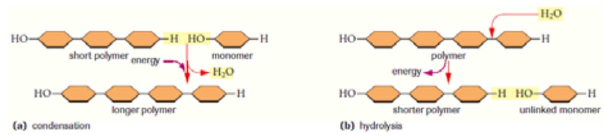
Biological Macromolecules:
Carbohydrates

Section 1.2

Macromolecules

- Four classes of biologically-important macromolecules
- ¾ are **polymers**
  - chain of similar or identical **monomer** units



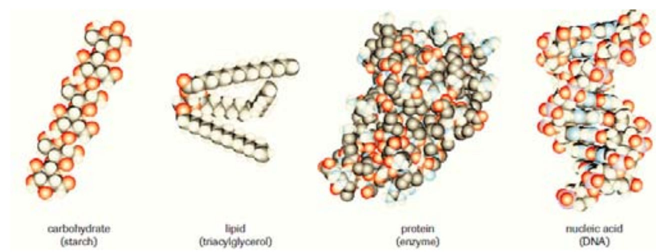
Condensation reactions link monomers together to build polymers

Hydrolysis reactions break polymers apart into their monomers

All the diversity of life is produced by 40-50 common monomers!

Four classes of macromolecule:

1. carbohydrates (today)
2. proteins (tomorrow)
3. nucleic acids (...the day after)
4. lipids



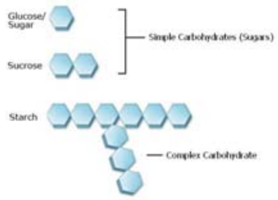
Carbohydrates

- **Biological importance**:
  - easily-accessible energy
- **Composition**:
  - C, H, O → $(CH_2O)_n$
  - monosaccharide monomers joined by **glycosidic linkages**
- **Structure**:
  - high proportion of OH and carbonyl groups
  - most are polar, and many are water-soluble

Carbs are classified based on size (number of monomers):

a) **Simple carbohydrates**
- few carbon atoms
- monosaccharides (one sugar) and disaccharides (two)

b) **Complex carbohydrates**
- polysaccharides
- long-chain polymers of monosaccharides



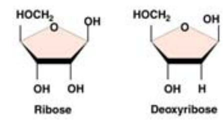
a) Simple carbs

Monosaccharides

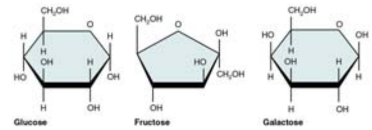
Monomers of complex carbohydrates

- Structure:
  - linear (3 or 4 carbons)
  - ring (5 or 6 carbons)
- Examples of 6-carbon hexoses:
  - glucose (blood sugar)
  - fructose (fruit sugar)
  - galactose

Pentoses (5 carbons)

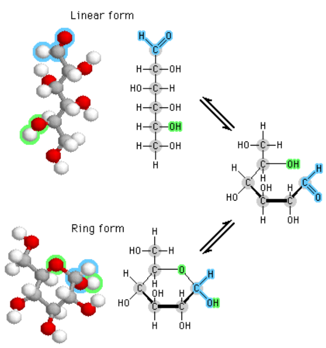


Hexoses (6 carbons)



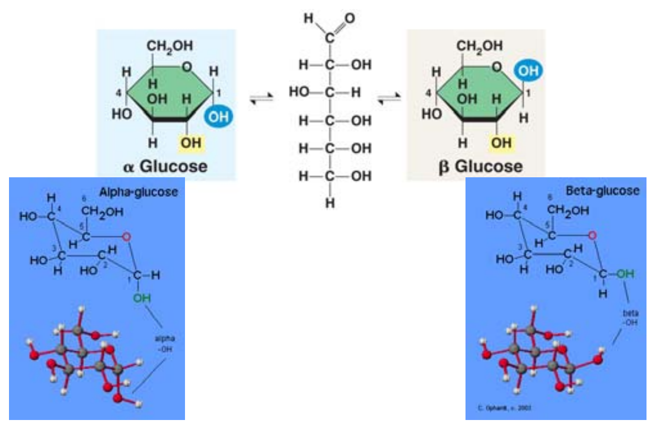
When dry, pentoses and hexoses are **linear**.

In aqueous solution, they form **rings**.



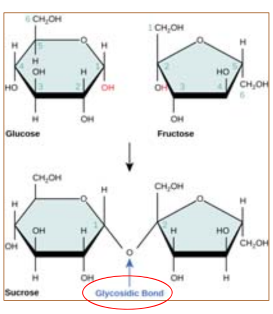
3D model of glucose

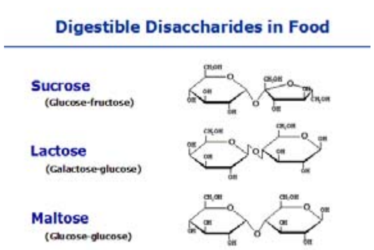
When glucose forms a ring, there is a 50/50 occurrence:
- OH group ends up **below** plane of ring → **α-glucose**
- OH group ends up **above** plane of ring → **β-glucose**



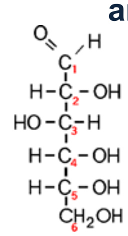
Disaccharides

Two monosaccharides joined by **glycosidic** linkages

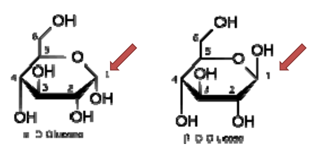




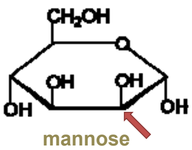
The carbons in monosaccharides are numbered.



Linear
Start #'s at the carbonyl group

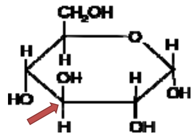


Ring:
Start #'s at the C just right of the O

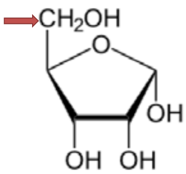


mannose

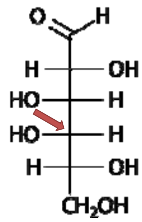
Practice:
Number that carbon!



glucose

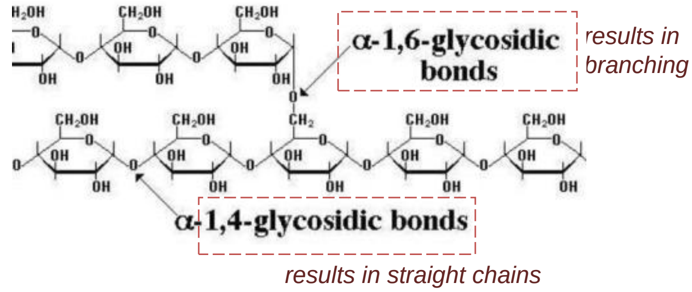


ribose



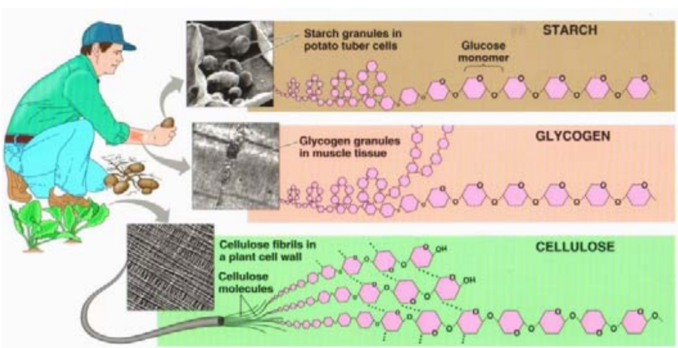
galactose

Glycosidic linkages are classified by which carbons are involved in the bond.

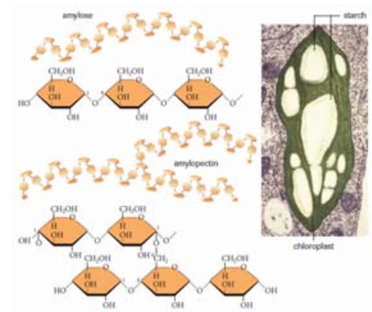


b) Complex sugars (polysaccharides)

Three common polymers of glucose:
- starch
- glycogen
- cellulose

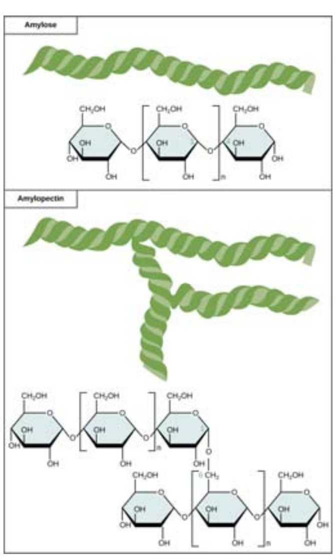


Starch:
- storage in plants
- α-glucose monomers
- 20-30% **amylose**
- 70-80% **amylopectin**



20-30%

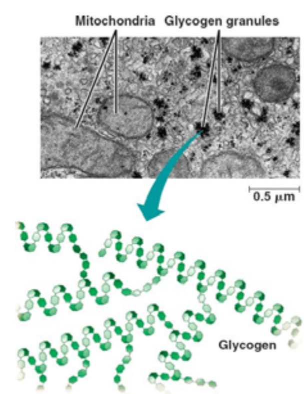
70-80%



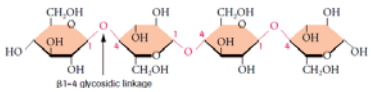
Amylose
- unbranched
- 1,4 glycosidic linkages
- tightly coiled
- insoluble

Amylopectin
- branched due to presence of 1,6 linkages

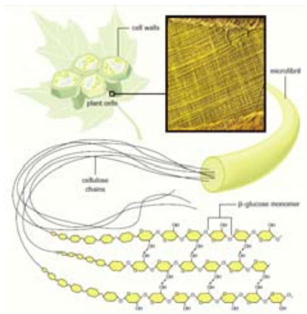
Glycogen:
- energy storage in animals
  - muscles, liver
- α-glucose monomers
- lots of branching = easily broken down
  - more 1,6 linkages than amylopectin



Cellulose:



- structural support in plant walls
- 1,4 linked β-glucose monomers
  - straight chain structure
- extremely stable
  - hydrogen bonding btw adjacent chains → intertwined bundles
- insoluble in water



Trends

1-4 Linkages

- straight chains
- amylose starch, cellulose
- linear structure allows tight packing - makes monomers hard to access
  - insoluble
  - difficult to break down chemically
  - physical strength

1-6 Linkages

- branched chains
- amylopectin starch, glycogen
- branching prevents tight packing - makes monomers easier to access
  - soluble
  - easy to break down chemically

Summary

- Carbohydrates can be small and simple (mono or disaccharides), or large and complex.
- Complex carbohydrates are polymers of monosaccharides, which are held together by glycosidic linkages.
- Properties of complex carbohydrates are influenced by the structure of the monosaccharides, and the specific carbons involved in linkages.

Homework

- Complete handout: Carbohydrates
- Read 1.2 (pg. 18-20)
- Pg. 21 #7-12