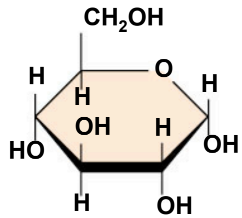


Carbohydrates

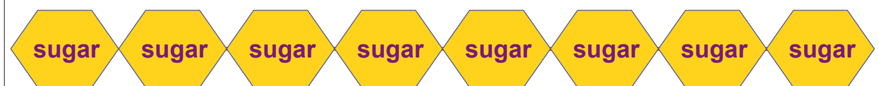
Function in providing structural support, as a source of energy and carbon, and as a way of storing energy and carbon

Carbohydrates
(Carbon skeletons with -OH & =O functional groups)

- Includes sugars and polymers of simple sugars
- Carbohydrates are composed of C, H, O

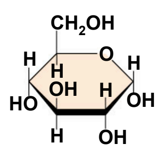
  carbo - hydr - ate

- Function:
  - provide energy
  - raw building materials
  - energy storage
  - structural materials
- Ex: sugars, starches, glycogen, cellulose, chitin

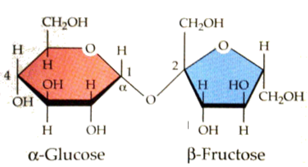


Simple & Complex Sugars

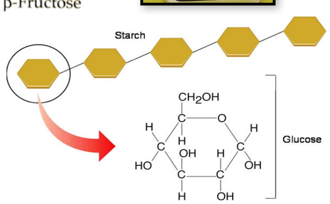
- Monosaccharides
  - Simple 1 monomer sugars
    - Empirical Formula: CH_2O
  - Ex: Glucose $(CH_2O)_x \longrightarrow C_6H_{12}O_6$



- Disaccharides
  - 2 monomers
  - Ex: Sucrose



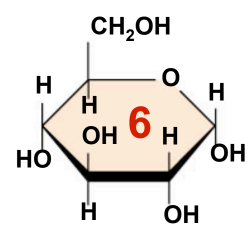
- Polysaccharides
  - Large polymers
  - Ex: Starch



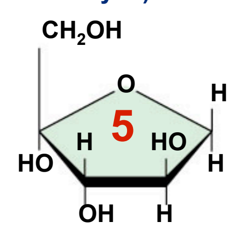
Monosaccharides:
* Provides energy for cells.
* Raw material for construction of other organic molecules (ex: polysaccharides, fatty & amino acids.

- Most names for sugars end in *-ose*
- Can be classified by number of carbons

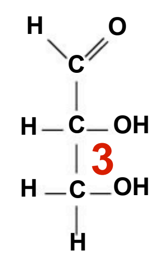
  (range from 3 to 7 C's long)
  - 6C = hexose (glucose)
  - 5C = pentose (ribose)
  - 3C = triose (glyceraldehyde)



Glucose



Ribose

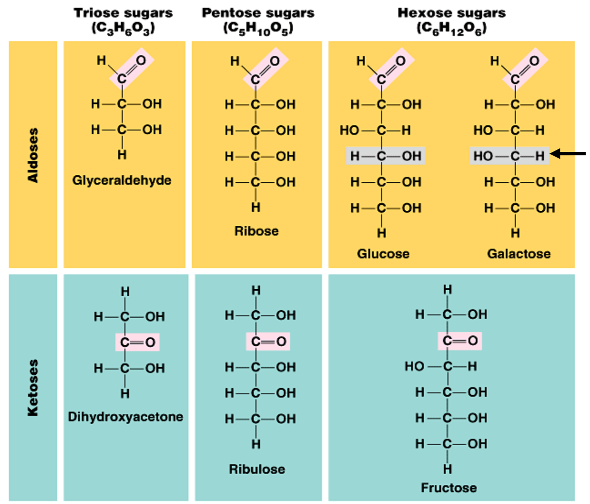


Glyceraldehyde

Classifying sugars according to location of Carbonyl Group

Aldehyde Sugar = aldose

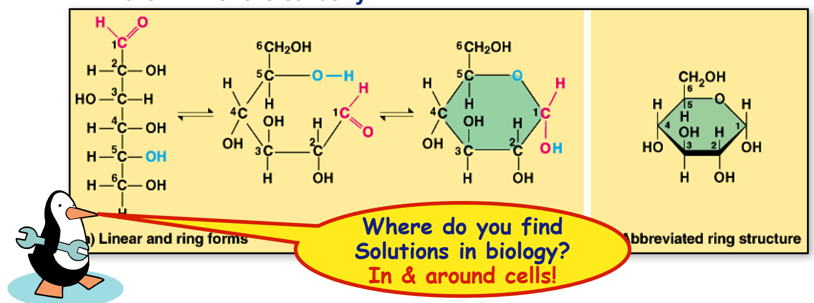
Ketone sugar = ketose



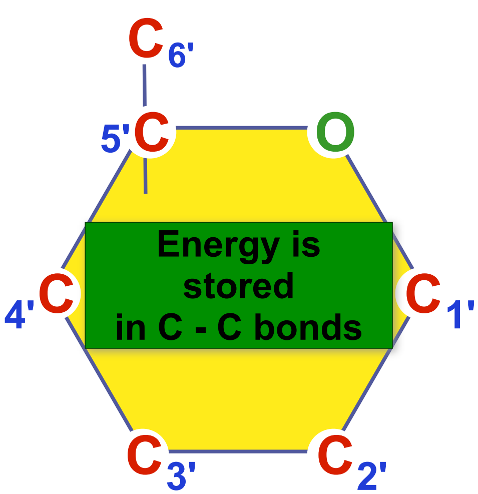
Type of isomer? Structural Isomer

Sugar Numbering & Structure

- Linear sugars are drawn carbonyl end up
- Carbons are numbered starting from the carbonyl end
- 5C & 6C sugars form rings in solution (there exists a chemical equilibrium between the two shapes, linear and ringed. *Ringed is favored in solution*)
  - The O of the hydroxyl on the #5 C, covalently bonds to the #1 C of the carbonyl

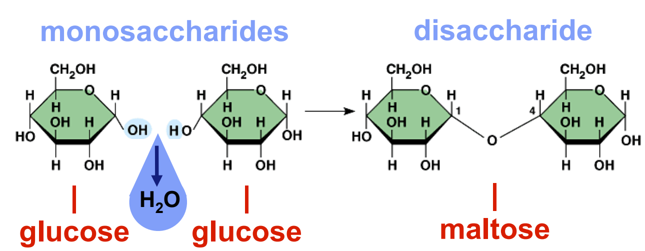


Position of Numbered Carbons



Building double sugars

- Dehydration synthesis

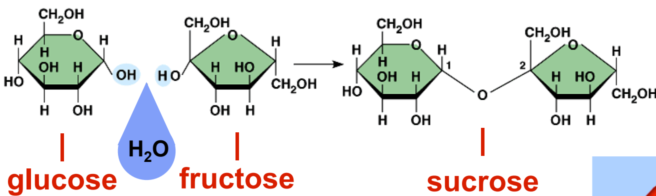


What is the name of the covalent bond joining two sugar monomers through a dehydration reaction?

A Glycosidic Linkage

Building double sugars

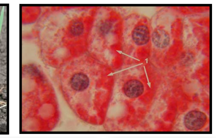
- Can make distinct sugars by combining different monosaccharides



Glucose + Glucose = Maltose
Glucose + Fructose = Sucrose
Glucose + Galactose = Lactose

Polysaccharides are MACROMOLECULES

- Polymers of sugars (100's to 1000's of monomers)
  - costs little energy to build
  - easily reversible, releasing energy when needed
- Function - determined by the types of sugar monomers and the positioning of glycosidic linkages.



- energy storage - can be hydrolyzed to release sugar for cells when needed
  - starch (plants)
  - glycogen (animals)
    - in liver & muscles
- structural
  - cellulose (plants)
  - chitin (arthropods exoskeleton & fungi cell wall)

Storage Polysaccharides: Linear vs. Branched

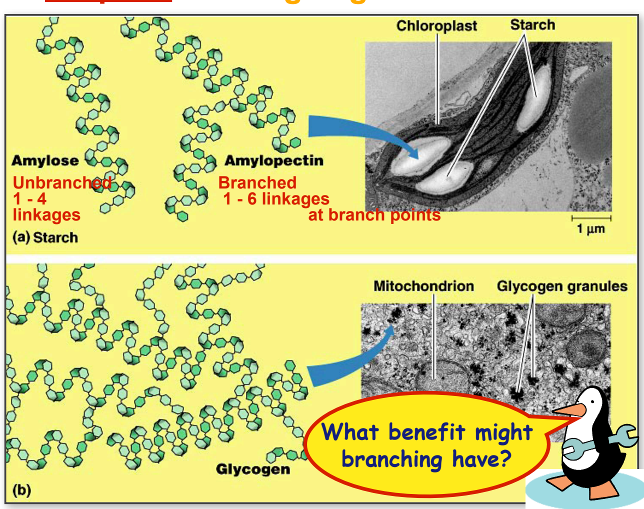
Purpose: Storing sugars for later use

Plants store starch in plastids.

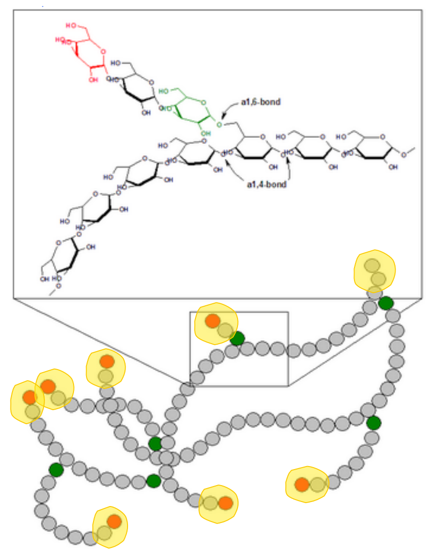
Starch = polymer of glucose monomers

Animals store glycogen in liver and muscles

Glycogen = *HIGHLY BRANCHED* polymer of glucose



Benefits of Branched Polysaccharides



Form Follows Function:

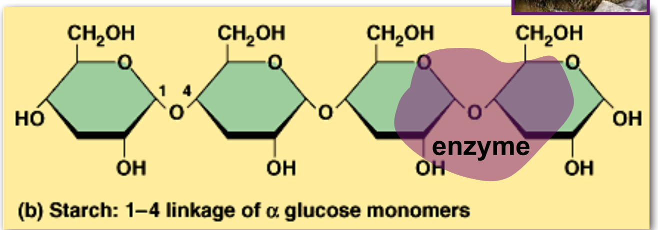
During times of shortage, enzymes attack one end of the polymer chain and cut off glucose molecules, one at a time.

The more branches, the more points at which enzymes attack the polysaccharide.

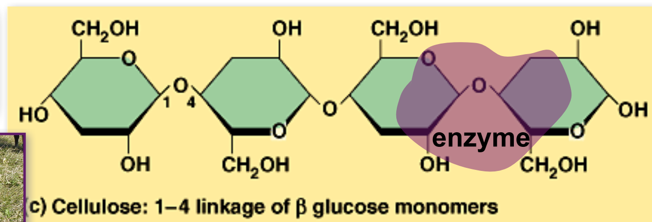
Thus, a highly branched polysaccharide is better suited for the rapid release of glucose than a linear polymer.

Digesting starch vs. cellulose

starch easy to digest

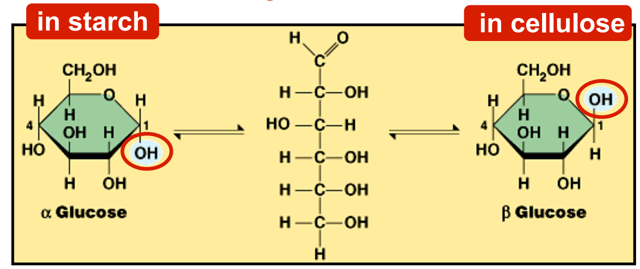


cellulose hard to digest



Structural Polysaccharides: Cellulose & Chitin

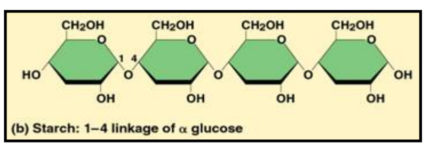
- **Cellulose: Most abundant organic compound on Earth**
  - Component of cell walls in plant cells
  - Polymer of glucose
    - Cellulose contains β glucose monomers
    - Starch contains α glucose monomers

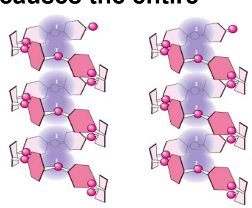


- Structural isomers of glucose
- Structure determines function…

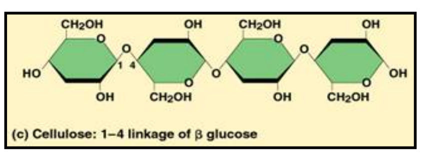
Linkage determines shape of polymers

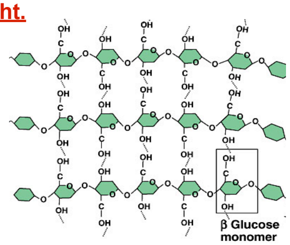
- In Starch glucose monomers are in the same orientation one after the other, but their glycosidic bond causes the entire chain to be helical.



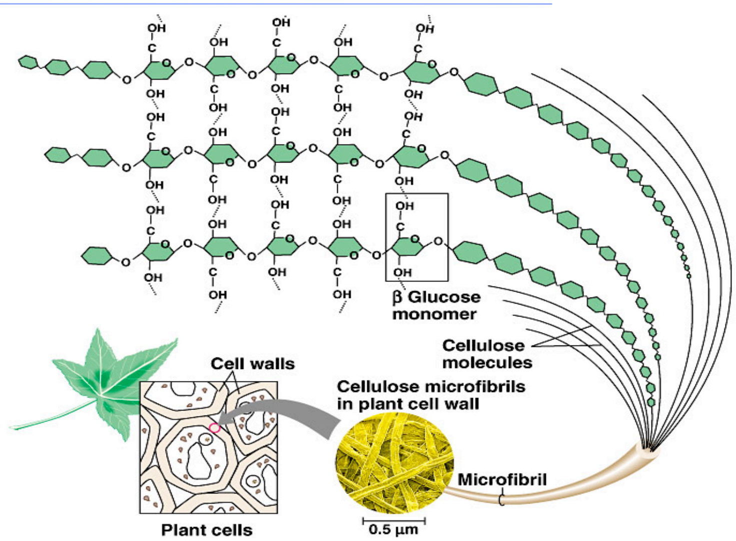


- In Cellulose every other glucose monomer is upside down compared to its neighbor and the chain remains straight.





Cellulose: Hydroxyls of adjacent strands hydrogen bond forming strong microfibrils

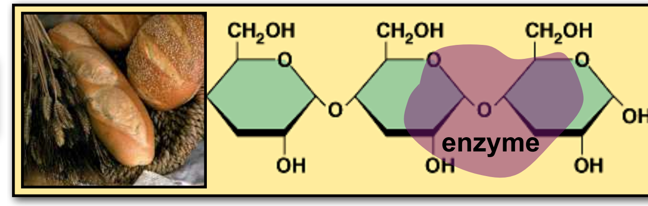


Cellulose

- Herbivores have evolved a mechanism to digest cellulose
- Most carnivores have not
  - That's why they eat meat to get their energy & nutrients
  - For us, omnivores, cellulose = undigestible roughage but still a necessary component of a healthy diet

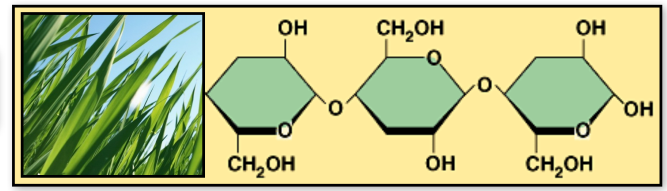
For us humans for example:

Starch = easy to digest



We have enzymes that can hydrolyze α glycosidic bonds and lack those that hydrolyze β glycosidic bonds.

Cellulose = hard to digest

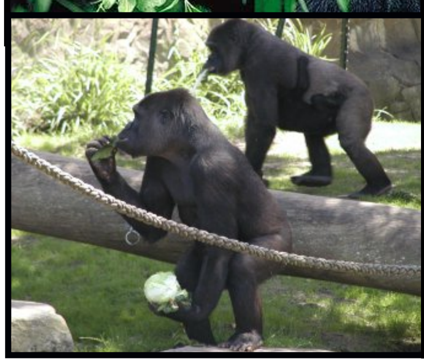


Cow:

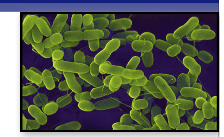
can digest cellulose well; no need to eat other sugars

Gorilla:

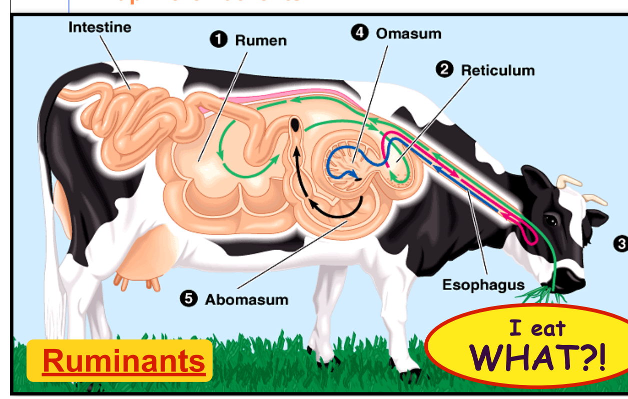
can't digest cellulose well; must add another sugar source, like fruit to diet



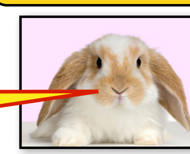
Helpful bacteria



- How can herbivores digest cellulose so well?
  - BACTERIA live in their digestive systems & help digest cellulose-rich (grass) meals *(These prokaryotes have the right enzyme)*
  - Some will pass the food through the digestive system twice to help soak up more nutrients

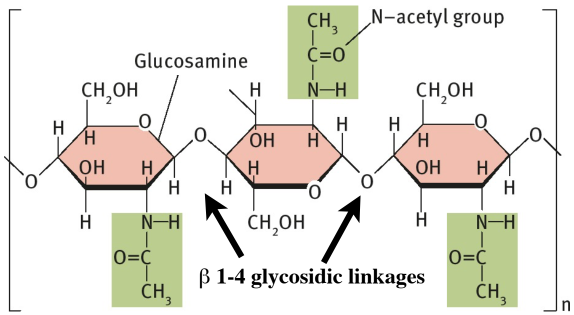


Rabbits practice Coprophagia (consuming feces).



Chitin

- Same structure as cellulose polysaccharide but hydroxyl on the 2' Carbon is replaced with nitrogen-containing group of atoms.
  - Forms the exoskeleton of arthropods (insects, spiders, lobsters, shrimp)
  - Also forms the cell walls of fungal cells



EAT

Let's build some

Carbohydrates!