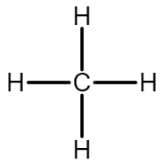
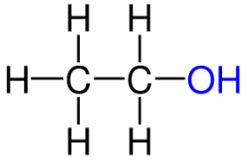
# **Virtual Molecular Model Kit Lab:** FUNCTIONAL GROUPS

*Reference: NELSON section 1.3*

## Introduction:

Macromolecules often contain one or more specific groups of atoms (sub-molecules), called **functional groups**. These sub-structural components are responsible for the chemical behaviour of a macromolecule. This virtual lab will help you learn about the various functional groups that are found in biological macromolecules.

The **structural diagram** graphically outlines the bonding arrangement of a particular molecule. For example, ethanol's **molecular formula** is $C_2H_5OH$, but its **structural formula** is represented graphically with the hydroxyl functional group written as –OH.

| Name of Compound | Molecular Formula | Structural Diagram/Foruma |
|---|---|---|
| methane | $CH_4$ |  |
| ethanol | $C_2H_5OH$ |  |

**Legend:**

| **Atom** | Hydrogen | Oxygen | Nitrogen | Carbon |
|---|---|---|---|---|
| **Colour** | white | red | blue | black |
| **# of bonds** | 1 | 2 | 3/4 | 4 |

## Procedure:

Go to https://chemagic.org/molecules/amini.html

Make models of each of the following and answer the following questions in the space provided.

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1. Construct a **water** molecule.
    a. *Draw a water molecule. Label the partially negative and positive ends.*
    b. *What specific type of bond occurs between an oxygen atom and hydrogen atom in a molecule of water?*
    c. *What specific type of bond occurs between separate water molecules?*

Diagram of water:

2. Construct a **carbon dioxide** molecule.
    a. *How many bonds link each oxygen atom to the carbon atom?*
    b. *What specific type of bonds are present in the molecule?*
    c. *Is this a polar or non-polar molecule overall? How do you know?*

Diagram of carbon dioxide:

3. Construct a **methane** molecule ($CH_4$).
    a. *Describe the shape of the model.*
    b. *Is methane a polar molecule?*
    c. *Draw a methane molecule.*
    d. *Can you tell whether or not the molecules are polar from the models? Explain.*

Diagram of methane:

4. Now remove one hydrogen atom and replace it with a methyl group ($CH_3$). You have formed **ethane**.
    a. *Draw the structural diagram for ethane.*
    b. *Why is ethane called a hydrocarbon?*

Structural Diagram of ethane:

5. **Alcohols** are characterized by having an hydroxyl (OH) group. Using your previous model for methane, make **methanol.**
    a. *Draw the structural diagram for methanol.*
    b. *Write its molecular formula.*
    c. *Name the functional groups.*
    d. *Methanol is a liquid and methane is a gas. Explain why the molecules exist in this state.*

Structural Diagram of methanol:

6. Remake a methane molecule. Now remove two hydrogen atoms from the carbon atom and attach one oxygen atom (remember to make a double bond from the carbon atom and the oxygen atom). You have made **formaldehyde**, a preservative for dissection specimens.
    a. *Draw the structural diagram for this molecule.*
    b. *Is formaldehyde a polar or a non-polar molecule overall?*
    c. *What functional group does it contain? Circle it on your diagram.*

Structural Diagram of formaldehyde:

7. Remove one hydrogen atom from formaldehyde and replace it with a methyl group.
8. Remove the hydrogen atom from the central carbon atom (i.e. not from the methyl group) and add on another methyl group. You should now have a molecule with 2 methyl groups called **acetone**.
    a. *Draw the structural diagram for this molecule.*
    b. *What functional group does it contain? Circle it on your diagram.*

Structural Diagram of acetone:

9. Remove a methyl group and add a hydroxyl group. You have produced vinegar or **acetic acid**.
    a. *Draw the structural diagram for this molecule.*
    b. *What is the chemical formula of acetic acid?*

Structural Diagram of acetic acid:

10. Construct the molecule $CH_3NH_2$ (called **methylamine**).
    a. *Draw the structural diagram for this molecule.*

Structural Diagram of methylamine:

Before beginning this section, it is important that you understand one more thing about amino acids. Normally an amino group will have two hydrogen atoms bonded to a nitrogen atom, and a carboxyl group will have one carbon double bonded to an oxygen and single bonded to an hydroxyl (OH) group. However, when an amino acid is dissolved in water, such as when it is inside the human body, the hydrogen from the carboxyl group will leave and will bond to the nitrogen in the amino group. This will create an amino group with three hydrogen atoms and a carboxyl group with only two oxygen atoms and no hydrogen atoms.

11. Using the molecule of methylamine from step 10, remove a hydrogen atom from the carbon. Add a carboxyl group (-COOH) to this carbon. You have just constructed **glycine**, the simplest of the amino acids. Now construct glycine as it would appear when dissolved in water. *Draw BOTH structural diagrams for these molecules.*

Structural Diagram of glycine:

Structural Diagram of glycine in water:

12. In this step you will continue with the molecule from step 11. Locate the central carbon and remove one of the two remaining hydrogen atoms. In place of this hydrogen add a methyl group (1 carbon bonded to 3 hydrogen atoms). This is the amino acid **alanine**. *Draw this molecule when it is dissolved in water.*

Structural Diagram of alanine in water:

13. Name TWO functional groups that were not constructed in this lab.

_____and _____