Water Carbon Macromolecules

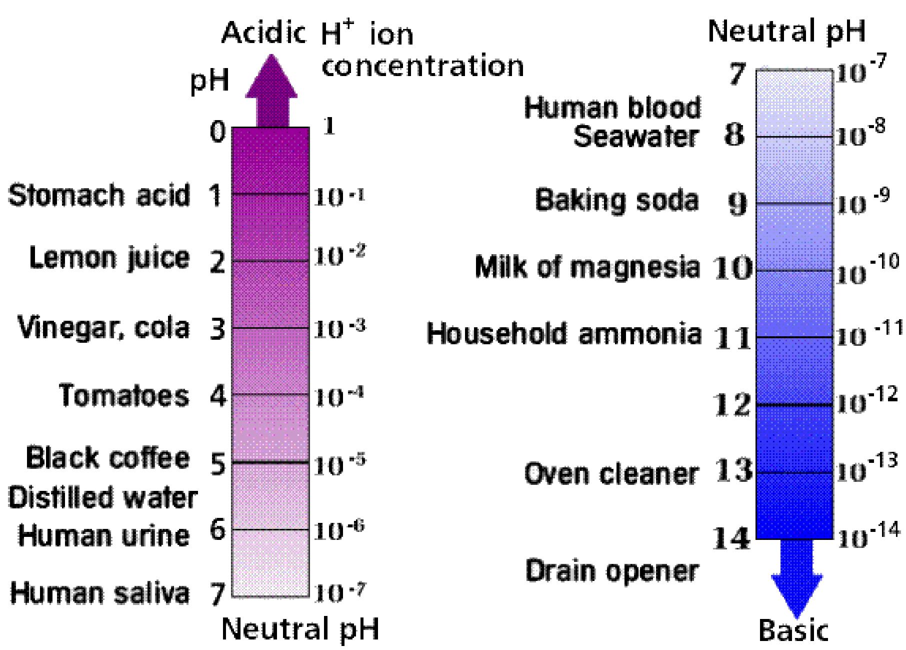
I. CHEMISTRY: THE BASIS FOR LIFE

Hydrogen bond

Hydrogen bonds happen mainly between water molecules. The electrons between hydrogen and the other atoms are shared unequally due to the electronegativity of oxygen. This unequal sharing causes the hydrogen to have a partial positive charge and the oxygen to have a partial negative charge. The hydrogen is attracted to the oxygen from another water molecule.

water can hydrogen bond with 4 other water molecules

G. **Dissociation and pH scale**



1. **Acids**

   Substances that yield H+ when they dissociate in water are called acids

Bases

Substances that yield OH- when they dissociate in water are called

3. pH

The pH scale goes from 0-14. Acidic is <7, and the Basic is >7. Neutral=7. A pH of 5 is 10 times more acidic than a pH of 6. A pH of 4 is 100 times more acidic. A pH of 8 is 100 times more basic. The more hydrogen ions present, the higher the hydronium. H30+ or H+, ion concentration, and the more acidic the solution. The more hydroxide ions, OH-, the more basic the solution.

Buffers

Buffers are substances that resist swings in pH.

1. **Water Properties**

The unique structure of water gives water its four important properties.

a. **Water is a Powerful Solvent**

Water is able to dissolve anything polar due to polarity. Water separates ionic substances, hydrophilic (water loving) compounds. Nonpolar substances do not dissolve in water and are called hydrophobic (water fearing). Ex: Blood is able to circulate food and waste in the body because it is mostly water that can dissolve most materials.

b. **Water moves up a plant due to capillary action**

Water adheres to a surface due to two properties.

1) Adhesion: The attraction between water and other substances.

2) Cohesion: The attraction of water molecules to other water molecules.

These two properties allow capillary action.

d. **Water has a High Specific Heat**

It takes a lot of heat to increases the temperature of water and a great deal of heat must be lost in order to decrease the temperature of the water. Stays as liquid on earth temp

e. **Water has a high heat of vaporization and can used in evaporative cooling**

A great deal of energy must be present in order to break the hydrogen bonds to change water from a liqid to a gas.

Because it takes a lot of energy to change water from a liquid to a gas, when the vapor leaves it takes a lot of energy with it. When humans sweat, water absorbs the heat from the body. When water turns into water vapor, it takes that energy (heat) with it.

II. BIOLOGICAL CHEMISTRY: ORGANIC MOLECULE

B. CARBON BACKBONE

Carbon can form covalent bonds directly with one to four atoms since it as four valence electrons. In many biological molecules carbon atoms form long chains. Carbon is unique in that it can form single, double, and triple covalent bonds with itself and other atoms. Also, carbon backbone can have many functional groups. The functional groups help fold the molecule in many different shapes.

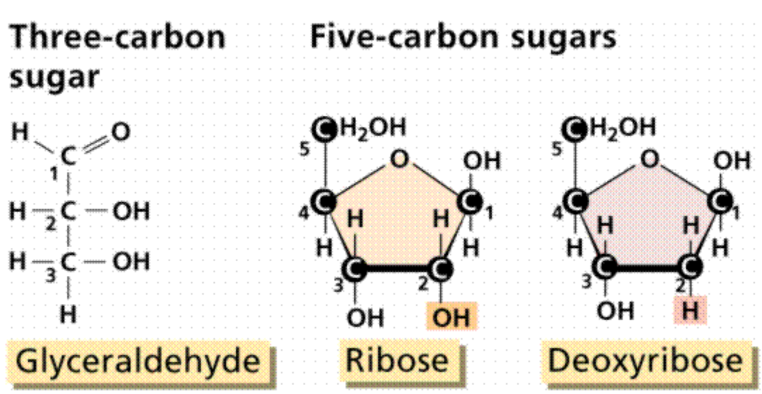
DIFFERENT SHAPES = DIFFERENT FUNCTIONS

know these functional groups- be able to identify them: hydroxyl, carbonyl, carboxyl, amino, sulfhydryl, phosphate, methyl.

(pictures in book and also in cliff notes)

There are four main groups of biologically important organic molecules: carbohydrates, proteins, lipids, and nucleic acids.

E. CARBOHYDRATES



Most carbohydrates have the empirical formula $C(H_2O)_n$. Carbohydrates are composed of covalently bonded atoms of carbon, hydrogen, and oxygen.

1. **Monomer of Carb: Monosaccharides or glucose or sugar.**

2. A polymer is a large molecule composed of many similar or identical molecular subunits.

• A polysaccharide or carb consists of many monosaccharides joined together by condensation reactions.

Condensation reaction (dehydration) : the joining of two smaller organic compounds resulting in the formation of a larger organic molecule and the release of a water molecule. Synthesis reactions require energy to complete.

** applies to all polymers

$C_6H_{12}O_6 + C_6H_{12}O_6$ ==–– $C_{12}H_{22}O_{11} + H_2O$

glucose + fructose ===--- sucrose + water

Hydrolytic cleavage (hydrolysis): With the addition of water, the splitting of a large organic molecule into two smaller organic molecules. Hydrolysis reactions liberate energy. Hydrolytic cleavage, or hydrolysis, is the opposite of a dehydration reaction. For example, in the human digestive system, sucrose (disaccharide) is split into glucose and fructose (two monosaccharides).

** applies to all monomers

3. **Polysaccharides**

Glycosidic linkages connect one sugar to another.

a. **Starch**

Starch is the storage polsacchride in plants and is an important reservoir for energy. In starch, glucose is connect by linkages all on the same side. energy storage.

b. **Glycogen**

Glucogen is the storage polysaccharide in animals.

c. **Cellulose**

Cellulose is a structural polysaccharide and is the major building material made by plants. It gives the plant cell its shape, is not soluble, and is very strong.sugars connected by alternate glycosidic linkages

Some bacteria, protests, fungi, and lichens can break down cellulose. For example, bacteria and protests found in the stomachs of termites and grazing animals break down the cellulose in the grass and wood to provide the animal with glucose. Without these organisms, mammals cannot digest cellulose because they do not have the needed enzymes.

** know the difference between starch and cellulose (alternating glycosidic linkages) given a picture (see below)

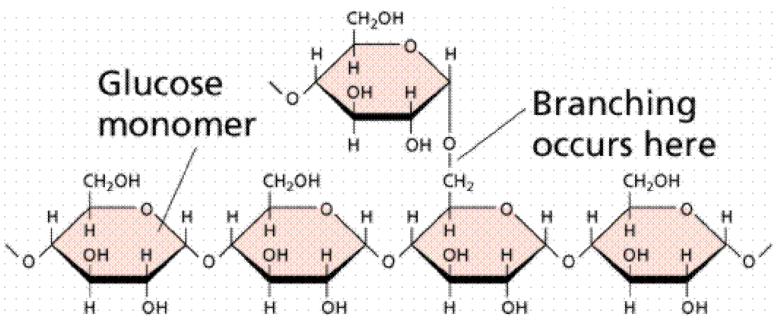


Figure of Starch

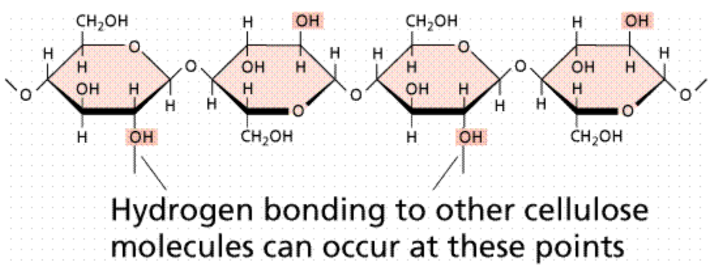


Figure of Cellulose

d. Other structural polysaccharides

1) *Chitin*: Chitin is principal component of the exoskeletons of insects and other arthropods, including lobsters. Chitin is very soft but is combined with $CaCO_3$ (calcium carbonate or limestone) to become hard. Most animals cannot digest chitin.

F. PROTEINS

Proteins are large, complex organic molecules that are made of smaller monomer units, amino acids. Proteins are naturally occurring biological molecules that are composed of amino acids linked together through dehydration reactions.

1. Amino Acids

Amino acids are the building blocks of proteins. There are 20 amino acids.

a. Basic Structure of an Amino Acid

Each amino acid has a carbon with four different groups attached.

1) Amine group, NH_2, (basic charge).

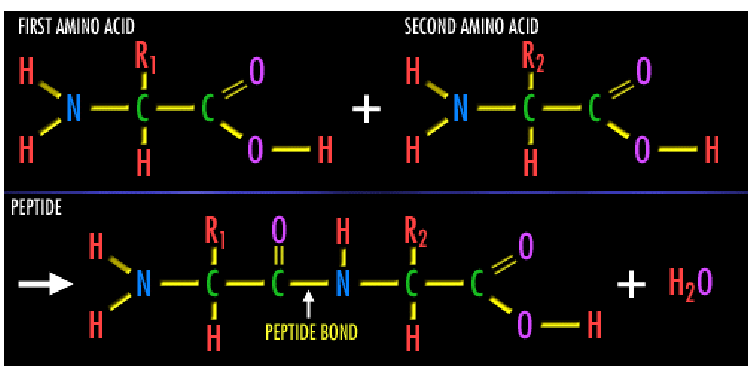
2) Carboxyl group, COOH, (acidic).

3) Hydrogen

4) R group: the R group is the portion of the amino acids that is different in each amino acid. ** know the functional groups - NH2 (amino), COOH (carboxyl), CH - hydrocarbon (hydrophobic- will bend inward away from water), SH (sulfur) and PO4 (phosphate)- needed for quick energy transfer as in ATP, -OH (hydroxy).

b. R Groups

The r group of the amino acid determines the physical and chemical properties of the protein. R groups can be nonpolar, polar, acidic, or basic.



To synthesize proteins, a dehydration reaction occurs. The amino end of one amino acid and the carboxyl end of a second amino acid are joined together. The covalent bond formed is called a peptide bond. The molecule that is formed by adding many amino acids together is called a polypeptide.

Proteins have a three dimensional configuration which is determined by the amino acid sequence. Proteins can be stringy or globular. The conformation of the protein is its three dimensional shape. The function of the protein is determined by its configuration or folding. A protein may have four different levels of structure or folding that determined its conformation.

c. Levels of protein Structure

The amino acid sequence is called the primary structure. The protein is defined by the amino acid sequence held together by peptide (covalent) bonds.

d. Secondary Structure

The secondary structure of a protein refers to the way in which some segments of the polypeptide repeatedly coil or fold in patterns which contribute to the proteins overall shape. These folds and coils are the result of hydrogen bonding forming repeated folds called beta pleated sheets or alpha helices.

e. TETIARY STRUCTURE

The tertiary structure is the actual three-dimensional shape of the polypeptide. The 3-D structure is held together by hydrogen and disulfide bonds

The non-polar (hydrophobic) R groups will tend to group together away from the surface of the polypeptide since water is the usual medium surrounding these molecules (fold inside)

f. QUATERNARY STRUCTURE

A protein consisting of two or more polypeptide chains has a quaternary structure. The quaternary structure is held together by hydrogen bonds, disulfide bridges, electrostatic attractions and hydrophobic forces.

g. DENATURATION

excessive heat or low pH will cause the hydrogen bonds to break and the structure will come apart. will lose function- called denaturation. Denaturation is reversible. If heat is lowered, hydrogen bonds can reform

2. **Types of Proteins**

example, Hemoglobin, a globular protein, binds with oxygen.

1. Collagen: Collagen consists of long fibrous molecules that clump together to make large fibers;
2. Elastin: Elastin has the ability to stretch and gives elasticity to connective tissues such as skin. Loss of elastic property over time causes bagginess in the face, neck and skin.
3. Keratin: Keratin is found in hair, nails, outer layer of skin, feathers, claws, horns, and scales. Cells fill up with keratin, then die and leave the keratin behind.

H. LIPIDS

Lipids are a diverse group of molecules defined by their solubility rather than by their structures. Lipids dissolve in nonpolar solvents. Lipids are hydrophobic and do not dissolve in water. There are 5 types of lipids: triglycerides, phospholipids, glycolipids, steroids and waxes.

Lipids are made of three fatty acids attached to a glycerol (know picture)- the long fatty acid chains are made of CH2 groups)

b. Saturated, Unsaturated and Polyunsaturated Fats

Some fatty acids have no double bonds. The have the most hydrogens possible. These are called saturated fats. Animal fats are usually saturated fats and solidify at room temperature. Some fatty acids have double bond between two adjacent carbons. This structure means that they have fewer hydrogens then the saturated fats; these are called unsaturated fats. Unsaturated fats tend to be oily liquids. They can be found in plants (olive oil, peanut oil and corn oil) more commonly than animals and are usually liquids at room temperature. We can't make unsaturated fats, so we need to eat small amounts of unsaturated fats. Polyunsaturated fats have more than one double bond.

2. Phospholipids

Phospholipids are closely related to triglycerides. Two fatty acids, one saturated and the other unsaturated are linked to a backbone of glycerol. In the place of the third fatty acid is a phosphate group. The phosphate group is hydrophilic while the hydrocarbon chains are nonpolar and hydrophobic. The cell membrane is made up of two layers of phospholipids and proteins.

4. Steroids

Steroids are not structurally similar to fatty acids or lipids. Since they are hydrophobic, however they are called lipids. All steroids have four linked carbon rings. Steroids have a tail and many have an –OH group.

b. Cholesterol

A major constituent of the cell membrane. given stability and fluidity to the membrane

I. NUCLEIC ACIDS

Nucleic acids are the largest organic molecule made by organisms. There are two types: DNA (Deoxyribonucleic Acid) and RNA (Ribonucleic Acid). The pentose sugar in DNA, deoxyribose, has one fewer oxygen atom than ribose, the sugar in RNA.

DNA contains an organism's genetic information. Basically, DNA encodes the instructions for amino acid sequences of proteins. RNA carries the encoded information to the ribosomes, carries the amino acids to the ribosome, and is a major constituent of ribosomes.

1. Structure

Nucleotides are the basic units of both DNA and RNA and can exist as free molecules. A nucleotide is made up of three parts.

a. Pentose sugar: deoxyribose or ribose.

b. Phosphate: in free nucleotides, they occur as a group of phosphates bonded to a sugar. the bond is called a phosphodiester bond

c. Nitrogenous base: there are two types of nitrogenous bases. They are called bases because of the amine groups, which are basic.

1) Pyrimidines: single ring compounds. The two pyrimidines in DNA are cytosine and thymine. In RNA, thymine is replaced by Uracil.

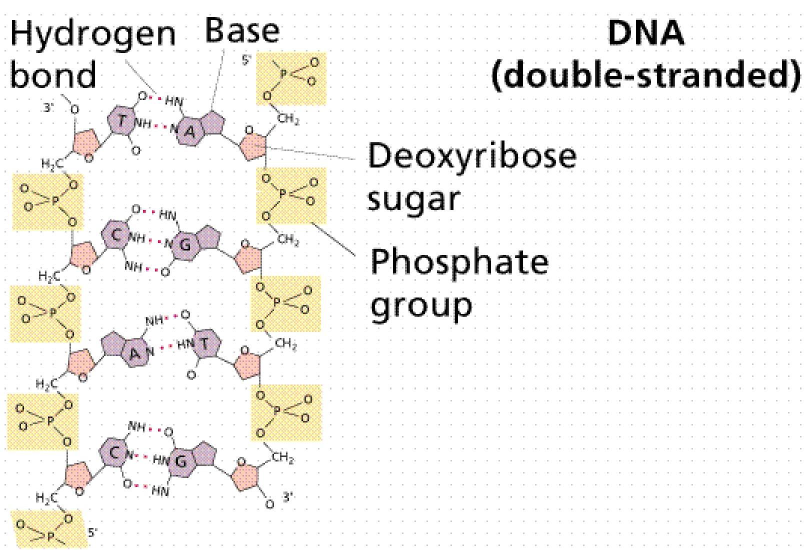
2) Purines: double ring bases. The two purines are adenine and guanine.

2. Importance of Nucleic Acids

a. DNA is the hereditary material; RNA enables proteins to e synthesized from the DNA instructions.

b. A cell's energy source for chemical reactions is stored as ATP (adenosine triphosphate). Between the phosphate groups are bonds, which can be broken to yield usable energy, 7 kcal/mole.

c. CAMP (cyclic adenosine monophosphate) is used as a second messenger in many hormonal reactions.



Practice problems: macromolecules-practice-questions