PASSION ACADEMIC TEAM

Sheet#1

YU - MEDICINE

GASTROINTESTINAL SYSTEM

Lec. Title : 18-10-2020

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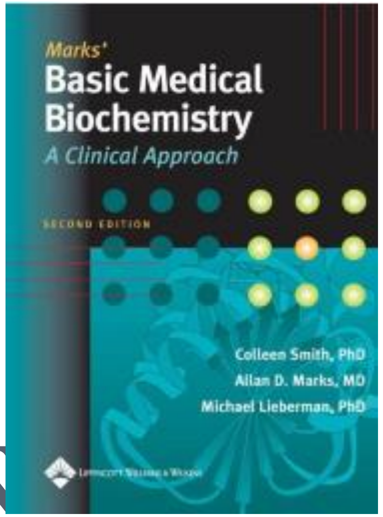
Lec. Date : Digestion and Absorption

DIGESTION AND ABSORPTION OF BASIC NUTRITIONAL CONSTITUENTS



Dr. Mazhar Al Zoubi, 2020

Chapters: 27, 32 and 38

Nutrient Types

Digestible : can be digested as a part of nutrients.

-Proteins

-Carbs

-Fats

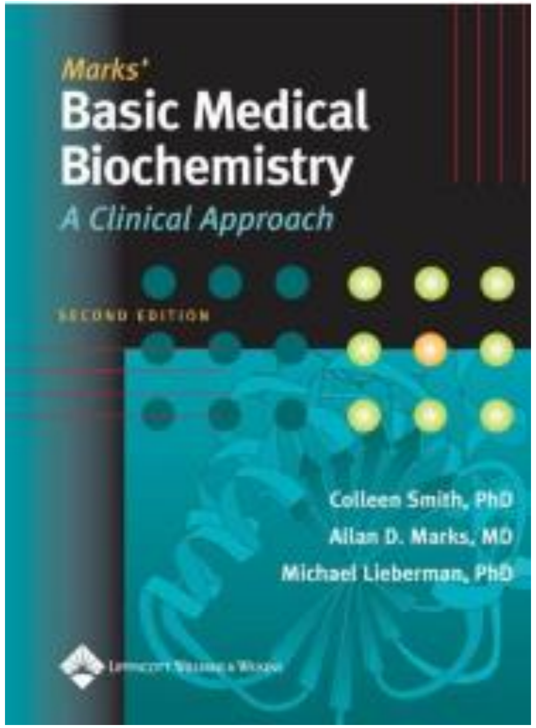
-Nucleic acids

Indigestible (Fibers) : they are helping the digestive system in order to make certain physiological movement.

-Cellulose

-Pectin (complex mixture)

-Others



Chapters 27, 32 and 37

Indigestible component: Cannot be digested by enzymes.

a common example: cellulose, we don't have the enzyme that is responsible for the digestion of the β-glycosidic bonds that found in the cellulose. This enzyme is just found in the microorganisms, that's why these microorganisms are found in the digestive system, to digest this components in order to release the glucose monomers to give the benefit from them.

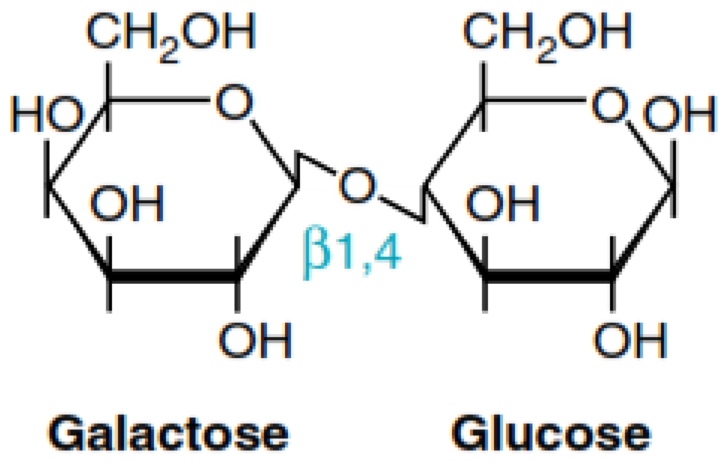
They are just fibers we can’t use them as a source of energy.

Digestion, Absorption and transport of carbohydrates

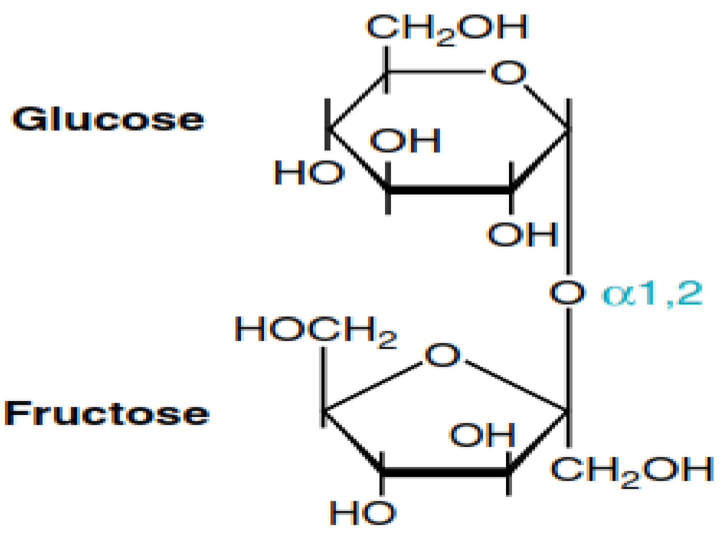
Carbohydrates: one of the major nutrients that we should have an our diet.

*The major carbohydrates in the American diet are **starch, lactose,** and **sucrose**.*

-We have the same components in our diet like in the USA (starch, lactose, sucrose) , but not in the same proportion because we have different lifestyle and different food habits.



Lactose



Sucrose

-Starch is the polyglucose molecule consist of amylose and amylopectin that are going to be digested by certain enzymes which are called glucosidase enzyme, (break the bonds between glucose units with a different in the point of breaking).

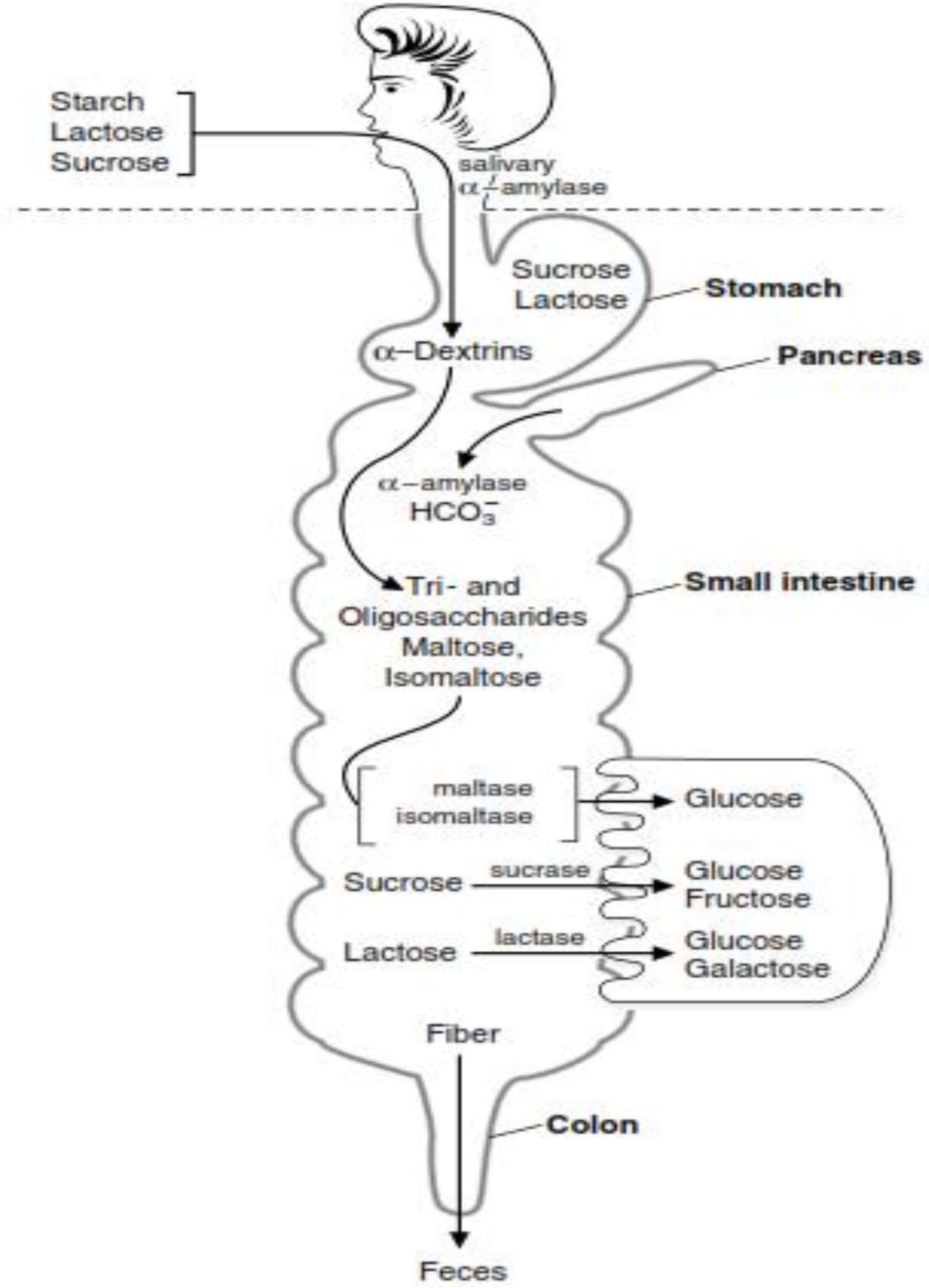
-As we said, the lactose and sucrose are the most common disaccharide that we could have in our diets.

Lactose is formed of glucose and galactose that are connected by (β-1,4) glycosidic bond.

Sucrose is formed of glucose (in carbon 1) and fructose (in carbon 2) which connected by (α-1,2) glycosidic bond.

These bonds need an enzymes to be hydrolyzed or digested.

Overview of carbohydrate digestion.



-We have carbohydrates in food as we said, which contains mainly (starch, lactose and sucrose).

-When enter **the mouth** they face the first site of digestion (salivary glands) or its secretion (saliva) that contain α-amylase.

-Then the components of these nutrients will pass to **the stomach** (we have intact sucrose and lactose).

-Starch has already been digested in the oral cavity by the α-amylase enzyme, but we still have α-dextrin (fragment of the starch) they are small molecule having less (α-1,4) bonds.

-In pancrease we have α-amylase enzymes secreted from the pancrease instead of salivary glands with other components (digestive juice).

- In small intestine we have some new molecules: (maltose, isomaltose, tri and oligosaccharides), which results from starch digestion as well as the intact disaccharides (sucrose and lactose).

-We will have one more step of digestion in order to convert all of these disaccharides as well as trisaccharides to be monosaccharides, so we will be able to absorb them because we cannot absorb trimers or dimers at all.

-We have an abundant amount of enzymes on the brush border of ilium cells to facilitate the digestion as well as to protect them from the self-digestion by other self proteins.

-Maltase and isomaltase digest maltose and isomaltose ,respectively, in order to release or produce glucose.

-Finally, the undigested molecules are excreted as intact fibers at the end of the day

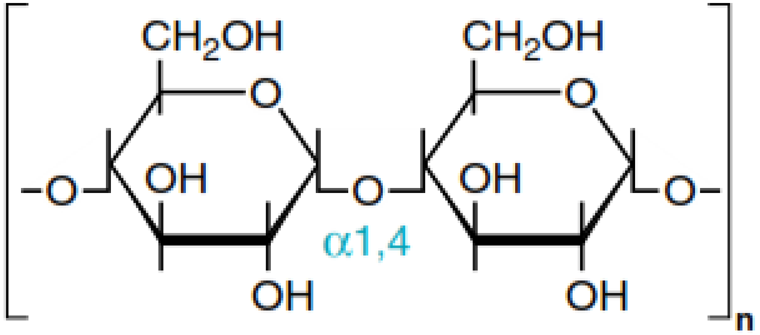
I. DIETARY CARBOHYDRATES

40 to 45% of caloric intake in USA diet.

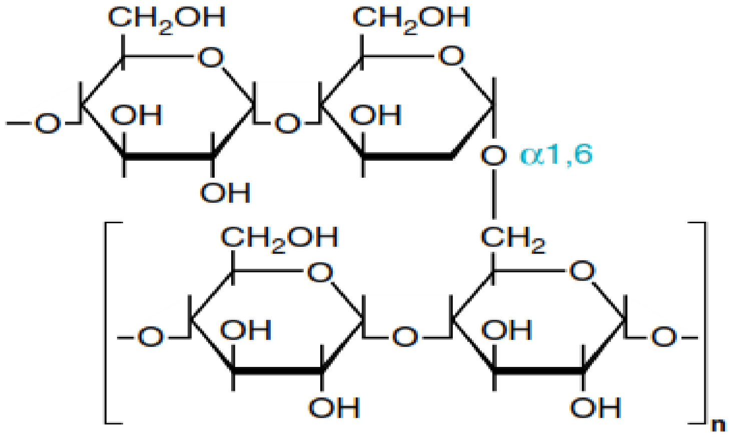
50-60 % came from starch

The animal origin carbs is lactose (milk and milk products)

Sucrose and small amounts glucose and fructose are the major natural sweeteners found in fruit, honey, and vegetables.



Amylose



Amylopectin

Amylose has α-1,4 bonds, it is not branched that's why it is easily digested.
Amylopectin trans alpha 1,6 bonds at the point of branching that's why it isn't easily digested.

Inter-conversion of Monosaccharaides

Q….

-Can we gain carbohydrates from other sources?

-Yes… For example: the amino acids under certain conditions can be converted into glucose which can be interconverted into other molecules (fructose, galactose, xylose) , in the non oxidative phase of the hexose mono phosphate pathway, to use them in the synthesis of other molecules like ribose sugar in the DNA.

II. DIGESTION OF DIETARY CARBOHYDRATES

- Glycosidase exhibit some specificity for the glycosidic bond and number of residues

Undigested Carbs → **Bacterial Fermentation**

-The undigested carbs will have two fates : either secreted as fibers or bacterial fermentation (depending on the microbiota in our digestive system).

A. Salivary and Pancreatic-Amylase

- 1 L of saliva/Day
- 1.5 L of pancreatic juice/Day
- Limit dextrins: are oligosaccharides (4 -9 residues with one or more α-1,6 branches).

-We secretes a huge amount of secretion daily, about 2.5l.

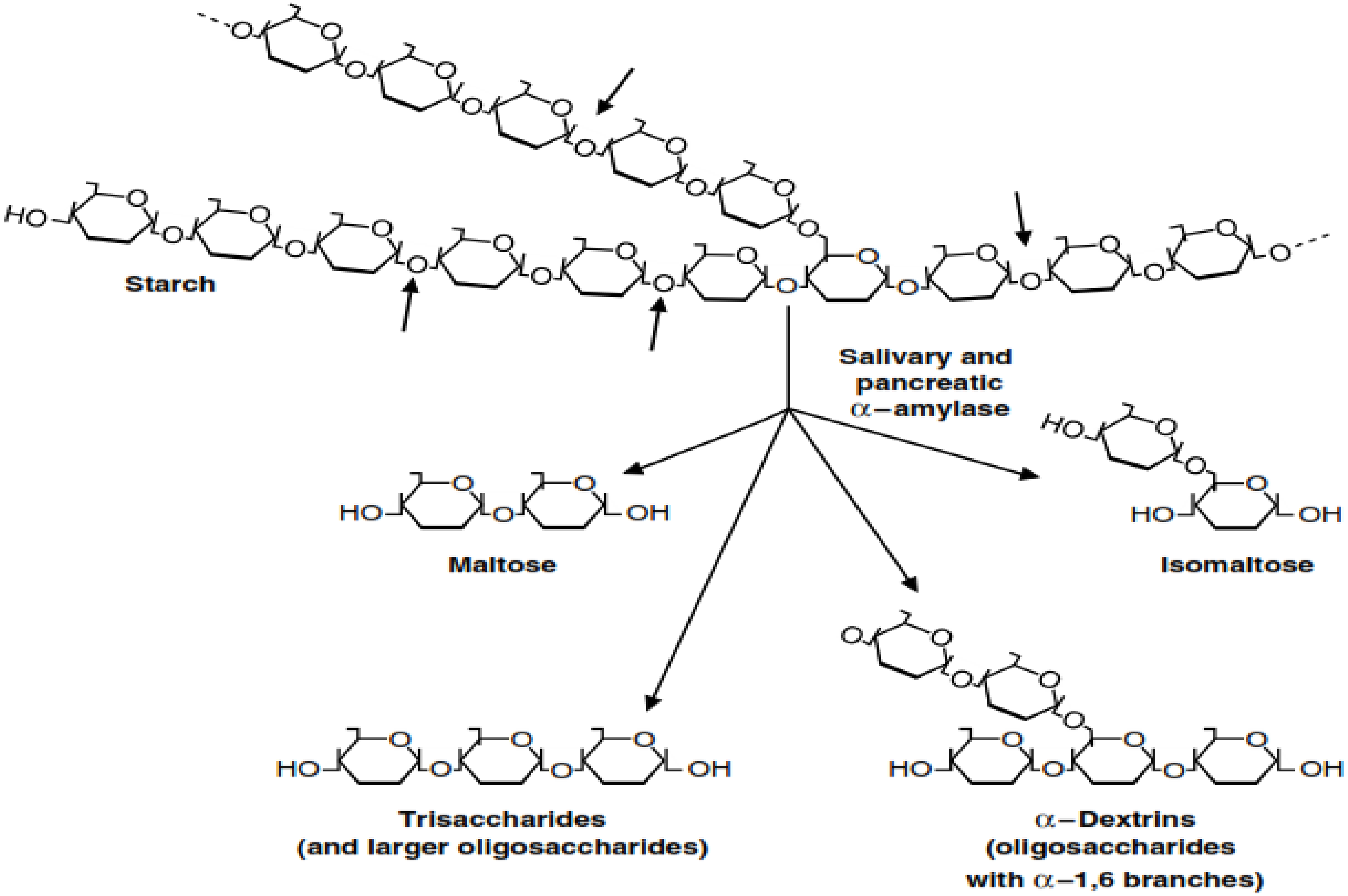


Fig. 27.3. Action of pancreatic and α-amylase.

B. Disaccharidases of the Intestinal Brush-Border Membrane

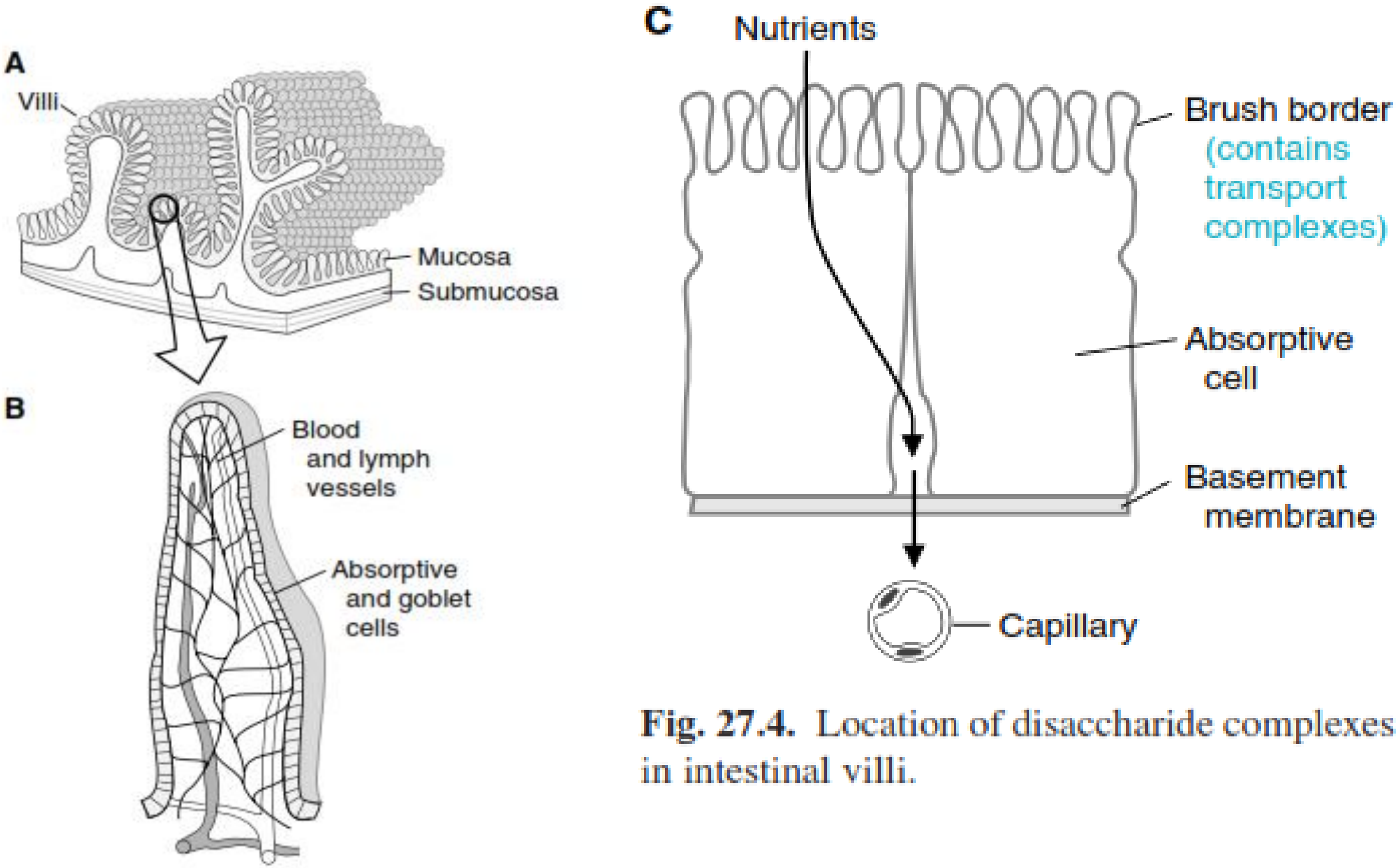


Fig. 27.4. Location of disaccharide complexes in intestinal villi.

1. Glucoamylase.
2. Sucrase–maltase complex.
3. Trehalase.
4. Lactase-glucosylceramidase

Disaccharidases: the enzyme that digest the disaccharide, they are found on the brush border cell as we said, we also have transporters.

***4 major types of disaccharides :**

1.glucoamylase: it means we have a glucose monomer in that dimer.

2.sucraae-maltose complex

3.trehalase: digest the di glucose molecule (1,1 glycosidic bond)

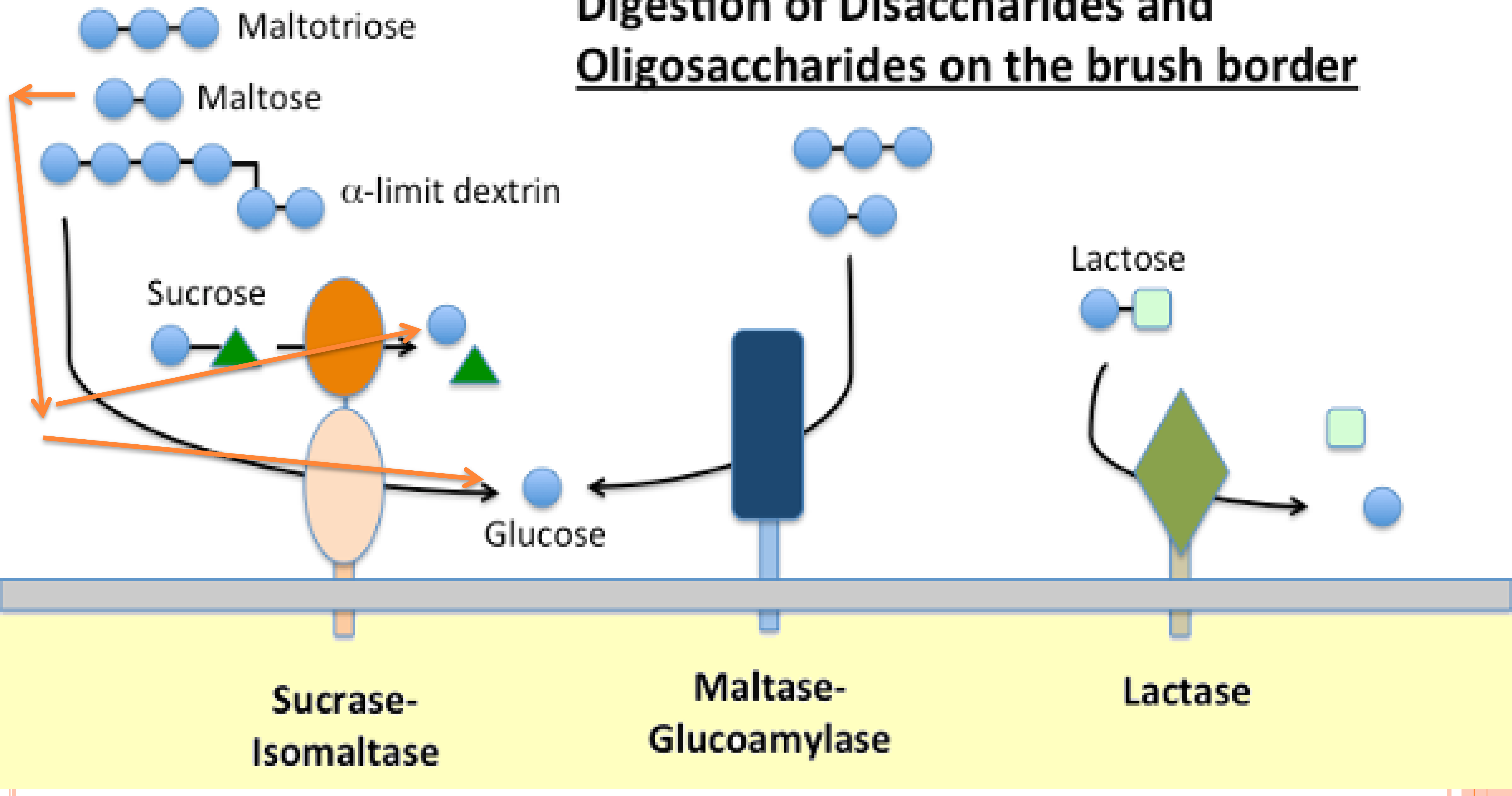
4. Lactase-glucosylceramidase

Table 27.1. The Different Forms of the Brush Border Glycosidases

Complex	Catalytic Sites	Principal Activities
β-Glucoamylase	α-Glucosidase	Split α-1,4 glycosidic bonds between glucosyl units, beginning sequentially with the residue at the tail end (nonreducing end) of the chain. This is an exoglycosidase. Substrates include Amylose amylopectin, glycogen and maltose
	α-Glucosidase	Same as above, but with slightly different specificity and affinities for the substrates
Sucrase–Isomaltase	Sucrase–maltase	Splits sucrose, maltose, and maltotriose
	Isomaltase–maltase	Splits α-1, 6 bonds in a number of limit dextrins, as well as the α-1,4 bonds in maltose and maltotriose.
β-Glycosidase	Glucosyl–ceramidase (Phlorizin hydrolase)	Splits β-glycosidic bonds between glucose or galactose and hydrophobic residues, such as the glycolipids glucosylceramide and galactosylceramide
	Lactase	Splits the β-1,4 bond between glucose and galactose. To a lesser extent also splits the β-1,4 bond between some cellulose disaccharides.
Trehalase	Trehalase	Splits bond in trehalose, which is 2 glucosyl units linked α-1,1 through their anomeric carbons.

We have one or more catalytic sites in the same complex.

Digestion of Disaccharides and Oligosaccharides on the brush border

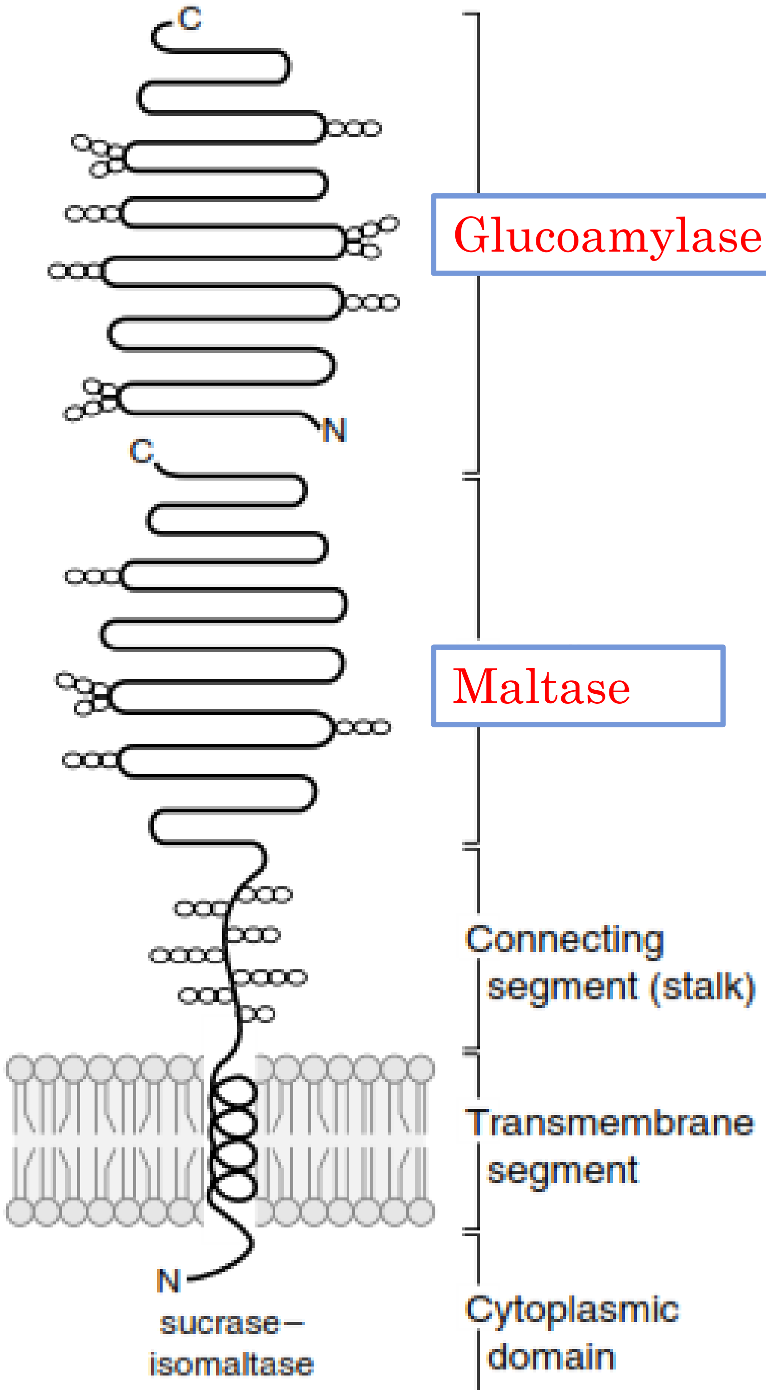


***sucrose isomaltose complex** consists of 2 domains, one of them is responsible for digestion of sucrose ro peoduce glucose and fructose, and the other one works on maltose or maltiteiose. (The difference is in the specicfity).

*the same about **maltose glucoamylase** (one alpha 1,4).

***lactose** is completely different, works on different type of bond.

. MALTASE-GLUCOAMYLASE



Glucoamylase

Maltase

- Glucoamylase is similar to the sucrase–isomaltase complex structures

- It is an exoglucosidase that is specific for the α–1,4 bonds

- begins at the non-reducing end of a polysaccharide or limit dextrin

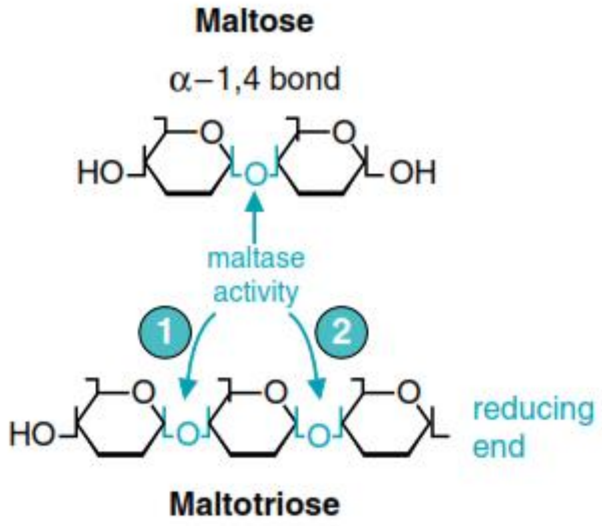
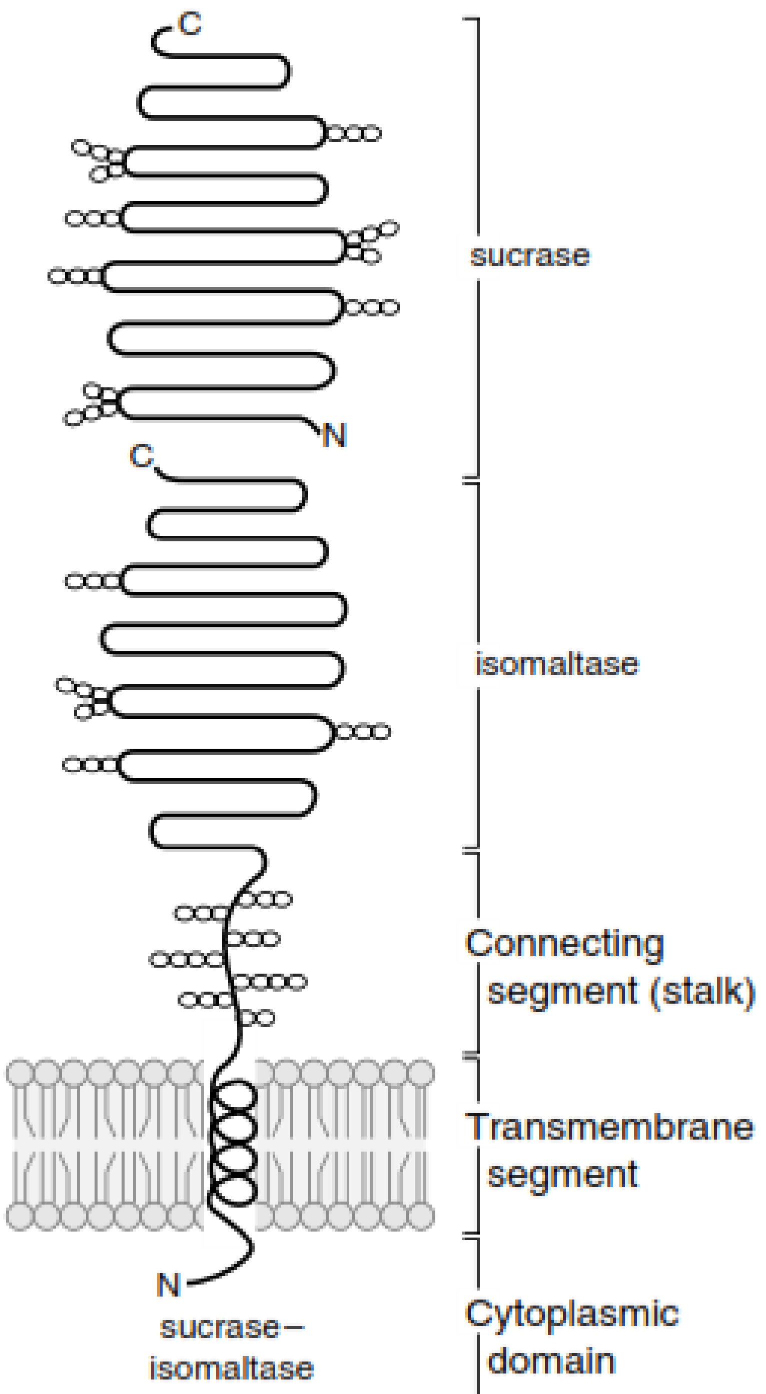


Fig. 27.6. Glucoamylase activity. Glucoamylase is an α-1,4 exoglycosidase, which initiates cleavage at the nonreducing end of the sugar. Thus, for malotriose, the bond labeled 1 will be hydrolyzed first, which frees up the bond at position 2 to be the next one hydrolyzed.

2. SUCRASE–ISOMALTASE COMPLEX



- similar structure to the glucoamylase

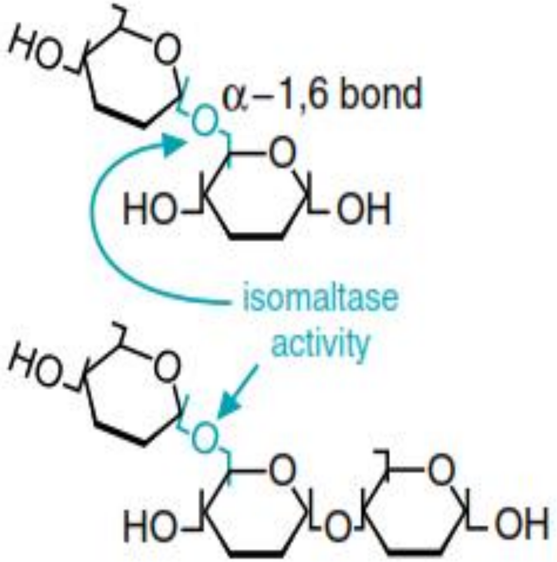
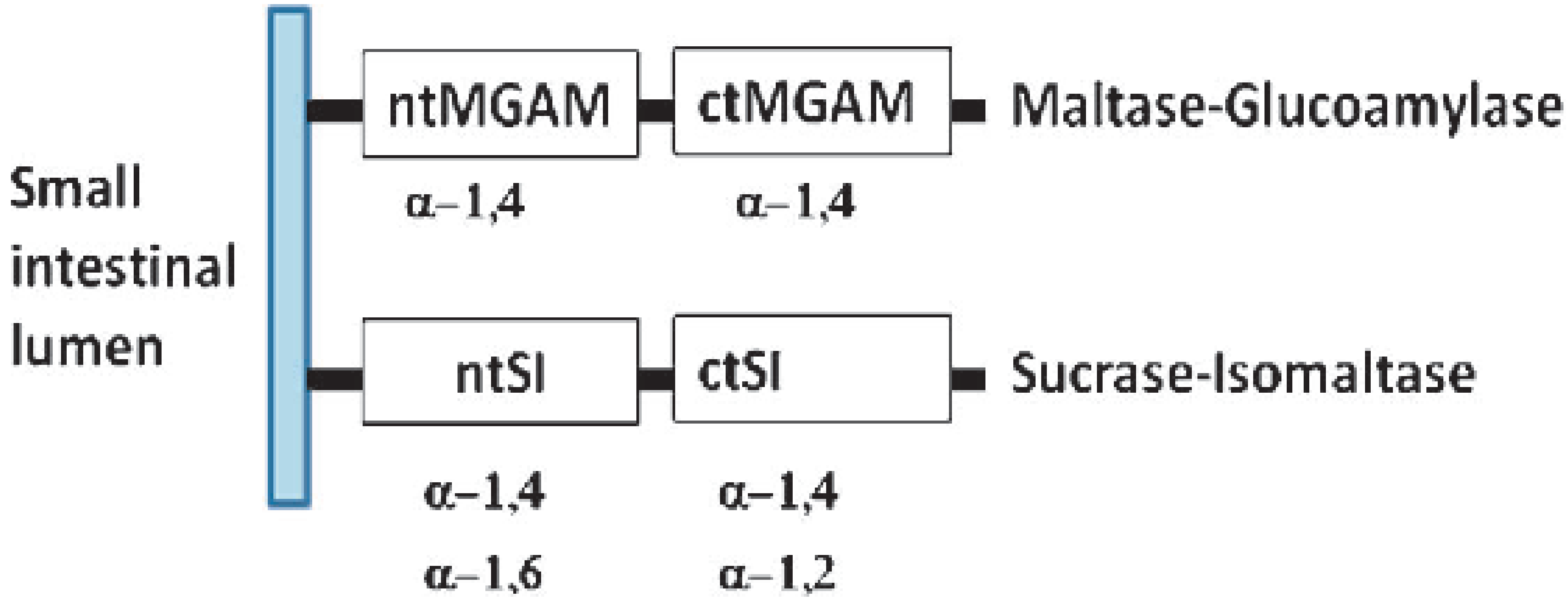


Fig. 27.7. Isomaltase activity. Arrows indicate the α-1,6 bonds that are cleaved.



gure 1. Diagram of MGAM and SI indicating hydrolytic activity.

3. TRELASE

- has only one catalytic site.
- Trehalose (insects, algae, mushrooms, and other fungi) is not currently a major dietary component
- Trehalase deficiency (a woman became very sick after eating mushrooms and was initially thought to have α–amanitin poisoning.

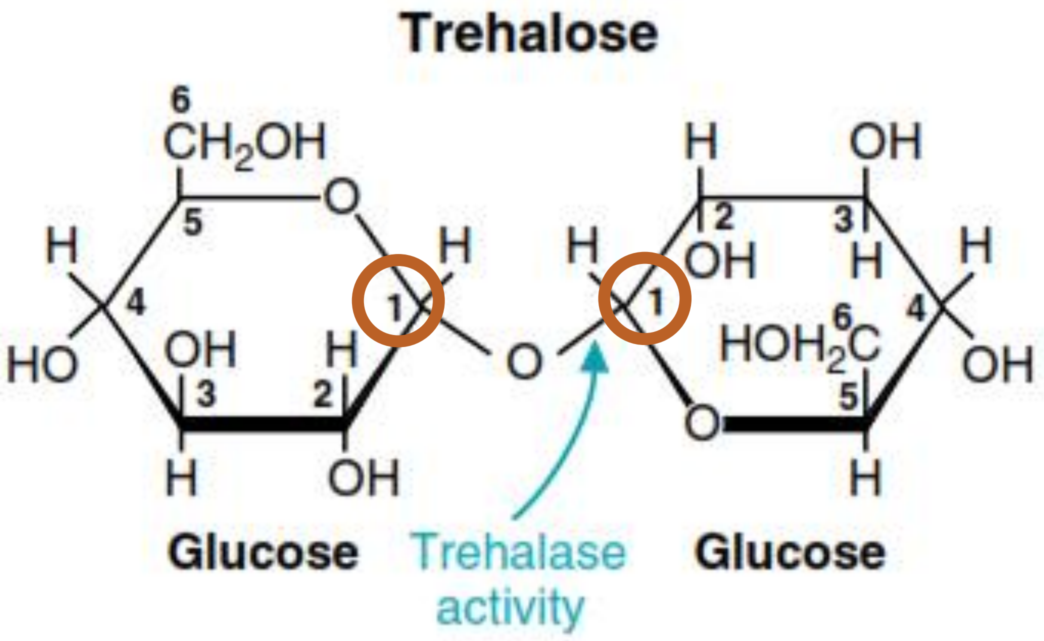
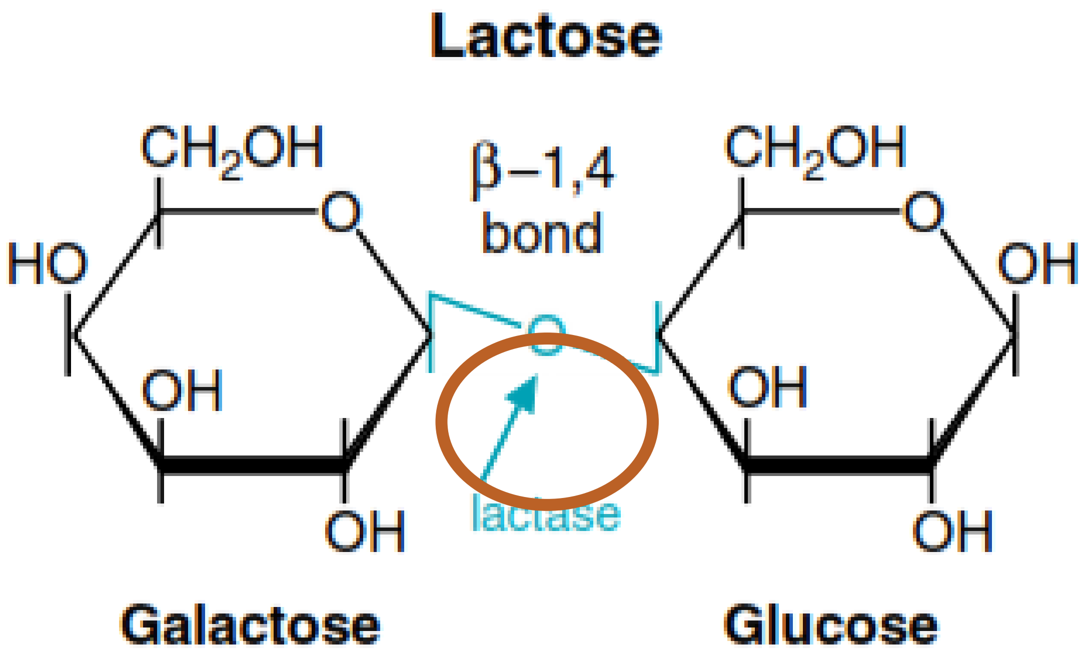


Fig. 27.8. Trehalose. This disaccharide contains two glucose moieties linked by an unusual bond that joins their anomeric carbons. It is cleaved by trehalase.

4. -GLYCOSIDASE COMPLEX (LACTASE-GLUCOSYLCERAMIDASE)



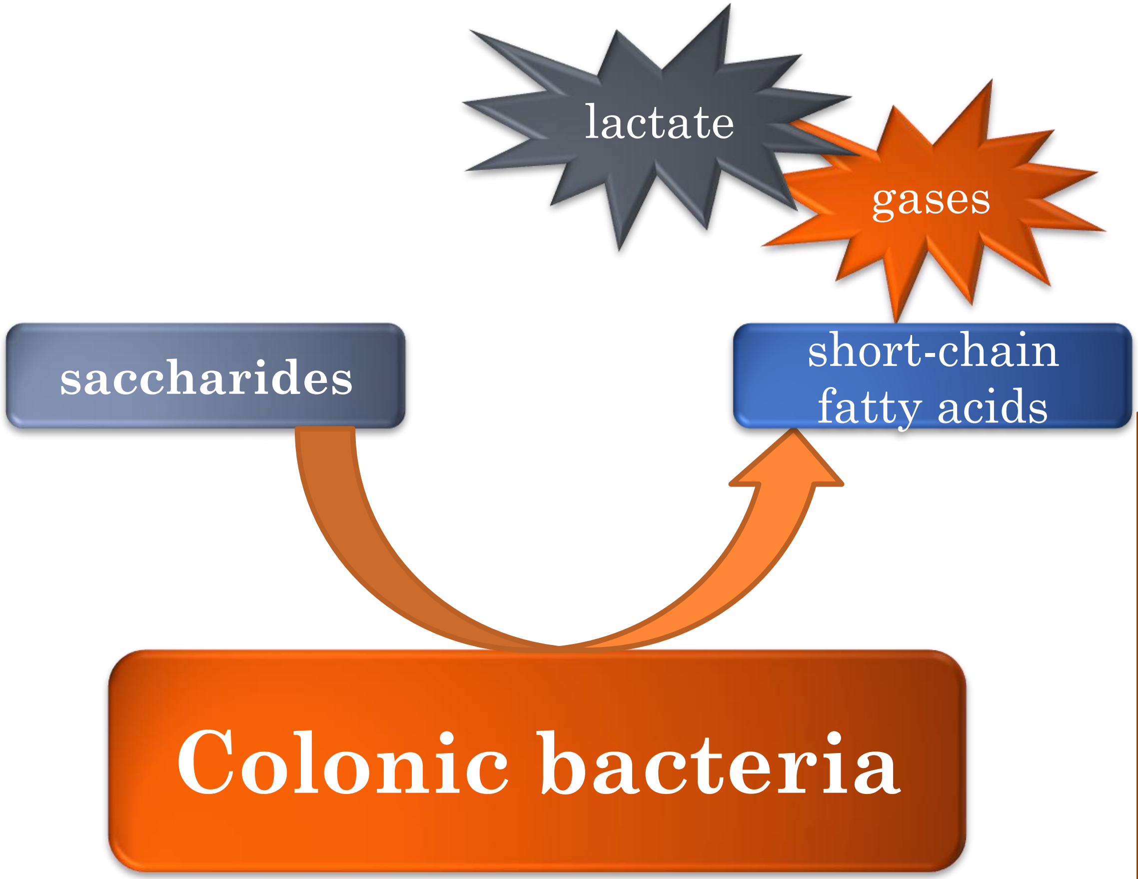
- hydrolyzes the -bond connecting glucose and galactose in lactose

5. LOCATION WITHIN THE INTESTINE

- The production of maltose, maltotriose, and limit dextrins by pancreatic –amylase occurs in the duodenum
- Sucrase–isomaltase, β-Glycosidase activity is highest in the jejunum
- Glucoamylase activity progressively increases along the length of the small intestine, and its activity is highest in the ileum.

We have a kind of localization of previous enzymes in order to match the availability of these carbohydrates because we started with polymers and end up with dimers.

Metabolism of Sugars by Colonic Bacteria

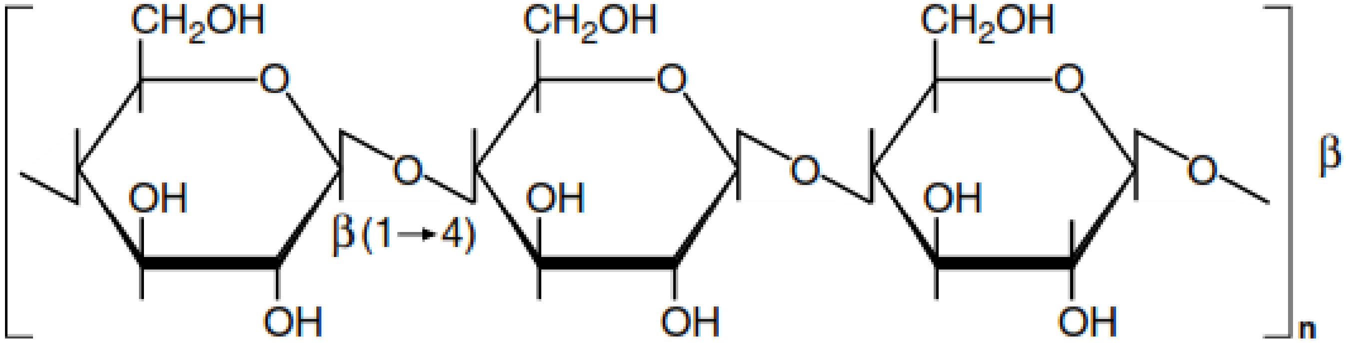


- Starches high in amylose, or less well hydrated (e.g., starch in dried beans), are resistant to digestion and enter the colon.

- Dietary fiber and undigested sugars also enter the colon.

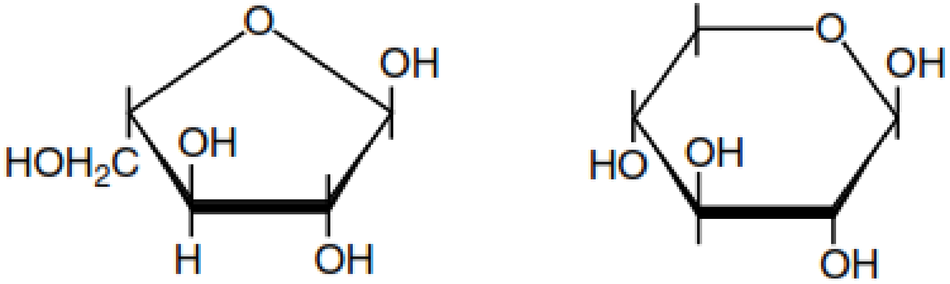
If we have a deficiency in some of these enzymes, the bacteria will take the action in order to digest these carbs.
Bacteria itself will generate certain kinds of short chain fatty acids that will produce gases and lactate due to the oxidation process.

Indigestible carbohydrates



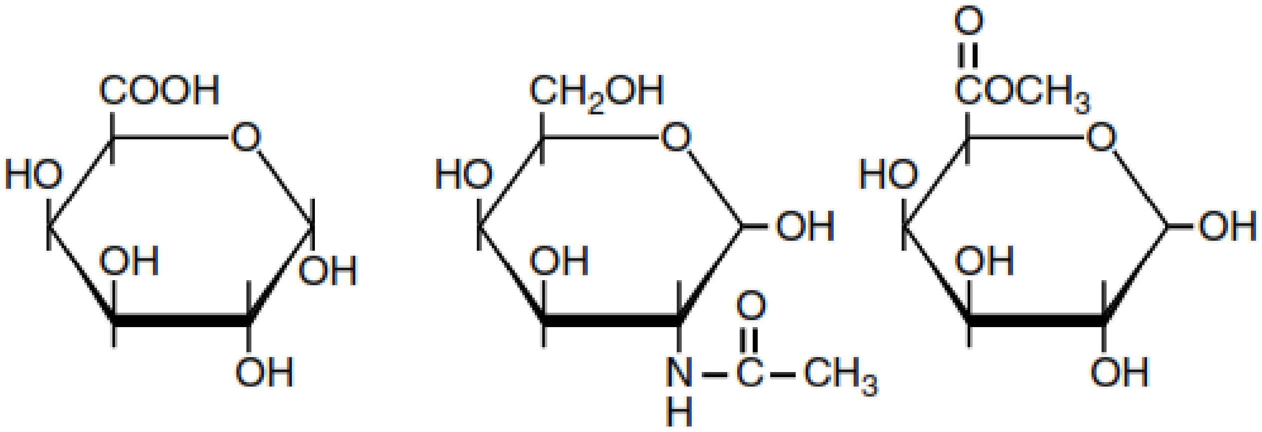
β–1,4–linked glucose

Cellulose



α–L–**Arabinose** β–D–**Xylose**

- Found in hemicelluloses, gums and mucilages



Galacturonic acid ***N*–Acetyl–galactosamine** **Methylated galacturonic acid**

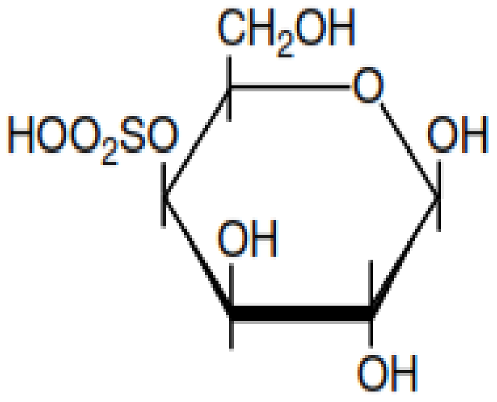
- Components of pectin

-Cellulose as we said is very abundant, common and known due to its presence in the walls of plants.

-Have β-1,4 bonds, excreted as fibers cause they are indigestible carbohydrates.

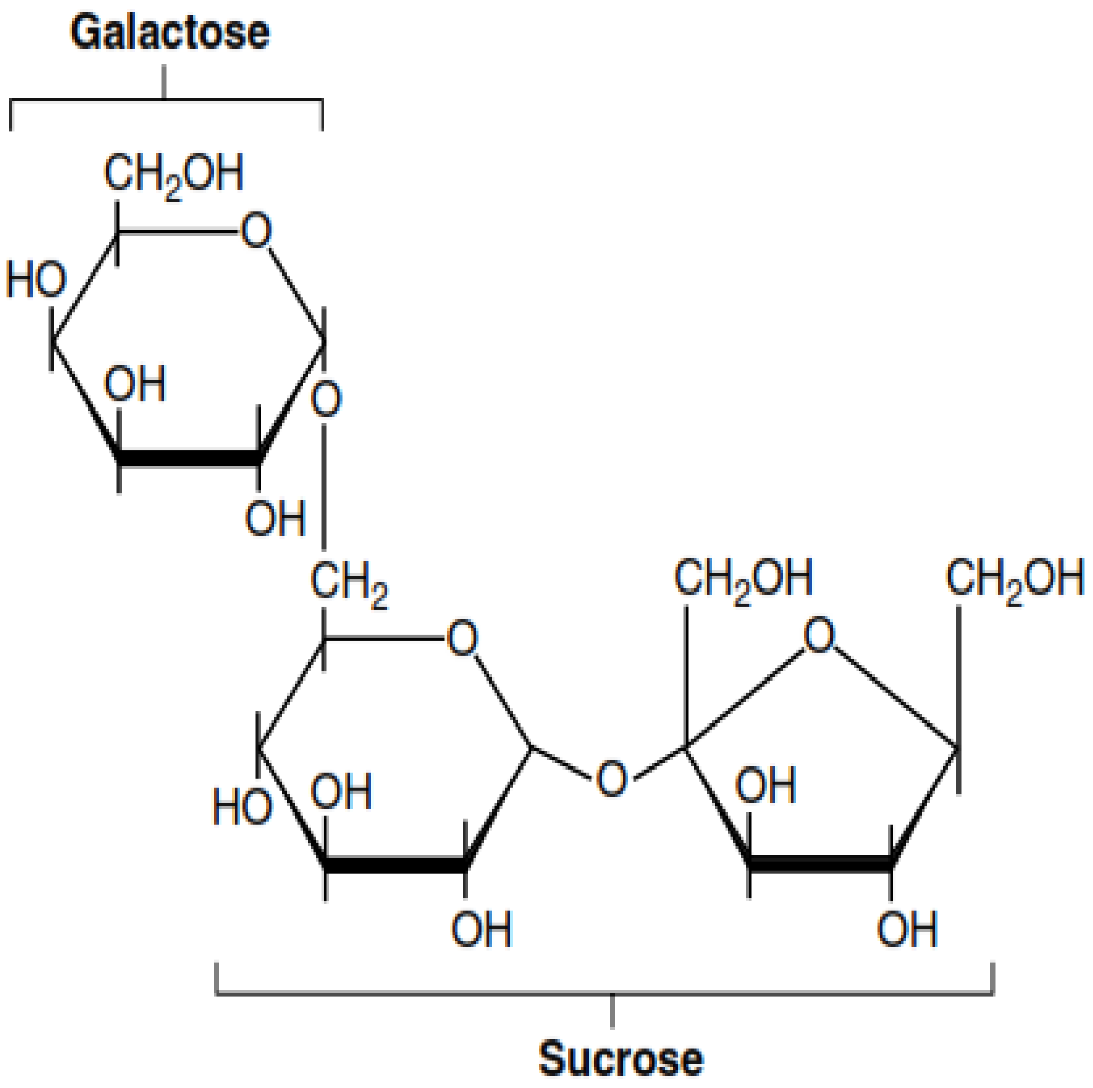
-Other monosaccharides in this slide are also parts or components of plants and we can't digest.

Indigestible carbohydrates

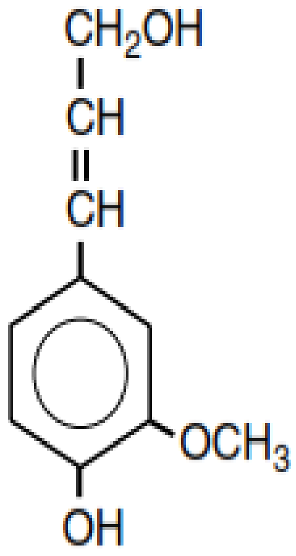


Galactose–4–SO_4

- Component of carrageenan



Raffinose



Phenyl propane derivatives

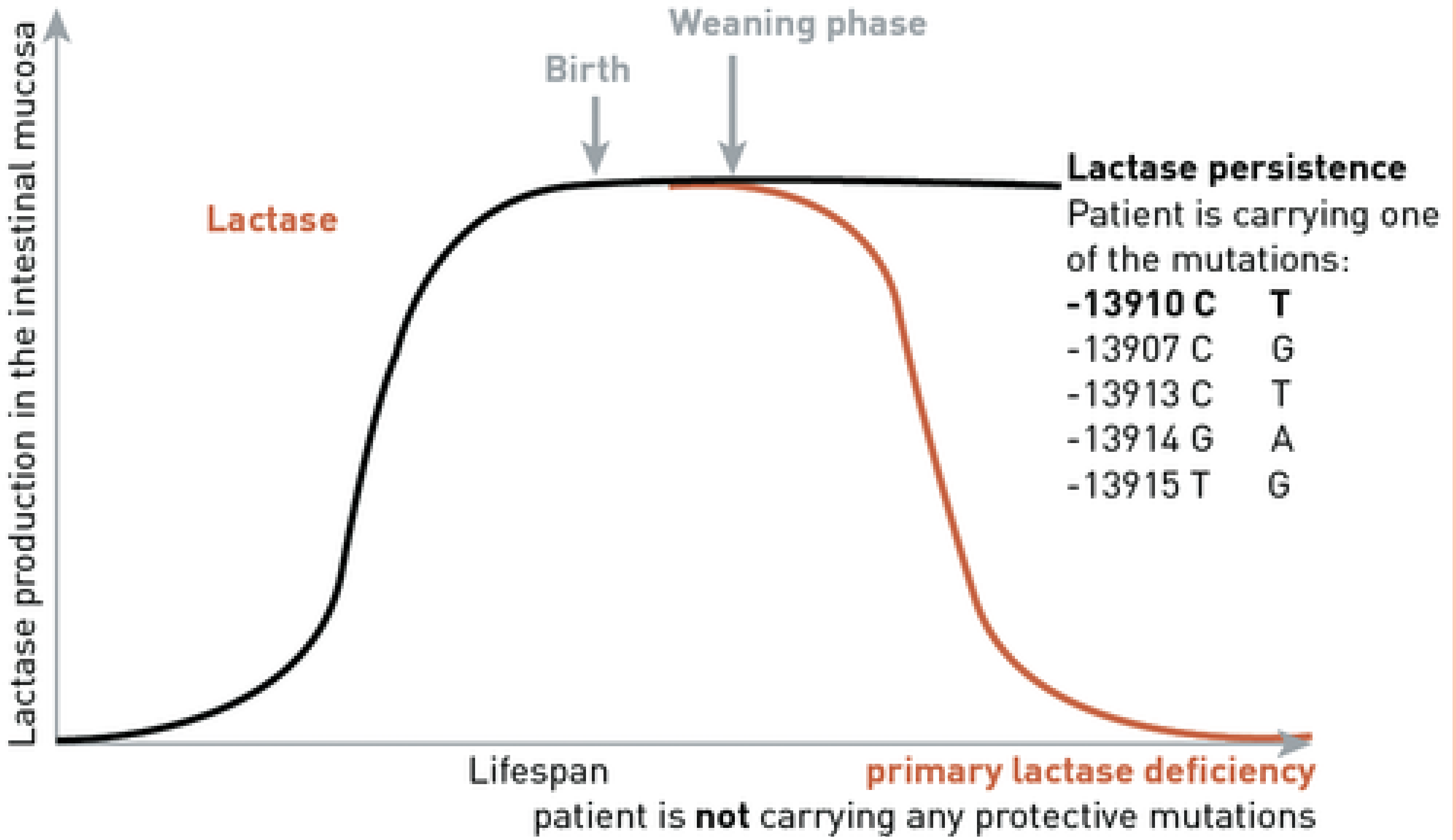
- Found in lignin

LACTOSE INTOLERANCE

caused by low levels of lactase

1. NONPERSISTENT AND PERSISTANT LACTASE

- Adult levels are less than 10% of that present in infants (lactase non-persistence phenotype).
- When the levels of lactase remain at, or only slightly below infant levels throughout adulthood (lactase persistence phenotype)



-**Lactose intolerance**: it is just a condition not a disorder, that happens when the body is unable to digest lactose because it doesn't have lactase enzymes (low level) which is one of the most sensitive enzymes that can be damaged by certain injuries.(the first to be damaged and the last to be stored).

-The Curve discuss the activity of the enzyme during lifespan, which shows that the birth time is the maximum level of the activity

-In some individuals: the activity persists for long time but in others they are going to have descending activity of the enzyme.

*What is the cause of that? genetic polymorphism
-in the genes that is responsible for lactase synthesis, they are some mutations may occur, if we change one of the bases to another , the amino acid with change , so the whole enzyme will change, which leads to differences in the enzyme activity.
-Some of the amino acids if change the difference will be drastic.

بمعنى انه لو غيرنا حمض اميني غير قطبي الي اخر غير قطبي حيصير تغير خفيف في النشاط
بينما لو غيرناه ل حمض قطبي حيصير تغير كبير في النشاط

Table 27.2. Prevalence of Late-Onset Lactase Deficiency

Group	Prevalence (%)
U.S. population	
Asians	100
American Indians (Oklahoma)	95
Black Americans	81
Mexican Americans	56
White Americans	24
Other Populations	
Ibo, Yoruba (Nigeria)	89
Italians	71
Aborigines (Australia)	67
Greeks	53
Danes	3
Dutch	0

2. INTESTINAL INJURY

- Lactase is usually the first activity lost and the last to recover.

ABSORPTION OF SUGARS

Glucose and maltose have the highest glycemic indices

Glycemic incides : it means how much a concentration of sugar will be in the blood when absorption.

Table 27.4 Glycemic Index of Selected Foods, with Values Adjusted to White Bread of 100

Breads		**Legumes**	
Whole wheat	100	Baked beans (canned)	70
Pumpernickel (whole grain rye)	88	Butter beans	46
Pasta		Garden peas (frozen)	85
Spaghetti, white, boiled	67		
		Kidney beans (dried)	43
Cereal grains		Kidney beans (canned)	74
Barley (pearled)	36	Peanuts	15
Rice (instant, boiled 1 min)	65	Fruit	
Rice, polished (boiled 10–25 min)	81	Apple	52
Sweet corn	80	Apple juice	45
Breakfast cereals		Orange	59
All bran	74	Raisins	93
Cornflakes	121	Sugars	
Muesli	96	Fructose	27
Cookies		Glucose	142
Oatmeal	78	Lactose	57
Plain water crackers	100	Sucrose	83
Root vegetables		Dairy Products	
Potatoes (instant)	120	Ice cream	69
Potato (new,white, boiled)	80	Whole milk	44
Potato chips	77	Skim milk	46
Yam	74	Yogurt	52

A. Absorption by the Intestinal Epithelium

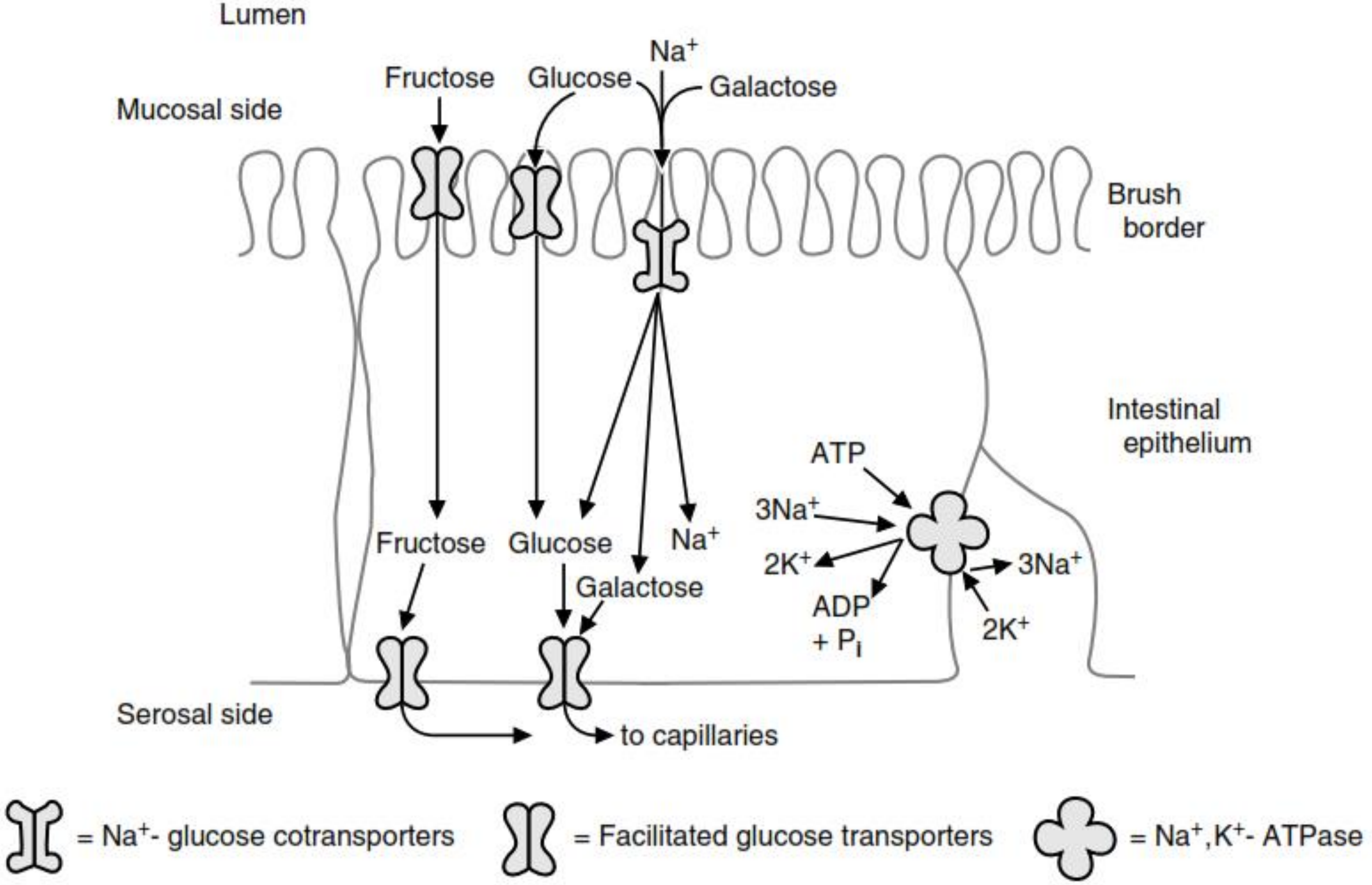


Fig. 27.12. Na^+-dependent and facilitative transporters in the intestinal epithelial cells. Both glucose and fructose are transported by the facilitated glucose transporters on the luminal and serosal sides of the absorptive cells. Glucose and galactose are transported by the Na^+-glucose cotransporters on the luminal

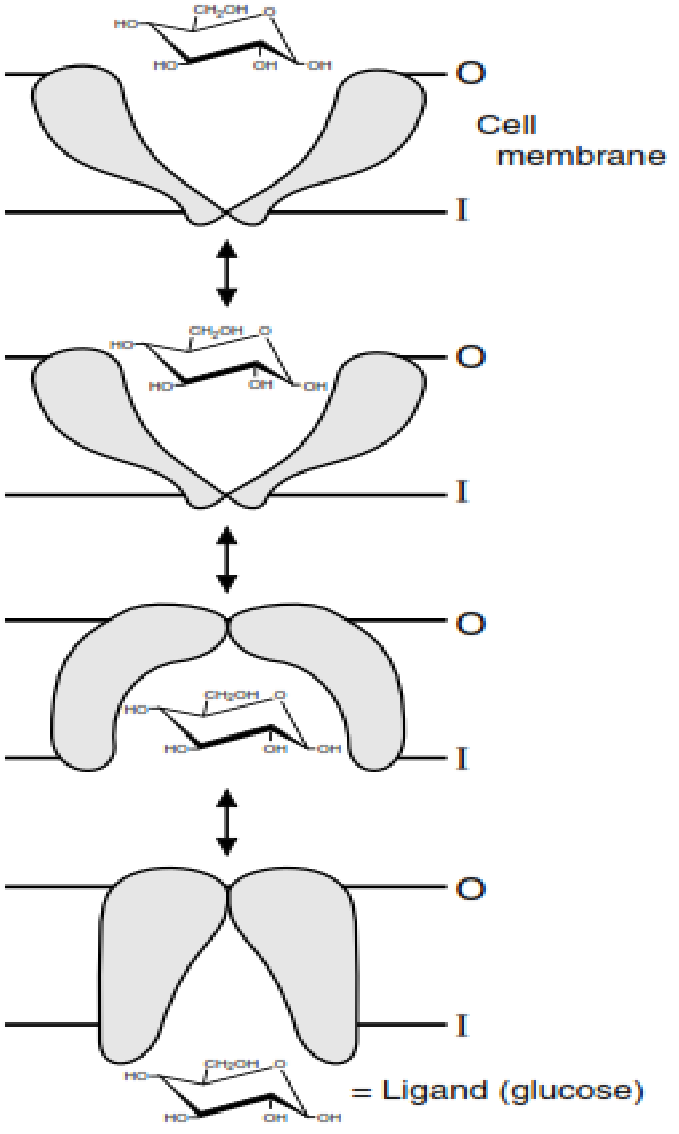


Fig. 27.11. Facilitative transport. Transport

*Absorption by the intestinal epithelium:

-It is a big story, because we have different tissues that needs glucose at different concentrations,,, for example, the nervous system is completely different from the vascular system, as we as the liver, eye tissue.

-It depends on needs of that tissue specifically, but in general they are sharing the same mechanism of transportation by the presence of Glut transporters, which presents on the cell membrane doing their action almost by passive transportation, that doesn't need energy but rely on the concentration of glucose or any other carbohydrates.

-Some of this transporters is insulin-dependent, and the other or insulin independent, which means that some of them needs the insulin hormone to facilitate this diffusion and activate the transporters and the other one work without the need of insulin that's why they diabetes doesn't affect all tissue. (due to the presence of this channels).

☺السمايلات للتسلية كونه السلايد ممل ☹
يلا هانت ...

Table 27.5. Properties of the GLUT 1-GLUT 5 Isoforms of the Glucose Transport Proteins

Transporter	Tissue Distribution	Comments
GLUT 1	Human erythrocyte Blood-brain barrier Blood-retinal barrier Blood-placental barrier Blood-testis barrier	Expressed in cell types with barrier functions; a high-affinity glucose transport system
GLUT 2	Liver Kidney Pancreatic β-cell Serosal surface of Intestinal mucosa cells	A high capacity, low affinity transporter. May be used as the glucose sensor in the pancreas.
GLUT 3	Brain (neurons)	Major transporter in the central nervous system. A high-affinity system.
GLUT 4	Adipose tissue Skeletal muscle Heart muscle	Insulin-sensitive transporter. In the presence of insulin the number of GLUT 4 transporters increases on the cell surface. A high-affinity system
GLUT 5	Intestinal epithelium Spermatozoa	This is actually a fructose transporter.

Genetic techniques have identified additional GLUT transporters (GLUT 7-12), but the role of these transporters has not yet been fully described.

So basically the first site of absorption is the lumen of the digestive system.
*a co-transporter (SGLT) transport either glucose and Na+ together or galactose and Na+ together.
Glut-5 is responsible for fructose transportation.
now after they are reaching the cells they transported to the blood by the same transport mentioned above.
there is a sodium-potassium pump activity transport Na+ from the cell into the interstitial fluid and then go back to that luman of the digestive system, this help in the Co-transportation of the glucose and galactose SGLT transporter