Chemistry of Life Chapter 3
ORGANIC CHEMISTRY

Introduction

Last week you learned about the atom, different types of chemical bond between atom giving rise to molecules, water (a special type of covalent bond) and pH or hydrogen ion concentration of a solution. This week we will explore four classes macromolecules found in living systems: carbohydrates, lipids, proteins, and nucleic acids. By definition organic compounds are carbon based. These carbon compounds share similar reactive properties. For instances, starting with a simple mono-saccharide produced through the process of photosynthesis plants produce various different types of polysaccharide. Potatoes tubers contain starch, a polysaccharide. Other forms of polysaccharide make up cellulose or wood products. When complex nitrogen bases are covalently bond with a sugar-phosphate molecule nucleic acid form. The common central theme to chapter 3 is the condensation/hydrolysis reactions: water removed through the formation of covalent bonds and water added across these very same bonds to reduce polysaccharides to their simpler forms.

Course outcome:
Describe structure and function of the four main biological macromolecules

Learning goals:

After studying this week's material you should:

1. Know what kinds of molecules are organic
2. Know how organic molecules differ from each other
3. Be able to describe how these molecules combine to form large organic macromolecules
4. Describe how these molecules are split apart by living things.
5. Know what roles these molecules play in living organisms.

Assignments:

These will be found in the Week 3 Folder

1. Read Chapter 3, Organic Chemistry.
2. Visit the following URL:

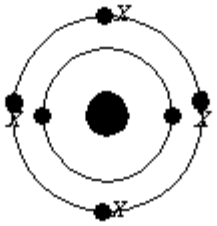
http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookCHEM2.html

Read and study the material here over looking the pKa section. This material is important. This page will provide additional diagrams of biological molecules and information about them. The page takes a long time to load since there are many diagrams and graphics here. Be patient. There is good information to augment material in your text and the diagrams and models of molecules can be very helpful.

I. INTRODUCTION

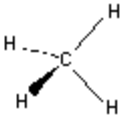
A. The Molecules of a living system

1. Carbohydrates, lipids, proteins, and nucleic acids all have **CARBON** in common

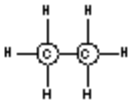


2. Carbon needs 4 more electrons
(X's in figure are electrons unpaired electrons)

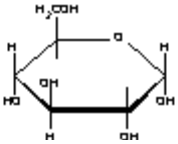
Methane



Ethane



Glucose

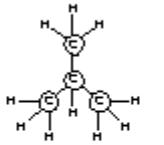


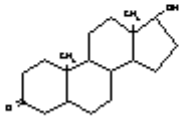
1. Many structural configurations possible

Branched

Ring

b. Carbon compounds are generally referred as **ORGANIC COMPOUNDS**





http://www.tvdsb.on.ca/westmin/science/sbioac/biochem/bioacu1.htm

II. PROPERTIES OF ORGANIC COMPOUNDS

A. Organic compounds consist of carbon and one or more additional elements, covalently bonded to one another

B. Carbon-to-carbon bonds and the stability to organic compounds

Carbon can **share e$^-$** with as many as 4 other atoms to form organic molecules of several configuration

C. Carbon-to-carbon bonds and these shapes can vary

1. Single bonded carbon atom can freely rotate
2. A double bond is restricted in rotation
3. Interactions between carbon atoms give rise to a 3-d shape and function

D. Hydrocarbons and functional groups

1. Only hydrogen atoms are attached to carbon backbone

2. FUNCTIONAL GROUPS: are atoms or groups of atoms covalently bonded to a carbon backbone;

a) Properties: solubility and chemical reactivity

III. HOW CELLS USE ORGANIC COMPOUNDS

A. Different classes of carbon reactions

1. *Enzymes* are a special class of proteins that mediated various biological type of reactions (we will not have to know all of these reactions... except for a. & b.)

a. A *condensation* reaction: Water removed between bonds of simple sugar to make a complex sugar

(2 monosaccharides) --------> disaccharide + H_2O

Glucose + Fructose --------> Sucrose + H_2O

b. *Hydrolysis* reaction is the reverse: Water added across bonds

Ex.: Protein + H_2O ---------> Protein + amino acids

http://www.tvdsb.on.ca/westmin/science/sbioac/biochem/condense.htm

IV. THE SMALL CARBOHYDRATES

A. Monosaccharides -- The simple sugars

Glucose Fructose Galactose

B. Oligosaccharide: Two or more units of a simple sugar

1) Disaccharides: Sucrose, Maltose, Lactose, ect....

C. Purpose: Carbohydrates provide quick and long term energy products, act in the capacity

of structural support materials, and provide carbon frame work skeletal structures.

V. COMPLEX CARBOHYDRATES: THE POLYSACCHARIDE

A. **Polysaccharide:** (meaning many)

Ex.: Large amounts of similar repeating subunits of simple sugars (Starch)

B. Starch: Glucose with linking in an α-1,4 configuration

C. Cellulose: Glucose with various cross linking in β-1,4 configuration

D. Glycogen: mammalian storage of glucose units...Storage in animal's liver.

E. Chitin: nitrogen sugar compound exoskeleton of insects and crabs

http://www.mansfield.ohio-state.edu/~sabedon/biol4020.htm

http://www.mansfield.ohio-state.edu/~sabedon/biol1025.htm

VI. LIPIDS

A. Lipids

B. Fatty Acids

1. A fatty acid is long chain of mostly carbon and hydrogen atoms with a -COOH group at one end

2. When they are part of complex lipids, the fatty acids are like long, flexible tails.

C. Neutrals fats (Triglycerides)

Fatty acid glycerol components

D. phospholipids

Phosphate nitrogen head.... Used in membrane stability

E. Waxes: Bee's wax

F. Sterols and their derivatives

G. Purpose: Lipids pack 2 times more energy value than carbohydrates providing structural membrane components and water proof coatings.

http://www.indstate.edu/thcme/mwking/lipids.html#role

VII. PROTEINS

A. Proteins are polymers of amino acids: (Review illustration in the text book)

B. Three-dimensional structure of proteins

1. Three-dimensional structure is determined by how amino acid sequences present their atoms for hydrogen bonding.
   a. ***Primary structure***: a straight chain of amino acid sequences

   b. ***Secondary structure***: refers to the interaction of a primary protein structure leading to a helical coil or sheet like array (such as mica or fools gold). This structure results from hydrogen bonding of side groups on the amino acid chains.

   c. ***Tertiary structure***: refers to the further folding due to interactions among R groups along the polypeptide chain.

   d. ***Quaternary structure*** describes the complexing of two of more polypeptide chains to form globular (example: hemoglobin) or fibrous proteins.

C. Protein Denaturation:

Loss of Structure: How does this happen?
Hydrogen bonds broken
Di-Sulfide bonds broken
Re-Structuring of protein molecule

D. Purpose: Proteins function in a number of ways –
1) The majority of enzyme are proteins;
2) Proteins make up a mammalian systems defenses against outside disease agents;
3) Protein form a cable like net-work within the cell providing structural support for the cell;
4) Subcellular proteins fulfill transport needs across the cell nuclear and vacuole membranes; And, contractile proteins behavioral characteristics like rubber bands mediating muscle movement.

VIII. NUCLEOTIDES AND NUCLEIC ACIDS

A. Nucleotides with key roles in metabolism
ATP, FAD, NAD

B. Arrangement of nucleotides in nucleic acids: DNA and RNA

Nucleic acids made up of phosphate, ribose sugar, nitrogen base.

C. Purpose: Nucleic acids function in energy translations needs of the cell (ATP), in storing Heritable information for the cell and acting as hydrogen//electron Co-factors in cellular biochemical reactions.

http://www.indstate.edu/thcme/mwking/nucleic-acids.html#intro

(The introduction to the above web is the necessary portion to read)

Special note: You should sight recognize a molecule illustration of:

1. ATP
2. Mono- and Di-saccharide
3. Triglyceride
4. Sterol
5. Amino Acid
6. Phospholid

http://www.gen.umn.edu/faculty_staff/jensen/1135/webanatomy/wa_cell_chem/wa2_BioChem1.htm

http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookCHEM1.html

http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookCHEM2.html

Biology 101 Chapter 3

Name _____

In the table below, enter the name of the carbohydrate described by its carbohydrate class and functions.

Carbohydrate	*Carbohydrate Class*	*Function*
		Most plentiful sugar in nature; transport form of carbohydrates in plants table sugar formed from glucose and fructose
		Five-carbon sugar occurring in DNA
		Main energy source form most organism; precursor of many organic organisms. Serve as building blocks for larger carbohydrates
		Structural materials for plant cell walls; formed from glucose chains
		Five-carbon sugar occurring in RNA
		Sugar present in milk; formed from glucose and galactose
		A branched starch that invites rapid mobilization of glucose; formed from glucose chains.
		Main structural material in some external skeletons and other hard body parts of some animals and fungi
		Animal starch; stored especially in liver and muscle tissue; formed from glucose chains
		Long-term glucose storage form in plants; a starch formed from glucose chains.

Choose the most appropriate answer for each item. Some letters may be used more than once.

1. _____ atherosclerotic plaques
2. _____ richest source of body energy
3._____ Honeycomb material
4. _____ Cholesterol
5. _____ Saturated tails
6. _____ Butter and lard
7._____ Lack fatty acid tails
8. _____ main cell membrane component
9. _____ All possess a rigid backbone of four fused carbon rings
10._____ Plant cuticles
11. _____ Triglycerides
12._____ Precursors of testosterone, estrogen, and bile salts
13. _____ Unsaturated tails
14. _____ Vegetable oil
15. _____ Vertebrate insulation
16. _____ Furnishes lubrication for skin and feathers

A. Fatty acid
B. Neutral fats
C. Phospholipids
D. Waxes
E. Sterols

Choose the most appropriate answer for each term.

17. _____ amino acid
18. _____ peptide bond
19. _____ polypeptide chain
20._____ primary structure
21. _____ protein
22. _____ secondary structure
23. _____ tertiary structure
24. _____ dipeptide
25. _____ quaternary structure
26. _____ lipoproteins
27. _____ glycoproteins
28. _____ denaturation

A. a coiled or extended pattern of protein structure caused by regular intervals of H bonds
B. Three or more amino acids joined in a linear chain
C. Proteins with linear or branched oligosaccharides covalently bonded to them; found on animal cell surfaces, in cell secretion or on blood proteins
D. Folding of a protein through interactions among R groups of a polypeptide chain
E. Form when freely circulating blood proteins encounter and combine with cholesterol, or phospholipids
F. The type of covalent bond linking one amino acid to another
G. An example is hemoglobin which contains four globular proteins
H. Breaking weak bonds in large molecules (such as protein) to change its shape so it no longer functions
I. Formed when two amino acids join together
J. Lowest level of protein structure; has a linear, unique sequence of amino acids an acid group, hydrogen atom, and R group
K. A small organic compound having an amino group, and acid group, a Hydrogen atom, and R group
L. The most divers of all the large biological molecules; constructed from pools of only twenty kinds of amino acids

Choose the most appropriate answer for each term

30. _____adenosine triphosphate 31. _____ RNA 32. _____ DNA 33. _____ NAD^+ and FAD 34._____ $_c$AMP	A. Single nucleotide strand; function in processes by which genetic instructions are used to build proteins B. ATP, a cellular energy carrier C. Nucleotide chemical messenger D. Single nucleotide units; coenzymes; transport hydrogen ions and their associated electrons from one cell reaction site to another E. Double nucleotide strand; encodes genetic instructions with nucleotide sequences.

Complete the tale below by entering the correct name of the major cellular organic compounds suggested in the ‘types’ column (choose from carbohydrates, lipids, proteins, and nucleic acids)

Cellular Organic Compounds	***Types***
a.	Phospholipids
b.	Antibodies
c.	Enzymes
d.	Genes
e.	Glycogen, starch, cellulose, and chitin
f.	Glycerides
g.	Saturated and unsaturated fats
h.	Coenzymes
i.	Sterols, oils and waxes
j.	Glucose and sucrose

Self-Quiz

____1. Amino acids are linked by _____ bonds to form the primary structure of a protein.
a. Disulfide b. hydrogen
c. ionic d. peptide

____2. Proteins _____
a. are weapons against disease-causing bacteria and other invaders.
b. are composed of nucleotides subunits
c. translate protein-building instructions into actual protein structures
d. lack diversity of structure and function

____3. Lipids ____
a. include fats that are broken down into one fatty acid molecule and three glycerol molecules
b. are composed of monosaccharides
c. serve as food reserves in many organisms
d. include cartilage and chitin.

____4. DNA ____
a. is one of the adenosine phosphates
b. is one of the nucleotide coenzymes
c. contains protein-building instructions
d. are composed of monosaccharides.

____5. Most of the chemical reactions in cells must have _____ present before they proceed.
a. RNA b. salt c. enzymes d. fats.

_____6. Carbon is part of so many different substances because_____
a. carbon generally forms two covalent bonds with a variety of other atoms
b. carbon generally forms four covalent bonds with a variety of atoms
c. carbon ionizes easily
d. carbon is polar compound

____7. The information built into protein's amino acid sequence plus a coiled pattern of the chain and the addition of more folding yields the ____ level of protein structure.
a. quaternary b. primary
c. secondary e. tertiary

____8. _____ are compounds used by cells as transportable packets of quick energy, storage forms of energy, and structural materials.
a. lipids b. Nucleic acids
b. carbohydrates d. proteins

____9. Hydrolysis could be correctly described as the ____.
a. heating of a compound in order to drive off its excess water and concentrate its volume
b. breaking of long-chain compound into its subunits by adding water molecules to its structure between the subunits
c. linking of two or more molecule by the removal of one or more water molecule
d. constant removal of hydrogen atoms from the surface of a carbohydrate.

____10. Genetic instructions are encoded in the bases of _____; Molecules of _____ function in processes using genetic instructions to construct proteins
a. DNA; DNA b. DNA; RNA
c. RNA; DNA d. RNA; RNA