1800 Cellular Chemistry - Student Instructions

Introduction

In many ways, biology is actually a study of the chemistry of life. Biologists now think of life as a series of chemical reactions. Most of the important discoveries in biology in the past 30 years have been made by biochemists. To fully understand the biological processes of birth, death, growth, and disease, biochemists will need to first understand the chemistry of life.

The chemical life of the cell is very complicated. It is possible, though, to define a few basic groups of compounds which are most important to the cell. In this kit you will identify these basic groups, and learn something of how they function within a cell.

Biochemists test living material and identify these chemical groups with specific chemical tests. You will be using a variety of testing methods, some of which will involve potentially dangerous laboratory chemicals. Make sure to follow all directions and to use careful laboratory procedures.

PART A - Sugars and Starches - The Carbohydrates

Work in groups of two for these activities. Obtain the following pieces of general equipment: one LabForm, one plastic dish, one razor blade, two glass slides, two cover slips, and a microscope. Before you begin, be sure you know how to focus and use the microscope correctly. Ask your teacher for assistance if you are not sure.

1a) Get a small piece of potato, and place it in the Petri dish. Make a thin slice from the potato, place it flat on the dish, and describe its appearance.

1b) Obtain a Chemstip. Blot the reagent end of the Chemstrip on a moist surface of the potato. Remove the strip and let it set 1-2 minutes. Examine the color chart on the Chemstrip package, and compare your strip with the various shades. The darker the green color, the higher the concentration of a sugar called *glucose*. According to the chart, what do you conclude about the concentration of glucose in the potato?

Glucose is a simple sugar made up of carbon, oxygen, and hydrogen. Oxygen and hydrogen make up water. Combining the word carbon with the Greek word for water (hydro), we get the name carbo-hydrate. All animal and plant cells contain many different kinds of sugars. Sugars are an important source of energy for the cells: sugar is often called an "energy food". Simple sugars all have the formula $(CH_2O)_n$. For example, the formula for glucose is $C_6H_{12}O_6$.

2a) If it is available, test a small piece of meat for the presence of sugar in the same way you tested the potato. Record your results.

2b) Meat is actually muscle tissue of an animal. Why would sugar be important to muscle cells?

The cell contains other carbohydrates besides simple sugars. Sometimes the cell joins sugars together into chains. A very simple chain is the molecule sucrose, which is two sugars hooked together (a disacharide), a glucose molecule, and another molecule called fructose. Sucrose is the table sugar that you put in coffee or on cereal.

3 Cells can make very long chains of sugars called *starches.* Starches are one way in which the cell stores energy. A sugar molecule that is not being used by a cell must be bound into a large starch molecule so that it is not lost.

a) Place a drop of Lugol's solution on the slice of potato, and notice the reaction which occurs. Describe what you see:

Lugol's solution contains iodine, which will combine with starch molecules to produce a dark blue or purple color. The darker the color, the more starch that is present.

b) Use the razor blade to make a very thin slice of potato. A good technique is to slice away a wedge shaped piece of potato, and to observe the thinnest section. Use forceps to carefully place the slice of potato on a clean glass slide. Add a drop of the Lugol's solution, and place a cover slip over the slice of potato. Place the slide on the microscope stage, and focus on the slide, using first low power, then high power. Make a drawing of what you see.

c) From what you know about the test for starch, what can you say about where the starch is inside of the potato cells?

You probably noticed that surrounding the cells was a coating which showed some of the purple or blue color. This material is the cell wall. The cell wall is composed of a special carbohydrate called *cellulose*. Cellulose is similar to starch, but is much more resistant to chemicals and breakdown.

PART B - Proteins

1) Get fresh pieces of potato and meat (both about 1 cm on a side). Using the razor blade, chop up the piece of potato in the Petri dish. Scrape the chopped potato into one tube of the LabForm, and add about 1 ml of water. Rinse the razor blade, and repeat the same procedure with the meat, putting it into a clean tube of the LabForm.

a) Get the bottle of Biuret reagent, and describe the color of the solution.

b) Carefully, to avoid skin contact, add 10 drops of the test solution to each of the two tubes in the LabForm. Let the mixtures sit for about 1 minute, then observe the color of the solution. Record your results.

The color change is the reaction between the Biuret solution and an important group of compounds in the cell called *proteins*. Proteins contain carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur, and are essential to the life of the cell. They are a part of the cell membrane which surrounds the cell. Enzymes are complex proteins which *catalyze* (help) the necessary chemical reactions in a cell. For example, if a cell wanted to build starch to store sugar for energy, it would use an enzyme to link the sugar molecules.

2) In the same way that cellulose and starches are chains of sugar molecules, proteins are also long chains of a certain type of molecule. They are made up of smaller molecules called *amino acids*. Let's test cells for the presence of amino acids.

Get a piece of filter paper at least 1" X 1" . Handle the filter paper with the forceps. Cut a small piece of fresh potato and press one surface of the potato onto the piece of filter paper. If the piece of filter paper is large enough, carefully press your fingers on a section of it away from where the potato was pressed, as if you were making a finger print.

You will use a reagent called ninhydrin to test for the amino acids. It will react with any amino acids that are left on the paper. The ninhydrin is dissolved in acetone, which is a rather irritating solvent. *Work in a well ventilated area* for this activity. Add 4 to 5 drops of ninhydrin to the paper, spreading the drops over the area where the potato was pressed. Holding the paper with the forceps, wave it in the air to evaporate the acetone.

a) After the paper is completely dry, place it on a warm surface, such as a radiator, or on a desk in the sun. If your teacher directs, place the paper, with your name in pencil, in a heating oven overnight. Observe the paper, and record your observations.

b) If you have time, blot a piece of fresh meat on a new piece of filter paper, and repeat the addition of ninhydrin, drying, and heating procedure (If you do this, remember to mark whether the paper is testing the meat or the potato). Does meat contain amino acids?

c) Why do you think it might be important for cells to have amino acids?

PART C - Lipids

1a) A third group of compounds contained in the cell is called *lipids.* This group, the lipids, includes substances like fats, oils, and waxes. Get a sample of whole milk, or cream, and add a drop to a clean glass slide. Add one drop of the Sudan IV dye and add a cover slip. Observe the slide under low and high power, and record what you see in a drawing below.

b) The red spots are drops of oil (lipids) scattered throughout the liquid which absorb the red dye. You can see fat stored in cells using this same procedure. Cut a very small piece of fat from a fresh piece of meat. Add a drop of Sudan IV to the sample on a glass slide. Place a cover slip on the sample, and gently squeeze the tissue by pressing with the eraser end of your pencil. Be careful not to crack the cover slip, since it is very fragile. Examine the slide under the microscope, and draw what you see below.

You should have noticed some small, round spots which had absorbed a large amount of the dye. You may be able to see that these are actually inside of the cells, and that the rest of the cell is in a very thick wall around the fat droplet. These cells store fat for use as energy when the body needs it.

There are other types of lipids beside fats: many hormones in the body are also lipids. Lipids, like proteins, are an important part of membranes surrounding the cell, and also within the cell.

PART D - Nucleic Acids

Another important group of compounds within the cell are nucleic acids, DNA and RNA. These substances control the production of protein in the cell. In this way, the nucleic acids really control the life of the cell. DNA is made up of two long chains of sugar molecules and phosphate groups, which are bonded together by small molecules called nucleotide bases that stick out from each sugar. The pattern of nucleotide bases is something like a code: the cell is able to recognize certain patterns as meaning certain proteins should be produced. The DNA is the "master copy" that carries the code from one generation of cells to the next. RNA is a temporary working copy of the DNA that the cell makes in order to produce proteins

The nucleic acids are found mostly in the nucleus of the cell. Complicated techniques are required to stain them, so these procedures are not included with this kit. Your book should have a description of their structure, and the ways in which they replicate themselves and control the activity of the cell.

PART E - Vitamins and Minerals

You probably know that vitamins are important for life. These molecules are found in very small amounts within the cell, so they are difficult to detect without complicated procedures. The vitamins usually act as an "assistant" to enzyme molecules, so they are called co-enzymes. Some vitamins are similar to proteins, and others are more similar to the lipids.

Several atoms are important to the life of the cell besides those mentioned so far. Examples are:

iron (Fe)	is found in the blood compound hemoglobin.
calcium (Ca)	important to muscle activity, bones, and teeth.
magnesium (Mg)	important for the process of photosynthesis in plant cells.
sodium (Na)	important in nerve cells and in cell membrane transport
potassium (K)	important in muscle tissue
chlorine (C)	is important in the activity of nerve cells
iodine (I)	is involved in several important hormones

Additional Work

If you have time, you may wish to test samples of various tissues and food to determine the presence of starches, sugars, amino acids, proteins, and fats.

Discussion Questions

1) A sample of cells is broken apart with a blender, then a centrifuge separates the various parts of the cell according to how heavy they are. One subset of material (in a laboratory referred to as a "fraction") is found to contain free membranes from the various parts of the cell. What groups of compounds would you expect to find in these membranes?

2) Compounds called glycoproteins are important to the membranes surrounding a cell. These molecules contain both protein and chains of sugars. A chemist gives you a sample of material which he claims is a glycoprotein. What test(s) could you perform to find out if he is correct?