Build Your Own Molecule
Teacher Activity

This activity lets the students get creative. It is also an activity well suited for students with body-kinesthetic intelligence as described in the theory of multiple intelligences. For this activity you will need molecular modeling kits, enough for each student. You will also need access to standard chemical references such as the *Merck Index* or the *CRC Handbook of Chemistry and Physics*. If those are unavailable, a catalog from a fine chemical supply house can be used.

Procedure

Building the Molecules

Since this activity is meant to put them in the shoes of the scientist as a builder of molecules, you may want to start by showing them models of salicylic acid and acetic anhydride. Then rearrange the atoms in your models to make acetylsalicylic acid and acetic acid. This will reinforce the idea of building molecules with specific designs for specific purposes.

Before the students can build their molecules, you may have to explain the "rules" to them. Let them know that a black ball is a carbon atom, a red ball an oxygen atom, and so forth, and that each color atom has a certain valency: the black carbons should have four bonds, the blue nitrogen three, the red oxygen two, and the white hydrogen one. Show them how to form single and double bonds using the models. Make sure they know that a double bond counts as two of an atom's available valences! You might want to use this opportunity to reinforce that each bond is a pair of electrons shared by two atoms, and that each double bond is four shared atoms.

To keep things manageable, and to make sure you have enough supplies for all students, it is a good idea to impose limits on how many atoms the students can use in their molecules. For example, you might give each student only a certain number of atoms with which to play, with most of them carbon and hydrogen, and smaller numbers of heteroatoms. This will also make their structures more likely to be real molecules. We suggest the following be given to each student:

- 10 black, tetravalent atoms to represent carbon
- 2 red, divalent atoms to represent oxygen
- 2 blue, trivalent atoms to represent nitrogen
- 24 white, monovalent atoms to represent hydrogen
- 40 single bond connectors
- 10 double bond connectors (enough for five double bonds)

Probably most the atoms in a modeling kit will be tetravalent, even the red and blue ones meant to represent heteroatoms. You have the option of filling in the extra holes in each model heteroatom with modeling clay to achieve the proper valency, or you may challenge your students to learn the valency of oxygen, nitrogen, and hydrogen as part of the game.

Inspect each molecule that each student makes to make sure that it is chemically sound (that is, that none of them has long chains of oxygen atoms or some other structural improbability). Also check for proper valency of the heteroatoms. Make sure the students know that it is not necessary to use every atom in their kits to make their molecules.

Let the students figure out the molecular formulas for themselves, as they should be able to count by this point! Then you will work with each student to determine the proper name for the molecules created, and how to draw properly flat structures for the molecules. The students need not learn all the rules of nomenclature or the conventions for drawing structures, just as long as they get a name and picture of their own molecule. They'll need them for the next step in this activity.

Data Analysis and Concept Development

Researching the Molecule

Once the students have the formulas, names, and structures of the molecules they have built, each student will have to find out whether his or her molecule really exists. If it does exist, the students will then answer a set of questions about the molecule. This will require research in the library or on the Internet. It will be necessary to have access to a fine chemical supply house catalog, and it will be very useful to have access to the other standard chemical references mentioned in the first paragraph.

If a student makes a molecule that does not exist have that student research a real molecule with a similar structure. As a challenge for advanced classes, after the students have finished their research you may want to present the original nonexistent structure to the class and have students speculate on what properties it would have.

Student Misconceptions

This activity will give you the opportunity to reinforce the connection between the symbols of chemical formulas and equations, macroscopic compounds, and unseen molecules. While these connections seem obvious to a chemist, some students have trouble connecting the three. Learning through research reinforces the idea that their symbolic molecules represent real microscopic molecules, and these microscopic molecules make up real macroscopic materials.

Post-Lab Questions

1. Does your molecule exist in real life?
2. If your answer is "yes," then answer the following questions. If your answer is "no," then find a molecule with a structure similar to the one you built, that does exist in real life. Then answer the following questions about the real-life molecule.
3. Does your molecule have any other names than the one you derived for it?
4. What is your molecule used for?
5. Is your molecule found in nature? If so, where?
6. If your molecule is not found in nature, from what materials is it made?
7. At room temperature, is your molecule a solid, liquid, or gas?
8. What is its melting point?
9. What is its boiling point?

10. Can you point to atoms or an arrangement of atoms in your molecule that gives it its properties or that makes the molecule useful?
11. Can you buy your molecule from a chemical supply catalog? If so, how much would 1 kg cost?
12. Is your molecule toxic? If so, how much of it would you need to kill an adult rhinoceros? Hint: the rhinoceros weighs 2000 kg.