and glucose)

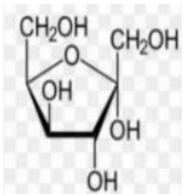
Past papers

1. Which of the following is L- Glucose:



A. a
B. b
C. c

2. The following figure represents D-sorbose.. which of the following statements is wrong?



A. It is a furanose
B. It is an alpha sugar
C. Carbon no.1 is the anomeric carbon
D. It is a ketose
E. It can re-open up into the chain form

3. Which of the following is not true about glucose:

A. Epimer of mannose
B. Epimer of galactose
C. Only D-isomer presents in mammalians
D. It mainly exist in as open chain in solution

4. D-glucose & D-galactose has all of the following except:

A. Hexoaldoses
B. They are Diasteriomers
C. They are anomers
D. They are reducing sugars

5. Which of the following is an aldo-pentose:

A. Ribose
B. Glucose
C. Fructose

6. One of the following is true in regard to L-glucose & D-glucose:

A. D-glucose is natural, but not L-glucose
B. They differ in the orientation of only the chiral carbon farther from the most oxidized group
C. D-glucose is cyclic, but L-glucose is a chain molecule
D. D-glucose has an anomeric carbon, but L-glucose does not
E. They are mirror images of each other