Macromolecules

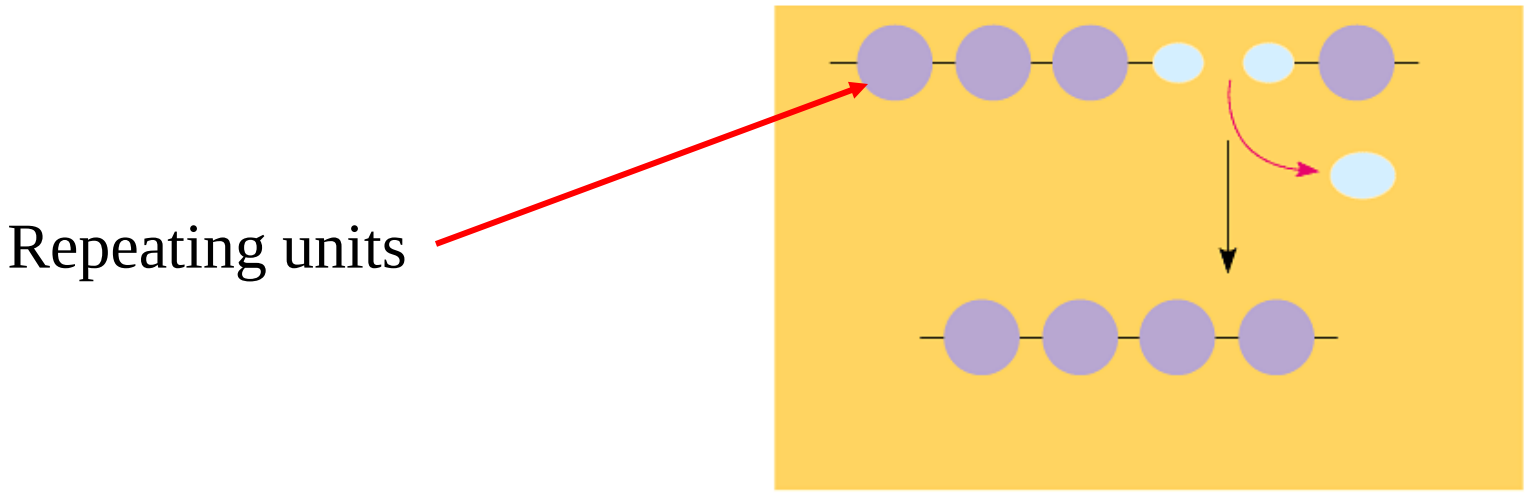
Chapter 5

Macromolecules - General

- Small organic molecules joined to form large molecules
- 4 classes:
  - Carbohydrates
  - Lipids
  - Proteins
  - Nucleic Acids

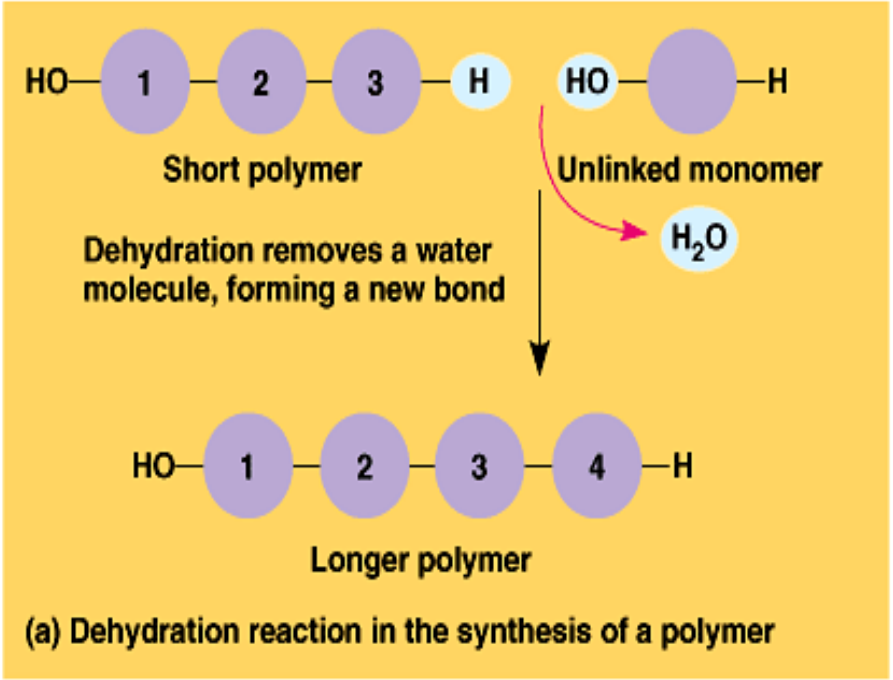
Polymers

- Carbohydrates, proteins and nucleic acids are polymers
- **Polymers**: long molecule built by linking repeating units covalently
  - Each unit of polymer = monomer

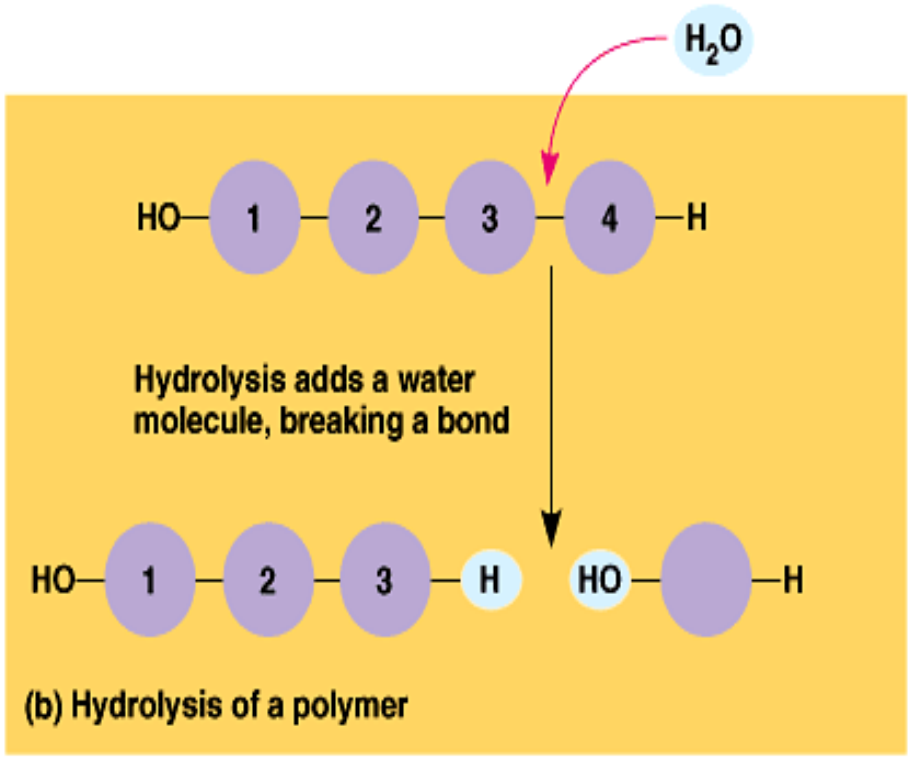


Synthesis of Polymers

- Condensation reaction:
  - Dehydration synthesis – H_2O is lost
  - Monomers joined by removal of water
    - One contributes –OH
    - One contributes –H
    - Together → H_2O
  - Process requires energy & enzymes

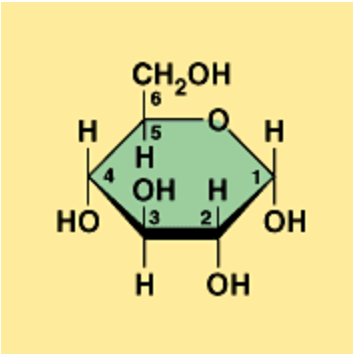


Breakdown of Polymers



- Hydrolysis Reaction:
  - Hydro = water
  - Lysis = to break apart
  - Reverse of condensation reaction
  - Uses water to split polymer
  - H2O splits into –H & -OH
  - -H & -OH bond to where covalent bond was before

Carbohydrates

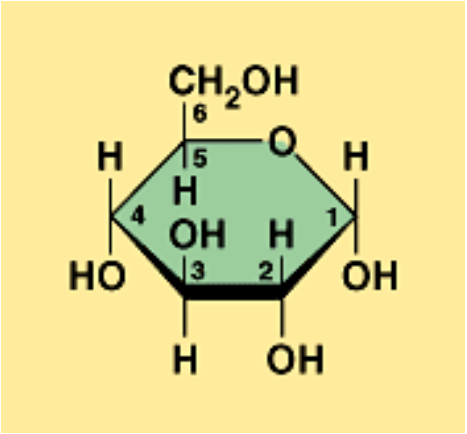


- Types
  - Monosaccharides – single sugars (1 monomer)
    - Ex: glucose
  - Disaccharides – double sugars; two monosaccharides joined through dehydration reaction.
    - Ex: sucrose
  - Polysaccharides – polymers composed of many sugar building blocks (monosaccharides)
    - Ex: starch

Functions:

- Energy – Cell respiration
- Energy Storage (not as long as lipids)
- Raw Materials
- Structural Materials
- Ex: sugars (sucrose) and starches

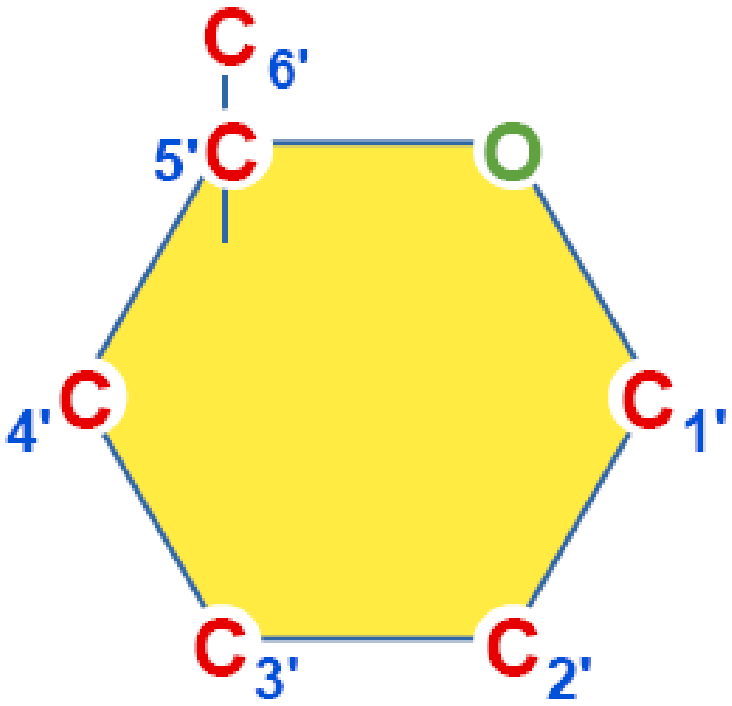
Structure:



- Composed of C, H, & O
- $(CH_2O)_x$; when x = 6 → $C_6H_{12}O_6$

- 5C & 6C sugars form rings in aqueous solutions
  - Carbons are numbered

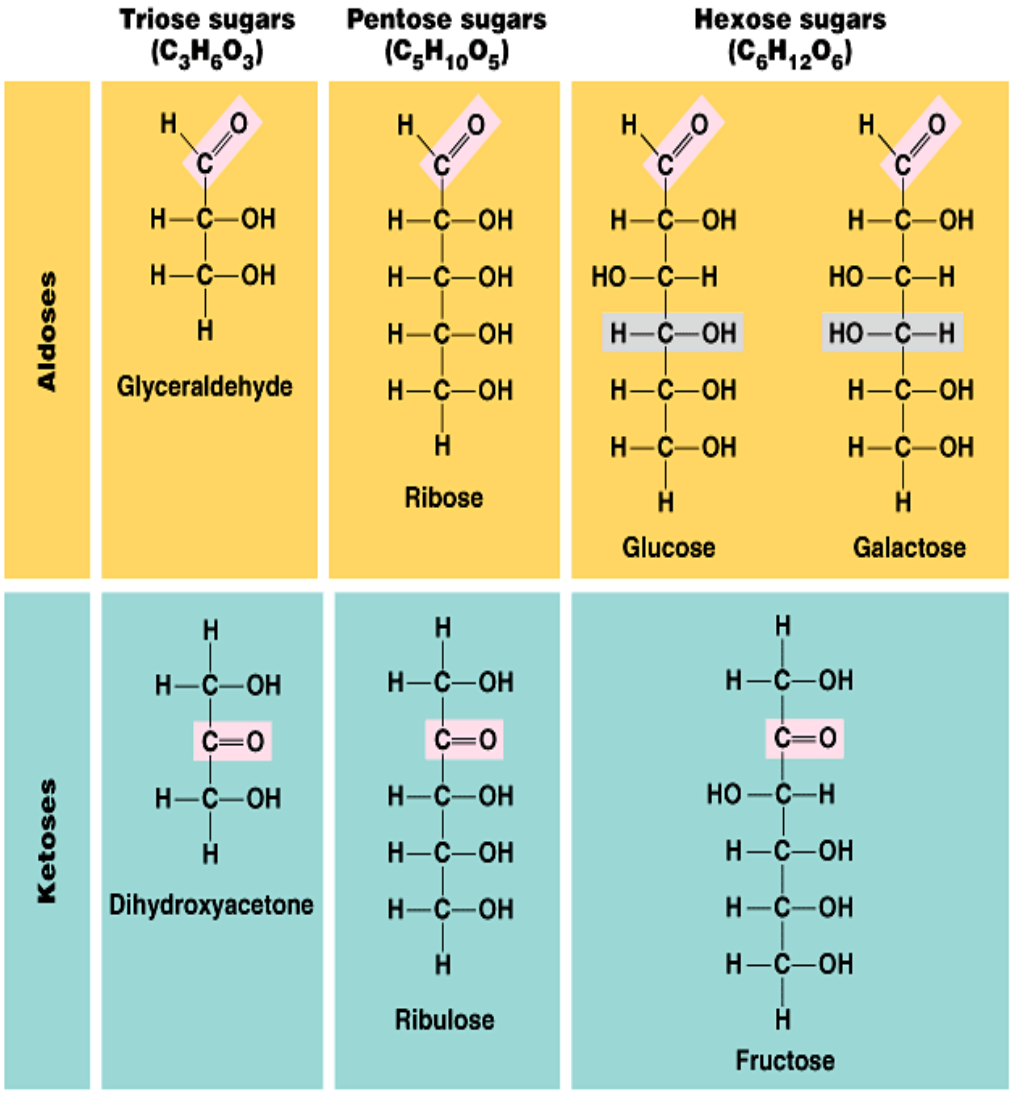
Numbered Carbons



Sugars

- Most sugars end in the suffix, -ose
- Classified by the number of Carbons
  - 7C = heptose
  - 6C = hexose (glucose)
  - 5C = pentose (fructose, ribose)
  - 4C = tetrose
  - 3C = triose (glyceraldehyde)

Functional Groups

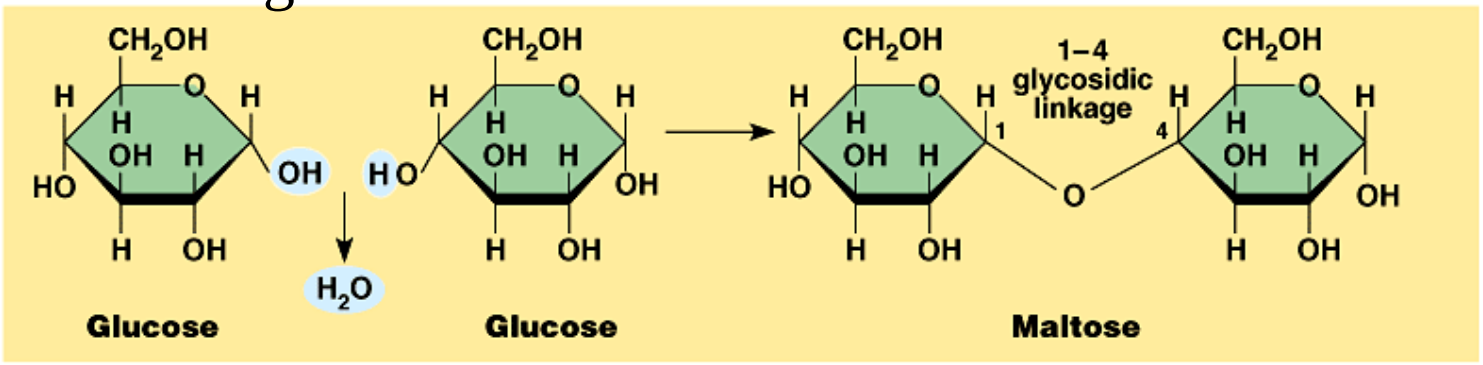


- Sugars have multiple hydroxl groups (-OH)
- <u>Aldose sugars</u>:
  - Carbonyl group (>C=O) is on the end of the molecule
- <u>Ketose sugars</u>:
  - Carbonyl group (>C=O) is located in the center of the molecule

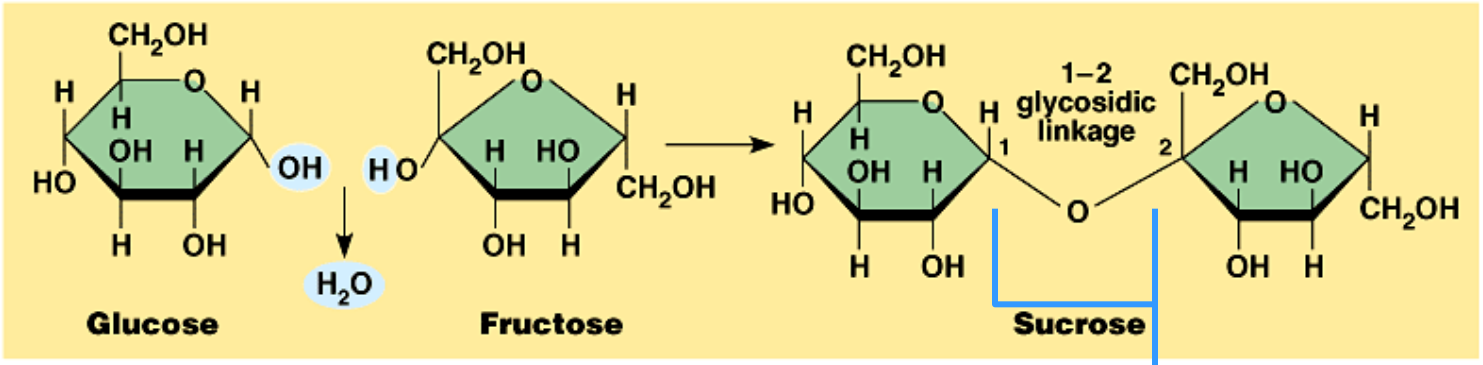
Building Sugars

- Dehydration synthesis
- Sucrose = table sugar

Disaccharide



(a) Dehydration synthesis of maltose



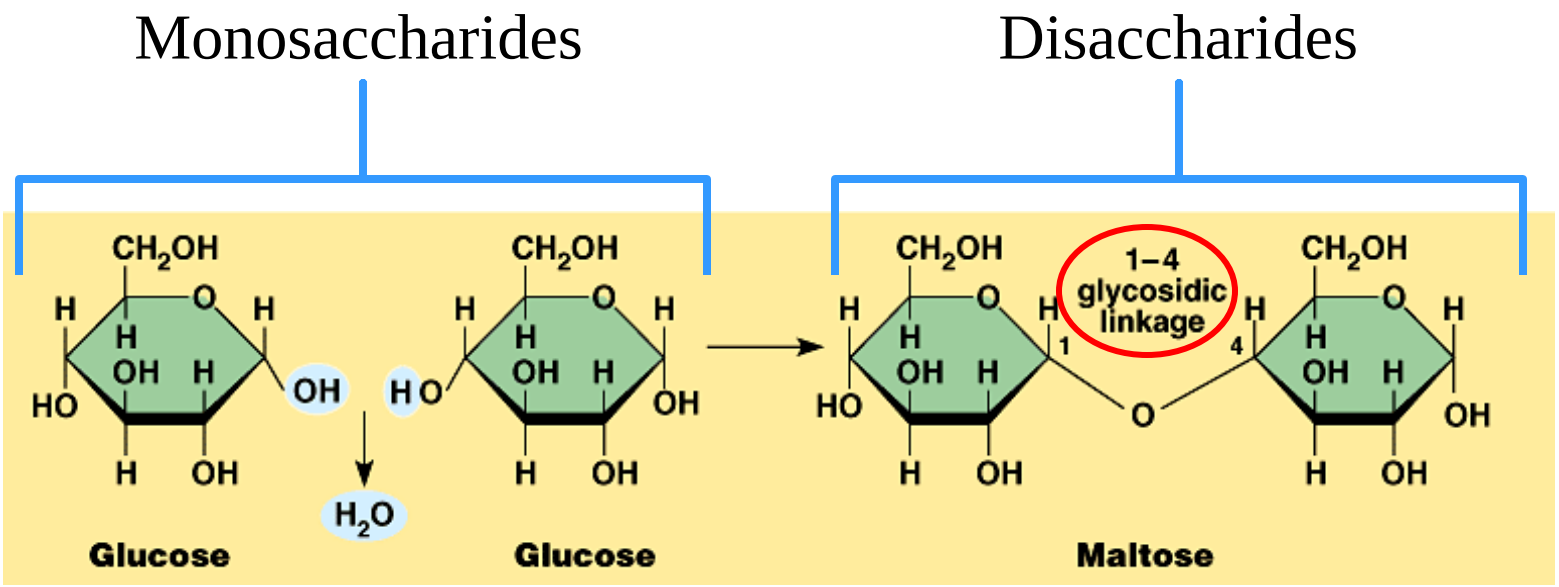
(b) Dehydration synthesis of sucrose

Glycosidic linkage

Structural Isomers

Building Sugars

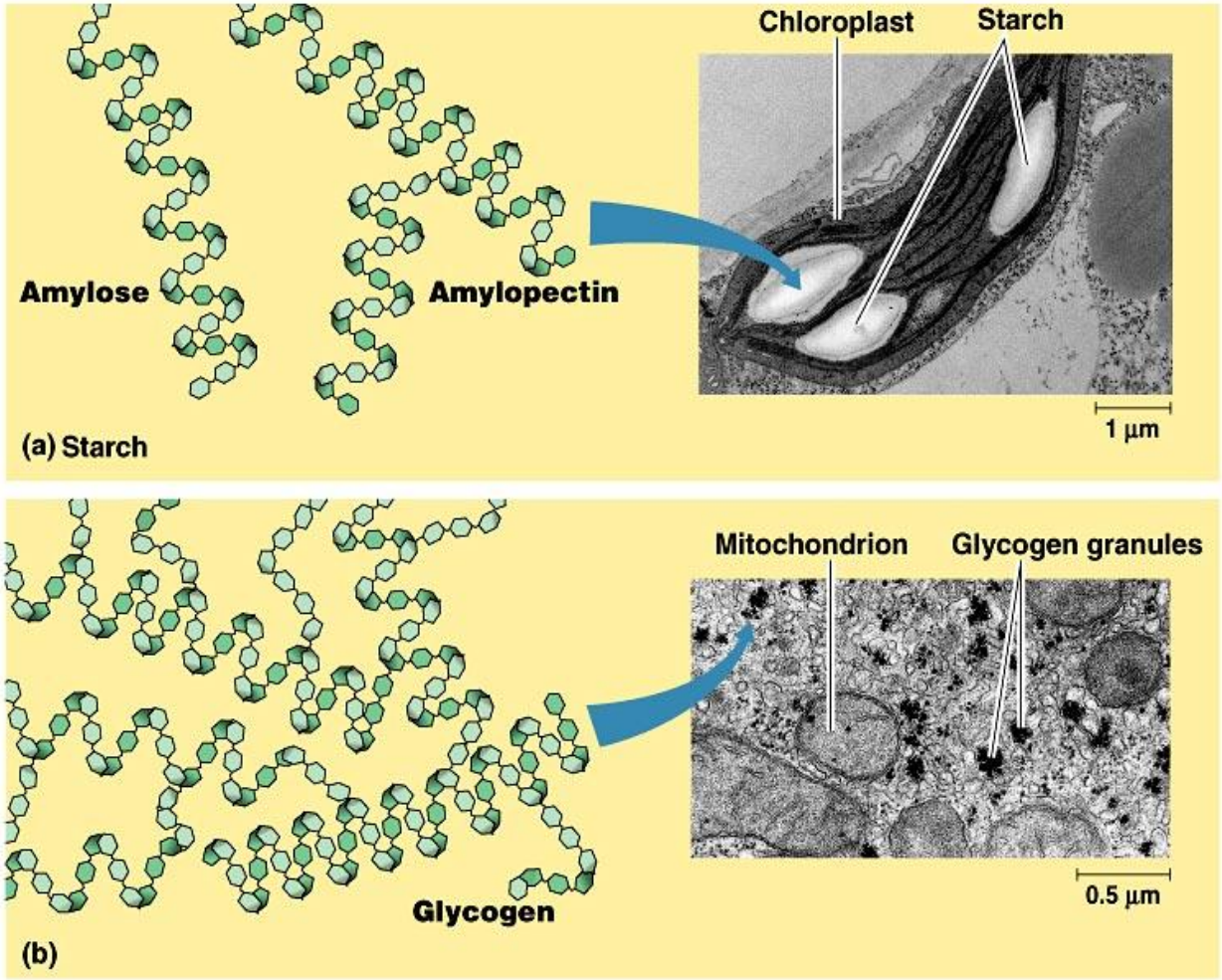
- Dehydration Synthesis -



Polysaccharides

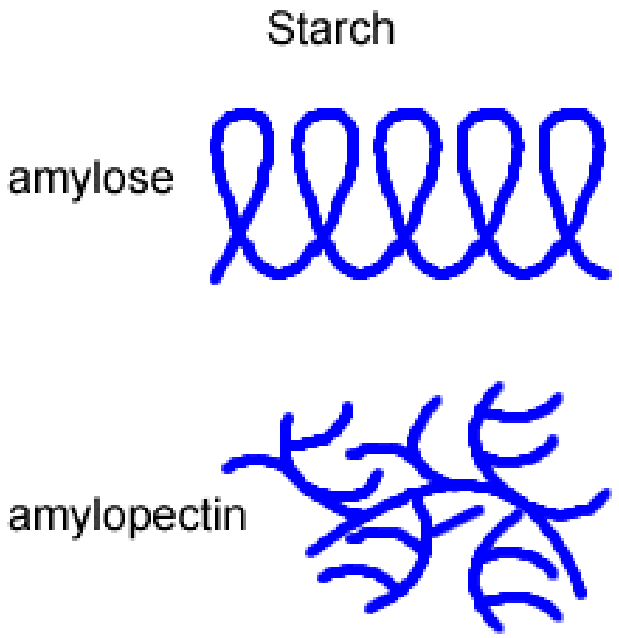
- Polymers of a few 100 → few 1000 monosaccharides
- Functions:
  - Energy Storage
    - Starch (plants)
    - Glycogen (animals)
  - Structural
    - Cellulose (plants)
    - Chitin (arthropods & fungi)

Branched vs. Linear Polysaccharides



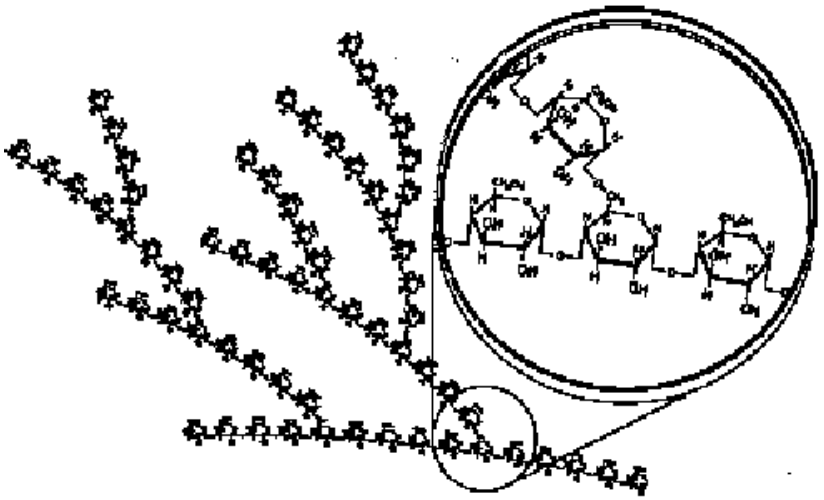
Branched vs. Linear Polysaccharides

- Starch
  - Stored as granules within plastids (chloroplasts)



  - Amylose – unbranched
  - Amylopectin – branched
  - All glucose in alpha (α) configuration (-OH group is below the plane on 1C)

Branched vs. Linear Polysaccharides

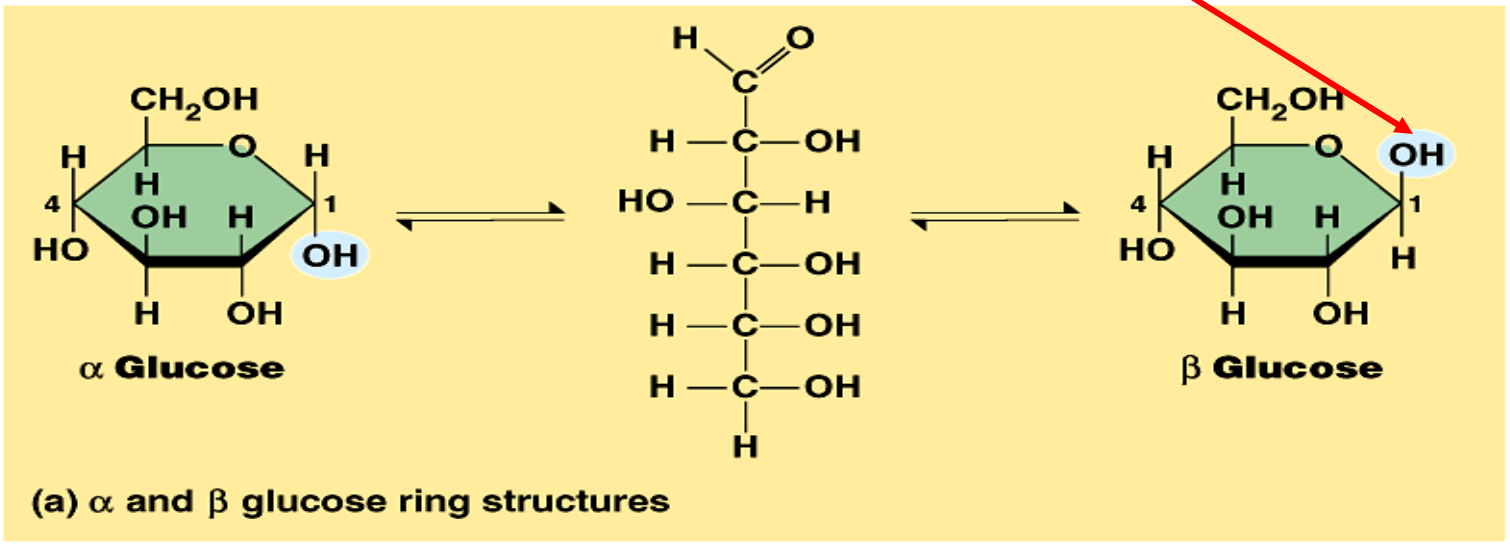


- Glycogen
  - Branched – creates several ends for quick release of glucose available for energy
  - Stored in muscle and liver cells

- Both starch and glycogen are broken down for energy through hydrolysis.

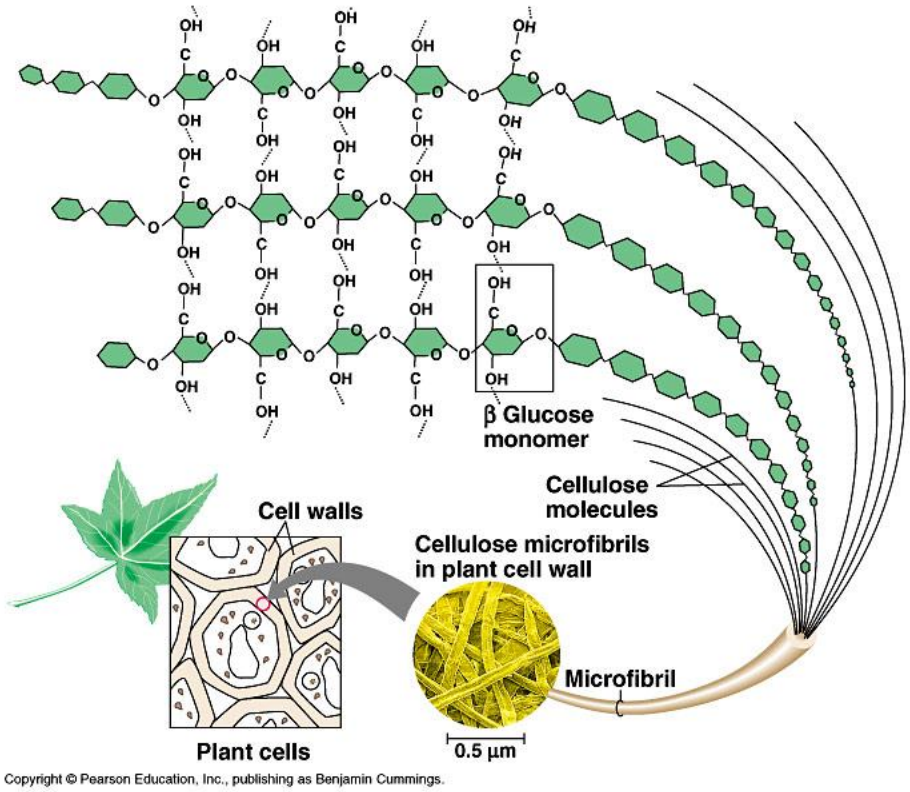
Structural Polysaccharides

- Cellulose
  - Component of cell walls in plants
  - Most abundant sugar on Earth
  - Polymer of glucose
  - All glucose monomers are in the beta (β) configuration (-OH is located above the ring plane on the 1C)



Cellulose

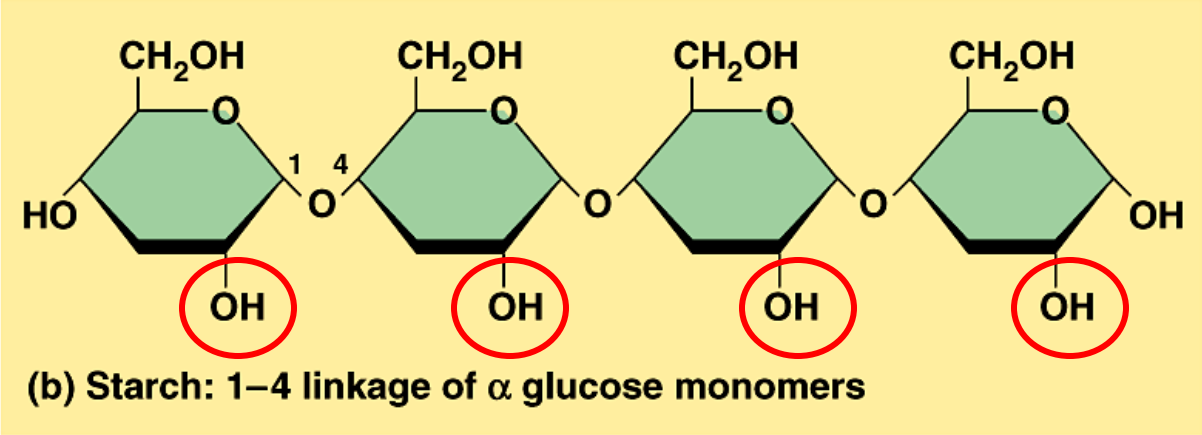
- Very difficult to digest
- Few organisms have enzyme that can digest cellulose
  - Humans do not
  - “insoluble fiber”
  - Cows have bacteria that are able to break down cellulose

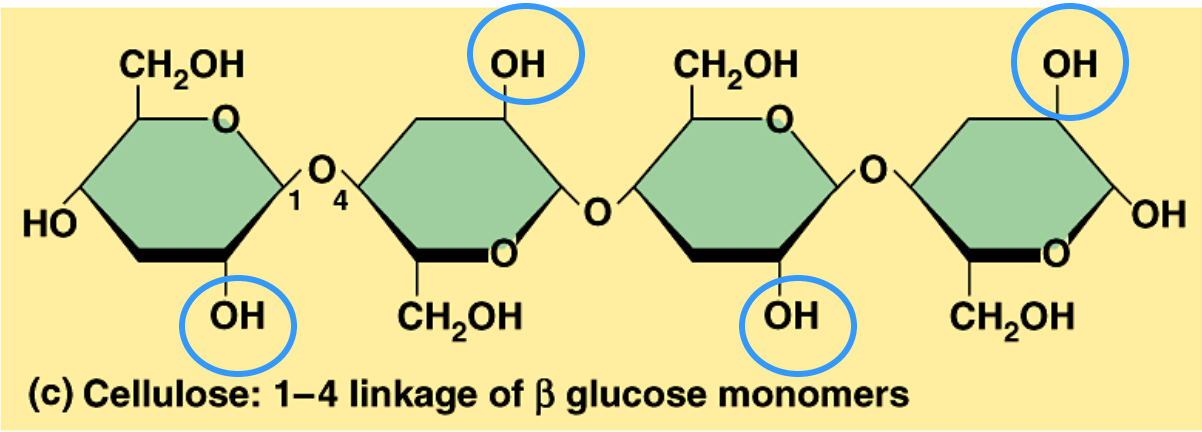


Starch vs. Cellulose Digestion

Glycosidic linkages in same plane --- easier to digest – molecule is branched.

Every other glucose monomer is upside down ⑧ molecule is straight.





Chitin

- Makes up cell walls in mushrooms and exoskeleton in arthropods (insects, lobster, crab) – even makes up surgical thread
- Tough, protective, indigestible – similar to cellulose
- Hydroxyl group on the second carbon is replaced with NHCOCH3 group