PART 1: Chemistry - A Fundamental Theme in the Study of Life.

Life is organized on many different structural levels - from atoms, to biological molecules, to organelles, to cells, tissues, organs, and organisms. This workshop is designed to review the basic principles of chemistry as they apply to living things. The behavior of atoms and molecules form the basis for our modern understanding of Biology.

Campbell portends that each new level of biological organization has emergent properties. The interactions among the components at each level of biological organization lead to the emergence of novel properties at the next level: *the whole is greater than the sum of its parts*. Emergent properties also are exhibited within each new level of chemical organization, as the subatomic particles - *protons, neutrons, and electrons* - are organized into atoms and atoms, are combined by covalent or ionic bonds into molecules, the chemical stuff of biological systems.

Exercise 1. Chapter Review

a. As a group, openly discuss the concept of **matter**, the **elements**, **compounds**. Select three different members of your Learning Community to define each of these terms to the rest. Make sure each member of your community understands these terms before proceeding. Ask questions of each other if you are not sure of the definitions.

b. Does a compound have different characteristics than its constituent elements? Have one member of your community name any compound; then tell the other members of your group, how that compound differs from the elements that make it up. Do this same exercise for at least 5 important biological compounds.

c. On the planet Earth weight and mass may be considered synonymous.

1. Define mass.
2. Define weight.

d. The symbolism used in biology and chemistry is often like trying to learn a new foreign language. In the table below are the symbols for many of the common elements found in the human body. Even though is seems trivial, fill in the names of the elements in Table 1 and then list a biological molecule known to contain that element or a biological function for that element; here is where you can test your base of knowledge.

Table 1. Chemical Symbols

Symbol	Element	Biological Molecule or Function
O		
C		
H		
N		
Ca		
P		
K		
S		
Na		
Cl		
Mg		

Exercise 2. Subatomic Particles.

a. Fill in the blanks:

The difference between mass number and atomic number is equal to the number of _____?

An atom of phosphorous contains _____ protons, _____electrons, and _____neutrons?

The atomic weight of phosphorous is _____?

b. Fill in the following chart for the major subatomic particles of an atom.

Particle	Charge	Mass	Location
?			
?			
?			

Table 2. The Major Subatomic Particles found in an Atom.

c. Each member of your learning community should select one of the following terms and verbally define it to all the other members of the community.

neutron, proton, electron, Dalton, atomic number, atomic weight, mass number, isotope, radioactivity.

d. Energy levels:

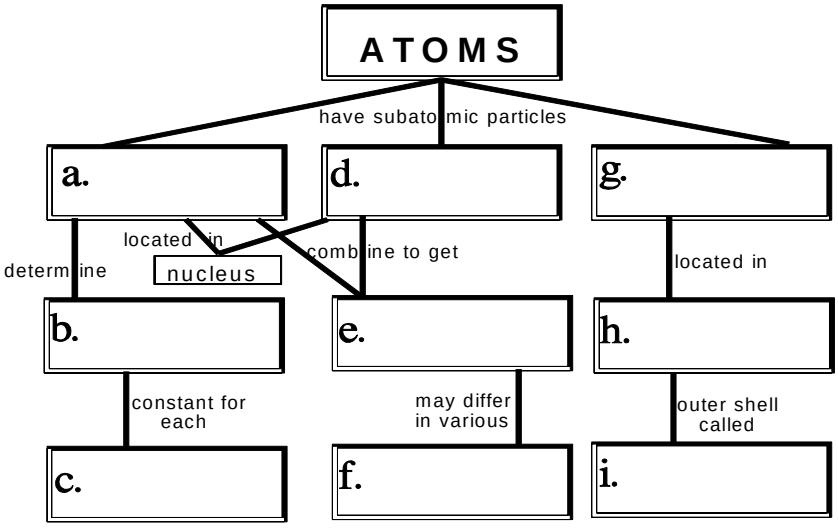
In turn, one member each of the group is to circle the correct answer in each of the following statements and then explain their choice to the entire community.

1. To move to a shell farther from the nucleus, an electron must (absorb/release) energy.
2. Energy is (absorbed/released) when an electron moves to a closer shell.
3. Select four different members of the community to draw the electronic configurations for the following atoms. Each community member should then tell all the others, which of these atoms would you expect to have similar chemical properties and why?

a. $_{7}N$ b. $_{15}P$ c. $_{8}O$ d. $_{17}Cl$

Exercise 3. Concept Map

To help you complete your review of the atomic structure of atoms fill in the blanks in the *concept map* displayed to the right. Each learning community member should define each blank that is filled in.



Exercise 4. Chemical Bonds, Molecules, and Water

In turn each member of your learning community should define the chemical terms below and discuss the significance of each term to all the other members of the community. Be sure not to go on until all members of the community are confident of their understanding of each term.

a. *valance, chemical bond, covalent bond, molecular formula, structural formula, nonpolar, polar, ionic bond, ion, cation, anion.*

b. What are the valences of the four most common elements of living matter?
1. hydrogen _____, 2. oxygen _____, 3. nitrogen_____ 4. carbon_____

c. Calcium and chlorine can combine to form the salt calcium chloride. Based upon the number of electrons in their valance shells and their bonding capacities,
1. What would the molecular formula for this salt be_____?
2. Which atom becomes the cation _____?

d. 1. Select a member of your community to go to the blackboard (or use a large piece of paper that all can see) and *sketch a water molecule*, showing its shape and the electron shells with the covalently shared electrons. Indicate the areas with slight negative and positive charges that enable a water molecule to form hydrogen bonds.

2. Have another member of the Learning Community defend to the whole community the assertion that all of life as we know it depends critically on the fact that the angle between the two hydrogen atoms in the water molecule is 109.5^{o} and not 180^{o}.

e. Hexadecane is a long chain hydrocarbon molecule composed of 16 carbon atoms that are fully saturated with hydrogen atoms. Its molecular formula is CH_3-$(CH_2)_{14}$-CH_3. Palmitate is a fatty acid composed of 16 carbons which has a carboxylic acid at one end of the molecule CH_3-$(CH_2)_{14}$-COOH. Why is the organic molecule hexadecane not a common chemical constituent of cells, whereas palmitate is ?

f. A Principle of Polymers. Biopolymers, long chain molecules composed of repeated individual monomeric subunits, clearly play an important role in the molecular economy of cells. Have one member of your community suggest what advantage it is to have a particular kind of polymer be formed using the same kind of condensation reaction to add each successive monomer unit [if necessary someone should define condensation reaction].

Exercise 5. Biological Building Blocks.

The Building Blocks of Chemical Biology. The great diversity of molecules and molecular structure found in all living cells is simplified when one realizes that most of the larger molecules found in cells are made from only 30 small precursor molecules. In the Table 3 below, have each member of your community *fill in* the spaces with the names of these 30 monomers; then compare your answers among all the members of your community.

These 30 small individual monomeric precursor molecules consist primarily of seven fundamental ***Functional Groups,*** which confer chemical reactivity on the molecules of which they are part. In Table 4 below, *identify* these 7 functional groups, draw the structural formula of the functional groups, indicate for each functional group at least 1 cellular molecule in which that group is found, and place an N, P, or U to indicate whether the group is negatively charged, positively charged or uncharged near neutral pH of cells.

Table 3. The 30 Most Common Monomers in Cells			
Kind of Molecule	**Number known to be present in cell**	**Monomer Name**	**Role in Cell**
?	**20**	?	?
?	**5**	?	?
?	**2**	?	?
?	**3**	?	?

Table 4. Some Common Functional Groups Found in Biological Molecules							
Functional Group --->							
Its Structure --->							
Typical Molecule Containing This Group							
Form that predominates at neutral pH							

N = Negatively Charged Groups @ Near Neutral pH of Cells
P = Positively Charged Groups @ Near Neutral pH of Cells
U = Uncharged Groups @ Near Neutral pH of Cells

Exercise 6. The Fitness of Water

For each of the following statements about water, have one member of your community decide whether the statement is TRUE and describes a property that makes water a desirable component of living cells (**T**); or whether the statement is TRUE and describes a property of water that has no bearing on water as a cellular constituent (**X**); or if the statement about water is FALSE (**F**).

a. Water is a polar molecule and hence an excellent solvent for polar compounds.
b. Water can be formed by the reduction of molecular oxygen (O_2).
c. The density of water is less that the density of ice.
d. The molecules of liquid water are extensively hydrogen bonded to one another.
e. Water does not absorb visible light.
f. Water is odorless and tasteless.

BIO-JEOPARDY

Each of the following statements is an ***answer***. Let a member of your learning community indicate what the ***question is*** for each statement.

a. This component of solar radiation (electromagnetic radiation) is sufficiently energetic to break carbon-carbon single bonds and also induce cancer.
b. This property of water makes it possible for land animals to cool themselves by surface evaporation with a minimum loss of body fluid.
c. The next monomeric unit to be added to a biopolymer must be in this form in order for the condensation reaction to be energetically favorable.

Exercise 7. Mathematical and pH Considerations in Chemistry and Biology.

The definition of logs is as follows : $Y = LOG_a X$ means $a^Y = X$

a. What is $\log_{10} 100$?

b. What is $\log_{10} 1$?

c. If acid rain has a pH of 4.5 and normal rain has a pH of 6.5

1. How many times as many protons are there in acid rain than normal rain ?

2. How many times as many hydrogens ions are there in acid rain ?

d. Fill in the Blanks in the following Table:

$[H^+]$	$[OH^-]$	pH	Acidic, Basic, or Neutral?
	10^{-11}	3	acidic
10^{-8}		8	
10^{-12}			
	1^{-7}		
		1	

e. What fraction of water molecules are H^+ and OH^- ?

(Hint #1 Think about the definition of pH as related to the concentration of H^+ in a water solution. Have a member of your community define and explain pH to the whole group. Hint #2 Can you figure out how many moles of water are in a liter of water? Have a member of your community define what a mole is? Hint #3 A liter of water weighs 1,000 gm and water has a molecular weight of 18).

Exercise 8. CHEMISTRY of the ORGANICS

A. Select one member to draw either the molecular or structural formula for each of the following organic molecules at the blackboard or on a piece of paper. Have the other members of your learning community verify that the structure drawn was correct.

molecular formula structural formula

1) glucose

2) triglyceride

3) phospholipid

4) amino acid

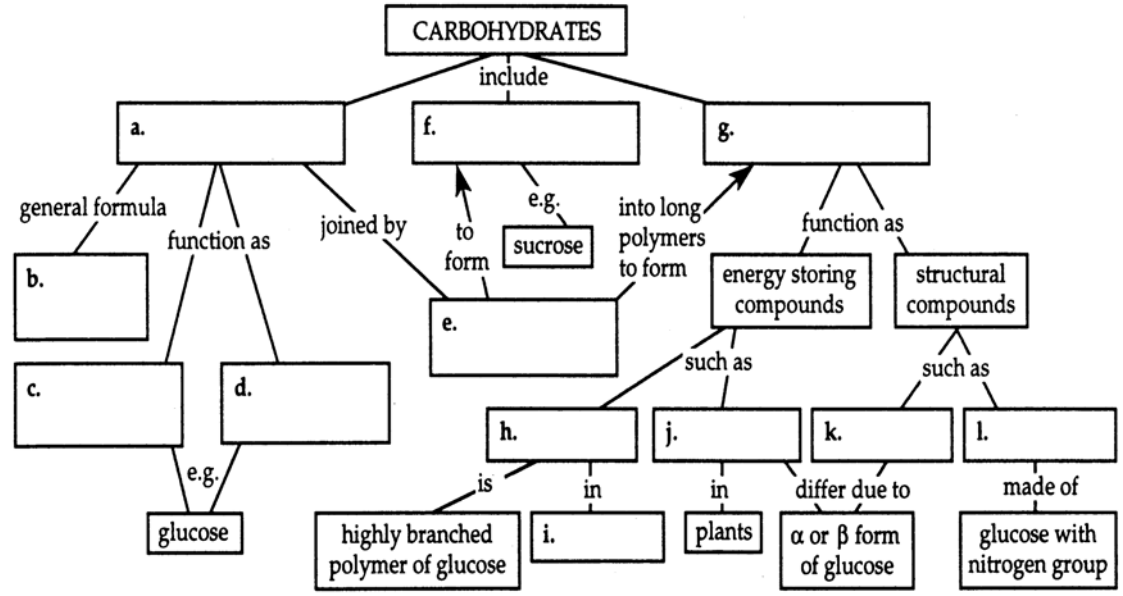
B. Have one member of your Learning Community each, in turn, list at least one of the molecular forces involved in the structure of proteins and tell the others at what level of protein structure that force functions.

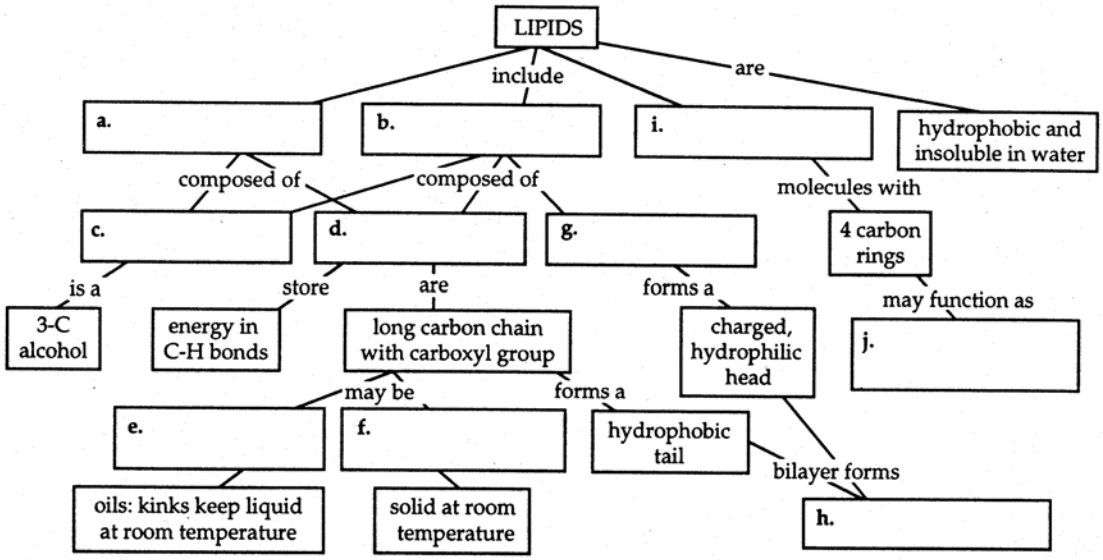
C. Individual members of the community may, for each of the following polymers, draw or otherwise define the monomer units that make up the polymer to the rest of the community. You will be able to find the answers in your textbook, if you look carefully.

Starch and glycogen
Cellulose
Insect Exoskeletons
Human hair, bird feathers, reptile scales
Silk

Exercise 9. CONCEPT MAPS for the major macromolecules [carbohydrates & lipids].

Have each member of your learning community in turn fill in one of the boxes in alphabetical order. If appropriate explain the concept at each lettered box.





Exercise 10. Short Answer/Discussion Problems

The level of difficulty of each of the following problems increases and may go beyond what you have covered in lecture to this point in the course. Do each of the following questions under the guidance of your facilitator.

a. A different member of your Learning Community is to answer each one of the following to the rest of the members of the community. Give the **SIGNIFICANCE** (not the definition) of each of these terms or phrases, i.e. say what they do or why they are important in biology.

For example : ***water*** **-** the fluid matrix of the cell; water is the solvent for the polar molecules of a cell, and determines the final structure of many biological molecules and their interactions.

1. electro-negativity 2. free radicals 3. carbon 4. functional groups

b. Water has been described as an excellent thermal buffer for cells. What does that mean, and what accounts for this property of water?