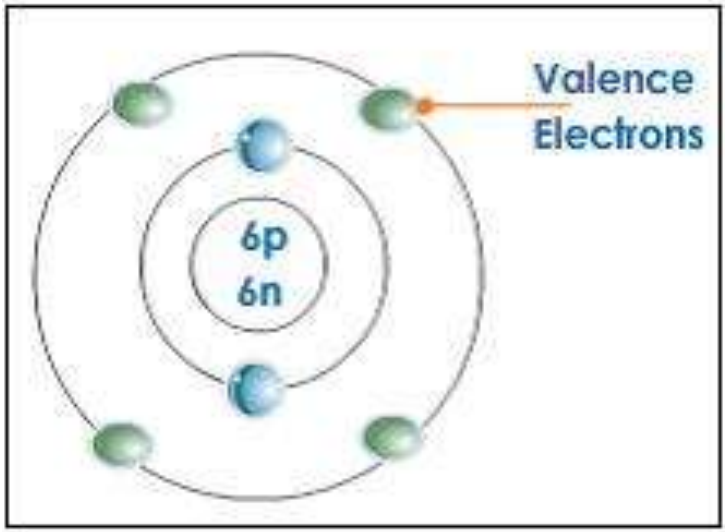
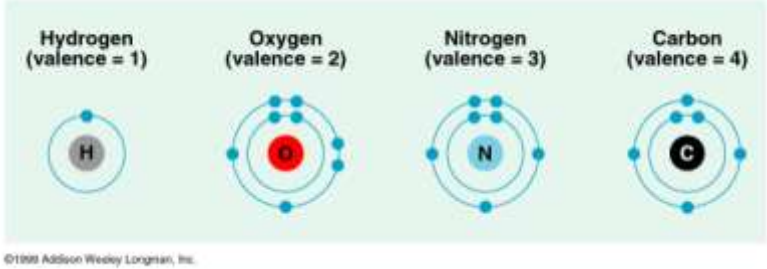
Organic Macromolecules



- Carbohydrates
- Proteins
- Lipids
- Nucleic Acids


We just can't be together...
H
O
H
Is it because I'm FAT?!
C
C
C
C
O
O

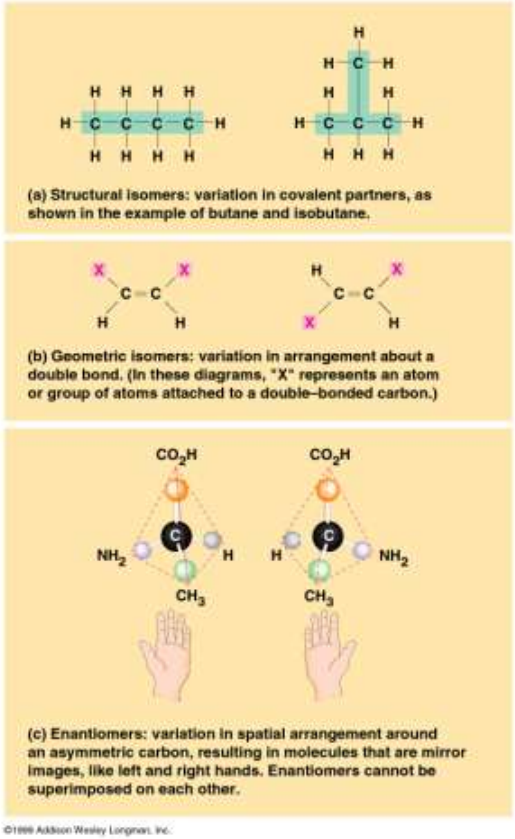
Organic chemistry



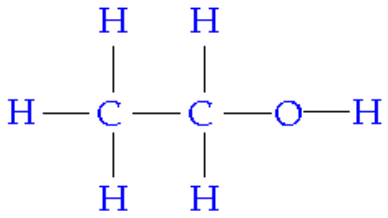
- **Biological thought:**
- **Vitalism** (life force outside physical & chemical laws) **Berzelius**
- **Mechanism** (all natural phenomena are governed by physical & chemical laws) **Miller**
- **Carbon**
  - tetravalence
  - Tetrahedron shape determines function

Hydrocarbons

- Only carbon & hydrogen (petroleum; lipid 'tails')
- Covalent bonding; nonpolar
- High energy storage
- Isomers (same molecular formula, but different structure & properties)
- structural~differing covalent bonding arrangement
- geometric~differing spatial arrangement
- enantiomers~mirror images pharmacological industry (thalidomide)



Functional Groups, I

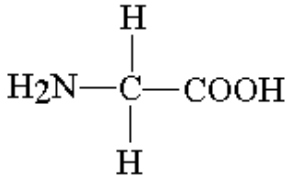


- Attachments that replace one or more of the hydrogens bonded to the carbon skeleton of the hydrocarbon
- Each has a unique property from one organic to another

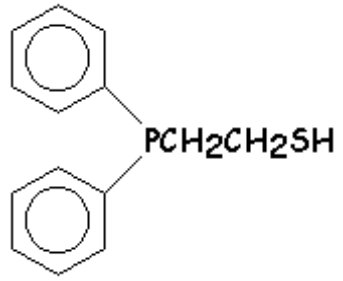
- Hydroxyl Group
  - **H bonded to O; alcohols**
  - **polar (oxygen); solubility in water**
- Carbonyl Group
- **C double bond to O;**
- **At end of H□C□□: aldehyde Otherwise: ketone**

Carbonyl	–C=O
Ketones	C=O
Aldehydes	–C=O H

Functional Groups, II



glycine



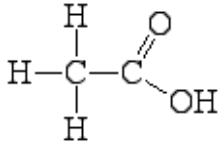
- Carboxyl Group **O double bonded to C to hydroxyl; carboxylic acids; covalent bond between O and H; polar; dissociation, H ion**

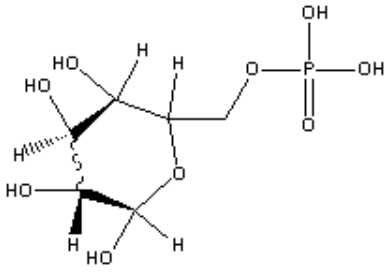
- Sulfhydral Group **sulfur bonded to H; thiols**

- Phosphate Group **phosphate ion; covalently attached by 1 of its O to the C skeleton;**

- Amino Group **N to 2 H atoms; amines; acts as a base (+1)**

CH_2O $C_2H_4O_2$



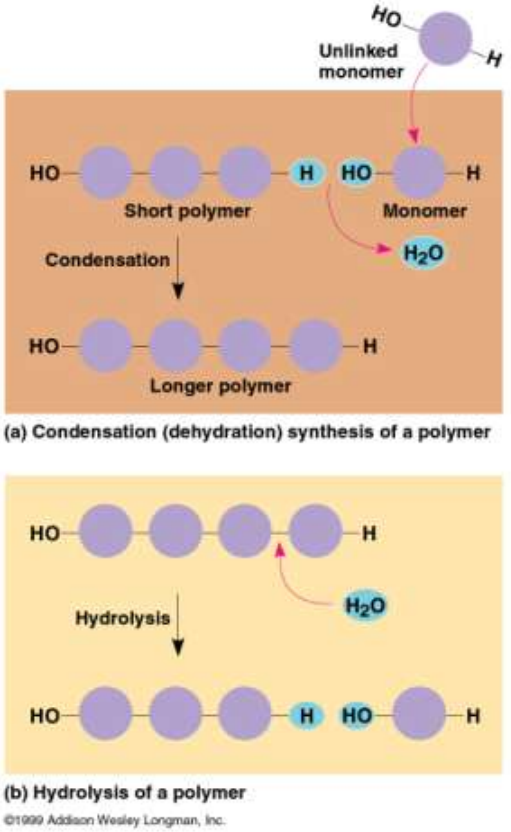


Polymers

- Covalent monomers
- Condensation reaction (dehydration reaction):

  One monomer provides a hydroxyl group while the other provides a hydrogen to form a water molecule
- Hydrolysis:

  bonds between monomers are broken by adding water (digestion)



(a) Condensation (dehydration) synthesis of a polymer

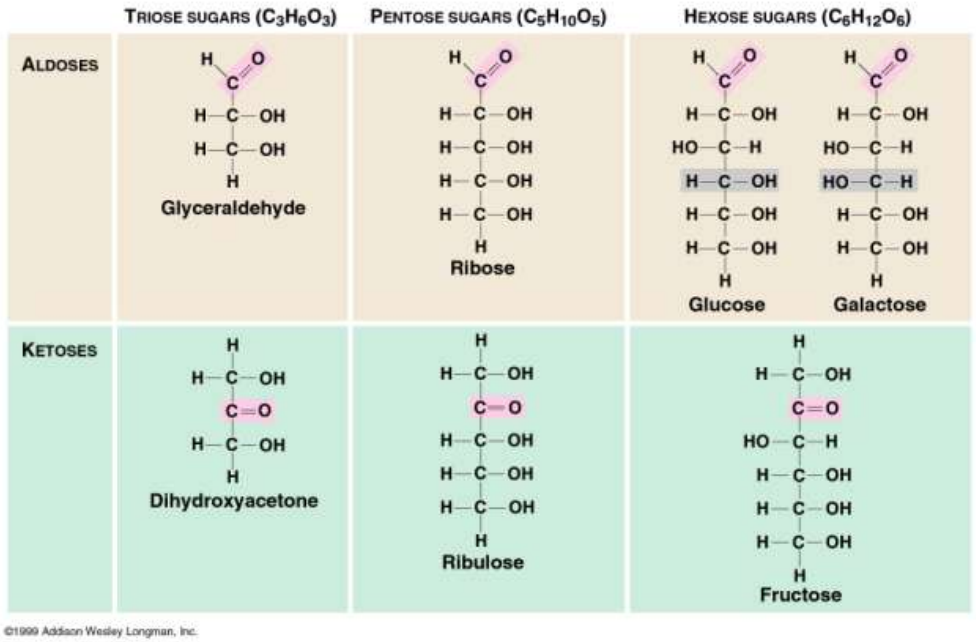
(b) Hydrolysis of a polymer

- Carbon free sugar – really?

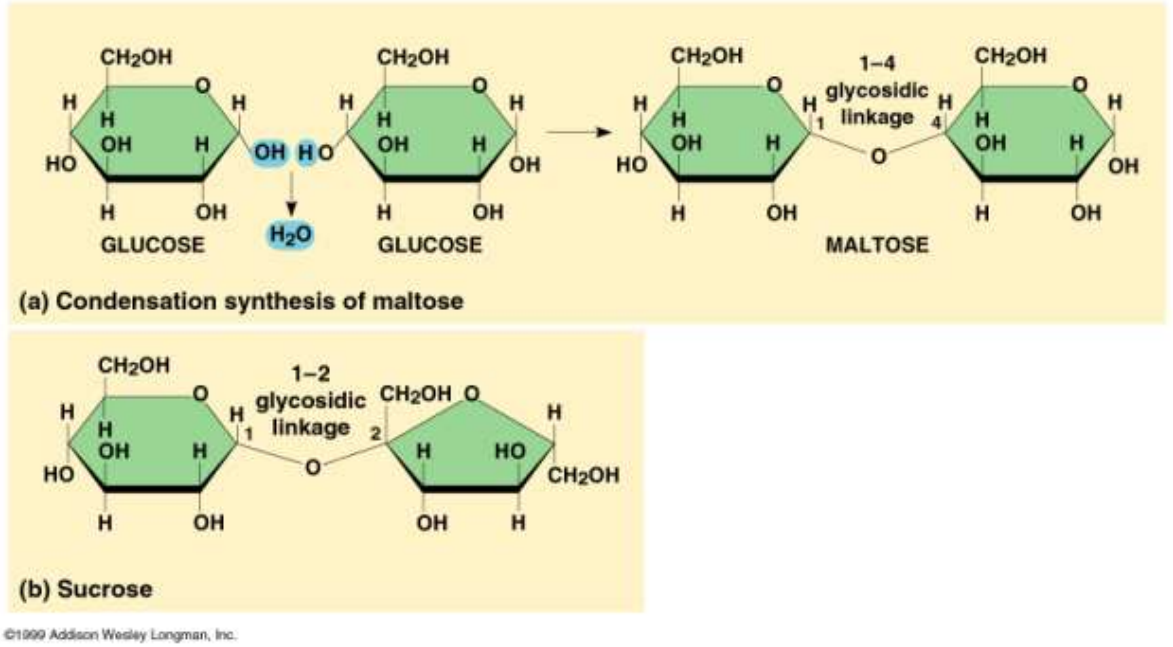
Carbohydrates, I

- <u>Monosaccharides</u>

  CH_2O formula;
  - multiple hydroxyl (-OH) groups and 1 carbonyl (C=O) group:
  - aldehyde (aldoses) sugar
    ketone sugar
  - cellular respiration;
    raw material for amino acids and fatty acids



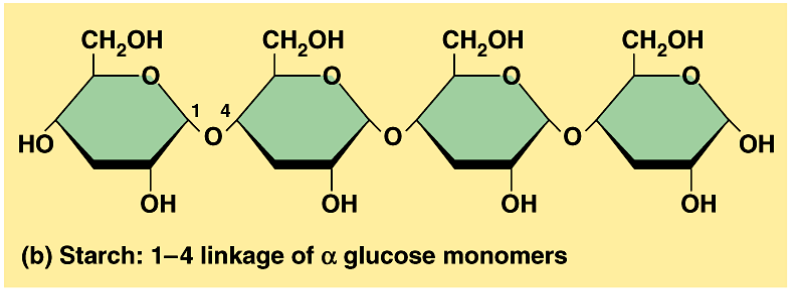
Carbohydrates, II



- Disaccharides — glycosidic linkage (covalent bond) between 2 monosaccharides;
  - covalent bond by dehydration reaction
- Sucrose (table sugar) — most common disaccharide

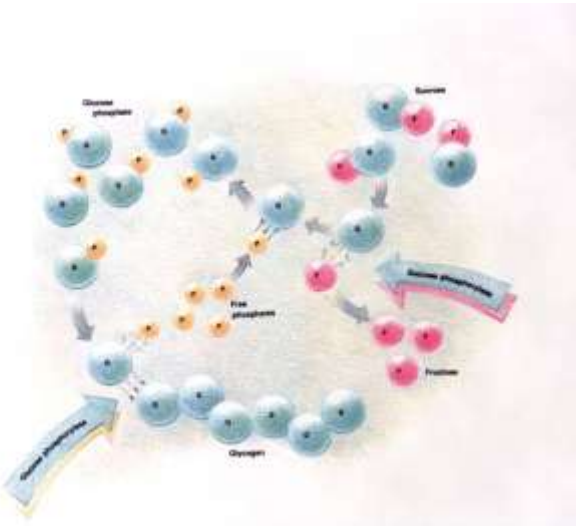
Carbohydrates, III

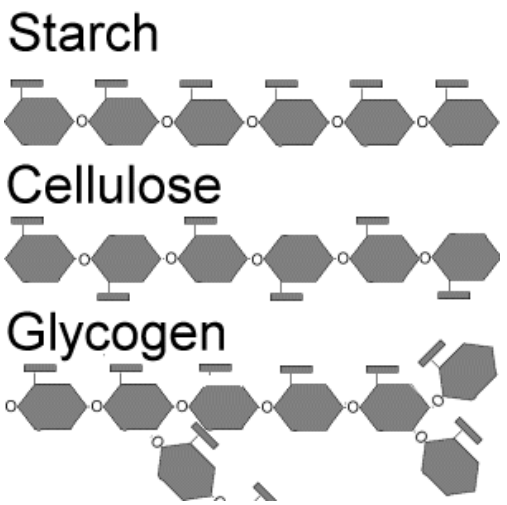
- <u>Polysaccharides</u> Storage:
  Starch~ glucose monomers
  Plants: plastids Animals: glycogen

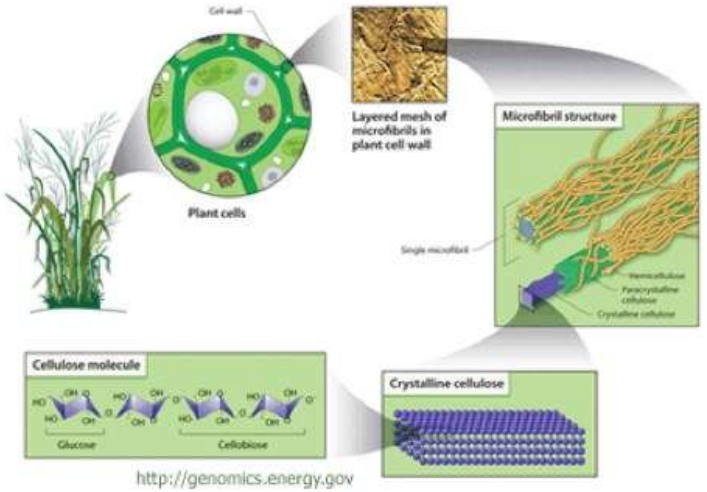


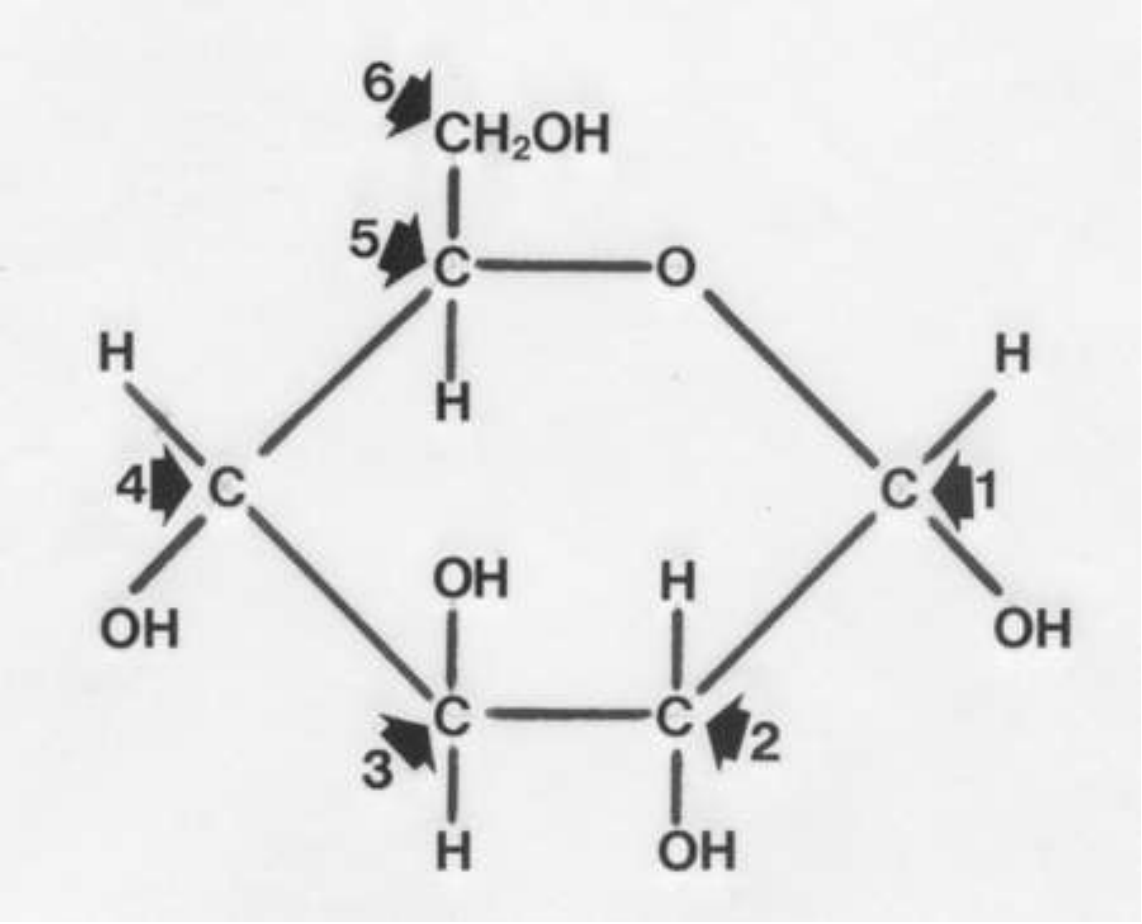
- <u>Polysaccharides</u> Structural:
  Cellulose~ most abundant organic compound;
  Chitin~ exoskeletons; cell walls of fungi; surgical thread

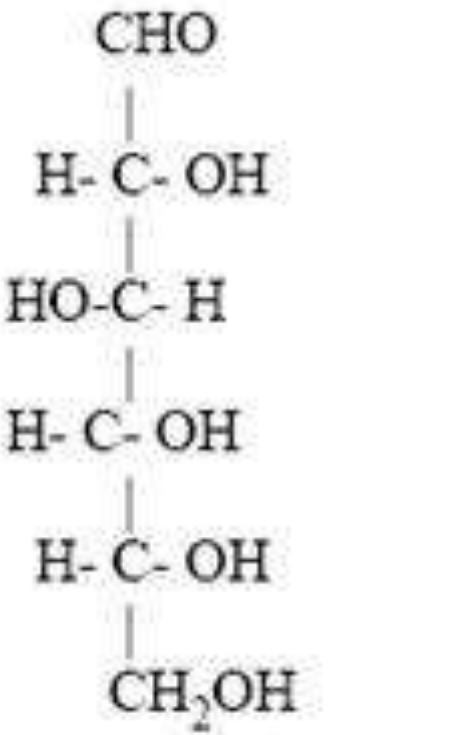
Polysaccharides



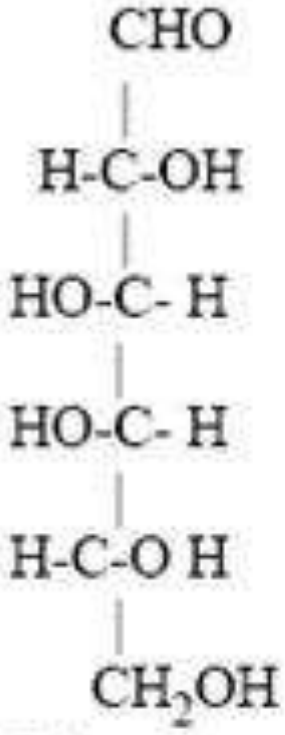




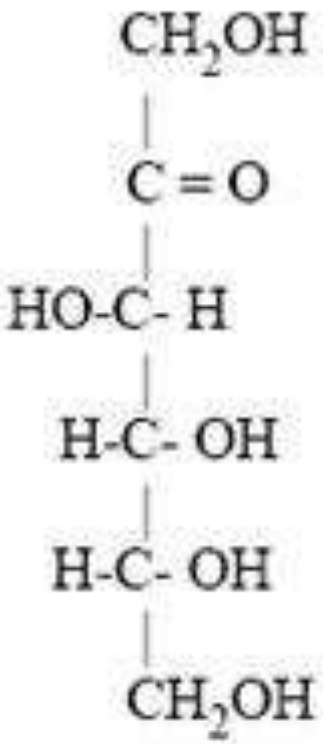

6
CH2OH
5
C
O
H
H
H
4
C
C
1
OH
OH
H
OH
C
C
3
2
H
OH



Glucose

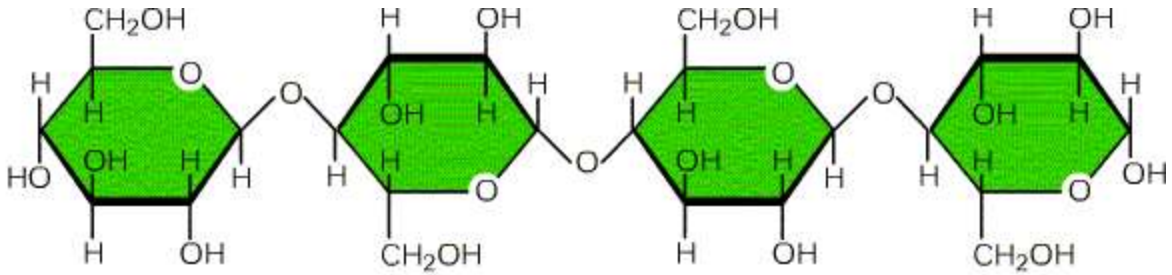


Galactose

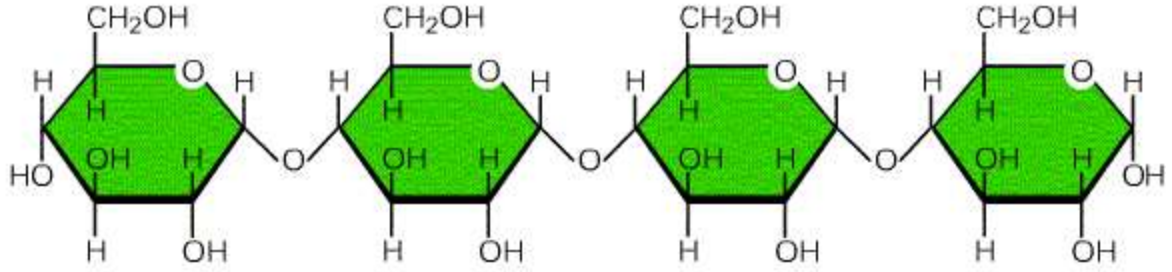


Fructose

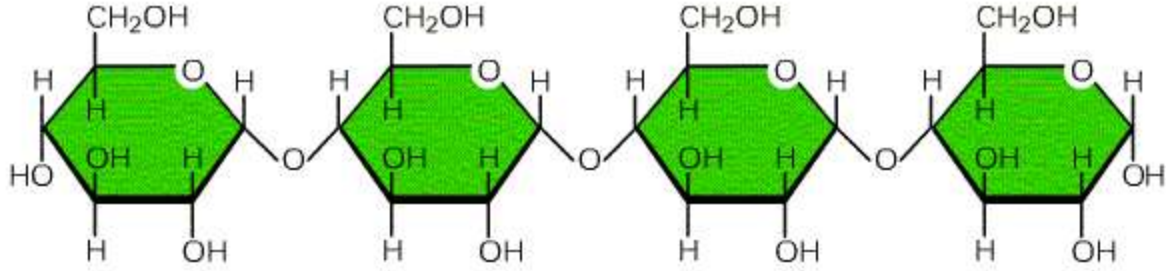
Cellulose



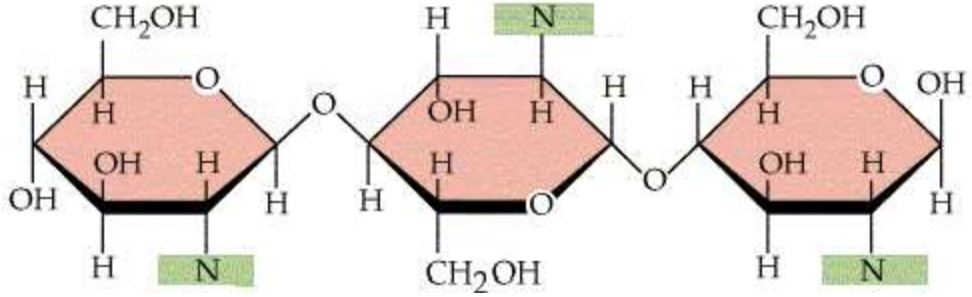
Starch



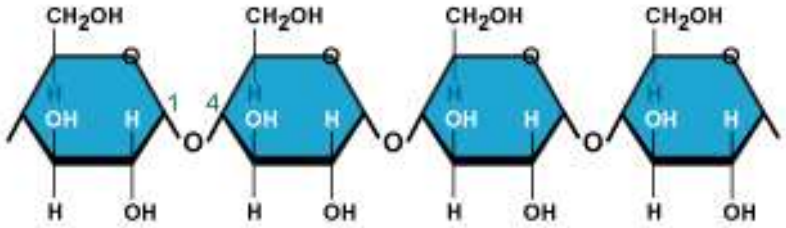
Glycogen



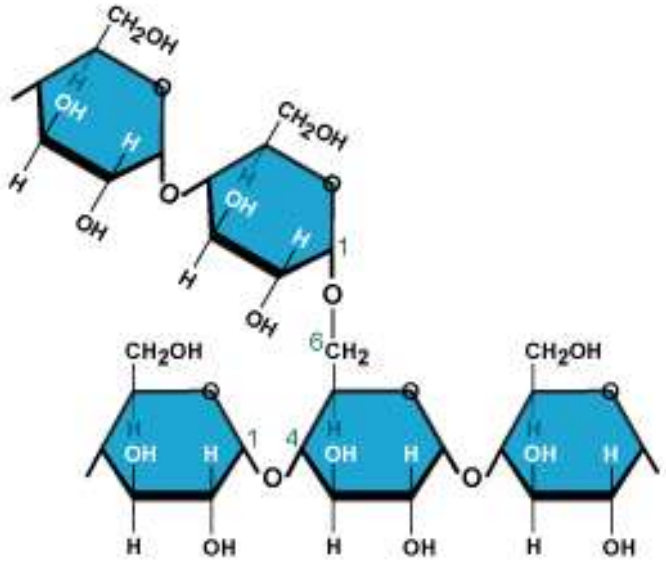
Chitin



α-glucose subunits

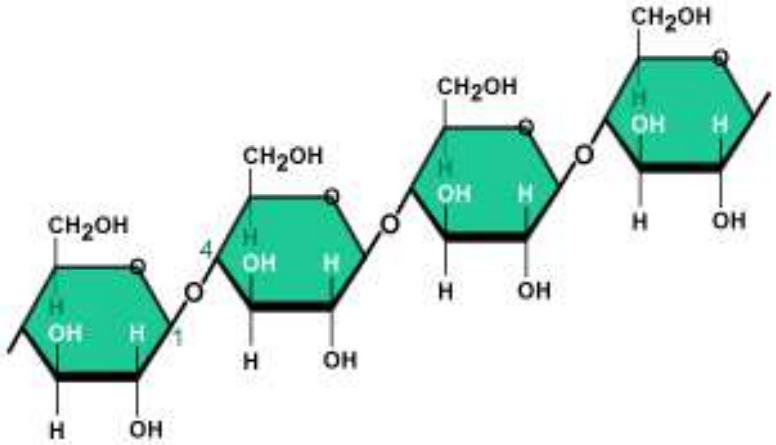


Starch: Chain of α-glucose subunits



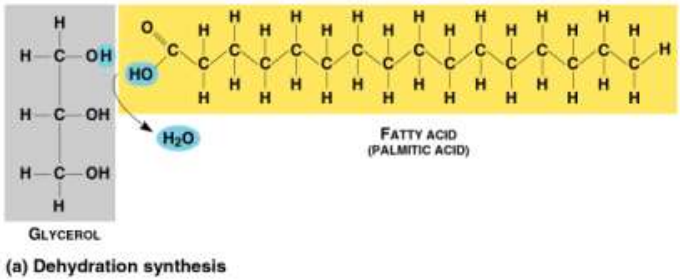
Glycogen: Branched chain of α-glucose subunits

β-glucose subunits



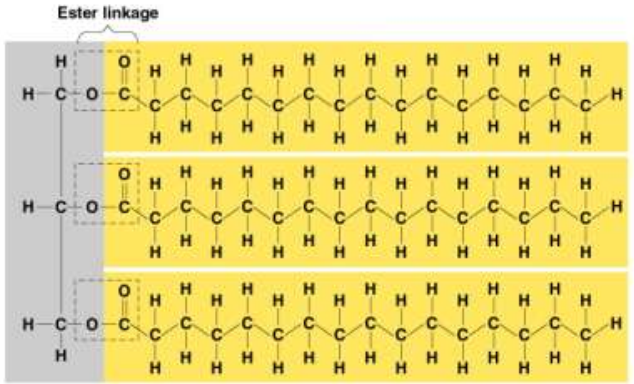
Cellulose: Chain of β-glucose subunits

Lipids



(a) Dehydration synthesis

- No polymers; glycerol and fatty acid
- Fats, phospholipids, steroids
- Hydrophobic; H bonds in water exclude fats
- Carboxyl group = fatty *acid*
- Non-polar C-H bonds in fatty acid 'tails'
- Ester linkage: 3 fatty acids to 1 glycerol (dehydration formation)
- Triacyglycerol (triglyceride)
- Saturated vs. unsaturated fats; single vs. double bonds

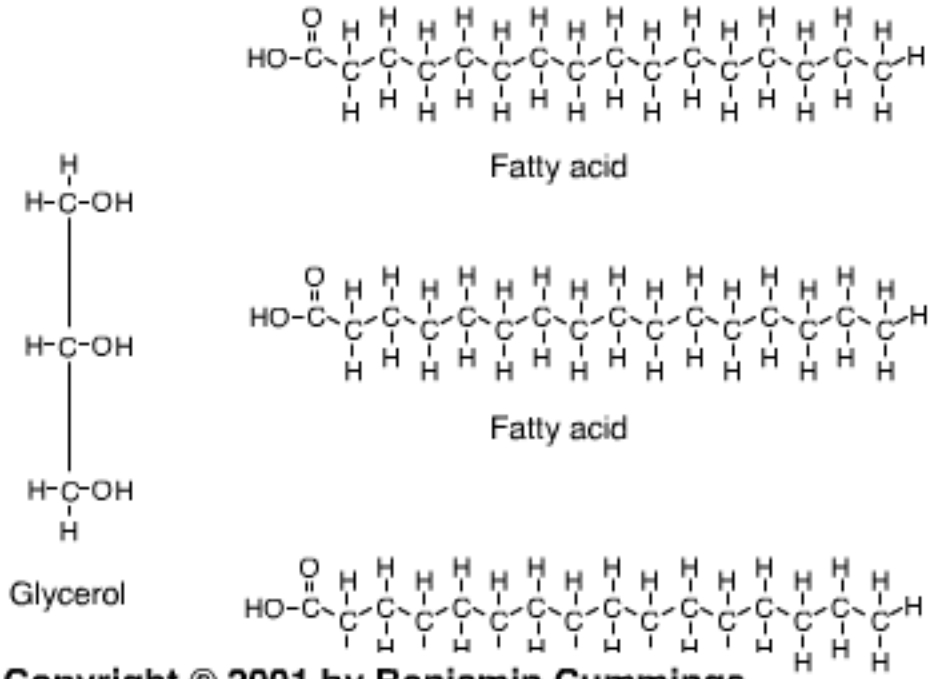


(b) Fat molecule

(a) Saturated fat and fatty acid

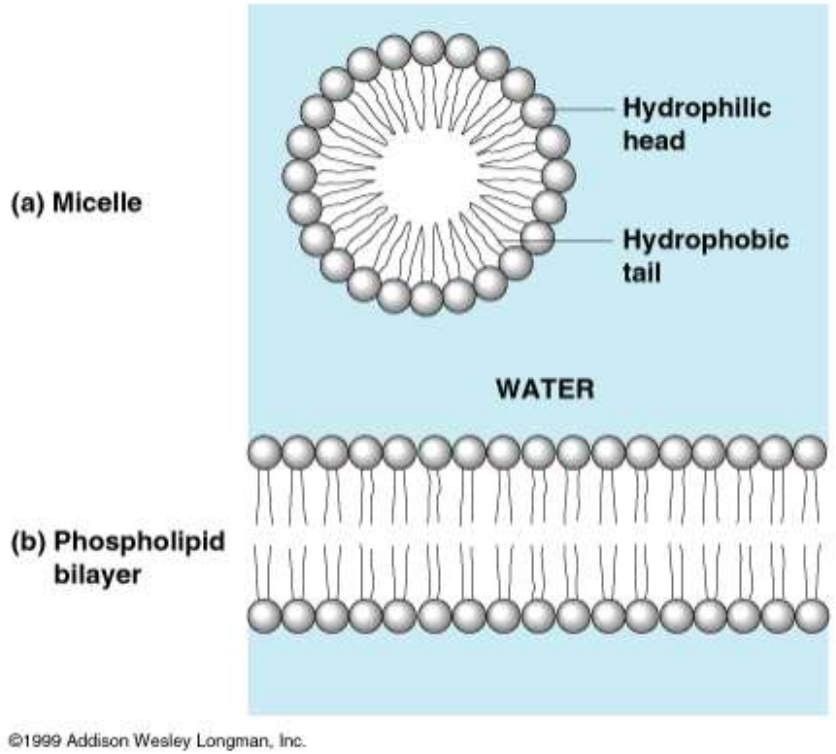
(b) Unsaturated fat and fatty acid

Lipids, II



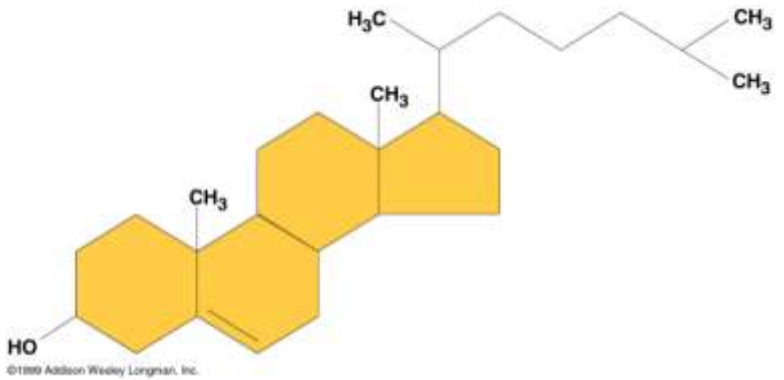
Phospholipids

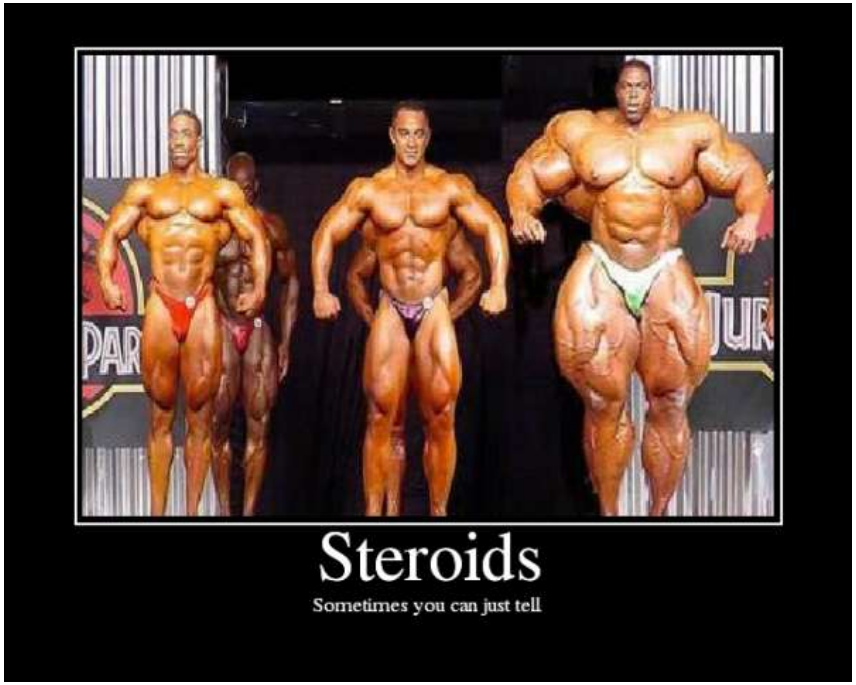
- 2 fatty acids instead of 3 (phosphate group)
- 'Tails' hydrophobic; 'heads' hydrophilic
- *Micelle* (phospholipid droplet in water)
- *Bilayer* (double layer); cell membranes



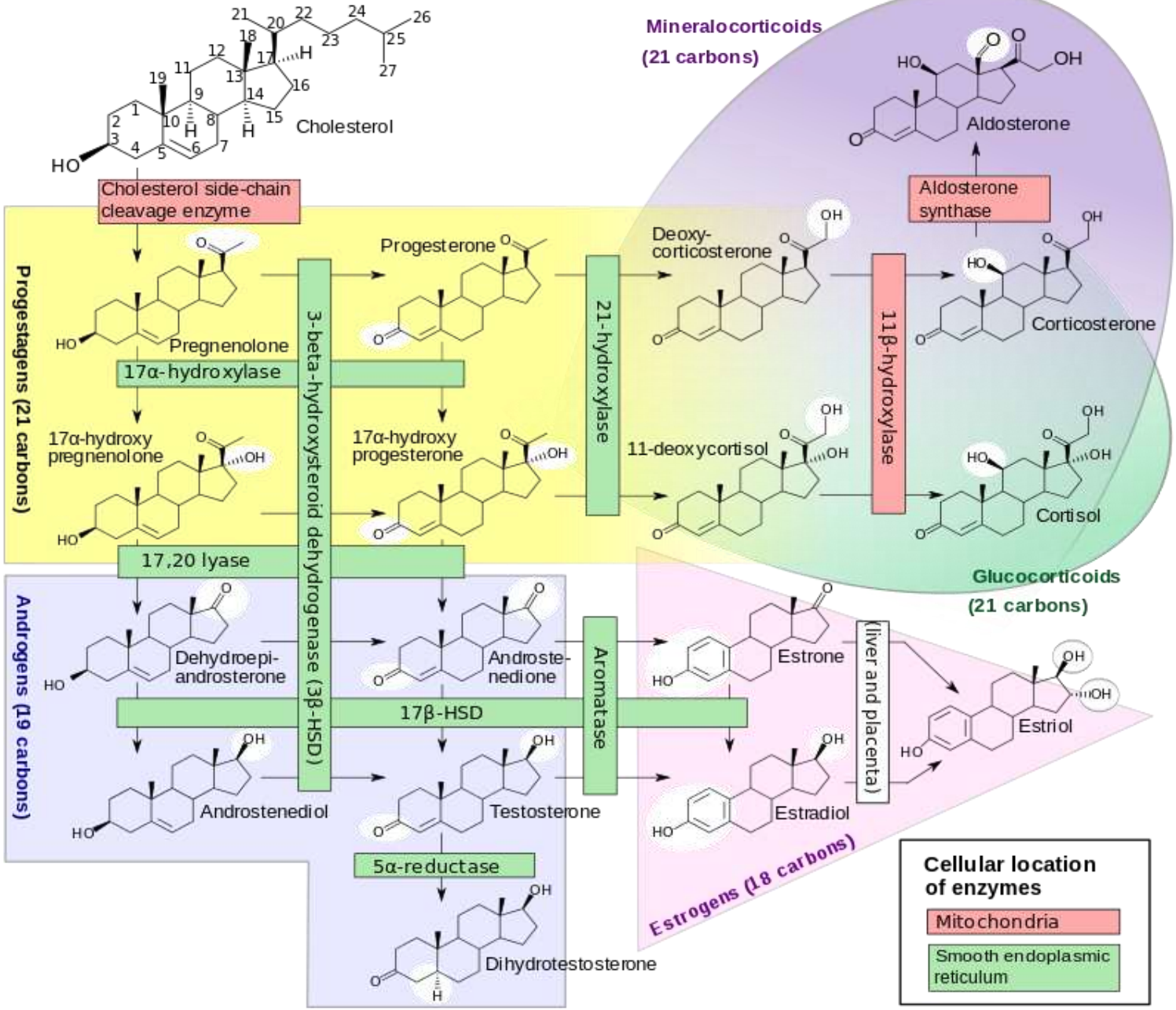
Steroids

- Lipids with 4 fused carbon rings
- Ex: cholesterol:
  cell membranes;
  precursor for other steroids
  - (sex hormones)



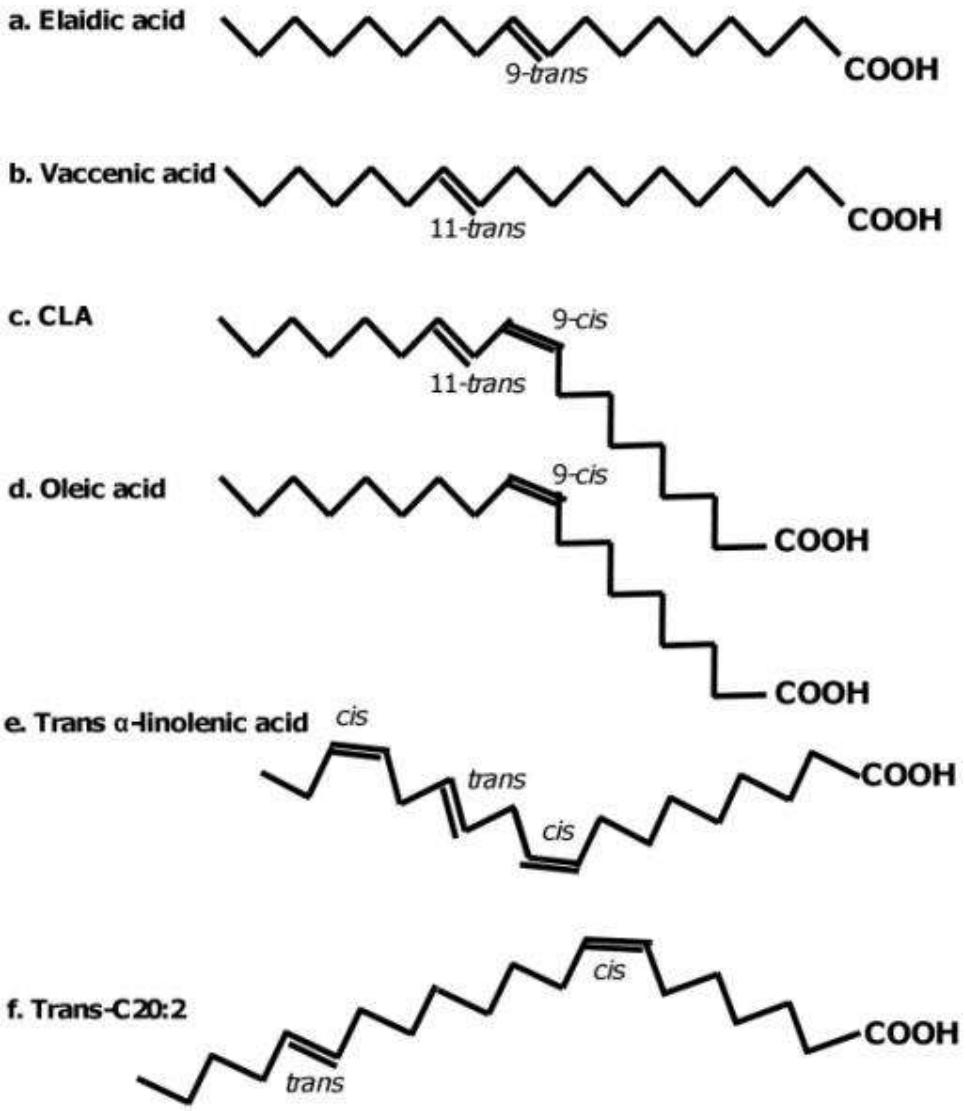


Steroidogenesis



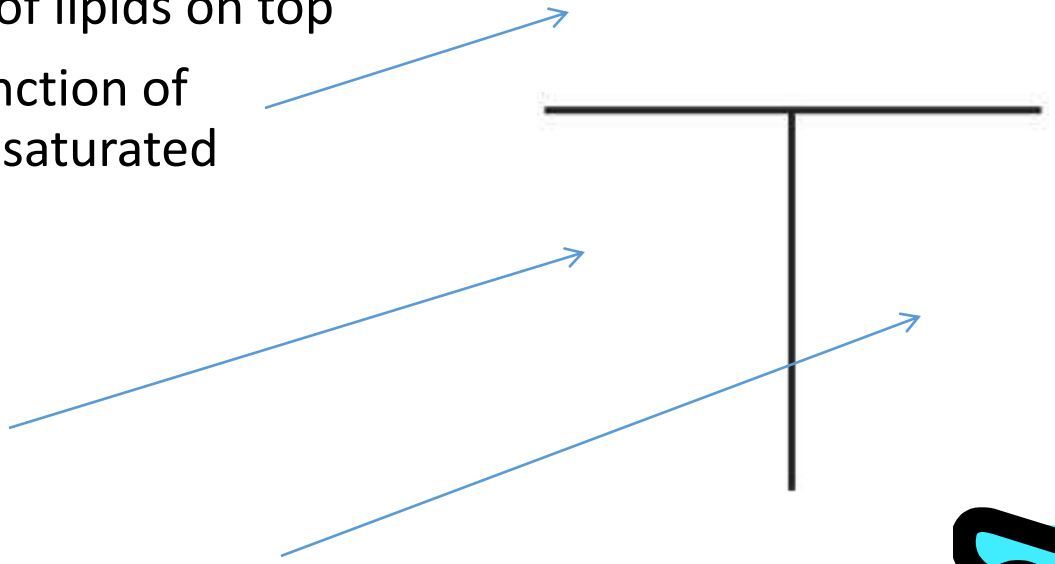
Trans fats

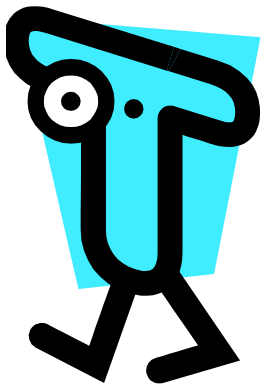
- Partially hydrogenated oils
- Margarine vs butter
- Asap science:
- http://www.youtube.com/watch?v=KG_ybdk1VaE



Saturated vs Unsaturated Lipids t-chart

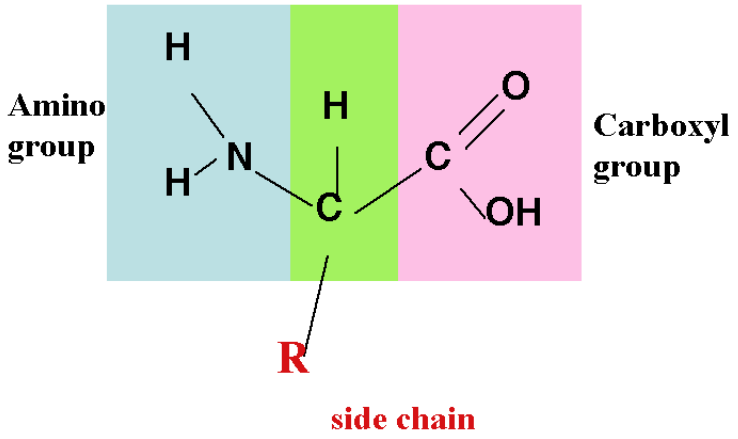
- Basic properties of lipids on top
- Structure and function of saturated and unsaturated lipids
-





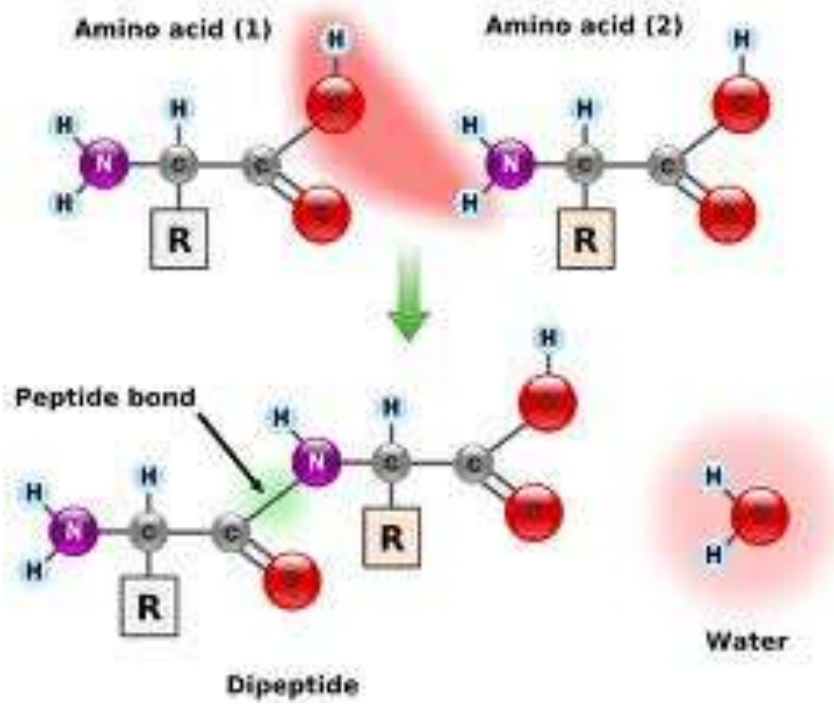
Proteins

- Importance:
  - basic structural component of nearly everything organisms
  - 50% dry weight of cells; most structurally sophisticated molecules known
- Monomer: amino acids
  - (there are 20)
  - carboxyl (-COOH) group
  - amino group (NH2),
  - H atom,
  - variable group (R)….



- Variable group characteristics: polar (hydrophilic), nonpolar (hydrophobic), acid or base
- Three-dimensional shape (conformation)
- Polypeptides (dehydration reaction):
  peptide bonds~ covalent bond; carboxyl group to amino group (polar)

Peptide Bond



- Dehydration synthesis reaction that bonds to amino acids together to form a dipeptide
- Repeated again and again it will yield a polypeptide which is a protein

Primary Structure

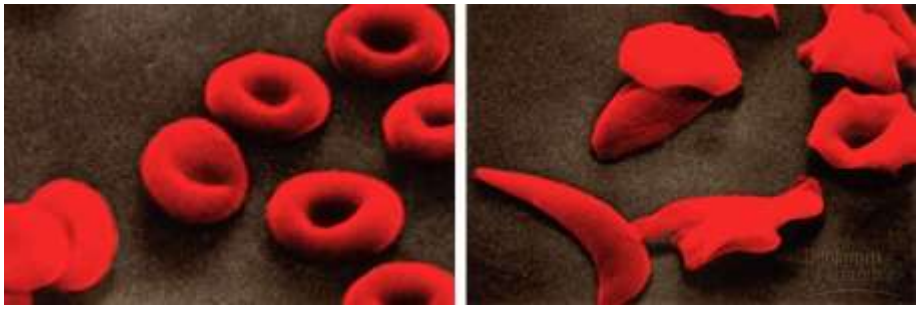
- Conformation:

  Linear structure

- Molecular Biology: each type of protein has a unique primary structure of amino acids

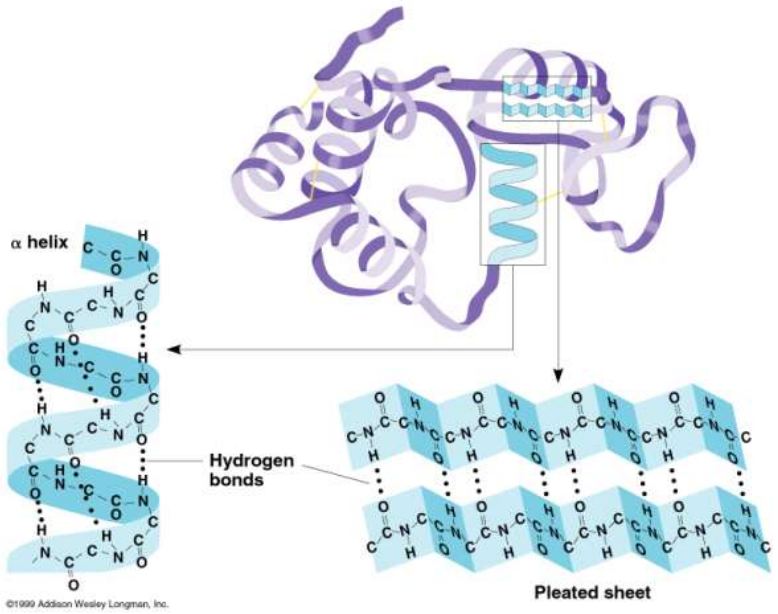
- Amino acid substitution:

  hemoglobin; sickle-cell anemia



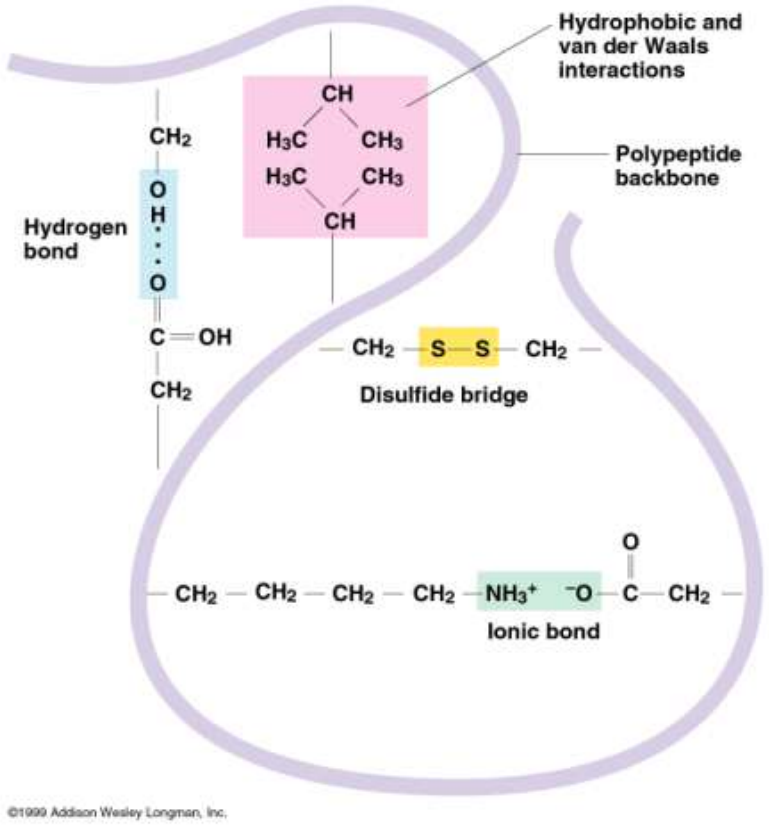
Secondary Structure

- Conformation: coils & folds (hydrogen bonds)
- Alpha Helix: coiling
  - –*keratin*
- Pleated Sheet:parallel
  - –*silk*



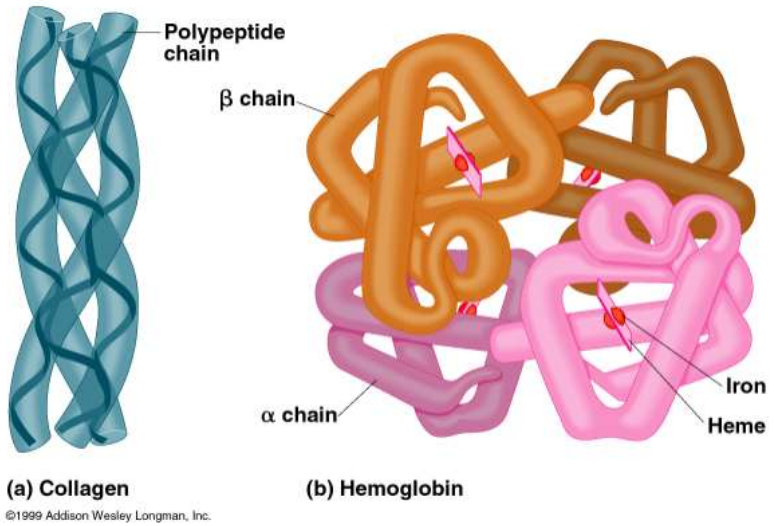
Tertiary Structure

- Conformation: irregular contortions from R group bonding
  - Hydrophobic
  - disulfide bridges
  - hydrogen bonds
  - ionic bonds



Quaternary Structure

- Conformation:
  2 or more polypeptide chains aggregated into 1 macromolecule
  - collagen (connective tissue)
  - hemoglobin



- Both

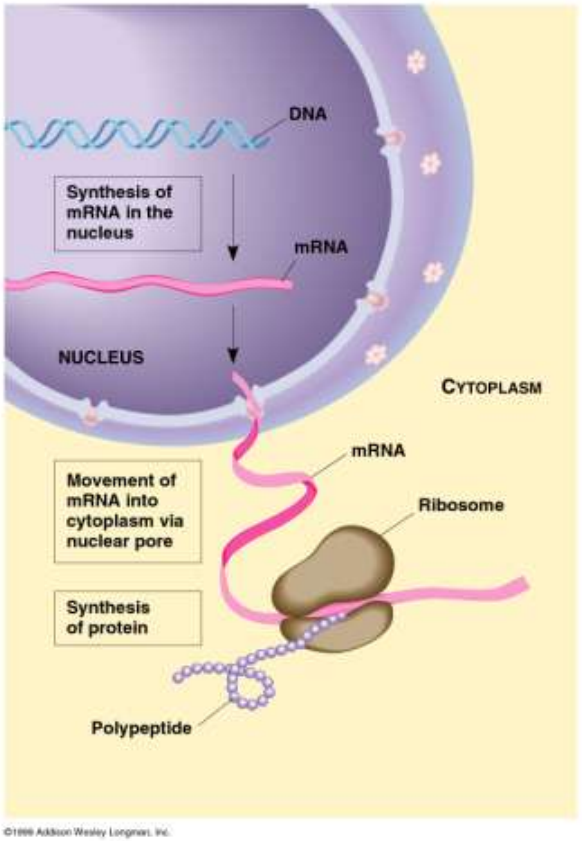
- DNA

- RNA

Nucleic Acids, I

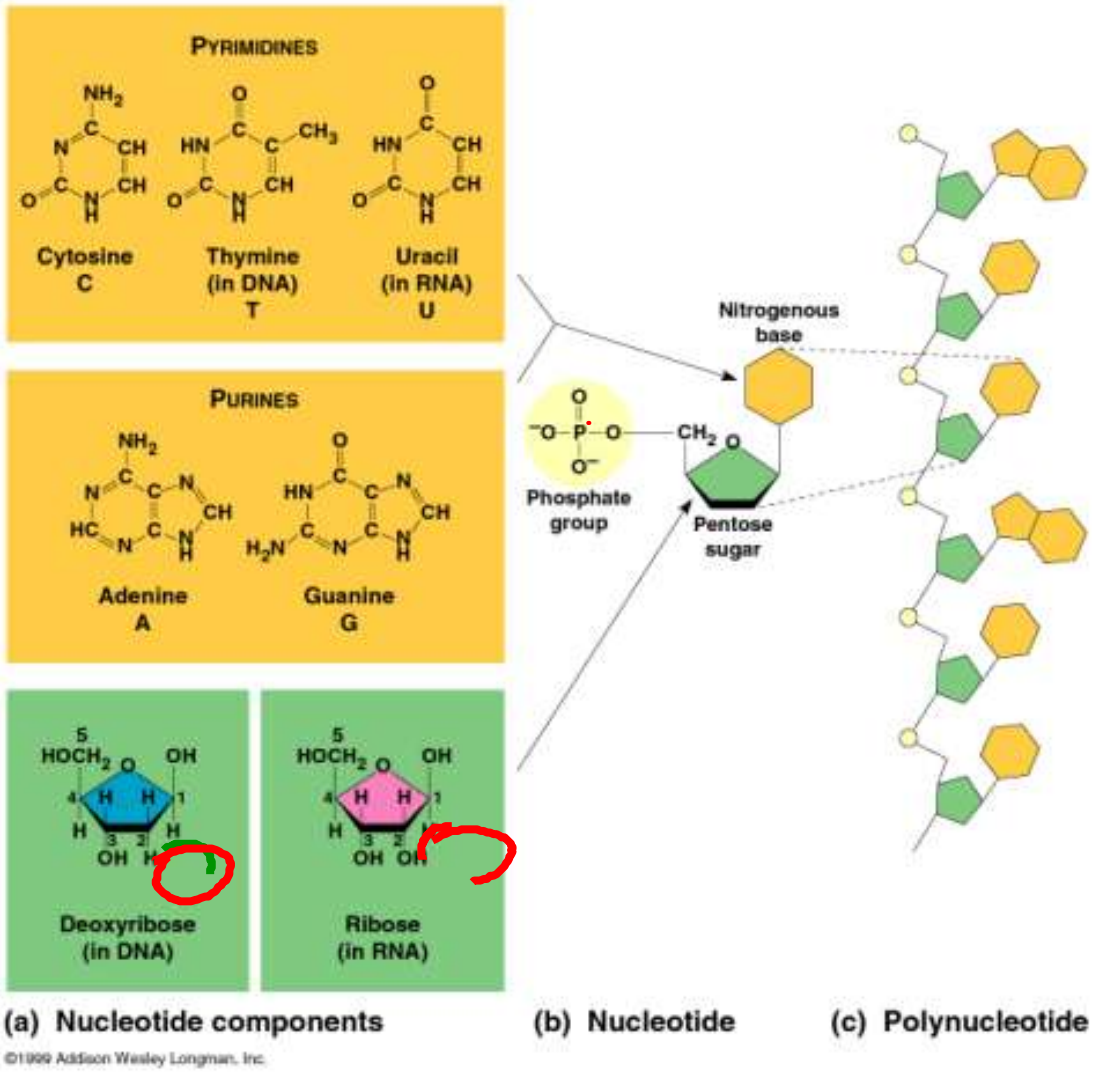
- Deoxyribonucleic acid (DNA)
- Ribonucleic acid (RNA)
- DNA->RNA->protein
- Polymers of nucleotides (polynucleotide):
  - nitrogenous base
  - pentose sugar
  - phosphate group
- Nitrogenous bases:

  pyrimidines~cytosine, thymine, uracil purines~adenine, guanine



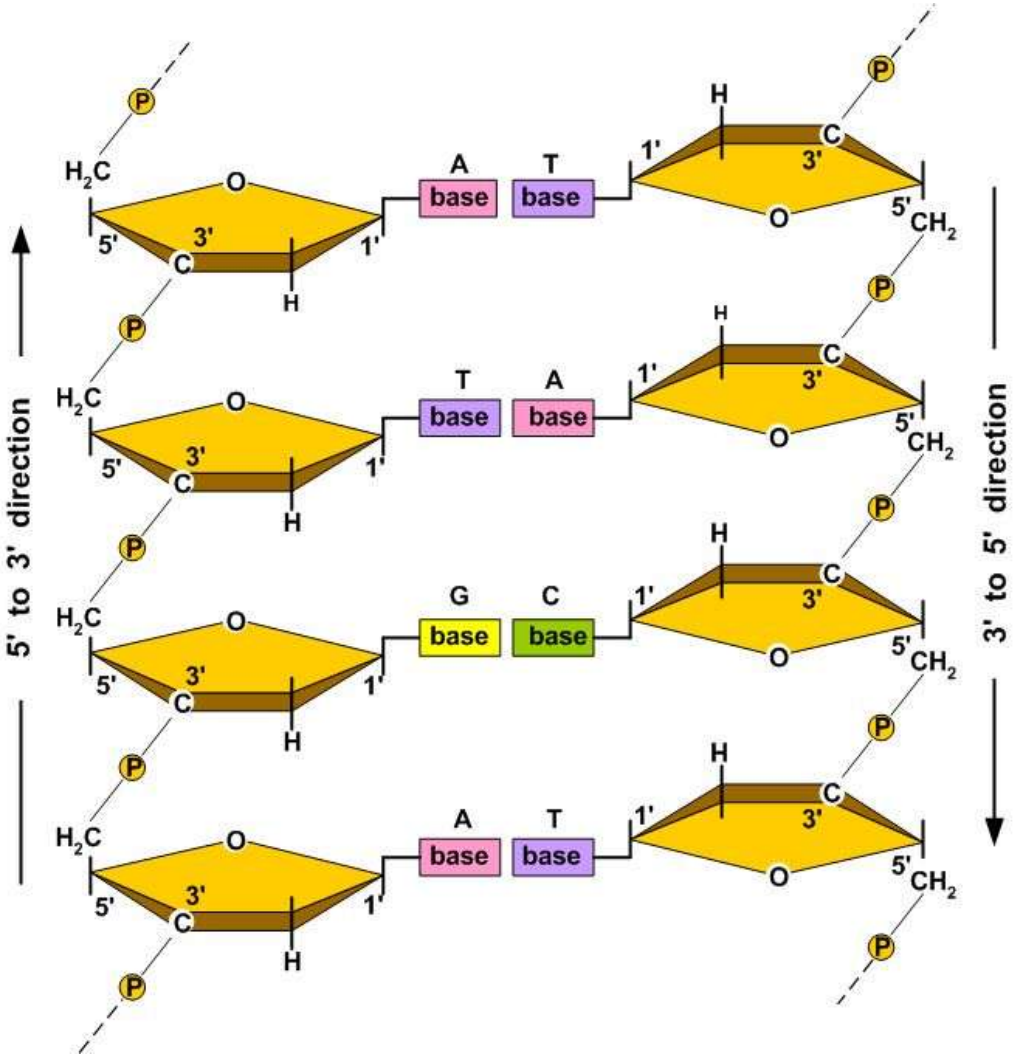
Nucleic Acids, II

- Pentoses:
  - ribose (RNA)
  - deoxyribose (DNA)
  - nucleoside (base + sugar)
- Polynucleotide:
  - phosphodiester linkages (covalent); phosphate + sugar



Directionality

- 5′ and 3′ carbons on the sugar of DNA gives it directionality
- Processes happen in specific directions.



Nucleic Acids, III

- Inheritance based on DNA replication
- Double helix (Watson & Crick - 1953)
- H bonds~ between paired bases
  van der Waals~ between stacked bases
- A to T; C to G pairing
- Complementary