

Chapter 3

Molecular Components of Cells



Molecular Components of Cells

- Chemical composition
 - C, H, N, O and small amount of other elements
- Molecular building blocks
 - Lipids
 - Carbohydrates
 - Proteins
 - Nucleic acid
 - DNA (deoxyribonucleic acid)
 - RNA (ribonucleic acid)

Atoms, Ions, and Molecules

■ Atoms

- Smallest piece of an recognizable element
- Nucleus (proton + neutron) + electron
- Same number of protons and electrons : no charge
- Biologically important atoms: C, H, O, N, S, P, Na, K, Ca, Cl

■ Ions

- Electrically charged atoms
- Biological importance: electrical impulse, ion balance
 - Ca^{2+} , Na^{+} , K^{+} , Cl^{-}

■ Molecules

- Generated from chemical bonding of atoms

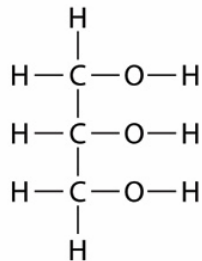
Subunits of Biological Molecules

| Class of Molecules | Examples | Repeating Unit |
|--------------------|---------------------------|----------------------|
| Lipid | Fats, oils | Glycerol, fatty acid |
| Carbohydrate | Sugars, starch, cellulose | Simple sugars |
| Nucleic acid | DNA, RNA | Nucleotide |
| Proteins | Enzymes | Amino acids |

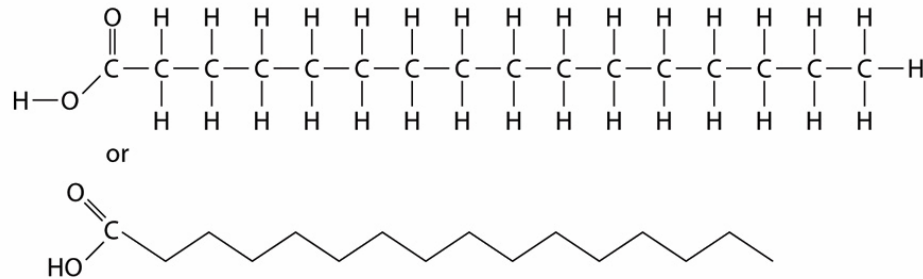
Lipids

- Hydrophobic fats, oils, and cholesterol etc.
- High energy C-H, C-C bonds → good energy storage
- Fats : glycerol + fatty acids

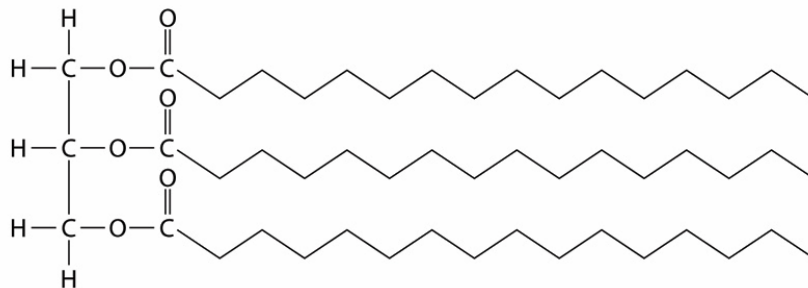
A. Glycerol



B. Fatty acid (palmitic acid)



C. A fat



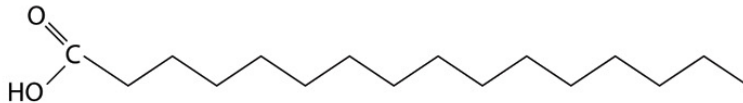
Triglyceride

Lipids

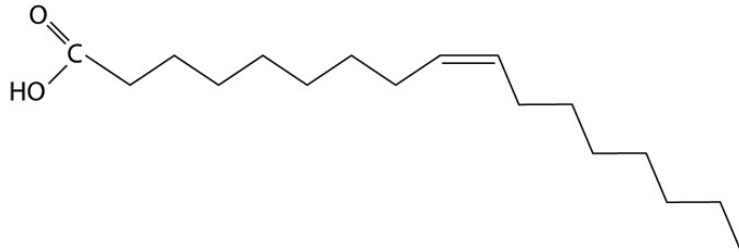
■ Fatty acid

- Saturated: tight packing → solid at room temperature
- Unsaturated: more than one cis-double bond → liquid

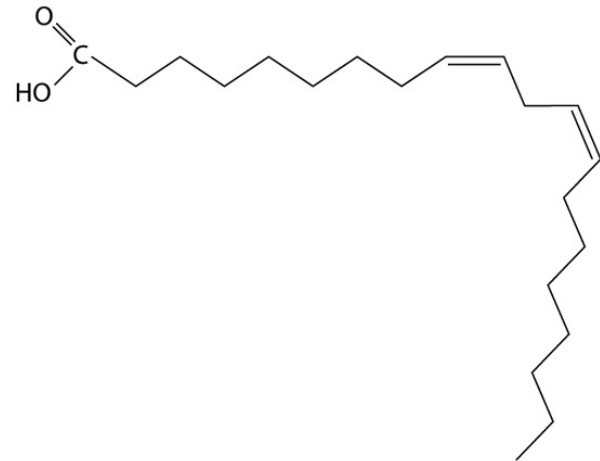
A. A saturated fatty acid



B. A monounsaturated fatty acid



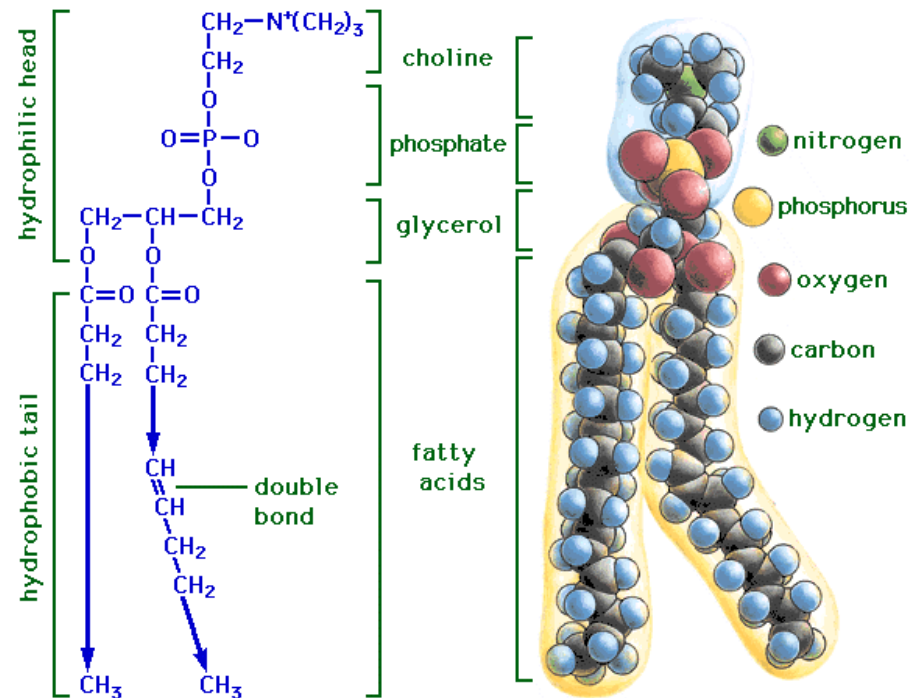
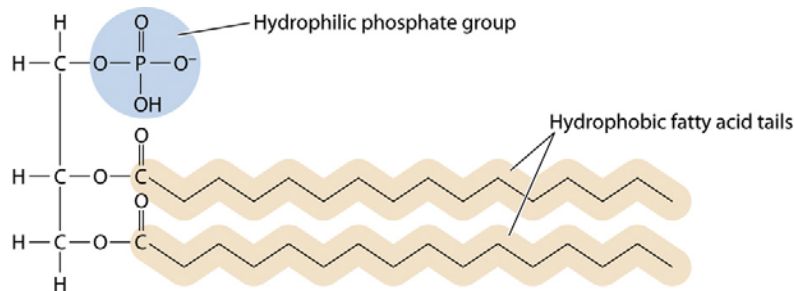
C. A polyunsaturated fatty acid



Lipids

■ Phospholipid

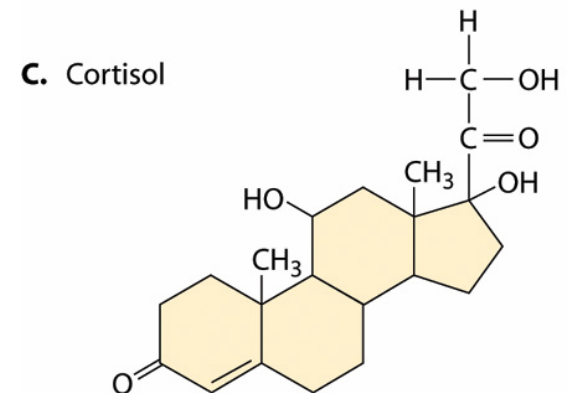
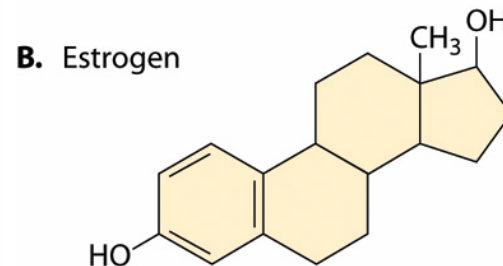
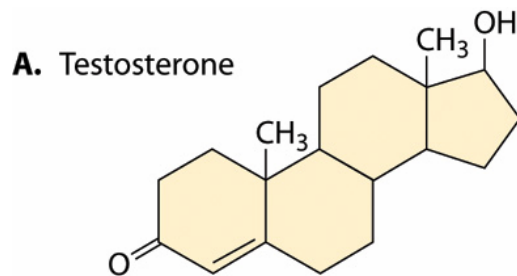
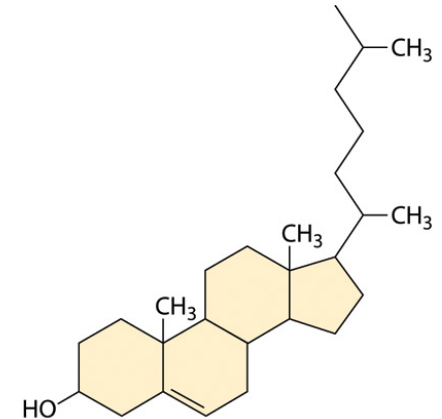
- Major component of cellular membrane
- Glycerol backbone
- two fatty acids (hydrophobic)+ phosphate (hydrophilic)
- Additional small polar molecules bound to phosphate group



Lipids

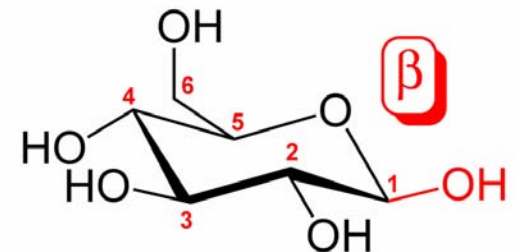
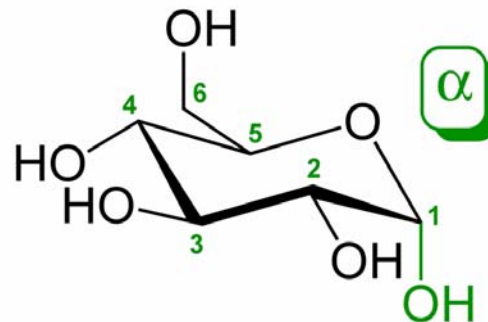
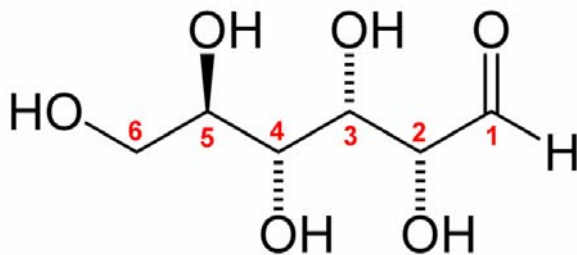
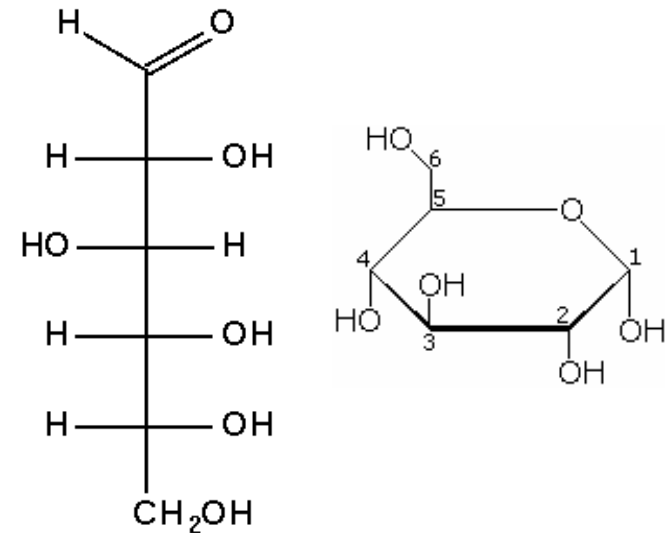
■ Sterols

- Cyclic hydrocarbon compounds
- Cholesterol
 - Component of animal cell membranes
 - decrease membrane fluidity
 - Starting material for steroid hormones and bile synthesis



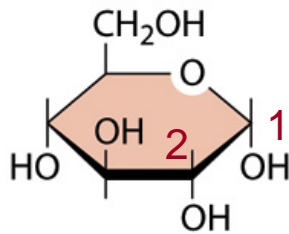
Carbohydrates

- $C:H:O = 1:2:1$
- Simple sugars (monosaccharide)
 - Glucose, fructose, galactose
- Disaccharide
 - Simple sugars linked by glycosidic bond
 - Sucrose (glucose- α -1,2-fructose)
 - Lactose (galactose- β -1,4-glucose)
 - Maltose (glucose- α -1,4-glucose)

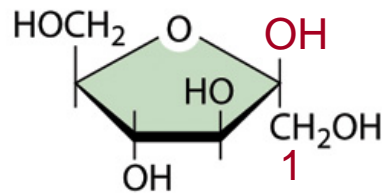


Carbohydrates

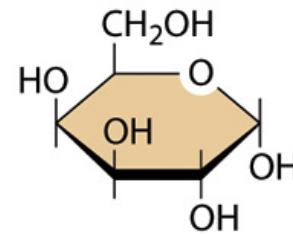
A. Simple sugars



Glucose

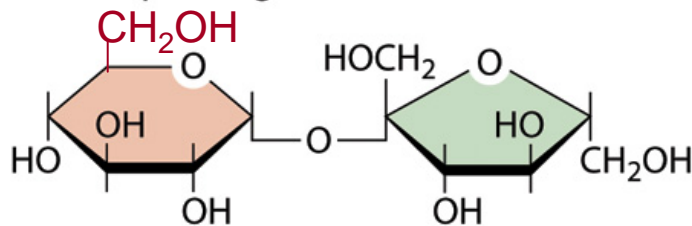


Fructose



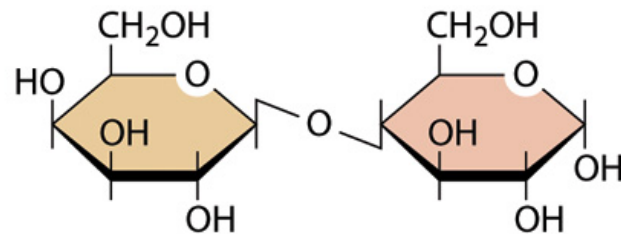
Galactose

B. Complex sugars



Sucrose (table sugar)
Glucose + fructose

Glc- α -1,2-Fru



Lactose (milk sugar)
Galactose + glucose

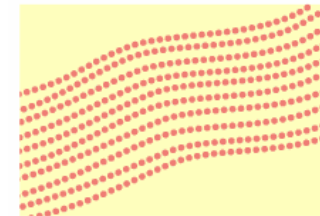
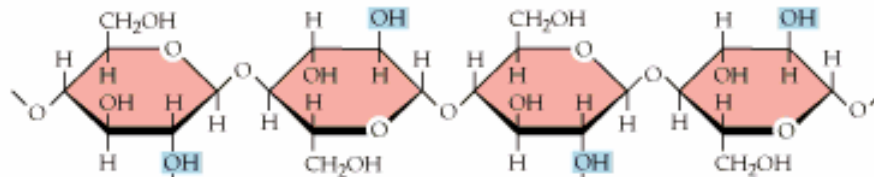
Gal- β -1,4-Glc

Carbohydrates

■ Polysaccharide

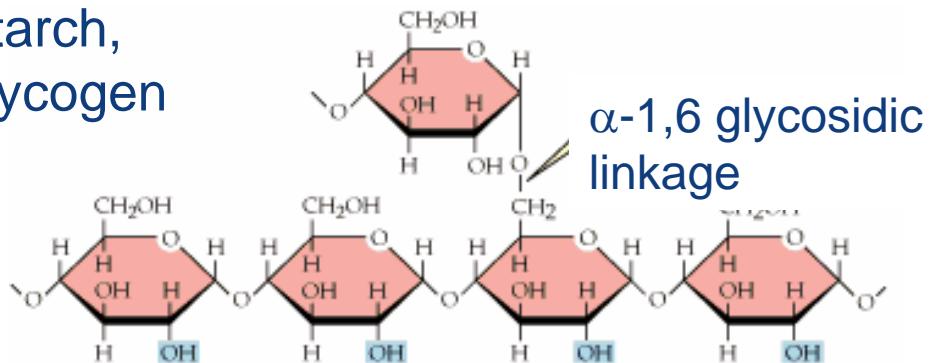
- Starch, Glycogen, cellulose from glucose
- Agar, carrageenan (thickener)

Cellulose



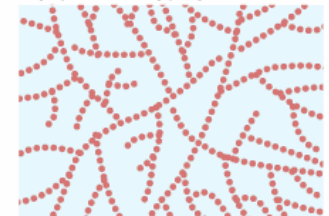
β -1,4 glycosidic linkage

Starch, glycogen



Starch

Glycogen



α -1,4 glycosidic linkage

Roles of Carbohydrates I

■ Carbohydrates in energy metabolism

■ Plant

- Glucose synthesis by photosynthesis



- Starch for energy storage
- cellulose for structural compound

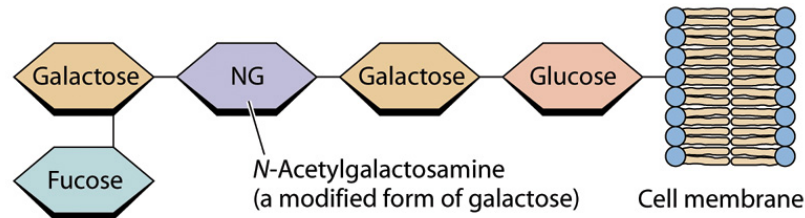
■ Animals

- Intake glucose from food
- Glycogen for energy storage

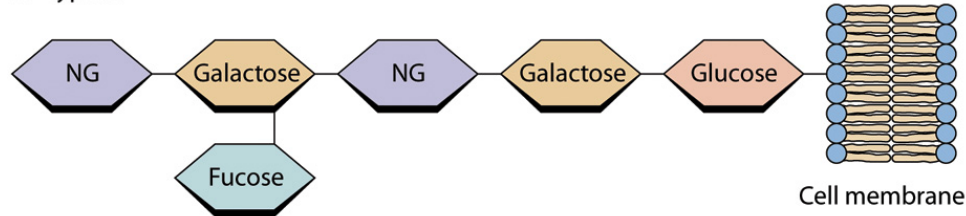
Roles of Carbohydrates II

- Carbohydrates in molecular recognition
 - Cellular recognition, cell signaling, cell adhesion
 - e.g. blood typing : sugar chains in the membrane of RBC

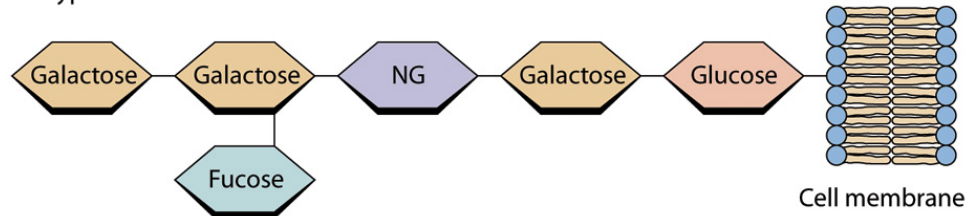
A. Type O



B. Type A



C. Type B



Proteins

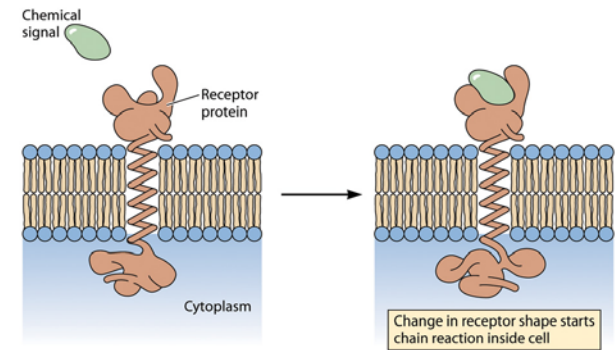
■ Roles of proteins

■ Most of the cellular functions

- Enzymes : chemical reactions
- Receptors : signal transduction
- Antibody : recognition of foreign molecules and trigger immune responses
- Transporters : e.g. hemoglobin for oxygen
- Structural proteins : keratin (hair and nails), actin and myosin (muscle)

■ Diversity of organism

- Diversity of organization of proteins within an organism



Proteins

- **Amino acids**

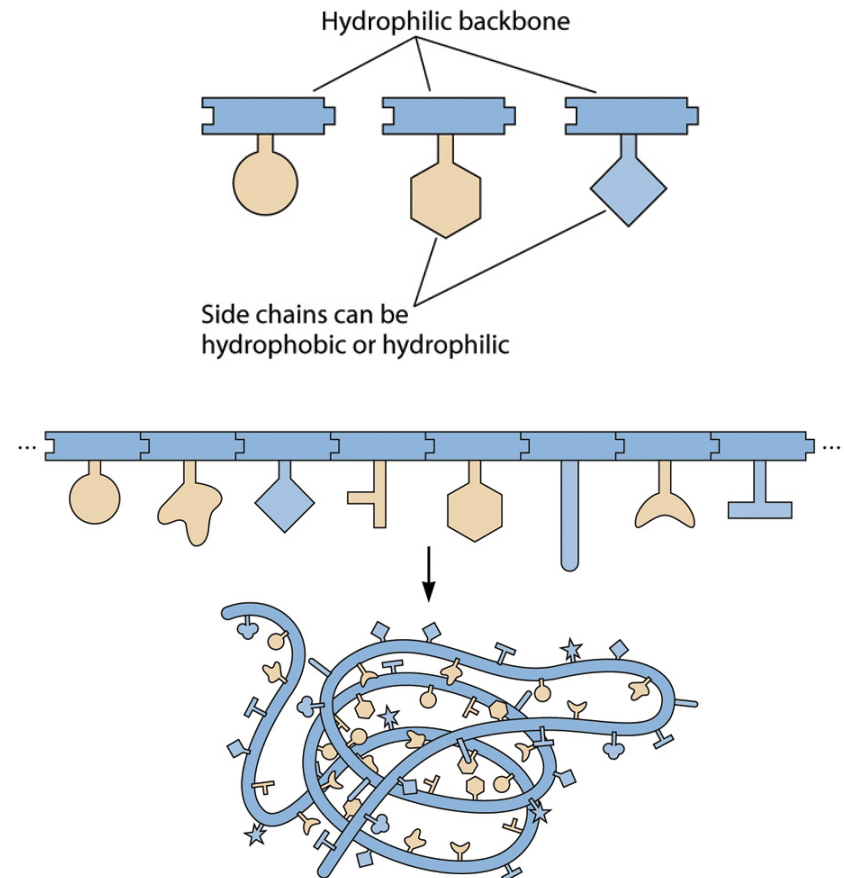
- Building blocks of proteins
- Hydrophilic backbone + 20 side chains

- **Polypeptide**

- Amino acid chains linked by peptide bond

- **Tree-dimensional structure**

- Determines protein function
- Determined by amino acid sequence



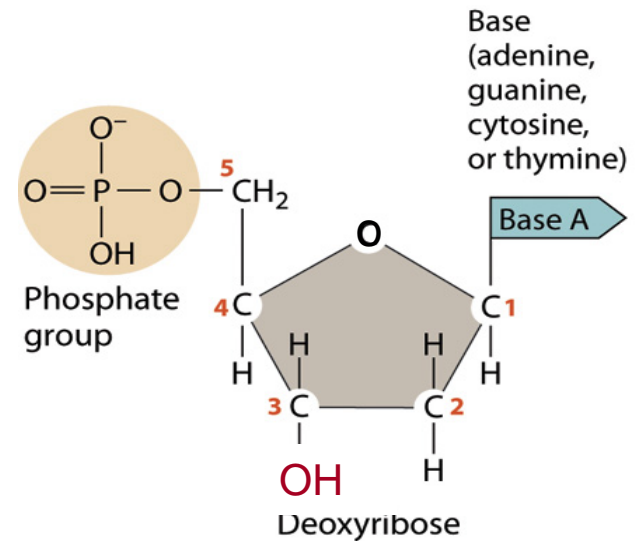
Nucleic acids

■ Nucleotides

- Building blocks of nucleic acids
- (deoxy)ribose + phosphate group + 4 bases
- Bases: adenine (A), guanine (G), cytosine (C), thymine (T)

■ Terminology

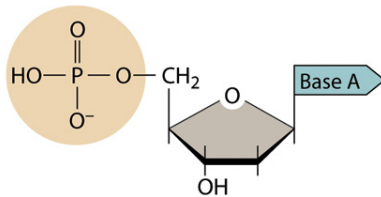
- Base
- Nucleoside : sugar + base
- Nucleotide : sugar + base + phosphate



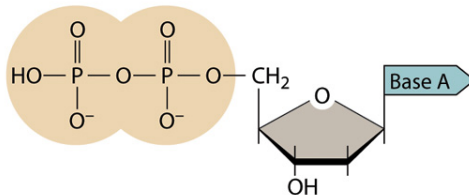
Nucleotide Chains

- Linkage of 5' carbon to 3' carbon through phosphodiester bond

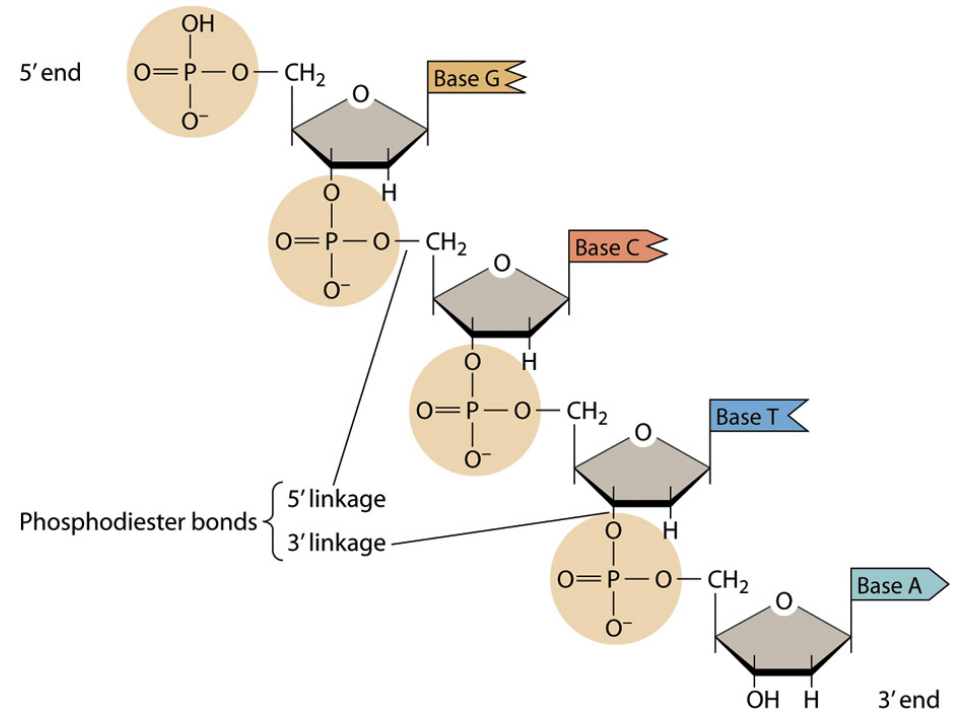
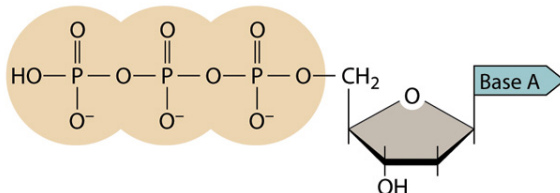
A. Adenosine monophosphate (AMP)



B. Adenosine diphosphate (ADP)



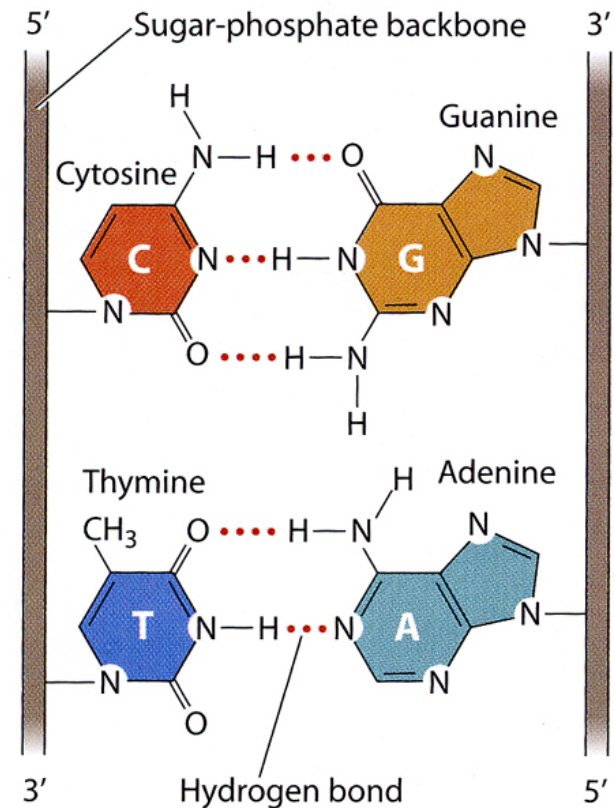
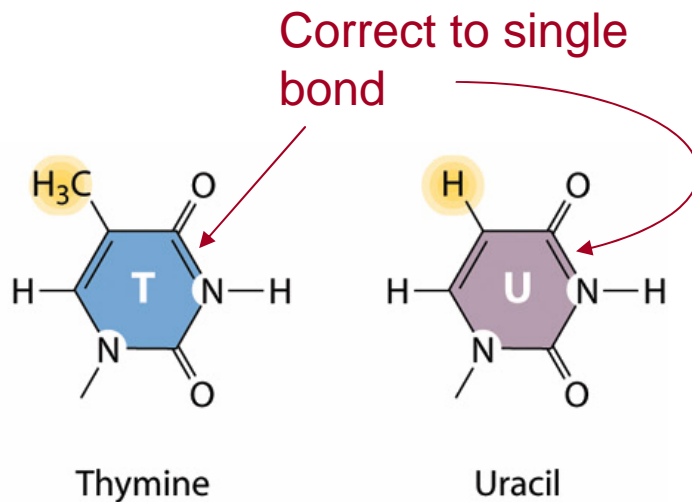
C. Adenosine triphosphate (ATP)



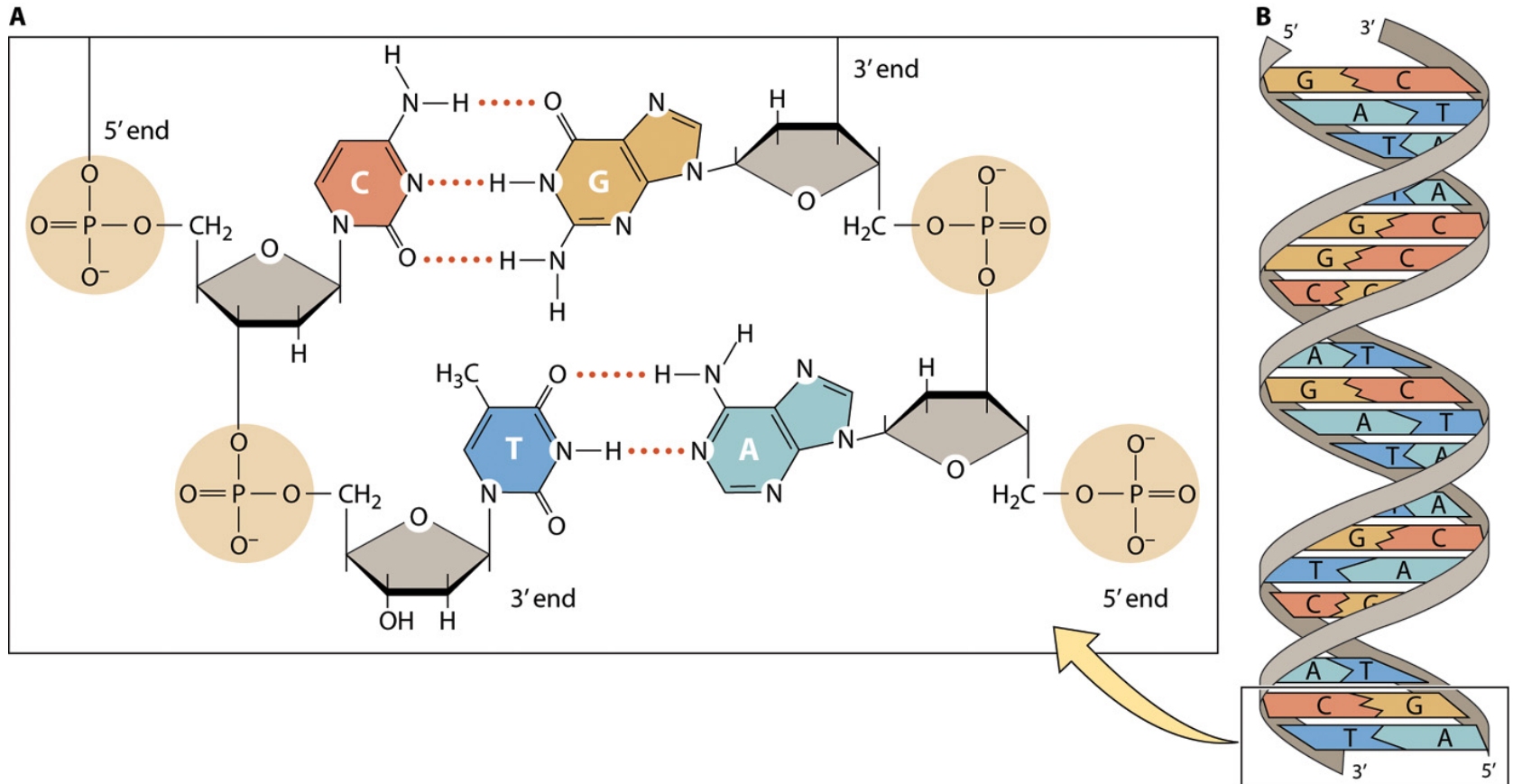
Nucleotide Chains

■ Base pairing

- C≡G, T=A : hydrogen bonding
- Complementary base pairs
- Antiparallel strand in DNA molecule



Nucleotide Chains



DNA Replication

- Synthesis of a complementary strand using the other strand as a template
- DNA polymerase

