MOHAVE COMMUNITY COLLEGE

Chemistry of the Cell

But this is biology!

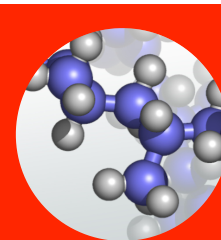
Chemistry has a place in biology as the driving force behind the natural phenomena we study.

Students often ask why they have to learn about chemistry in a biology class- isn't that a different science? Technically, yes! Chemistry is considered a physical science. Biology is a life science. Even though it has a different focus, chemistry is very closely tied to biology.

Four major **biological macromolecules** make up the vast majority of living cells and the way those macromolecules interact is solely due to their chemistry. Cells, tissues, organs, and organisms must ensure a balance in these molecules and trillions of other solutes to maintain life (this process is called homeostasis). If and when you take anatomy and physiology, you'll find that understanding chemistry is vital to understanding the human body.

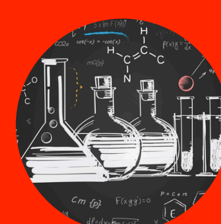
On a larger scale, we can consider the importance of chemistry in biology from an ecological stand point. Scientists are closely following the Arctic ice sheet as it melts, increasing ocean levels worldwide. The fact that ice is less dense than water, and therefore floats, is (you've probably guessed it) tied to chemistry. We track carbon dioxide levels and plastic particulates in the ocean too, both of which effect the health of our planet.

In this lab you'll look at the rates that molecules travel in a given space, you'll learn how to test for and identify biological macromolecules in known and unknown samples, and you'll extract DNA from a banana in order to examine it.



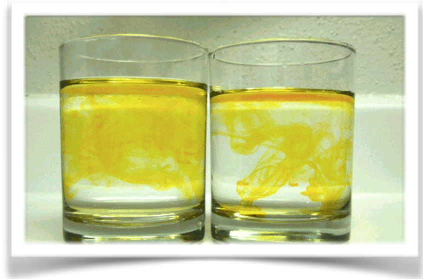
What are macromolecules?
You are made of four major groups of molecules.

How can I find them?
Learn to test for macromolecules.



How else does it affect cells?
Consider the implications of chemistry.

How Molecules Move in a Liquid



Movement in the universe is constant. Every atom in your body is vibrating right now. While we cannot look at those in this class, we can witness this in water with dye. Obtain a microscope and a depression slide. Place a drop of soapy water on the slide slide and get it so you can see the water clearly without a coverslip. Obtain a very small (a few grains on a toothpick) sample of carmine dye. Sprinkle the dye in the water. What do you see (**see worksheet, question 1-3)**?

This movement is called **Brownian movement** and it is caused by the vibrations between atoms. The dye will continue to appear to move until it reaches **equilibrium** with the water molecules, meaning they are evenly spaced. The molecules of water and dye *never* actually stop moving around due to the slight vibrations between the atoms.

How Molecules Move in a Solid Medium

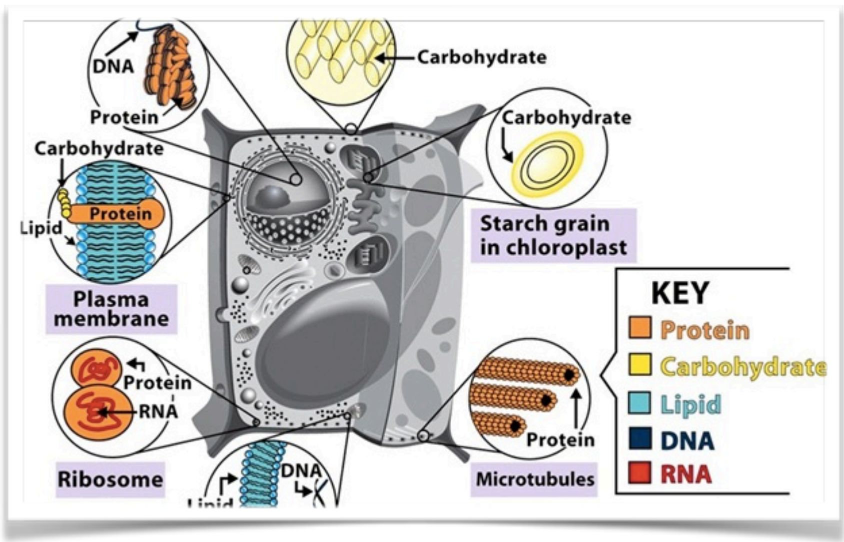
Chemistry matters in cells because the movement of molecules through cells is both life giving and life threatening. Larger molecules have a harder time moving through mediums (cells) than smaller ones. We can see those differences in travel due to size in an agar dish. Obtain an agar dish. Make two equal indentions with the point of a pair of tweezers. Drop a piece of (a) potassium permanganate in one indention and (b) malachite green in the other. Put the lid back on the petri dish, draw a circle around your dye, and measure the diameter. Measure the rate of change you see in mm every 15 minutes for the 45 minutes. Record your data on the **worksheet (questions 4-6)**.

Biological Macromolecules and Their Indicators

There are four different biological macromolecules in cells. Each macromolecule has its own indicator test that can signal its presence in a cell or a solution. Read carefully as the indicator tests are *not* the same for each macromolecule. You should obtain your samples (**see chart**) in test tubes or reaction wells. Follow the directions for performing each test, then empty and wash your test tubes or reaction wells. Refill them with samples and repeat the processes until you have tested each sample for the presence of each macromolecule.

Proteins are made of repeating units of amino acids in complex structures with other functional groups. They are structural elements in the human body and they also perform an untold number of chemical functions. They are tested for with **Biuret Reagent**. When protein is mixed with Biuret, the solution turns lavender in color. You need 2 ml of your solution and 10-15 drops of Biuret. This test can be performed in a reaction well if you prefer and does not need to be completed in a test tube. Note: It is easier to see in the test tubes.

Carbohydrates are made of simple sugars and form starches and cellulose when tightly coiled and chained together and occasionally branched. The presence of carbohydrates is tested for using Benedict's solution. **Benedict's solution** is blue in color. Fill test tubes with approximately 2 mLs of the sample solutions, add 10-15drops of Benedict's solution. Place the test tubes in a beaker of gently boiling water and watch for a color change for 2-3 minutes. You can place multiple test tubes in your beaker of gently boiling water at one time but be very careful not let the water over flow. If your test tubes are bouncing because of the bubbles from the boiling water, your hot plate is up way too high. If the color changes from blue to red-orange or green, this is a positive test.



The test for **starch** is different than the test for sugar because of the difference in structure. **Iodine** (IKI or Grams) is used to test for starch. When added to a substance or solution containing starch, iodine will quickly turn from its normal amber/brown color to dark blue or black. Occasionally only small amounts of back particulate matter fall out of the solution. This means the starch was not completely dissolved in the solution, you're seeing clumped of "dyed" or indicated starch! This should also be considered a slightly positive result. 2ml of sample solution is perfect with only 5-7 drops of iodine. If your solution is too dark from the iodine, you won't be able to read your test results. drops of iodine in a reaction well are suffice for this test, it can be seen more easily in test tubes however. No heat is needed.

Lipids, or fats, are tested for a few different ways. When you add lipids to brown paper, a stain will remain when the spot dries. Another test can be completed with a chemical called **Sudan IV**. When Sudan IV is added to a liquid solution that may contain fat it will cause the solution to separate into to visible fat and non-fat layers. This test should be done in a test tube so it is easier to see. **See the worksheet for further instructions (questions 8-21).**

DNA EXTRACTION: FINDING THE MOLECULE THAT DOESN'T HAVE AN INDICATOR TEST

DNA doesn't have an indicator test, so it won't have a section on your chart. Use these instructions to isolate DNA from a banana.

1). Pour 120 ml of hot water and 5g salt into a bag of mashed banana. Gently mix 30-45 sec.
2). Add a 2.5ml of dish soap or baby shampoo into the bag. Mix gently, avoid foam!
3). Place the bottom half of a coffee filter in a beaker. Secure it over the top with a rubber band.
4). Pour the contents of the bag into the filter and let it sit for several minutes until all of the liquid is in the beaker. (You can now throw out the coffee filter and its contents).
5). Slowly pour the liquid from the beaker into a test tube, fill approximately half way.
5). Obtain chilled 91% ethanol. Tilt the tube and slowly pour the ethanol down the side of the cup until there is a layer that is 2.5 to 5cm thick. You want to keep the ethanol and the liquefied banana as separate as possible, so complete this step slowly.
6). Let this two-layered mixture sit for eight minutes.

During this time, what do you see happening between the ethanol and the banana liquid layer? It looks cloudy and may have some tiny bubbles in it. The longer you wait, the more defined this layer becomes. This is the DNA pieces clumping together. Stick a glass stir rod and spool the DNA. - Adapted from "Find the DNA" by Molly Jones, Scientific American

Worksheet for Chemistry of the Cell

How molecules move in a liquid

1. What can you see in the microscope immediately after adding the dye? ________________

____

2. What is this movement called? ______________________________________

3. When will this movement stop on an atomic level? ______________________________

How molecules move in a solid

4. Using the information contained in the worksheet, fill out the following chart.

Dye Name	Size at 0 minutes	Size at 15 minutes	Size at 30 minutes	Size at 45 minutes

5. Which dye expanded the most? ____________________

6. How do you expect particle size to affect the rate of movement? ____________________

____

7. Which dye has larger particles? ____________________

8. How do you know that? ____________________

Biological Macromolecules and Their Indicators

8. What are the individual units of a protein molecule called? ____________________

9. What do they do in the cell? ____________________

10. What is the indicator solution for protein called? ____________________

11. What does a positive protein test look like? ____________________

12. What are carbohydrates made of? ____________________

13. A complex carbohydrate with advanced 3-D structure could be a ____________________.

14. What chemical test indicates the presence of starch? ____________________

15. What does a positive starch test look like? ____________________

16. What test do you use to test for reducing sugars? ____________________

17. How do you perform the test for reducing sugars? ____________________

____

____

18. Lipids are also known as ____________________.

19. What two tests can be used for lipids? ____________________

20. What does a positive lipid test look like (reference *both*)? ___________________________________

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21. Using directions in the lab, test the following substances for the presence of starch, sugar, protein, and lipids. Record your results (color changes or separation of liquids) in the table below. Also denote if each test is positive or negative by including a + or - in each box. You can indicate strong positive with +++ and weaker reactions with simply a +. For the row asking "Test tube or reaction well," write which testing method you plan to use. For the "Heat? Wait time?" row, note if you need heat or how long you must wait to know if your result is positive or not. For "Positive indicator" write what a positive result should look like so you know what you're looking for.

Substance	Iodine (Starch)	Benedict's (Sugar)	Biuret (Protein)	Sudan IV (Lipids)
Test tube or reaction well				
Heat? Wait time?				
Positive Indicator?				
10% Glucose				
1% Starch				
1% Albumen				
Corn Oil				
Lemon Juice				
Unknown				

22. Using your favorite resource for guidance, draw and label a single nucleotide here.

23. Using your notes on DNA and RNA, fill out the chart below:

	DNA	RNA
Major sugar		
Nucleotides		
Strand structure (1 or 2)		
Where is it found?		

24. Perform the DNA extraction. Describe the physical appearance of DNA. How does it feel? _______

____

____

25. What do you think the purpose of each of the following was in the DNA extraction activity?

a. Salt: ____

b. Soap: ____

c. Ethanol: ____