Osmosis and Diffusion: Guided Inquiry Lab

Overview

How do cell membranes help regulate internal cellular makeup? The purpose of this laboratory activity is to observe, measure, and identify factors that influence diffusion and osmosis in model cells.

Focus on Science Practices

SEP 2 Developing and Using Models

Materials Per Group

- Hydrochloric acid, HCl, 0.1 M, 100 mL
- Beaker, 150 mL
- Plastic knife
- Paper towel
- Phenolphthalein agar block
- Metric ruler
- Plastic spoon
- Dialysis tubing, 18 cm, 5
- Funnel
- Graduated cylinder, 25 mL
- Permanent marker
- Weighing dish, large
- Cups, plastic, 9 oz, 5
- Balance, 0.01 g precision
- Sucrose solution, $C_{12}H_{22}O_{11}$, 1 M, 125 mL
- Water, distilled or deionized, 300 mL
- Sodium chloride solution, NaCl, 1 M, 20 mL
- Glucose solution, $C_6H_{12}O_6$, 1 M, 100 mL
- Albumin, 5% solution, 100 mL

Safety

Hydrochloric acid is toxic by ingestion and inhalation. Hydrochloric acid solution is corrosive to skin and eyes. Phenolphthalein solution contains alcohol and is a flammable liquid. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles, nitrile gloves, and a lab coat or a chemical-resistant apron. Follow all normal laboratory safety guidelines and wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

1. Look up the acid-base properties of phenolphthalein indicator, including its expected color changes and the pH range for each color form.

2. The phenolphthalein-agar model cells used are initially pink.

   (a) Predict the observations when these cells are placed in dilute hydrochloric acid, assuming $H3O^+$ ions are able to diffuse into the agar.

   (b) How can these observations be used to measure the rate of diffusion?

3. Using a plastic knife and a metric ruler, cut the phenolphthalein agar block into a 2 cm cube.

4. Pour 100 mL of 0.1 M hydrochloric acid into a 150 mL beaker.

5. Using a plastic spoon, carefully place the agar cube in the beaker of hydrochloric acid.

6. Gently agitate the solution and turn the cube with a spoon occasionally while soaking.

7. After 10 minutes, gently remove the agar cube using the plastic spoon. Blot the cube dry using a paper towel.

8. Using a plastic knife, cut the cube in half and measure the depth to which acid penetrated the cube.

9. Record observations and results. Calculate the rate of diffusion of hydrochloric acid into the agar-phenolphthalein cube and compare the surface area-to-volume ratio of this agar "model cell."

Part I. Data Table: Rate of Diffusion and Cell Size					
Cube	Surface Area (cm^2)	Volume (cm^3)	Surface Area to Volume Ratio	Diffusion Depth (mm)	Diffusion Rate (mm/min)
2 cm					

Part II. Modeling Osmosis and Diffusion

10. Obtain five plastic cups and label them 1−5 using a permanent marker.

11. Obtain five 18-cm pieces of pre-soaked dialysis tubing.

12. Twist approximately 3 cm of tubing at one end and tie into a knot.

13. Using a graduated cylinder, measure 15 mL of the specified solution listed in the Model Cell column for cell number 1 in the Part II Data Table.

Part II. Data Table: Modeling Diffusion and Osmosis						
Number	**Model Cell** (inside dialysis tubing)	**Surrounding Environment** (plastic cup)	**Prediction:** Water will diffuse into or out of cell	Initial Mass (g)	Final Mass (g)	Percent Change in Mass
1	NaCl, 1 M	Water, DI				
2	Water, DI	Glucose, 1 M				
3	Sucrose, 1 M	Water, DI				
4	Water, DI	Albumin				
5	Water, DI	Water, DI				

14. Open the opposite end of the dialysis tubing by rubbing it together between your fingertips.

15. Place a funnel in the open end of the dialysis tubing and transfer the solution into the model cell.

16. Twist and knot the open end of the tubing to seal the bag of dialysis tubing.

17. Gently rinse the dialysis tube bag with DI water to make sure none of the solution within the bag has dripped on the outside. Note: This step may be omitted if the bag contains DI water.

18. Place the dialysis tube bag on a paper towel and gently roll it back and forth to remove any excess liquid.

19. Place a weighing dish on the balance and zero the balance.

20. Measure and record the mass of the dialysis tube.

21. Fill cup number one with approximately 100 mL of the solution listed in the Surrounding Environment column for cell number 1 in the Part II Data Table.

22. Place the dialysis tube bag in cup 1.

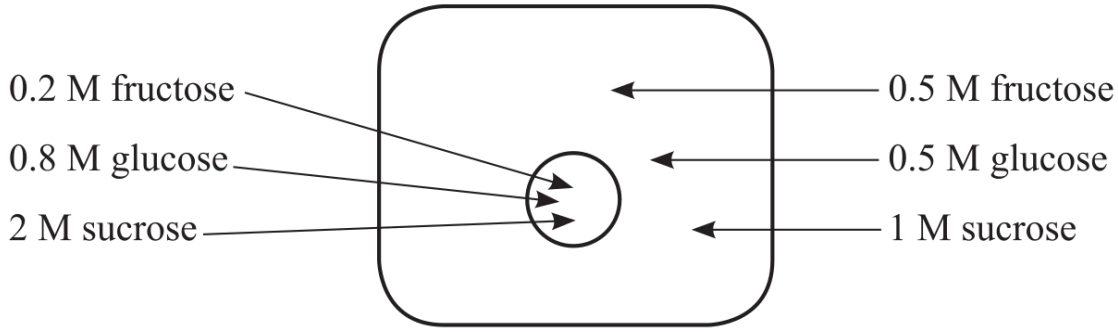
23. After 30 minutes remove the dialysis tube bag from the cup. Gently roll it back and forth on a paper towel to remove excess liquid. Measure and record the final mass of the dialysis tube bag.

24. Repeat steps 3−14 with the remaining cells in the Part II Data Table.

25. Calculate the percent change in mass for each model cell.

Analyze and Interpret

Consider the following scenario: An artificial membrane that is selectively permeable encloses an aqueous solution. The solution surrounding the model cell contains a different aqueous solution. Assume that monosaccharides such as glucose and fructose are able to cross the membrane but that larger disaccharides, such as sucrose, do not. The exact concentrations of each solute in the cell and surroundings are shown in the figure below.



1. **SEP Use Models** Which solute(s) will exhibit a net diffusion into the cell?

2. **SEP Use Models** Which solute(s) will exhibit net diffusion out of the cell?

3. **SEP Use Models** With respect to glucose, is the surrounding environment hypertonic or hypotonic to the cell?