Basic Biochemistry

ABE 580

Classes of Biomolecules

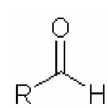
- Carbohydrates
- Lipids
- Amino Acids
- Nucleic Acids
- Other

Carbohydrates

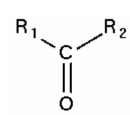
- Sugars
- Composed of C, H, O ($C_nH_{2n}O_n$)
- Biological Uses
  - Energy source/storage
  - Structural Strength or Support
  - Tag for IDing proteins, etc.
- Monosaccharides
- Oligo- and Polysaccharides

Monosaccharides

- Aldose
  - Sugars having an aldehyde moiety



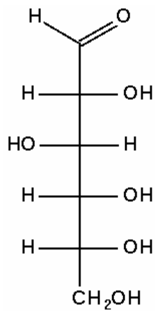
- Ketose
  - Sugars having a ketone moiety



- Hexoses
  - Sugars having 6 carbons: $C_6H_{12}O_6$
- Pentoses
  - Sugars having 5 carbons: $C_5H_{10}O_5$
  - Ribose, Xylose

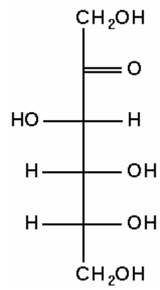
Hexose Isomers

Fischer Projections



Glucose

Aldose

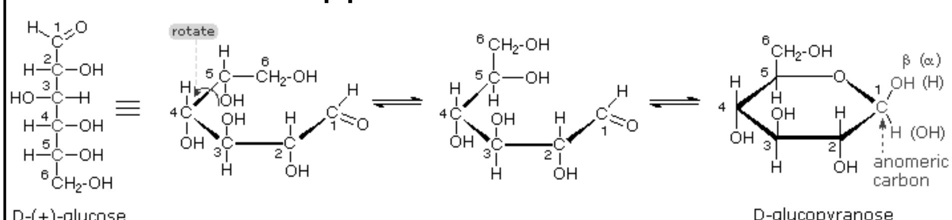


Fructose

Ketose

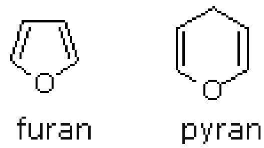
Chain vs Ring Structure

- Aldehyde (aldoses) and ketone (ketose) can form hemiacetal with hydroxyl of carbon on opposite end of chain

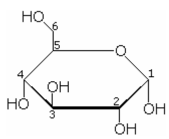


Ring Structures

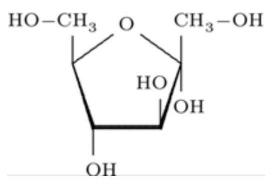
- Aldohexoses form 6 member rings – pyranose
- Ketohexoses form 5 member rings - pyranose
- Aldopentoses form 5 member rings - furanose



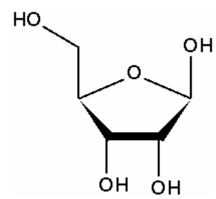
Haworth
Projection



Glucose
(pyranose ring)

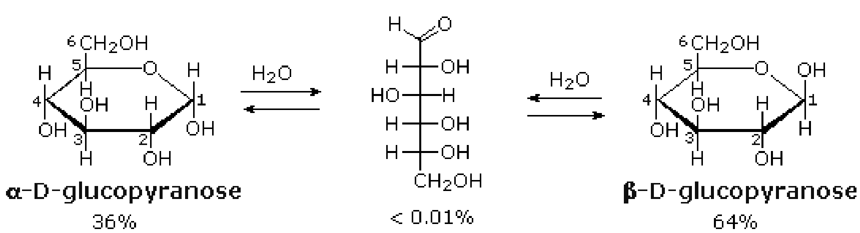


Frutose
(furanose ring)



Ribose
(furanose ring)

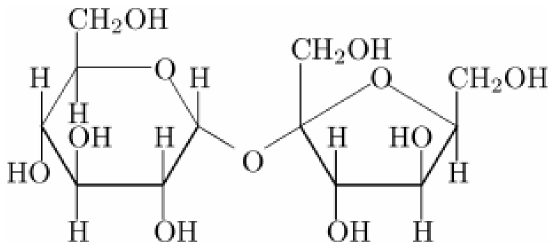
Mutarotation Equilibrium



Mutarotation Equilibrium
in Water

Carbohydrate Bonds

- Glycosidic Bonds: C – O – C
- Between hydroxyls
  - – Ring structures form these bonds!



Glucose α 1-2 fructose

Sucrose

Two Important Polysaccharides

- Polysaccharide – "many saccharides"
- Starch = Glucose α1-4 Glucose
  - – Two forms
    - Amylose (straight chain)
    - Amylopectin (branched chain)
  - – Important energy storage (plants) and food
- Cellulose = Glucose β1-4 Glucose
  - – Important structural sugar (wood)
  - – Straight chain

Difference in Glycoside Bonds Makes All the Difference

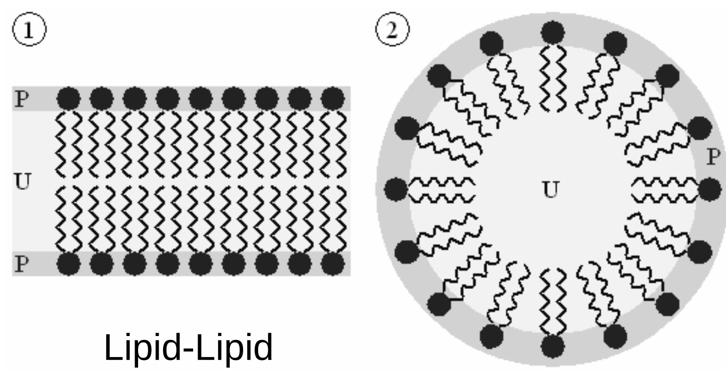
- Starch
  - Amylose chains form helix by hydrogen bonds between the hydroxyl groups of glucose
  - Allows it to be compacted for storage
  - Easy to break hydrogen bonds with water to “uncoil” and hydrolyze into glucose
- Cellulose
  - Straight, ribbon-like chains that stack into crystals through hydrogen bonds
  - Very strongly bound (high number of H-bonds)
  - Gives cellulose strength and resistance to hydrolysis
- 3-D Models

Lipids

- Hydrocarbons (largely C & H)
- Important Functions
  - Membranes! Cells, organelles
  - Energy storage (higher energy density than carbohydrates)
- Fatty acids – carbon chains with acetyl on one end
  - Saturated: no C=C (double bonds)
  - Unsaturated: Some C=C (double bonds)
- Phospholipids – hydrophobic carbon chains with hydrophillic head

Lipids are Amphiphilic

- Hydrophilic Head – Hydrophobic Tail

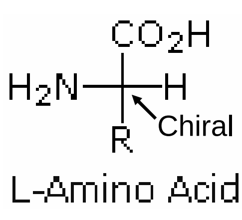


Lipid-Lipid Bilayer

Lipid Micelle

Amino Acids

- 20+ Amino acids
- Amino acid polymers = proteins
- Amino acids = amine + carboxylic acid



R = side chain

R = acidic, basic, hydrophilic, hydrophobic, charged, uncharged

Proteins

- Proteins are linear polymers of amino acids
- Peptide bonds = amine to carboxylic acid
- Structure and function of protein determined by 3-D structure that polymer assumes in water
- 3-D structure a function of lowest energy confirmation
  - Hydrophobic groups associate away from water
  - Hydrophilic groups associate toward water
- Protein Function
  - Enzymes catalyze biochemical reactions
  - Structure and support
  - Communication between cells (hormones)

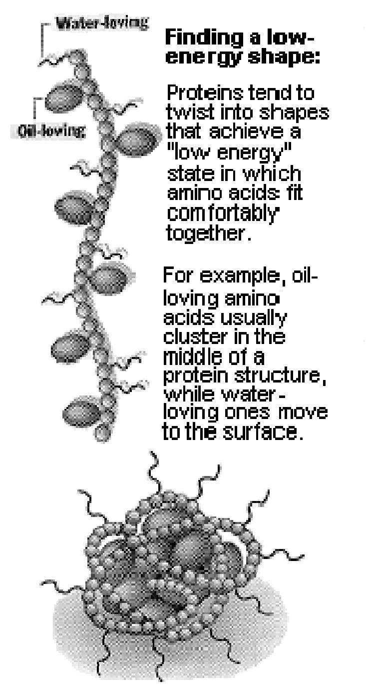
Protein Folding

Folding@Home

Distributed computing project studying protein folding using novel computational methods and large scale distributed computing, to simulate the thermodynamics of protein folding.

http://folding.stanford.edu/

3-D Models



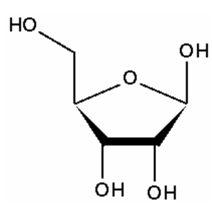
Nucleic Acids

- Composed of 3 parts
  - Pentose (sugar)
  - Heterocyclic Base
  - Phosphate

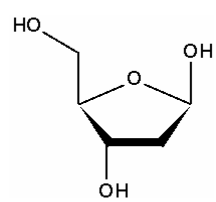
- A unit of all 3 (sugar+base+phosphate) called a **nucleotide**

Nucleic Acids

- Pentose
  - Ribose (RNA)
  - Deoxyribose (DNA) = lacking 1 hydroxyl group on sugar C2



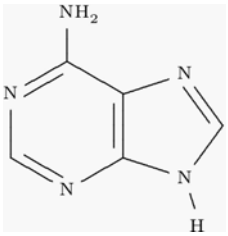
Ribose



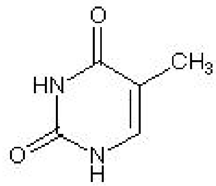
Deoxyribose

Nucleic Acids

- Bases
  - 5 bases
  - 4 used in RNA (U, A, C, G)
  - 4 used in DNA (T, A, C, G)
  - 2 Types
    - Purine (A, G)
    - Pyrimidine (T, U, C)



Adenine



Thymine

Polynucleotides

- DNA and RNA polymers store and convey genetic information
- Polymer consists of sugar backbone linked by -C-PO_4-C-
- Bases (esp. DNA) can associate through complementary pairing (A-T, C-G)
- 3-D structure is double helix
- <u>3-D Model</u>

Genetic Code

- Sets of 3 bases (codon)
- 4^3 = 64 codons
- Each codon specifies a unique amino acid
- Each amino acid specified by at least 1 codon
- Start codon (methionine)
- Stop codons (UAG, UAA and UGA)

Central Dogma of Biology

- DNA is transcribed to mRNA
- http://www.johnkyrk.com/DNAtranscription.html
- mRNA is translated into protein
- http://www.johnkyrk.com/DNAtranslation.html

- DNA makes RNA
- RNA makes Proteins