**Carbohydrate metabolism**

**Stages of energy metabolism:**

1-digestion and absorption: transforming macromolecules into monomers

2-transforming these monomers to acetyl-coA, however some monomers give directly one of krebs cycle intermediates

3-citric acid cycle

4-electron transfer chain and oxidative phosphorylation

-glucose is essential for life , some cells live only on glycolysis such as RBCs

-even if you don’t eat carbohydrates the body can synthesis it from other sources to maintain a good level of glucose concentration while fasting

- during feeding we consume carbohydrates and the excess will be stored in the form of glycogen which will be degraded if needed between meals to maintain glucose conc. In the blood .

- glucose is also important for producing NADPH (glucose monophosphate chunk pathway

 NADH : carries the electron for energy production

 NADPH : carries the electron for reductive biosynthetic pathway also it neutralizes oxidizing substances

-In carbohydrates we don’t have essential sugar as sugars can interconvert to each other and can be produced from non-carbohydrate source

 -The main source of carbohydrates we consume is starch 50-60% , 35% is lipids ,10-15% is protein .

Excess of carbs or protein will be transformed into fat ( glucogenisis) -

It is advisable that 60% of the carbs to be complex (starch)so the that digestion will take longer time in order to prevent fast formation of fat

-Starch has 2 types :

amylose : linear un-branched alpha 1-4( glucose)

 Amylopectin :alpha 1-4,branched alpha 1-6( glucose)

Lactose : beta 1-4 (glucose and galactose)

Sucrose : alpha glucose 1-2 beta fructose

Cellulose: can't be digested ,important for easy motion of large intestine

**Digestion of carbohydrates:**

In the mouth:

 alpha amylase is secreted, it has endoamylase activity ( cuts in the middle not from the ends whether reducing or non-reducing ends, attacks randomly so we will have : maltose, isomaltose, trimaltose and dextrin (partly degraded starch)

Isomaltose, maltose, lactose, sucrose and cellulose will not be affected by this enzyme.

In stomach :

the high acidic media will stop the action of alpha amylase

In duodenum:

 bicarbonate neutralizes the media and pancreatic alpha amylase is also secreted (same action as the one produced by the mouth)

Main product is maltose and isomaltose, others remain unchanged

In the upper jejunum:

 we have a group of enzymes named disaccharidases that work on all sugars (isomaltase, maltase , trihalase )

Haloses : bound by alpha 1-1 glucose , found in mushroom and other fungi and microorganisms , some people have deficiency in the trihalase enzyme so they are allergic to mushroom and might show the same symptoms as mushroom poisoning.

In the Upper ileum :

 a special enzyme for dextrin which is the last chance for its degradation

note: Usually all of these enzymes in the intestines are glycoslyated to prevent their degredation

**Disaccharidases complexes:**

1-Sucrase and isomaltase:

1 p.p with 2 domains when it is transferred to the luminal surface it splits but still associated together

Sucrase activity is limited to the sucrase domain in this enzyme

 These 2 enzymes have high maltase activity ( 80% )

Maltase activity refers to both maltose and maltotriose degradation

2-maltase and exoglucoamylase :

 they don’t split (remain one p.p)

Exoglucoamylase: works from the nonreducing end of remained oligosaccharides

(lower jejunum and upper ileum )

Also has maltase activity

3- lactase : found in the upper jejunum

4- trihalase

**Abnormalalities in digestion :**

Could be genetic or acquired.

1-Lactase :

Genetic deficiency in new born is very rare however 50-70 % are affected by adult hypolactesia which means that the gene that produces lactase which is on chromosome 2 is mutated so the quantity but not quality is changed

Usually when the baby is born the enzyme has full activity , then it declines and

At 7 years age only 10 % is active

The lactose will not be digested and because it is a small molecule it will pass into cells increasing the osmotic pressure causing diarrhea, also it will be metabolized by bacteria into acetic acid and lactic acid which also increases osmotic pressure

Gases will also be formed and accumulated in the abdomen , one of them is H2 gas which can be measured in the breath ( a way to measure carbohydrate consumption).

2-surcase deficiency:

Causes : genetic , malnutrition , injury to mucosa by drugs , diarrhea ( flushes out the enzymes, that is why it is advised to avoid milk and sugars during diarrhea because it will make things worse as there is no enzymes to digest the milk or the sugars)

**Absorption of sugars:**

1-Na-independent pathway :

 -14 different forms (isoforms)

found in all cells except kidney tubules and intestinal cells.-

-The transporter protein is found on the cell surface and it has a polar group which interacts with the sugar causing conformational change in the protein structure so the sugar can enter the cell now ( facilitated diffusion)

-Fructose is absorbed by facilitated diffusion by GLUT 5

2-Na-dependent pathway:

- found in kidney tubules and intestinal cells

-For glucose and galactose

The transport of Na coupled with the sugar into the cell requires energy -

-Glucose , galactose and fructose leave the mucosal cells to blood capillaries by GLUT2 which works only when the conc. Of sugar is high because it has a high km value and high Vmax.

 