SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIOPULMONARY PERFUSION CARE TECHNOLOGY

COURSE NAME : BIOCHEMISTRY

TOPIC : CARBOHYDRATES – GLUCOSE METABOLISM

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.

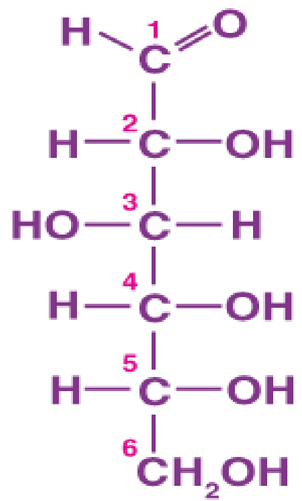
Monosaccharides

- 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.

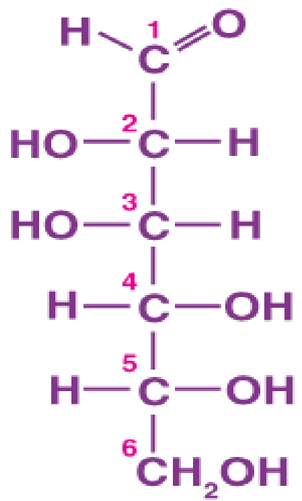
Glucose

- 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.

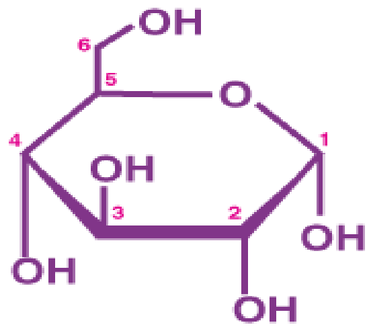
The cyclic structure of glucose is given below:



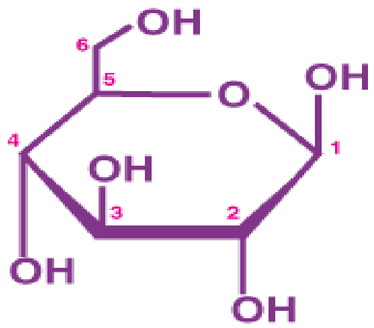
D Glucose



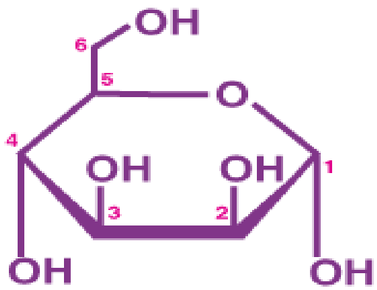
D Mannose



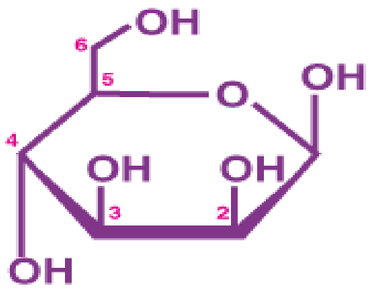
α D Glucose



β D Glucose



α D Mannose

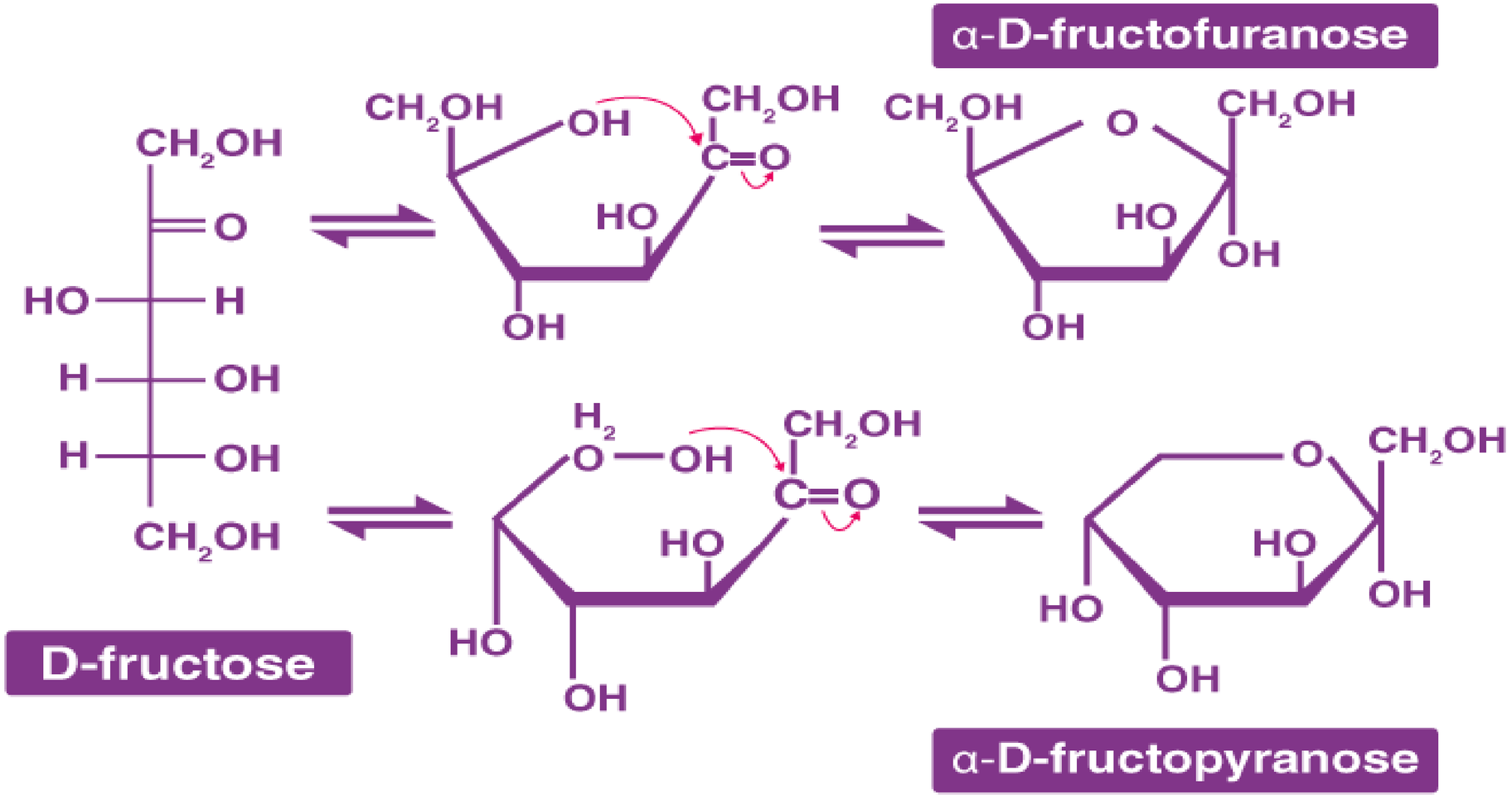


β D Mannose

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 are further classified depending on the type of molecules produced as a result of hydrolysis.
- 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.

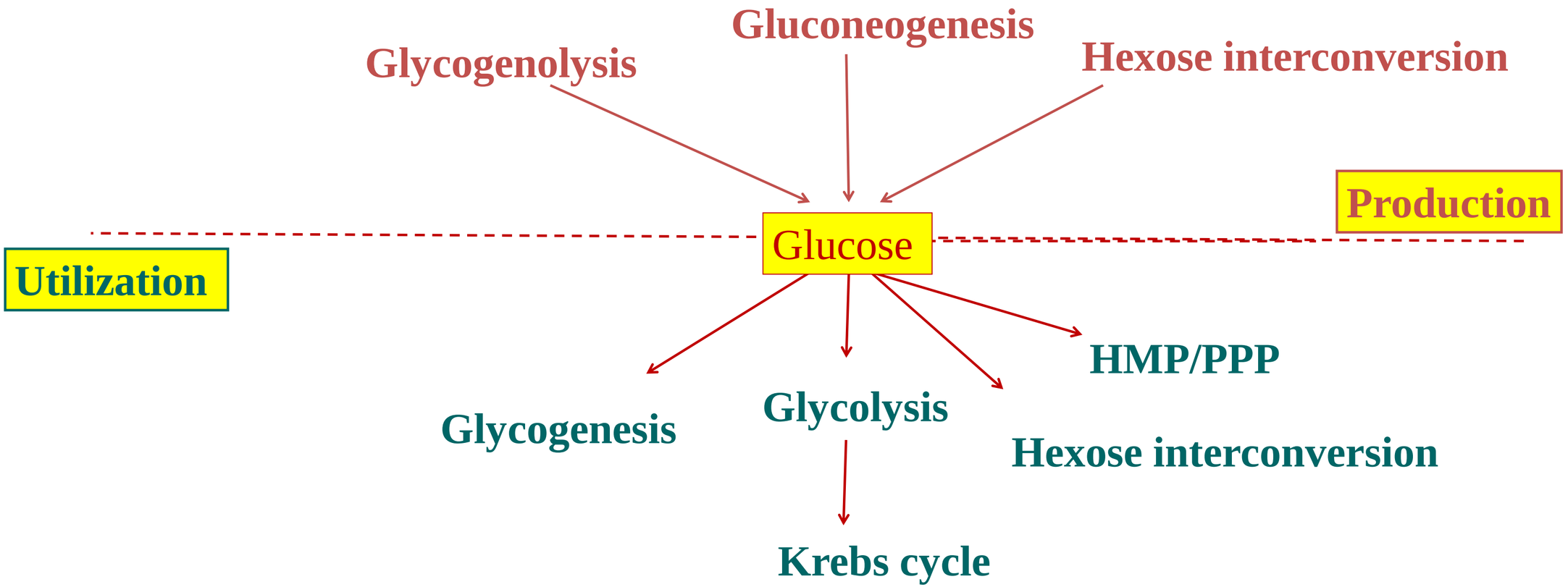
Functions of Carbohydrates

- 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.

Metabolic Pathways of Glucose Production and Utilization



Metabolic Pathways of Glucose: Catabolic and Anabolic

Catabolic cycles

- **Glycolysis (Mainly)**
- **Krebs (Mainly)**
- **Glycogenolysis**
- **HMP**

Anabolic cycles

- **Gluconeogenesis**
- **Glycogenesis**

Glycogenesis and Glycogenolysis

Glycogenesis:

- Synthesis of glycogen from glucose
- Mainly liver and muscle, Cytosol

Glycogenolysis

- Degradation of glycogen into glucose
- Mainly liver and muscle, Cytosol

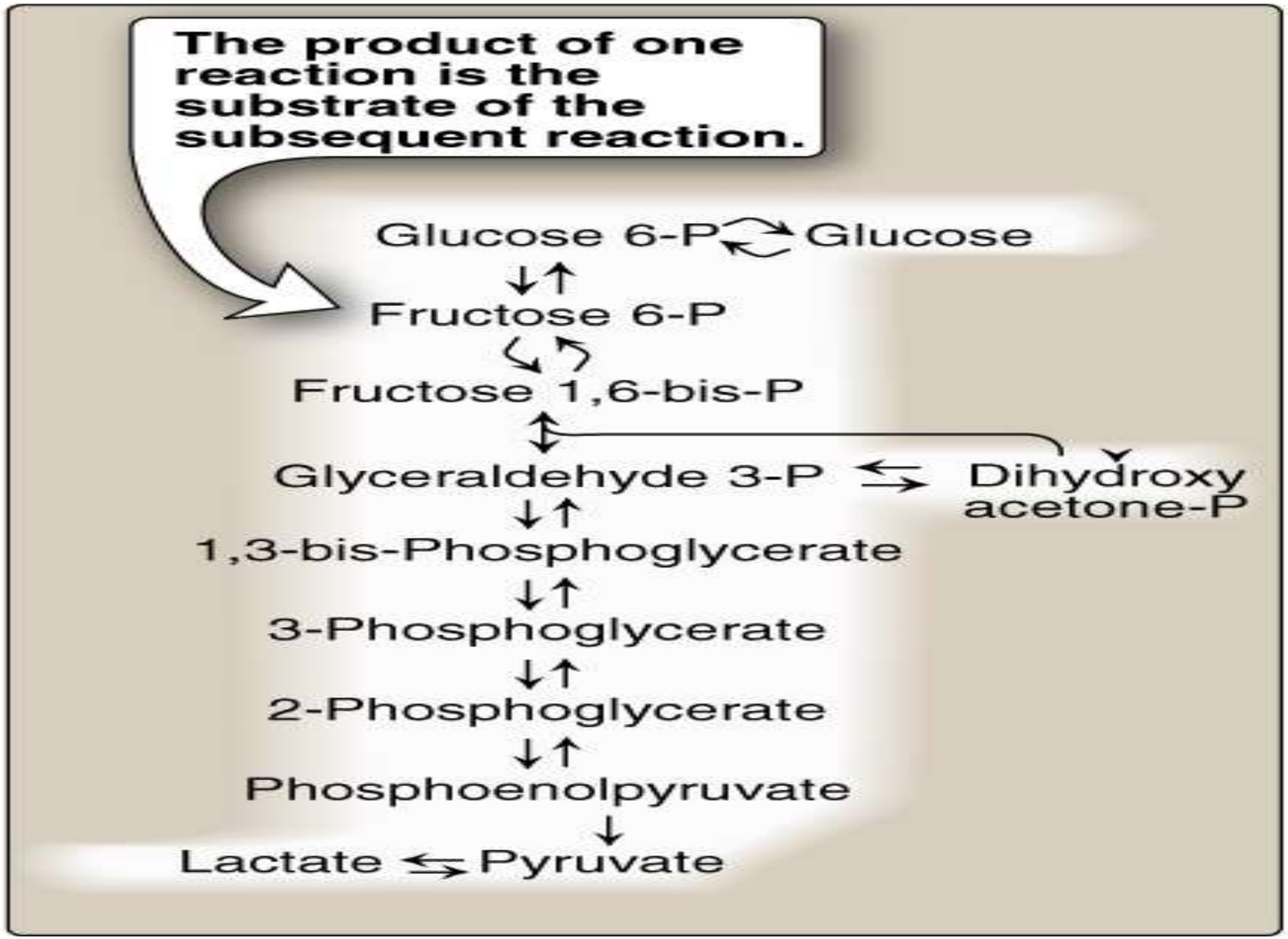
Glycolysis: Objectives

- Major oxidative pathway of glucose
- The main reactions of glycolytic pathway
- The rate-limiting enzymes/Regulation
- ATP production (aerobic/anaerobic)
- Pyruvate kinase deficiency hemolytic anemia

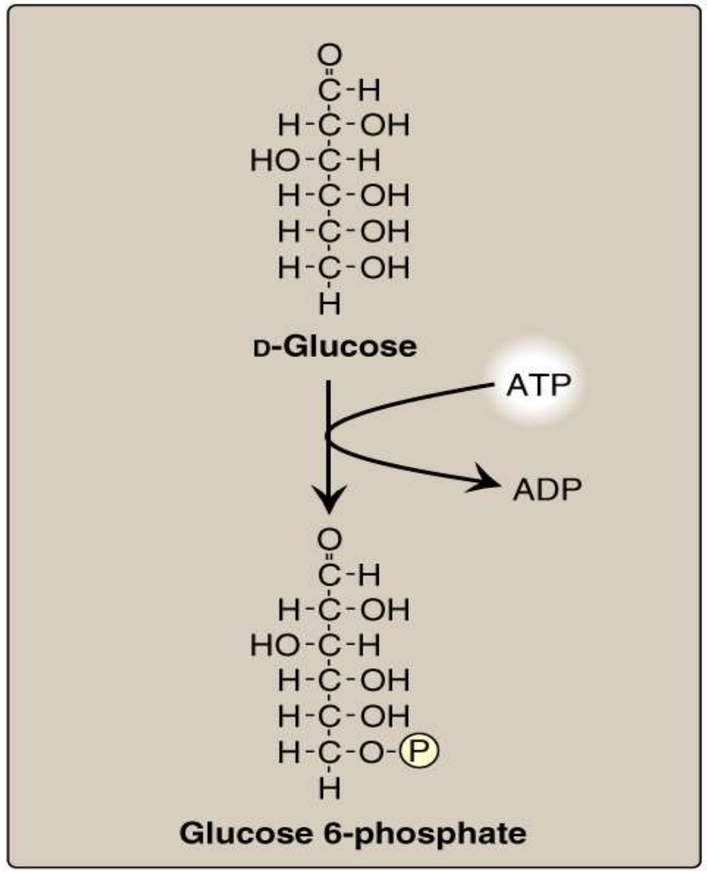
GLYCOLYSIS

- Glycolysis, the major pathway for glucose metabolism, occurs in the cytosol of all cells.
- It is unique, in that it can function either aerobically or anaerobically, depending on the availability of oxygen and intact mitochondria.
- It allows tissues to survive in presence or absence of oxygen, e.g., skeletal muscle.
- RBCs, which lack mitochondria, are completely reliant on glucose as their metabolic fuel, and metabolize it by anaerobic glycolysis.

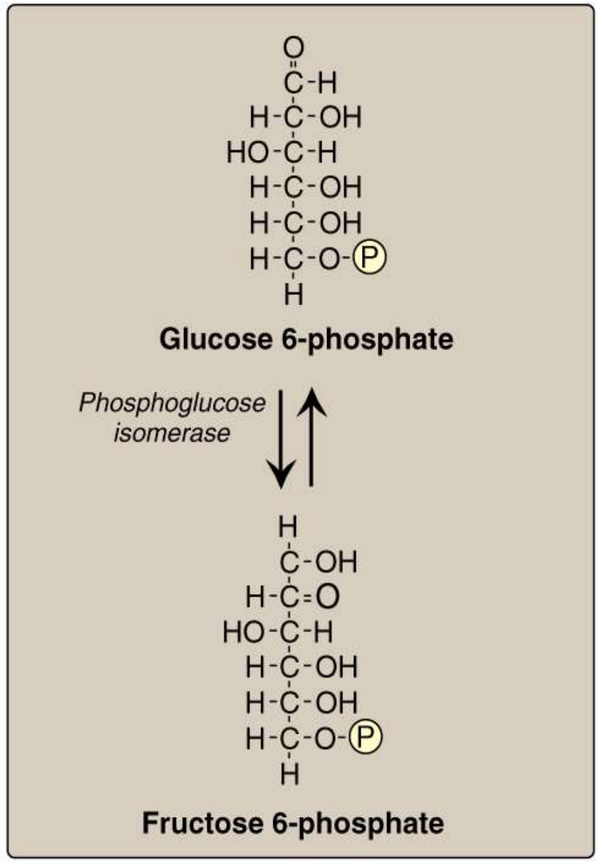
Glycolysis


The product of one reaction is the substrate of the subsequent reaction.
Glucose 6-P
Glucose
Fructose 6-P
Fructose 1,6-bis-P
Glyceraldehyde 3-P
Dihydroxy acetone-P
1,3-bis-Phosphoglycerate
3-Phosphoglycerate
2-Phosphoglycerate
Phosphoenolpyruvate
Lactate
Pyruvate

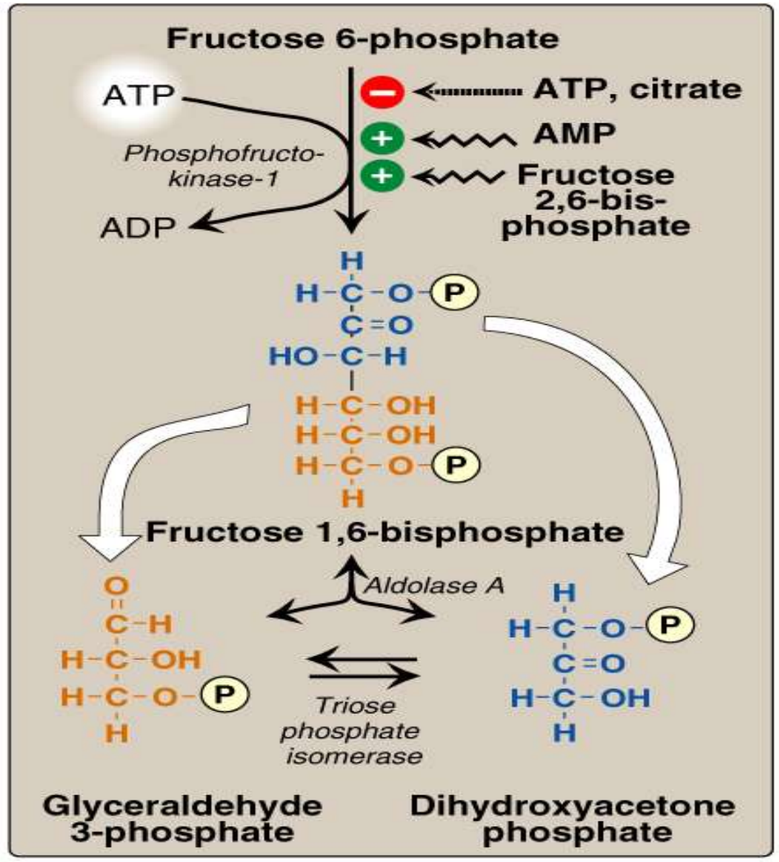
1


D-Glucose
ATP
ADP
Glucose 6-phosphate

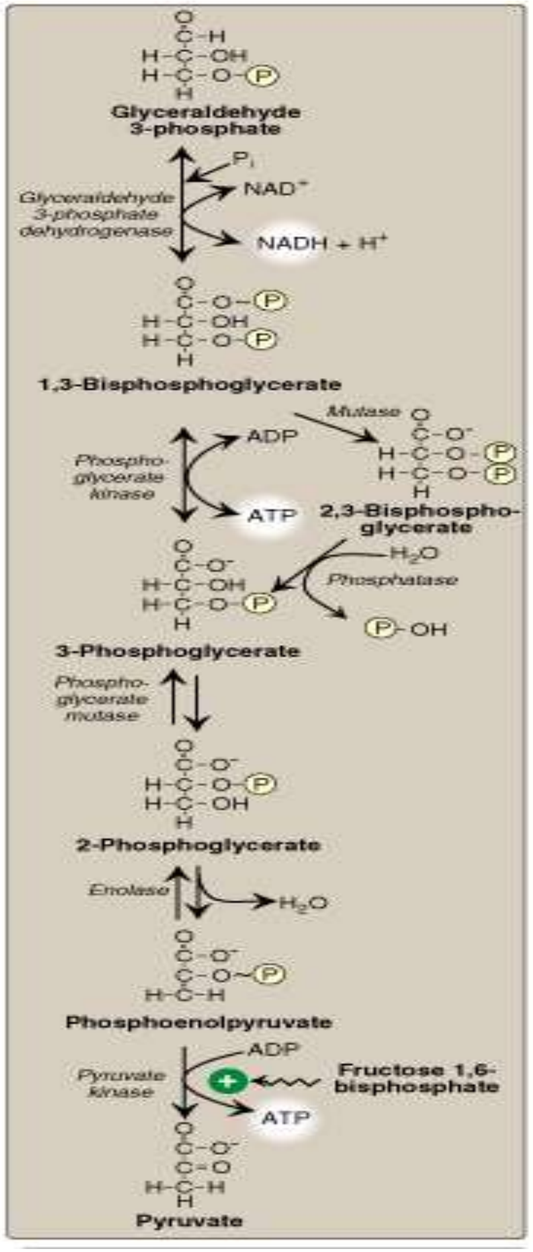
2


Glucose 6-phosphate
Phosphoglucose isomerase
Fructose 6-phosphate

3


Fructose 6-phosphate
ATP
ATP, citrate
AMP
Fructose 2,6-bis-phosphate
Phosphofructo-kinase-1
ADP
Fructose 1,6-bisphosphate
Aldolase A
Triose phosphate isomerase
Glyceraldehyde 3-phosphate
Dihydroxyacetone phosphate

4


Glyceraldehyde 3-phosphate
Glyceraldehyde 3-phosphate dehydrogenase
Pi
NAD+
NADH + H+
1,3-Bisphosphoglycerate
Mutase
Phospho-glycerate kinase
ADP
ATP
2,3-Bisphospho-glycerate
H2O
Phosphatase
P-OH
3-Phosphoglycerate
Phospho-glycerate mutase
2-Phosphoglycerate
Enolase
H2O
Phosphoenolpyruvate
Pyruvate kinase
ADP
Fructose 1,6-bisphosphate
ATP
Pyruvate

THANK YOU