4.4: Molecular Models for Ethanol Burning Reading

In your investigation you made some important observations of how ethanol burns, and you found patterns in those observations. For example, you found that ethanol loses mass when it burns, and that there is more CO_2 in the air after ethanol burns. These observations and patterns can help you answer some of the Three Questions, especially the Matter Movement Question: Ethanol must be moving into the flame, and CO_2 must be coming out of the flame.

But a good chemical explanation also needs to answer the Matter Change Question and the Energy Change Question. You need to explain what's happening to matter and energy *inside* the flame. Atoms are rearranging into new molecules inside the flame, but they are too small for even the most powerful microscopes to detect. So observations are not enough to answer the Matter Change and Energy Change questions. We need *scientific models.*

What Are Scientific Models?

In addition to systems or events that they can observe directly, scientists want to understand things that are too small, or too big, or too long ago, or too far away, for us to observe. For example, scientists want to understand:

- What is in the center of the Earth and the center of the Sun.
- What was living on the Earth millions of years ago.
- How our climate will change in the future.
- What is happening to matter and energy inside a flame.

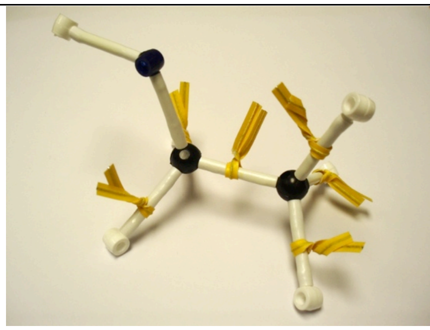
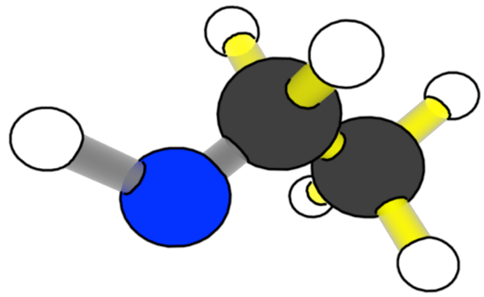
Scientists develop *models* to explain and predict events and phenomena in systems and support their models with evidence-based arguments. Scientific models are useful because they show the rules and mechanisms that govern how a system works. Scientific models can be represented in different ways – for example with diagrams, equations, simulations, or physical objects. Scientists also test their models in many different ways. For example, they use their models to make predictions about things that they can observe or measure, then check to see how accurate the predictions are. The best scientific models have been tested by thousands of different scientists, so scientists have great confidence in their accuracy.

Atomic-molecular Models of Chemical Change

Atomic-molecular models are perhaps the most important of all scientific models, in part because they are so useful for explaining chemical changes. The rules in the Three Questions Handout are an important part of the atomic-molecular scientific model because they describe how systems work at the atomic-molecular scale. Elizabeth Fulhame was a very careful observer, but when she conducted her investigations, she did not have access to accurate models of atoms and molecules. This limited her explanations and predictions.

Unlike Elizabeth Fulhame, you can explain ethanol burning by using materials to represent what is happening at the atomic-molecular scale. From your investigation, you know the reactants (or starting materials) and the products (or ending materials) when ethanol burns. With that information, you can 'zoom in' and model the change that is happening at the atomic-molecular scale.

You will use different representations of atoms and molecules when you answer the Matter Change Question and the Energy Change Question, particularly the three representations shown below, in your explanation. Even though these representations look different, they all show the same molecule, with the same atoms and the same bonds.

Three representations of an ethanol molecule	
C_2H_5OH 1. Chemical formula	
 2. Physical model	 3. Digital model

Rules to follow. The atoms in the different representations all follow the same rules. These rules are that:

- Atoms in stable molecules have a certain number of bonds to other atoms:
  - Carbon: 4 bonds
  - Oxygen: 2 bonds
  - Hydrogen: 1 bond
- Oxygen atoms do NOT bond to other oxygen atoms if they can bond to carbon or hydrogen instead.

You also know that atoms last forever in chemical changes, so you can make new molecules with the same atoms, but you cannot get rid of any atoms or bring in new atoms during the change.

Following these rules, you can model the chemical change that happens when ethanol burns.