

# Chapter 1 Biological molecules

## 1.3 Carbohydrates (碳水化合物 / 糖类)

- Sources: rice, bread, potatoes, sweets, fruits and etc
- Formula:  $C_n(H_2O)_m$
- Elements: C:H:O = 1:2:1
- Functions:
  - The main source of energy
  - A food storage compound (glycogen in human and animals; starch in plants)
  - Forms structural components in plant cells
- Types (based on their complexity):
  - Monosaccharides (simple sugars)
  - Disaccharides (double sugars)
  - Polysaccharides (complex sugars)

### Free sugars (游离糖) and intrinsic sugars (内源性糖)

Free sugars	Intrinsic sugars
Monosaccharides and disaccharides added to foods and drinks by the manufacturer, cook, or consumer, and sugars naturally present in honey, syrups, fruit juices, and nectar juices	Intrinsic sugars are those that present naturally within the cellular structure of food, these sugars are mainly found in fruits and vegetables

### Monosaccharides (单糖)

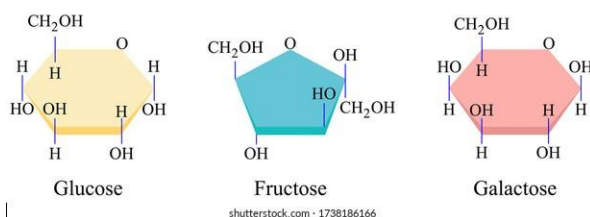
- The monosaccharides known as simple sugars because they cannot be further hydrolysed (水解) into smaller units
- Three common types of monosaccharides:

Monosaccharides	Molecular Formulas	Functions
Triose (三碳糖)	$C_3H_6O_3$	Important intermediate products in respiration and photosynthesis
Pentose (五碳糖)	$C_5H_{10}O_5$ / $C_5H_{10}O_4$	Ribose and deoxyribose are main components of nucleic acid
Hexose (六碳糖)	$C_6H_{12}O_6$	The most important respiratory substrate for all living organisms

- Trioses (3C): glyceraldehyde (甘油醛), dihydroxyacetone (二羟基丙酮)
- Pentoses (5C): ribose (核糖), deoxyribose (脱氧核糖)
- Hexoses (6C): glucose (葡萄糖), fructose (果糖), and galactose (半乳糖) have identical molecular formulas but different structural formulas, known as structural isomers (同分异构体 / 结构异构体)

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## Monosaccharide

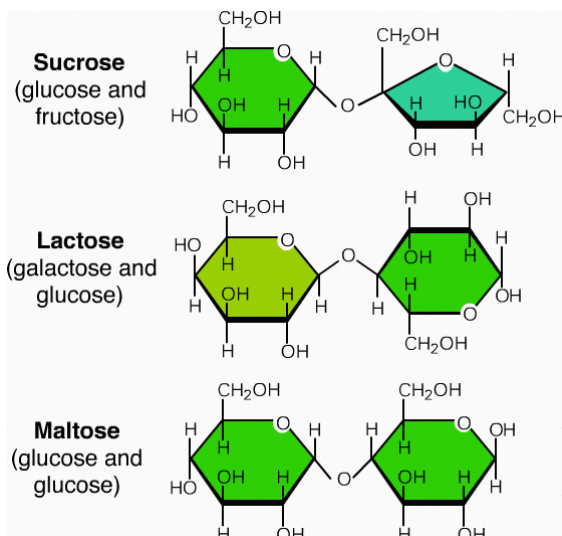


- Characteristics of monosaccharides:
  - Taste sweet
  - Soluble in water
  - All are reducing sugars (还原糖)

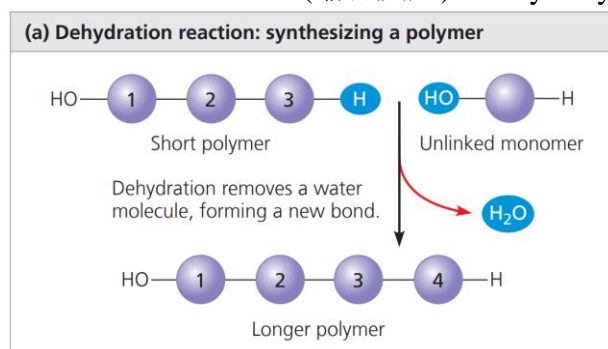
## Disaccharides (二糖)

- Disaccharides are double sugars
- The general formula for disaccharide is  $C_{12}H_{22}O_{11}$
- Three main types of disaccharides:

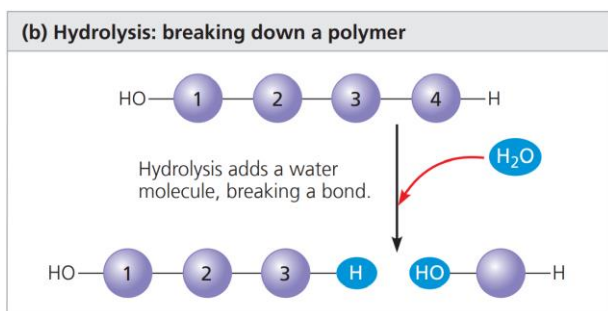
Disaccharides	Functions
Maltose (麦芽糖)	Maltose is a product of starch hydrolysis
Sucrose (蔗糖)	Sucrose is produced naturally in plants, from which table sugar (蔗糖) is refined
Lactose (乳糖)	Lactose is the sugar found in the milk of mammals



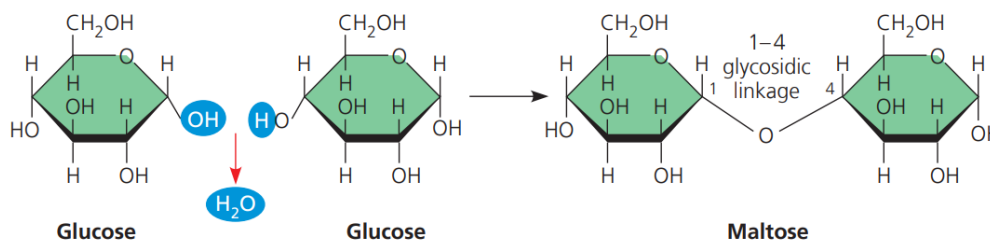
- Condensation reaction (缩合反应) and hydrolysis reaction (水解反应)



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- Dehydration reaction in the synthesis of maltose



- Characteristics of disaccharides:
  - Taste sweet
  - Soluble in water
  - All are reducing sugars except sucrose (non-reducing sugar 非还原糖)

## Polysaccharides (多糖)

- Polysaccharides are large complex sugars
- The monomer (单体) of polysaccharide is glucose
- Three main types of polysaccharides:

Polysaccharides	Functions and structures
Starch (淀粉)	<ul style="list-style-type: none"> <li>• Major storage of carbohydrates in plants</li> <li>• Starch is a mixture of amylose and amylopectin                             <ul style="list-style-type: none"> <li>(1) Amylose (直链淀粉): consists of straight chain with several hundred units of glucose</li> <li>(2) Amylopectin (支链淀粉): differs from amylose in that it is highly branched</li> </ul> </li> </ul>
Glycogen (糖原)	<ul style="list-style-type: none"> <li>• Major storage of carbohydrates in animals (liver and muscles) and fungi</li> <li>• Highly branched chains</li> </ul>
Cellulose (纤维素)	<ul style="list-style-type: none"> <li>• The main component for plant cell wall</li> <li>• Unbranched chains</li> </ul>

- Characteristics of polysaccharides:
  - Do not taste sweet
  - Insoluble in water
  - All are non-reducing sugars

## Reducing sugars (还原糖)

- Reducing sugar is any sugar that can act as a reducing agent
- Benedict's test:

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- Used to detect the presence of reducing sugar
- The reducing sugar reduces the copper (II) sulphate ions (blue) in the Benedict's reagent (本氏试剂) to insoluble copper (I) oxide (brick-red precipitate)
  - blue → green → yellow → orange → brick-red precipitate (砖红色沉淀)
- Fehling's test:
  - Used to detect the presence of reducing sugar
  - The reducing sugar reduces the solution of copper (II) (blue) in Fehling's reagent to insoluble copper (I) oxide (brick-red precipitate)

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