AP Biology **Student Interactive Learning Guide**

North Salem University

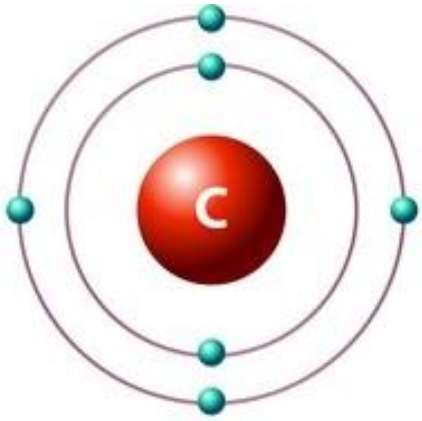
MISSION: *Engage students to continuously learn, question, define and solve problems through critical and creative thinking.*

Summer 2024

*Although water is the universal medium for life on Earth, most of the compounds that make up living organisms are based on the element **carbon**. Of all chemical elements, carbon is unparalleled in its ability to form molecules that are large, complex and diverse. It is this molecular diversity that has made the evolution of life possible on Earth. We will be going through this chapter VERY quickly as much of the information contained in it is considered "**prior knowledge**". The questions and activities that follow in this Interactive Learning Guide should help you focus on the most important points in the chapter.*

If you have any problems – feel free to drop me an email.

Chapter 4:
Carbon and the Molecular Diversity of Life



Chapter 4: Carbon and the Molecular Diversity of Life

OBJECTIVES:

The Importance of Carbon

___1. Explain how carbon's electron configuration determines the kinds and numbers of bonds that carbon will form.
___2. Describe how carbon skeletons may vary, and explain how this variation contributes to the diversity and complexity of organic molecules.
___3. Distinguish among the three types of isomers: structural, geometric, and enantiomer.

Functional Groups

___4. Name the major functional groups and describe the chemical properties of the organic molecule in which they occur.

KEY TERMS:

alcohol	aldehyde	amine	amino group
carbonyl group	carboxyl group	carboxylic acid	functional group
hydrocarbon	hydroxyl group	isomer	ketone
organic chemistry	phosphate group	sulfhydryl group	

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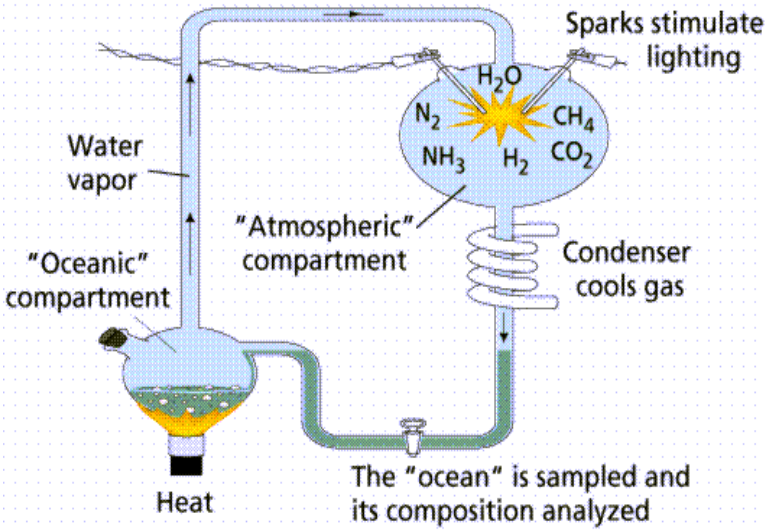
WORD ROOTS:

hydro- = water (*hydrocarbon*: an organic molecule consisting only of carbon and hydrogen)
iso- = equal (*isomer*: one of several organic compounds with the same molecular formula but different structures and therefore different properties)
enanti- = opposite (*enantiomer*: molecules that are mirror images of each other)
carb- = coal (*carboxyl group*: a functional group present in organic acids, consisting of a carbon atom double-bonded to an oxygen atom)
sulf- = sulfur (*sulfhydryl group*: a functional group which consists of a sulfur atom bonded to an atom of hydrogen)
thio- = sulfur (*thiol*: organic compounds containing sulfhydryl groups)

Guided Reading: Chapter 4

1. Why is organic chemistry so important in the study of biology?

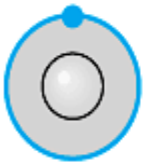
2. Use the figure of Stanley Miller's experiment below to help explain the keys elements of his experiment.



3. What was collected in the sample for chemical analysis?

4. What was concluded from the results of this experiment?

5. Identify the atoms below, list their valence numbers and identify how many different atoms each can covalently bond with.



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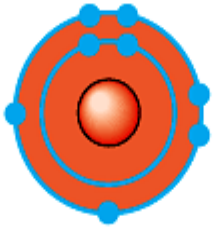

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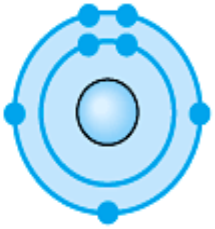

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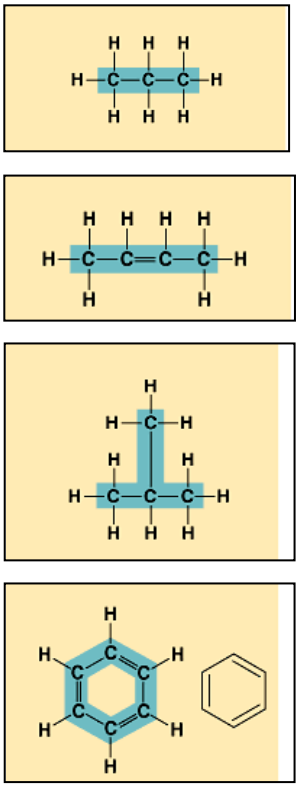
6. In the space to the right, draw an electron distribution diagram of carbon. It is essential that you know the answers to these questions:

a. How many valence electrons does carbon have? _____

b. How many bonds can carbon form? _____

c. What type of bonds does it form with other elements? _____

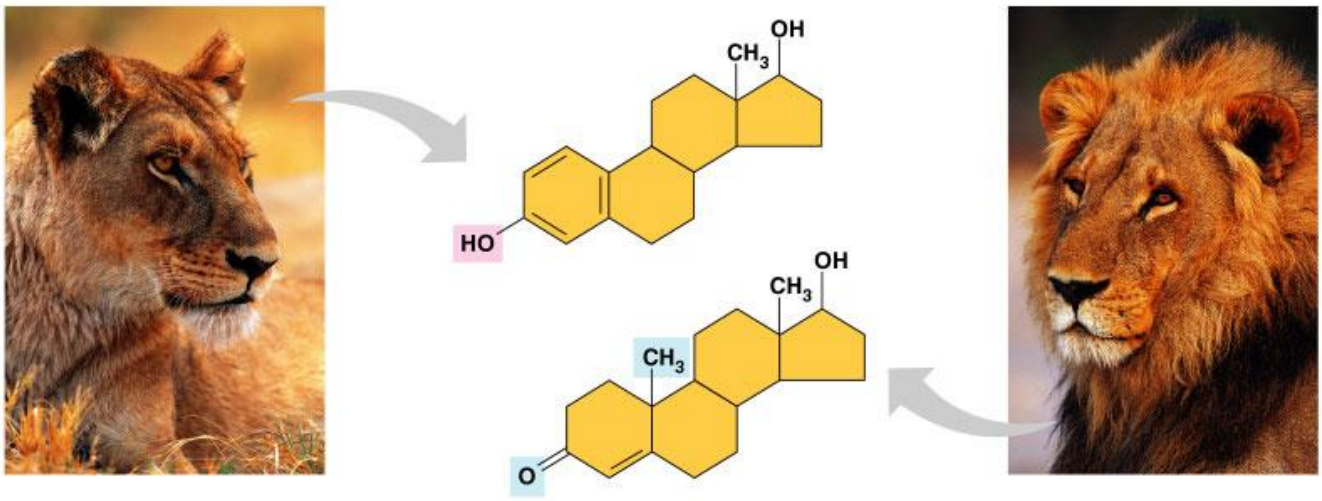
7. Carbon chains form skeletons. Label the diagrams below and use them to describe the types of carbon skeletons that can be formed.



8. What is special about carbon that makes it the central atom in the chemistry of life?

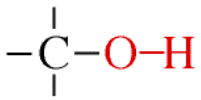
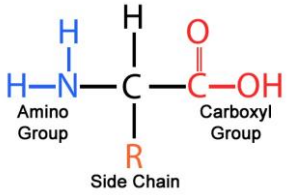
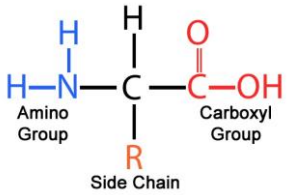
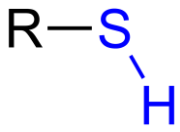
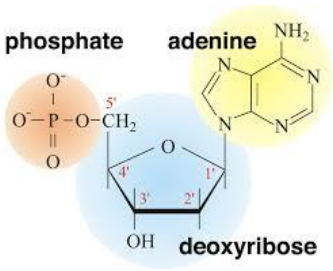
9. What is a *hydrocarbon*? Name two. Are hydrocarbons hydrophobic or hydrophilic?

10. Here is an idea that will recur throughout your study of the function of molecules: Change the structure, change the function (***Structure dictates Function***). You see this in the study of proteins and enzymes, and now we are going to look at testosterone and estradiol (*estrogen*). Notice how similar these two molecules are, and yet you know what a vastly different effect each has. Label each molecule in the sketch below, and circle the differences.



11. Define functional group.

12. Fill in the table below: after each functional group – write an example and note the functional properties.

Group	Structure	Example	Functional Properties
Hydroxyl			
Carboxyl			
Amino			
Sulfhydryl			
Phosphate			

Chapter 4: Summary of Key Concepts

THE IMPORTANCE OF CARBON

- Organic chemistry is the study of carbon compounds **(pp. 52-53)** Organic compounds were once thought to arise only within living organisms, but this idea (vitalism) was disproved when chemists were able to synthesize organic compounds in the laboratory.
- Carbon atoms are the most versatile building blocks of molecules **(pp. 53-55, FIGURE 4.2)** A covalent-bonding capacity of four contributes to carbon's ability to form diverse molecules. Carbon can bond to a variety of atoms, including O, H, and N. Carbon atoms can also bond to other carbons, forming the carbon skeletons of organic compounds.
- Variation in carbon skeletons contributes to the diversity of organic molecules **(pp. 55-57, FIGURE 4.4)** The carbon skeletons of organic molecules vary in length and shape and have bonding sites for atoms of other elements. Hydrocarbons consist only of carbon and hydrogen. Carbon's versatile bonding is the basis for isomers, molecules with the same molecular formula but different structures and thus different properties. Three types of isomers are structural isomers, geometric isomers, and enantiomers.

FUNCTIONAL GROUPS

- Functional groups contribute to the molecular diversity of life **(pp. 57-59, TABLE 4.1)** Functional groups are specific chemically reactive groups of atoms within organic molecules that give the overall molecule distinctive chemical properties. The hydroxyl group (--OH), found in alcohols, has a polar covalent bond, which helps alcohols dissolve in water. The carbonyl group can be either at the end of a carbon skeleton (aldehyde) or within the skeleton (ketone). The carboxyl group (--COOH) is found in carboxylic acids. The hydrogen of this group can dissociate, making the molecule a weak acid. The amino group (--NH_2) can accept a proton (H^+), thereby acting as a base. The sulfhydryl group (--SH) helps stabilize the structure of some proteins. The phosphate group has an important role in the transfer of cellular energy.
- The chemical elements of life: a review **(p. 59)** Living matter is made mostly of carbon, oxygen, hydrogen, and nitrogen, with some sulfur and phosphorus. Biological diversity has its molecular basis in carbon's ability to form a huge number of molecules with particular shapes and chemical properties.

Chapter 4 - Review Questions

___1) Organic compounds -
A) always contain nitrogen.
B) are synthesized only by animal cells.
C) always contain carbon.
D) always contain oxygen.

___2) Since carbon has four electrons in its outermost shell it can bind to as many as _____ other atoms.
A) two B) four C) six D) eight

___3) The chemistry of carbon allows the formation of varied organic molecules which accounts for -
A) the sameness of living things.
B) the diversity of living things.
C) both A and B.

___4) Which of the following is considered a macromolecule?
A) nucleic acid
B) fatty acid
C) amino acid
D) none of the above

___5) Organic molecules are ones that always contain -
A) carbon and nitrogen.
B) hydrogen and phosphorus.
C) hydrogen and carbon.
D) carbon and potassium.

___6) Inorganic molecules do not affect living things.
A) True B) False

___7) Functional groups of organic molecules -
A) determine the polarity of an organic molecule.
B) have specific chemical characteristics.
C) can distinguish one type of organic molecule from another.
D) all of the above.

___8) The process by which polymers are turned into monomers is called -
A) condensation synthesis.
B) hydrolysis.
C) ionization.
D) phagocytosis.

___9) During a condensation or dehydration synthesis reaction, water and a chemical bond are formed.
A) True B) False

___10) Which is the INCORRECT association between monomer and polymer?
A) monosaccharide – polysaccharide
B) nucleotide - nucleic acid
C) nucleic acid - polypeptide
D) amino acid - polypeptide

___11) During hydrolysis, _____ is used to break a bond.
A) starch B) cholesterol C) water D) DNA

___12) Glucose and hexanoic acid each contain six carbon atoms, but they have completely different properties. Glucose is necessary in food; hexanoic acid is poisonous. Their differences must be due to different -
A) monomers.
B) hydrolysis.
C) macromolecules.
D) functional groups.

___13) Which of the following statements regarding carbon is false?

A) Carbon has a tendency to form covalent bonds.
B) Carbon has the ability to bond with up to six other atoms.
C) Carbon has the capacity to form single and double bonds.
D) Carbon has the ability to bond together to form extensive, branched, or unbranched "carbon skeletons."

___14) Which of the following statements about hydrocarbons is false?
A) Hydrocarbons are inorganic compounds.
B) Hydrocarbons contain only carbon and hydrogen atoms.
C) Hydrocarbons consist of atoms linked by single and double bonds.
D) Hydrocarbons can form straight, branched or ringed structures.

___15) Propanol and isopropanol are isomers. This means that they have -
A) the same molecular formula, but different chemical properties.
B) different molecular formulas, but the same chemical properties.
C) the same molecular formula and the same chemical properties.
D) the same molecular formula, but represent different states of the compound.

___16) A hydroxyl group is -
A) also called a carbonyl group.
B) characteristic of proteins.
C) characteristic of alcohols.
D) basic.

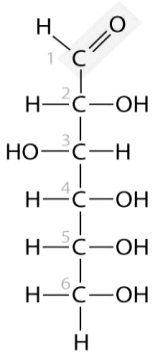
___17) Which of the following is a carboxyl group?
A) CO B) OH C) NH_2 D) COOH

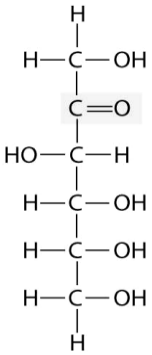
___18) Which of the following is an amino group?
A) OH B) NH_2 C) COOH D) CO

___19) Which of the following statements about the functional groups of organic compounds is false?
A) Functional groups help make organic compounds hydrophilic.
B) Many biological molecules have two or more functional groups.
C) Functional groups participate in chemical reactions.
D) All functional groups include a carbon atom.

___20) The two molecules to the right are structural isomers. What is the difference between them?

A) the number of carbon atoms
B) the number of hydrogen atoms
C) the location of a double-bonded oxygen atom
D) Only one of them has a double bond between carbon atoms.


Glucose
(an aldose)


Fructose
(a ketose)