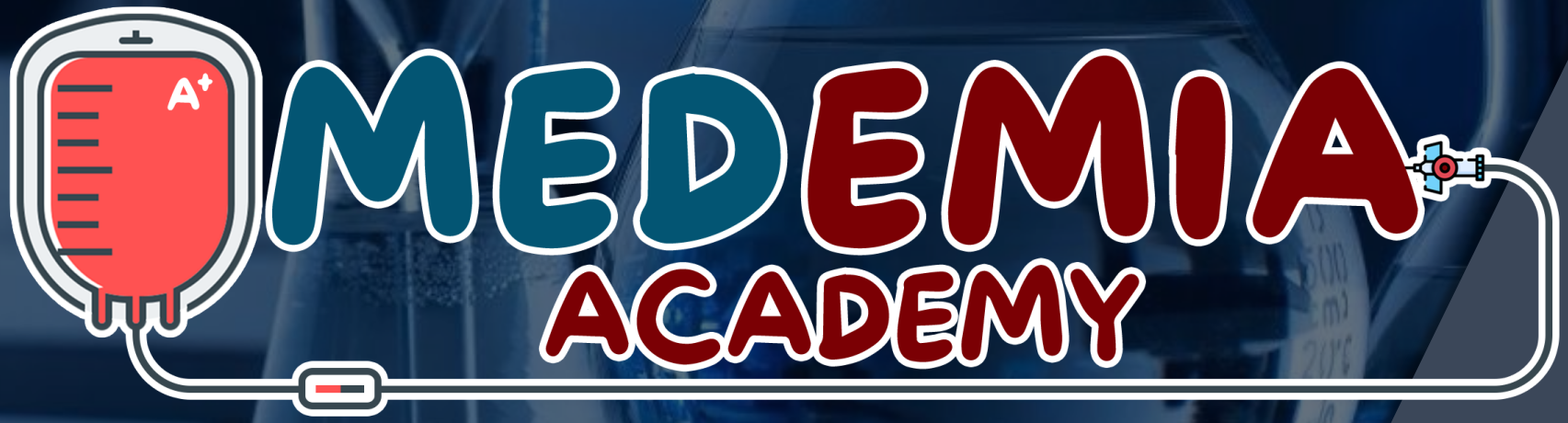
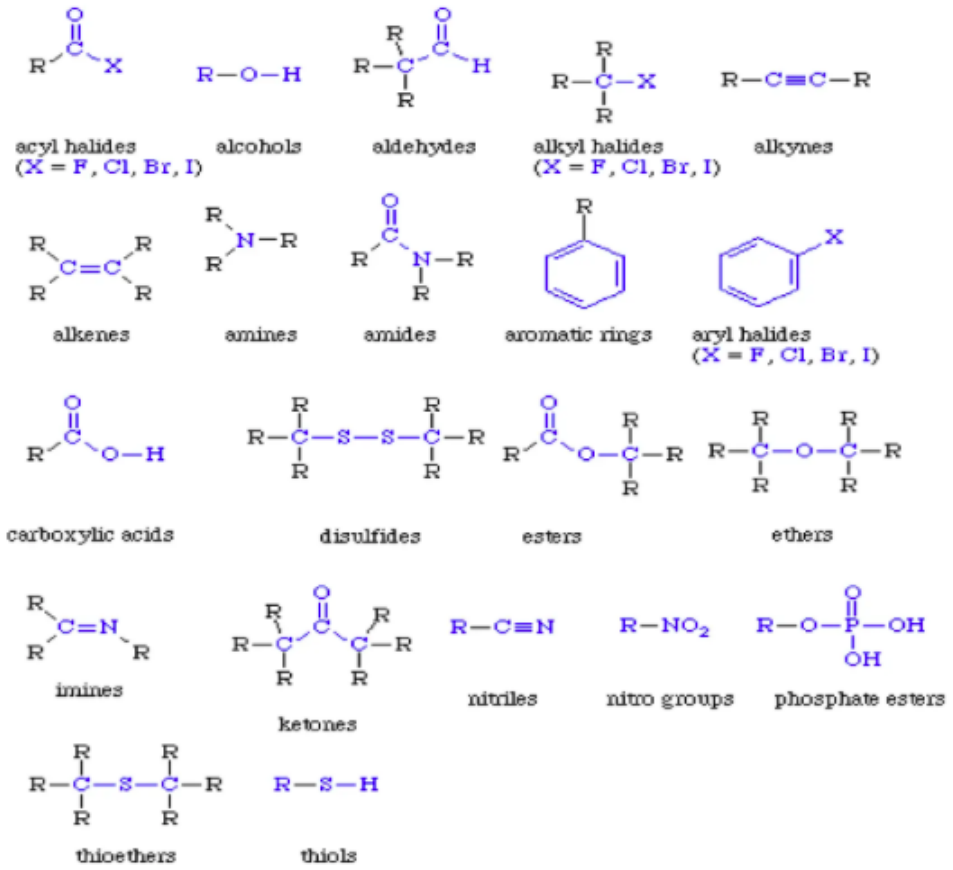
Functional Groups



MEDEMIA ACADEMY

Functional Groups

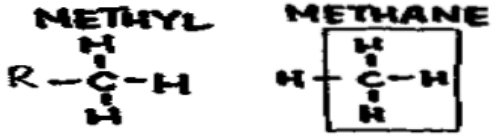
- **Functional groups** are specific groups of atoms or bonds within molecules that are responsible for the characteristic chemical reactions of those molecules.
- The same functional group will undergo the same or similar chemical reaction(s) regardless of the size of the molecule it is a part of.
- Carbon, nitrogen, oxygen, hydrogen, and phosphorus are a few of the elements involved in forming functional groups.
- Carbon can make four bonds. Nitrogen makes three, oxygen two, and hydrogen one.



Functional Groups Cont.

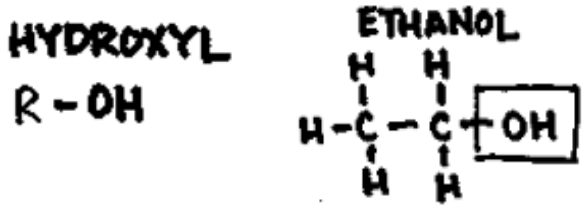
I. Hydrocarbons

- Long chains of carbon and hydrogen ending with a methyl group (-CH3).
- Hydrocarbons are non-polar, hydrophobic (doesn't dissolve in water).
- Form the backbone of most organic molecules.
- An example of a hydrocarbon is methane.
- There are three types of hydrocarbons
  - **Alkanes** are the simplest type of hydrocarbon and have only single bonds between carbon atoms.
  - **Alkenes** have double bonds between carbon atoms.
  - **Alkynes** have triple bonds between carbon atoms.



II. Alcohols

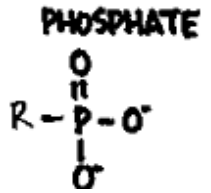
- Characterized by a hydroxyl group. This group makes the compound polar and hydrophilic (dissolve in water easily).
- Alcohols are good fuels.
- An example of an alcohol is ethanol.

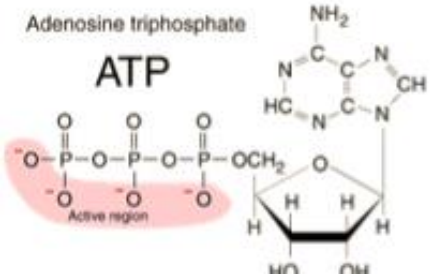


Functional Groups Cont.

III. Organic phosphates

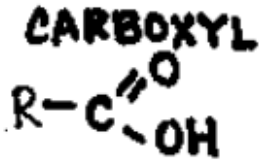
- characterized by a phosphate group.
- These compounds are usually acidic.
- They are polar and hydrophilic.
- Organic phosphates can be found in ATP and in DNA.

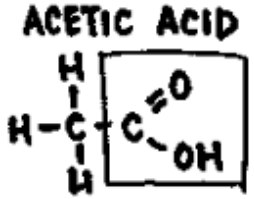




IV. Carboxylic acids

- characterized by a carboxyl group.
- Also referred to as organic acids.
- These compounds are polar, water soluble weak acids that are often aromatic.
- An example of a carboxylic acid is acetic acid (otherwise known as vinegar).

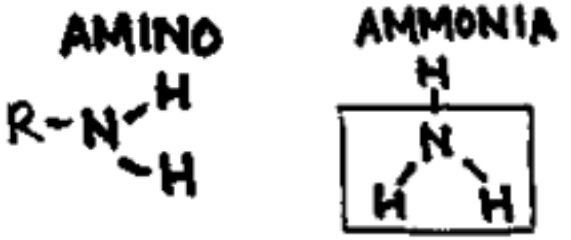




Functional Groups Cont.

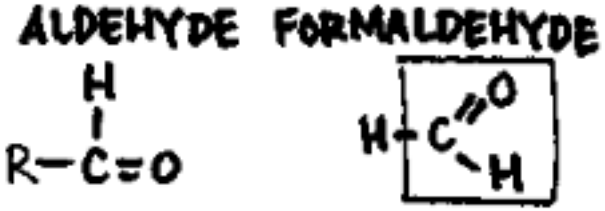
V. Amines

- Characterized by an amino group.
- These compounds are polar, water soluble weak bases.
- An example of an amine is ammonia.



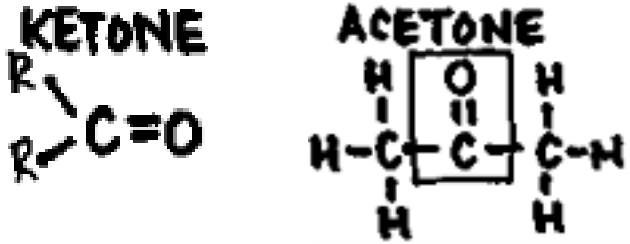
VI. Aldehydes

- Characterized by an aldehyde group.
- These compounds are polar and hydrophilic.
- An example of an aldehyde is formaldehyde.



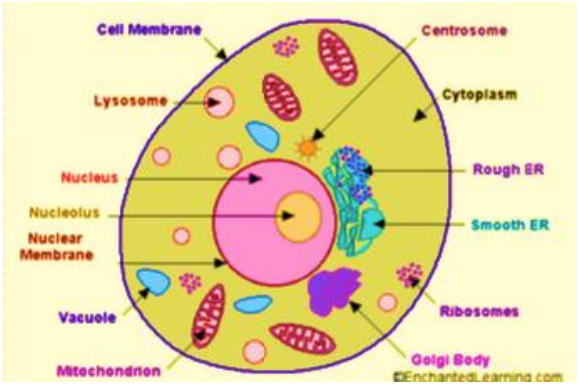
VII. Ketones

- Characterized by a ketone group.
- These compounds are polar and hydrophilic.
- Many steroids contain ketones.
- An example of a ketone is acetone.



Biomolecules

❖**Cell** is the unit of structure and functions in living organism. Chemical compositions of the cell in all organisms from bacteria to man are almost similar and mainly involve organic molecules.



❖ Usually there are two types of biochemical molecules :

- **Micromolecules** (small)
  - Represented by inorganic compounds like water and minerals, and organic compounds like monosaccharide sugars, amino acids , fatty acids and nucleotides.
- **Macromolecules** (large)
  - Involve polysaccharides , proteins ,some lipids and nucleic acids.

Biomolecules Cont.

- Micro and macromolecules are present in a dynamic state.
- Micromolecules are converted to macromolecules in an energy requiring process called **synthesis** .
- Macromolecules are also hydrolyzed to produce micromolecules in a process of **breakdown** that leads to liberation of energy.
- This interconversion process of micromolcules to macromolecules and vice versa is called **metabolism .**
  - Metabolism involves series of chemical reactions that are grouped either in anabolism (synthesis) or catabolism (breakdown) branches of metabolism.
  - The selection of anabolism or catabolism depends on the state of cell activity.
    - If cell growth and development are needed, the anabolism will be selected.
    - While during cell physical activities like muscle movement, then catabolism is favored.

Biomolecules Cont.

- **Amino acids and Proteins**
  - Amino acids classes and properties.
  - Polypeptides structure and functions.
  - Proteins structure , types , physical and chemical properties.
  - Proteins structural functions relationship:
    - Examples of fibrous proteins function: collagen , keratin and motor proteins.
    - Examples of globular proteins function: myoglobin and hemoglobin.
  - Clinical examples on protein abnormalities.
- **Carbohydrates**
  - Monosaccharides and polysaccharides.
  - Structure and functions.
  - Nutritional significance to the body.
- **Enzymes**
  - Catalytic functions, specificity and classifications.
  - Factors affecting enzyme activity.
  - Enzyme kinetics .
  - Enzyme inhibitions and regulations.
  - Isozymes and enzyme cofactors.
  - Application of enzymes in medicine.
- **Lipids**
  - Types, structure and functions.
  - Lipid profile.
  - Classes of lipoproteins.
  - Clinical significance of lipids.

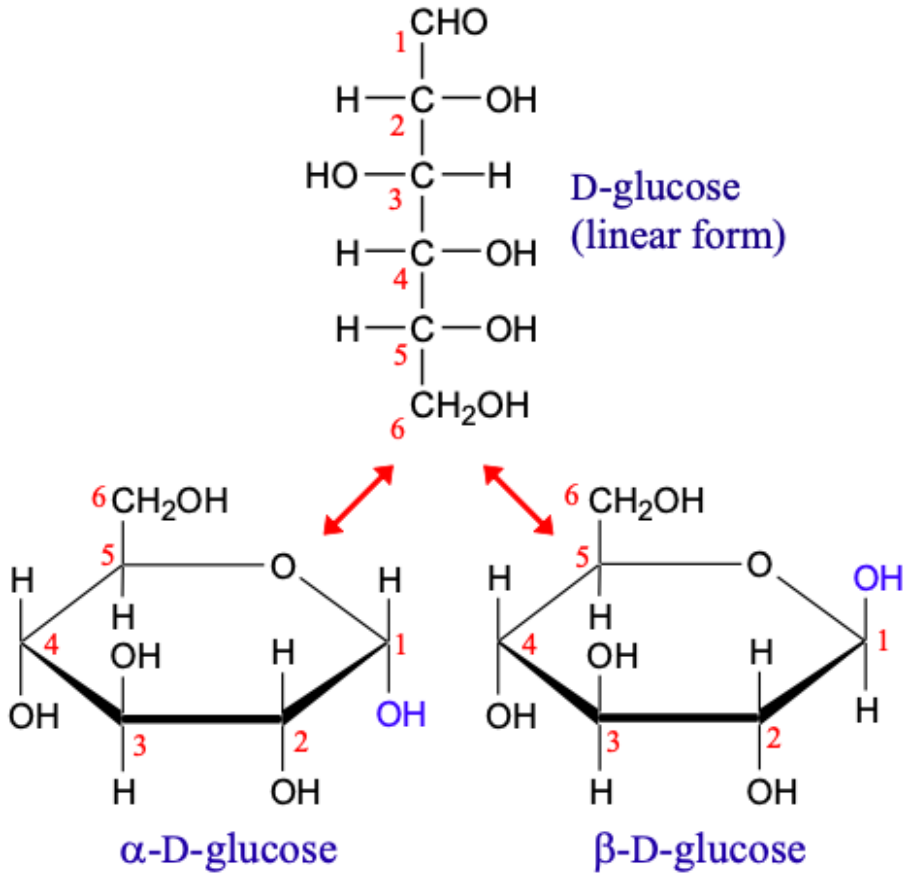
Carbohydrates

- Carbohydrates provide fast energy (4 kcal/gram) for the human body.
- Carbohydrates are typically classified according to the number of saccharide (sugar) units they have.

I. **Monosaccharides** are composed of 3 to 7 carbon atoms. They have the general formula **$(CH_2O)_n$** (example: glucose $C_6H_{12}O_6$).
   - All monosaccharides contain hydroxyl (-OH) groups and either an aldehyde or ketone group.
   - According to the number of carbon atoms, they are classified into trioses, tetroses, pentoses, hexoses and heptoses respectively.

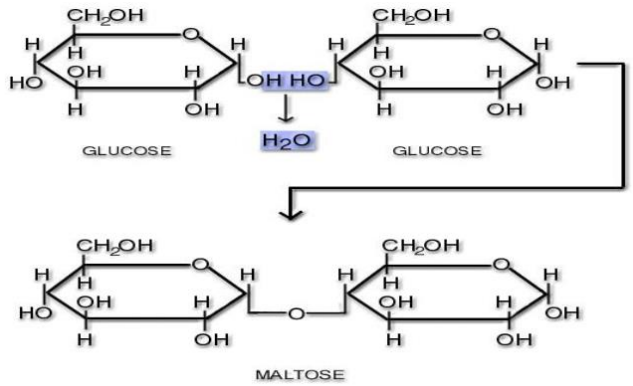
Carbohydrates Cont.

- Pentoses and hexoses can cyclize as the ketone or aldehyde group reacts with a distal OH.
- Glucose forms an intramolecular hemiacetal, as the C1 aldehyde & the C5 OH react, to form a 6- member pyranose ring.
- These representations of the cyclic sugars are called **Haworth projections.**



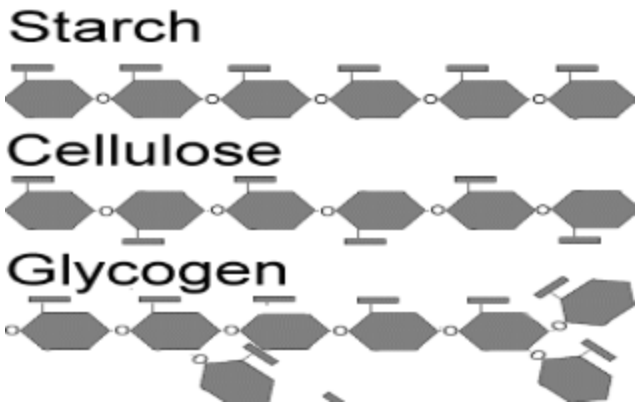
Carbohydrates Cont.

II. **Disaccharides** are formed when the OH group on the anomeric carbon of one sugar molecule interacts with one of several OH groups in the other sugar molecule in a **condensation** (dehydration) **reaction** to form a **glycosidic bond.**



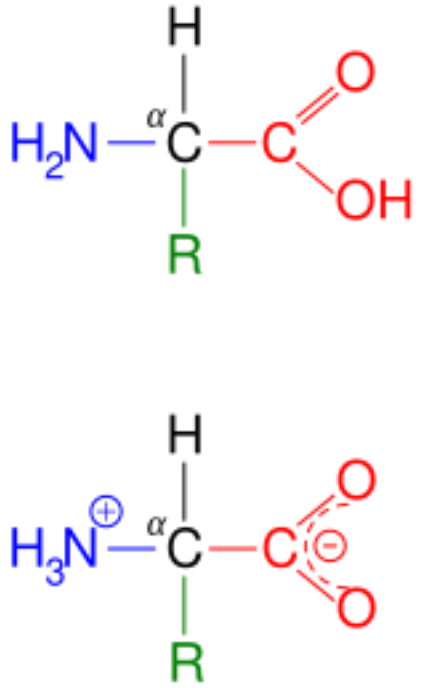
III. **Polysaccharides** are polymers of monosaccharides, they are long carbohydrate molecules of repeated monomer units joined together by glycosidic bonds.

- They are created without a template by the addition of particular monosaccharide residues.
- They range in structure from linear to highly branched.
- They differ from each other in:
  1. The identity of their monosaccharide units.
  2. The length of their chains.
  3. The degree of branching..



Amino Acids and Proteins

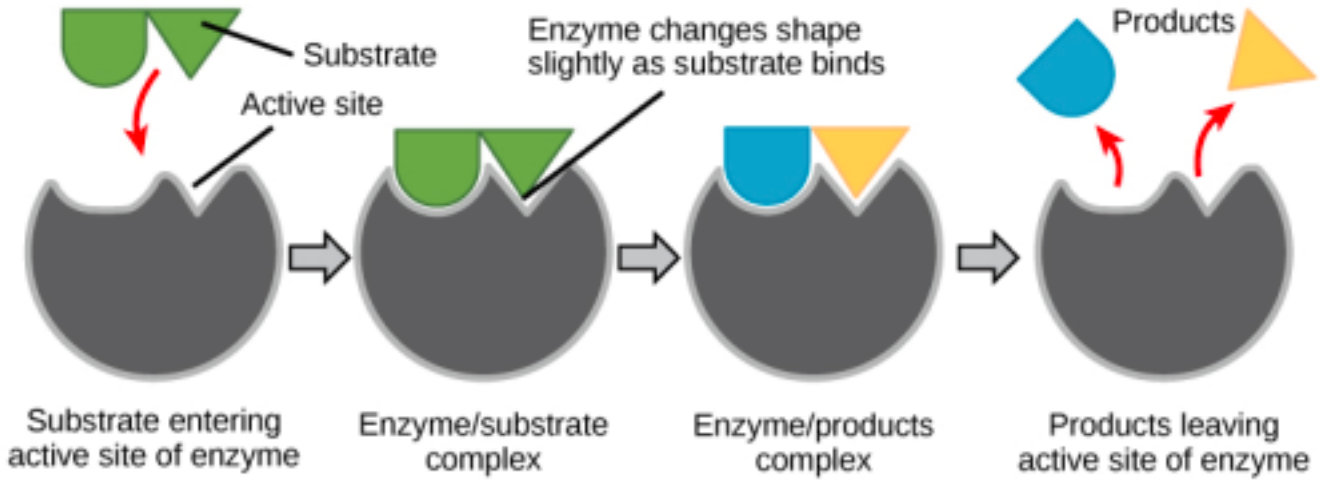
- **Amino acids** are the building blocks of proteins. They are biologically important molecules made from amine (-NH2) and carboxylic acid (-COOH) functional groups, along with a side chain (R) specific to each amino acid.
- **Proteins** are biochemical compounds consisting of one or more polypeptides.
- **A polypeptide** is a single linear polymer chain of amino acids bonded together by **peptide bonds** between the carboxyl and amino groups of adjacent amino acid residues through a condensation (dehydration) reaction.



An amino acid in its unionized (up) and zwitterionic (down) forms

Enzymes

- **Enzymes** are biological molecules that catalyze chemical reactions.
- In enzymatic reactions, the molecules at the beginning of the process, called **substrates**, are converted into different molecules, called **products.**
- Catalysis takes place at the **active site** which is a special pocket or cleft.
- The catalytic activity of many enzymes depends on the presence of small molecules termed **cofactors**.



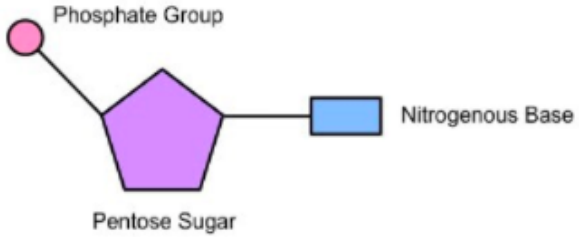
Enzymes Cont.

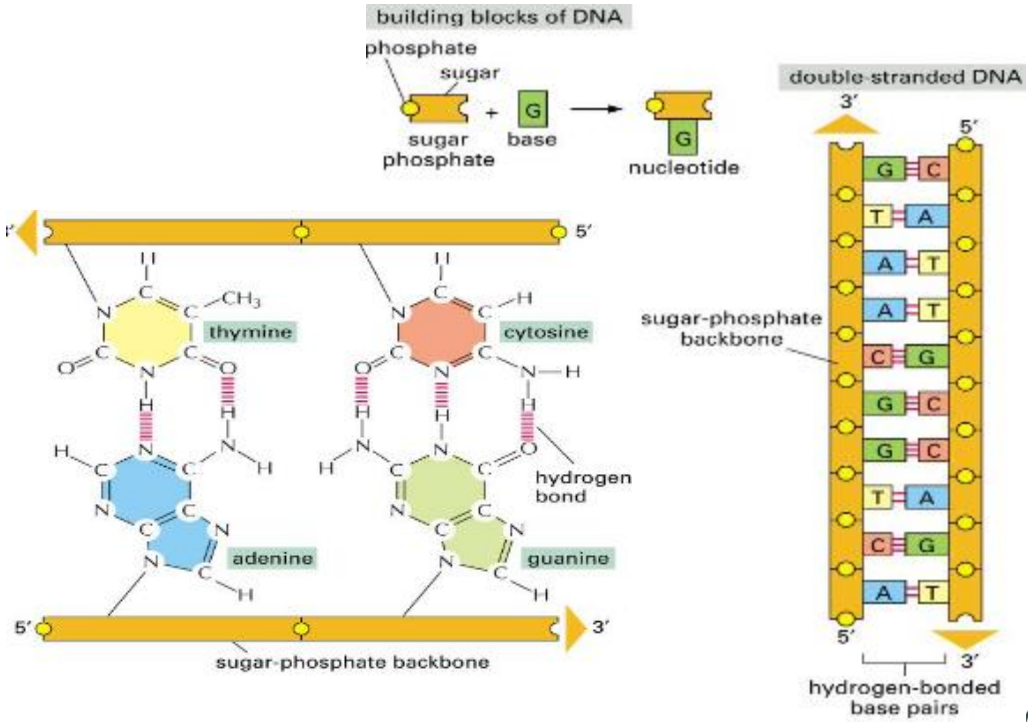
❖Enzymes are classified into about 6 categories based on the reaction they catalyze:

1. **Oxidoreductases**
   - Catalyze oxidation/reduction reactions.
2. **Transferases**
   - Transfer a functional group (e.g. a methyl or phosphate group).
3. **Hydrolases**
   - Catalyze the hydrolysis of various bonds.
4. **Lyases**
   - Cleave various bonds by means other than hydrolysis and oxidation.
5. **Isomerases**
   - Catalyze isomerization changes within a single molecule.
6. **Ligases**
   - Join two molecules with covalent bonds.

Nucleotides and Nucleic Acids

- **Nucleotides** are molecules that, when joined, make up the individual structural units of the nucleic acids (RNA, DNA)
  - Nucleotides are made up of :
    1. Ribose sugar (in RNA), or deoxyribose (in DNA).
    2. Phosphate group
    3. Nitrogenous base (A,C,G,T)
- **Nucleic acids** include DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).
  - Together with proteins, nucleic acids are the most important biological macromolecules.



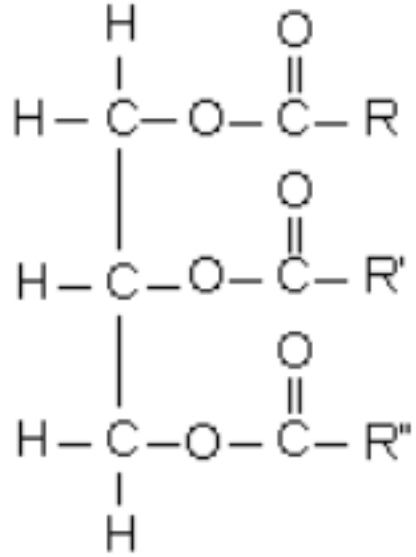


Lipids

❖Lipids provide long-term storage of energy (9 kcal/gram) in humans. They also provide padding and insulation, store fat soluble vitamins (A, D, E, K), and form the backbone of hormones and cell membranes.

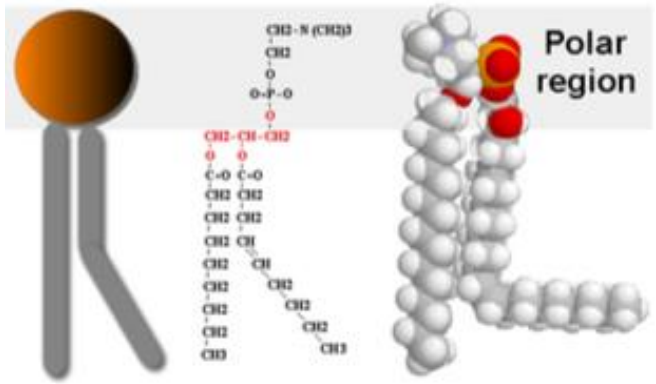
I. **Fats** are three fatty acids linked to an ester of glycerol. They can be saturated or unsaturated. **Essential fatty acids** include linoleic and linolenic acid.

II. **Waxes** are similar to fats but are composed of much longer fatty acids. Molecular attractions between fatty acid chains accounts for their higher melting point.



Lipids Cont.

III. **Phospholipids** are similar to fats but one of the fatty acid groups is replaced by a phosphate group.
   - The structure of this lipid gives it some interesting characteristics. The ester of glycerol is hydrophilic but the fatty acid chains are hydrophobic.
   - The most abundant cell membrane lipids are the phospholipids.



IV. **Steroids** are the last common kind of lipids. Steroids have a high hydrogen to carbon ratio. Examples of steroids include cholesterol and hormones like testosterone and estrogen.

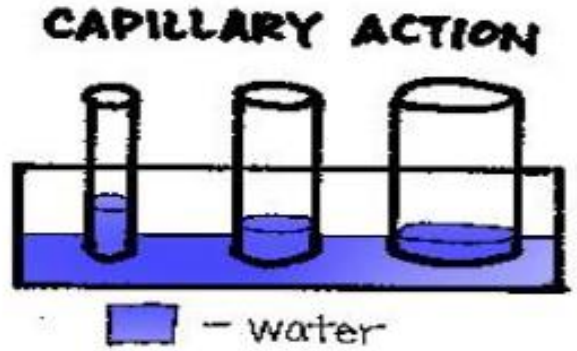
Water

- Water has many unique properties that make it essential to all life. Most of water's unique properties are a result of the hydrogen bonding between water molecules.
- Water is an excellent solvent. When ionic compounds are placed into water, the ions dissociate or separate.
- Polar covalent compounds (because they too have charged poles), also dissolve in water (hydrophilic).
- Nonpolar covalent compounds, however, do not dissolve in water (hydrophobic).

Water Cont.

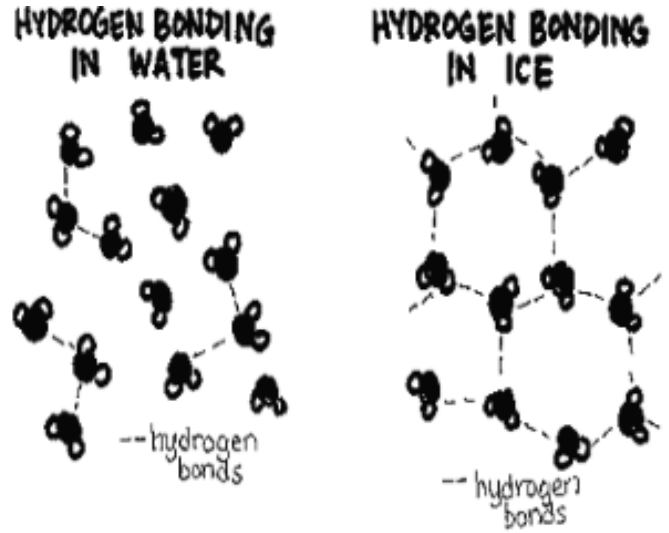
❖Water has **high cohesion**: Individual water molecules tend to "stick" with other water molecules due to hydrogen bonding. This leads to two characteristics of water:

1. **High surface tension**
   - Is what allows some insects to run across the surface of water.
2. **Strong capillary action.**
   - Is what allows the liquid level in a straw to be higher than that in the surrounding drink. Using hydrogen bonding, water molecules attract others up the sides of the straw.
   - This effect is the more noticeable in thinner straws.



Water Cont.

- Water has a **high specific heat capacity**: It takes a lot of energy to change the temperature of water.
- When you sweat, your body is using water as a coolant. The evaporating water removes heat with it.
- At night, oceans are a good insulator. The energy that the sun spent in heating the water all day is slowly released into the night.
- Hydrogen bonding arranges water molecules into hollow "cells" when water freezes, making it less dense than liquid water $(\text{Density} = \frac{\text{Mass}}{\text{Volume}})$.



MCQ 1, 2

❖Glycogen and starch:

a. Starch can be linear, but glycogen is branched.
b. Both are polymers of fructose.
c. Glycogen is the storage form of glucose in plants.
d. Both are proteins.

❖The bonding of unit molecules to produce a polysaccharide is called:

a. Cellular respiration
b. Condensation
c. Translation
d. Hydrolysis
e. Degradation

MCQ 3,4

❖The functional group (COOH) is:

a. Aldehyde group
b. Amine group
c. Phosphate group
d. Hydroxyl group
e. Carboxyl group

❖The anomer carbon is originated from:

a. Amino group
b. Carbonyl carbon
c. Alcohol
d. Phospholipids

MCQ 5, 6

- In the formation of a macromolecule, what type of bond would join two monosaccharide subunits?
  a. Glycosidic bond
  b. Hydrogen bond
  c. Ionic bond
  d. Phosphodiester bond
  e. Peptide bond
- The bonding of unit molecules to produce a polysaccharide is called:
  a. Degradation
  b. Condensation
  c. Translation
  d. Cellular respiration
  e. Hydrolysis

MCQ 7, 8

- In the formation of a macromolecule, what type of bond would join two amino acids subunits.
  a. Hydrogen bond
  b. Ionic bond
  c. Peptide bond
  d. Glycosidic bond
  e. Phosphodiester bond
- The functional group - NH2 is a/an
  a. Amino group
  b. Hydroxyl group
  c. Carbonyl group
  d. Carboxyl group
  e. Phosphate group

MCQ 9, 10

- The functional group - OH is a /an?
  a. Carbonyl group
  b. Hydroxyl group
  c. Amino group
  d. Phosphate group
  e. Carboxyl group
- The neutral form of amino acid is called ?
  a. Ampholyte (molecule that can act as both an acid and a base)
  b. Zwitterion
  c. Anionic
  d. Cationic
  e. Isoelectric point

MCQ 11, 12

- The sugar found in DNA is?
  a. Erythrose
  b. Sucrose
  c. Deoxyribose
  d. Ribulose
  e. Ribose
- The sugar found in RNA is:
  a. Erythrose
  b. Sucrose
  c. Deoxyribose
  d. Ribulose
  e. Ribose

MCQ 13

❖After the cyclic sugar formation, the carbonyl carbon will be converted to?
Select one:

a. Carboxylic acid
b. Anomeric carbon
c. Achiral carbon
d. Alcoholic carbon
e. Ketonic group

MCQ Answer Key

Q	Answer	Q	Answer
1	a	**8**	a
2	b	**9**	b
3	e	**10**	b
4	b	**11**	c
5	a	**12**	e
6	b	**13**	b
7	c		