Name _____ Period ____ Date _____

Molecular Models and the Origin of Life

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Introduction:

Atoms in the universe share a fundamental architecture. Formed in the birth of stars since the Big Bang many billions of years ago, groups of atoms called molecules compose all of matter, including living things. Life's atomic structure is not fundamentally different. By creating 3-dimensional models of organic and inorganic compounds using ball and stick(or spring) kits, students recognize that it is the number, type, and arrangement of atoms that gives each compound its unique set of physical and chemical properties. Life is merely the most splendid of all atomic creations.

Atoms bond with each other in order to fill their outermost electron shell. This is generally true for all atoms except the noble gases. The number of electrons needed to fill this outer shell is equal to the number of bonds (shared pairs of electrons) formed between atoms. The biochemical magic of carbon, so essential to life on Earth and probably elsewhere in the universe, lies in the four electrons of its outer shell. Needing four electrons to fill its outer shell, carbon can form four bonds. In some cases carbon forms four single covalent bonds: as in methane CH4. It can also form double bonds (each with two shared pairs of electrons) as in carbon dioxide, with carbon in the middle and an oxygen atom on each side: O=C=O. Carbon can even form triple bonds as in acetylene gas: H-C≡C-H; and in hydrogen cyanide H-C≡N. It is this extremely flexible molecular architecture that produces the multitude of different organic compounds.

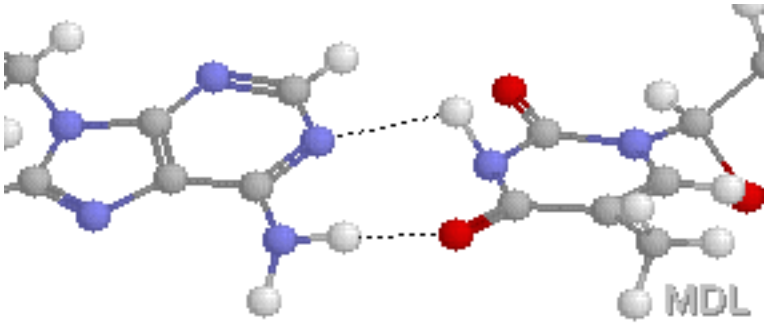

image from U. Mass., Boston: http://www-nss.oit.umass.edu/microbio/rasmol/workshop.htm

Purpose: To create 3-dimensional models of simple inorganic molecules and more complex organic molecules.

Materials: (per team of 2) ___ molecular model kit ___ 3 page student lab sheet
___ teacher provided disk or printout of molecule images, unless drawn on the chalkboard

Procedure: In this exercise you are to create 3D molecular models of each of the compounds listed on the next page. Each color-coded ball of the kit represents a particular kind of atom. Before starting note the color of each kind of atom you will be using in this lab. Carbon = _____, Nitrogen = _____, Hydrogen = _____, and Oxygen = _____.
Have your instructor check off each molecule after you feel you have correctly constructed your 3D ball and stick model. As a guide, each molecule's structural formula may be on handouts, on disk or on the chalkboard . Notice the molecular formula in parentheses.

With one organic structure kit shared between 2 individuals make the following molecules:

___ 1. **water (H_20)**, the most important molecule on planet Earth. Universal solvent.

___ 2. **ammonia (NH_3)**, a base (as opposed to an acid) used in cleaning, and possibly existed as a gas in the earth's early atmosphere.

___ 3. **hydrogen peroxide (H_2O_2)**; a bleach blonde's favorite recipe. Also a natural , but poisonous by-product of cellular metabolism that is constantly being broken down in your body by the enzyme catalase.

___ 4. **ethanol (C_2H_5OH)** , the "active" ingredient in alcohol.

___ 5. **hydrogen cyanide (CHN)**, the gas that you get if you get "the gas chamber"(hint: need a triple bond)

___ 6. **Glucose ($C_6H_{12}O_6$)**, the most important energy source in living things.

___ 7. **Urea (CH_4N_2O)**; principle component of urine and product of protein metabolism.

___ 8. **Acetic acid ($C_2H_4O_2$)**; also called vinegar, the sour ingredient in Italian salad dressing.

___ 9. **Lactic acid ($C_3H_6O_3$) or** ; the substance that makes your muscles ache after heavy exercise.

___ 10. **Benzene (C_6H_6)**; a very, VERY dangerous substance now banned from use in K-12 schools.

___ 11. **Phenol**; (**C_6H_6O**) the active numbing ingredient in many sore throat medications like Chloroseptic.

___ 12. **Alanine ($C_3H_7NO_2$)**; 1 of the 20 different amino acids that make up proteins in LIVING things

___ 13. **Thymine ($C_5H_6N_2O_2$)**; 1 of 4 different "information" molecules that make up DNA (the life code inside the nucleus of every cell)

___ 14. **Aspirin ($C_9H_8O_4$)**; the famous "headache" medicine developed in the late 1800's

Using 2 kits shared between two teams of two working together as group of four.

___ 15. **Aspartame** (**$C_{14}H_{18}N_2O_5$**) the 3rd generation artificial sweetener (after cyclamates and saccharin). The first 2 are hazardous to your health. And cyclamates are actually banned in this country because they are known carcinogens.

___ 16. **Testosterone ($C_{19}H_{28}O_2$)**; The male hormone often used as an excuse for explaining why boys are always running after girls.

___ 17. **TNT ($C_7H_5N_3O_6$)** Trinitrotoluene, the famous explosive.

___ 18. **Vitamin C ($C_6H_8O_6$)**; an important co-enzyme that is important for proper cell function and repair.

(for fun you might want to look up and create molecules of chocolate, caffeine, vanilla, vitamin E, etc.)

DISCUSSION: (answer on a separate piece of paper and attach to this lab sheet)

1. Of what kinds of atoms do most of the molecules that you constructed seem to be made?

2. Are most of the molecules you created organic or inorganic?

3. What 3 factors cause each molecule to be unique from the other molecules?

4. Does it seem possible that you could make a whole piece of DNA from bits and pieces of any of the other molecules? Explain.

5. Though still the subject of considerable debate, scientists conclude that life, and the molecules that led to the evolution of life, formed on earth under natural conditions many billions of years ago. How is an answer to the question about "how" the first pre-biotic molecules formed different from "if" the first pre-biotic molecules ever evolved?