Chapter-14

# Biomolecules

## LECTURE – 01

**Carbohydrates:**

Carbohydrates are optically active polyhydroxy aldehyde or ketones which produce such units on hydrolysis e.g sucrose, lactose, and maltose.

**Classification of carbohydrates.**

On basis of their behavior on hydrolysis, carbohydrates are classified into three groups.

- ❖ Monosaccharides
- ❖ Oligosaccharides

**Monosaccharides:**

This type of carbohydrate cannot be hydrolyzed into a simple unit. e.g. Glucose, fructose, Ribose, etc.

**Oligosaccharides:** This type of carbohydrates on hydrolysis produces 2-10 monosaccharides. Oligosaccharides may be disaccharides, trisaccharides depending open the no. of monosaccharides they provide on hydrolysis among these, the common are disaccharides.

**Polysaccharides:** Carbohydrates that yield a large no of monosaccharides units on hydrolysis. E.g. starch, cellulose, glycogen, etc. Carbohydrates may also be classified as reducing sugar and non-reducing sugars.

**Reducing Sugars:**

Carbohydrates which reduces Tollen's reagent and Fehling solution are called reducing sugars.

**For Examples:** Maltose & Lactose

**Non-Reducing Sugar:** Sugar which does not reduce Tollen's reagent or Fehling solution is called Non-reducing sugars. e.g. – Sucrose.

**Preparation of Glucose:**

From sucrose : (Inversion of cane sugar

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{(glucose)}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

From starch : (Hydrolysis of starch)

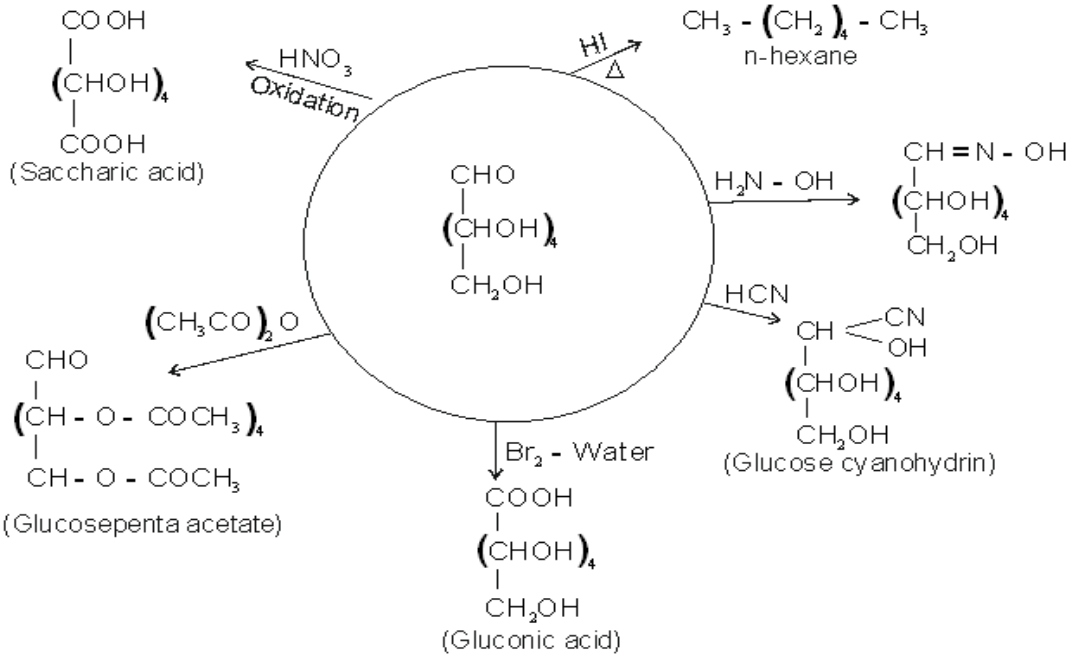
$$(C_6H_{12}O_5)_n + nH_2O \xrightarrow[393.2.3\ ATM]{H^+} nC_6H_{12}O_6$$

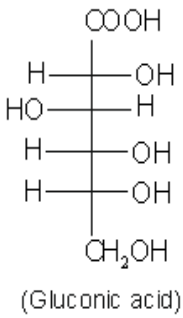
**Elucidation of Structure of Glucose:**

$$(C_6H_{12}O_5)_n + nH_2O \xrightarrow[393.2.3\ ATM]{H^+} nC_6H_{12}O_6$$

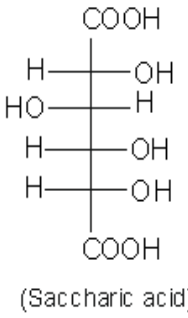
**On basis of the following evidence.**

- Suggesting that all six carbon atoms are linked in a straight chain.
- Glucose reacts with hydroxylamine to form an oxime and adds a molecule hydrogen cyanide to give cyanohydrins. These reactions indicate the presence of a carbonyl group > C = 0 in the glucose molecule.
- Glucose gets oxidized to six carbon carboxylic acid (gluconic acid) on reaction with a mild oxidizing agent like bromine water. This indicates that the carbonyl group is present as an aldehyde group.
- Acetylation of glucose with acetic anhydride gives glucose Penta acetate which confirms the presence of five –OH groups.
- Oxidation with nitric acid, glucose as well as gluconic acid both yield a dicarboxylic acid called saccharic acid, this indicates the presence of a primary alcoholic (- OH) group in glucose.



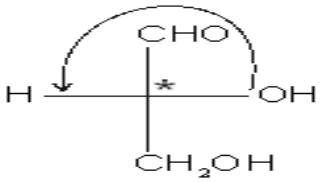
(Gluconic acid)



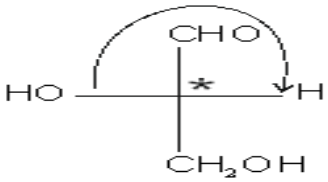
(Saccharic acid)

Glucose is correctly named as D (+) - glucose

D and L are configurations not related to the optical activity of the compound. But (+) and (-) represent dextrorotatory and laevorotatory in nature.



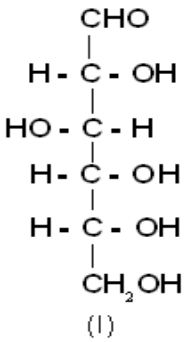
(-) - Glyceraldehyde



(+) - Glyceraldehyde

**Cyclic Structure of Glucose**

Structure (1) of glucose explained most of its property and facts could not be explained by this structure



(I)

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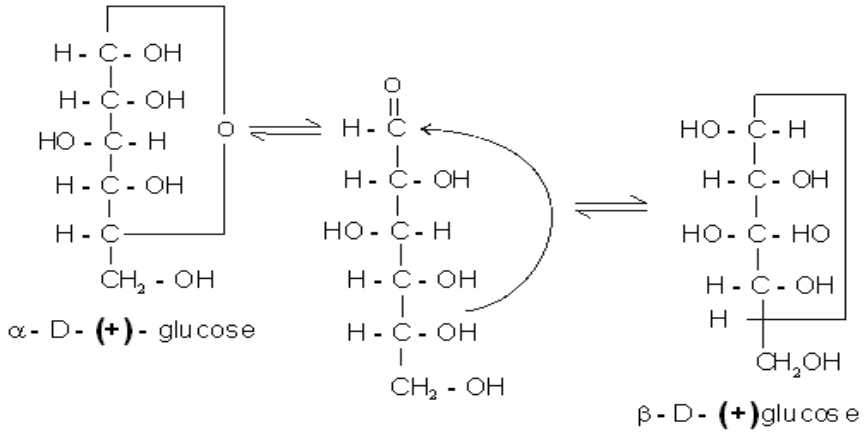
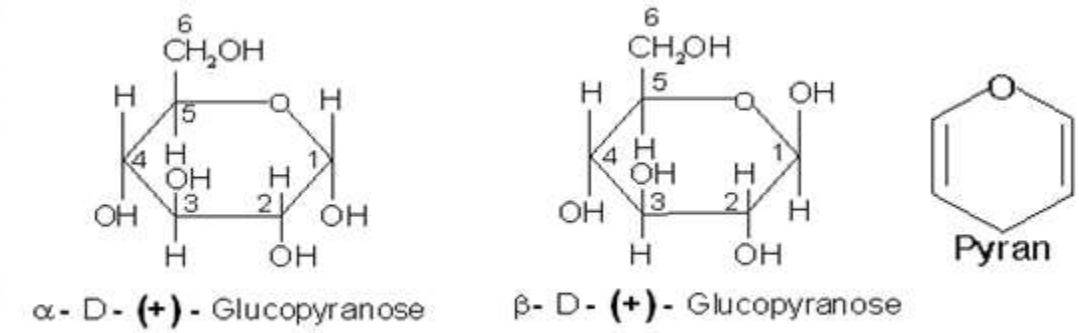
❖Although glucose having an aldehyde group. But it does not give schiff's test and it does not form precipitated with $NaHSO_3$ solution.
❖Does not respond to 2,4 DNPH.
❖The Penta acetate of glucose does not react with hydroxyl amine indicating the absence of free –CHO group.

- Glucose is found to exist in two different crystalline forms which are named as $\alpha$ and $\beta$ Alfa form of glucose is obtained by crystallization from a concentrated solution of glucose at 303 K while the beta form is obtained by crystallization from hot and saturated aqueous solution at 371 K. Alfa glucose (m.p 419k), -glucose (m.p – 423k) This behavior could not be explained by the open-chain structure for glucose. It was proposed that one of the – OH groups may add to the – CHO group and form a cyclic hemiacetal structure. It was found that glucose forms a six-membered ring in which –OH at C-5 is involved in a ring formation.

This explains the absence of –CHO group and also the existence of glucose in two forms.



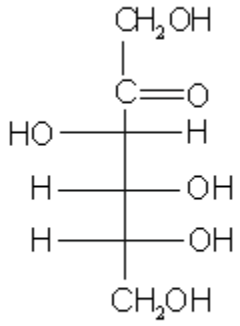

The two cyclic hemiacetal forms of glucose differ only in the configuration of the hydroxyl group at C-1 called anomeric carbon such as isomers i.e, alfa-form and beta-form are called anomers. The cyclic structure of glucose is compared to pyran. Which is a cyclic organic compound? With one oxygen and five carbon atoms in the ring.




**Fructose :**

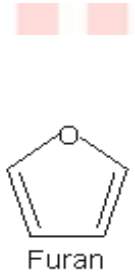
Fructose is an important ketohexose, it is obtained along with glucose by the hydrolysis of disaccharides, i.e sucrose.

**Structure of fructose**

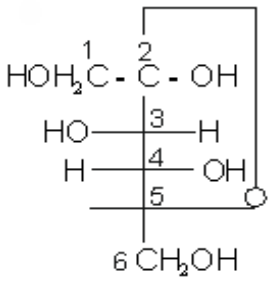


D - (- ) - fructose

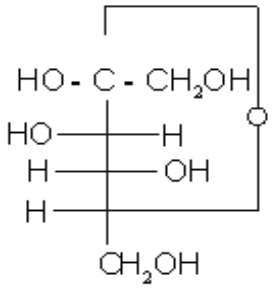
It also exists in two cyclic forms which are obtained by the addition of –OH at C-5 to the $>C=O$ it is compared to 5 membered ring and is named as furanose.



Furan

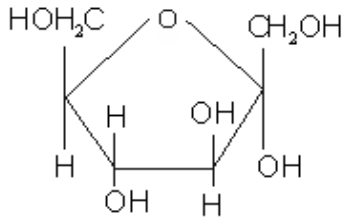


α - D - (+)Fructo furanose

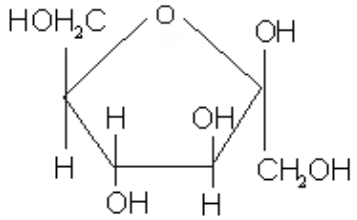


β - D - (+)Fructo furanose

The cyclic structure of two anomers of fructose is represented by Howorth.



α - D - (- )Fructofuranose



β - D - (- )Fructofuranose

# LECTURE 02

## Disaccharides

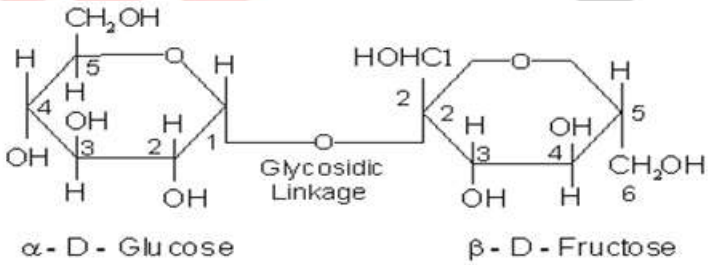
We have already read that disaccharides on hydrolysis with dil acids or enzymes yield two molecules of either the same or different monosaccharides. Two monosaccharides are joined together by an oxide linkage formed by the loss of a water molecule such a linkage between two monosaccharides units through oxygen atom is called glycosidic linkage.

**Hydrolysis product of Disaccharides**

**1. Sucrose:**

$$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

Sucrose D-(+) glucose D- (-) fructose



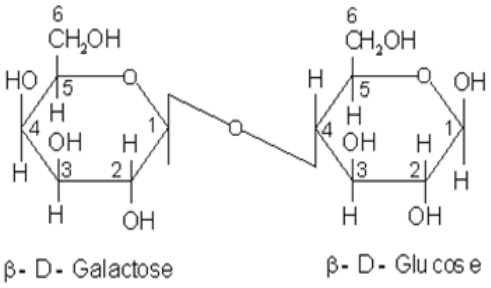

**Maltose :**

$$\text{Maltose} \xrightarrow{\text{Hydrolysis}} 2(\text{Glucose})$$

The glycosidic linkage formed between C-1 of glucose and C-1 of another glucose unit – II.

**Lactose :**

It is otherwise called milk sugar. Since it is composed of β–D– galactose and β–D– glucose. The linkage is between C-1 of galactose and C-4 of glucose is called glycosidic linkage. It is also a reducing sugar.



# LECTURE 03

**Polysaccharides :**

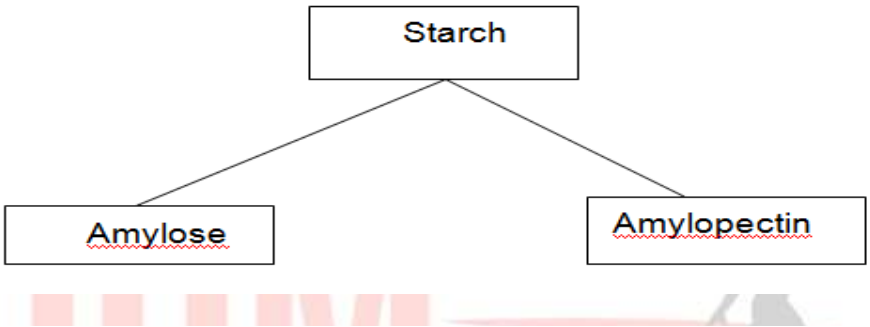
Polysaccharides contain a large no of monosacharides units joined together by glycosidic linkage. These are the most commonly encountered carbohydrates in nature.

e.g. starch, cellulose, glycogen

**Starch**

It is a plant polysaccharides. It is found in cereals, roots, tubers and some vegetables.

It is polymer of




| AMYLOSE | AMYLOPECTIN |
|---|---|
| 1. Water Soluble | 1. Water Insoluble |
| 2. 15-20 % of starch | 2. 80-85% of starch |
| 3. It is a long unbranched chain | 3. It is a branched chain polymer |
| 200-1000 $\alpha-D(+)$ glucose units | of $\alpha-D-$ glucose units in which |
| held by $C_1-C_4$ glycosidic linkage. | Chain is formed by $C_1-C_4$ glycoside Linkage whereas branching occurs by $C_1-C_6$ glycosidic linkage. |

**CELLULOSE :**

Cellulose occurs exclusively in plants and it is the most abundant organic substances in plant kingdom. It is a straight chain polysaccharides composed only of $\beta$ -D- glucose units which are joined by glycosidic

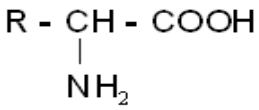
the linkage between C-1 of one glucose unit and C-4 of the next glucose unit.

**GLYCOGEN: -**

The carbohydrates are stored in the animal body as glycogen. It is also known as animal starch. It is similar to amylopectin. It is present in the liver, muscles, and brain. When the body needs glucose. Enzymes break the glycogen down to glucose, it is also found in yeast and fungi.

**AMINO ACIDS: -**

Amino acids are organic compounds that contain amino -$NH_2$ and carboxyl -COOH functional groups.



**Amino acids are classified into**

(i) $\alpha$ -Amino acids
(ii) $\beta$-Amino acids
(iii) $\gamma$ - Amino acids

Depending upon the position of amino group present at $\alpha, \beta$ and $\gamma$ carbon of amino acids.

Again amino acids are classified into

- Essential amino acids
- Non-essential amino acids

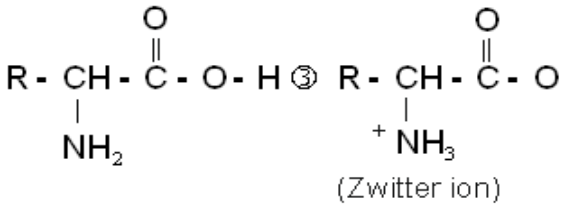
**Essential Amino Acids**

Amino acids can't be synthesized in our body but that can be obtained through diet. e.g. valine, leucine, Isoleucine arginine, etc.

**Non-essential Amino acids:**

The amino acids which can be synthesized in the body are known as non-essential amino acids e.g. Glycine, Alanine, Aspartic acid, etc. Again Amino acids, are classified as acidic, basic, or neutral depending upon the relative no of amino and carboxyl groups in their molecule. Amino acids are usually colorless, crystalline solids. These are water-soluble, high melting solids, and behave like salts rather than simple amines or carboxylic acids. This behavior is due to the presence of both acidic (Carboxylic group) and basic amino groups in the same molecule. In aq solution, the carboxyl group can lose a proton and amino group.

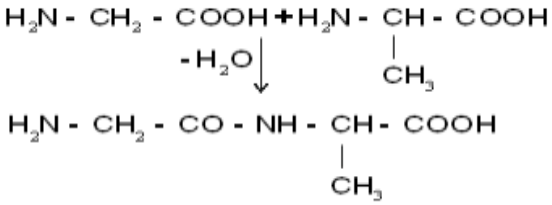
Can accept a proton giving rise to a dipolar ion known as a zwitterion. This is neutral but contains both positive and negative charges. In zwitterionic form. Amino acids show amphoteric behavior as they react both with acids and bases.



(Zwitter ion)

Except glycine, all other naturally occurring α - amino acids are optically active.

**PROTEINS :** Are polymers of α -amino acids connected by peptide bond or peptides linkage. (Amide linkage) $\left(-CO-NH_2^-\right)$




**Classification of proteins**

It is classified into two types of molecular shape.

- Fibrous proteins
- Globular proteins

| **Fibrous Proteins:** | **Globular Proteins** |
|---|---|
| 1. When the polypeptide chains run parallel and are held together by hydrogen and disulphide bonds. | 1. It is spherical. |
| 2. Insoluble in water | 2. Soluble in water |
| 3. E.x. keratin myosin | 3. Insulin and albumins. |

4. **Denaturation of proteins:** Proteins found in a biological system with a unique three-dimensional structure and biological activity is called a native protein.

5. When a protein in its native form is subjected to physical charges like change in temperature or chemical change like change in pH, the hydrogen bonds are disturbed, due to these globules unfold and helix becomes uncoiled. Proteins lose their biological activity. This is called the denaturation of proteins. During denaturation

$2^0$ & $3^0$ structure of protein are destroyed but $1^0$ structure remain intact. For example coagulation of egg white on boiling, curdling of milk.

1. Explain why vitamin C cannot be stored in the body.

2. The deficiency of which vitamin causes the disease pernicious anemic.

3. Give two examples of water-soluble vitamins.

4. Give the chemical name of vitamins $B_{12}$

5. Name the vitamin whose deficiency is responsible for poor coagulation of blood.

6. Deficiency of which vitamin causes beri-beri and pain in joints.

7. Deficiency of which vitamin causes scurvy.

8. Among vitamin – B complex ($B_1$,$B_2$,$B_6$ & $B_{12}$) which vitamin can be stored in own body ?

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## LECTURE 04

**VITAMINS:** Are organic compounds requires in the diet in small amounts to perform specific biological functions normal maintenance of optimum growth and health of the organism.

**Classification:** Vitamins are classified into two groups depending upon their solubility in water or fat.

Water-soluble vitamins: B and C except $B_{12}$

Fat-soluble vitamins : A,D,E & K

Important vitamins, their sources, and their deficiency diseases.

| SL NO | Name of Vitamins | Sources | Dificiency disease |
|---|---|---|---|
| 1 | A (Retinol) | Fish liver oil, carrots, Butter and milk | Xeroophthlmia, night blindness |
| 2 | $B_1$ (Thiamine) | Yeast, milk, egg yolk Cereals and grams | Beriberi |
| 3 | Vitamin B6 (pyridoxin) | Yeast, milk, egg yolk Cereals and grams | Convulsions |
| 4 | $B_{12}$ ( Cyanocobalamine) | Meat, fish, egg and curd | Pernicious Anaemia |
| 5 | Vitamin C | Citrus fruits, Amla and green leafy vegetables | Scurvy (bleeding gums) |
| 6 | Vitamin – D | Exposure to sunlight, fish and egg yolk | Rickets/bone deformities in children |
| 7 | Vitamin – E | Vegetable oils like wheat germ, sunflower oil | Increased fragility of RBC, muscular weakness. |
| 8 | Vitamin – K | Green leafy vegetables | Increased blood clotting time. |

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**NUCLEIC ACIDS**

Nucleic acids are long-chain polymers of nucleotides, nucleic acids are 2 types.

- DNA (Deoxyribonucleic acid)
- RNA (Ribonucleic acid )

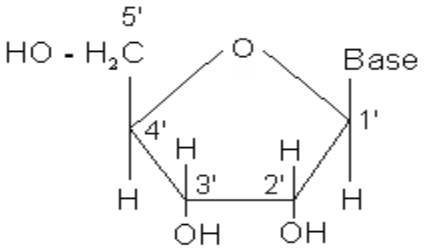
Chemical composition of Nucleic Acids

Complete hydrolysis of DNA or RNA yields a pentose sugar, phosphoric acid, and heterocyclic nitrogenous bases.

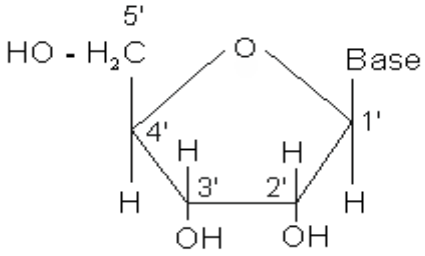
**Strcutural and Functional difference between DNA & RNA**

| | DNA | | RNA |
|---|---|---|---|
| 1. | Sugar is $\beta-D-2-$deoxyribose | 1. | Sugar is $\beta-D$ - ribose. |
| 2. | Heterocyclic nitrogenous bases are Adenine, Guanine, cytocine & thymine | 2. | Nitrogenous bases are Adenine, guanine, cytocine & uracil. |
| 3. | DNA is double strand | 3. | May be single strand or double strand. |
| 4. | It is the chemical basis of heredity and may be regarded as the reserve of genetic information. It is capable of self duplication. | 4. | Basically it is stand for protein synthesis. |

**Nucleoside:** A unit formed by the attachment of a base to 1' – position of sugar is known as a nucleoside.




**Nucleotide –** When nucleoside is linked to phosphoric acid at 5' – position of sugar moiety the unit obtained is called a nucleotide.




Nucleotides are joined together by phosphodiester linkage between 5' and 3' carbon atoms of the pentose sugar.

**Hormones:** Hormones are molecules that act as intercellular messengers, these are produced by endocrine glands in the body and are released directly in the bloodstream.

**Functions of hormones :**

(1)They help to maintain the balance of biological activities in the body. e.g. insulin keeps the blood glucose level within the square. Epinephrine and norepinephrine mediate response to external stimuli growth hormones and sex hormones play role in growth and development.

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