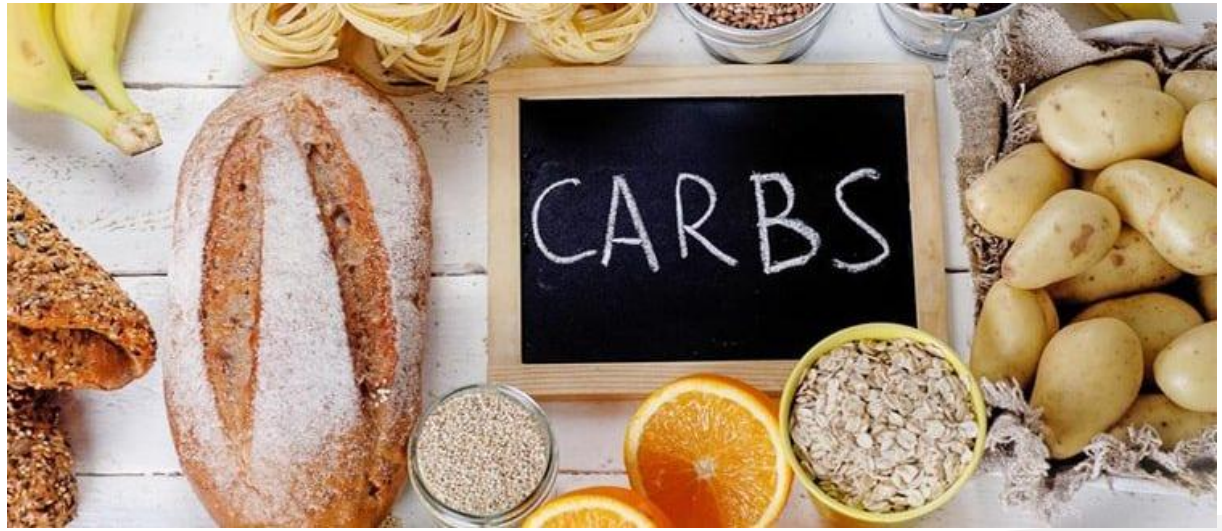
Tishk International University
Faculty of Applied Sciences
Nutrition and Dietetics Department
Principles of Food Science

Carbohydrate Structure and Functions in Food



 Assistant Lecturer: Pary Ameer

Quiz

Previous Lecture

Cont. of 4th lecture

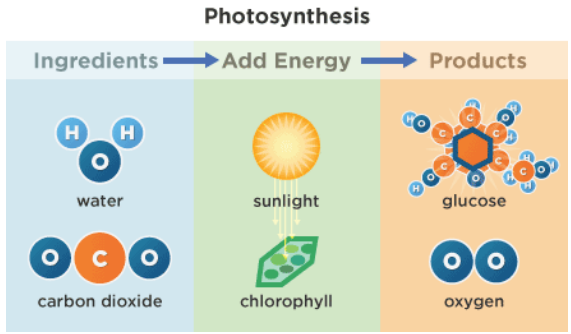
Carbohydrates

Carbohydrates

- are organic compounds found in living tissues and foods as sugars, starch, cellulose, etc.

Chemical Nature:

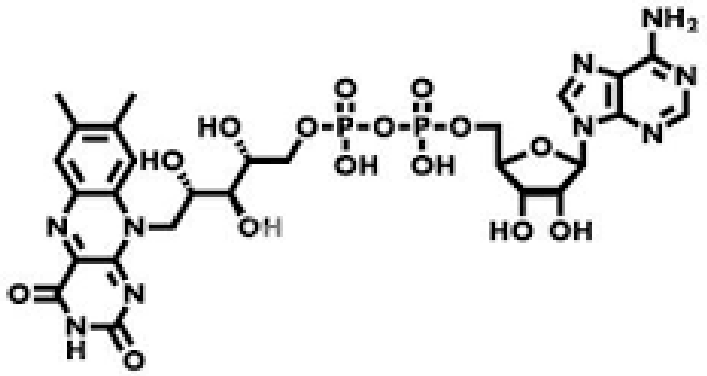
- Initially defined as compounds with the empirical formula CH_2O (hydrated carbon).
- Includes polyhydroxy aldehydes and ketones.
- Examples include starch, glycogen, and cellulose.



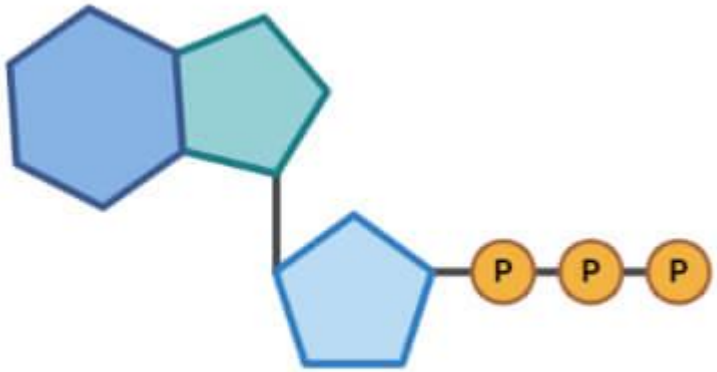
Carbohydrates Function

Functions:

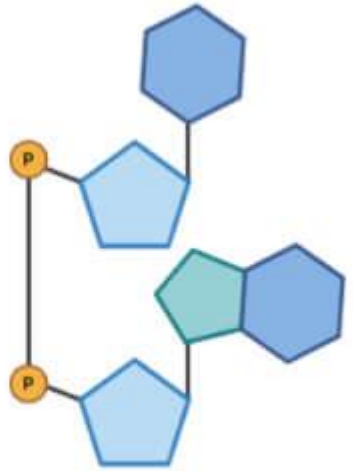
- Serve as energy sources and reserves.
- Store energy as starch or glycogen.
- Act as components in coenzymes (e.g., ATP, FAD, NAD).
- Serve as nucleotide components in RNA (ribose) and DNA (deoxyribose).
- Play roles in the immune system, fertilization, growth, and development.



FAD



ATP



NAD

Types of Carbohydrates:

- Simple carbohydrates
- Complex Carbohydrates

Characteristics of Simple Carbohydrates:

- **Simple carbohydrates** are the basic type of carbohydrates.
- Mainly include monosaccharides and disaccharides.
- Comprised of the elements **carbon, hydrogen, and oxygen** (CHO).

Monosaccharides:

- Contain only **one sugar** unit, making them the smallest carbohydrates.
- Their **small size** gives them a unique role in digestion and metabolism.
- Food carbohydrates must be broken down into **monosaccharides** for absorption in the gastrointestinal tract.

Digestion:

- Simple carbohydrates are quicker to digest than complex carbohydrates.
- Made up of shorter chains of molecules, which provide a rapid energy source.

Complex Carbohydrates:

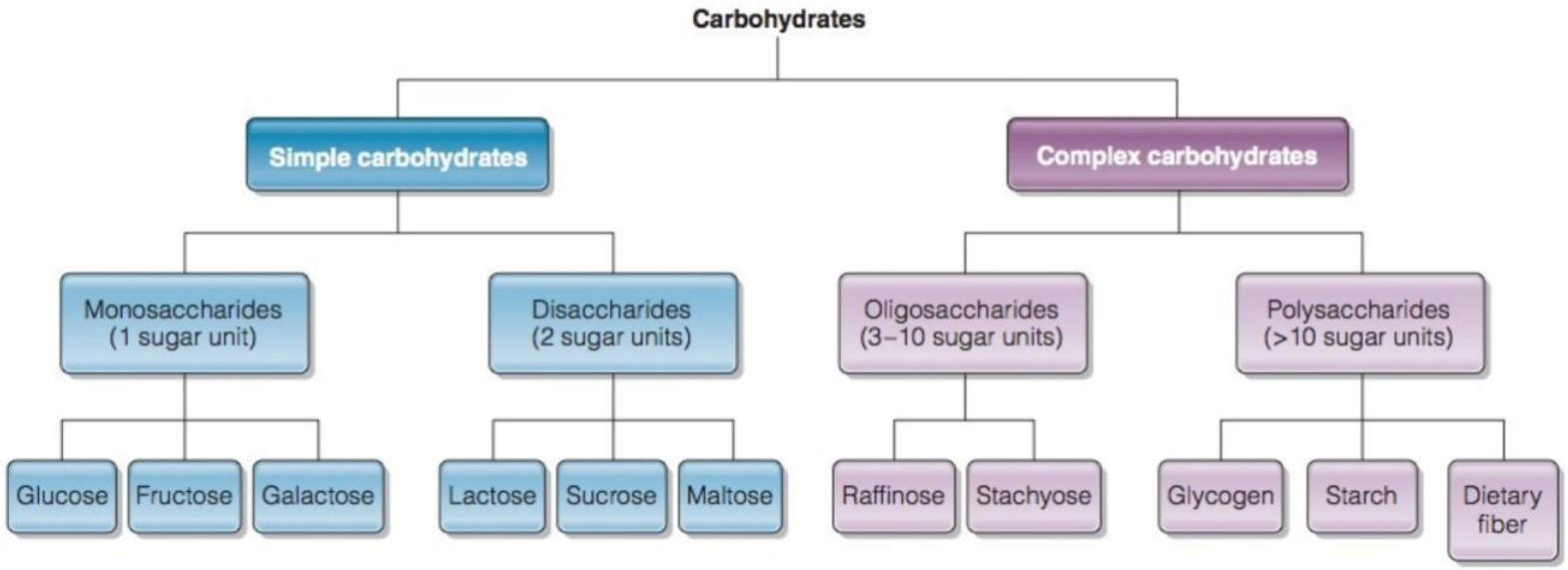
Composed of **single sugar units (monosaccharides)** bound together.

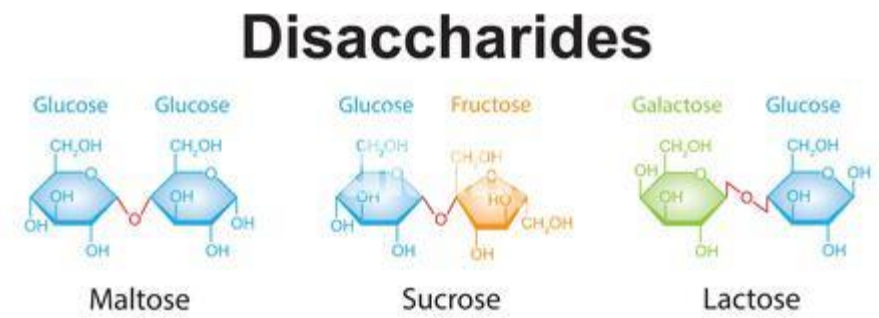
Oligosaccharides **contain 2–10 simple sugar units.**

Polysaccharides are made up of hundreds to thousands of monosaccharides.

Energy:

Provide long-lasting energy due to their complex structure.


Carbohydrates
Simple carbohydrates
Complex carbohydrates
Monosaccharides (1 sugar unit)
Disaccharides (2 sugar units)
Oligosaccharides (3–10 sugar units)
Polysaccharides (>10 sugar units)
Glucose
Fructose
Galactose
Lactose
Sucrose
Maltose
Raffinose
Stachyose
Glycogen
Starch
Dietary fiber


Disaccharides
Glucose
Glucose
Maltose
Glucose
Fructose
Sucrose
Galactose
Glucose
Lactose


COMMON DISACCHARIDES
Maltose (malt or beer sugar)
two glucose molecules
Lactose (milk sugar)
glucose and galactose
Sucrose (table sugar)
glucose and fructose
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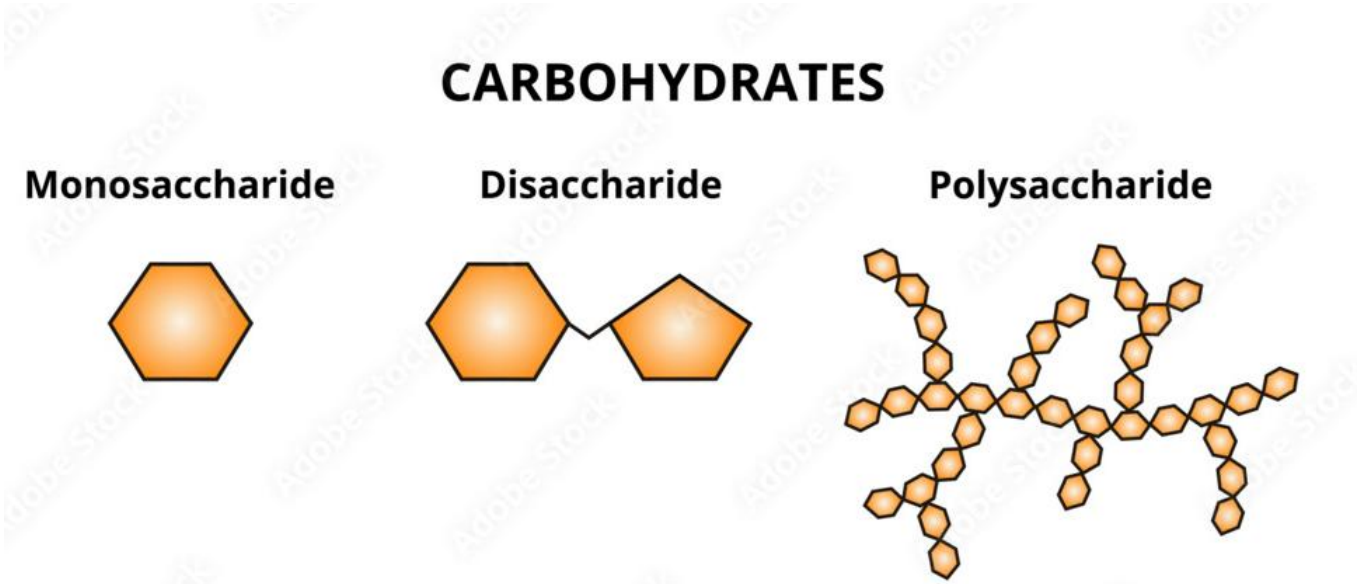
The different types of carbohydrates can be classified on the basis of their behavior in hydrolysis. They are mainly classified into three groups:

- **1. Monosaccharides**
- **2. Disaccharides**
- **3. Polysaccharides**

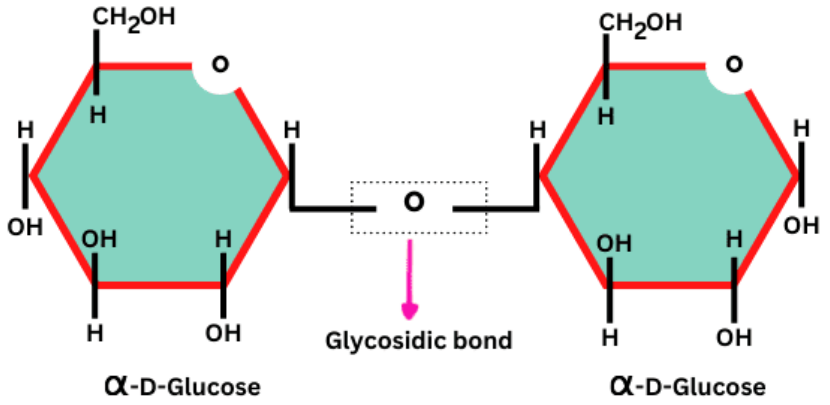


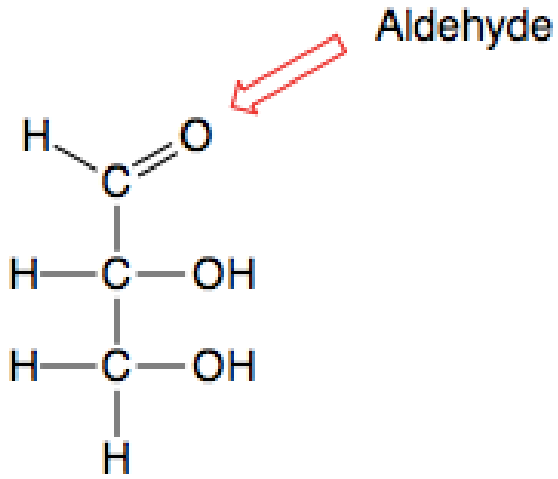
Monosaccharide Carbohydrates:

- Cannot be hydrolyzed further to give simpler units of polyhydroxy **aldehyde or ketone**.
- Monosaccharides with an **aldehyde group** are called **aldoses**.
- Monosaccharides with **a keto** group are called **ketoses.**

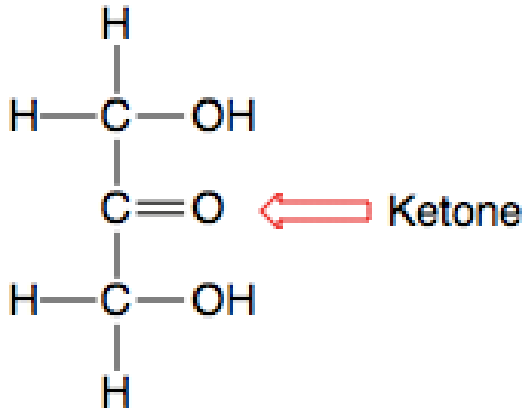
Glycosidic Bonds:

- Form between monosaccharides.
- These bonds lead to the formation of disaccharides and polysaccharides.

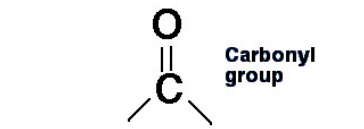


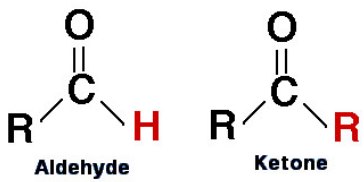


An aldose



A ketose





NO. Carbons	Category Name	Aldehyde or ketone	Relevant examples
2	Diose	Aldodiose Ketodiose	No sugars
3	Triose	Aldotriose Ketotriose	Glyceraldehyde, Dihydroxyacetone, Smallest Carbohydrates molecules occur
4	Tetrose	Aldotetrose	Erythrose
5	Pentose	Aldopentose Ketopentose	Ribose, Ribulose, Xylulose
6	Hexose	Aldohexose Ketohexose	Glucose, Galactose, Mannose, Fructose
7	Heptose	Aldoheptose Ketoheptose	---------- Sedoheptulose
8	Octose	Aldooctose Ketooctose	---------- ----------
9	Nonose	Aldonanose Ketonanose	N-acetylneuraminic acid also called sialic acid And N-acetylmuramic acid

Examples of Monosaccharides

1. Glucose

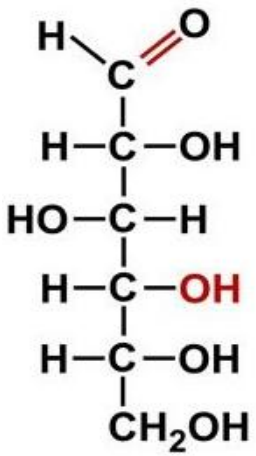
- A simple sugar that provides energy to the body.
- Found in fruits, honey, and blood sugar.
- Enzyme: **Hexokinase** starts using glucose for energy.
- The **main energy** source for cells.

Galactose

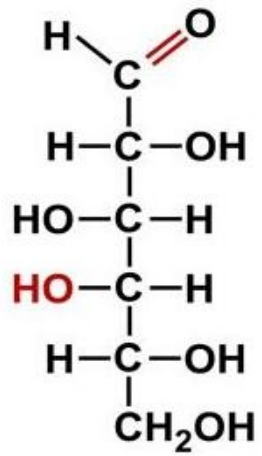
- A sugar similar to glucose, found in dairy products.
- Found in milk and as part of lactose.
- Enzyme: **Galactokinase** helps the body use galactose.
- Helps make lactose and other important molecules.

Fructose

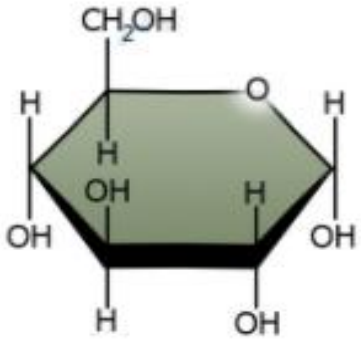
- A simple sugar (monosaccharide) naturally found in fruits, honey, and some vegetables.
- Known as "fruit sugar" and is sweeter than glucose.
- Enzyme: **Fructokinase** converts fructose into fructose-1-phosphate for energy use.
- Plays a role in energy metabolism and is part of sucrose (table sugar).
- Chemical Formula: $C_6H_{12}O_6$.



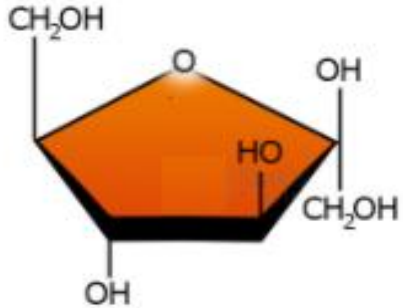
Glucose



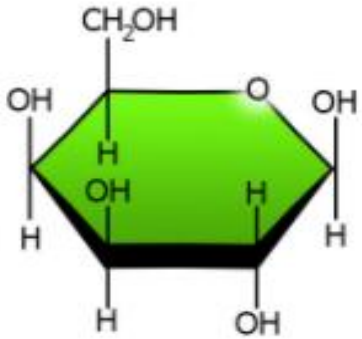
Galactose



Glucose



Fructose



Galactose

Disaccharides

- A disaccharide is a sugar formed when two monosaccharides are joined by a **glycosidic linkage** (formed through the loss of a water molecule).

Solubility:

- Disaccharides are soluble in water.
- On hydrolysis, disaccharides yield **two monosaccharides**, which may be the same or different.

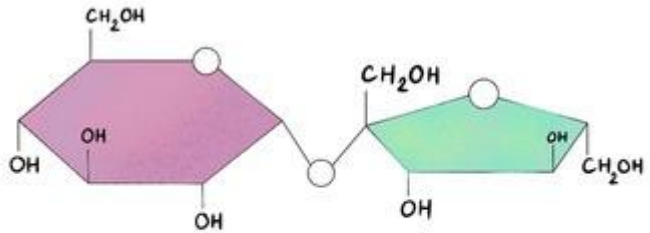
Examples:

- **Sucrose (Table Sugar)**: Composed of glucose and fructose.
- **Maltose (Starch Sugar)**: Made of two α-D-glucose molecules.
- **Lactose (Milk Sugar)**: Contains β-D-galactose and D-glucose linked by a glycosidic bond.

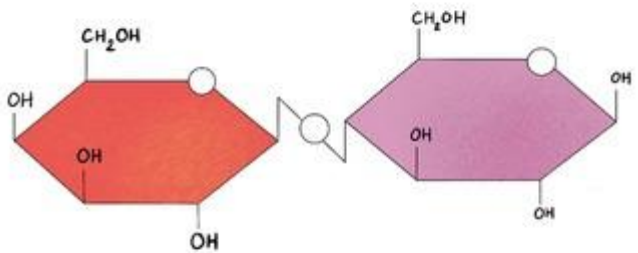
Importance:

- Disaccharides provide energy and are commonly found in everyday foods like sugar, milk, and starch products.

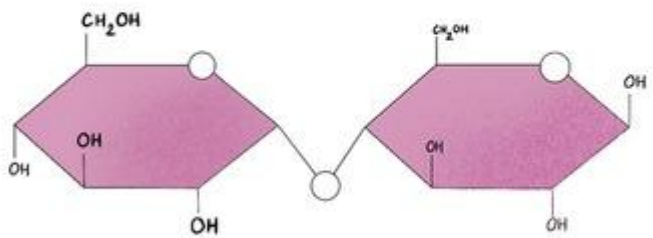
Sucrose
(Glucose - fructose)



Lactose
(Galactose - Glucose)



Maltose
(Glucose - Glucose)



Oligosaccharides

- are carbohydrates made up of **3 to 10 monosaccharide (simple sugar) units** linked together.
- They are smaller than polysaccharides but larger than simple sugars like monosaccharides and disaccharides.

These sugars are classified based on the number of monosaccharides they contain:

- **Trisaccharides:** Contain 3 sugar units.
- **Tetrasaccharides:** Contain 4 sugar units, and so on.

Oligosaccharides are often attached to proteins and lipids through N-glycosidic bonds or O-glycosidic bonds.

- They play a vital role in biological functions, especially in the structure and communication of cells.

Examples of Oligosaccharides

- **Raffinose:** A trisaccharide made of glucose, galactose, and fructose, found in legumes, beetroots, and cabbage.
- **Stachyose:** A tetrasaccharide made of two galactose molecules, one glucose, and one fructose, found in beans and other legumes.

Functions

- They are part of **glycoproteins and glycolipids,** which are key components of the cell membrane.
- They serve as receptors for signals and play a role in the immune system by helping cells recognize pathogens.
- They are involved in **protein localization**, guiding proteins to their correct locations in the body.
- In cancer research, changes in oligosaccharides are used to understand **tumor behavior,** as they are linked to cell invasion and metastasis.
- Oligosaccharides are critical for **cellular communication, defense mechanisms, and maintaining healthy biological functions.**

Polysaccharides

- are complex carbohydrates composed of long chains of monosaccharide units (simple sugars) linked together by glycosidic bonds. These polymers can have varying structures, from linear to highly branched, depending on the type of monosaccharide and the glycosidic linkages between them.

Key Features of Polysaccharides:

- **Monomer Units**: The building blocks are mostly monosaccharides, with **D-glucose** being the predominant sugar.

Classification:

- **Homopolysaccharides**: Composed of only one type of monosaccharide (e.g., starch, glycogen, cellulose, chitin).
- **Heteropolysaccharides**: Composed of more than one type of monosaccharide (e.g., hyaluronic acid, heparin).

Function:

- **Storage Polysaccharides**: Serve as energy reserves (e.g., starch in plants, glycogen in animals).
- **Structural Polysaccharides**: Provide structural support (e.g., cellulose in plant cell walls, chitin in exoskeletons of insects).

Examples of Polysaccharides:

Starch:

- **Source:** Plants Composition: A polymer of α-glucose.
- **Amylose:** Unbranched, helical structure.
- **Amylopectin:** Branched structure.Function: Main storage polysaccharide in plants.

Glycogen:

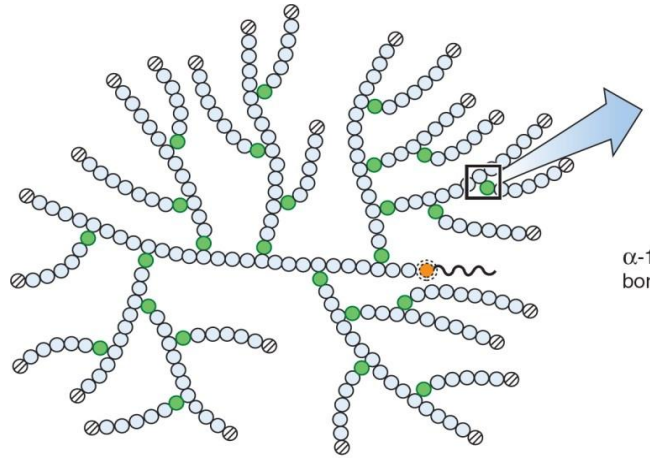
- **Source:** Animals.
- **Composition:** A highly branched polymer of α-glucose.
- **Function:** Main storage polysaccharide in animals, stored in liver and muscle cells.

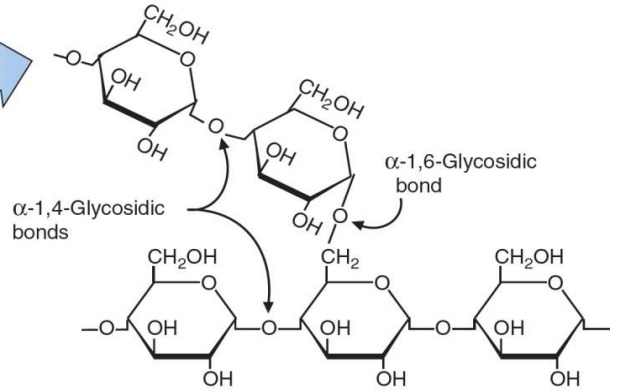
Cellulose:

- **Source:** Plants.
- **Composition:** A polymer of β-D-glucose with β(1→4) glycosidic linkages.
- **Function:** Provides structural support in plant cell walls. Note: Indigestible for humans due to lack of cellulase enzyme.

Chitin:

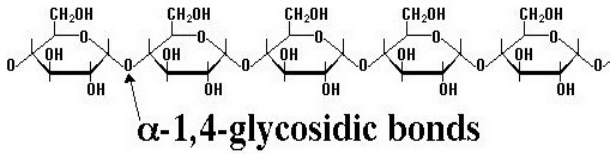
- **Source:** Arthropods and fungi.
- **Composition:** A polymer of N-acetylglucosamine (a derivative of glucose).
- **Function:** Structural component of exoskeletons and fungal cell walls.
- Polysaccharides play essential roles in energy storage and structural integrity across various biological systems.



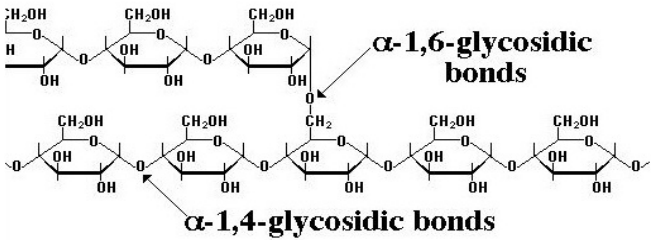


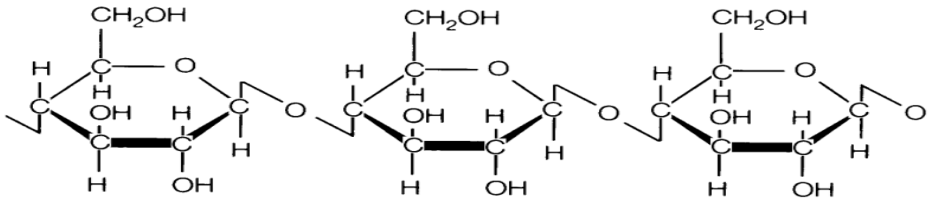
○ Glucose residue linked α-1,4
● Glucose residue linked α-1,6
Reducing end attached to glycogenin
⊘ Nonreducing ends

Amylose



Amylopectin





Cellulose

Role of Carbohydrates in Food Processing

Energy Source:

- Carbohydrates are essential for providing energy in processed foods, commonly found in forms like sugar, starch, and fiber.

Sweetening Agents:

- Sugars such as sucrose, glucose, and fructose are used as **sweeteners** in baked goods, beverages, and confectionery.

Texture and Structure:

- Starches act as **thickeners** and **stabilizers** in soups, sauces, and desserts.
- Cellulose and other fibers contribute to the **texture** and **mouthfeel** of processed foods.

Moisture Retention:

- Carbohydrates, particularly polysaccharides, help retain **moisture** in baked products, extending shelf life and improving texture.

Fermentation:

- Sugars are used as substrates for **fermentation**, crucial in producing bread, beer, yogurt, and other fermented products.

Role of Carbohydrates in Food Processing

Preservation:

- Sugars act as **preservatives** by reducing water activity, inhibiting microbial growth in products like jams and jellies.

Color and Flavor:

- Caramelization and the Maillard reaction (between sugars and proteins) contribute to the **browning** and **flavor development** in baked and roasted foods.

Color and Flavor:

- Caramelization and the Maillard reaction (between sugars and proteins) contribute to the **browning** and **flavor development** in baked and roasted foods.

Dietary Fiber:

- Insoluble and soluble fibers, often added to processed foods, enhance **nutritional value** and promote **digestive health**.

Low-Calorie Alternatives:

- Modified carbohydrates such as sugar alcohols (e.g., sorbitol, maltitol) and artificial sweeteners are used in **low-calorie** and **sugar-free** products.

Functional Ingredients:

- Specialty carbohydrates like **inulin** and **oligosaccharides** are used as **prebiotics** and to improve gut health.


SUGAR


laperva
Perfect
Stevia
ZERO
KCAL
SUGAR
FREE
ASPARTAME FREE

Calorie-Free Sweeteners and Carbohydrates

1. Artificial Sweeteners

- **Examples**: Aspartame, Sucralose, Saccharin
- **Carbs?** No
- **Details**: Synthetic, non-nutritive.

2. Natural Zero-Calorie Sweeteners

- **Examples**: Stevia, Monk Fruit
- **Carbs?** Pure forms: No; Blends: Maybe (e.g., maltodextrin).
- **Details**: Derived from plants.

3. Sugar Alcohols (Polyols)

- **Examples**: Erythritol, Xylitol, Sorbitol
- **Carbs?** Yes (low digestibility).
- **Details**: Carbohydrate derivatives, fewer calories than sugar.

4. Blended Sweeteners

- **Examples**: Splenda, Truvia
- **Carbs?** Sometimes (added fillers like maltodextrin).
- **Details**: Mix of sweeteners and fillers.


thank
you