Biobeads: Modeling Cell Processes

Overview: Create beads of sodium alginate, a polysaccharide extracted from seaweed and used to produce edible caviar-like spheres, to model and investigate cell functioning. The alginate bead cell models can be used to investigate diffusion and osmosis, and rates of cellular respiration in yeast cells embedded in beads.

Adapted from the Northwestern University Biology Investigations on Oncofertility (NUBIO) and additional resources can be found at http://nubio.northwestern.edu/labs

Purpose: To model cell processes using yeast cells immobilized in alginate.

Background

Sodium Alginate is a gelatinous material isolated from seaweed. Sodium alginate is a very large polymer. Alginate is used in several cooking processes such as making ice cream and the 'beads' in tapioca pudding. These alginate beads are also used in several biotechnology processes. The beads can be used to enclose enzymes, from artificial seeds for plant tissue culture and as wound dressing. They also serve as an important tissue engineering substrate to encourage cells grown in culture to maintain a healthy spherical shape.

For this activity we will create several types of sodium alginate beads. The dyed and paint tinted beads will be used to investigate the permeability of cells. Yeast suspended in alginate will be used in student designed respiration experiments. Yeast alginate spheres will be suspended in a pH indicator solution. As the yeast release CO2 into the solution, carbonic acid forms, decreasing the pH of the solution and causing a color change?.

Materials

Sodium Alginate
Calcium Chloride
Food coloring
Tempera paint
Yeast package
pH sensitive growth media- dilute pH indicators such as bromothymol blue or gentian violet solutions can be used. These solutions are blue or purple under basic conditions and turn yellow in acidic conditions.
1.7 mL microcentrifuge tubes (or other container for immobilized cells and solutions)
5 ML tube with cap
Disposable cups or bowls
Dropper/Transfer pipette
Plastic spoon

Safety: Eye protection is needed to avoid splashing chemicals. Use caution when handling solutions.

Preparation:

1% Alginate solution:

1. Add 0.11 grams of alginate powder per 10 mL of water.
2. Mix aggressively using a blender, until powder is no longer visible. Pour into a sealable container and soak overnight at 4^0C.
3. Distribute into smaller containers. Each student group will need one of the following:
    a. Approximately 20 mL of clear sodium alginate.
    b. Approximately 20 mL of dyed alginate. Add a few drops of food coloring and mix thoroughly.
    c. Approximately 20 mL of paint alginate. Add ¼ teaspoon of tempera paint and mix thoroughly.
4. Keep alginate solution refrigerated to avoid mold formation.

2% Calcium Chloride solution:

1. Dissolve 1.0 g of Calcium chloride per 50 mL of distilled water. It may take several minutes to dissolve.
2. May be stored at room temperature.

Procedure:

Part I Making Beads

Basic Procedure**:**

1. Fill one of the plastic cups approximately half full of calcium chloride solution.
2. With a disposable pipette, draw up some of the colored sodium alginate solution. Alginate is thick, about the consistency of a milkshake.
3. Hold the pipette over the calcium chloride solution and gently drop the alginate into the solution. Try to make separate drops, rather than a stream of solution. Remember your goal is to make beads.
4. After making several beads, scoop one or two out of the solution using the plastic spoon. Place the beads on a plate and check the consistency. At this point, gel beads have a thin skin and a liquid center.
5. Leave a few beads in the solution for 3-5 minutes to completely set and become a solid. Note: Practice bead forming. Biobeads should be as close to spherical as possible. Teardrop or worm-shaped beads indicate too much pressure or speed during dripping.

Part II Colored Bead Creation

1. Using techniques perfected above from making beads instructions, create 6 – 10 alginate beads from the alginate solution that has been dyed with food coloring.
2. Store beads on a labeled tray for later use.
3. Using techniques from making beads instructions, create 6 – 10 alginate beads from the alginate solution that is colored using tempera paint.
4. Store beads on a labeled tray for later use.

Part III Encapsulation

1. Using dry yeast and uncolored alginate solution, practice encapsulating the yeast within a spherical alginate bead. Experiment with several techniques to find the one that works best for you.
2. Create 10 – 20 encapsulated yeast cells using the prepared clear alginate solution and dry yeast.

Part IV Testing Cell Membrane behavior using beads
Permeability

1. Label a 1.7 mL clear microcentrifuge tube “Dye”
2. Label a second 1.7 mL clear microcentrifuge tube “Paint”
3. Aliquot 1 mL of water into each of the two 1.7 mL clear microcentrifuge tubes.
4. Add 3-4 Dye colored alginate beads to one tube labeled “Dye”.
5. Add 3 -4 paint colored alginate beads to the tube labeled “Paint”.
6. Carefully observe the tubes over the course of several minutes and record your observations.

Design an Experiment with Immobilized Yeast

Prompt students to design individual experiments on yeast respiration with the alginate yeast spheres. Investigations could include varying sugar concentrations in the culture solution or adding an aquatic plant along with the alginate spheres. Other types of cells such as algae or protists could be immobilized and studied in student experiments. Students should use appropriate experimental design, collect, analyze and share data.

Basic Procedure

1. Label a clear 5 mL tube with your initials.
2. Add 4 mL of cell culture solution to the labeled tube
3. Add 5 – 6 yeast embedded alginate beads to the tube.
4. Close the cap tightly.
5. Carefully observe your tube over the course of several days and record your observations.