BIOCHEMISTRY LECTURE

BY

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OUTLINE

- OLIGOSACCHARIDES : FUNCTIONS OF OLIGOSACCHARIDES
- POLYSACCHARIDES: STRUCTURE AND LINKAGES OF STARCH, GLYCOGEN AND CELLULOSE
- FUNCTIONS OF POLYSACCHARIDES- STARCH, GLYCOGEN AND CELLULOSE
- DIGESTION AND ABSORPTION OF SUGARS

MONOSACCHARIDES

- Monosaccharides have only one sugar unit and are called simple sugars.
- They have the empirical formula $(CH_2O)_{n,}$ where n is at least 3.
- Monosaccharides with three, four, five, six carbon atoms are called trioses, tetroses, pentoses and hexoses respectively.

OLIGOSACCHARIDES

- The word ‘oligo’ means ‘few’. Oligosaccharides consist of 2 to 10 monosaccharides.
- Disaccharides are simplest oligosaccharides and are formed when 2 monosaccharides are combined together with the elimination of a water molecule. Examples of disaccharides are lactose, sucrose and maltose.

- Disaccharides serve as source of nutrients. They are broken down to monosaccharides which are metabolized to yield energy.

- Higher oligosaccharides such as raffinose (a trisaccharide present in beans, cabbage, broccoli) and stachyose (a tetrasaccharide found in beans, peas, brans and whole grains) cannot be digested by humans.

- The problem of flatulence after ingestion of leguminous seeds (beans, peas and soya) is caused by higher oligosaccharides (such as raffinose and stachyose) that cannot be hydrolyzed by human intestinal enzymes. The glycosidic bonds of galactose in these seeds can be split only by bacterial enzymes and gases are released in the process.

POLYSACCHARIDES

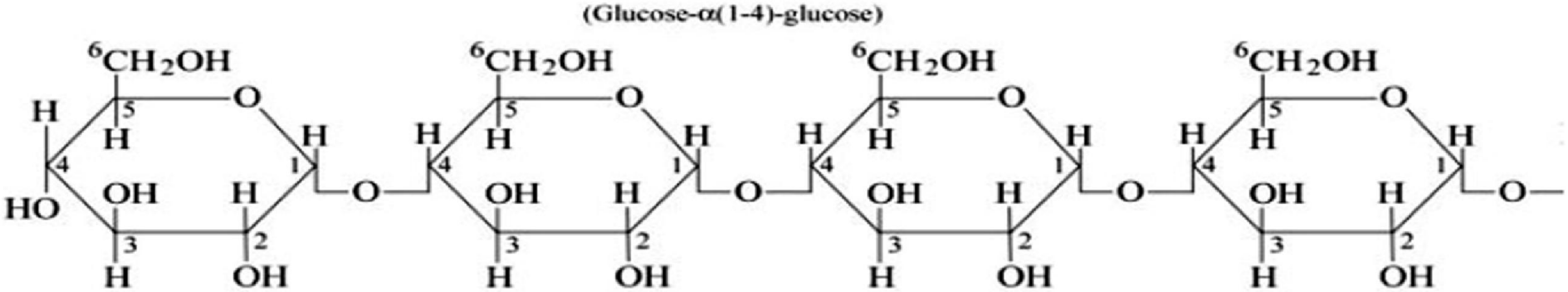
- Polysaccharides contain more than 10 sugar units.
- Polysaccharides having only one type of monosaccharide unit are called **homopolysaccharides or homoglycans** (e.g starch, glycogen, cellulose).
- Polysaccharides having different types of monosaccharide units are called **heteropolysaccharides or heteroglycans**.

STARCH (STRUCTURE AND LINKAGES)

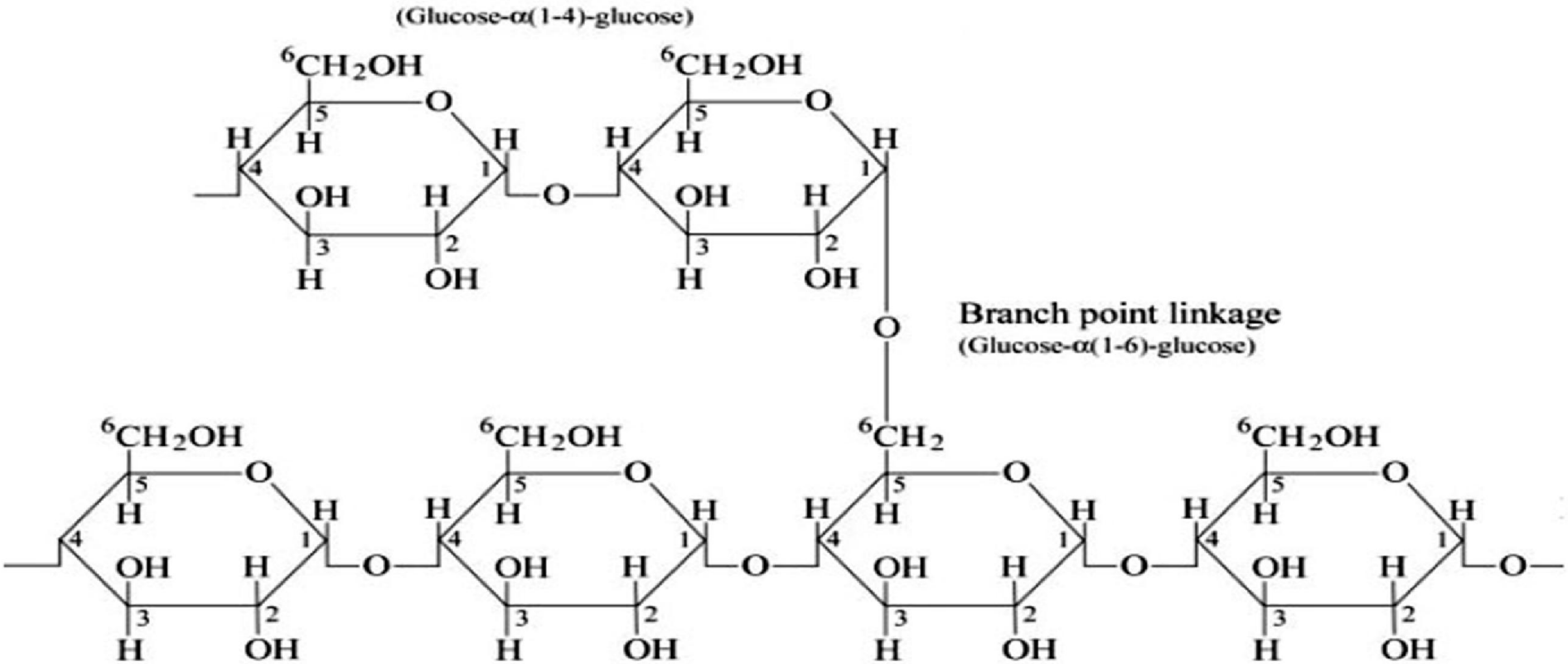
- Starch is a homopolymer of glucose forming an α-glucosidic chain. It consists of amylose (10-30%) and amylopectin (70-90%).

- **Amylose** is an unbranched polymer of about 100-1000 D-glucose residues linked by α (1 → 4) glucosidic bonds

- **Amylopectin** is a highly branched polymer of glucose units. Branches of polymeric side chains are attached via α(1 → 6) glucosidic bond to the linear chains of glucose residues linked by α(1 → 4) glucosidic bonds.



Amylose



Amylopectin

FUNCTIONS OF STARCH

- Starch is one of the most common storage polysaccharide in plants.

- Starch is a major source of energy in carbohydrate diets, complete hydrolysis of starch yields glucose which is further metabolized to produce energy.

GLYCOGEN

- Glycogen is the major form of storage polysaccharide in animals.
- Glycogen is a very large, branched polymer of glucose residues. The linear chains of glucose residues are linked by α (1 ⟶ 4) glucosidic bonds, while the branches are formed by α (1 ⟶ 6) glucosidic bonds.

- The branches in glycogen are smaller and more frequent than those found in amylopectin, and usually occur in every 8-12 glucose residues.

- In general, glycogen molecules are larger than starch molecules containing up to about 50,000 glucose residues.

CELLULOSE

- Cellulose is a structural polysaccharide. It is the most abundant natural polymer found on earth.

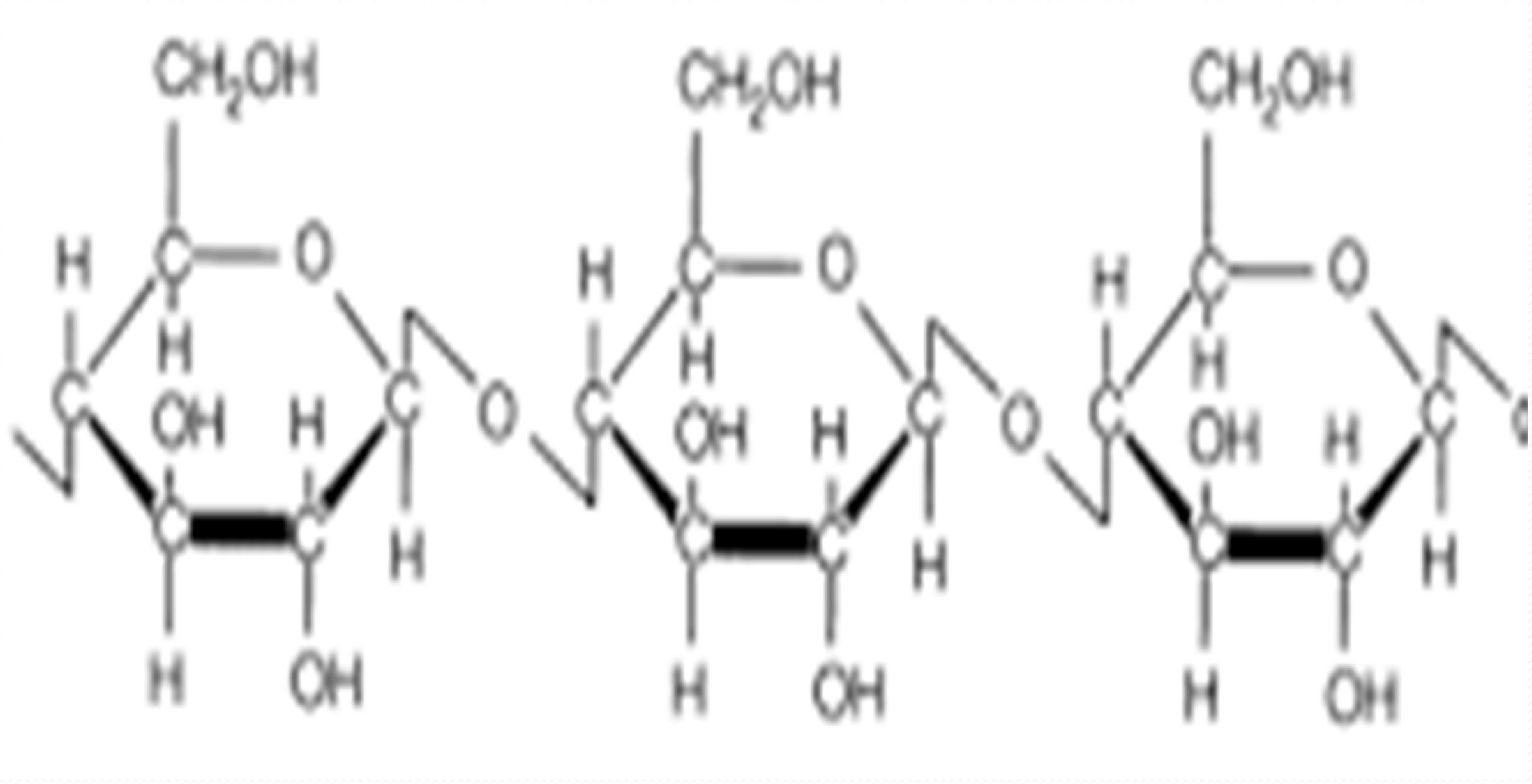
- Cellulose is found in the cell walls of plants and is one of the principal components providing physical strength.

- Cellulose is a linear homopolymer of glucose just as amylose.

- The structural difference, which completely alters the properties of this polymer, is that in cellulose the glucose units are linked by β (1⟶4) glucosidic bonds, whereas in amylose the linkage is α (1⟶ 4).

- Cellulose cannot be digested by humans because they lack the enzyme that hydrolyzes the β linkage. It is an important source of bulk in the diet and it increases the rate of movement of food along the gastrointestinal tract.

STRUCTURE OF CELLULOSE



DIGESTION AND ABSORPTION OF SUGARS

- Monosaccharides are absorbed directly without digestion
- Starch is hydrolyzed by α-amylase (an endosaccharidase) present in the saliva and pancreatic juice
- Amylase only attacks α (1 $\rightarrow$ 4) glucosidic bonds and does not hydrolyze α (1 $\rightarrow$ 6) glucosidic bonds of amylopectin

DIGESTION OF SUGARS

- α (1 → 6) glucosidase or debranching enzyme is responsible for the hydrolysis of α (1 → 6) glucosidic bonds and this gives room for the complete hydrolysis of amylopectin

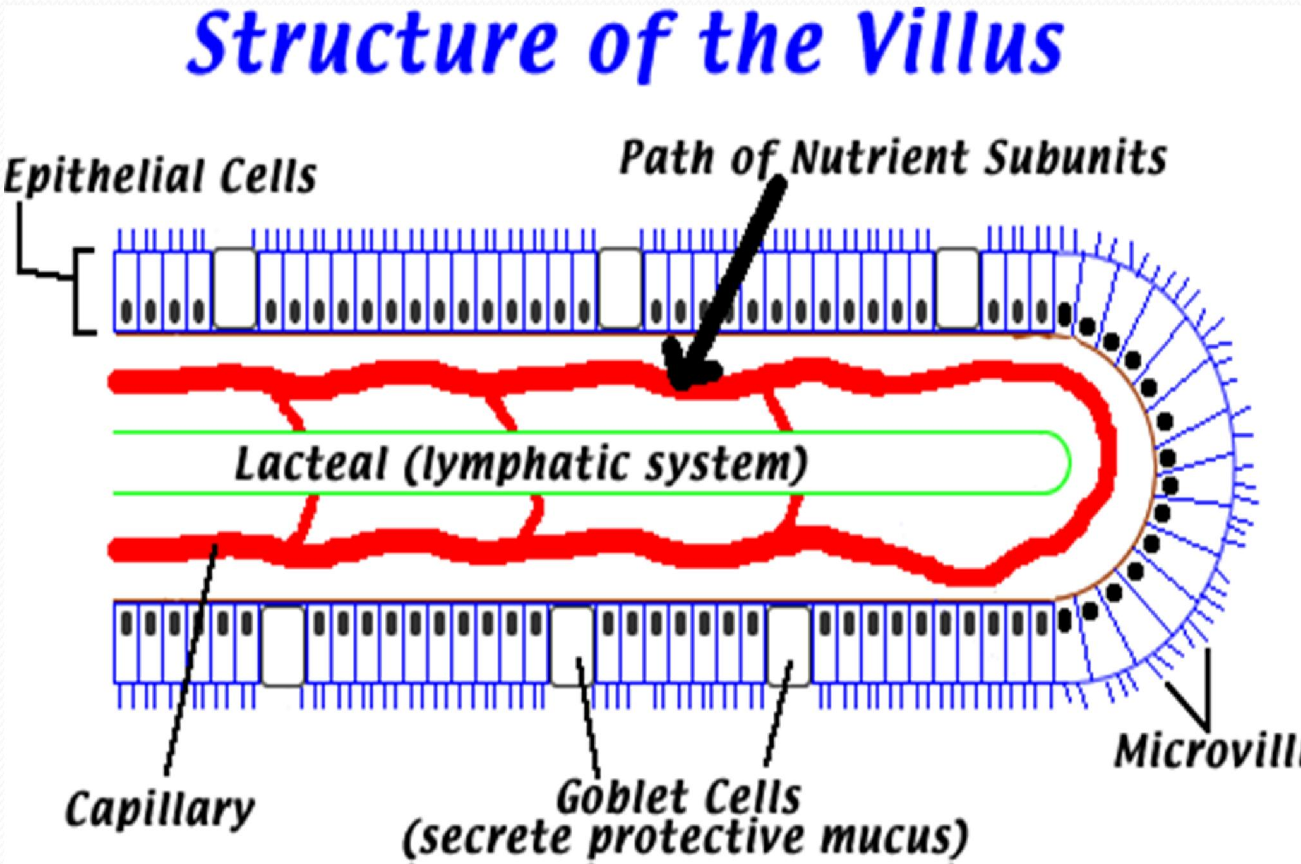
- Products of α – amylase digestion of starch are maltose, maltotriose and α – limit dextrin.

- Invertase is responsible for the break down of sucrose. Maltase hydrolyzes maltose while lactase hydrolyzes lactose.

ABSORTION OF SUGARS

- Absorption of sugars occurs in the small intestine
- The interior wall of the small intestines is covered with tiny finger-like projections called the 'villi' which play important role in the absorption of digested food.
- The villi are coated with epithelial cells that are responsible for nutrients absorption from the lumen of intestines. The epithelial cells of the villi are lined with microvilli.
- Embedded in the microvilli are digestive enzymes needed to further breakdown sugars. These include invertase (which breaks down sucrose), maltase (which breaks down maltose) and lactase (which breaks down lactose), giving rise to monosaccharides.
- The monosaccharides are the absorbed by the epithelial cells and transported to the capillaries of the villi from the capillaries, they enter the blood stream.
- They are then transported to various tissues such as liver, kidney, muscles for metabolism.

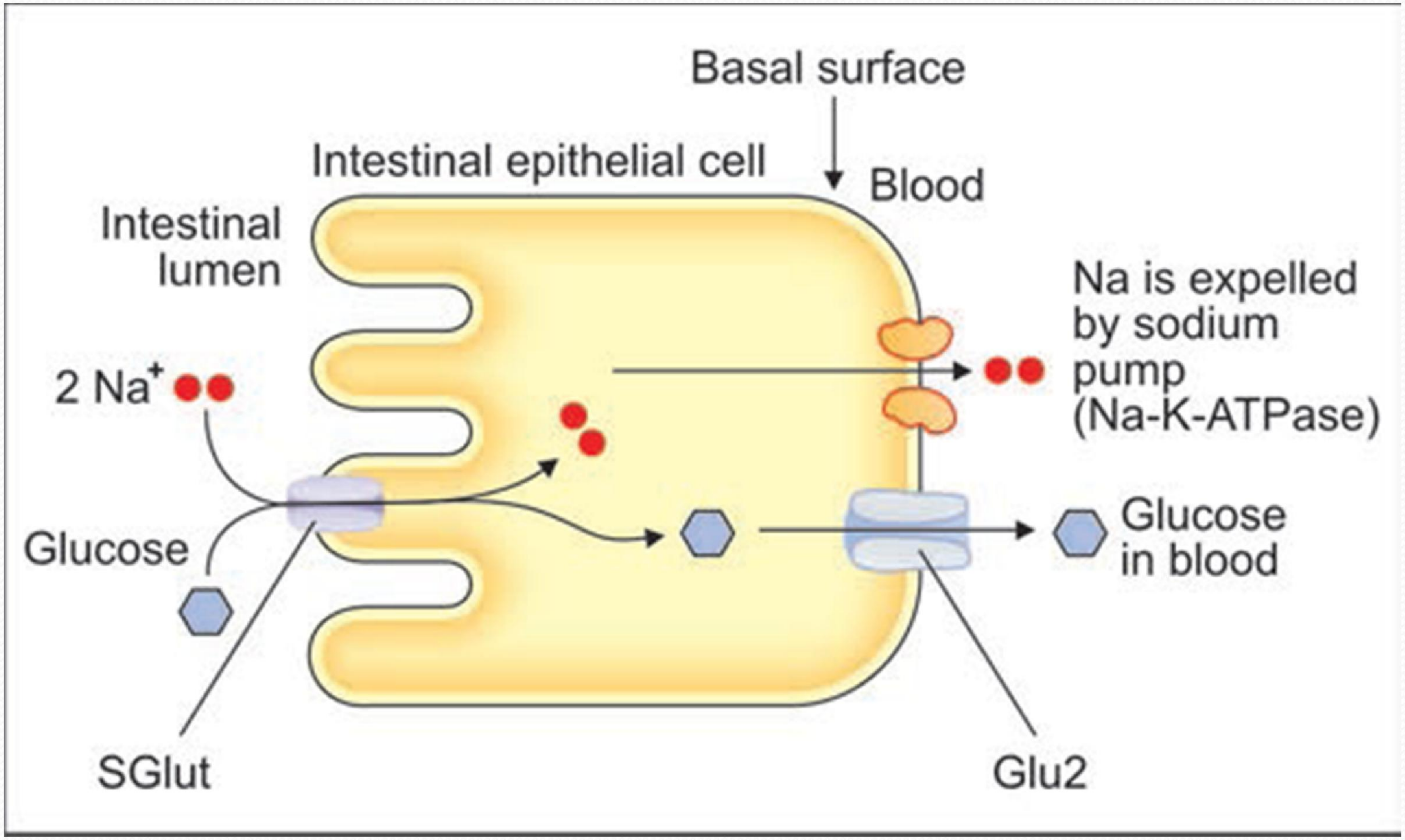
ABSORPTION OF SUGARS



MONOSACCHARIDES TRANSPORTERS

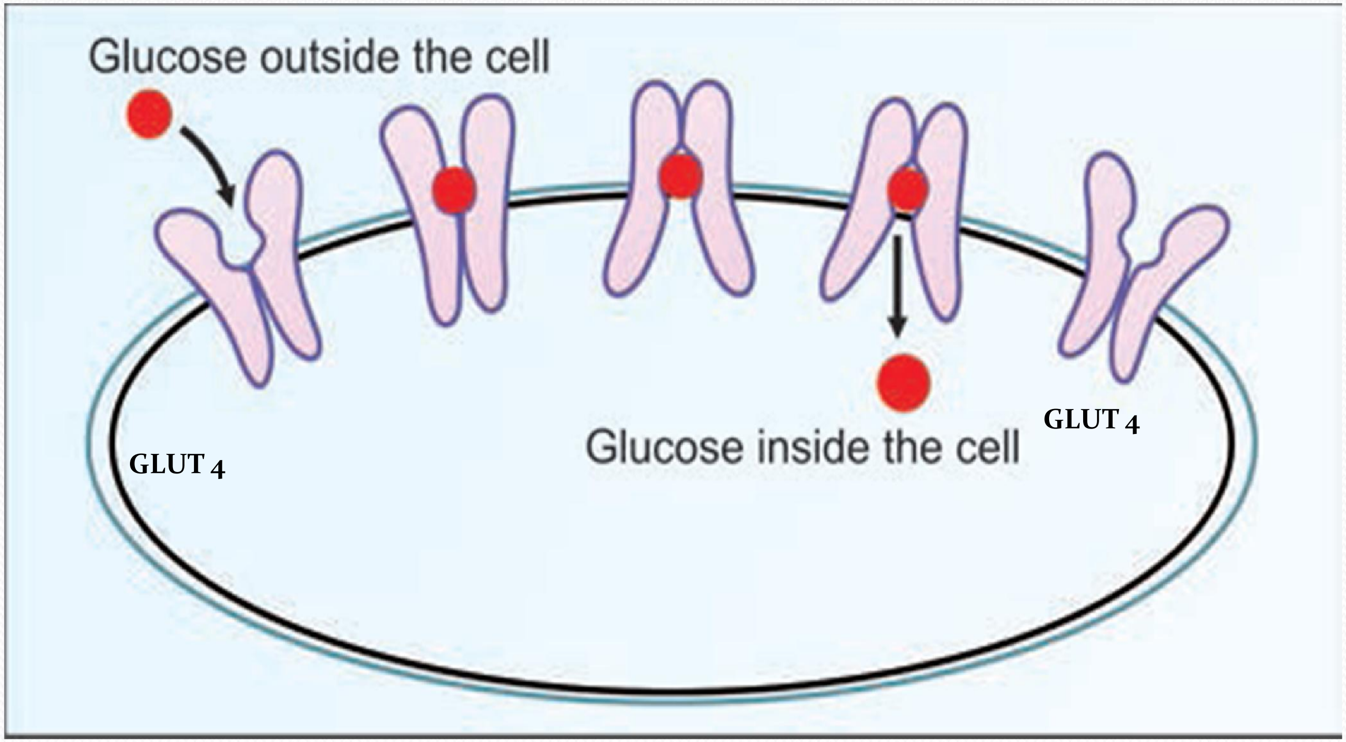
- Monosaccharide transporters enhance uptake of monosaccharides from the lumen into the cell. Examples are:
- **SGLUT 1** Sodium-monosaccharide co-transporter- 1 or Sodium Dependent Glucose Transporter-1 . It has a high specificity for D-glucose and D-galactose. It mediates transport of monosaccharides along with sodium from intestinal lumen into intestinal epithelial cells.

- **GLUT-2** accepts all 3 monosaccharides (glucose, galactose and fructose) and is present in the small intestine, liver, beta cells of pancreas , Glut-2 of the small intestine transports glucose from intestinal epithelial cells into the blood stream. GLUT 2 mediates glucose uptake by beta cells of pancreas. In Liver cells it mediates bi-directional fluxes of glucose i.e in and out of the cells.


Basal surface
Intestinal epithelial cell
Blood
Intestinal
lumen
Na is expelled
by sodium
pump
(Na-K-ATPase)
2 Na+
Glucose
Glucose
in blood
SGlut
Glu2

- GLUT 4: GluT4 is the major glucose transporter in skeletal muscle and adipose tissue. GluT4 is insulin sensitive (under the control of insulin). But other glucose transporters are not under the control of insulin. Insulin induces the movement of intracellular GluT4 molecules to the cell surface thus increasing glucose uptake by the cells.

- GluT1: RBC, placenta, brain, colon, retina. It mediates glucose uptake in the cells


Glucose outside the cell
Glucose inside the cell
GLUT 4
GLUT 4