

## Functional Group

**With Dr.Hamzeh Al-Shar`e , MD**

**Original Slides for Prof. Sameeh Al-Saraireh**

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Cell

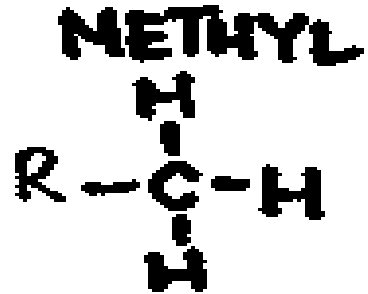
Biomolecules



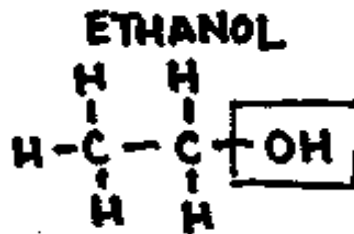
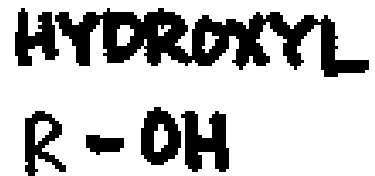
# Functional groups

- **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.

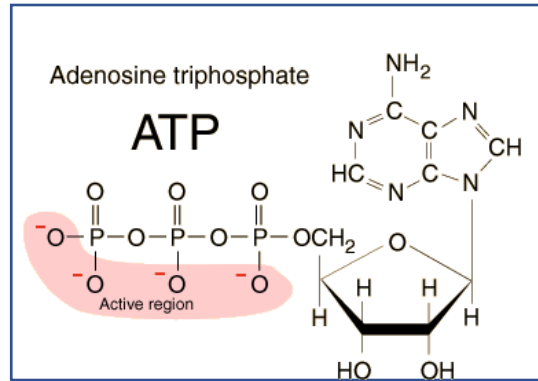
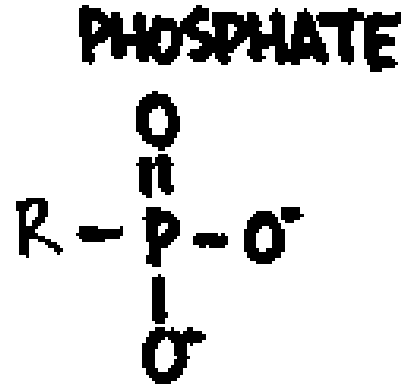
- **Hydrocarbons** are long chains of carbon and hydrogen ending with a methyl group (-CH<sub>3</sub>). Hydrocarbons are **hydrophobic** and form the backbone of most organic molecules. An example of a hydrocarbon is **methane**.



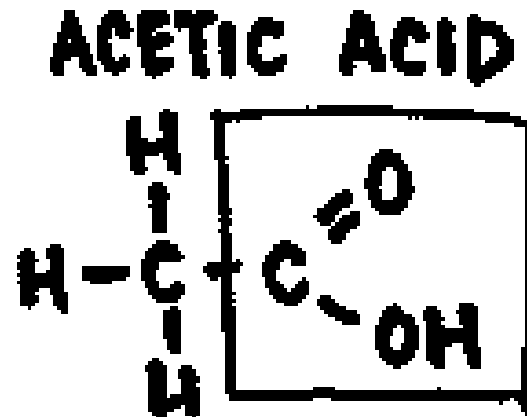
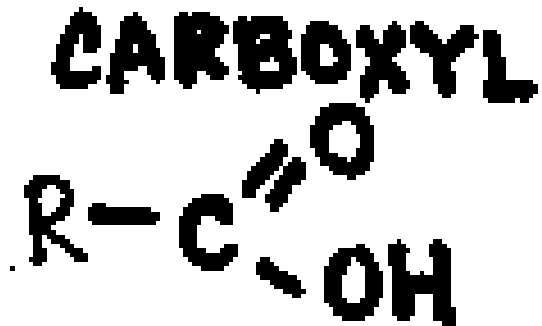
- **Alcohols** are characterized by a hydroxyl group. This group makes the compound **polar** and **hydrophilic**. Alcohols dissolve in water easily and are good fuels. An example of an alcohol is ethanol.



Organic phosphates are characterized by a phosphate group. These compounds are usually **acidic**. Organic phosphates can be found in ATP and in DNA. ( **Polar, Hydrophilic** )

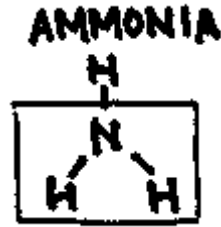
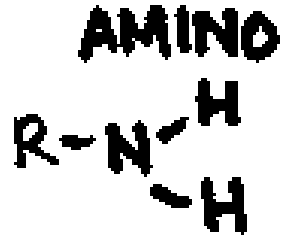


Carboxylic acids are characterized by a carboxyl group. Also referred to as organic acids, these compounds are **water soluble weak acids that are often aromatic**. An example of a carboxylic acid is acetic acid (otherwise known as vinegar).



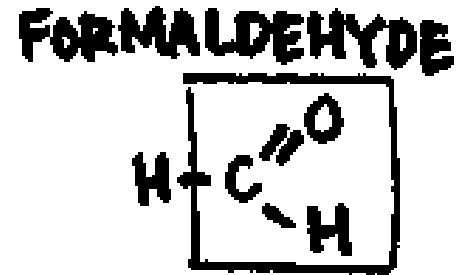
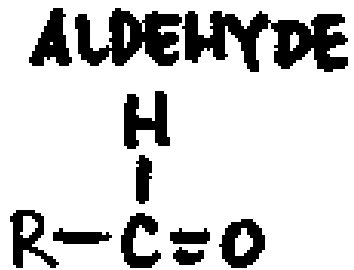
Amines are characterized by an amino group. These compounds are **water soluble weak bases**.

An example of an amine is **ammonia (simplest type of amines)**



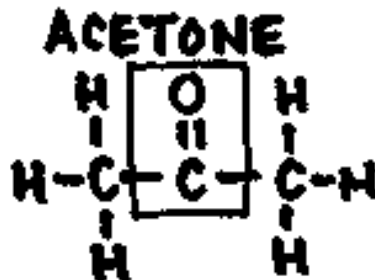
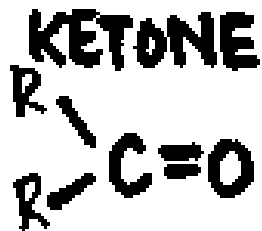
Aldehydes are characterized by an aldehyde group. These compounds are **polar and hydrophilic**.

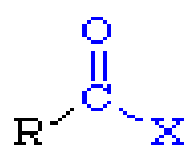
An example of an aldehyde is **formaldehyde (simplest type of aldehydes)**



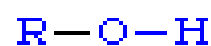
Ketones are characterized by a ketone group. These compounds are **polar and hydrophilic**.

Many steroids contain ketones. **An example of a ketone is acetone. (simplest type of ketones)**

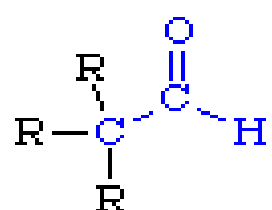




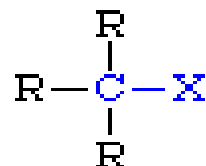
acyl halides  
(X = F, Cl, Br, I)



alcohols



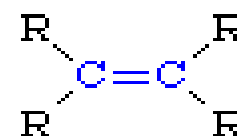
aldehydes



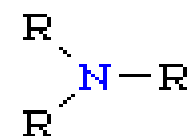
alkyl halides  
(X = F, Cl, Br, I)



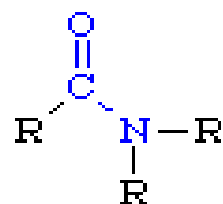
alkynes



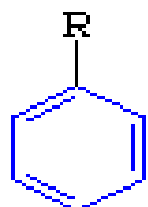
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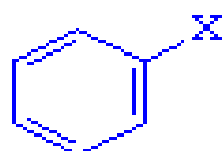
amines



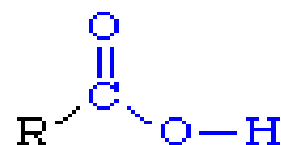
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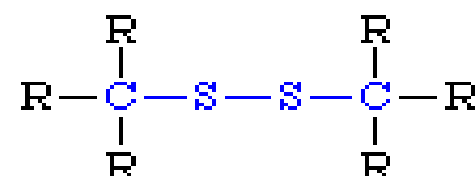
aromatic rings



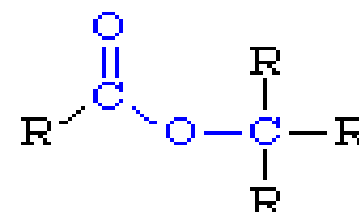
aryl halides  
(X = F, Cl, Br, I)



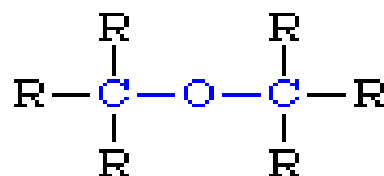
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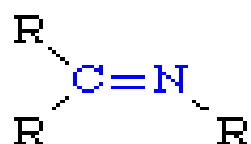
disulfides



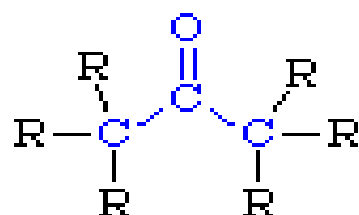
esters



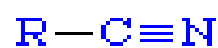
ethers



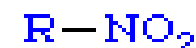
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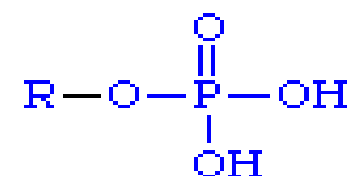
ketones



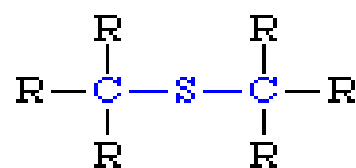
nitriles



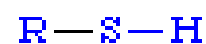
nitro groups



phosphate esters



thioethers



thiols

## Cell :

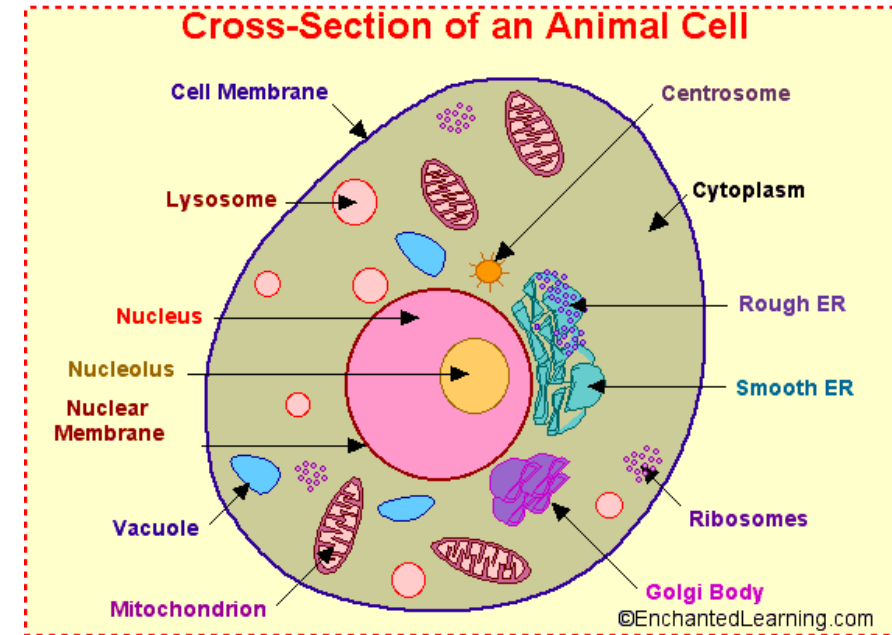
the unit of structure and functions in living organism.

Chemical compositions of the cell in all organisms from bacteria to man are almost similar and mainly involving organic molecules.

Usually there are two types of biochemical molecules :  
small size (micro) and large size molecules (macro).

**The micromolecules** are represented by monosaccharide sugars, amino acids , fatty acids and nucleotides.

**The macromolecules** involve polysaccharides , proteins ,some lipids and nucleic acids.





## Micro and macromolecules are present in a **dynamic state**.

- The micromolecules are converted to macromolecules in an energy requiring process called **synthesis** .
- Also the macromolecules are hydrolyzed to produce micromolecules in a process of **breakdown** that leads to liberation of energy.
- This interconversion process of micromolecules 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**

- **1- Micromolecules**: represented by inorganic compounds like water and mineral and organic compounds like monosaccharides, amino acids, fatty acids and nucleotides.
- **2- Macromolecules**: represented by proteins; nucleic acids; polysaccharides, and some lipids

## **Amino acids and Proteins**

- Amino acids classes and properties
- Polypeptides structure and functions
- Proteins : Structure , types , physical and chemical properties.

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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.**

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## **lipids :**

**Types, structure and functions.**

**Lipid profile**

**Classes of lipoproteins**

**Clinical significance of lipids**

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## **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**

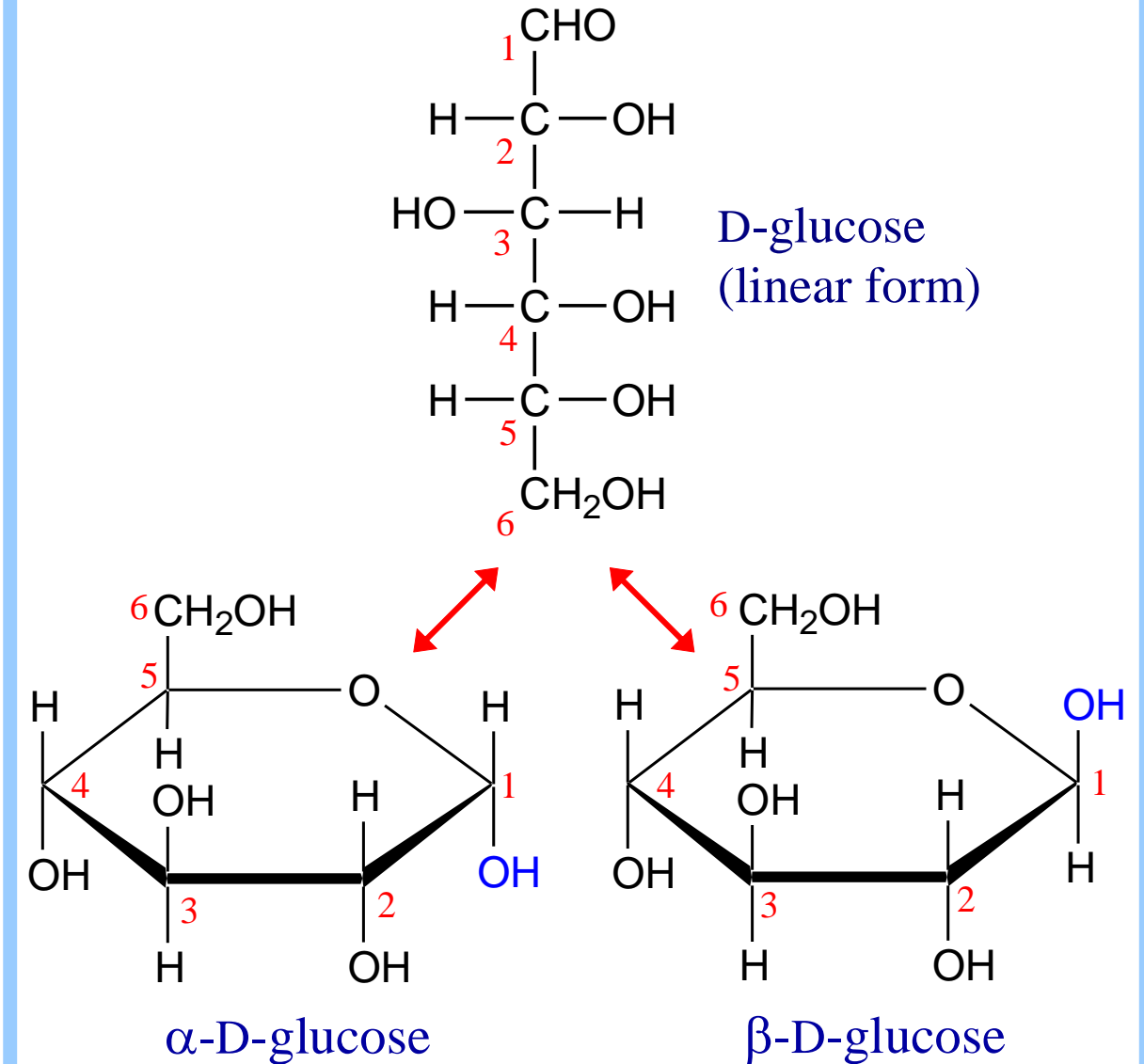
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# Carbohydrates

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

Pentoses and hexoses can **cyclize** as the ketone or aldehyde group reacts with a distal OH.

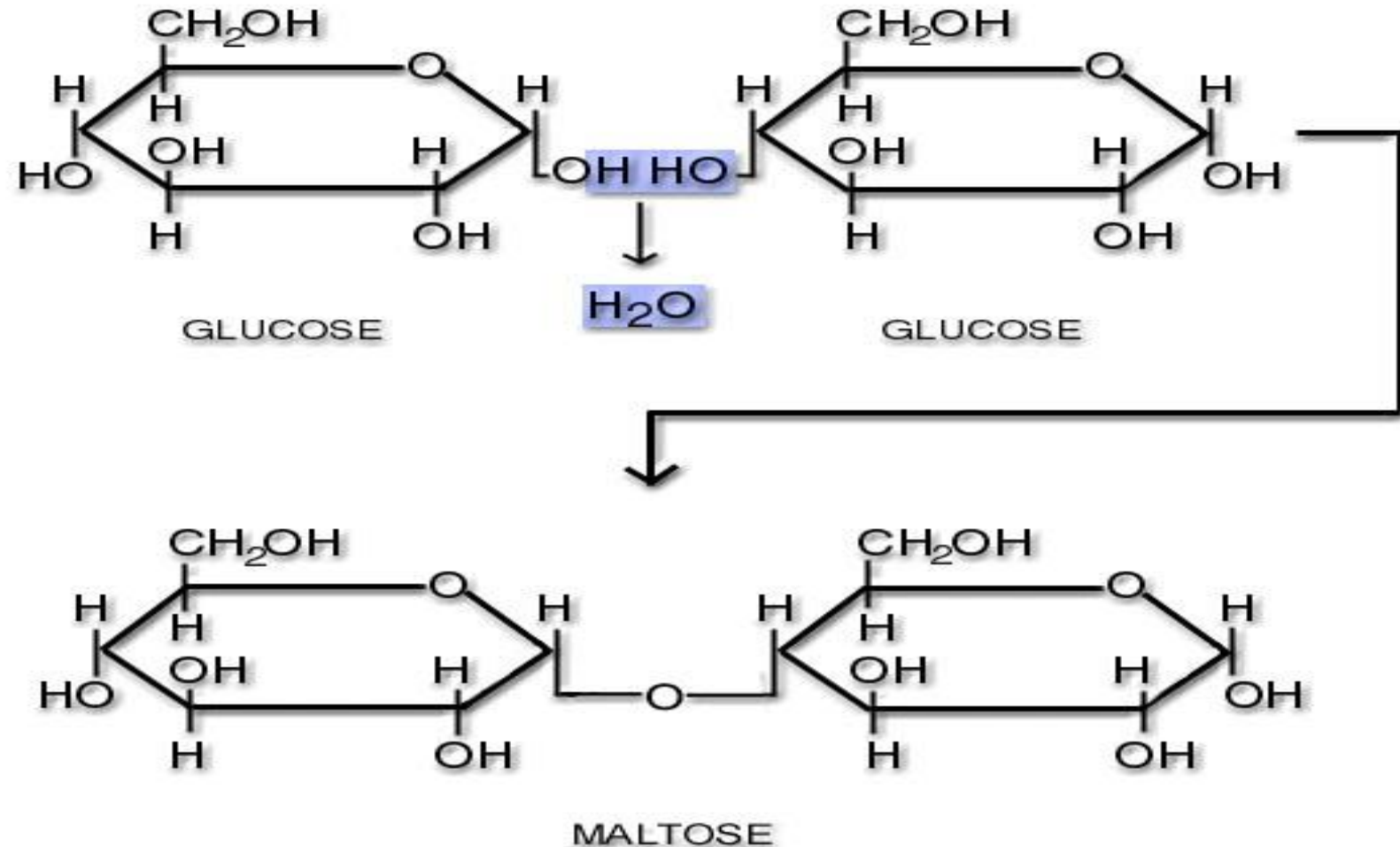
**Glucose** forms an intra-molecular hemiacetal, as the C1 aldehyde & C5 OH react, to form a **6-member pyranose ring**.



These representations of the cyclic sugars are called **Haworth** projections.

**Disaccharides** : are formed when the hydroxyl group on the anomeric carbon of one sugar molecule interacts with one of several hydroxyl groups in the other sugar molecule

Type of bond is: glycosidic bond , by dehydration reaction



## Polysaccharides

Polysaccharides are polymers of monosaccharides

Polysaccharides are created without a template by the addition of particular monosaccharide residues

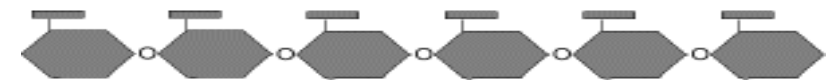
Polysaccharides are long carbohydrate molecules of repeated monomer units joined together by glycosidic bonds.

**They range in structure from linear to highly branched.**

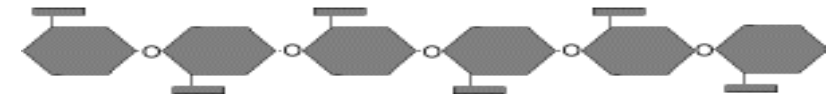
**They differ from each other in**

- 1- the identity of their monosaccharide units;
- 2- the length of their chains;
- 3- the degree of branching. (starch, cellulose and glycogen)

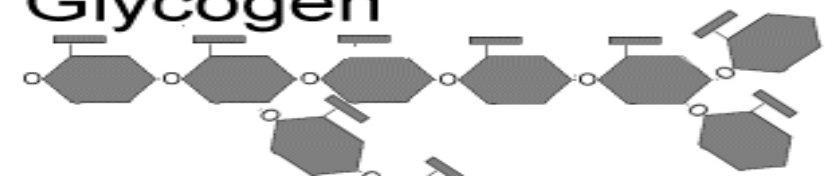
Starch



Cellulose

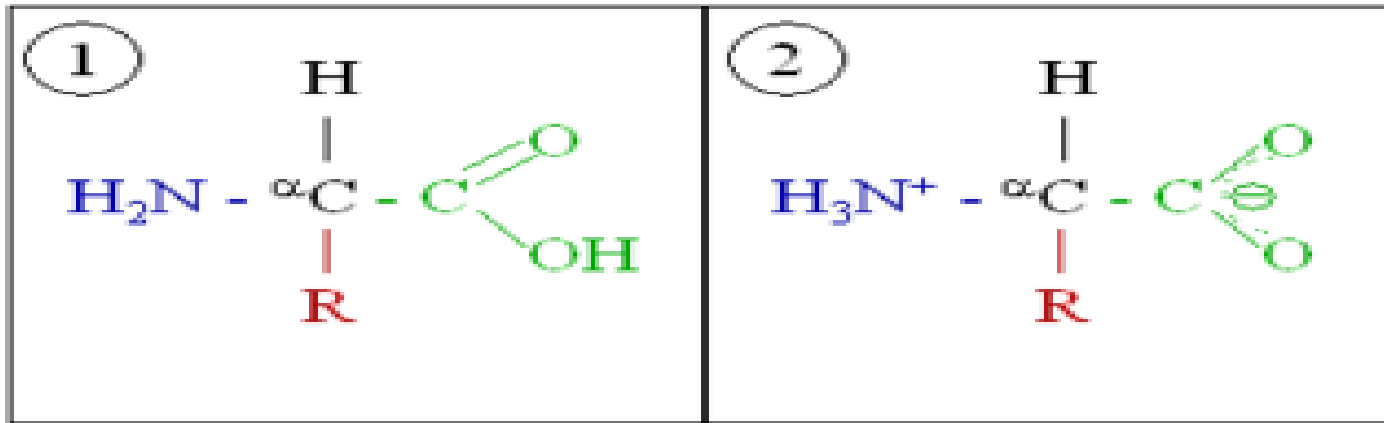


Glycogen



## Amino acids, and Proteins

- Amino acids are the building blocks of proteins. They are biologically important molecules made from amine (-NH<sub>2</sub>) and carboxylic acid (-COOH) functional groups, along with a side-chain specific to each amino acid.



An amino acid in its (1) unionized and (2) zwitterionic forms

- Proteins

Are biochemical compounds consisting of one or more polypeptides

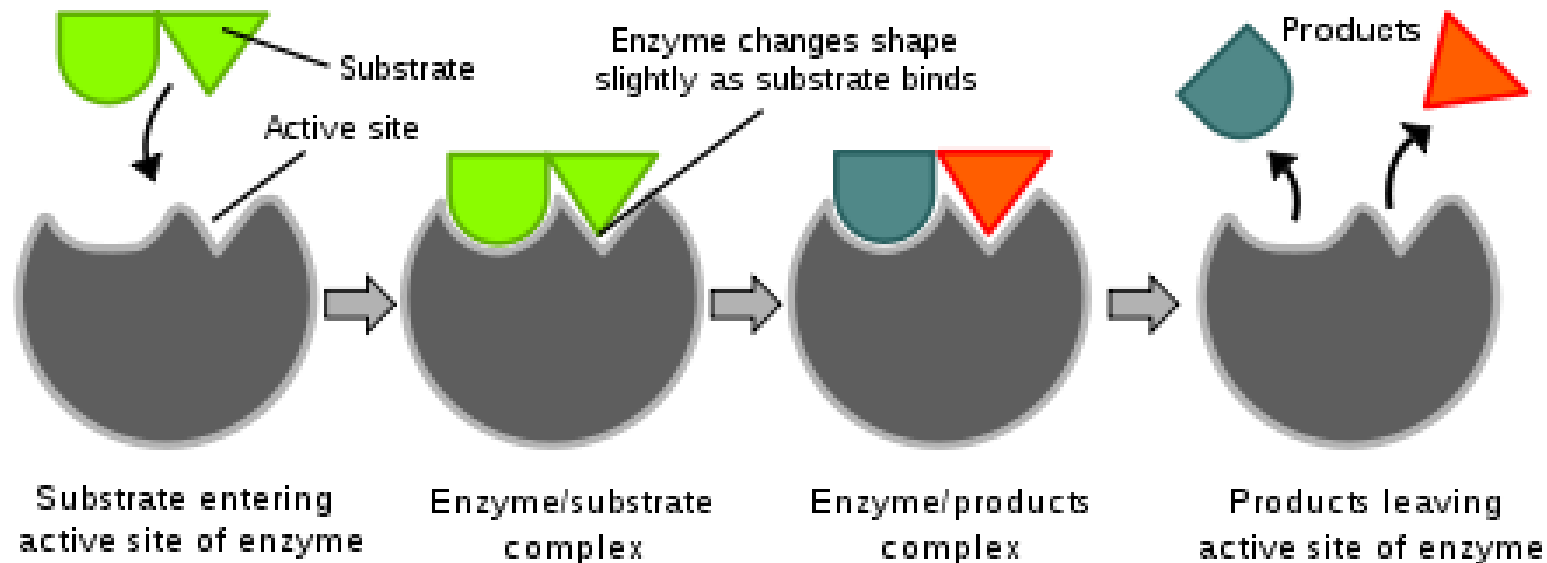
A polypeptide is a single linear polymer chain of amino acids bonded together by peptide bonds between the carboxyl and amino groups of adjacent amino acid residues.



# 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.



- **Classification of enzymes:**

- Enzymes are classified into about 6 categories based on the reaction they catalyse.

**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

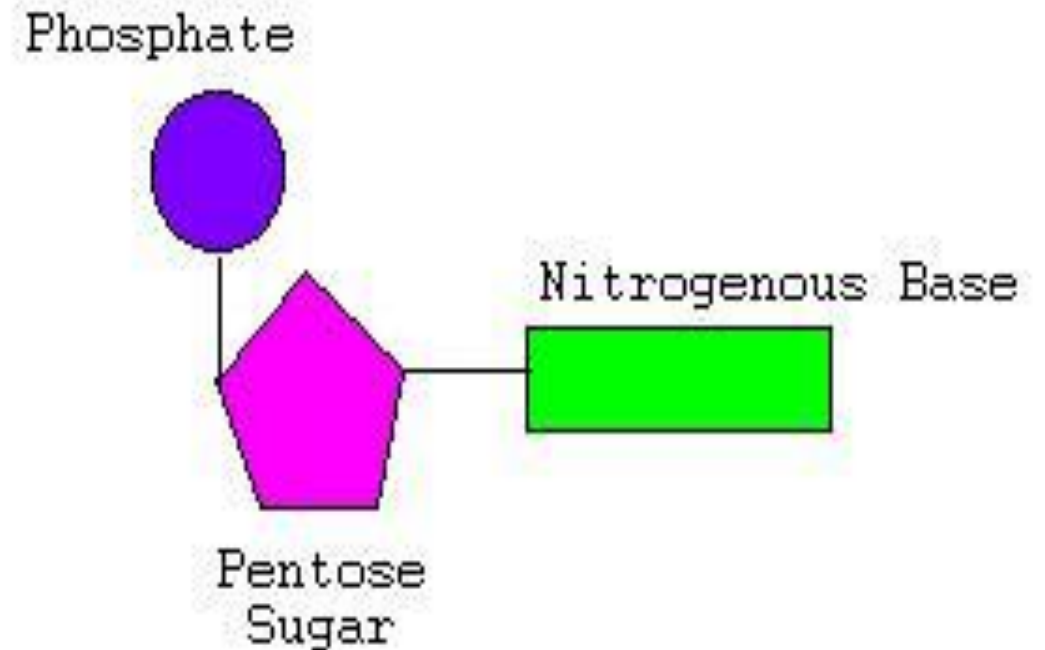
**6- Ligases:** join two molecules with covalent bonds

## Nucleotides and Nucleic acids

- Nucleotides: are molecules that, when joined, make up the individual structural units of the nucleic acids RNA and 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

They include DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).

Together with proteins, nucleic acids are the most important biological macromolecules

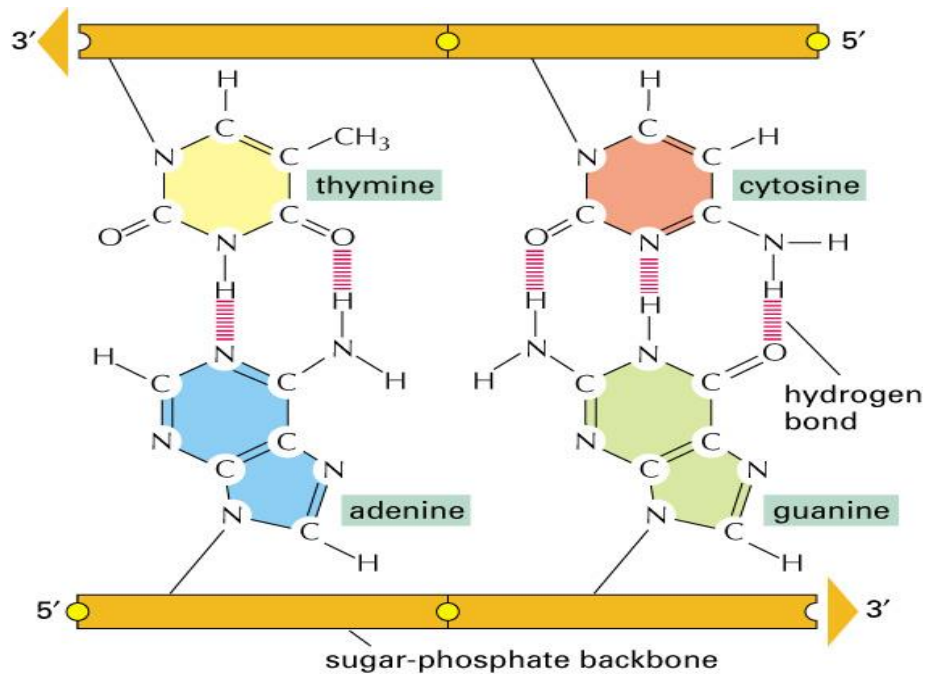


Figure 4-4. Molecular Biology of the Cell, 4th Edition.

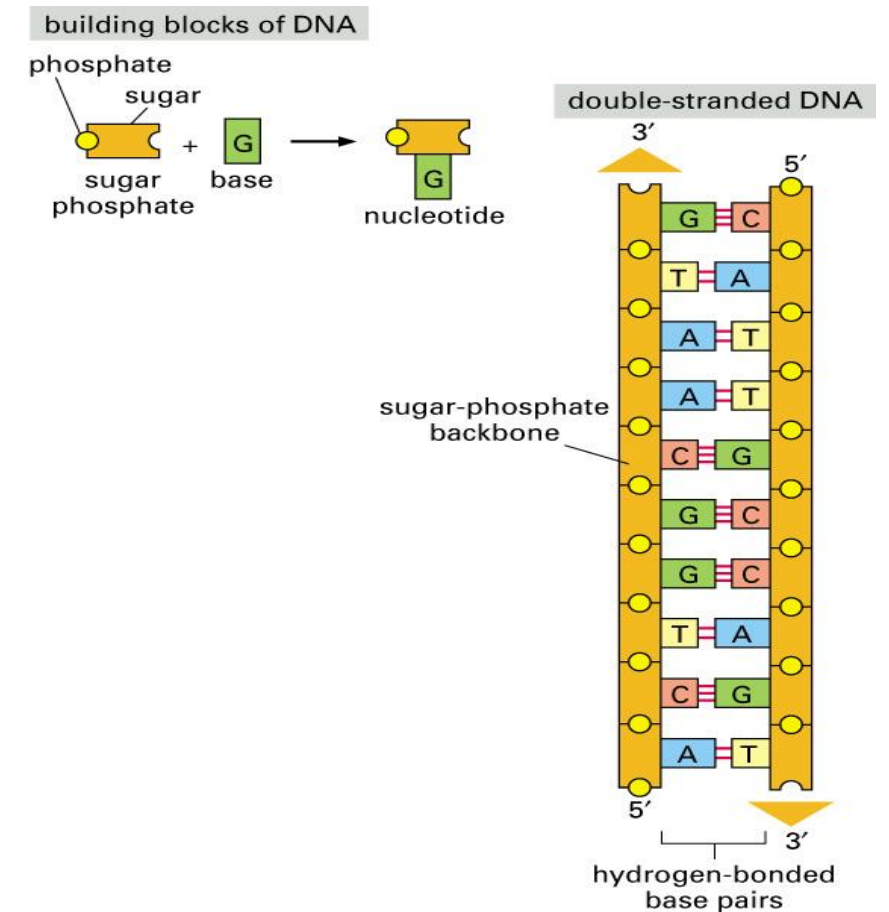
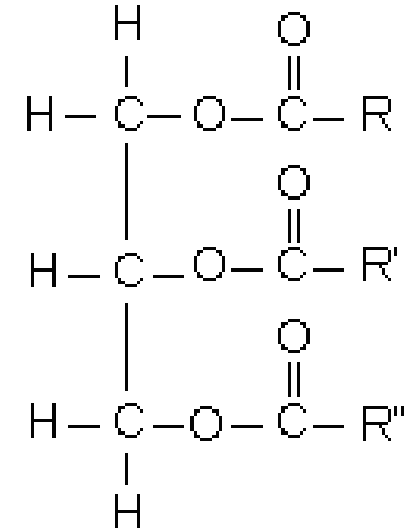


Figure 4-3 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

# 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, etc.), and form the backbone of hormones and cell membranes.

**1- 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.

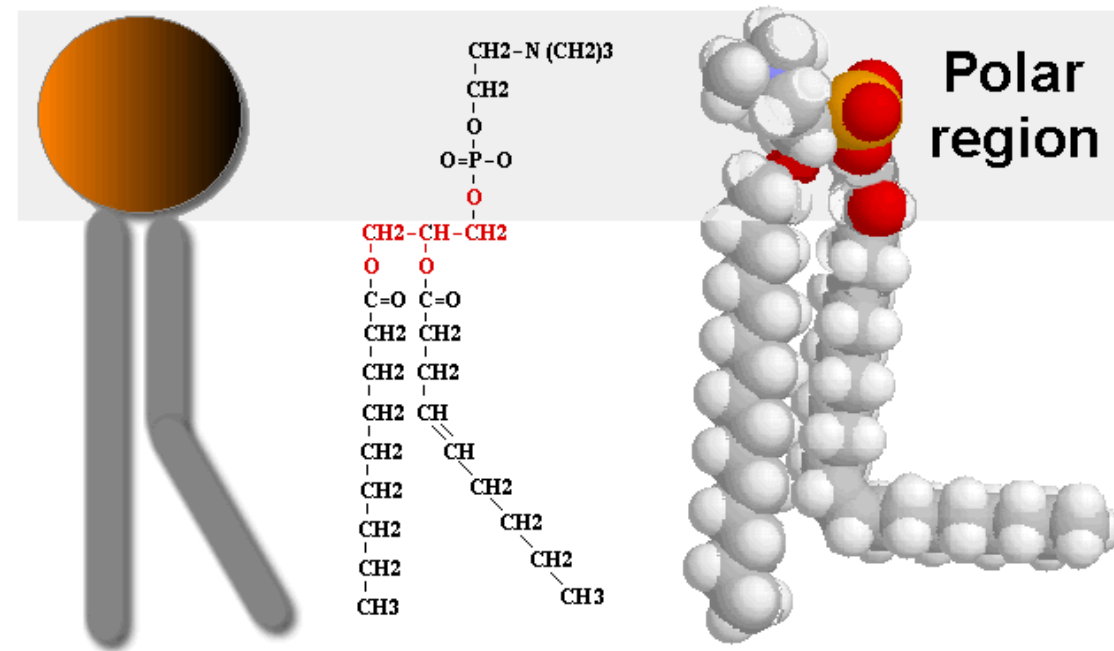


**2- Waxes** are similar to fats but are composed of much longer fatty acids.  
Molecular attractions between fatty acid chains accounts for their higher melting point.

**3- 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.

## Phospholipids



**4- 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.
- Nonpolar covalent compounds, however, do not dissolve in water.
- **Thus polar covalent compounds are hydrophilic (water loving) while nonpolar covalent compounds are hydrophobic (water fearing).**

**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- a high surface tension    and    2- a strong capillary action.

Water's high surface tension is what allows some insects to run across the surface of the water.

Water's 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 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.

$$\text{Density} = \text{mass} / \text{volume}$$

