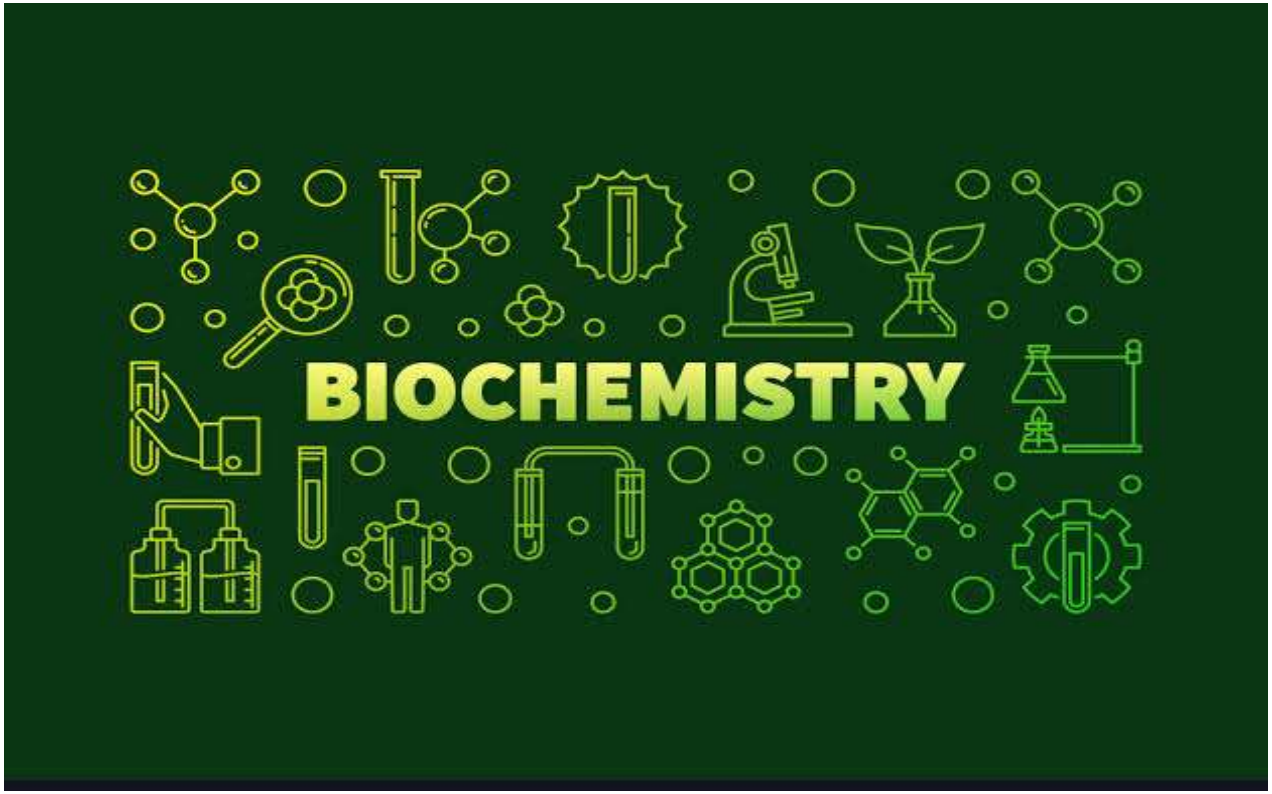


BC3.2 Describe the digestion, absorption and transport of carbohydrates from food along with its disorder

SLO

The learner will be able to:

- **Outline the digestion of carbohydrates with clinical application**
- **Describe the absorption of glucose and glucose transporters with clinical application**

- **Cooking** helps in breaking **of glycosidic linkages in polysaccharides ,** makes the digestion process easier
- In the diet carbohydrates as **polysaccharides (starch, glycogen),**

  Disaccharides (sucrose and lactose). hydrolysed to monosaccharide units in gastro intestinal tract.

- Digestion in mouth
- Pancreatic digestion by PJ
- Intestinal Digestion by IJ

- **Digestion in mouth by the salivary alpha-amylase ,** inhibited by gastric HCl

- **Pancreatic digestion by PJ alpha-amylase** which will hydrolyse **alpha-1,4 glycosidic linkages randomly,**

  Products are smaller subunits like

  maltose, isomaltose, dextrins and branched or unbranched oligosaccharides.

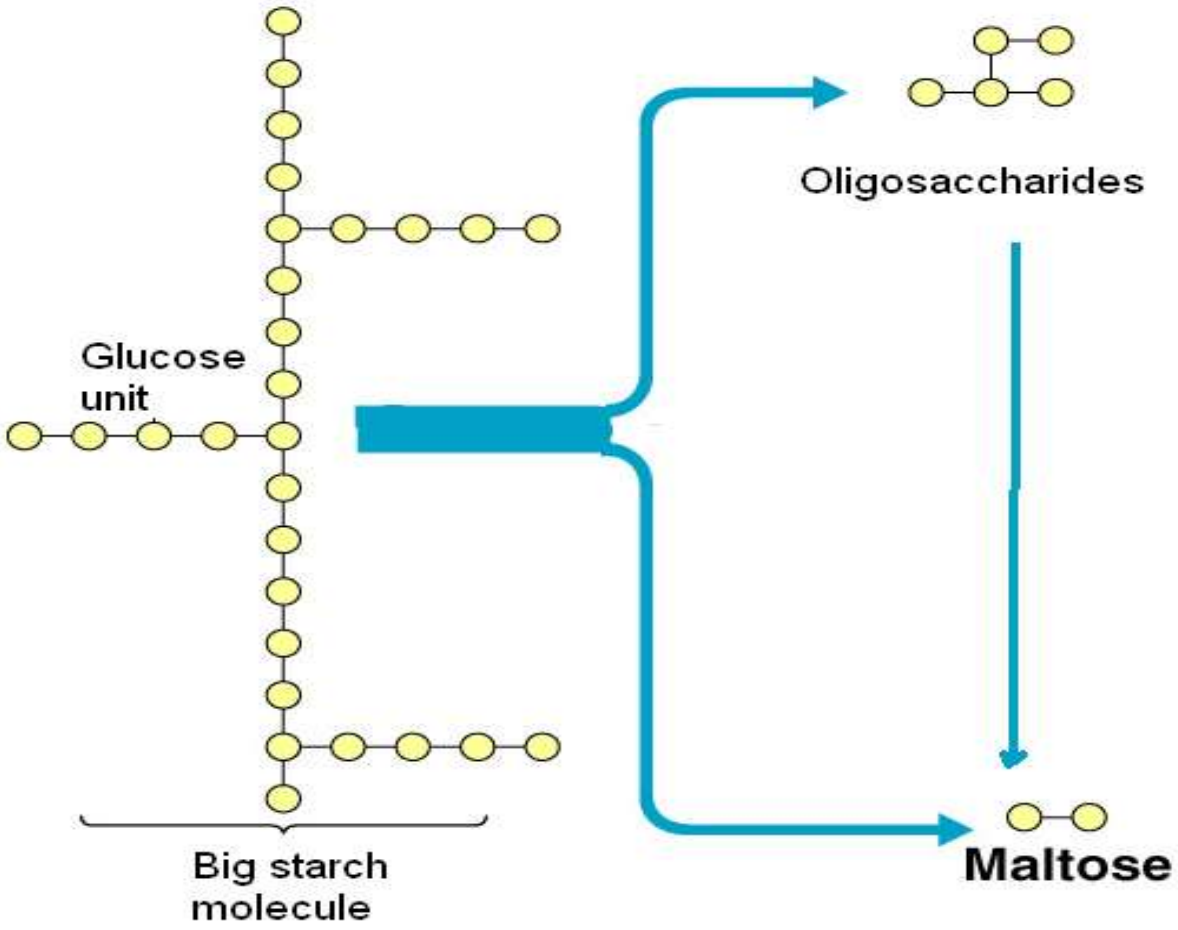
- **Intestinal Digestion**

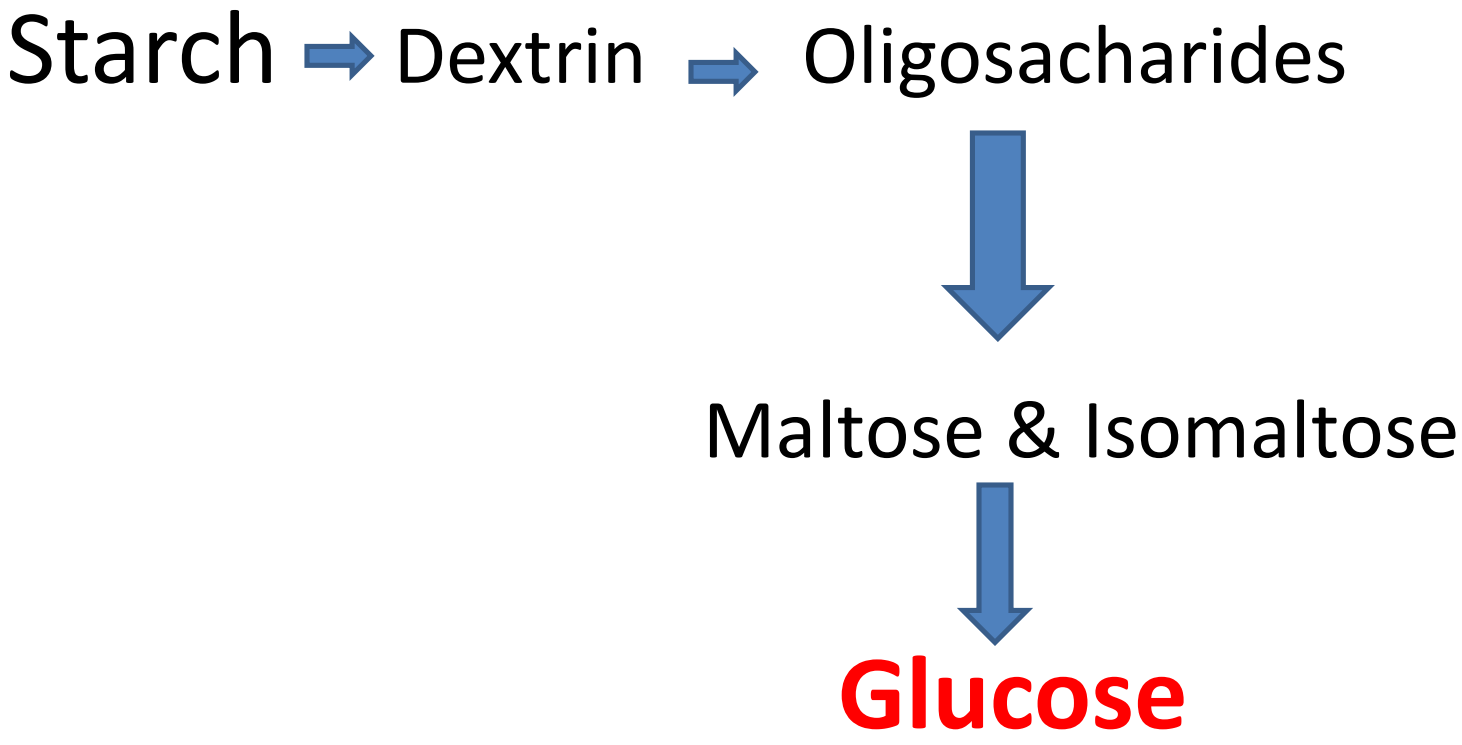
  The intestinal juice (succus entericus) and brush border of intestinal cells contain **sucrase, maltase, isomaltase and lactase**

End products The monosaccharides are then absorbed

Enzyme complex in Jejunum

- Sucrase Isomaltase complex
  - **Sucrase-maltase site**
    (Alpha1-2,alpha1-4)
  - **Isomaltase maltase site**
    (Alpha1-6, alpha1-4)
- Beta-Glycosidase complex
  - beta-galactosidic bond
    (Lactase)
  - Beta glucosidase bond
    (glucose ceramide)


Glucose
unit
Oligosaccharides
Big starch
molecule
Maltose


Starch
Dextrin
Oligosacharides
Maltose & Isomaltose
Glucose

Clinical application

Lactose Intolerance

- Lactase hydrolyzes lactose to glucose and galactose. **Lactase** is present in the brush border of enterocytes.
- **Deficiency of lactase** leads to lactose intolerance. lactose accumulates in the gut.
- Irritant diarrhea and flatulence are seen.
- should be treated immediately in newborns by giving lactose free formula diet instead of milk.

Congenital (primary) or Acquired (secondary) causes. As age **advances, l**actase enzyme will be lost.

- **Acquired lactose intolerance** sudden change into a milk based diet. Lactase is an **inducible enzyme.** Milk could be withdrawn temporarily, the diarrhoea will be limited.
- **Curd** is an effective treatment, lactobacilli in curd contains the enzyme lactase. Lactase is abundantly seen in **yeast**, which is also used in treatment

- Deficiency of lactase (alactasia) in Asian population.
- Adults have low lactase activity than children (hypolactasia).

- Elderly people develop lactose intolerance when more milk is consumed

Dietary Carbohydrates and their Digestion

Name of CHO	Dietary source	Digestive Enzyme	Location	Products
Starch	Cereals – Rice, Wheat	Alpha amylase	Salivary amylase Pancreatic amylase	Dextrins Maltose Isomaltose
Glycogen	Meat	Alpha amylase	Pancreatic amylase	Maltose and isomaltose
Lactose	Milk sugar	Lactase	Intestinal brush border	Glucose and galactose
Sucrose	Cane sugar	Sucrase	Intestinal brush border	Glucose and fructose

Carbohydrates Absorption

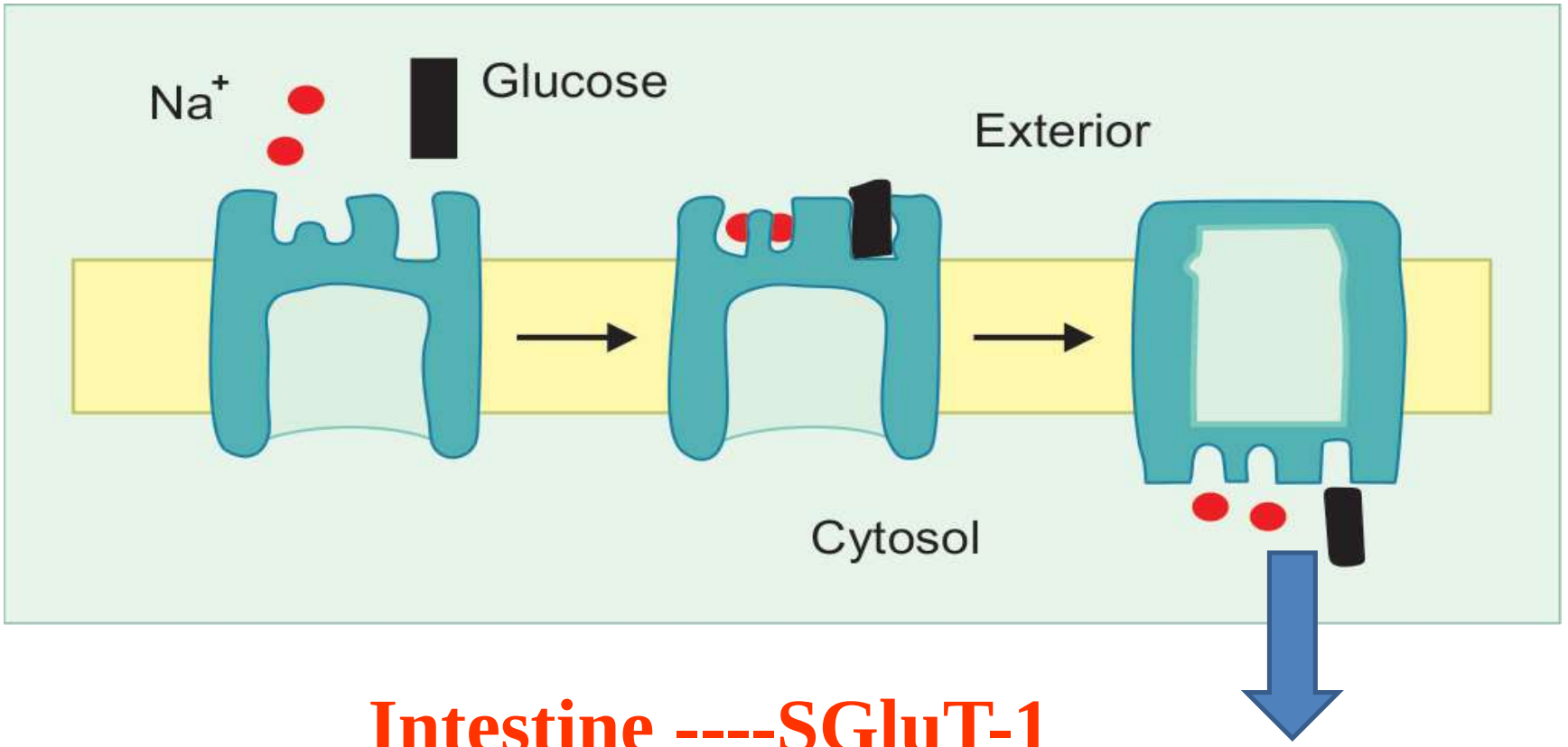
- A) Glucose absorption
- B)Other monosacharides absorption

A) Glucose absorption

From **intestinal lumen into intestinal cell** is by co-transport mechanism (secondary active transport)

Sodium Dependent Glucose Transporter (SGluT)

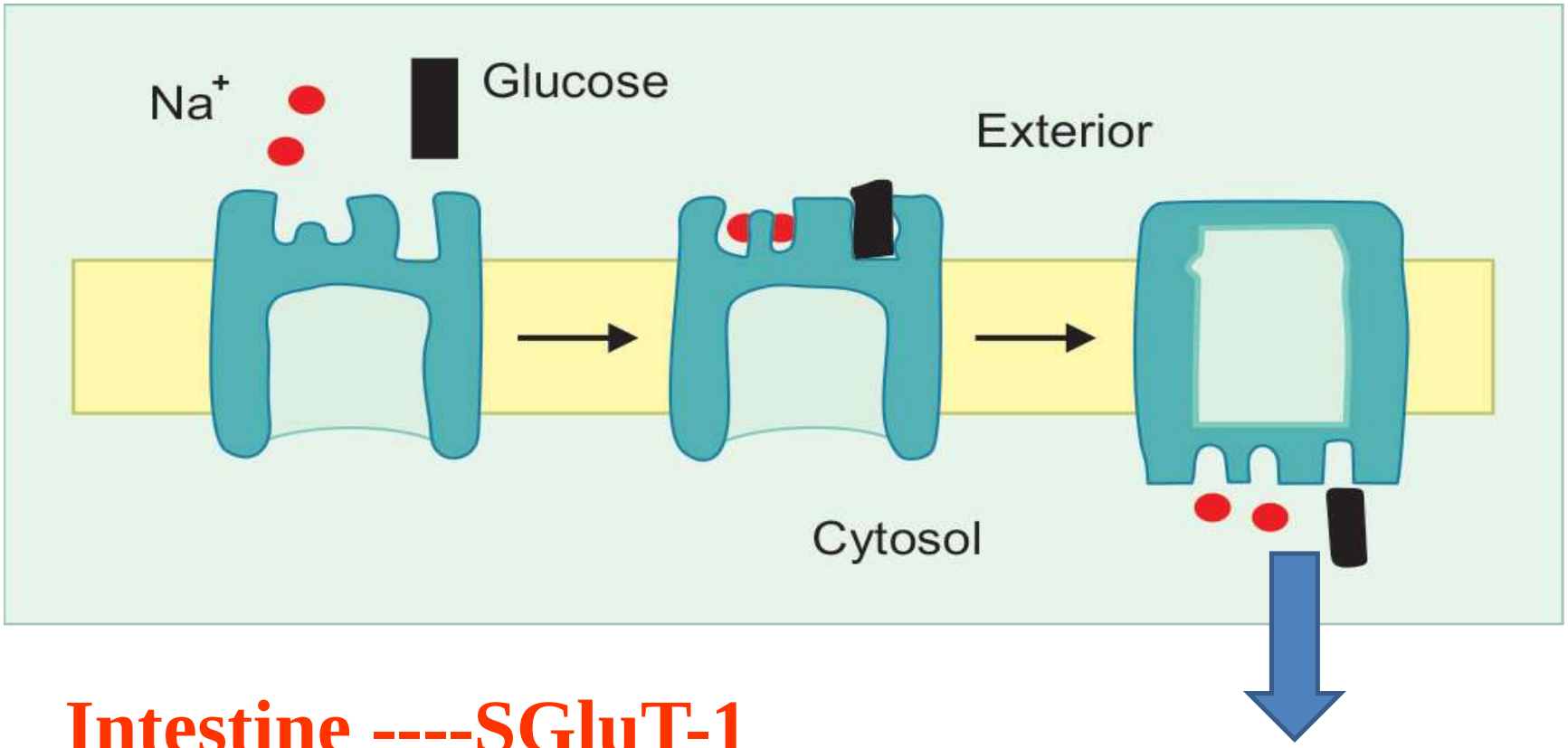
SGluT Cotransport system at luminal side; (From lumen to cell)



Intestine ----SGluT-1

kidney ------ SGluT-2

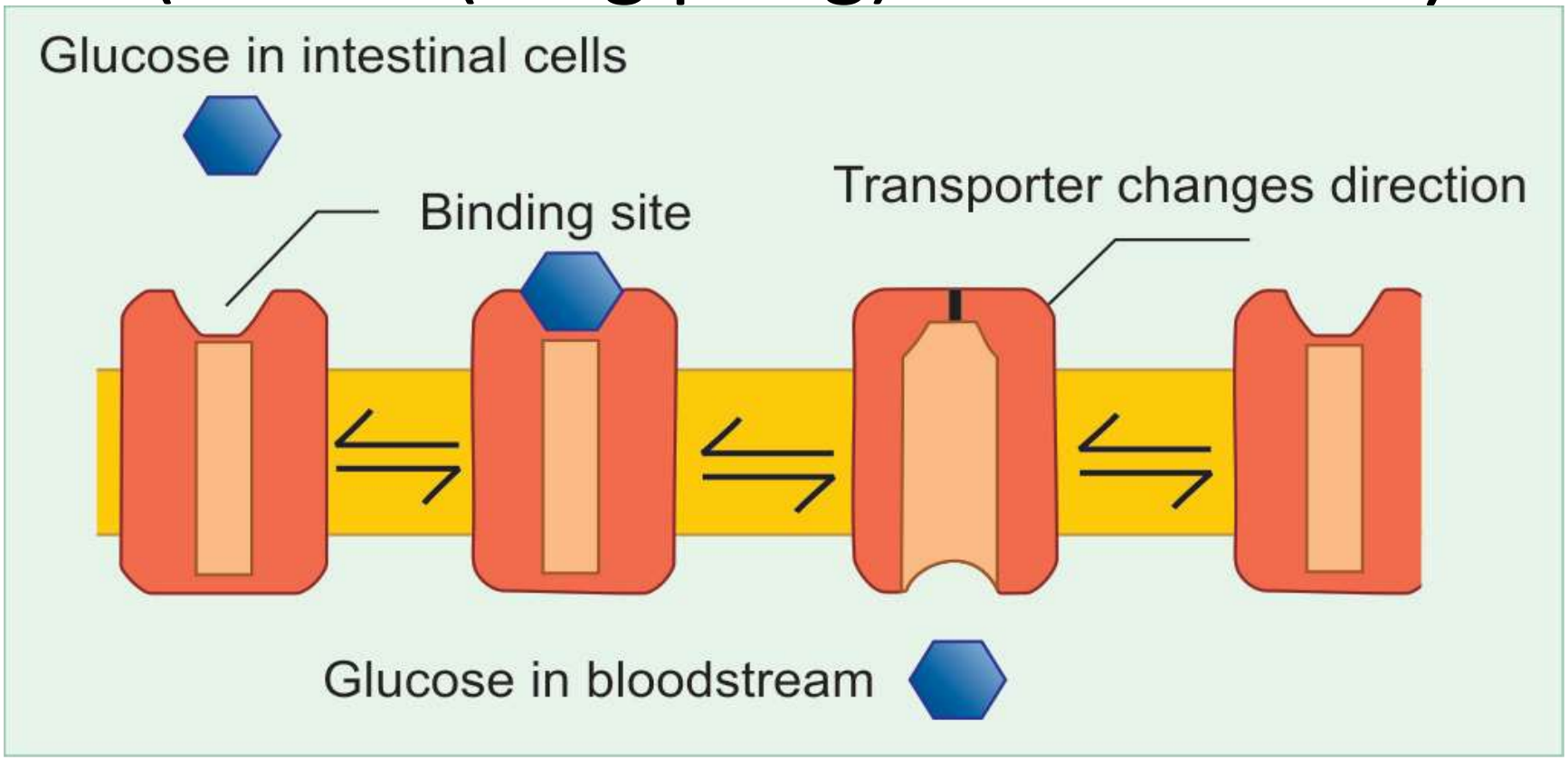
SGluT Cotransport system at luminal side; (From lumen to cell)



Intestine ----SGluT-1
kidney ------ SGluT-2

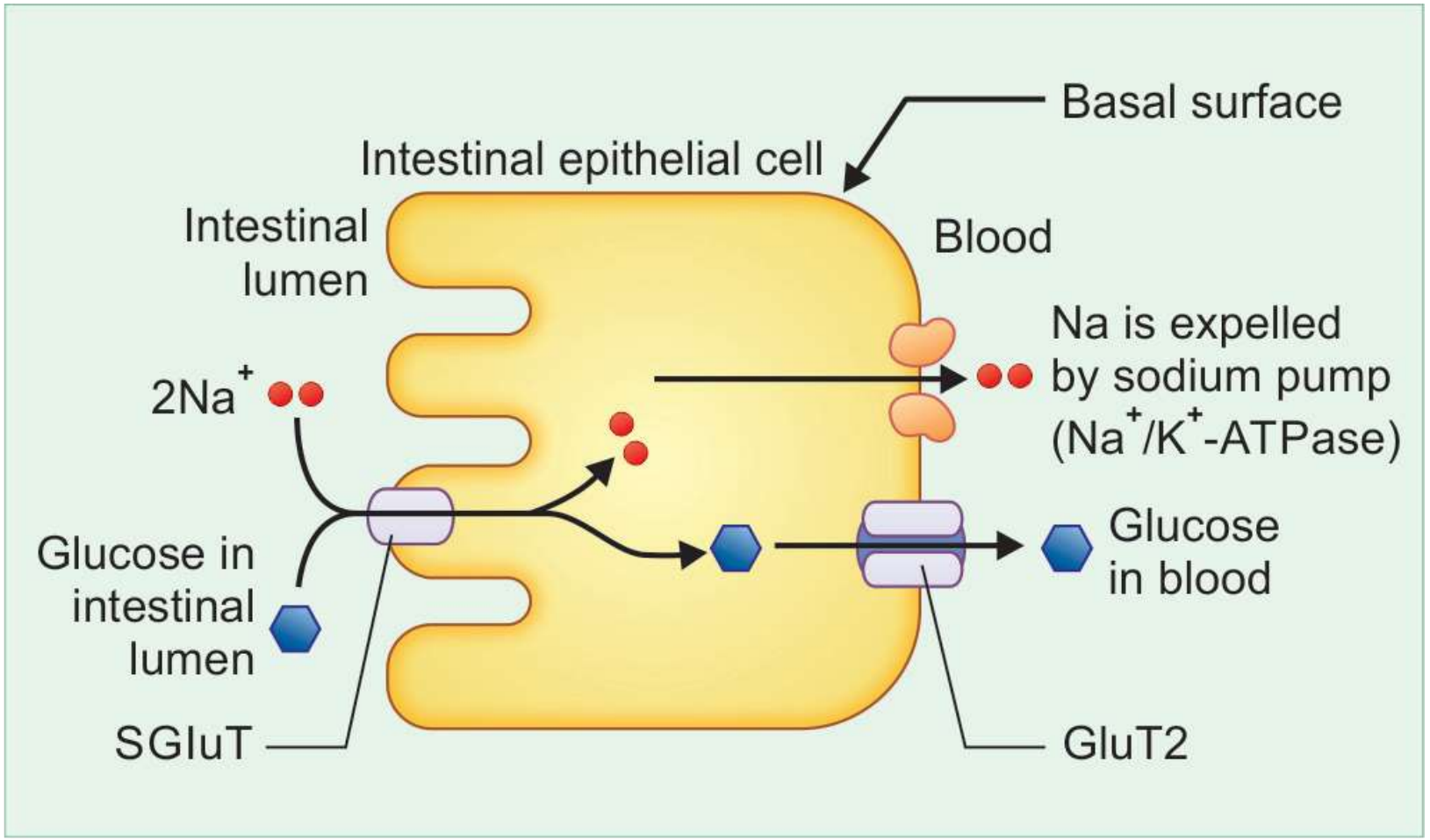
Sodium pump
Secondary active transport)

Intestinal cell to blood
(Glu T2 (Ping pong) Mechanism)



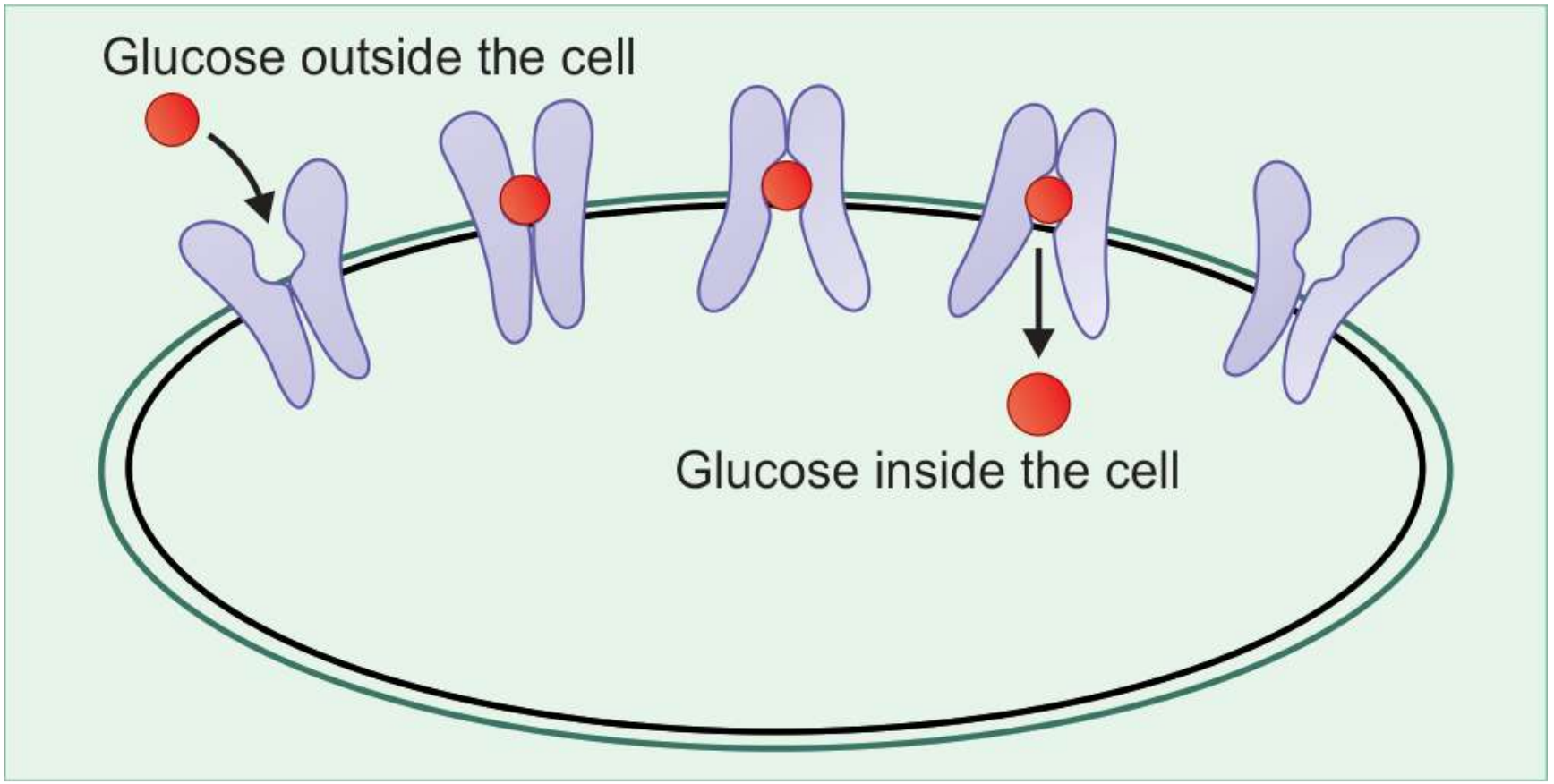
Glucose Transporter Type 2 (GluT2)

uniport, facilitated diffusion system

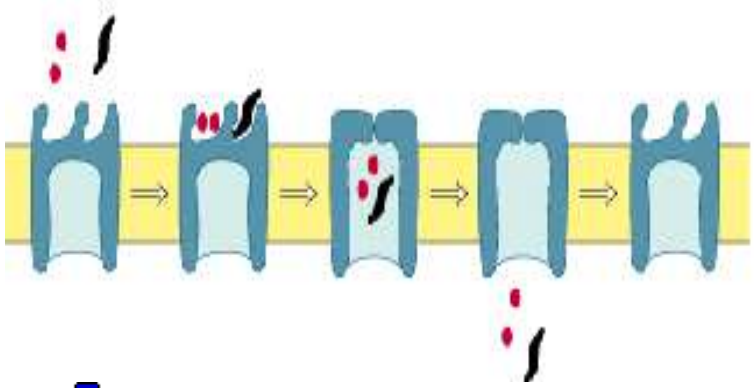

Basal surface
Intestinal epithelial cell
Intestinal lumen
Blood
Na is expelled by sodium pump (Na^+/K^+-ATPase)
$2Na^+$
Glucose in intestinal lumen
Glucose in blood
SGluT
GluT2

GluT4Mechanism

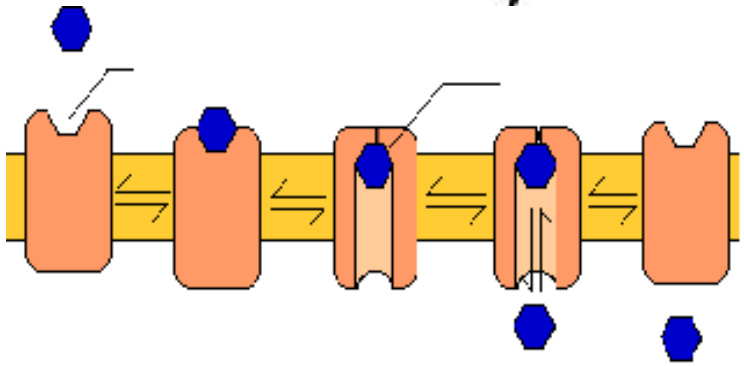
in skeletal muscle,heart muscle &adipose



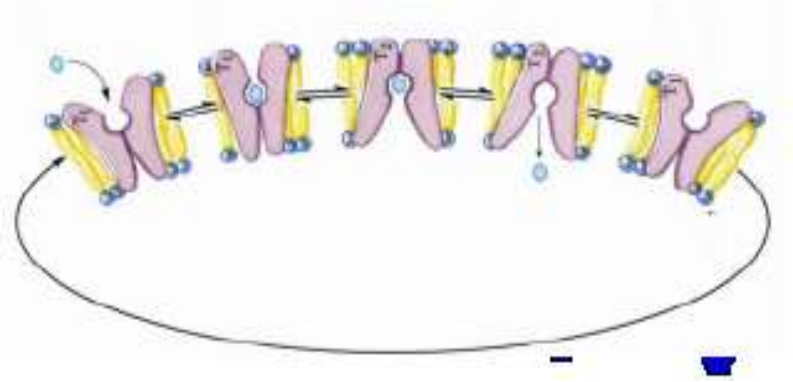
Glucose transport in cells



SGluT. Sodium and glucose Co-transport at luminal side;



Glu2 at vascular site.



GluT4.Glucose transport in cells

Glu T2 Mechanism

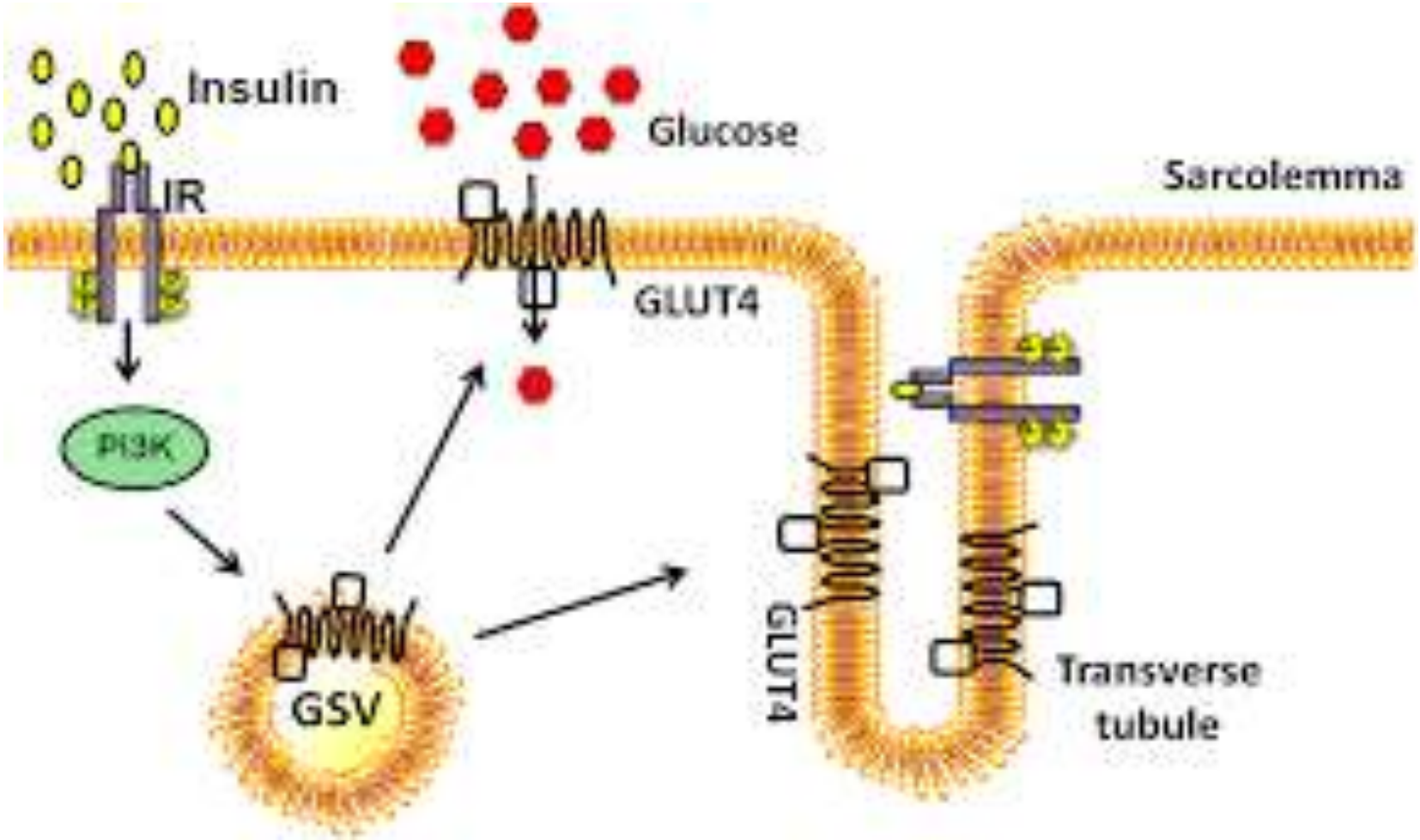
- **Well-fed state(blood sugar level is high) glucose is taken up by liver and deposited as glycogen.**

- **This mechanism also enables the pancreas to monitor the glucose level and adjust the rate of insulin secretion**

GluT4Mechanism

in skeletal muscle,heart muscle &adipose

- The GluT4 is **under control of insulin.**
- Other glucose transporters are not under the control of insulin.
- Insulin induces intracellular GluT4 molecules to move to the cell membrane and **thus increases glucose uptake.**


Insulin
Glucose
IR
Sarcolemma
GLUT4
PI3K
GSV
GLUT4
Transverse
tubule

Clinical application of CHO absorption

- 1)SGluT-1 is defective in Glucose galactose malabsorption
- 2)SGluT-2 defective in congenital renal glycosuria

Oral rehydration fluid.

- 3)Glucose in oral rehydration fluid allows uptake of sodium to replenish body sodium chloride.

- **Insulin induces the movement of intracellular GluT4 molecules to cell surface&increases glucose uptake**
- **In Type 2 diabetes mellitus, insulin resistance is seen in muscle and fat cells.**
- **In diabetes, entry of glucose into muscle is only half of normal cells.**
- **Reduced recycling of membrane bound GluT4**

B.Other monosacharides absorption

- Galactose absorption by same transporter as Glucose **(SGluT)**
- Fructose absorption by **Glu T5** transporter
- Others by **carrier mediated facilitated transport**

Glucose transporters		
	Present in	Properties
GluT1	RBC, brain, kidney,	Glucose uptake in colon, retina, most of cells placenta
GluT2	Serosal surface of intestinal cells, liver, beta cells of pancreas	**Glucose uptake in liver; glucose sensor in beta cells**
GluT3	Neurons, brain	Glucose into brain cells
GluT4	Skeletal, heart,adipose tissue	**Insulin mediated muscle, adipose tissue glucose uptake**
GluT5	Small intestine, testis, sperms, kidney	**Fructose transporter**; poor ability to transport glucose
SGluT	Intestine, kidney	**Cotransport; from lumen into cell**

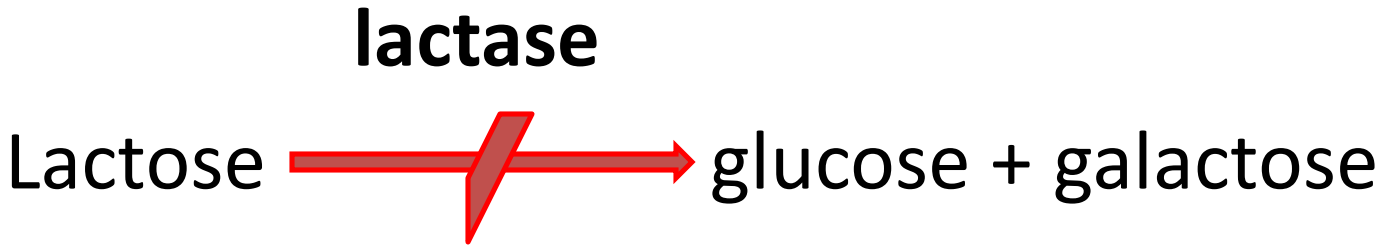
Clinical Case

- A young man visited the physician complaining of bloating and diarrhea.His eyes were swollen and the physician noted additional signs of dehydration .The patient's temperature was normal. The episode occurred after ingesting a lot of ice cream at a birthday party. The patient reported prior episodes following ingestion of a significant amount of dairy products.

- 1.What is the provisional diagnosis ?
- 2.Which enzyme is likely to be deficient?
- 3.What dietary advice would you give the patient?

- **Diagnosis : Lactose Intolerance**

Enzyme deficient :Lactase



Dietary Advice : withdrawal of ice cream & other dairy products, as milk contains lactose

but **curd can be given; as lactobacilli present in curd contains lactase**. **Yeast is also rich in lactase.**

What are Isomers?

Definition: Compounds having the same molecular formula, but differ in chemical and physical properties.

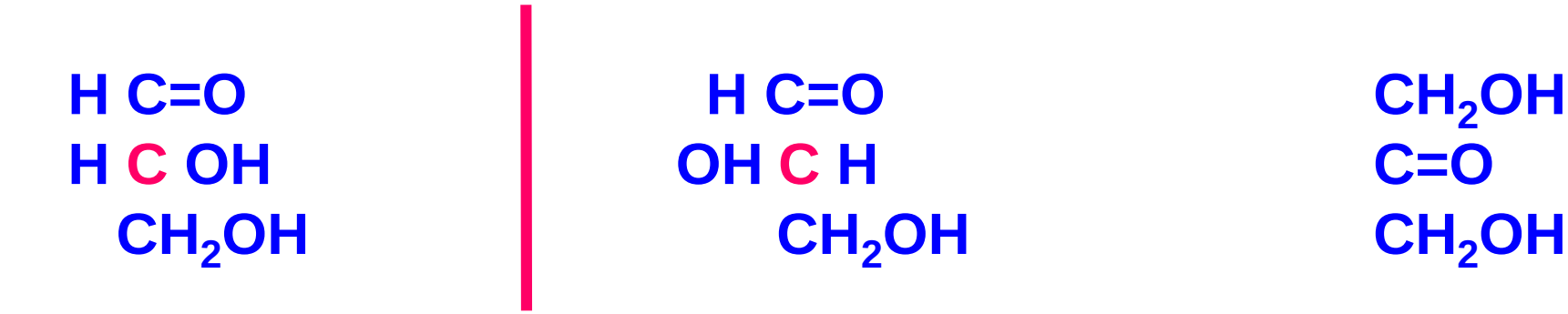
Phenomenon is called Isomerism.

2 Types of Isomerism

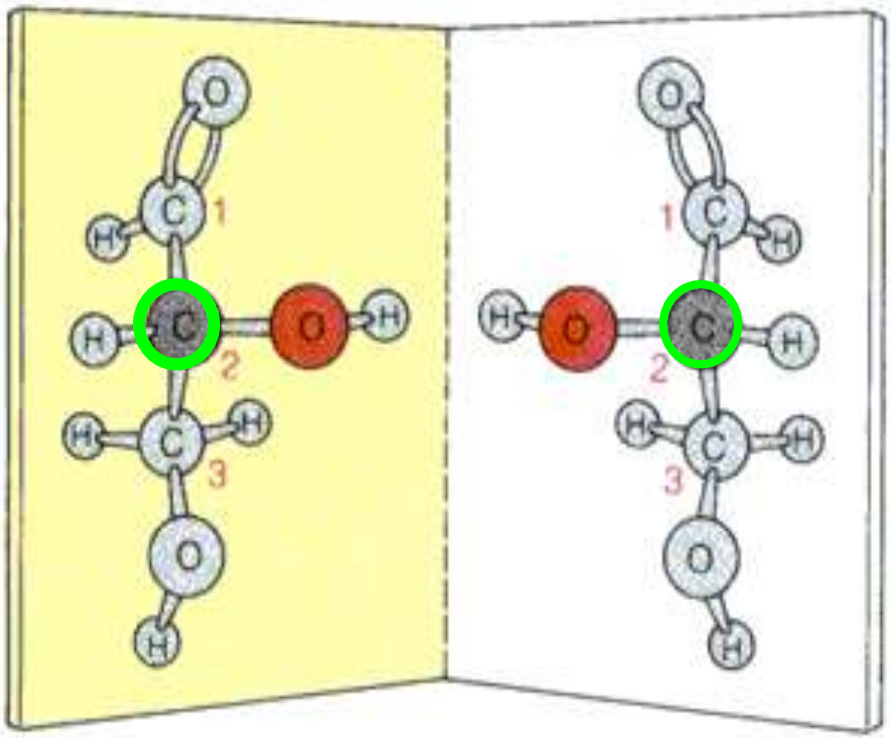
- Structural (Positional)
- Stereo

Isomerism of Carbohydrates

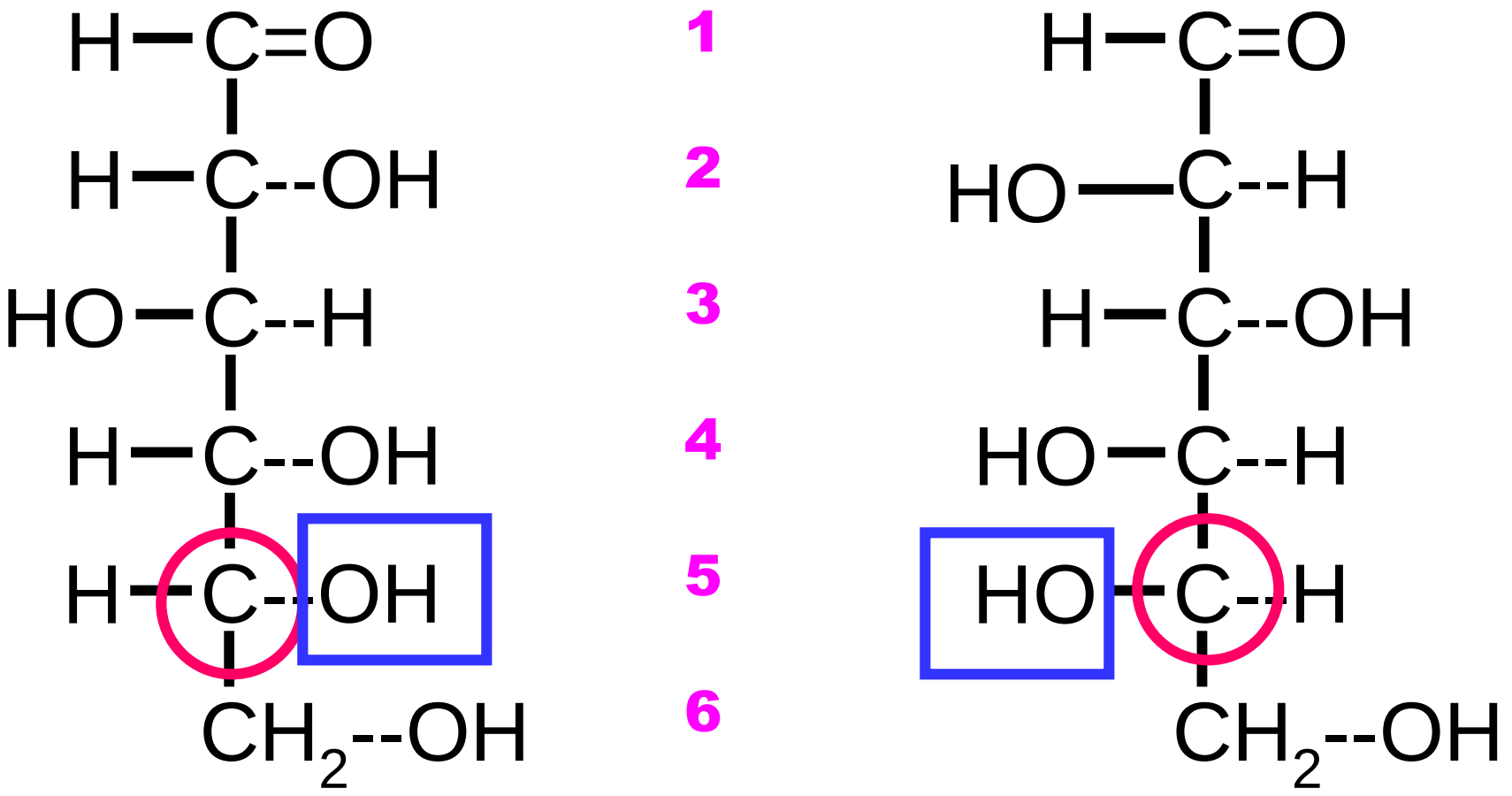
1. Optical Isomerism: Presence of asymmetric carbon atom allows the formation of Optical isomers.



D Glyceraldehyde **L Glyceraldehyde** **DHA**



D & L forms are mirror images of each other and are called Enantiomers

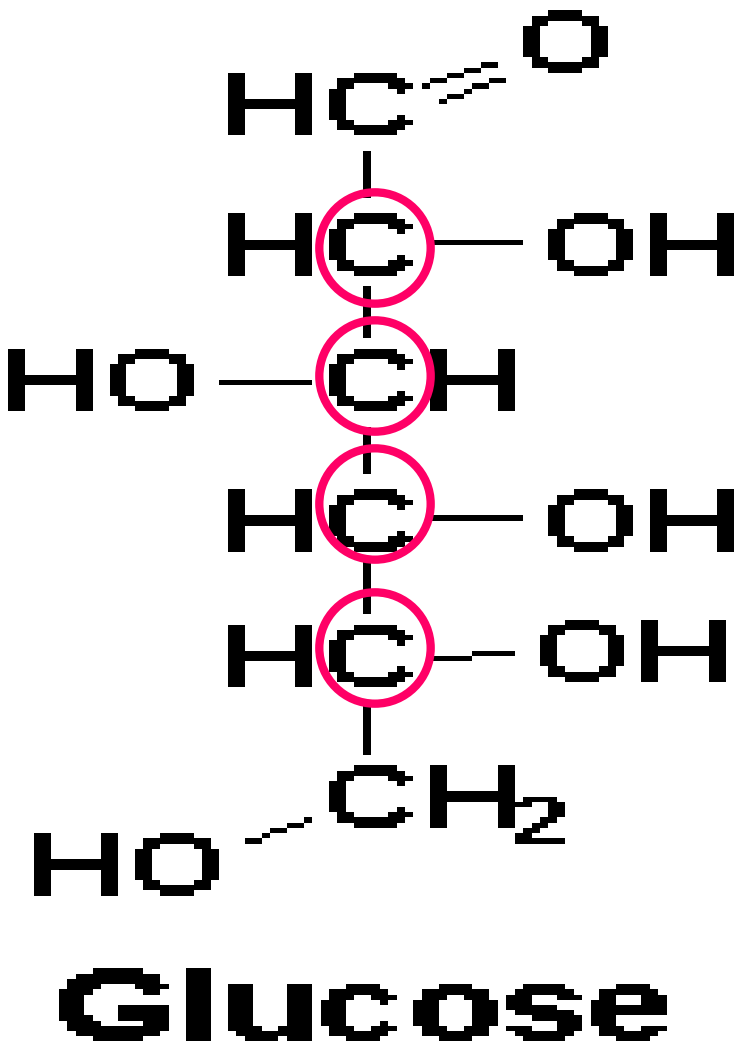


D-glucose (natural) **L-glucose**

Penultimate (reference) carbon atom

- Lebel Vont Hoff rule of ‘n’ – Total number of optical isomers **will be 2^n** where n is the number of asymmetric Carbon atom.
- So for Glyceraldehyde there will be 2 optical isomers-
- D Glyceraldehyde and L Glyceraldehyde

- No of asymmetric Carbon in an aldo hexose is 4
- So No of possible isomers $2^4 = 16$



Most of the monosaccharides in mammalian system are of D series.

Eg. D Glyceraldehyde, D Erythrose
D Ribose D Glucose
D Fructose

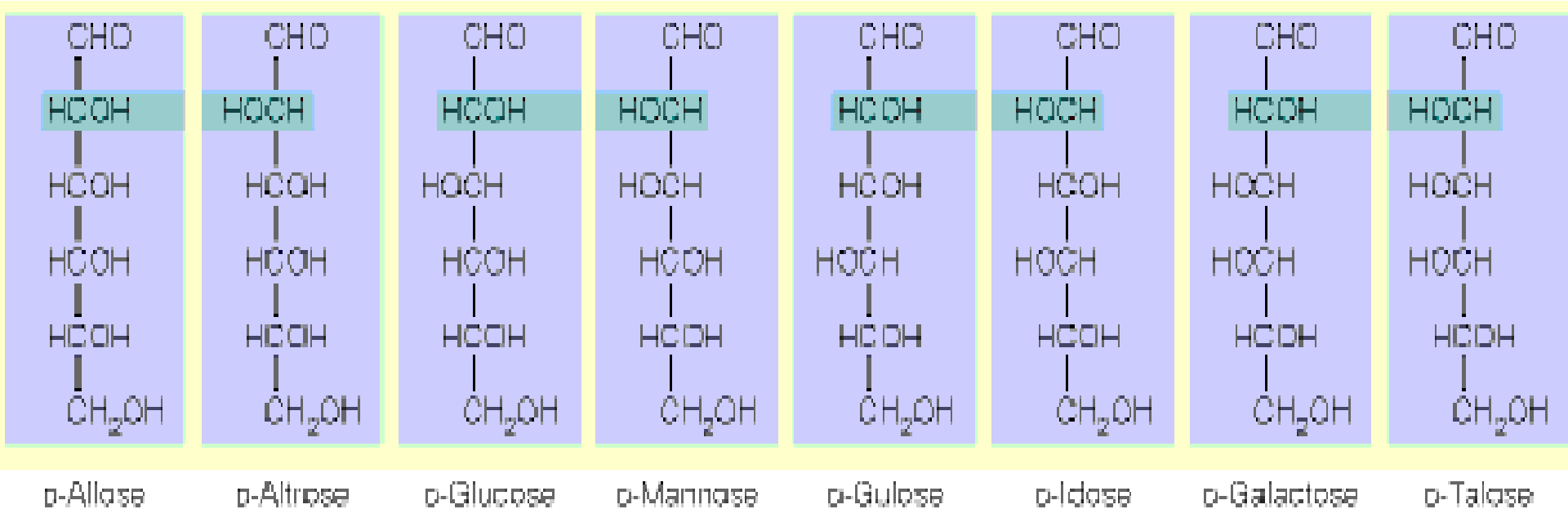
But some L sugars are also Biologically important

Eg. L Fucose,
L Xylulose

- Configurational changes with regard to C2,C3 and C4 and C5 will produce 8 different monosaccharides

- Allose,Altrose,**Glucose,Mannose**,Gulose, Idose,**Galactose**,Talose

Allose Altrose Glc Man Gulose Idose Gal Talose



There will be 8 D isomers and 8 L isomers

- Thus according to the difference in the spatial arrangement of the constituent groups ,there are 16 different monosaccharides.

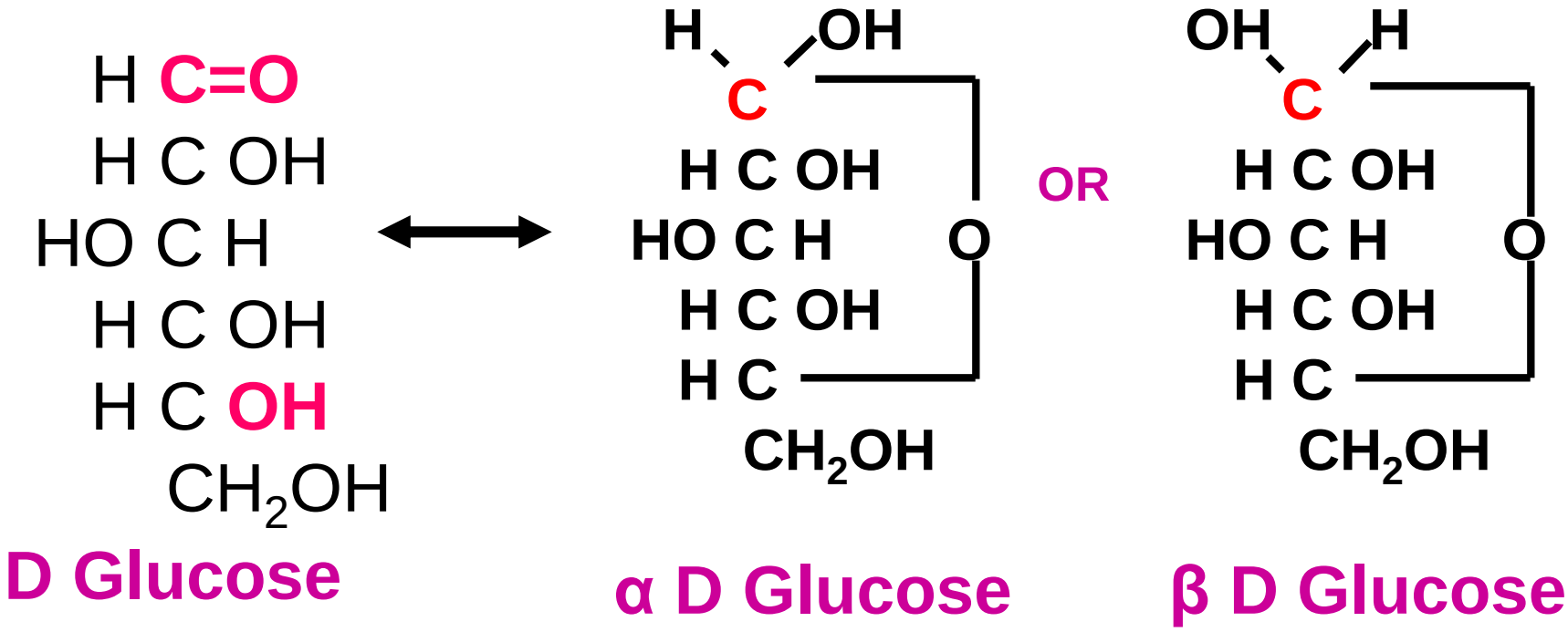
Each of them will have 2 anomers and hence there are total of 32 isomers for glucose.

2. Anomerism (Ano= Upper)

- In aqueous solutions monosaccharides have one more asymmetric center.
- In solutions sugars exist as cyclical forms by forming hemiacetal / hemiketal

- In solutions, aldehyde or keto group reacts with one of the OH group to form intramolecular hemiacetal/ hemiketal hence 1st C also becomes asymmetric

Eg. D Glucose



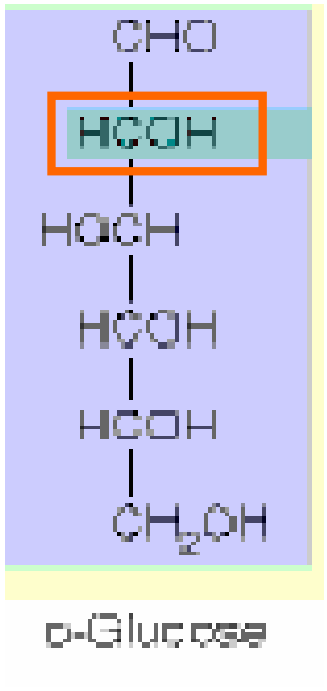
D Glucose **α D Glucose** **β D Glucose**

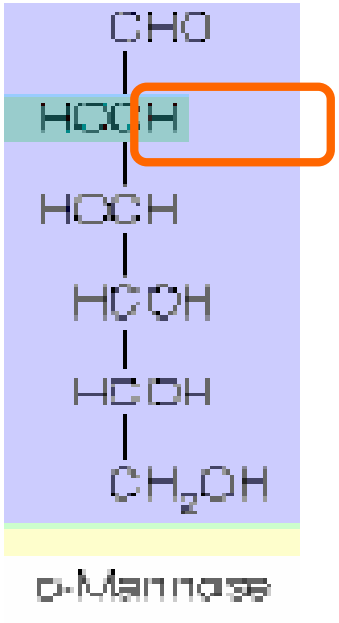
The differences between alpha and beta anomeric forms are dependent on the 1st carbon atom only.

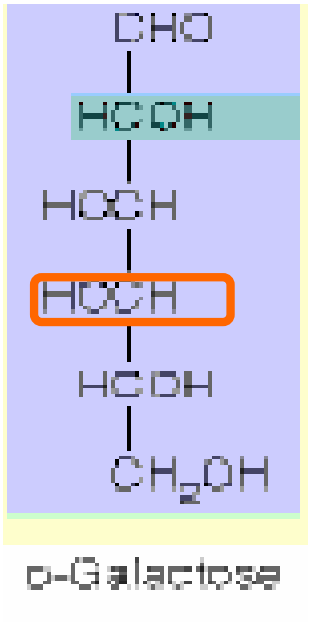
EPIMERISM

- Isomers formed as a result of interchange

of H and OH group **in any one of the carbon atom other than the anomeric and penultimate Carbon atom** is known as **Epimers.**





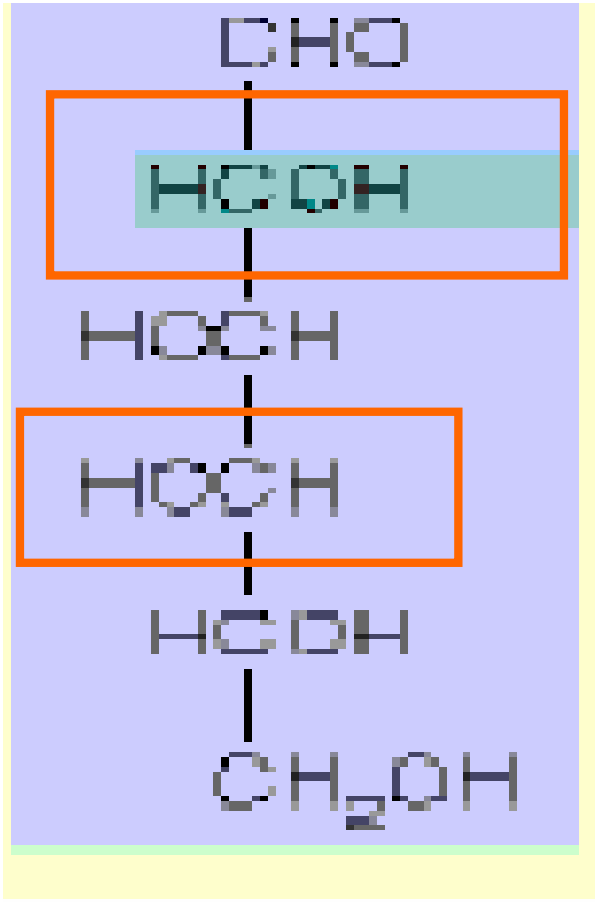


D-GLUCOSE **D-MANNOSE** **D-GALACTOSE**

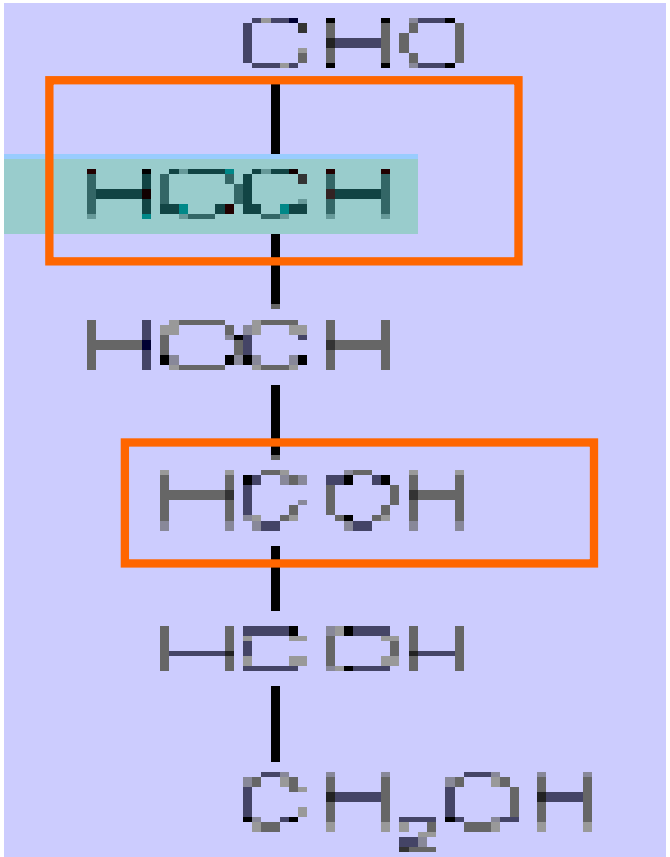
DIASTEREO ISOMERS

- Diastereoisomerism occurs when configurational changes occurs with regard to 2 or more carbon atoms

- Eg: Galactose and mannose



D-Galactose



D-Mannose

Optical Activity

When a beam of plane-polarised light is passed through a solution of carbohydrates,

it will rotate the light either to right or to left.

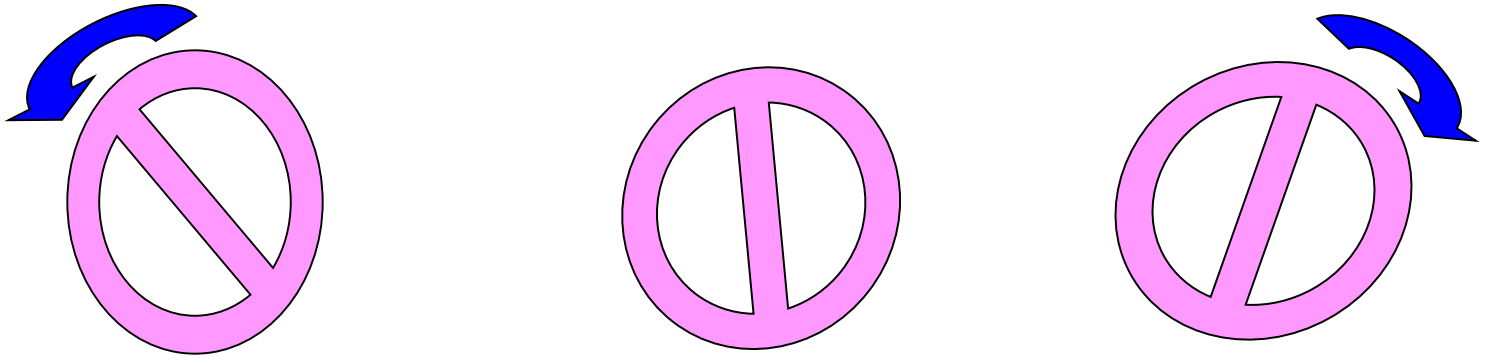
dextrorotatory (+) (d)

or levorotatory (-) (l)

Heyrovsky
NP 1924
1890-1967

Optical activity

- Presence of asymmetric C atom confers the property of Optical activity to a compound.
- Optical isomers are capable of rotating the plane of polarized light .
- When a monochromatic light is passed through a ‘Nicol’ Prism the light emerging is said to be plane polarized.



Anticlock wise (Left)

Clock wise (Right)

Compounds capable of rotating the plane polarized light to right are called **dextrorotatory or d or + sugars** and to left are called **laevorotatory l or – sugars**.

D- and L-notation has no bearing with the optical activity (d or l)

Thus D-glucose is dextrorotatory but D-fructose is levorotatory.

Equimolecular mixture of optical isomers has no net rotation (*racemic mixture*).

Mutarotation.

When a fresh solution of D glucose is prepared, its specific rotation of polarised light is +112°;

but after 12-18 hours it changes to +52.5°.

This change in rotation with time is called mutarotation.

- Due to the presence of alpha and beta anomers of glucose

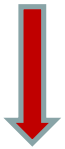
- D Glucose crystallised at room temperature

- Fresh solution prepared

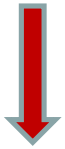
- Pass light through it → $+112^0$

- After 12-18 hours → $+ 52.5^0$

- D Glucose crystallised at 98^0C



- Solution prepared



- Pass light through it  $+19^0$
- After few hours  $+ 52.5^0$

•Alpha-D-glucose has specific rotation of +112 degree and beta-D-glucose has +19 degree.