DIGESTION AND ASSIMILATION OF CARBOHYDRATES

Asst. Prof. Dr. Jaafaru Sani Mohammed

Advance Clinical Biochemistry I (MA 407)

Summer Semester

Lecture Six

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Outlines

- Objectives
- Introduction
- Classification of CHO
- Digestion of CHO
- Absorption from blood
- Blood regulation of Glu
- Functions of CHO

Objectives

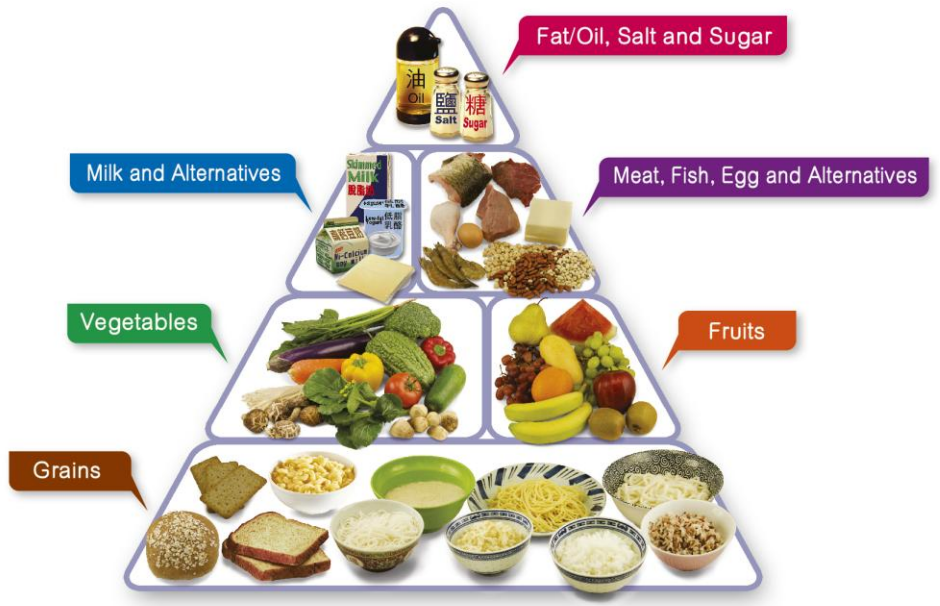
- At the end of the lesson, the students should be able to understand:

- The different classes of carbohydrates
- The enzymes responsible for digestion of carbohydrates
- The sites for absorption
- The Molecular basis of glucose transportation.
- The function of carbohydrates

Introduction

- **Carbohydrate**: consists of carbon, hydrogen, and oxygen atoms in a ratio of 2:1
- The empirical formula for Carbohydrates is $C_n(H_2O)_n$ (where n is a number starting from 3).
- Plants are the major source of carbohydrates.
- Glucose is the universal fuel for human cells.
- The glucose concentrations in the body are maintained within limits by various metabolic processes.

Cont.



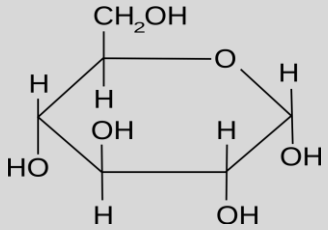
- Approximately 45% to 60% of dietary CHO is in the form of starch (polysaccharide).

- Balanced Diet: consisting of the proper quantities & and proportions of foods needed to maintain health or growth.

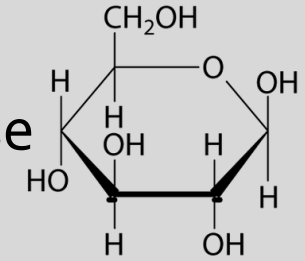
- Complex: (starch and fiber)
- Simple sugars:
  - Monosaccharide – One unit
  - Disaccharides – Two units
  - Oligosaccharides – 10 or fewer units
  - Polysaccharides – Up to 1000 units

Monosaccharides

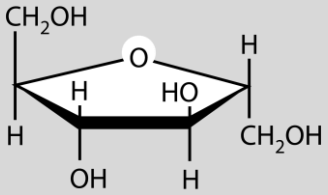
- Glucose



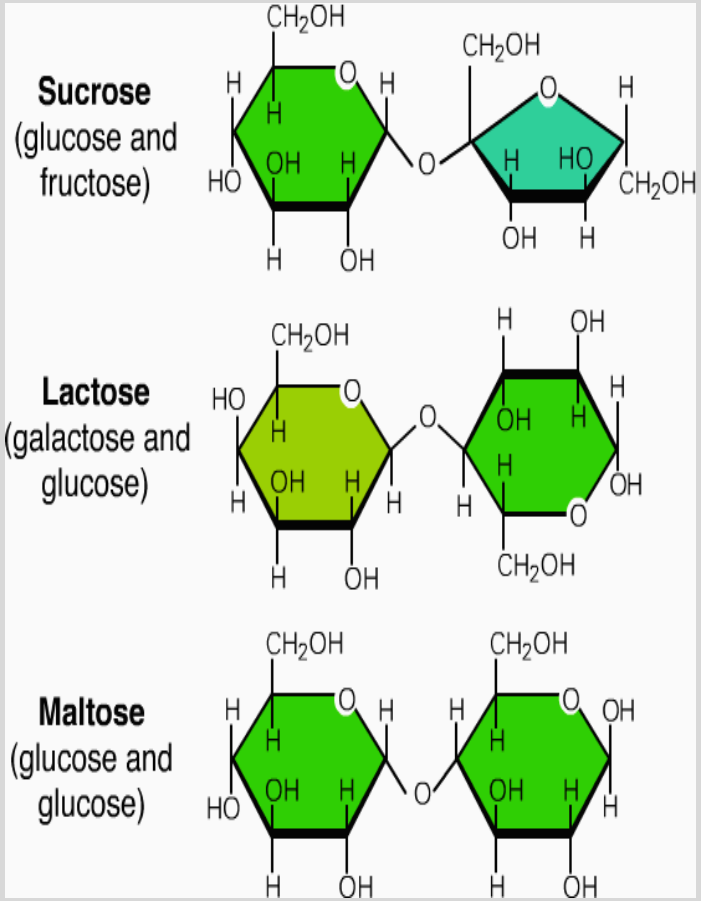
- Galactose



- Fructose



Disaccharides

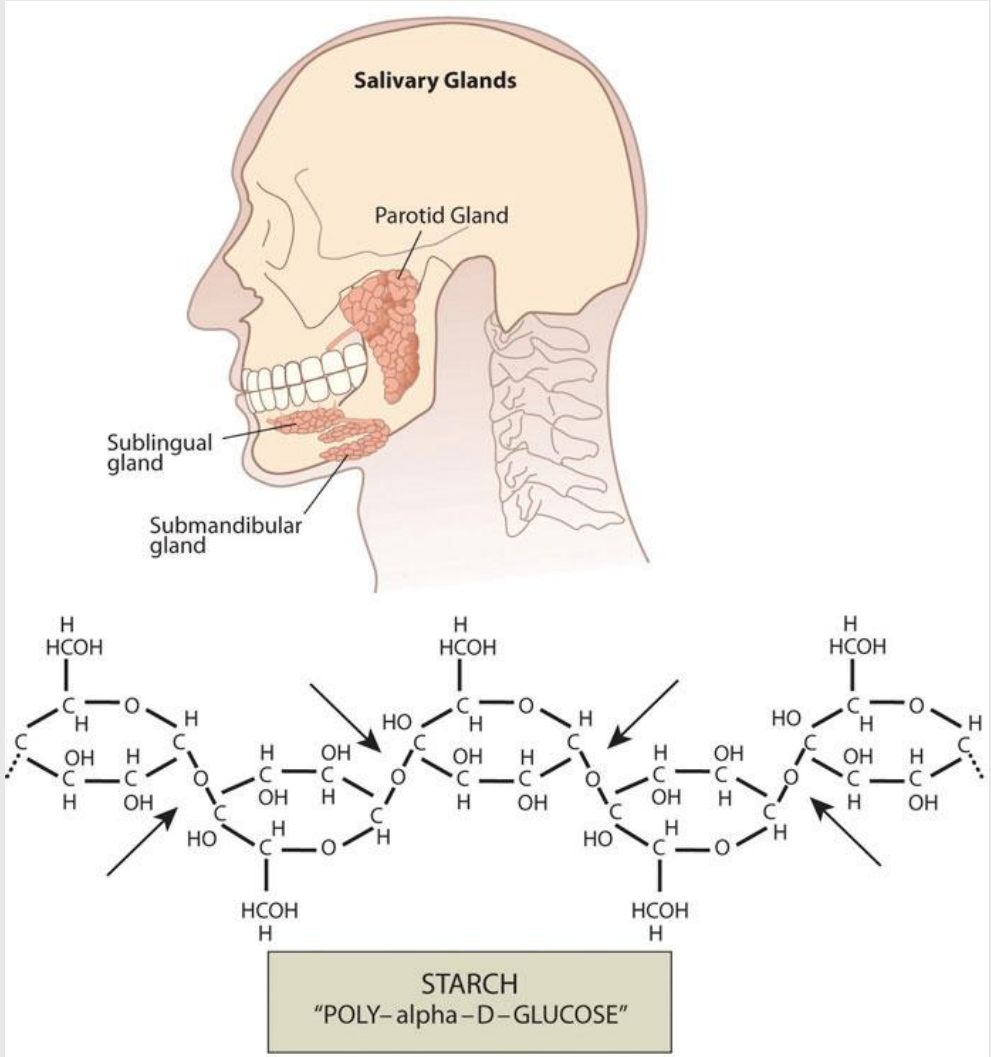


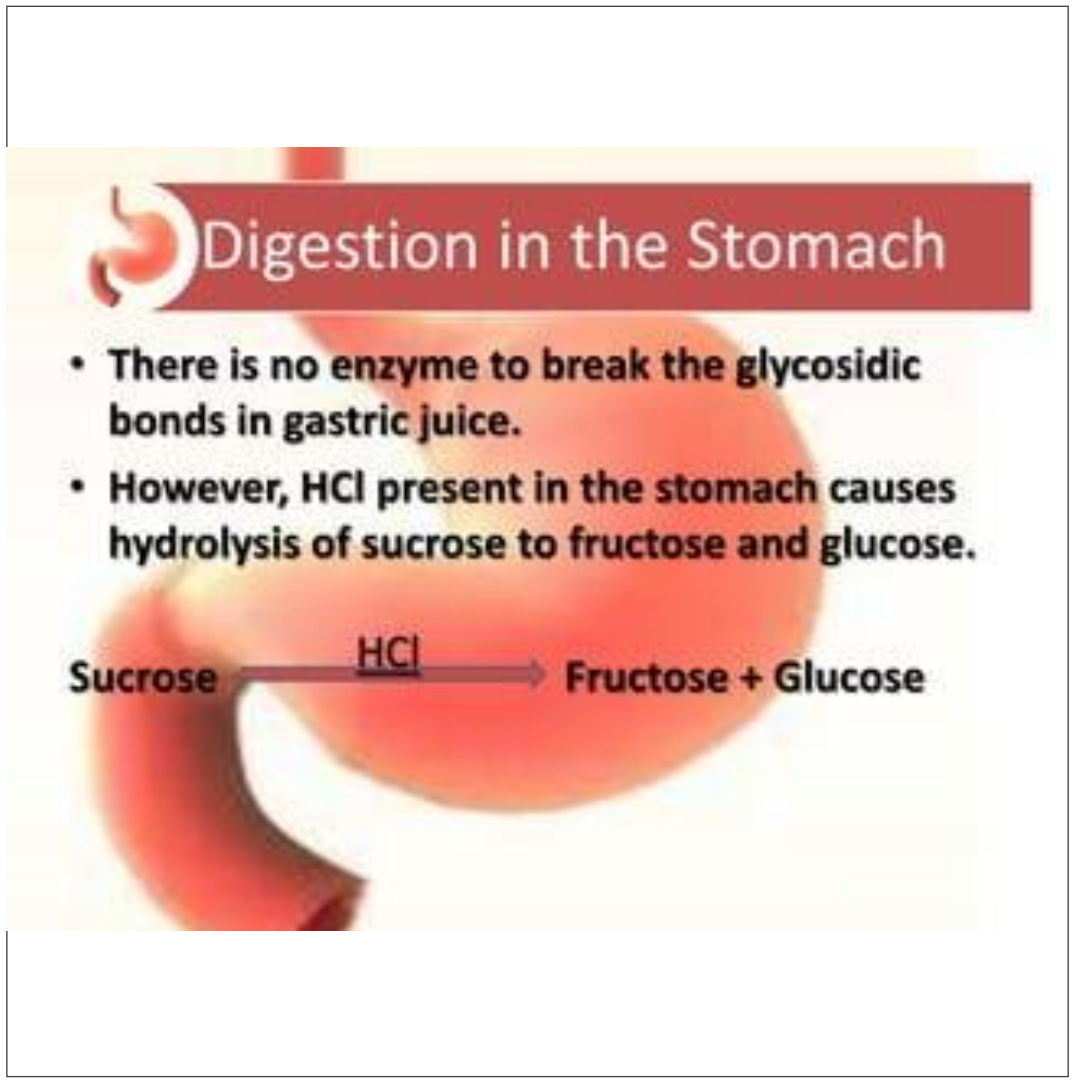
Polysaccharides

- Starch
  - Amylose
  - Amylopectin
- Dextrins – Enzymatic product of Starch break down
- Glycogen
- Plant Fiber Components

- Mechanical and chemical digestion of carbohydrates into the smaller–mouth
- Salivary glands - secrete saliva that coats the food particles.
- Salivary amylase breaks disaccharides, oligosaccharides, and starches.
- It also breaks down amylose and amylopectin into dextrins and maltose
- Only about five percent of starches are broken down in the mouth. Why?
- When carbohydrates reach the stomach, only mechanical breakdown continues via strong peristaltic contractions of the stomach to form chyme.

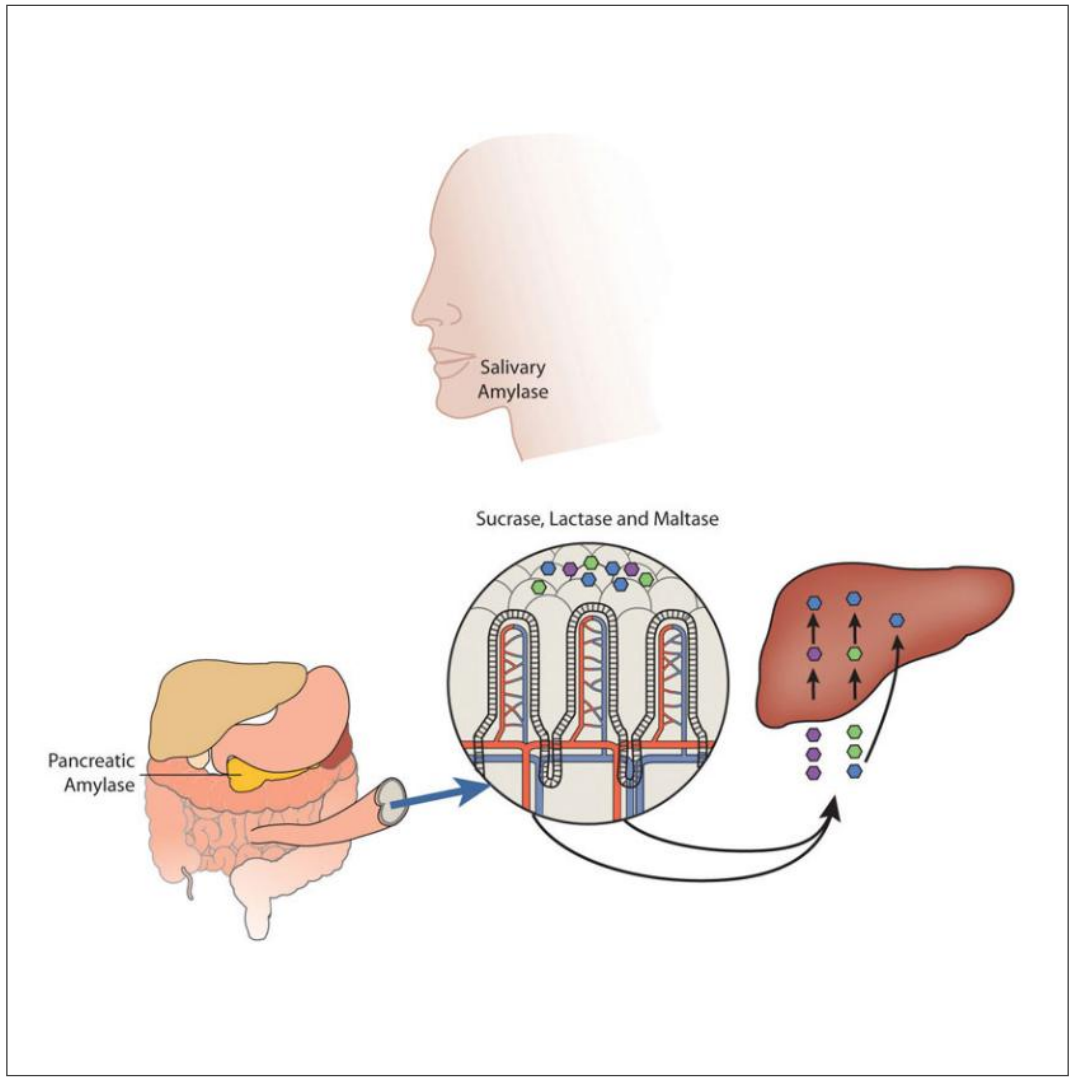
Digestion from mouth





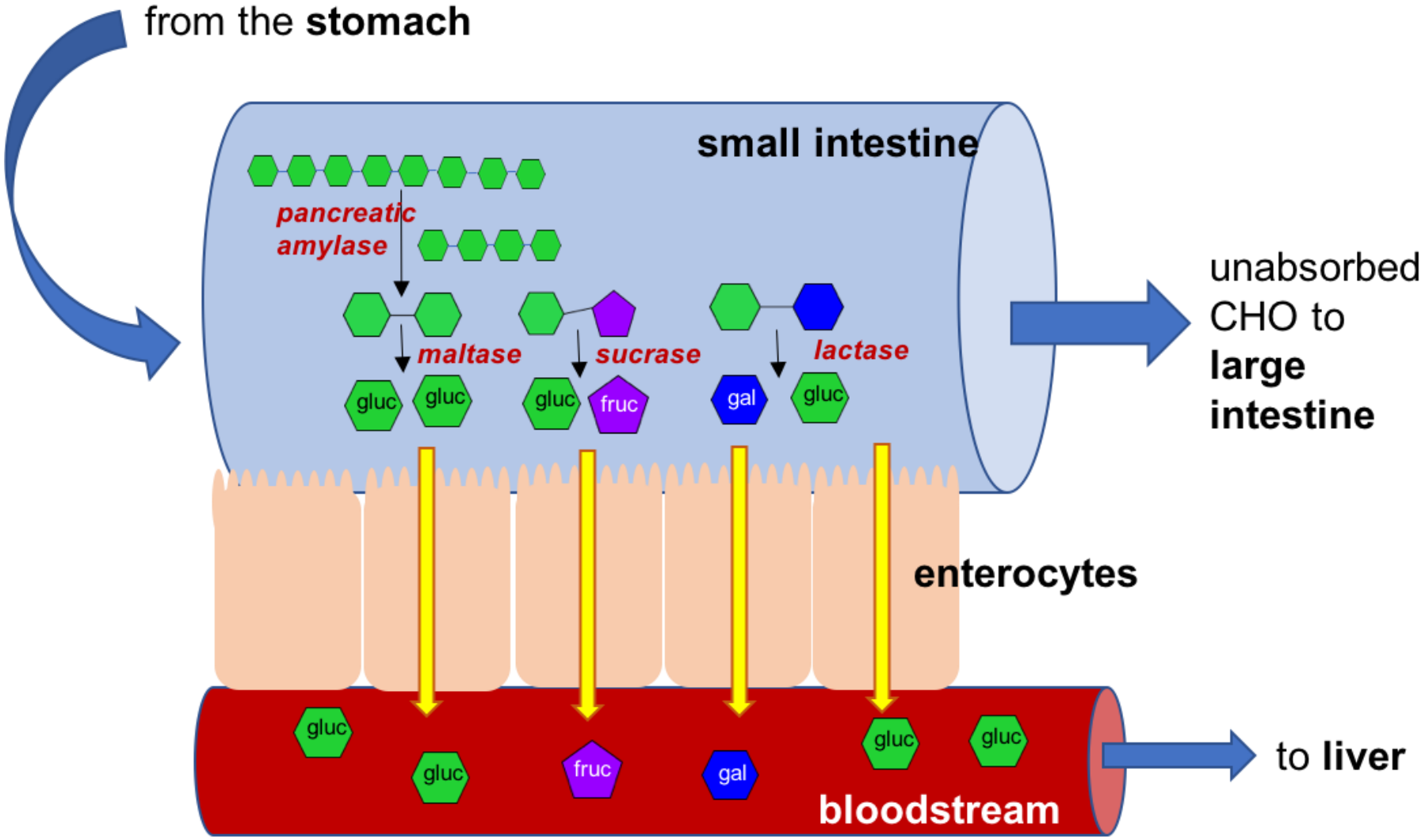
Digestion from stomach to SI

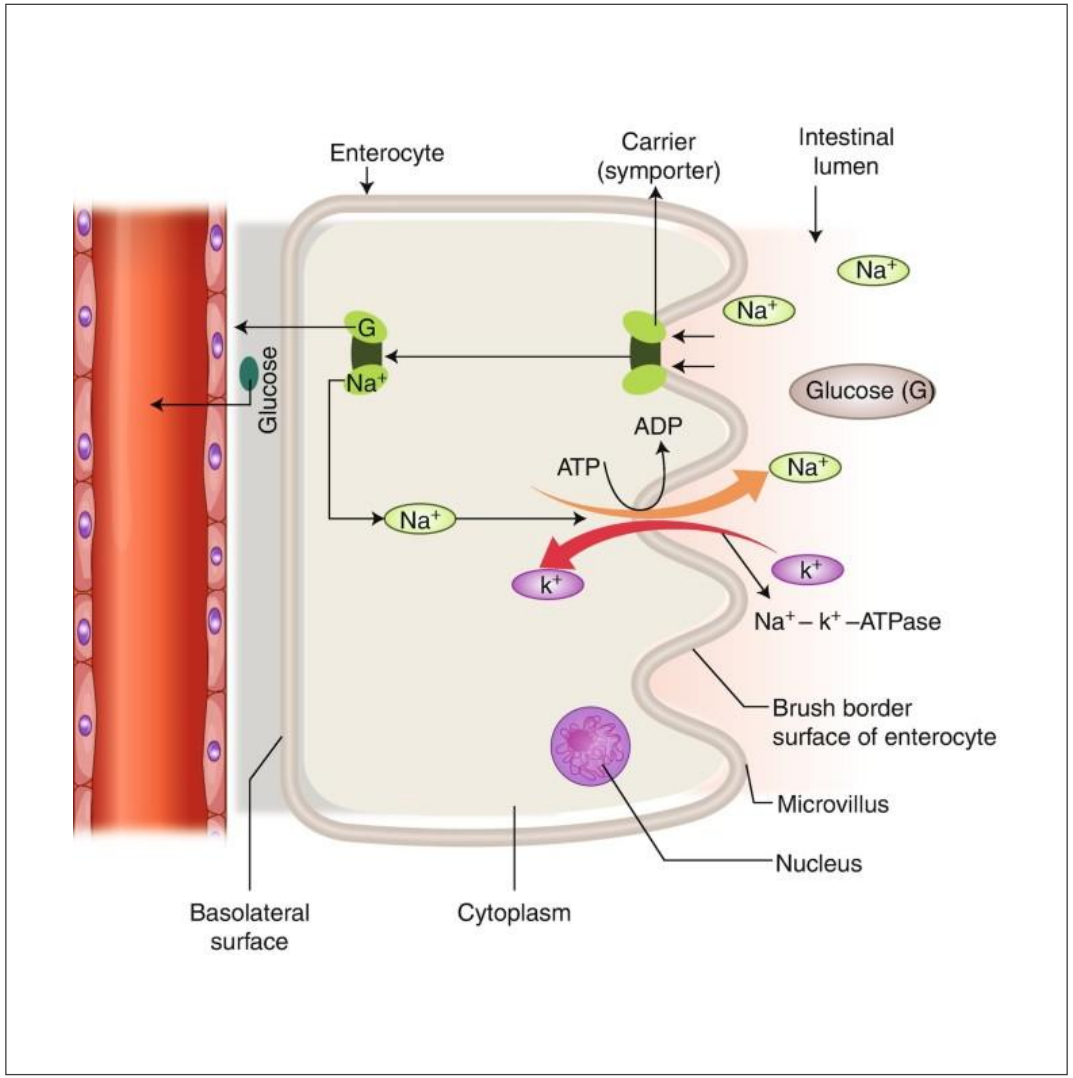
- The chyme is gradually expelled into the small intestine and received pancreatic juice through a duct.
- Pancreatic amylase (in the juice), continues with the breakdown of dextrins into shorter carbohydrate chains.
- Disaccharidases are secreted by the intestinal cells that line the villi (Sucrase - glucose + fructose; Maltase – 2 glucose units; and lactase – galactose + glucose).
- Chemically broken-down sugars are transported into the inner part of small intestine cell.
- Deficiency of such enzymes - lactose intolerance.



Absorption into blood

- Villi membrane transporters allow the entry of monosaccharides to the systemic circulation and distributed.
- Liver takes the free sugars and convert galactose to glucose and either store them as glycogen or releases them back into circulation.
- The amount of glucose exported back to blood circulation is determined by hormonal regulation and the glucose itself.


from the **stomach**
small intestine
pancreatic amylase
maltase
sucrase
lactase
gluc
gluc
gluc
fruc
gal
gluc
unabsorbed CHO to **large intestine**
enterocytes
gluc
gluc
fruc
gal
gluc
gluc
bloodstream
to **liver**

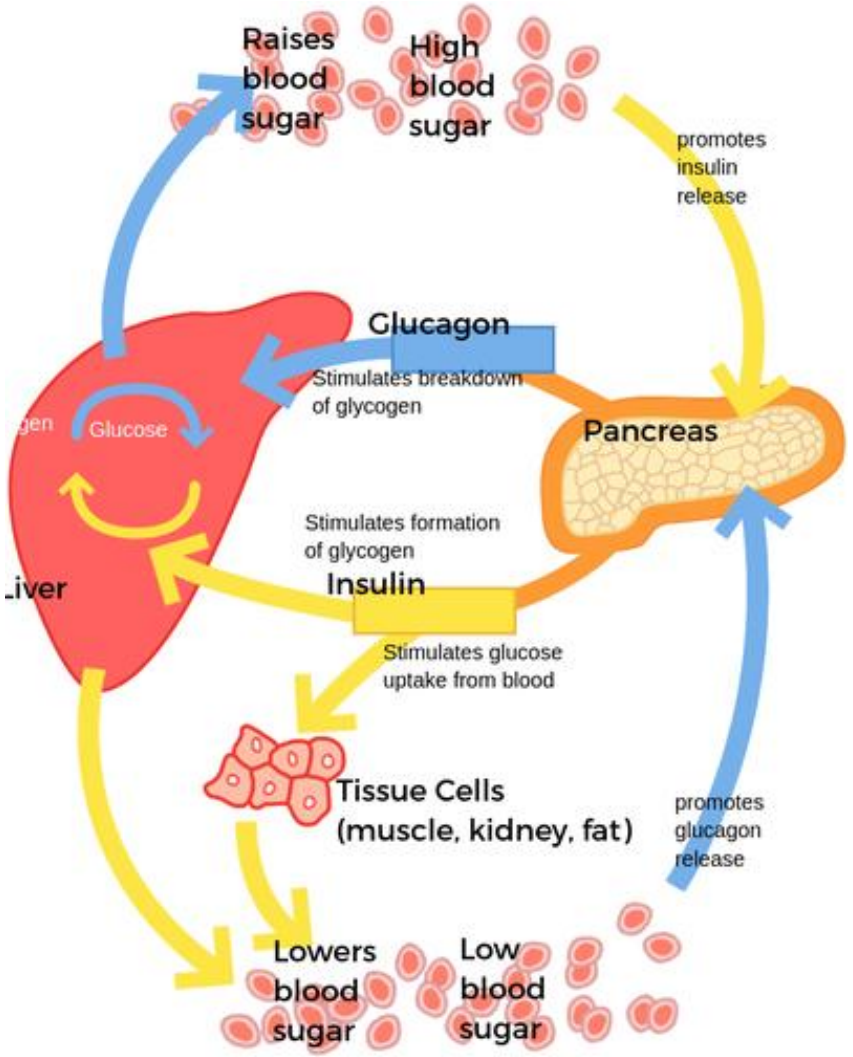


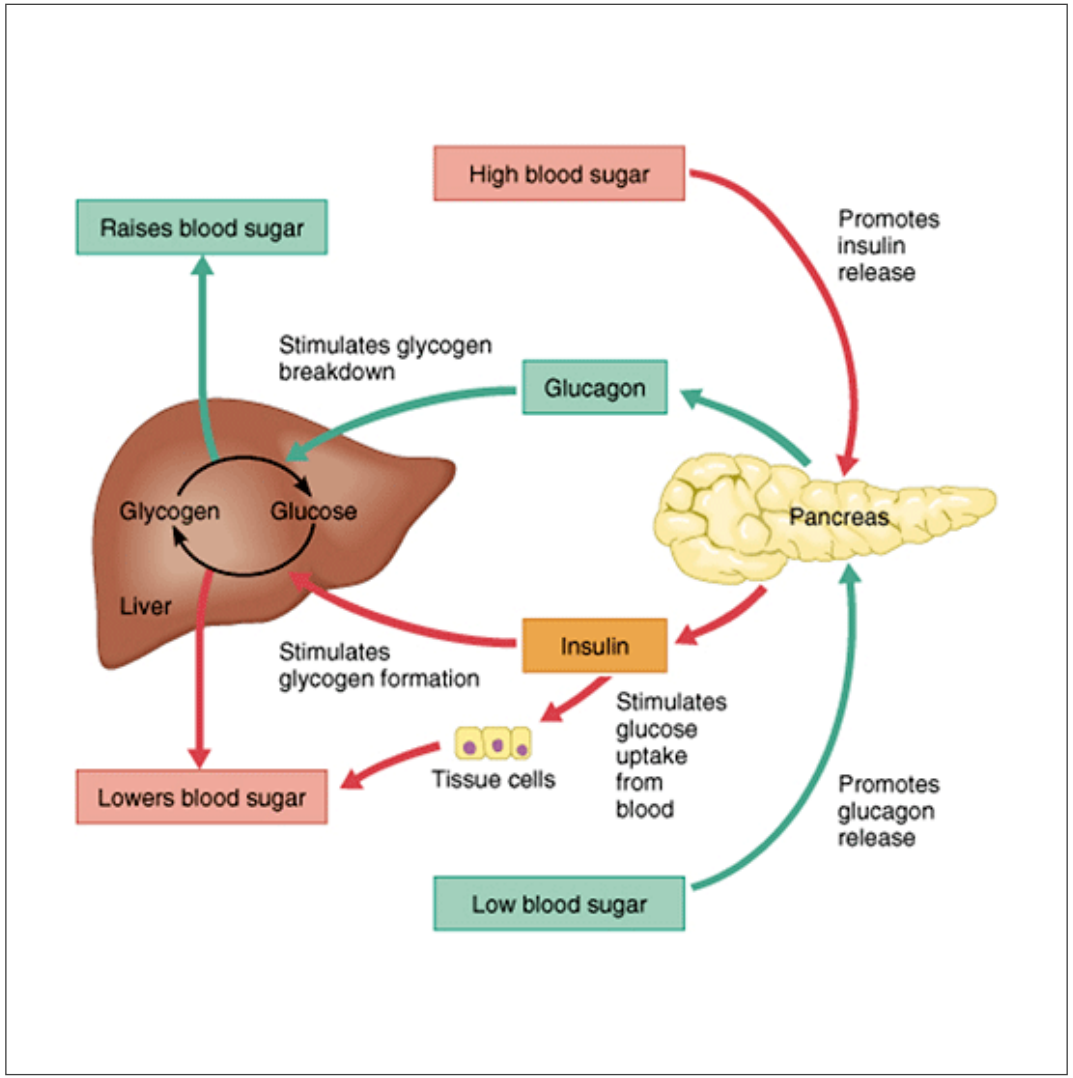
Leftover carbohydrates in LI

- Almost all of the carbohydrates, except for dietary fiber and resistant starches, are efficiently digested and absorbed into the body.
- Some of the remaining indigestible carbohydrates are broken down by enzymes released by bacteria in the large intestine.
- The products of bacterial digestion of these slow-releasing carbohydrates are short-chain fatty acids and some gases.
- The short-chain fatty acids are either used by the bacteria to make energy and grow, are eliminated in the feces, or are absorbed into cells of the colon.

Maintaining Blood Glucose Levels (Pancreas and Liver)

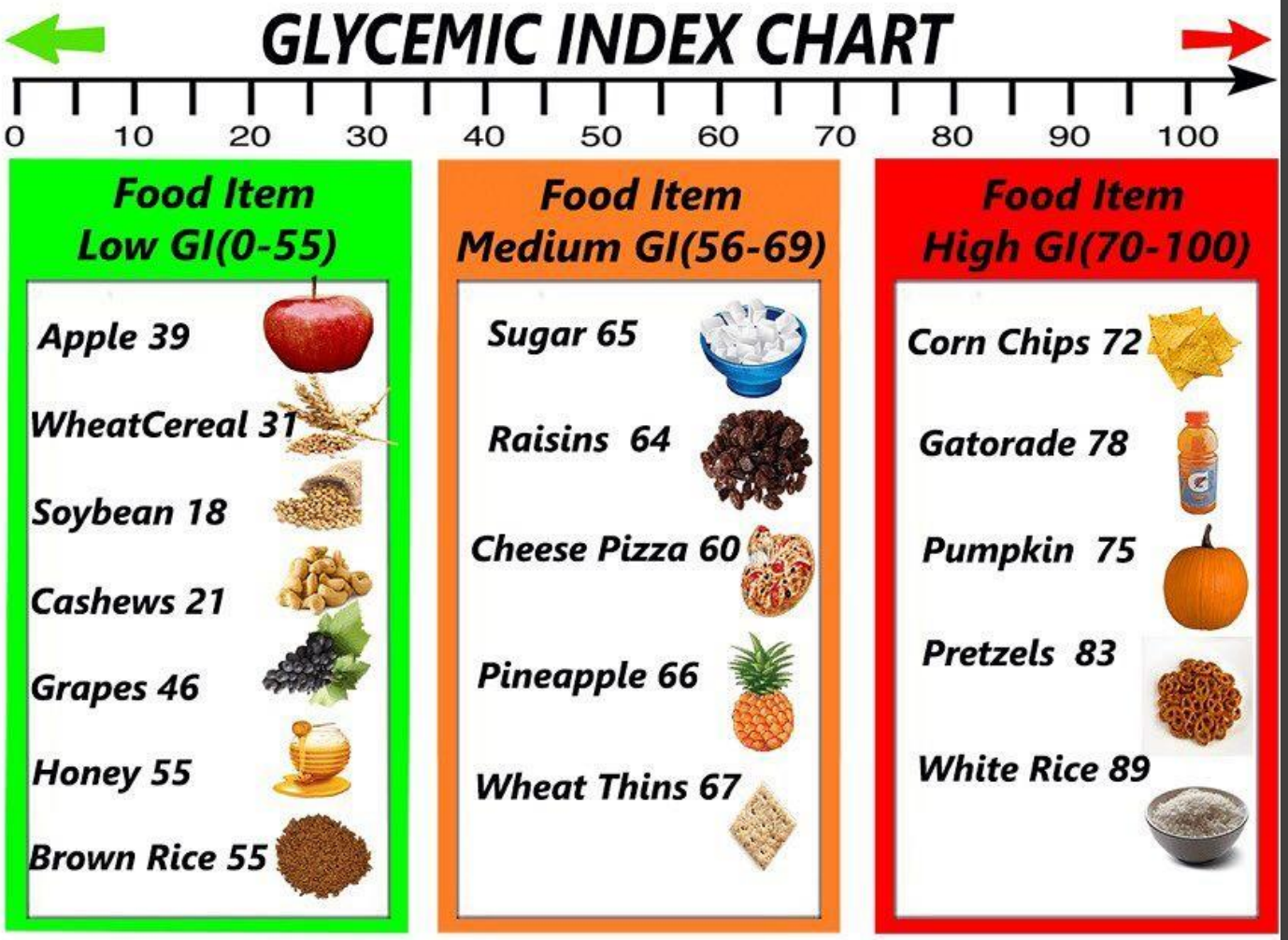
- Glucose levels in the blood are tightly controlled, as having either too much or too little glucose in the blood can have health consequences.
- Glucose regulates its levels in the blood via a process called negative feedback (e.g. thermostat).
- After eating a meal glucose levels rise in the blood and Insulin-secreting cells in the pancreas sense the increase and release insulin, into the blood.
- Insulin sends signals to the body's cells to remove glucose from the blood by transporting it into different organ cells around the body for energy.





Maintaining Blood Glucose Levels (Pancreas and Liver)

- Insulin sends the biological message to store glucose away as glycogen in muscles and liver.
- As glucose is transported into the cells around the body, the blood glucose levels decrease.
- Glucagon-secreting cells in the pancreas sense the drop and release glucagon into the blood to regulate it
- More specifically, it signals the liver to break down glycogen and release the stored glucose into the blood to have normal level.



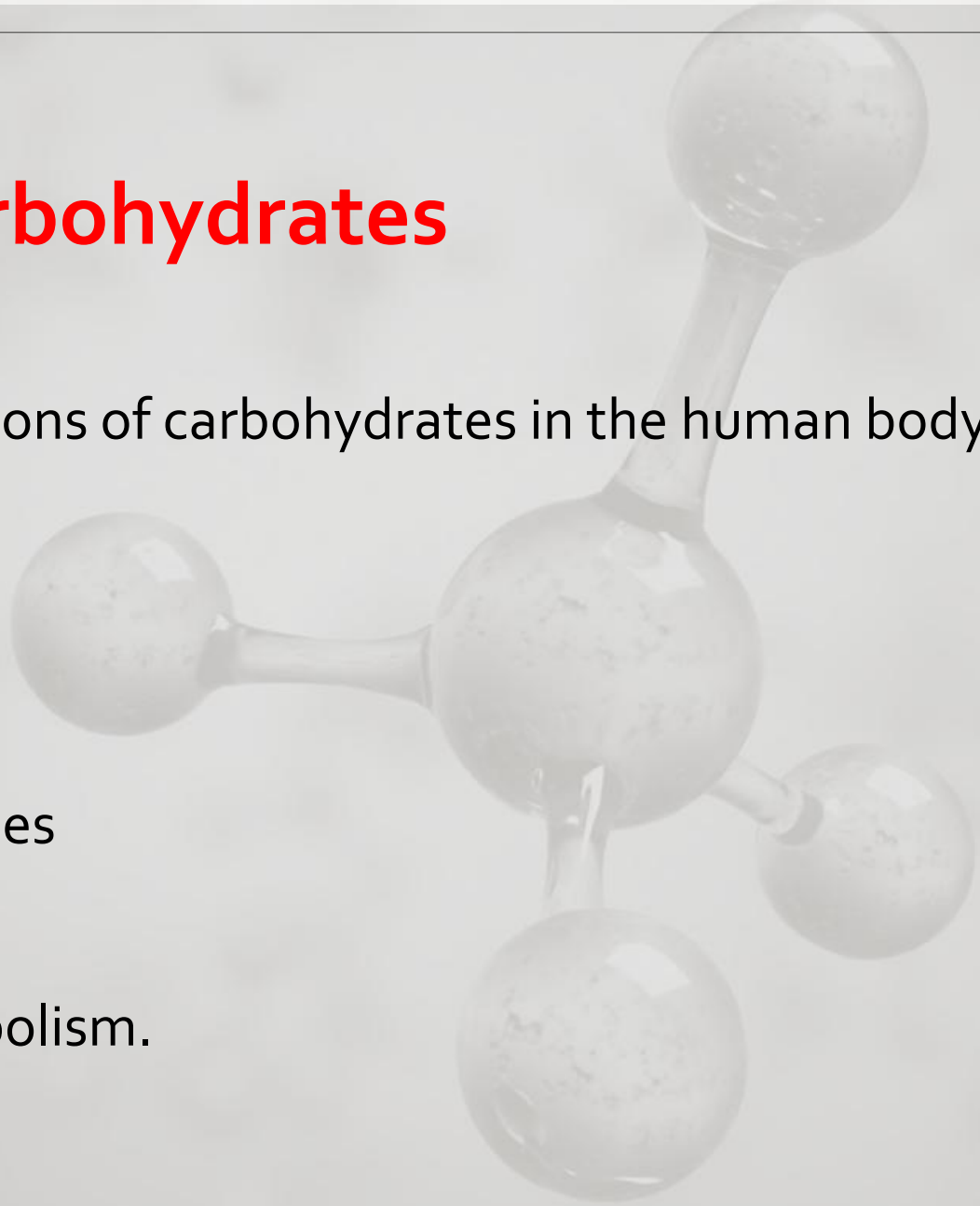
Maintaining Blood Glucose Levels (Pancreas and Liver)

- Densely carbohydrates containing food releases sugar quickly and cause a sharp spike of insulin level
- Contrastingly, high fiber-containing foods release glucose slowly.
- The measurement of the effects of a carbohydrate-containing food on blood glucose levels is called the **GLYCEMIC INDEX**.

Functions of carbohydrates

- The Five primary functions of carbohydrates in the human body are:

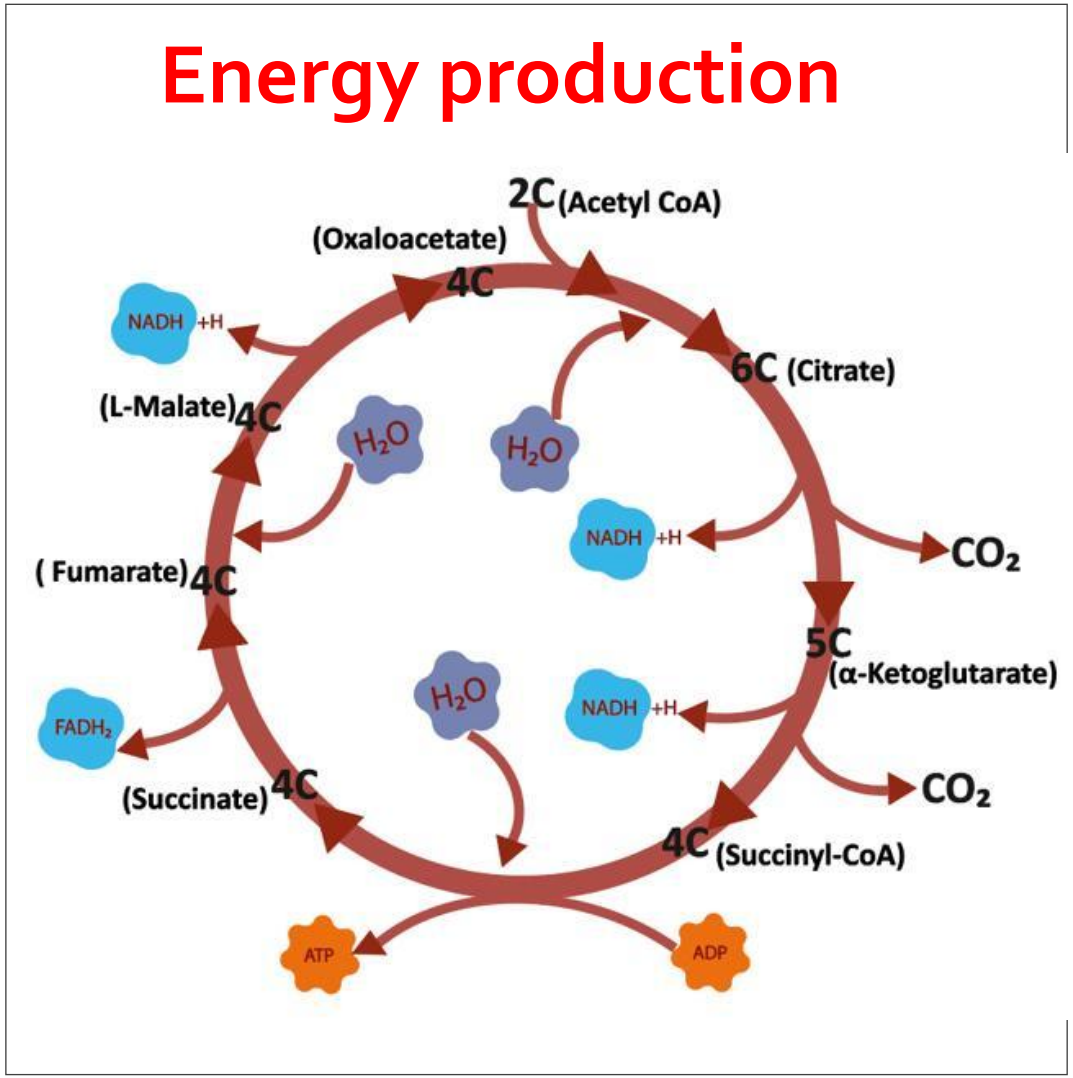
- Energy production.
- Energy storage.
- Building macromolecules
- Sparing Protein
- Assisting in lipid metabolism.



Energy production

- The primary role of carbohydrates is to supply energy to all cells in the body.
- Many cells such as RBC and brain cells prefer glucose as a source of energy versus other compounds like fatty acids.
- About 70% of the glucose entering the body from digestion is redistributed (by the liver) back into the blood for use by other tissues.
- Cells that require energy remove the glucose from the blood with a transport protein in their membranes.
- The energy from glucose comes from the chemical bonds between the carbon atoms.

Energy production



- Sunlight energy was required to produce these high-energy bonds via photosynthesis.
- Body cells break the bonds & capture energy to perform cellular respiration.
- Respiration is basically a controlled burning vs uncontrolled burning of glucose.
- A cell uses many chemical reactions in multi-enzymatic steps to slow the release of energy and more efficiently capture the energy held it.

- The energy is generated in three steps:
- Glycolysis
- Tricarboxylic acid cycle
- Electron transport chain

Energy storage

- If the body already has enough energy to support its functions, the excess glucose is stored as glycogen.
- The glycogen stored in the muscles is released under the control of glucagon during starvation to replenish blood glucose.
- The liver uses this glycogen reserve to keep blood glucose levels within a narrow range between meal times.
- When the liver's glycogen supply is exhausted, glucose is made from amino acids to maintain metabolic homeostasis.

Building of molecules

Some glucose are converted to ribose and deoxyribose, which are essential building blocks of important macromolecules, such as RNA, DNA, and ATP.

Glucose is additionally utilized to make reducing equivalent like NADPH and NADH used in many chemical reactions in the body.

If all the body energy needs are met, excess glucose can be used to make fat. This is why a diet too high in carbohydrates and calories can add on fat.

Sparing Protein

In a situation where there is not enough glucose to meet the body's needs, glucose is synthesized from amino acids.

Because there is no storage molecule of amino acids, this process requires the destruction of proteins, primarily from muscle tissue.

The presence of adequate glucose spares the breakdown of proteins from being used to make glucose needed by the body.

Lipid Metabolism

- As blood-glucose levels rise, the use of lipids as an energy source is inhibited. Thus, glucose has another sparing effect on fat.
- This is because an increase in blood glucose stimulates the release of hormone insulin, which tells cells to use glucose (instead of lipids) to make energy.
- Adequate glucose levels in the blood prevent the development of ketosis.
- Ketosis is a metabolic condition resulting from an elevation of ketone bodies in the blood.

HOW ARE CARBOHYDRATES DIGESTED?

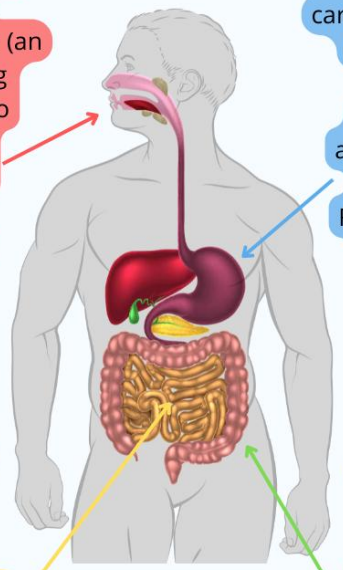
HAVING A BASIC UNDERSTANDING OF DIGESTION CAN ENHANCE YOUR NUTRITIONAL LITERACY

1. MOUTH

Chemical and mechanical digestion begins in the mouth. Salivary amylase (an enzyme) begins breaking down carbohydrates into shorter polysaccharide chains. Chewing breaks down food into more manageable pieces for digestion.

2. STOMACH

Mechanical digestion of carbohydrates continues in the stomach. No further chemical breakdown occurs because salivary amylase is neutralised by our stomach acid (HCl). Food contents are mixed into a substance called chyme.



3. SMALL INTESTINE

The majority of carbohydrate digestion occurs in the small intestine. The enzyme pancreatic amylase is released by the pancreas which breaks down the larger carbohydrate chains. Brush border enzymes help convert these larger chains into simple sugars which are then absorbed into the bloodstream.

4. LARGE INTESTINE

Dietary fibre and other indigestible carbohydrates are metabolised by our gut bacteria. This produces certain byproducts such as short chain fatty acids and gas. The remaining fibre is excreted in the faeces.

TBD
THE BODYBUILDING DIETITIANS


Questions
Comments
Feedback