





Biomedical Importance of Carbohydrates



What Are Carbohydrates?

Carbohydrates are defined chemically as aldehyde or ketone derivatives of the higher polyhydric alcohols, or compounds which yield these derivatives on hydrolysis.

A carbohydrate is an organic compound that is the body's main source of energy.

Cont...

- Produced by plants during photosynthesis
- After eating plant foods, humans convert the carbohydrates into glucose
- Glucose
 - Most abundant carbohydrate
 - Preferred source of energy for the blood, brain, and nervous system
- Carbohydrate-rich plant foods make up the foundation of diets all over the world



Classification of Carbohydrates

- Simple carbohydrates
 - Monosaccharide
 - Disaccharide
 - Perceived as sweeter than complex carbohydrates
 - Mixes with saliva and reacts with taste buds
- Oligosaccharides
- Complex carbohydrates
 - Polysaccharides



1. Monosaccharides: (also called 'simple' sugars) are those which cannot be hydrolysed further into simpler forms.

2. Disaccharides: Those sugars which yield two molecules of the same or different molecules of monosaccharide on hydrolysis.



3. Oligosaccharides: Those sugars which yield 3 to 10 monosaccharide units on hydrolysis, e.g. Maltotriose.

4. Polysaccharides (Glycans): Those sugars which yield more than ten molecules of monosaccharides on hydro- lysis



Biomedical Importance of Carbohydrates

- Chief source of energy.
- Constituents of compound lipids and conjugated proteins.
- Certain carbohydrate derivatives are used as drugs like cardiac glycosides/antibiotics.

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- Degradation products utilised for synthesis of other substances such as fatty acids, cholesterol, amino acid, etc.
 - Inherited deficiency of certain enzymes in metabolic pathways of different carbohydrates can cause diseases, e.g. galactosemia, glycogen storage diseases (GSDs), lactose intolerance, etc.
 - Derangement of glucose metabolism is seen in diabetes mellitus.



Monosaccharides

- Three nutritionally important monosaccharides
 - Glucose
 - Fructose
 - Galactose



Monosaccharides

- Glucose
 - Blood glucose and blood sugar in the body
 - Most abundant monosaccharide in the body
 - Is the preferred and main source of energy for the brain and red blood cells
 - Part of every disaccharide
 - Only monosaccharide in starches



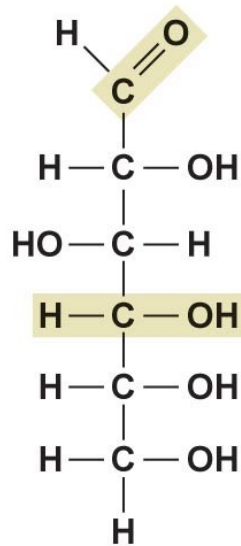
Monosaccharides

- Fructose
 - Sweetest of natural sugars
 - Found abundantly in fruits
- Galactose
 - Commonly occurs as part of dissaccharide lactose

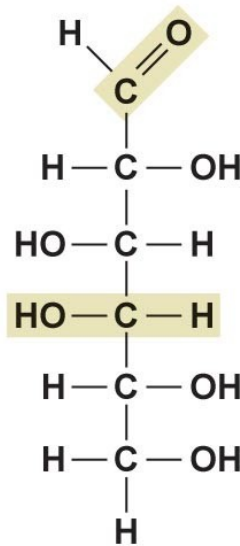
The Structural Differences between Glucose, Galactose, and Fructose

Hexose sugars ($C_6H_{12}O_6$)

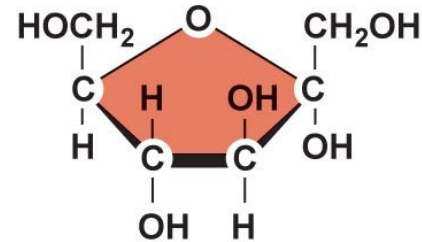
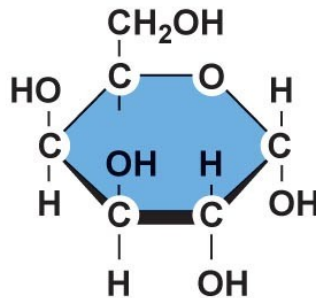
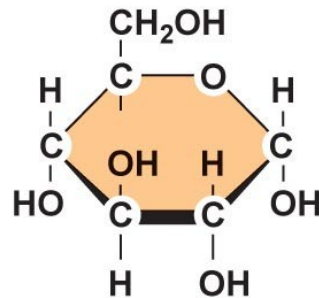
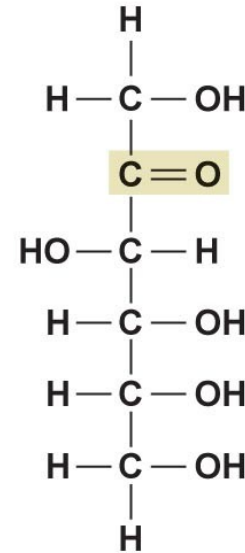
Glucose



Galactose



Fructose



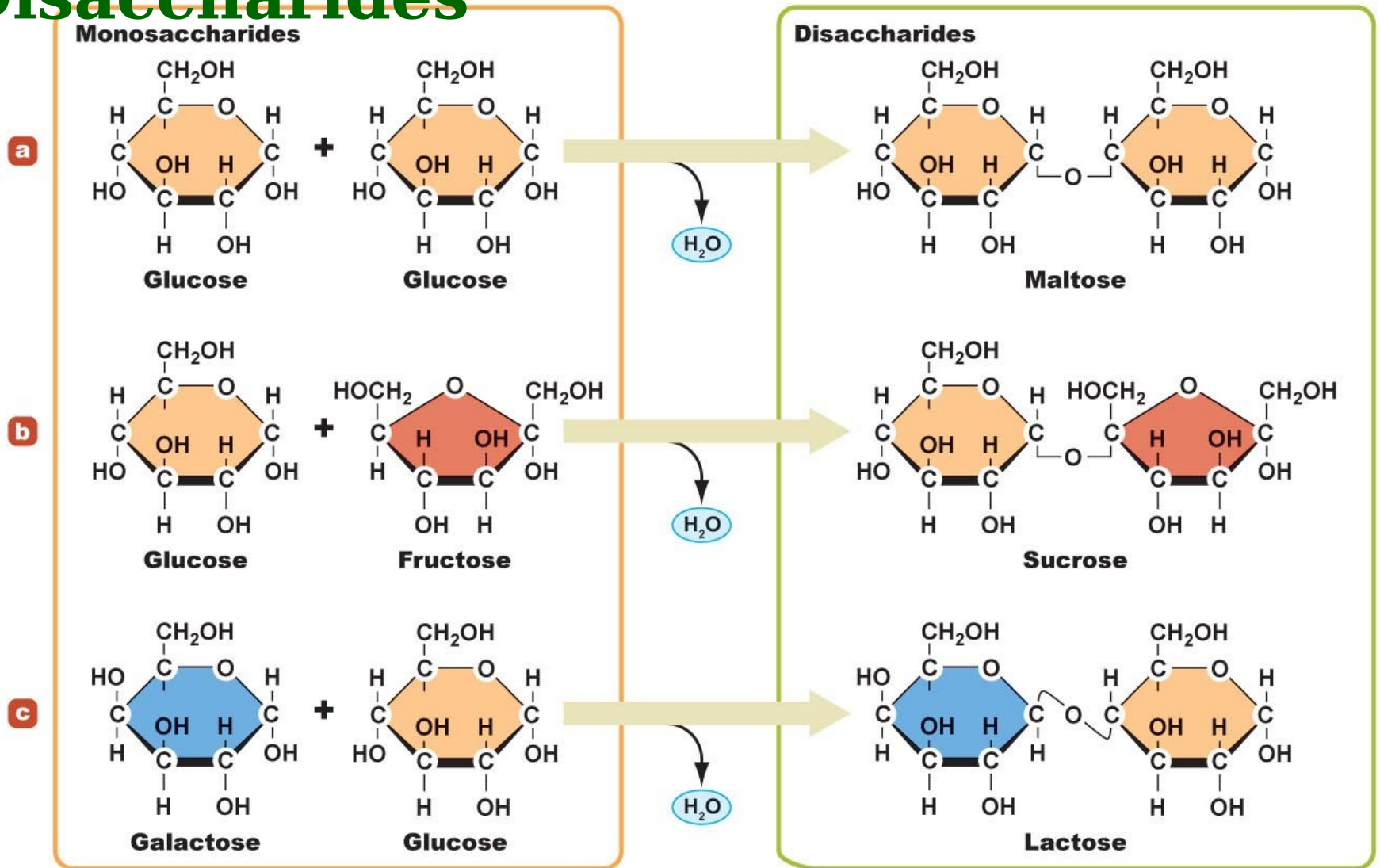
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Disaccharides

- Three Disaccharides
 - Sucrose
 - Most common
 - Lactose
 - Maltose
 - Least common
 - Formed from digestion of starches

Monosaccharides Link to Form Disaccharides



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Polysaccharides

- Starch
 - Plants store glucose in chains of starch
 - Amylose
 - Straight chain
 - More resistant to digestion
 - Resistant starch
 - ✓ May improve health of digestive tract
 - ✓ May improve glucose tolerance
 - ✓ May stimulate growth of beneficial intestinal bacteria
 - Amylopectin
 - Branched chains
 - Easier to digest



Fiber Health Benefits

- Slow gastric emptying and may delay absorption of some nutrients
 - Helps reduce serum cholesterol
 - Improve appetite control
 - Normalize blood glucose levels
- May help protect against colon cancer.



Polysaccharides

- Glycogen
 - Storage form of glucose in animals
 - Long, branched chains of glucose
 - Stored in liver and muscle
 - Liver glycogen response to blood glucose (BG) levels
- ↓ BG → glycogen breakdown → ↑ BG
- Muscle glycogen can be broken down for energy for the muscle



Oligosaccharides

- Similar in length to simple carbohydrates
- Similar in makeup to polysaccharides
- Humans lack the enzymes necessary to digest them.



- Digestion of carbohydrates begins in the mouth
- Most carbohydrate digestion takes place in the small intestine
- Carbohydrates are broken down to monosaccharides for absorption
- Monosaccharides are converted to glucose in the liver and
 - Used as energy
 - Stored as glycogen in the liver and muscle cells
 - Stored as glycerol and fatty acids in the adipocytes.



Lactose Intolerance

- Deficiency of lactase, the enzyme that digest lactose
 - Maldigestion – inability to digest lactose due to low levels of the enzyme
 - Intolerance
 - Maldigestion resulting in nausea, and diarrhea



Functions of Carbohydrate

- Provide energy
 - 4 kilocalories per gram
- Maintain blood glucose
 - Carbohydrate intake
 - Glycogenolysis > 4 hours after a meal.

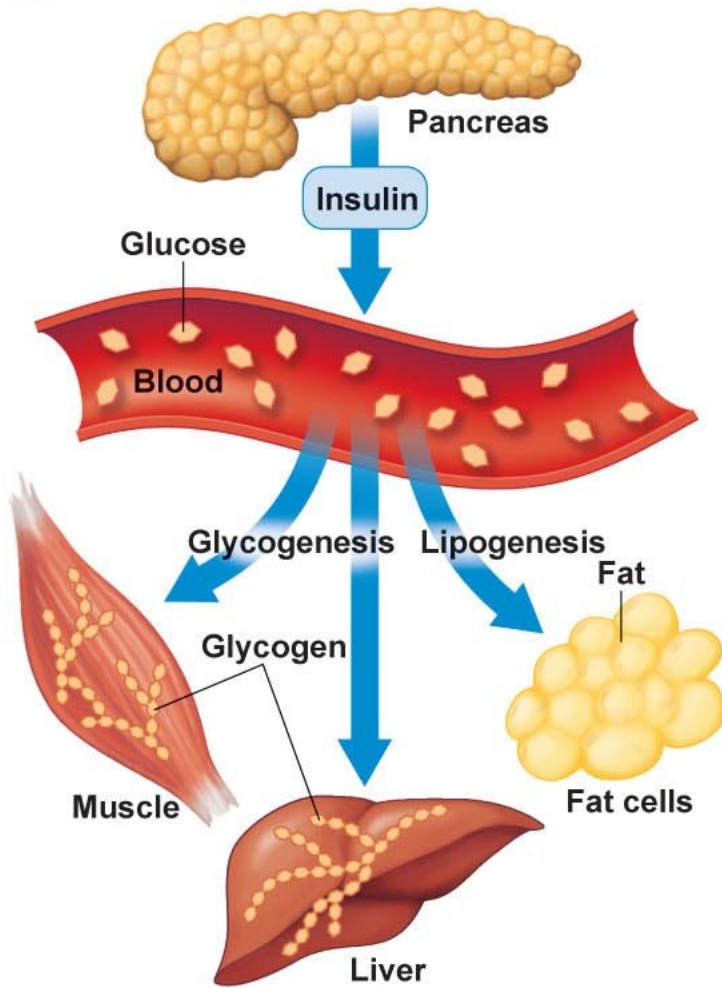


How to Maintain Blood Glucose Levels

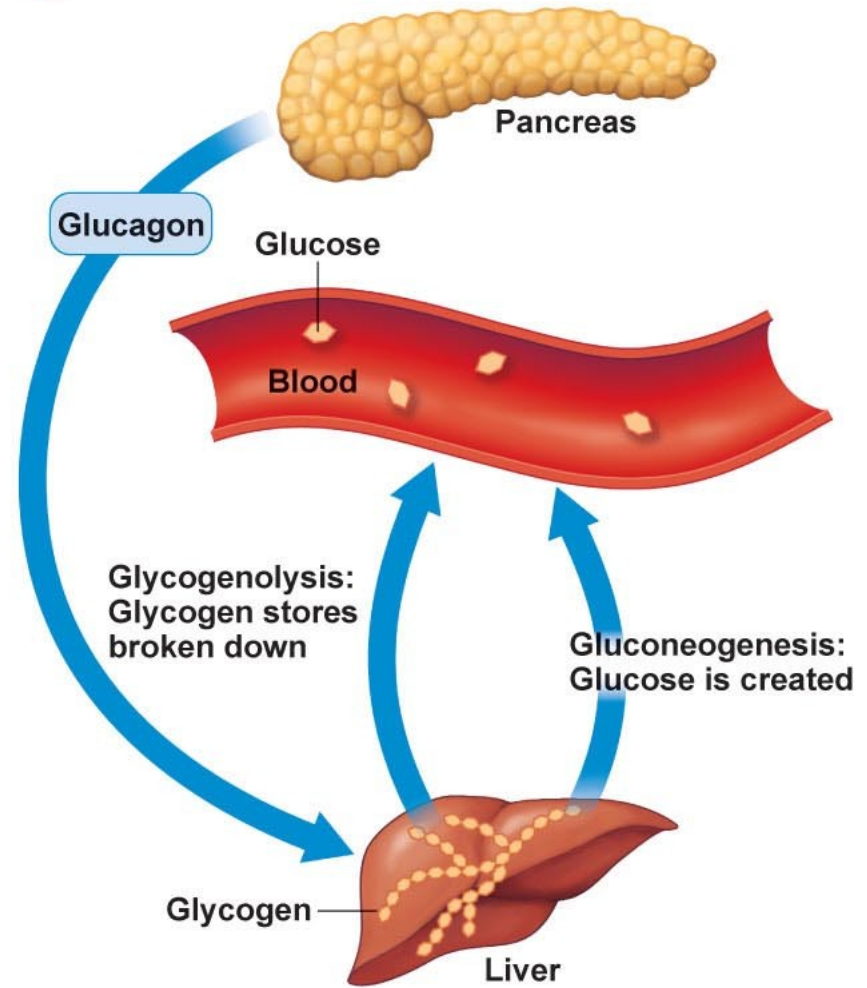
- Goal for blood glucose is 75–115 mg/dl
- Insulin – lowers blood glucose levels
 - Needed for glucose to enter the cell from the blood stream
 - Exception: liver, kidney, and brain cells
 - Helps convert glucose to glycogen through glycogenesis
 - Helps convert glucose to fatty acids through lipogenesis
- Glucagon – increases blood glucose levels
 - Stimulates the release of glucose into the blood
 - Stimulates glycogenolysis
 - Stimulates gluconeogenesis

Insulin and Glucagon Regulate Glucose Metabolism

a High blood glucose levels



b Low blood glucose levels



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How to Maintain Blood Glucose Levels

- Epinephrine and norepinephrine – increases blood glucose
 - Stimulate glycogenolysis and gluconeogenesis
- Cortisol – increases blood glucose
 - Stimulates gluconeogenesis
 - Reduces uptake of glucose by the muscle cells
- Growth hormone – increases blood glucose
 - Stimulates fat breakdown for energy
 - Reduces uptake of glucose by the muscles
 - Increase glucose production in the liver



- Glucose is the body's preferred source of energy
 - Especially the brain and red blood cells
- Adequate carbohydrate intake
 - Maintains blood glucose levels
- Blood glucose levels are maintained by two hormones
 - Insulin which lowers blood glucose levels
 - Glucagon which raises blood glucose levels
- Epinephrine, norepinephrine, cortisol, and growth hormone raise blood glucose levels.



Dietary Fiber

- Benefits
 - Helps lower risk of
 - Obesity
 - Heart disease
 - Cancer
 - Diabetes mellitus



Forms of Diabetes

- Type 1
 - Usually begins in childhood or early adulthood
 - 5-10% of diabetics
 - Immune system destroys beta cells of the pancreas
 - No insulin produced
 - Common symptoms of elevated blood sugar.
 - Polyuria
 - Require insulin and frequent blood glucose monitoring



Forms of Diabetes

- Type 2
 - Overweight individuals develop this form frequently
 - 90–95% of diabetics
 - Can go undiagnosed
 - Damages vital organs without individual being aware of it
 - Hormonal imbalance in women
 - Have higher incidence of insulin resistance
 - Increased risk of developing type 2 diabetes



Forms of Diabetes

- Prediabetes
 - Impaired glucose tolerance
 - Fasting blood sugar between 100 mg/dl and 126 mg/dl
 - High risk of developing diabetes and heart disease



Diabetes

- Long-term damage from diabetes
 - Nerve damage
 - Leg and foot problem
 - Eye diseases
 - Blindness
 - Tooth loss
 - Kidney disease
 - Heart disease
- Slowing of complications
 - Control level of blood glucose through
 - Diet
 - Insulin or oral medication
 - Monitoring blood glucose
 - Regular healthcare visits



- Diabetes involves inadequate regulation of blood glucose levels
- Type 1 diabetes – inadequate production of insulin
- Type 2 diabetes – insulin resistance
- Chronic high blood glucose can damage vital organs
- Diabetics need medications and/or insulin to manage blood glucose
- High-fiber diet and routine exercise play a key role in managing and preventing diabetes.



Hypoglycemia

- A blood glucose level that is too low (usually below 70 mg/dl)
 - Confused
 - Weak
- Signs and symptoms
 - Hunger
 - Nervousness



Fasting Hypoglycemia

- Occurs in the morning after an overnight fast

May be caused by

- Medications
- Illness
- Drinking too much alcohol
- Certain tumors
- Hormone imbalances



Health Effects of Sugar

- Sugar can contribute to
 - Dental problem
 - Elevated level of fat in the blood
 - Lowing of HDL cholesterol
- Sugar does not cause
 - Increased risk of diabetes



THANK YOU