Lab: The Origin of Life
Making Coacervates

Introduction: How did life begin on Earth? One of the first scientists to propose a hypothesis about for how organic compounds formed on Earth was a Russian scientist named Alexander Oparin. He believed that the early atmosphere on Earth consisted of various gases, such as ammonia, hydrogen gas, water vapor and methane. At very high temperatures, these gases may have formed organic compounds that collected in the newly formed lakes and seas of early Earth. He hypothesized that through a series of chemical reactions, these compounds formed droplets called coacervates. Although the origin of life has not been duplicated in the laboratory, it is very simple to observe the formation of coacervates. Coacervates are simply droplets that are composed of molecules of different types. Coacervates are not alive, but they do share some of the same characteristics as those found in living cells. Because of this, many scientists have hypothesized that structures similar to coacervates may have been the precursors to the first living cells.

Purpose:

1. To simulate Oparin's work by mixing a protein solution with a carbohydrate solution to produce coacervates.
2. To observe the shared characteristics between coacervates and living cells.
3. To determine the ideal pH level for producing the most coacervates in a solution.

Materials List:

Glass test tube with cap
Gelatin solution (protein)
Glass stirring rod
.1M HCl solution
Microscope
Microscope slides
Graduated cylinders
Gum Arabic (carbohydrate)
pH paper
Dropping pipets
Test tube rack

Safety Precautions:

1. Safety goggles and laboratory apron are required
2. Hydrochloric acid is caustic and can burn skin, eyes and clothing.
3. Report all spills to the instructor so that they may be cleaned up in the proper way.
4. Never touch, taste, or smell a laboratory chemical unless instructed to do so.
5. Handle all glassware with care as it can break and easily cut you.

Procedure:

1. Obtain a glass test tube with accompanying cap.

2. Use a graduated cylinder to measure 8 mL of gelatin solution. Add the gelatin solution to your test tube.

3. Using a graduated cylinder, add 4 mL of gum arabic to the same test tube. Replace the cap on the test tube.

4. Place your finger over the cap and gently invert the tube 2 or 3 times to mix the contents. **Do not shake the tube.** Shaking the tube will prevent the formation of coacervates.

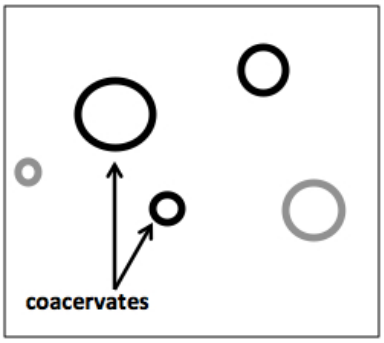
5. Hold the tube up to the light and carefully observe the contents. Is the solution clear or cloudy? Does there appear to be a precipitate? (You will be asked in the analysis questions whether the cloudiness or clearness is an indication that coacervates are forming. Watch the cloudiness as the experiment progresses and start forming an opinion about the relationship of cloudiness and coacervate formation.)

6. Coacervates form more readily under specific environmental conditions. One particular condition is the acidity of the environment. Remove the cap or stopper from the tube and dip a glass stirring rod into the solution. Obtain a piece of pH paper and touch the glass stirring rod to the pH paper. Use the color scale to determine the pH of the solution.

7. You will be adding drops of hydrochloric acid solution to the tube a few drops at a time to determine the effect of pH on the formation of coacervates. Design a data table to show the data you collect over 5 separate trials. Include the following in your data table: (1) number of drops of HCl added, (2) appearance of solution, (3) pH of solution, (4) number of coacervates observed, and (5) observations of coacervates.

8. In trial 1, zero drops of HCl have been added to the solution. Record your observations of the solution and the pH of the solution.

9. Use a Beral dropping pipet or medicine dropper to remove 1 to 2 drops of the solution from your test tube. Place these drops on a clean microscope slide. Add a coverslip and observe under the microscope using the 10x objective. Scan the slide and count the number of coacervates seen. Coacervates will appear as spheres or circles with darkly outlined "membranes". (Coacervates are dependent on acidity. Do not get discouraged if few coacervates are observed at this time.) Record your count on the data table.



10. What characteristics do you notice in the coacervates you see? Record your observations in your data table.

11. Add 2 drops of the hydrochloric acid solution to the tube containing your coacervates. Place the cap on the tube and gently invert 2 or 3 times to mix the solutions. Repeat steps 5 through 10. Record all information in the data table.

12. Repeat 3 more times, adding 2 drops of hydrochloric acid solution each time. Record all data and observations in the data table.

13. Construct a graph showing a comparison between the number of coacervates formed and the pH.

Analysis Questions:

1. What are coacervates?

2. Make a drawing of the coacervates as they appear under the microscope. Be sure to label the coacervates and indicate what objective is being used to make the drawing.

3. What is the total magnification of the objective you used to view the coacervates?

4. What is the diameter of the field of view with this objective?

5. What is the estimated size of the coacervates? (Your estimate is based on the diameter of the field of view for the objective being used.)

6. Prokaryotic cells typically range in size from 1 – 3 micrometers (μm). Eukaryotic cells are about 20μm. How does the size of your coacervates compare to the size of prokaryotic and eukaryotic cells?

7. You may have noticed a few coacervates of very large size! It is not unusual to see a coacervate that is much larger than the typical cell. Why is it unlikely that living cells will grow to this size?

8. What is the independent variable? Why is this the independent variable?

9. What is the dependent variable? Why is this the dependent variable?

10. What was the optimum pH for coacervate formation?

11. In your observations you were asked to determine if the solution was clear or cloudy. What is the relationship between cloudiness/clearness and coacervate formation?

12. List 8 characteristics of life.

13. What characteristics did you observe in the coacervates that you might also observe if viewing living cells?

14. What type of organic compound is gelatin? What role would this compound play in a living cell?

15. What type of compound is gum arabic? What role would this compound play in a living cell?

16. Why is the formation of a membrane essential to life on Earth?