1.1: READING, DRAWING AND UNDERSTANDING; THE POWER OF VISUALIZATION

There are several reasons why a systematic plan for preparation is so integral to a laboratory experience, but it boils down to the fact that an organic chemist must have information that far supersedes the information provided in a typical lab manual. When you are performing an experiment, there is little time to look up densities, perform calculations, look up safety and hazard information for chemicals and do any in-depth research on the theory behind the techniques you use. You must bring all this information with you. In many cases the lack of this information can have detrimental consequences for your experiment, your learning outcome and last but not least the safety of the laboratory.

So how can you prepare better?

Let us start by looking at the procedure. It is a recipe that describes the order of events, and the key operations that must be performed. However, just reading the procedure will never prepare you adequately.[1] Why is that? The first reason, is that there is far too much material to remember, at any given time, and events that happen early in the experiment, will influence the outcome later. The second reason, is that any lab manual, even the ones designed for undergraduate use, never spells out everything that must be done. A third reason, is that any lab manual expects that the reader has some expertise and some level of experience.

This is something you most likely already know, from your everyday life.

Let's say that you want to follow a recipe you are not familiar with to make a birthday cake. You start on step 1 and work your way through the recipe, but after a while, you run into a problem.

1 Every term we see many students that simply read the procedure (sometimes repeatedly), and end up confused and suffering through a sub-par experience.

The recipe calls for four cups of flour, but you only have two. You have a hot oven that is ready for the cake batter, a half-made frosting, and a batter that is not ready at all. You switch off the oven and rush to the store for more flour. By the time you come home, the oven is cold (and must be re-heated), and the frosting has split because you left it out in room temperature for half an hour.

This example might seem far removed from the lab, but it is perfectly transferrable. Because you had not read the recipe (or prepared adequately), you wasted time and part of your cake. Nobody wants to waste a cake.

If we take another cake-analogy and move closer to what an experiment in a lab might look like, we can say that you have a recipe for your great grandmother's favorite chocolate cake that you wish to make. Here is the start of the recipe:

GREAT GRANDMOTHER ELSA'S FAVORITE CHOCOLATE CAKE:

1. Pre-heat oven.
2. Beat 1 stick of butter with 1 cup of sugar until mixture is light.
3. Add 3 eggs, one at the time, to the sugar and butter mixture.
4. In a bowl, add 2 cups of flour, 1 small spoon of baking powder and 1 cup of cacao-powder.

Let us think of this recipe as a lab procedure. What we absolutely do not want is to read the procedure once, and then go to the kitchen (lab) and start to make the cake (the experiment). Why not? Well, we will immediately run into many problems. In step one; Elsa says to pre-heat the oven. To what temperature, exactly? Moreover, in step 2, we beat together butter and sugar. With what? And in what? What size bowl do we need? What will we use to do the actual beating? In step 3, we add one egg at the time, but surely, we should carefully beat in each egg, before the next one is added? Elsa does not clarify that, but if we did not have to beat in each egg, there would be no point in adding one egg at the time.

As in Elsa's recipe and in a lab manual (even one designed for undergraduate use) we absolutely need to visualize the recipe or procedure, before we move on. You might have noted that through the act of visualizing Elsa's recipe, I identified several issues and questions. We want to be aware of these up front, so that we have the answers and solutions before we start cooking.

Visualization is the act of seeing the procedure before your eyes, as you read it. This is a very important part of preparation, as it allows you to identify any problems, questions or issues before you go into the lab. It also allows you time to look up valuable information. Elsa did not give us the exact temperature for baking her cake, but we could always look up what baking times for similar cakes are.

At this stage, I want to introduce another powerful tool: the flow chart. The flow chart is a graphical over- view of a procedure that should contain the essentials needed to complete the procedure. The flow chart is a product created after visualization, and it should be something you bring with you to lab. It should outline the flow of the experiment, but also provide something additional to the procedure: namely, the answers to all those questions that came up during visualization.

In the figure shown I have shown a flow chart for Great Grandmother Elsa's recipe. Note that I have included all the information from the questions above.

I have the temperature of the oven (based on a search I did for similar cakes), I have the sizes of the bowl, and the added clarification to beat in each egg, before adding the next.

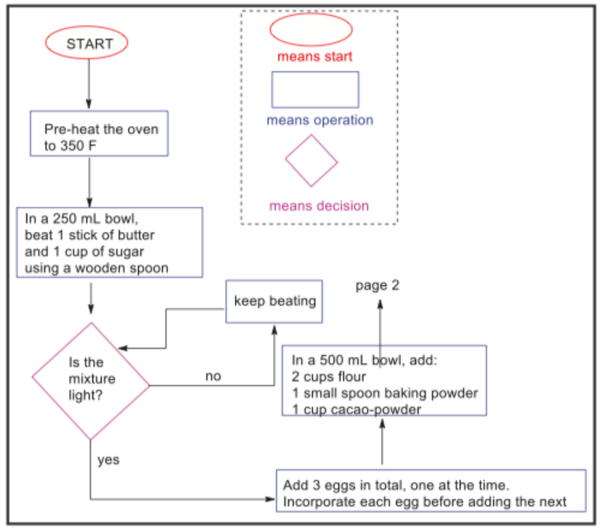

Figure 1.1. An example of a flow chart for Great Grandmother Elsa's chocolate cake. Note that I have incorporated the questions that arose during the visualization phase.