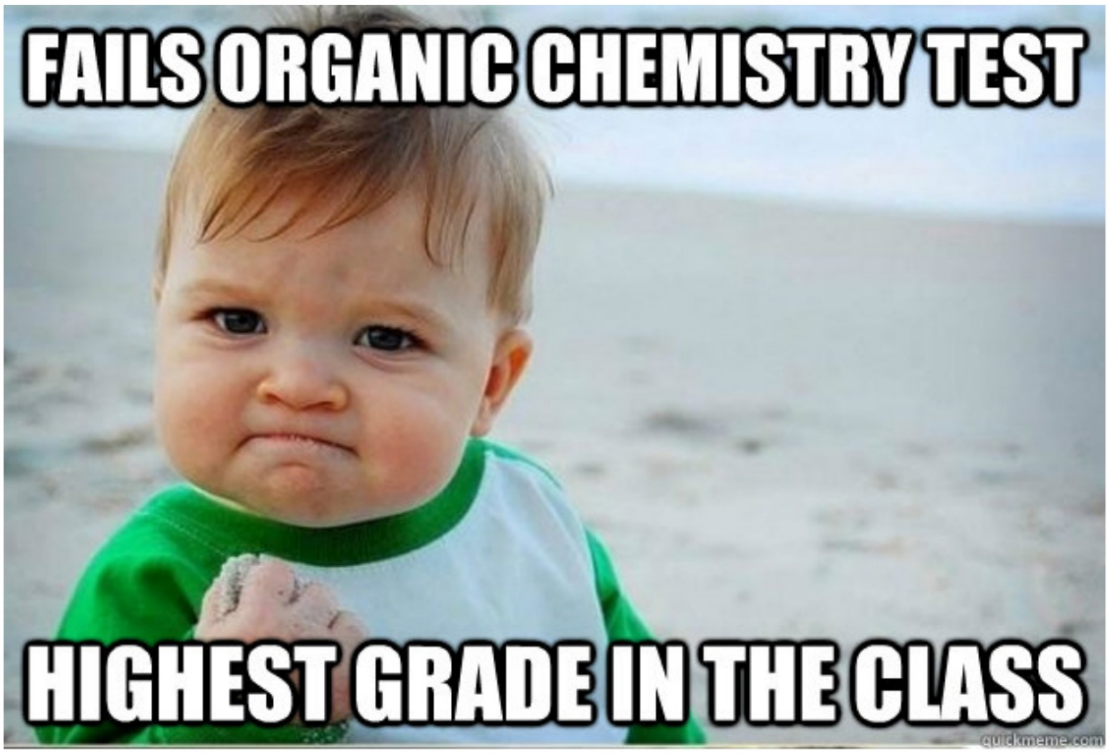
Chapter 3: The Chemistry of Organic Molecules



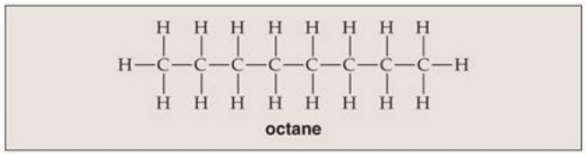
http://s2.quickmeme.com/img/b6/b61d57fcbc0f40a210c5b2c5fdf157630967bfa1cff380fdeaa20b1f1ff55839.jpg

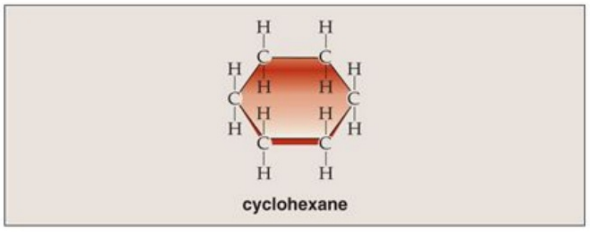
3-1 Organic Molecules

- contain carbon and hydrogen; important for living things
- biomolecules - carbohydrates, lipids, proteins, nucleic acids

Carbon Atoms

- six electrons; 4 valence electrons
- can make up to 4 bonds
- number of atoms it bonds with determines shape of molecule
- often bonds with CHNOPS
- C-C bonds are stable and allow formation of carbon skeleton
- chains and rings



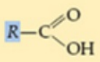
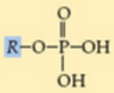


Functional Groups

- specific combination of bonded atoms that always reacts the same way (regardless of skeleton)
- allow diversity of biomolecules
- determine much of chemistry of biomolecules (use *R* to represent rest of mol)
- You must know this table (p. 39)

- note that polarity is affected by addition of functional groups
- this is especially important in watery cell env

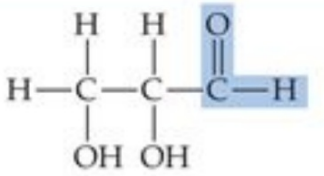
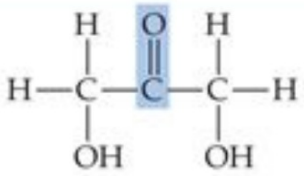
Table 3.2 Functional groups.

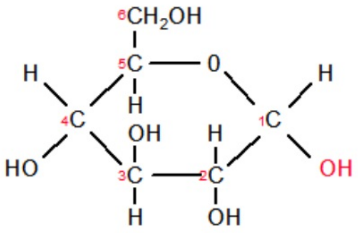
Functional Groups			
Group	**Structure**	**Compound**	**Significance**
Hydroxyl	R—OH	Alcohol as in ethanol	Polar, forms hydrogen bond Present in sugars, some amino acids
Carbonyl		Aldehyde as in formaldehyde	Polar Present in sugars
		Ketone as in acetone	Polar Present in sugars
Carboxyl (acidic)		Carboxylic acid as in acetic acid	Polar, acidic Present in fatty acids, amino acids
Amino		Amine as in tryptophan	Polar, basic, forms hydrogen bonds Present in amino acids
Sulfhydryl	R—SH	Thiol as in ethanethiol	Forms disulfide bonds Present in some amino acids
Phosphate		Organic phosphate as in phosphorylated molecules	Polar, acidic Present in nucleotides, phospholipids

R = remainder of molecule

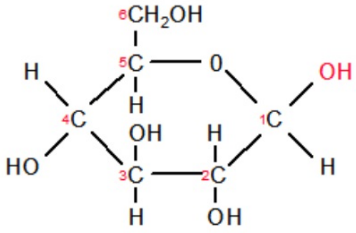
Isomers

- same molecular formula; different arrangement
- different functional groups lead to different chemical behaviors

glyceraldehyde	dihydroxyacetone
	



α-glucose



β-glucose

http://faculty.clintoncc.suny.edu/faculty/michael.gregory/files/bio%20101/bio%20101%20lectures/biochemistry/alpha%20glucose.gif

The Biomolecules of Cells

- molecules are taken in, broken down and rearranged
- monomers are linked together to build polymers

Biomolecules		
Category	**Subunit(s)**	**Polymer**
Carbohydrates*	Monosaccharide →	Polysaccharide
Lipids	Glycerol and fatty acids →	Fat
Proteins*	Amino acids →	Polypeptide
Nucleic acids*	Nucleotide →	DNA, RNA

Synthesis and Degradation of Biomolecules

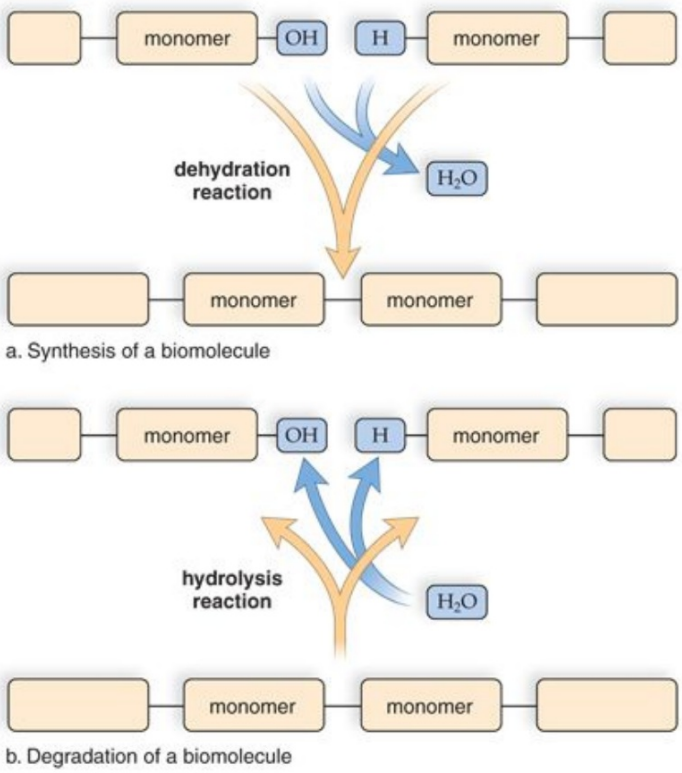
- condensation reaction/dehydration

  synthesis builds polymer from monomers
  - molecule of water formed in reaction

- hydrolysis reaction breaks polymers into monomers
  - water is added to split bonds

- enzymes are required for these reactions

p. 41 questions 1 and 3

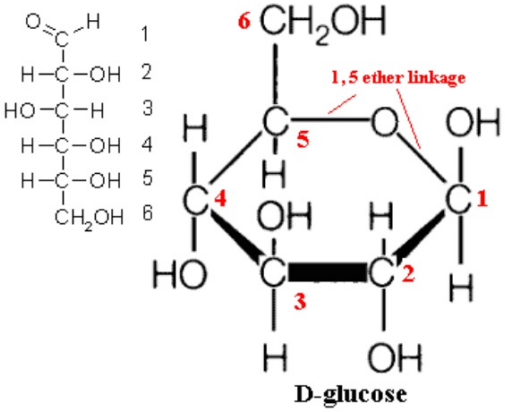


3-2 Carbohydrates

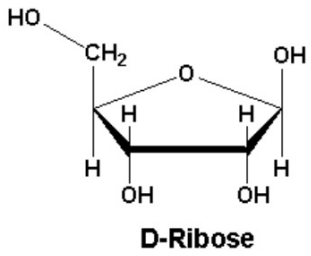
- carbon water
- $C_m(H_2O)_n$ is general formula

Monosaccharides

- simple sugars
- 3 - 7 carbons (naming)
- soluble in water due to presence of hydroxyl groups (polar)
- glucose
  - $C_6H_{12}O_6$ (also formula for fructose and galactose)
  - fuels cellular respiration (converted into ATP)
  - transported in blood
- deoxyribose - DNA
- ribose - RNA

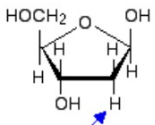


http://palaeos.com/fungi/fpieces/images/Glucose.gif



http://www.pearsonhighered.com/mathews/QR/RIBO

DEOXYRIBOSE

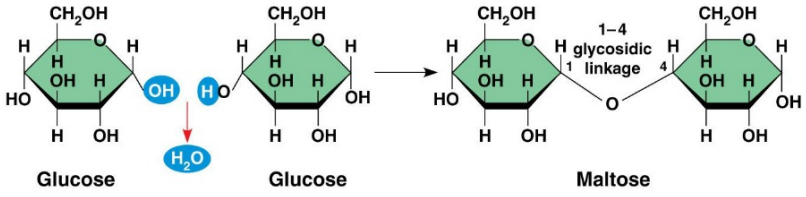


Deoxyribose has a hydrogen here rather than -OH.

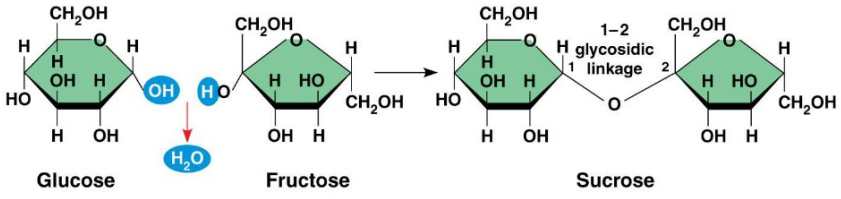
http://www.chemguide.co.uk/organicprops/aminoacids/deox

Disaccharides: Varied Uses

- 2 monosaccharides
- sucrose - table sugar
  - glucose + fructose
  - sugar transport in plants
- maltose - used in brewing
  - glucose + glucose
  - formed in starch digestion
- lactose - found in milk
  - glucose + galactose
  - intolerance



(a) Dehydration reaction in the synthesis of maltose

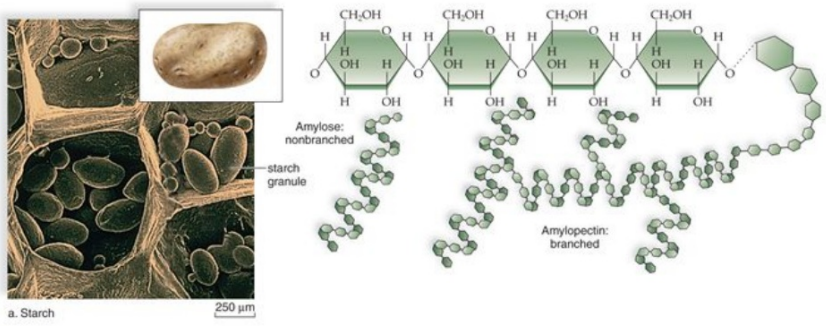


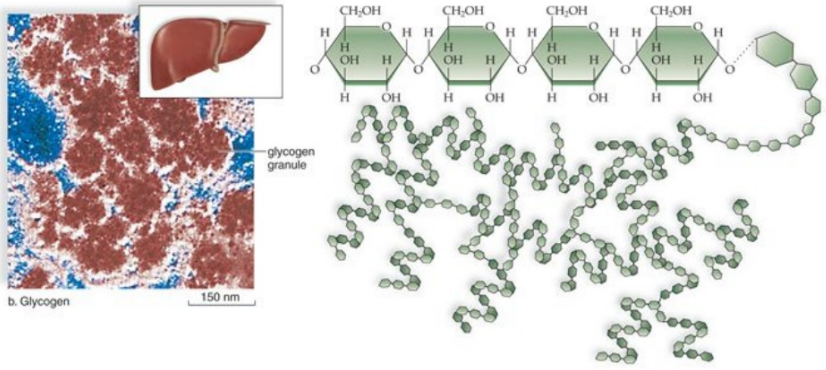
(b) Dehydration reaction in the synthesis of sucrose

http://classconnection.s3.amazonaws.com/652/flashcards/729652/jpg/05_05disaccharidesynth-l1316447585157.jpg

Polysaccharides: Energy Storage Molecules

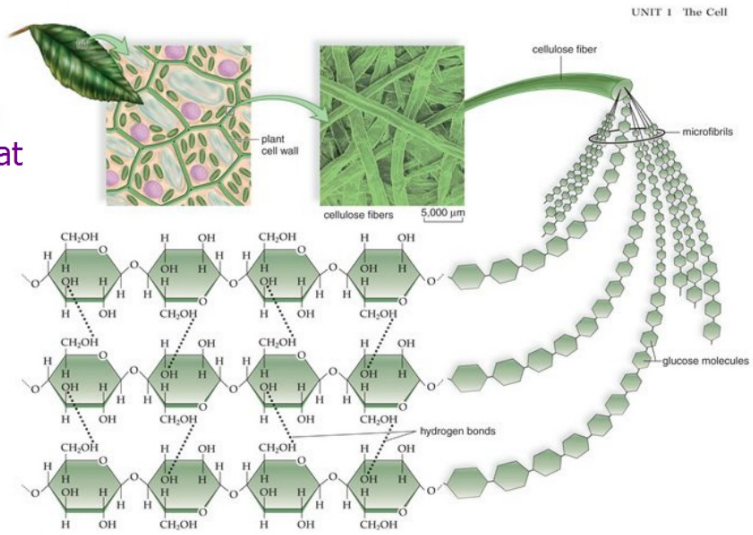
- helical shape allows enzymes to access linkages for breaking down
- breaking down releases sugar mols
- not as soluble in water
- starch - glucose storage in plants
  - stored in granules in cells
  - amylose - nonbranched
  - amylopectin - branched
- glycogen - glucose storage in animal
  - stored in granules in liver cells
  - storage and release controlled by hormones
  - insulin promotes storage
  - glucagon promotes release





Polysaccharides: Structural Molecules

- cellulose - plants
  - glucose
  - most abundant carb and org mol on Earth
  - microorgs can digest, but not animals
  - some animals have endosymbionts that aid in use of cellulose
  - dietary fiber in others
- chitin - animals and fungi
  - glucose with amino group
  - fungal cell walls
  - exoskeleton of arthropods
  - used in medicine and cosmetics
- peptidoglycan - bacteria
  - amino acid chain added to monomer



p. 58 Testing Yourself questions 1-4, 10, 11

3-3 Lipids

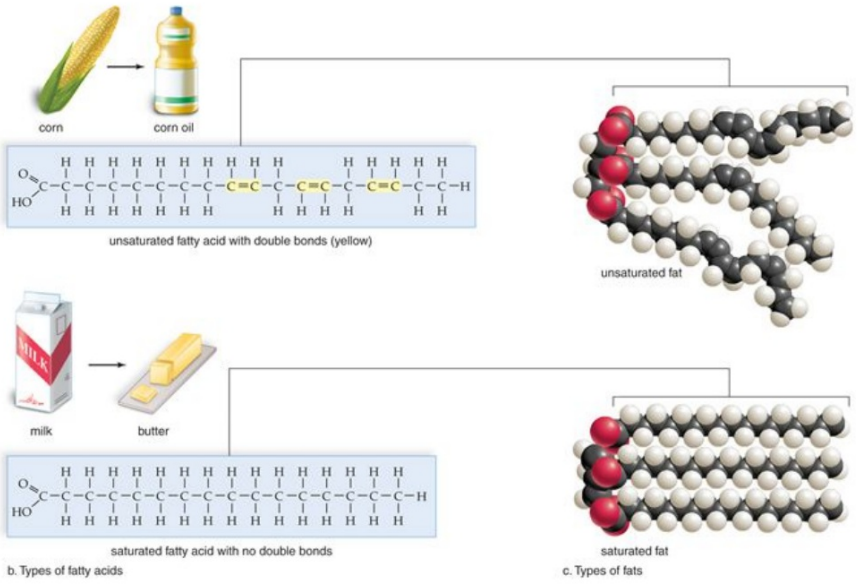
- hydrocarbon chains
- insoluble in water
- C, H and little O

http://www.nofima.no/imagearchive/ingressimage_OlivenOlje02.jpg

http://www.ksre.k-state.edu/kvafl/fullsize3609.ashx

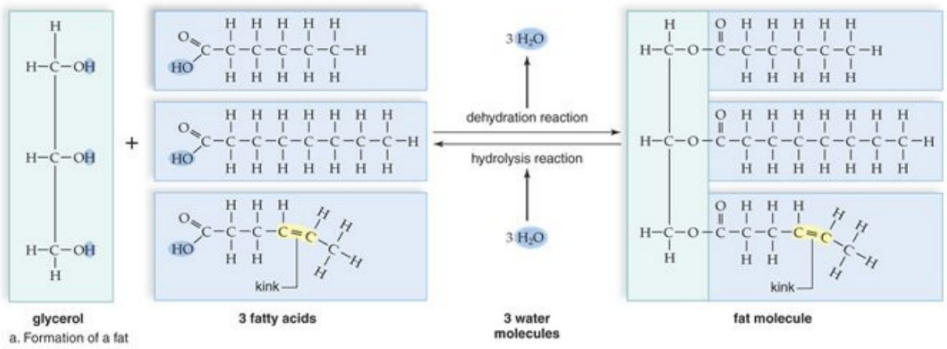
Fatty Acids

- long hydrocarbon chain with a carboxyl group at one end
- saturated fatty acids contain no double bonds between carbon atoms
  - contain as many hydrogens as they can hold
- unsaturated fatty acids have double bonds in hydrocarbon chain
  - reduces number of hydrogens that can bond



Triglycerides

- three fatty acids attached to a glycerol molecule (dehydration synthesis - results in three H_2O)

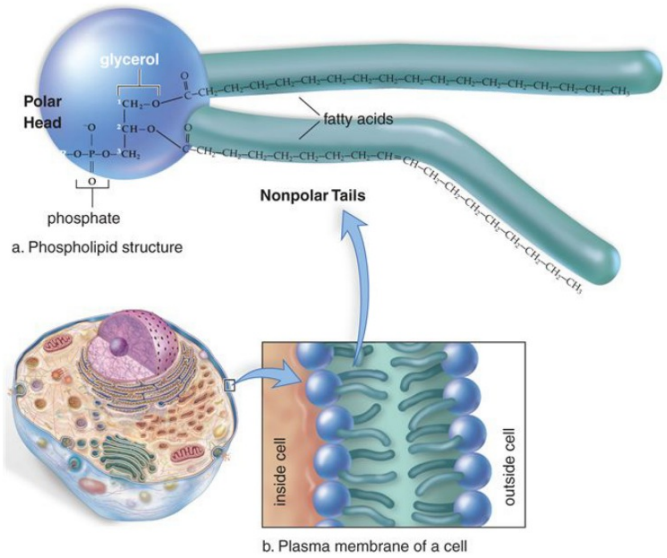


a. Formation of a fat

- nonpolar
- unsaturated fatty acids prevent packing of molecules and remain liquid at room temp (oils)
- saturated fatty acids have no kinks and remain solid at room temp (fats)
- saturated fats can accumulate in blood vessels
- long-term energy storage (C-H bonds and lighter than glycogen per amt of energy)

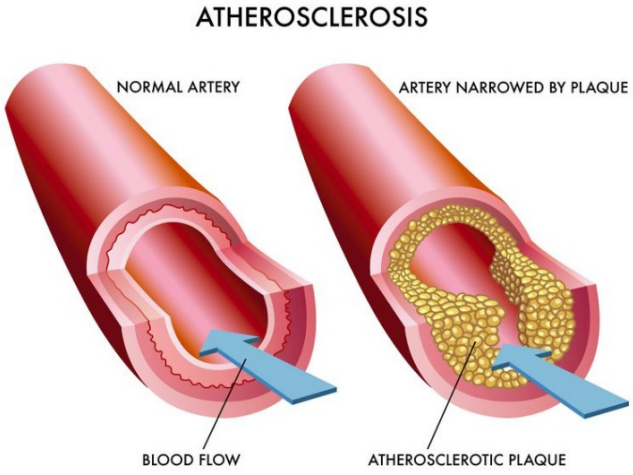
Phospholipids

- glycerol with two fatty acids and a phosphate group (polar)
- phosphate group bonded to another organic group
- hydrophilic head region
- hydrophobic tail region
- separate biological compartments by forming bilayers (plasma membrane)



Steroids: Four Fused Rings

- four fused carbon rings with different functional groups
- cholesterol
  - physical stability in plasma membrane
  - precursor to steroid hormones (see p. 48)
  - contributes to circulatory disorders due to build up in vessels



https://www.azvascular.com/wp-content/uploads/2013/07/atherosclerosis-vein-problem-azvascular.jpg

Waxes

- long-chain fatty acid and long-chain fatty alcohol
- solid at room temp
- protective cuticle
- skin/fur
- ear - repels insects and prevents dirt from reaching eardrum

p. 49 question 3
p. 58 Testing Yourself q 5
p. 59 Think Scientifically q 1

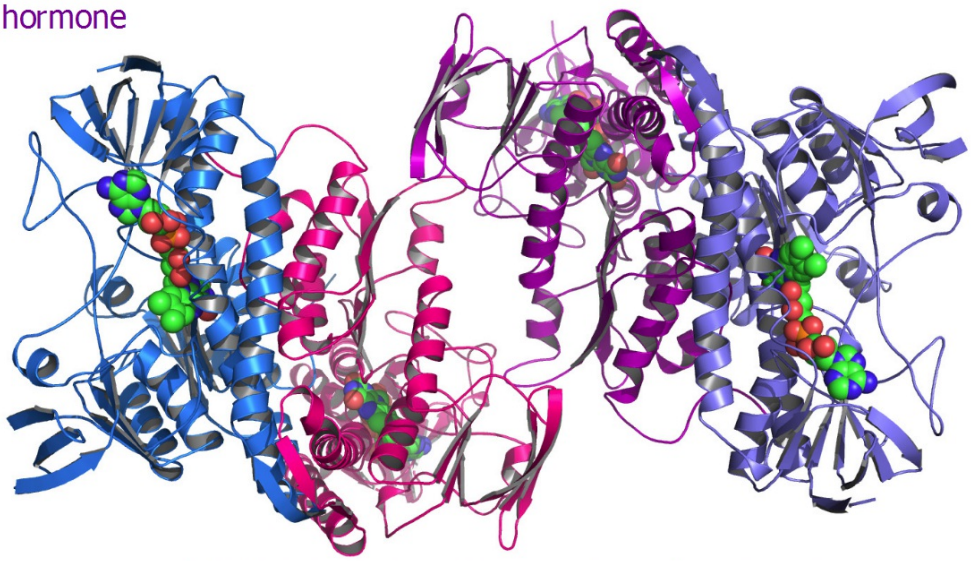
a.

b.

3-4 Proteins

Functions in Animals:

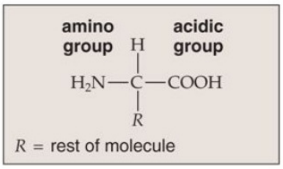
- metabolism - enzymes
- support - keratin, collagen
- transport - channel and carrier proteins
  - hemoglobin
- defense - antibodies
- regulation - insulin, growth hormone
- motion - actin, myosin

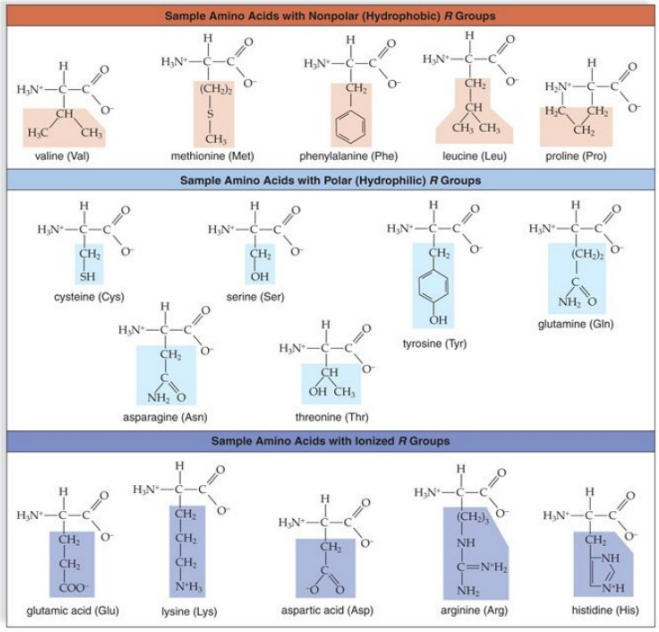


http://upload.wikimedia.org/wikipedia/commons/8/86/Argonne%27s_Midwest_Center_for_Structural_Genomics_de
posits_1,000th_protein_structure.jpg

Amino Acids

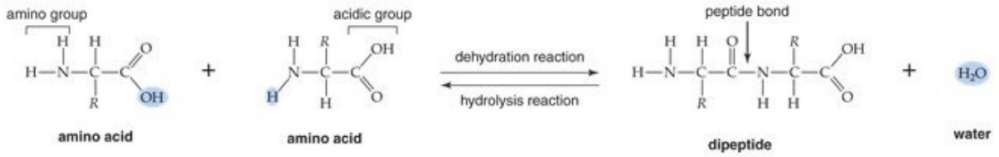
- alpha carbon
- amino group ($-NH_2$)
- carboxyl group (-COOH)
- hydrogen atom
- R group - variable

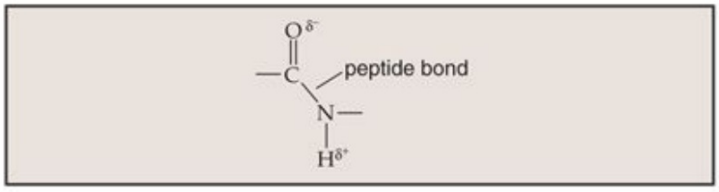




Peptides

- amino acid monomers join together in a condensation reaction
- bond bet. carboxyl group of one amino acid and amino group of another is peptide bond
- polar (oxygen more electronegative than nitrogen)
- leads to hydrogen bonding bet. amino acids in polypeptide chain



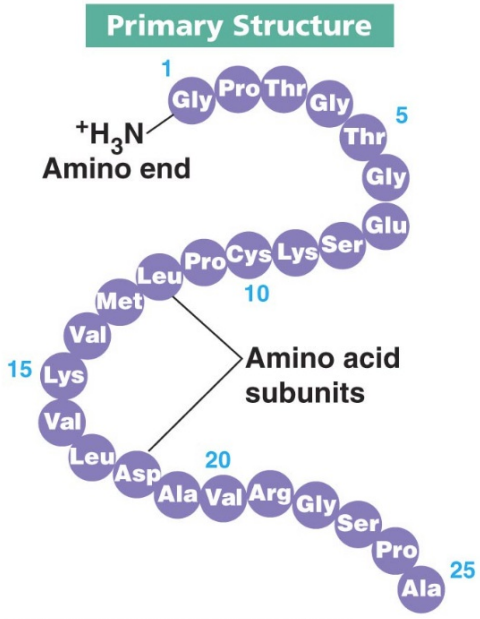


Shape of Proteins

- proteins are polypeptides that have been folded into a particular shape and have function
- amino acid sequence affects folding/function

Primary Structure

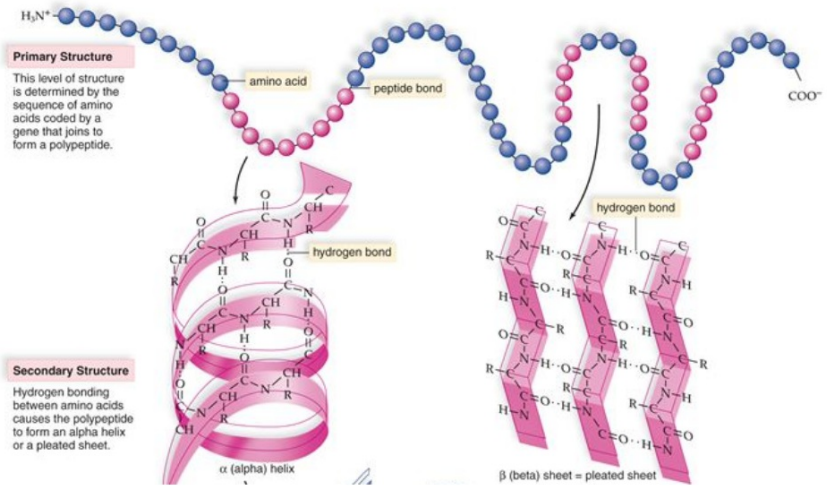
- sequence of amino acids
- dictated by genes (DNA --> RNA --> protein)



http://biochemanics.files.wordpress.com/2013/04/protein_-_primary_structure.jpg

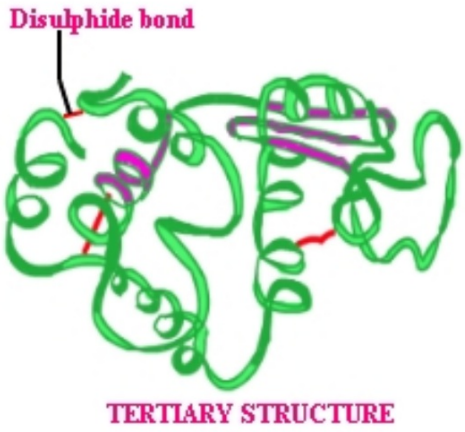
Secondary Structure

- polypeptide coils or folds due to hydrogen bonding
- α helix formed by hydrogen bonding bet every 4th amino acid
- β pleated sheets formed when polypeptide turns back on itself and hydrogen bonding occurs along length of fold
- keratin, silk and other fibrous proteins exist as long helices or pleated sheets



Tertiary Structure

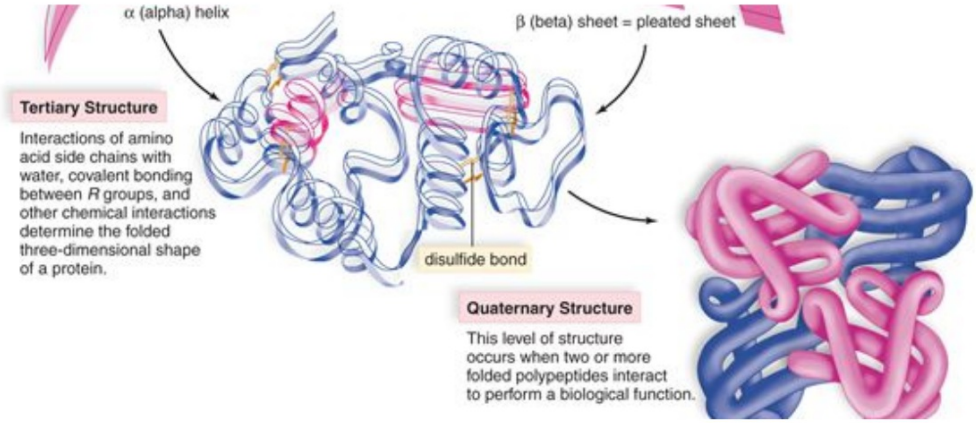
- folding resulting in final 3-D shape of protein
- globular proteins have tertiary structure
- caused by
  - hydrophobic interactions
  - ionic, covalent and hydrogen bonding bet R groups
  - disulfide linkages
- denaturing of a protein occurs at high temp or change in pH



http://images.tutorvista.com/cms/images/123/tertiary-structure-protein.JPG

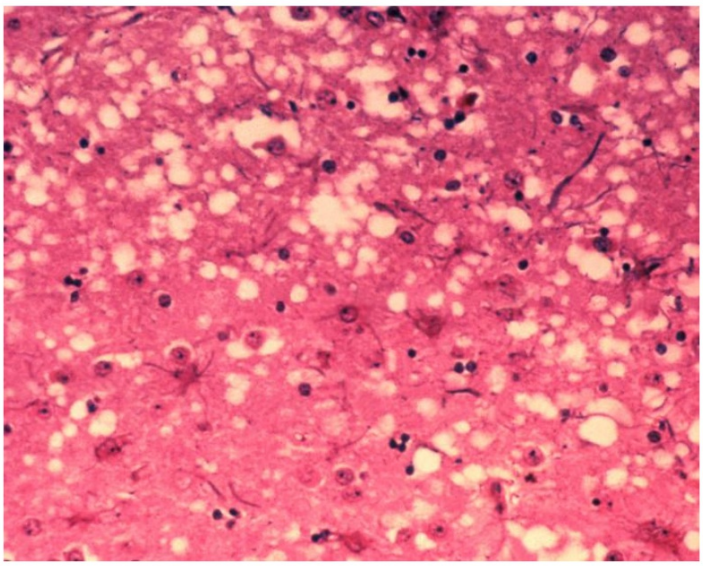
Quaternary Structure

- found in proteins that consist of more than one polypeptide
- hemoglobin



Protein-Folding Diseases

- chaperone proteins - aid in folding and possibly correct errors in folding
- cystic fibrosis and Alzheimer's are associated with misshapen proteins (possibly missing chaperones)
- TSEs (ex: mad cow) may be due to misfolded proteins that cause other proteins to misfold (called prions)

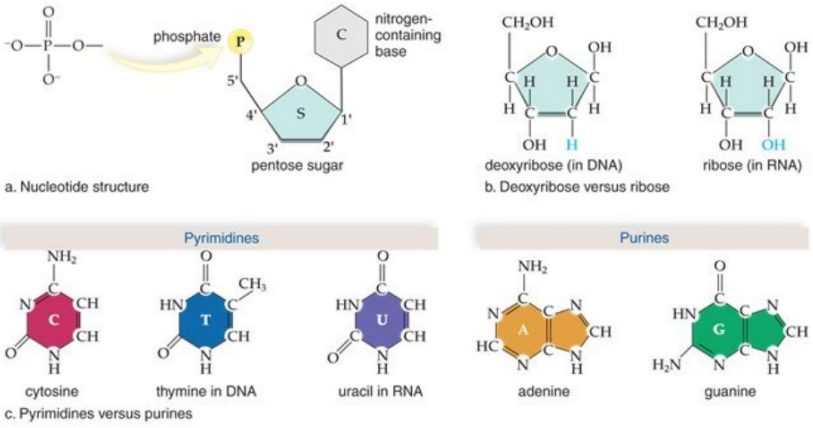


http://upload.wikimedia.org/wikipedia/commons/2/23/Histology_bse.jpg

p. 53 q. 2,3
p. 58 TY q. 6,7,12,13
p. 59 TS q. 2

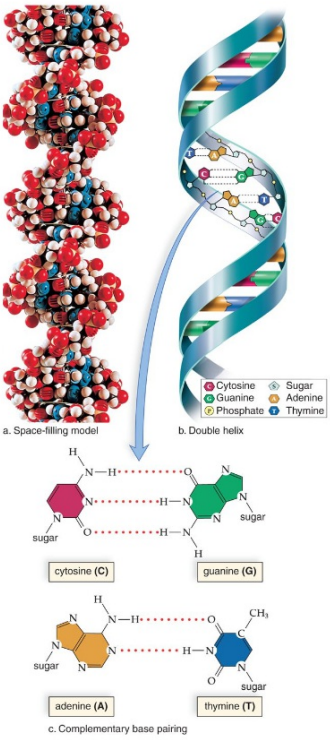
3-5 Nucleic Acids

- monomers = nucleotides
- joined together in cond rxn to make DNA and RNA
- some function as monomers
- contain:
  - 5-carbon sugar
  - phosphate
  - nitrogen-containing base
    - purines - double ring
    - pyrimidines - single ring



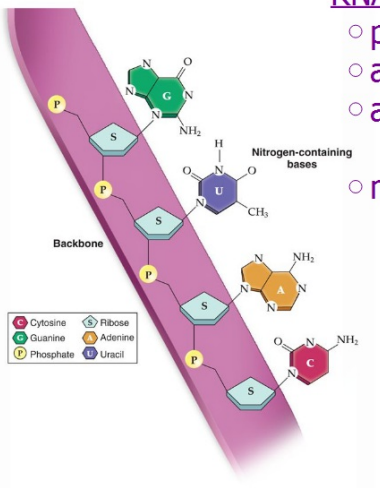
DNA

- pentose sugar is deoxyribose
- adenine, guanine, cytosine and thymine
- alternating sugar-phosphate backbone with bases hydrogen bonded in center; double stranded
- twisted into double helix
- stores replication information and order of amino acids in proteins



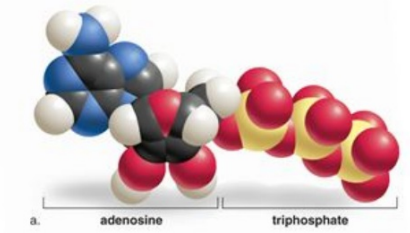
RNA

- pentose sugar is ribose
- adenine guanine, cytosine and uracil
- alternating sugar-phosphate backbone; single stranded
- mRNA, tRNA, rRNA and others



ATP

- adenosine triphosphate
- adenine, ribose and three phosphates
- high energy - last 2 phosphate bonds are unstable and can be broken releasing energy
- ADP, AMP
- ATP hydrolysis powers many cell processes



p. 56 q3
p. 57 TY q8,9,14,15-18