BIOL 200

Chapter 3

Organic Molecules-

The molecules of life.

Organic molecules contains carbons (C) arranged in rings or chains. Related words to organic are organism, organ organize. The link between organic chemistry and chemistry of living things is called Biochemistry or Biological chemistry.

All organic molecules contain C. C belongs to group 4 in periodic table. It has 4 electrons in its outer shell. It needs 2 more electrons to achieve octet.

C is usually involved in covalent linkages or it can form double bonds or triple bonds or with N.

C-C

C=C

C≡C

C=N

C≡N

Other atoms that are found in organic compounds are O, H, N, P in different classes of molecules.

**Isomers:**

The three dimensional arrangement of the atoms within the molecule is very important.

Molecules that have the same number of atoms and same kinds of atoms are said to have empirical formula. Like ether and ethyl alcohol, both have 2C, 6 H and 1 O

CH3-O-CH3 ( ether) and CH3-CH2-OH( ethyl alcohol).

The arrangement of the atoms and their bonding within the molecule describe its structural formula.

See fig 3.6 for different structural formulas of C6H12O6.

Molecules that have the same empirical formula but different structural formula are called isomers.

**Carbon skeleton and functional groups:**

- The carbon skeleton of the molecules determines the overall shape of the molecule.

- organic molecules may have specific functional groups like OH, NH2, COOH, SH and they determine the chemical properties of your molecule. See Fig 3.7 for functional groups.

**Macromolecules of life:**

Macro means large.

These are carbohydrates, proteins nucleic acids and lipids. They are all polymers.

They are made of smaller units called monomer. Only lipids are not polymer.

When you link two monomers, you usually remove a water molecule. OH form 1 and H form the other.

(see fig 3.9a).

Note that opposite reaction describe a degradation reaction known as **hydrolysis**.

**3.2 Carbohydrates:**

Made of C, H, and O.

* Simplest ones are the monosaccharides. Their main function is to give energy. They are sweet. Example: Glucose, Fructose ,galactose
* 2 to 10 or 15 monomer linked together form oligosaccharides.
* More than 15 moosaccharide linked together for a polysaccharide.

Corn syrup is made mostly of glucose. Fructose comes mostly from fruit and honey.

Starch is a polysaccharide made of long polymer of glucose.

Sugar can be stored in our body in the form of glycogen.

Sugar can be part of RNA and DNA.

A mixture of glucose and fructose is known as an invert sugar. Invert sugar absorb more water hence it is hygroscopic.

**Complex sugar:**

Di saccharide : 2 sugars loss of water when they are linked

Trisaccharide: 3 sugar …..

Very common disaccharides:

Sucrose a disaccharide is made of a glucose and fructose linked together.

Maltose: glucose-glucose

Lactose: glucose-galactose

Sugar can be converted to glucose in your body. Glucose most important sugar for your brain.

**Polysaccharides:**

Examples: starch, glycogen, cellulose (we cannot cellulose digest as we do not have the enzyme, but ruminant can as they have microorganism their guts that help in the digestion).

Fiber add bulk to our diet without adding the calories.

**Proteins:**

They are made of amino acid: C linked to NH2 and COOH and a side chain. Amino acids are linked to each other by a dehydration reaction. The bond is called **peptide bond**.

Amino acids are divided into two groups: **essential and non-essential.**

We have 20 different amino acids that are sued to build our proteins.

Proteins have different levels of structure:

Primary,

secondary,

Tertiary and

Quaternary.

**Primary**: list the amino acid sequence. It is controlled at the DNA level.

**Secondary**: forms either a helix (twist/ spring/coil) or sheet (flat folds that resemble pleated skirt called beta pleated sheet). They are stabilized by **H bonds** .

**Tertiary:** when the secondary structures fold on each other, they give the tertiary shape. Example: Myoglobin that is found in muscle.

**Quaternary:** some proteins are made of more than one polypeptide chain. Each will assume a tertiary structure. The interactions between these chains will form the quaternary structure.

See fig 3.13.

**Form and Functions of Proteins:**

Proteins have specific functions dictated by their shape. If you change the shape, you lose the function. See fig 3.14.

Example: Hemoglobin is made of 2 alpha chains and 2 beta chains. If you change 1 amino acid, function will be lost and diseases like sickle cell anemia or thalassemia occur.

* In sickle cell anemia, a single amino acid number 6 in beta chain glu is changed to Val. Shape of RBC goes from biconcave to sickle.
* Another disease is the mad cow disease (bovine spongiform encephalopathy/ Creutzfeldt- Jacob disease) is casued by prions. Protein sequence is the same but different folding. That cause the disease.

Human protein is rich in alpha helices it changes its shape to beta sheets. This leads to loss of function that causes the disease.

Conditions that change the shape of the protein (**denaturation**):

There are different conditions that may denature proteins. These are:

1. Heat (example heating an egg)
2. pH
3. chemicals

**Functions of proteins:**

1. Structural: they give shape to cells and organism.
2. Regulatory: like enzymes and hormones
3. Carrier

**Nucleic acids:**

They are complex polymers that store genetic information in cell (DNA and RNA)

DNA (deoxyribonucleic acid) is the genetic material.

RNA (ribonucleic acid) is the link between DNA and proteins.

They are made of base, a sugar , and phosphate (either 1 or 2 or 3).

Base is either a purine (adenine A or guanine G) or a pyrimidine (cytosine C, uracil U, and thymine T).

Sugar is either ribose or deoxyribose.

Nucleotides are arranged in different genes that give different proteins.

Sequence at beginning and end specify beginning and end of gene. Human contain 46 chromosome of double helical DNA. Each chromosome has many genes.

Before cell division, DNA has to be copied of each strand duplex so daughter cells receive a full copy of the parent DNA for survival.

DNA genes can:

1. Replciate
2. Mutate to give different proteins
3. Store info
4. Use info to direct synthesis of different proteins.

**RNA:**

There are different types of RNA, mRNA, tRNA, rRNA,etc…

mRNA is a copy of a coding DNA used to give protein. Protein synthesis takes place on special organelles called ribosomes. Ribosomes, sites for protein synthesis, are made of proteins and rRNA.

tRNA are considered to be the carriers of amino acids during process of protein synthesis ( translation).

See fig 3.18, 3.19.

RNA differs from DNA in terms of bases It has U instead of T. In terms of sugar it has a ribose instead of deoxyribose.

**Lipids:**

There are three main types of lipids: Triglycerides (TG) phospholipids, Steroids.

They are non-polar that do not dissolved in water. They do not form polymers. They can be solubilized in ether or acetone. They ar made of C, H, O. Less oxygen compared to carbohydrates.

Simplest lipids are called fatty acids. They are long chains of carbon with a carboxylic head.

Complex lipids may be hydrolyzed.

**True Fat/Neutral Fat (TG)**

They are made of a glycerol unit and linked to three fatty acids. Fatty acids are either saturated (no double bonds) or unsaturated (with double bonds). Saturated fatty acids tend to be solid at room temperature.

You can either identify the position double bonds from omega carbon (the terminal carbon of the fatty acid away from carboxylic head) or from carbon 1 which is the carboxylic head.

Example : 14:15.

This fatty acid is made of 14 carbon with 1 double bond locate at carbon number 5.

Essential fatty acids may not be synthesized in our body. They are 18:29,12, and 18:39,12,15.

These are needed to produce other important molecule for physiological functions..

Double bonds in fatty acids is always is cis configuration and not trans.

Trans fatty acids can be obtained during hydrogenation process of cis to make fatty acid more solid at room temperature. Trans fatty acids are bad for body because they increase bad cholesterol in body (LDL) and decrease good cholesterol (HDL).

-Fat stores more energy than carbohydrates. They are less oxidized than sugar hence can give more energy. You can store more fat in a certain place than carbohydrates because fat are not hydrated.

-Fat is also very important for protection. It is found in ear, under skin of animals to prevent heat loss and around some organs where it acts as a cushion and protects from shocks.

TG: 1 gycerol and 3 fatty acids

DG: 1 gycerol and 2 fatty acids

MG: 1 gycerol and 1 fatty acid.

**Phospholipids:**

They look like TG but have a phosphate at carbon number 3 linked to another group X. They are found on cell membranes. They help emulsification of fats. Lecithin (a phospholipid) can be degraded by digestive enzymes that are called phospholipases.

**Steroids:**

They are made of different number of rings. Parent steroid is cholesterol. It is synthesized in body, it is part of lipid bilayer. It is used in synthesis of bile acids that are needed to emulsify lipids during digestion. It is needed in vitamin D synthesis and synthesis of different hormones.