Biological Chemistry

What we are going to be looking at today in class is something known as biological chemistry; and what this is going to allow us to do is to get a good handle on some very detailed processes just by looking at a few simple chemical facts. First thing we want to recognize is that the elements carbon, hydrogen, oxygen, nitrogen, phosphorous and sulfur or C, H, O, N, P, and S for short make up about 99% of the major compounds found in living organisms. (00'30") If you understand these elements a little bit, you would come a long way in understanding more complex biological processes. Further more, these elements are actually put together into small groups of elements called functional groups.

A functional group is a very reductionist way of looking at things. A lot of times, if we see a functional group is a molecule, we do not have to look at the whole molecule. We just know by processing that functional group that it is going to have certain chemical processes (01'00") and carry out certain types of reactions. For instance, if a substance has a sulfhydryl group in it, this is an indication that we are looking at protein. We do not have to test for the entire protein. We just have to look for the presence of the sulfhydryl and the chances are that we have a protein. This reductionist view in using chemistry is actually very beneficial because believe it or not, it simplifies things enormously for scientists.

What we are going to be looking at for today is seven functional groups. These seven functional groups are carboxyl (01'30"), hydroxyl, amino, aldehyde, ketone, sulfhydryl, and hydrocarbon (Repeated once more). You will be seeing those groups again and again in this lab. You also want to make sure that you spend some time recognizing them very specifically because they are used throughout biology to sort of describe chemicals. When we look at a

protein, we might say: "Let's look at this amino group" and "what is that amino group doing there?" (02'00") Or if we are looking at flour, we might say: "Look at these long hydrocarbon chains". Do not fool around now and just ignore this. It is extremely important to have a good grasp on these functional groups, what they are, and recognize them on sight. Then, you are going to carry out a series of test for these functional groups using some basic forms of chemistry that we looked at a little bit already and some new techniques as well.

The first test we are going to ask ourselves is: "Is our molecule biological or does it have calories?" (02'30") A very simple test is one that you and I are actually very familiar with. If you are burning something on the stove, you are actually carrying out what is called the char test. A char test is a test used to look for organic molecules in a solution and to see if they have calories. For instance, if you burn some sugar or if you burn some food on this stove, it will eventually turn black. This is an indication that the molecule has calories in it. However, if you burn salt or if you try to burn (03'00") baking soda, you will discover that you do not get a char test because the substance does not have any calories. You do a quick char test and this is the way of seeing: "Does my food items or does my biological molecule have calories in it?"

The next test is the Benedict's test or reducing sugar. This test is something you will be looking at a number of times in biology 107. This test for reducing sugar look specifically for something called the free aldehyde or "does sugar have (03'30") an aldehyde in it?" If the sugar has an aldehyde in it, the substance will react with the Benedict's agent turning it from a light blue to anywhere from a green to an orange depending on the concentration. Again, not all sugars have the free aldehyde. Therefore, not all sugars will give you a positive reaction. That said then, the next major test is an iodine test. The iodine test looks for the presence of starch and specifically the iodine itself is brown (04'00") in solution. However if there is starch

present, the solution will turn a very dark blue sometimes almost even looking black. This iodine test checks for carbohydrates, which are in the same major class of molecules as sugars. Remember that sugars themselves are simply put together in large clumps or in what is called the polymer to make something like the carbohydrate and starch. Both the Benedict's test for reducing sugar and the iodine for starch help to check (04'30") for this type of organic macromolecules including the sugars and carbohydrates.

The next test is the Biuret test for protein. The Biuret test for protein essentially is going to check for the presence of the amino group. The amino group is a very common molecule in proteins. The Biuret test is a lot like the Benedict's test at first glance. It is a clear blue solution; however, it does not require heating. The solution itself almost instantly reacts with the protein turning from a light blue (05'00") to a lavender or light purple color. Again, if there is lavender or a light purple in your test tube after you add the Biuret reagent, you know for a fact that you have a protein.

The last test is called the Sudan Four test. The Sudan Four looks for hydrocarbons. Hydrocarbons are very abundant in fats. In fact, most of the molecule is a hydrocarbon and the Sudan Four tests for the presence of fats by staining them. (05'30") You add a bunch of drops of solution to a small piece of paper. If there are fats in that solution, the Sudan Four would stain that drop. Now you take your piece of paper that you added a drop of food earlier, say margarine, coconut oil, or flour, and you add them to a stain containing Sudan Four. If the Sudan Four stains is the dot, you look and you see if it has a lot of fat. With that said, the next thing (06'00") you are going to be doing is actually to take those five tests that you just learned about and to apply them to identify particular food item.

Just to briefly review, you want to make sure that you understand the five tests, what they test for, what is a positive test, what is a negative test, and what those tests tell you about the particular substance that you are looking for. For instance, in the Benedict's test, it tells you that you are looking for sugar with the free aldehyde group. In the Sudan Four test, it tells you (06'30") that you are looking for the hydrocarbons in fats. Once you have got all that information done, you have gone through and have done all of the checks for yourself, you are then going to be assigned a particular food.

This food is going to come from series of unknown foods. Now if you look on the last page of your handout, on page 7, there is actually a series of food items that are possibly on your lab. (07'00") Page 7 has a large table, which tells you what is the composition of a number of foods. For instance, there is glucose, table sugar, egg whites, so on and so forth. Once you get an unknown, you are going to go through and predict what that unknown might have. The unknowns are in different groups. There is group A, B, and C. These different groups then are specifically contained within the four different (07'30") foods. When you get your group A, B, C, or D, you are going to write down the four foods that are in your group and there is a space for you to do that right below the nutrition label. Then what you are going to do is that you are going to predict what the tests will do. It is very important because a lot of scientists are not surprise by the results. You know you don't go: "Oh wow! I did not expect that to happen". You actually predict what will happen and often test for them. For instance if you get a food item such as egg white (08'00"), you can see if you read across that the egg white has protein. So you would predict that it has a positive test for the Biuret's reagent. Furthermore, the egg whites have calories. So you would predict that it has a positive test for the char. With that said then, you are actually going to predict. This way when you go do the test, you will actually see

if the test either supports or do not support your prediction as to what type of food you might have.

Now, once you have gone through and made all of your predictions, you will then (08'30") be assigned specifically a particular food. You will get C1 or A4 or what not. That food item is from the A, B, or C category and you know what the letter is. It is one of the four foods. What you will then do is to go back and you will repeat all of the tests you just did: the char test, the Benedict's test, iodine test, Biuret test, and Sudan Four test on your food item. You will record the result for every test (09'00") on the bottom part of that sheet until you have essentially information on 5 different tests on your food item. Then what you would do is to go back and compare these tests with your earlier predictions.

Now this is an extremely powerful tool in science. Making a series of test and comparing against predictions is exactly what scientists do lots of. What you would be able to do is basically if you have a test and it eliminates a food (09'30"), then you can say: "Ok well this test was negative for char". If it is negative for char, that eliminates all food with calories because all food with calories would be positive for char. Let's say you looked at flour and the flour had starch in it. Well if you did a test for starch and flour has starch in it, it does not eliminate flour but maybe another food group in your listing does. Maybe another one of your foods under (10'00") your A, B, or C category is baking soda. Well baking soda does not have any carbohydrates in it so it eliminates baking soda. What you are doing is both eliminating all of the other foods and determining which food is yours.

One of the four substances you have been assigned is your particular sample. What happens then is that at the end of the lab, your faculty member will tell you what you unknowns were and again the most important thing is not the answer. In fact, the answer is meaningless

(10’30”), you can simply guess. In the end, the crucial thing is the process. Can you use the nutritional label to predict the outcome of the five tests on your four different foods within your group? Then, can you do the five tests on your particular food and use that information to eliminate some of the members of the group, and then to include one of the last members in your group? This particular test is extremely powerful, very useful, and is one of the best (11’00”) 107 labs we currently have in practice.

A couple of quick hints to help you move things along are that if you work in groups, that is fine as long as you make sure that as you go through the tests, maybe you could break up the tests. If your partner does one, you do another. Show each other positive and negative results. Do not just say: “Oh this was purple and this was blue”. Show each other what the positive and negative results are as well. You also want to make sure that everything that you work with is done quickly and cleanly, (11’30”) how to avoid for instance using a pipette to suck up some protein solution and using that very same pipette to suck up some sugar solution later. It might cause contamination. So rinse your pipettes out every time that you do the reaction. The char test is located up at the front instructor’s desk and that one takes a few minutes to sort of warm up. So make sure that you try to give it a little bit of time for that one. The Benedict’s test takes about ten minutes to cook but the other three tests (12’00”): The Sudan Four, the Biuret and the Iodine are virtually instantaneous. So you do have plenty of time to go through and test all of the items for your particular foods and to see if it does or does not have that substance in it. Spend some time learning what each test results are, whether or not those test results agree or disagree with your particular food groups that are in your unknown.