Carbohydrates

AICE BIOLOGY

JONES & FOSBERY CHAPTER 2

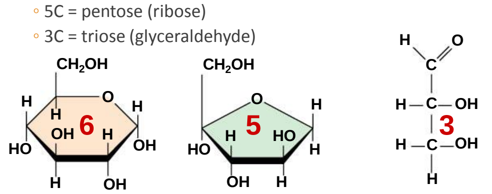
Carbohydrates

- Carbohydrates are composed of C, H, O
  - carbo - hydr - ate
  - CH_2O
  - $(CH_2O)_x \rightarrow C_6H_{12}O_6$
- Function:
  - fast energy
  - energy storage
  - raw materials
  - structural materials
- Monomer: sugars
- ex: sugars, starches, cellulose

Sugars

Most names for sugars end in *-ose*

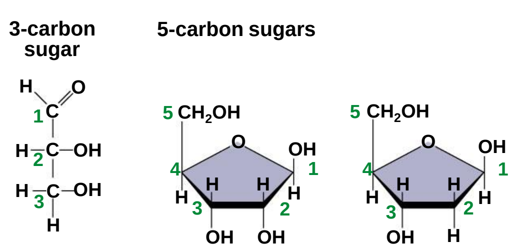
Classified by number of carbons
- 6C = hexose (glucose)
- 5C = pentose (ribose)
- 3C = triose (glyceraldehyde)



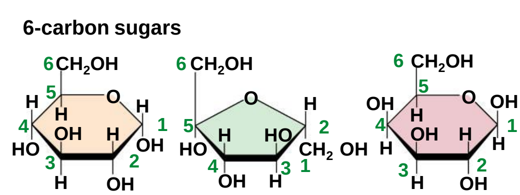
Glucose Ribose Glyceraldehyde

Monosaccharides

- *Single Sugars*
- Dissolve easily in water
- Sweet taste
- 3 forms: Sugars all end in "ose"
  - Triose (3C) $C_3H_6O_3$ (Gylceraldehyde)
  - Pentose (5 C) $C_5H_{10}O_5$ (Ribose, Deoxyribose = components of nucleic acids)
  - Hexose (6 C) $C_6H_{12}O_6$ (Glucose, Fructose, Galactose)



Glyceraldehyde Ribose Deoxyribose



Glucose Fructose Galactose

A. Molecular Formula

(empirical formula) ie. $C_6H_{12}O_6$

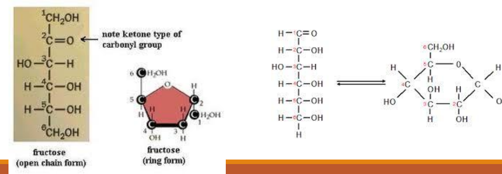
B. Structural Formula

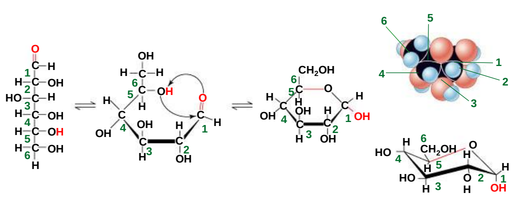
Diagram showing the arrangement of atoms.

- Glucose, fructose & galactose all have the same empirical formula, but have different structural formulae.

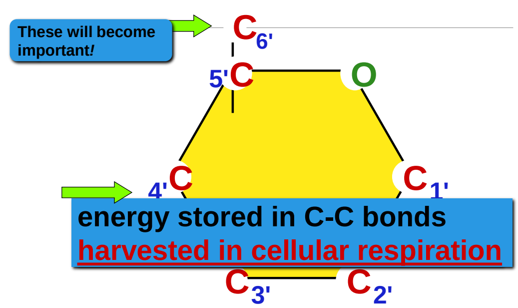
Structural Forms

- **Chain Form:** Carbon backbone with oxygen & hydrogen forming side bonds.
- **Ring Form:** In aqueous solution, the molecule closes upon itself to form a more stable ring form.



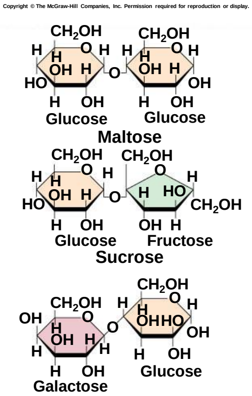


Numbered carbons



Isomers

Molecules with the same empirical formula but different structural formulae (arrangement of atoms determines functional differences)



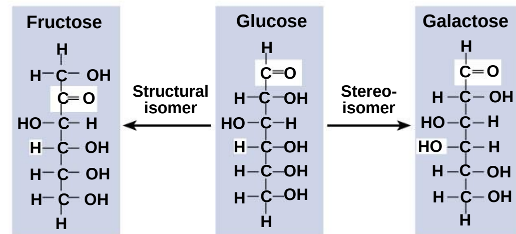
There are 2 types of isomers

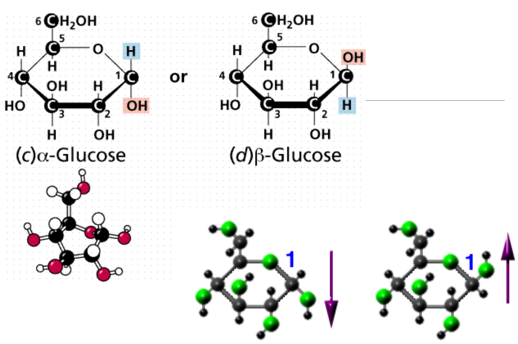
Structural Isomers: different arrangement of bonds.

- eg glucose & fructose (See O=C Bonds)
- Your taste buds can tell the difference → fructose much sweeter
- Form different polymers (repeating subunits)

Stereoisomers: Same bond structure but different orientations of molecule groups.

- eg. Glucose & galactose: Hydroxyl groups are mirror images of one another
- ∂ glucose (OH above the plane)
- ß glucose (OH below the plane)





alpha-D-Glucopyranose (alpha- glucose)

beta-D-Glucopyranose (beta - glucose)

Roles of Monosaccharides

Source of energy in respiration.

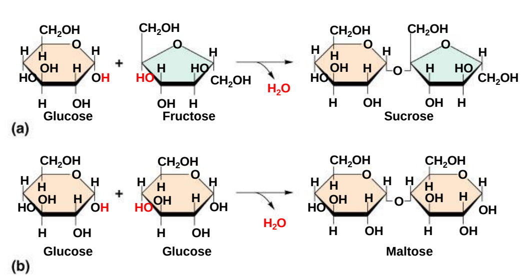
- C-H bonds release lots of energy when broken → used to convert ADP to ATP.
- Glucose is the most important, metabolically.

Building blocks of larger molecules.

- glucose → starch, glycogen, cellulose
- ribose → RNA (ribonucleic acid) & ATP
- deoxyribose → DNA (deoxyribonucleic acid)

Disaccharides

- Two monosaccharides joined by a covalent bond

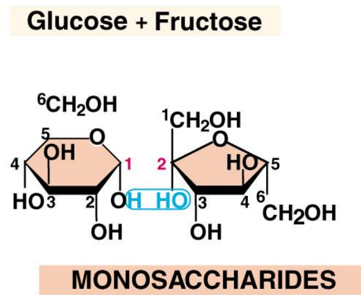


Bond formation: Condensation

Condensation: The name for the bonding process by which two monosaccharides form a disaccharide. *AKA dehydration synthesis.*

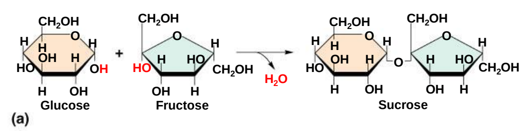
2 hydroxyl (-OH) groups line up with one another

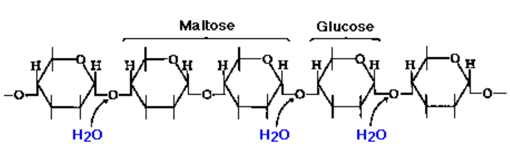
- One combines with a hydrogen from the other to form a water molecule: HENCE, *CONDENSATION*
- Forms an oxygen bridge "glycosidic bond"
- Any two hydroxyl groups can line up & bond
- Large variety of possible disaccharides

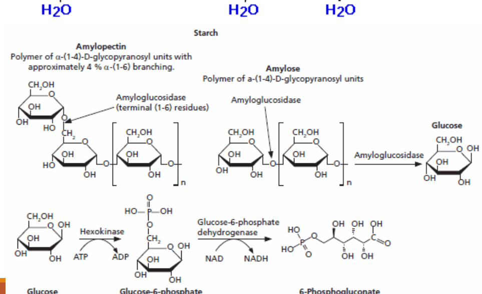


Breaking Bonds: Hydrolysis

- Hydrolysis: When polysaccharides break apart to form smaller molecules.
- Hydro = water
- Lysis = breaking apart
- Breaking a molecule apart by adding water
- Both Condensation & hydrolysis are controlled by enzymes.

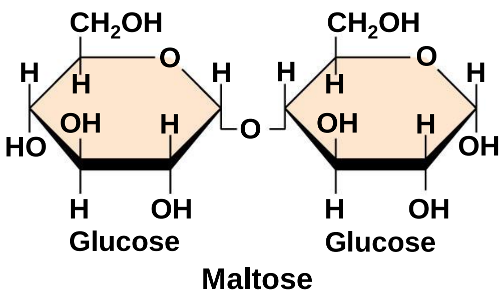


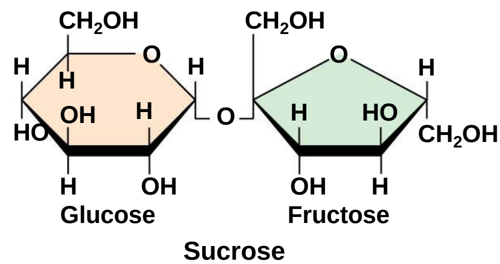


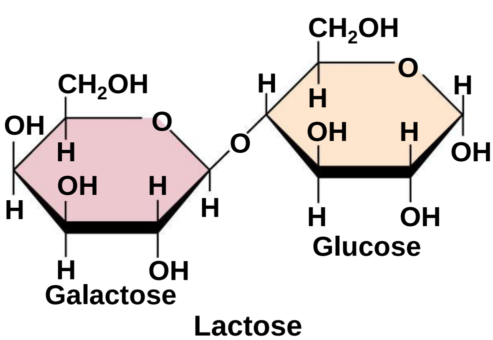


Transport Disaccharides

- In humans, glucose can circulate in the blood
- In plants & many other organisms, glucose must be converted for transport to keep glucose from being "used up" while in transport
- The bond breaking enzymes are only located in tissue where glucose is meant to be used.
- Glucose + fructose = sucrose
- Glucose + galactose = lactose
- Glucose + glucose = maltose







Polysaccharides

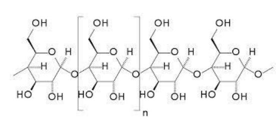
- Formed by joining long chains of monosaccharides through condensation.
- Each successive monosaccharide is joined by a glycosidic bond.
- Polysaccharides *are not* sugars.
- Most important: Starch, cellulose & glycogen

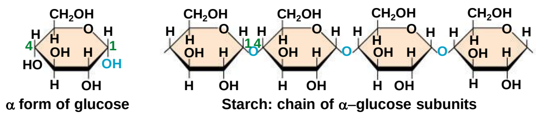
Storage Polysaccharides

- Transport disaccharides may be linked together as polysaccharides for storage within cells.
- Plant polysaccharides = starches.
- Animal polysaccharides = glycogen

Starches: Amylose

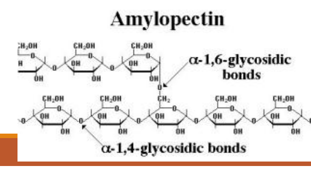
- Amylose = simplest starch, hundreds / thousands of linked, unbranched alpha glucose molecules.
- #1 carbon links to #4 of next molecule = long chains of maltose.
- Long chains coil up in water making it insoluable in water
- Potato starch ~ 20% amylose

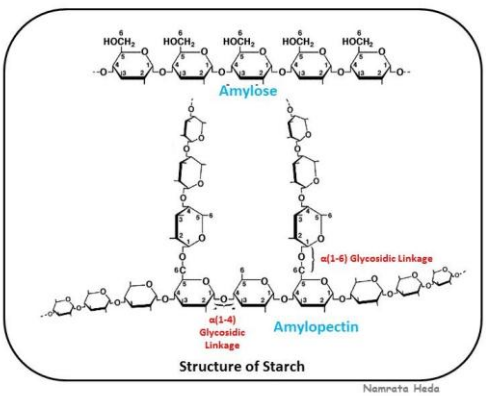




Starch: Amylopectin

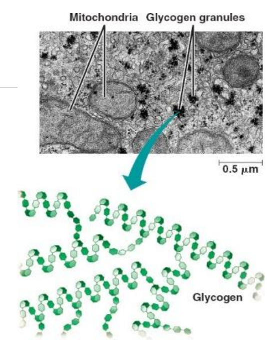
- Most plant starch is amylopectin.
- Also made of many 1,4 linked glucose, but also have 1,6 branching linkages (2.6 JF)
- Only 20-30 glucose subunits.
- Mixtures of amylose & amylopectin build up as starch grains in chloroplasts & stroage vaculoes.

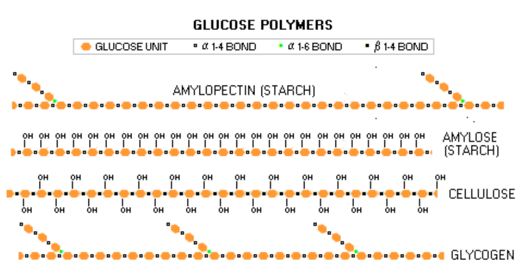




Glycogen

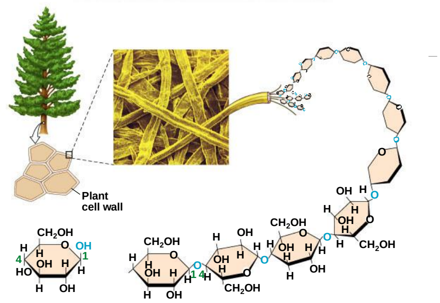
- "Animal version of starch."
- Insoluable polysaccharide of branched amylose chains
- Average chain much longer and greater # of branches than plant starch.
- Animal form of energy storage.





Structural Carbohydrates: Cellulose

- Unbranched chains of beta glucose
- Several chains are crosslinked by H-bonding to form fibrils
- Several fibrils crosslink to form fibres
- Forms cell walls of plants



β form of glucose

Cellulose: chain of β–glucose subunits