SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIAC TECHNOLOGY

COURSE NAME : BIOCHEMISTRY

TOPIC : CARBOHYDRATES

INTRODUCTION

- Carbohydrates, or carbs, are sugar molecules.
- Along with proteins and fats, carbohydrates are one of three main nutrients found in foods and drinks.
- Our body breaks down carbohydrates into glucose.
- Glucose, or blood sugar, is the main source of energy for your body's cells, tissues, and organs.
- Glucose can be used immediately or stored in the liver and muscles for later use.

3 types of carbohydrates:

Sugars: They are also called simple carbohydrates, they can be added to foods, such as the sugar in candy, desserts, processed foods, and regular soda and are found naturally in fruits, vegetables, and milk.

Starches: They are complex carbohydrates, which are made of lots of simple sugars strung together. Our body needs to break starches down into sugars to use them for energy. Starches include bread, cereal, and pasta and also include certain vegetables, like potatoes, peas, and corn.

Fiber: It is also a complex carbohydrate. Diets high in fiber have other health benefits. They may help prevent stomach or intestinal problems, such as constipation. They may also help lower cholesterol and blood sugar. Fiber is found in many foods that come from plants, including fruits, vegetables, nuts, seeds, beans, and whole grains.

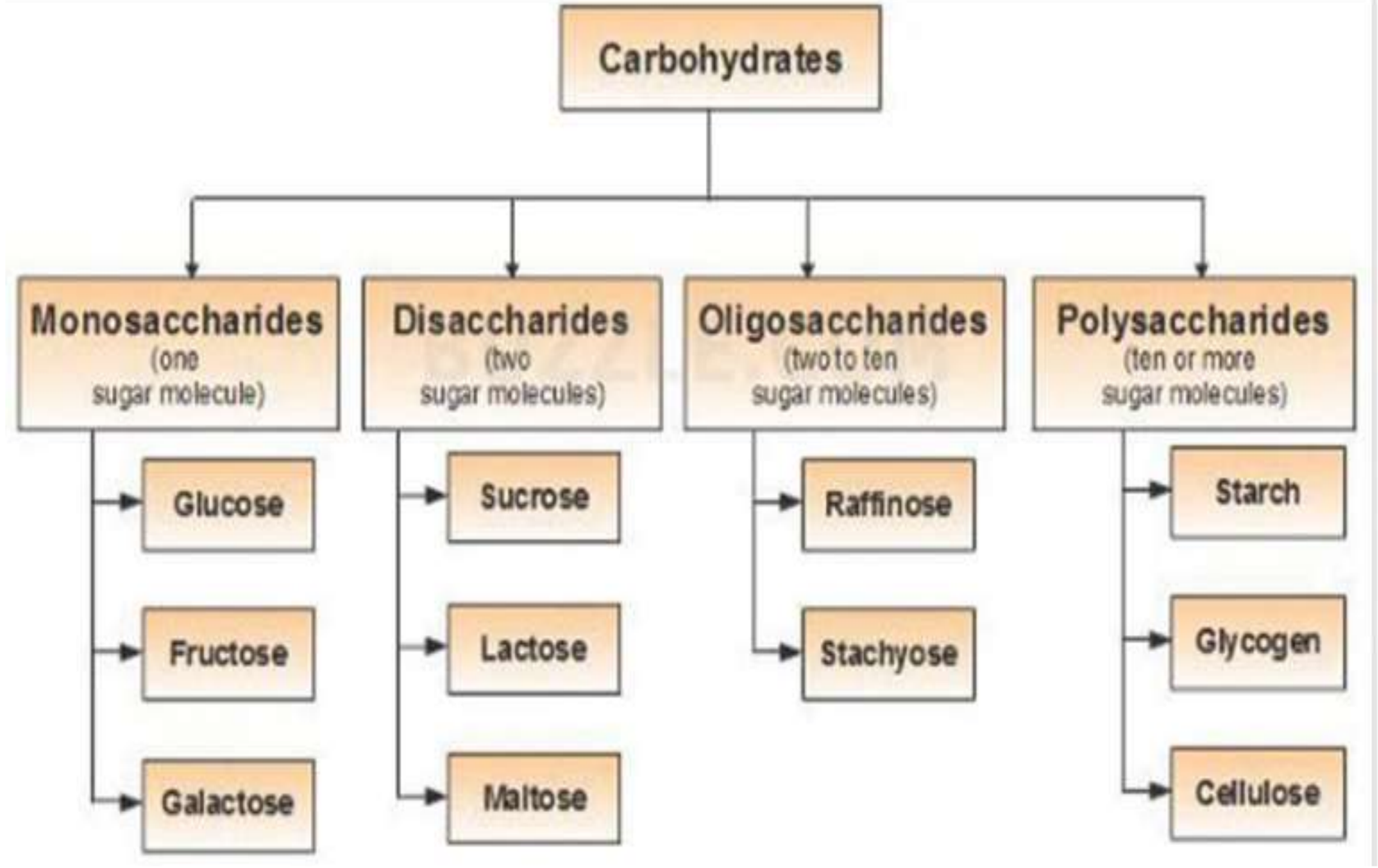
- Common foods with carbohydrates include:

- Grains, such as bread, noodles, pasta, crackers, cereals, and rice
- Fruits, such as apples, bananas, berries, mangoes, melons, and oranges
- Dairy products, such as milk and yogurt
- Legumes, including dried beans, lentils, and peas
- Snack foods and sweets, such as cakes, cookies, candy, and other desserts
- Juices, regular sodas, fruit drinks, sports drinks, and energy drinks that contain sugar
- Starchy vegetables, such as potatoes, corn, and peas

Structure of Carbohydrates

- Carbohydrates consist of carbon, hydrogen, and oxygen.
- The general empirical structure for carbohydrates is (CH20)n.
- They are organic compounds organized in the form of aldehydes or ketones with multiple hydroxyl groups coming off the carbon chain.
- The carbohydrates can be structurally represented in any of the three forms:
- Open chain structure
- Hemi-acetal structure
- Haworth structure
- **Open chain structure -** It is the long straight-chain form of carbohydrates.
- **Hemi-acetal structure -** Here the 1st carbon of the glucose condenses with the -OH group of the 5th carbon to form a ring structure.
- **Haworth structure -** It is the presence of the pyranose ring structure.

Classification of Carbohydrates



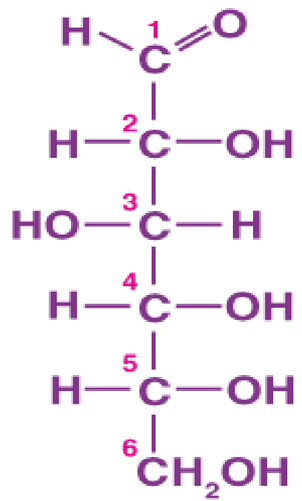
Monosaccharides

- The building blocks of all carbohydrates are simple sugars called monosaccharides.
- A monosaccharide can be a polyhydroxy aldehyde (aldose) or a polyhydroxy ketone (ketose).
- Monosaccharide carbohydrates are those carbohydrates that cannot be hydrolyzed further to give simpler units of polyhydroxy aldehyde or ketone.
- If a monosaccharide contains an aldehyde group then it is called aldose and on the other hand, if it contains a keto group then it is called a ketose.
- One of the most important monosaccharides is glucose. The two commonly used methods for the preparation of glucose are
- **From Sucrose**: If sucrose is boiled With dilute acid in an alcoholic solution then we Obtain glucose and fructose.
- **From Starch**: We can obtain glucose by hydrolysis of starch and by boiling it with dilute H2S04 at 393K under elevated pressure.

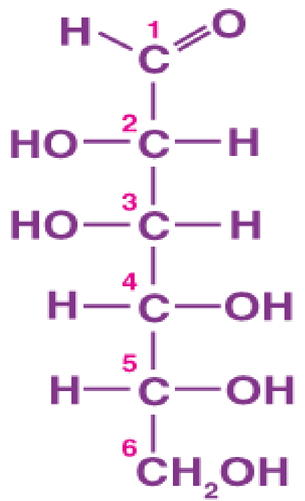
Glucose

- Glucose is also called aldohexose and dextrose and is abundant on earth.
- Glucose is named as D (+)-glucose, D represents the configuration whereas (+) represents the dextrorotatory nature of the molecule.
- The ring structure of glucose can explain many properties of glucose which cannot be figured by open- chain structure.
- The two cyclic structures differ in the configuration of the hydroxyl group at C1 called anomeric carbon.
- Such isomers i.e. α and β form are known as anomers.
- The cyclic structure is also called pyranose structure due to its analogy with pyran.

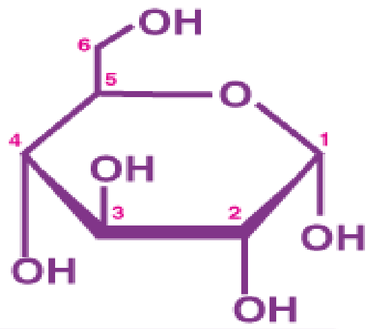
The cyclic structure of glucose is given below:



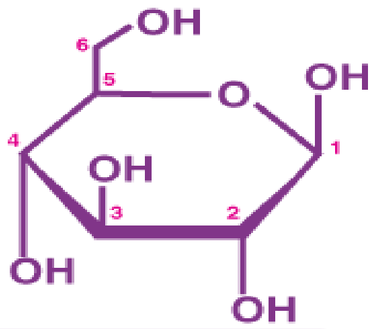
D Glucose



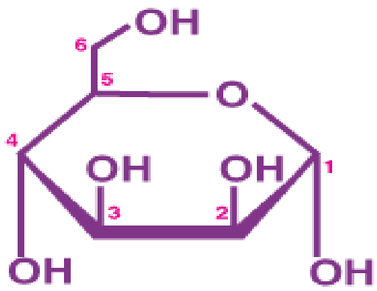
D Mannose



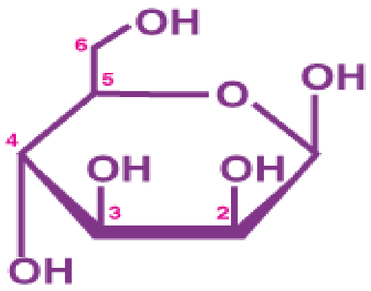
α D Glucose



β D Glucose



α D Mannose

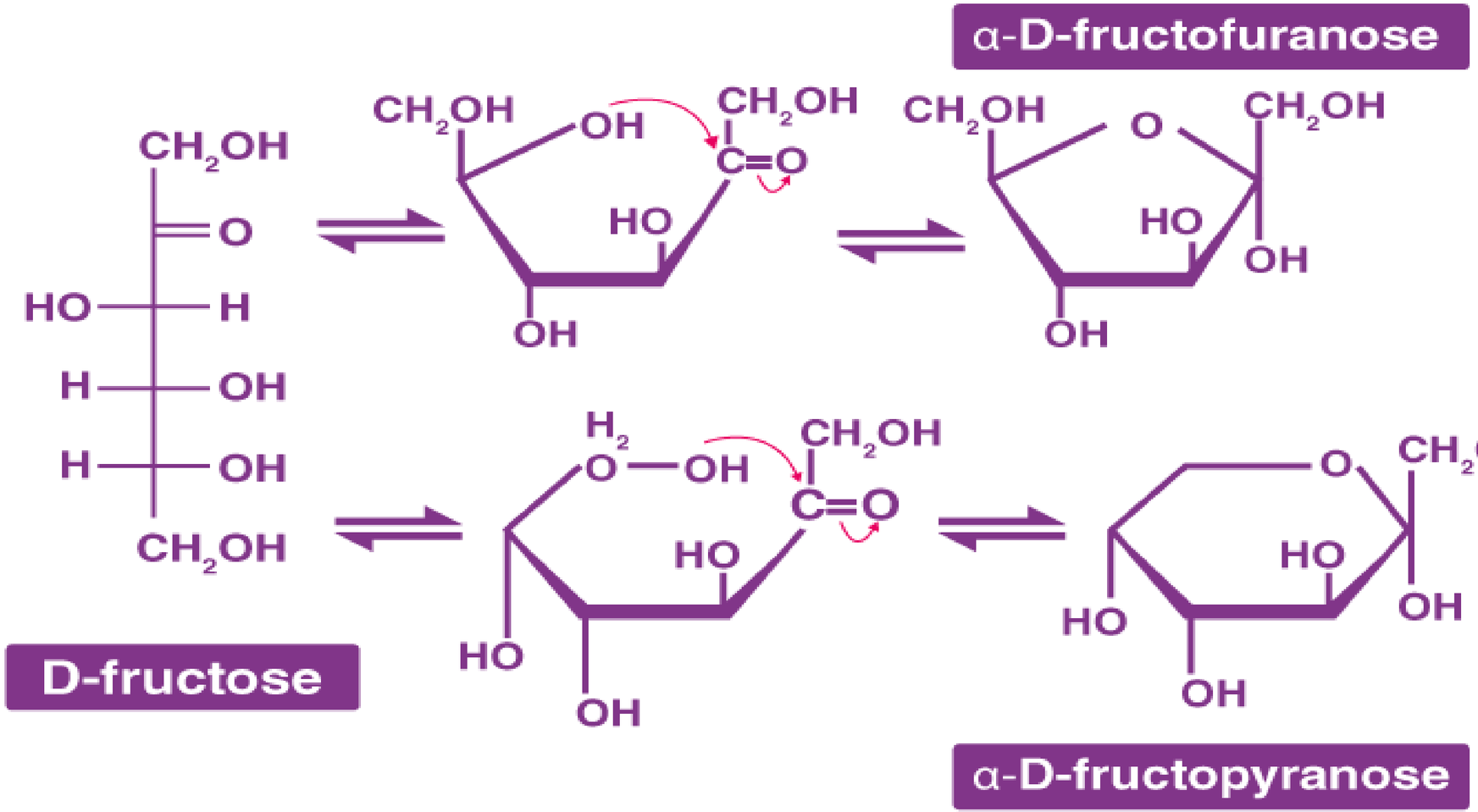


β D Mannose

Fructose

- It is an important ketohexose.
- The molecular formula of fructose is C6H1206 and contains a ketonic functional group at carbon number 2 and has six carbon atoms in a straight chain.
- The ring member of fructose is in analogy to the compound Furan and is named furanose.

The cyclic structure of fructose is shown below:



Disaccharides

- On hydrolysis, disaccharides yield two molecules of either the same or different monosaccharides.
- The two monosaccharide units are joined by oxide linkage which is formed by the loss of water molecule and this linkage is called glycosidic linkage.
- Sucrose is one of the most common disaccharides which on hydrolysis gives glucose and fructose.
- Maltose and Lactose (also known as milk sugar) are the other two important disaccharides.
- In maltose, there are two a-D-glucose and in lactose, there are P-D-glucose which are connected by an oxide bond.

Polysaccharides

- Polysaccharides contain long monosaccharide units joined together by glycosidic linkage.
- Most of them act as food storage for e.g. Starch.
- Starch is the main storage polysaccharide for plants.
- It is a polymer of a glucose and consists of two components-Amylose and Amylopectin.
- Cellulose is also one of the polysaccharides that are mostly found in plants.
- It is composed of D- glucose units joined by a glycosidic linkage between Cl of one glucose unit and C4 of the next glucose unit.
- Polysaccharides are also called "glycans".
- Polysaccharides contain more than 10 monosaccharide units and can be hundreds of sugar units in length.
- They yield more than 10 molecules of monosaccharides on hydrolysis.

- Polysaccharides differ from each other in the identity of their recurring monosaccharide units, in the length of their chains, in the types of bond linking units and in the degree of branching.
- They are primarily concerned with two important functions ie. Structural functions and the storage of energy.
- They may be homopolysaccharides/ Homoglycans, containing monosaccharides of the same type (Contains more than 10 same repeating units.)
- Examples are starch, glycogen, cellulose, pectin.
- Heteropolysaccharides/ Heteroglycans i.e., monosaccharides of different types (Contains more than 10 different repeating units.)
- Examples are Hyaluronic acid, Chondroitin.

HOMOPOLYSACCHARIDES

- Homopolysaccharides are chemical compounds that are composed of a single type of monomer
- Composed of the same repeating unit
- Single type of monosaccharide is involved in the formation
- Have simple structures when cornpared to heteropolysaccharides

HETEROPOLYSACCHARIDES

- Heteropolysaccharides are polysaccharides made out of two or more different monosaccharides
- Composed Of different repeating units
- Different types of monosaccharides are
- involved in the formation
- Have complex structures

Oligosaccharides

- Oligosaccharides are compound sugars that yield 2 to 10 molecules of the same or different monosaccharides on hydrolysis.
- The monosaccharide units are joined by glycosidic linkage.
- Based on the number of monosaccharide units, it is further classified as a disaccharide, trisaccharide, tetrasaccharide, etc.
- Oligosaccharides yielding 2 molecules of monosaccharides on hydrolysis is known as a disaccharide, and the ones yielding 3 or 4 monosaccharides are known as trisaccharides and tetrasaccharides respectively, and so on.

Examples: Disaccharides include sucrose, lactose, maltose, etc.

Trisaccharides are Raffinose, Rabinose.

Functions of Carbohydrates

- Carbohydrates are widely distributed molecules in plant and animal tissues.
- In plants and arthropods, carbohydrates from the skeletal structures, they also serve as food reserves in plants and animals.
- They are important energy sources required for various metabolic activities, the energy is derived by oxidation.

Some of their major functions include

- Living organisms use carbohydrates as accessible energy to fuel cellular reactions.
- They are the most abundant dietary source of energy (4kcal/gram) for all living beings.
- Carbohydrates along with being the chief energy source, in many animals, are instant sources of energy.
- Glucose is broken down by glycolysis/ Kreb's cycle to yield ATP, it serve as energy stores, fuels, and metabolic intermediates.
- It is stored as glycogen in animals and starch in plants.
- Stored carbohydrates act as an energy source instead of proteins.

Glycoproteins

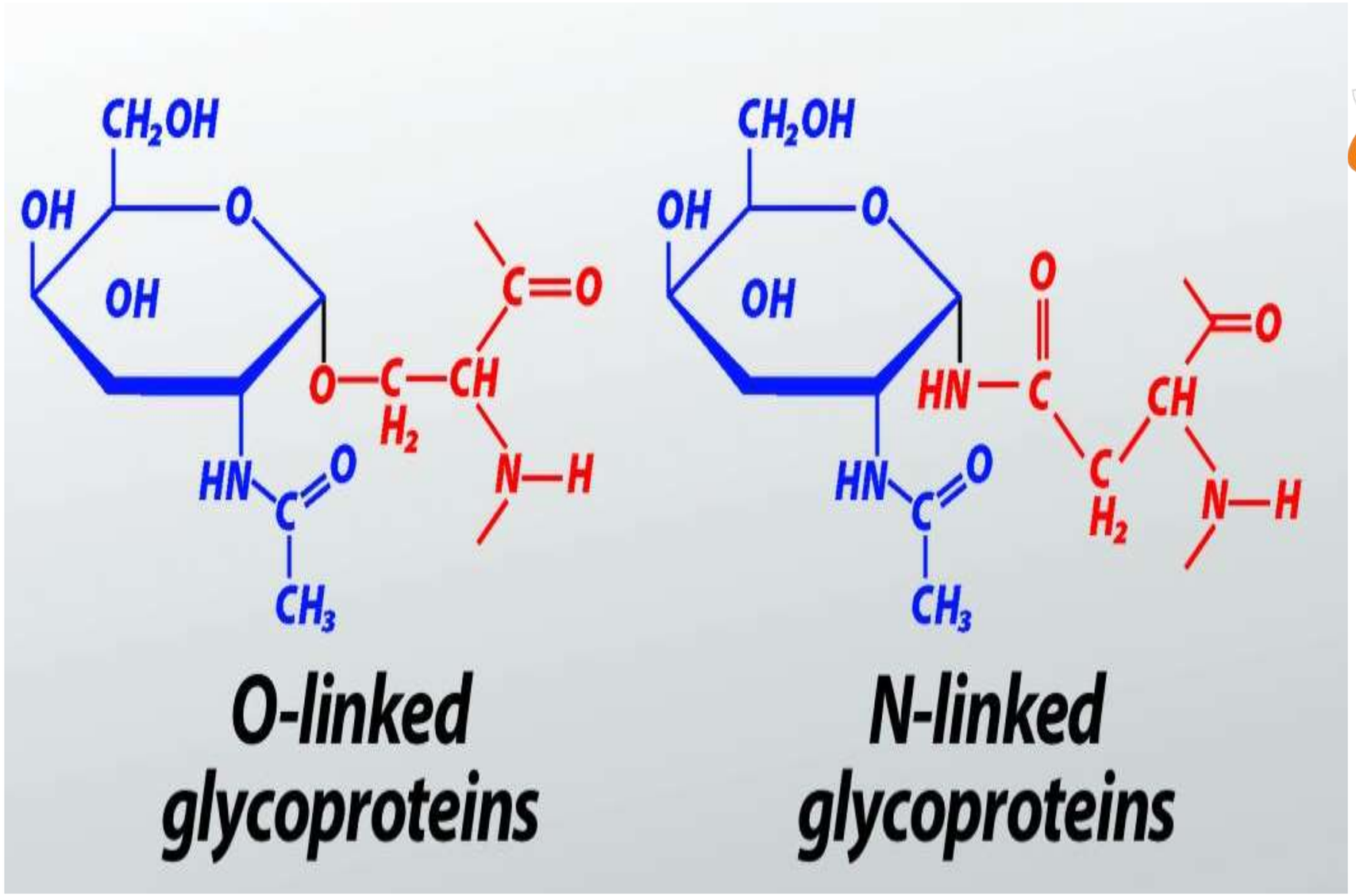
- Any protein molecule with a carbohydrate attached is known as a glycoprotein.
- The protein’s polypeptide side chains are covalently joined to the carbohydrate, an oligosaccharide chain (glycan).
- Either the process takes place during protein translation, or it occurs post-translationally via glycosylation.
- Glycoconjugates are formed when carbohydrates are linked to proteins and lipids.
- They exist in three forms: glycoproteins, glycolipids and proteoglycans.
- Glycoproteins are formed when the protein component predominates in the combination of carbohydrates and proteins.
- It is referred to as a proteoglycan if the association comprises more carbohydrates than proteins.
- Glycolipids are formed when a carbohydrate combines with lipids.
- The primary site of glycoprotein and glycolipid synthesis is the Golgi apparatus.

Structure

- Glycoproteins are proteins containing glycans attached to amino acid side chains.
- Glycans are oligosaccharide chains; which are saccharide polymers, that can attach to either lipids (glycolipids) or amino acids (glycoproteins).
- Typically, these bonds are formed through a process called glycosylation.
- A sugar component (glyco) linked to a protein describes the structure of glycoproteins. Covalent bonds are used to bind the two components together.
- Glycoproteins have higher hydrophilicity than simple proteins due to the -OH groups of sugars. This implies that compared to other proteins, glycoproteins are more drawn towards water. The hydrophilic properties of the molecule also result in the distinctive folding of the tertiary structure of the protein.

N-Linked and O-Linked Glycoproteins

- Based on where the carbohydrate attaches to an amino acid in the protein, glycoproteins are divided into different groups.
- A carbohydrate is attached to the nitrogen (N) of the amino group (-NH2) of the R group of the amino acid asparagine in N-linked glycoproteins. The amide side chain of asparagine often serves as the R group.
- The process of bonding is known as N-glycosylation. The endoplasmic reticulum (ER) membrane provides sugar to N-linked glycoproteins, which are then transferred to the Golgi complex for processing.
- O-linked glycoproteins are those in which the carbohydrate forms a chemical bond with the hydroxyl group (-OH) of either the R group of the amino acid threonine or the R group of the amino acid serine.
- A hydroxylysine or hydroxyproline molecule can also form a connection with O-linked carbohydrates.
- The action is known as O-glycosylation.
- In the Golgi complex, sugar is bound to O-linked glycoproteins.


CH2OH
OH
O
OH
O
C=O
O—C—CH
H2
HN
C=O
CH3
N—H
CH2OH
OH
O
OH
HN
C=O
O
HN—C
CH
C
H2
N—H
CH3
O-linked glycoproteins
N-linked glycoproteins

Functions

- Nearly all cellular processes involve glycoproteins.
- They play various roles in our body, including those related to our immune systems, physical protection, cell-to-cell communication, and reproductive systems.
- Glycoproteins are present on the lipid bilayer of cell membranes. They can operate in the aqueous environment due to their hydrophilic character, which plays a role in chemical bonding and cell-cell recognition.
- Cell surface glycoproteins are crucial for cross-linking proteins (such as collagen) and cells to strengthen and stabilise a tissue.
- Plants can resist gravity because of glycoproteins found in their cells.
- The glycoproteins thrombin, prothrombin, and fibrinogen are necessary for blood coagulation.
- Due to their ability to facilitate sperm cell attachment to the egg’s surface, glycoproteins are essential for reproduction.

- The type of glycoprotein on human red blood cells is referred to as the blood type.
- Red blood cells with type A blood have A antigens or A glycoproteins.
- A Glycoproteins called mucins are present in the mucus.
- The molecules protect delicate epithelial surfaces in the digestive, reproductive, urinary, and respiratory tracts.
- Glycoproteins support the immunological response.
- The specific antigen to which an antibody (or glycoproteins) can bind depends on the carbohydrate it contains.
- Surface glycoproteins on B and T cells also bind antigens.
- Glycoproteins also maintain the health of our skin.
- The epithelial cells that form skin have glycoproteins on their surface—these aid in bonding the skin cells in our bodies, creating a strong barrier to protect them.
- Another glycoprotein that helps in the stability of human skin is cadherin.

Glycoproteins in health & disease

- Specific glycoproteins (and glycolipids) present on the surface of red blood cells determine blood group type. A
- -oligosaccharide for A group, B-oligosaccharide for B group, both A & B oligosaccharides for AB group, and the absence of both A & B for O group (H-oligosaccharide precursor only).
- Certain hormones are glycoproteins including follicle-stimulating hormone (FSH) – a gonadotropin hormone that has several functions in development, growth, puberty, and reproduction.
- Others include erythropoietin – a cytokine secreted by the kidneys that stimulate red blood cell production in bone marrow in high levels in response to hypoxia (low levels normally).
- Many viruses have surface glycoproteins called spike domains; S (including SARS-CoV-2; the virus causing COVID-19, discussed below) which enable viruses to bind to their target receptors and enter cells.

THANK YOU