NEO/SCI STUDENT'S GUIDE

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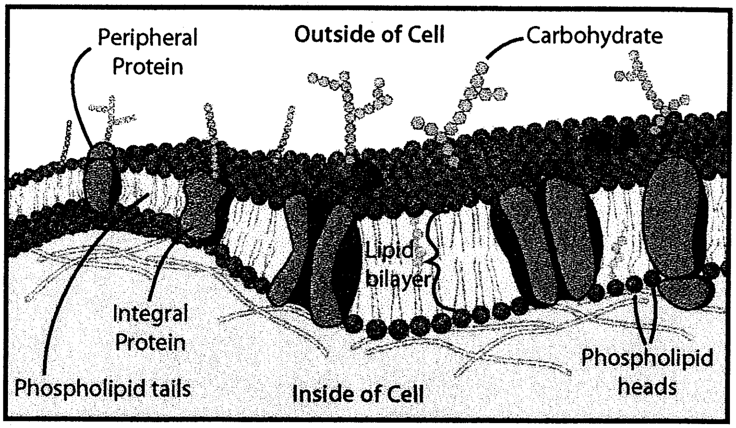
Osmosis and Diffusion

WARNING — This set contains chemicals that may be harmful if misused. Read cautions on individual containers carefully. Not to be used by children except under adult supervision.

Objectives

- ***Construct*** **models of cells using dialysis tubing to simulate the semipermeable nature of the plasma membrane.**
- ***Observe*** **the effects of osmosis on a model cell.**
- ***Study*** **the effects of diffusion through a semipermeable membrane.**
- ***Predict*** **the characteristics of substances which allow them to pass through a semipermeable membrane.**



Background

The plasma membrane is made up of a variety of different organic molecules, with the most common component being "phospholipids". Phospholipid molecules have a dual nature, with one end of the molecule being polar - the phosphate head - and the other being non-polar - the lipid tail. The phospholipid molecules in a cell membrane line up in two adjacent layers, much like two pieces of bread in a sandwich. The polar phosphate groups arrange themselves on the outside of the sandwich, while the non-polar lipid tails are found in the center of the sandwich. Since water is a polar molecule, having a slight negative charge at one end and a slight positive charge at the other end, it is attracted to these polar phosphate groups. The lipid tails, which do not mix well with water - much like salad oil in water - are hidden on the inside of the membrane and do not have to interact with the polar water molecules. This arrangement allows the cell membrane to mix well with the fluids, which are mostly water, both outside and inside the cell. The fluid outside the cell is called "extracellular," and the fluid inside the cell is called "intracellular" or "cytosol."

The cell membrane has several components besides phospholipids, including proteins which act as channels through the membrane, cholesterol molecules, enzymes, and carbohydrates. The cell membrane is said to be selectively permeable, that is, it lets some substances into and out of the cell, while not allowing other substances pass at all. Molecules which are large, such as proteins and starch, and charged particles, such as ions, are usually not able to get through the cell membrane unless the appropriate "protein gate" is present. Molecules which cannot pass from one side of the membrane to the other can become concentrated on one side of the membrane.

Remember that a solution is a mixture of different types of molecules in a liquid. One of the molecule types acts as the solvent - the substance in which the other substance is dissolved. The molecule which is dissolved in the solvent is called the "solute". In living cells, the solvent is water. This is true for both the extracellular fluid and the cytosol. Many substances are dissolved in these aqueous solutions, including ions, proteins, waste products such as urea, and nutrient molecules such as glucose.

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Recall, also, that diffusion occurs whenever a concentration gradient exists between two areas and nothing blocks the diffusing substance from spreading out through that area. The cell membrane, however, acts as a barrier to certain types of molecules. If a solution becomes more concentrated on one side of a semipermeable membrane than on the other, osmosis will occur. Osmosis is the passive (i.e. no energy) diffusion of water molecules down their concentration gradient (i.e. from high concentration to low) across a semipermeable membrane. In other words, if the extracellular fluid solutes become more concentrated than the solutes in the cytosol, water will leave the cell by osmosis. Water is moving down its own concentration gradient. The solution outside the cell in this case is said to be hypertonic to the cytosol, meaning that it has a greater concentration of solutes than does the cytosol. In animal cells, this process is called crenation, and can lead to the shrinkage and death of the cell. In plants, this process is called plasmolysis, and can also lead to the death of the plant cell.

The opposite process, also involving osmosis, can occur if the intracellular fluid (i.e. cytosol) becomes more concentrated than the extracellular fluid. In this case, the concentration of water is greater outside the cell, so water moves across the membrane down its concentration gradient. The extracellular fluid in this case is said to be "hypotonic" to the intracellular fluid. The movement of water into the cell can lead to the rupture of the cell membrane in animal cells, a process called "lysis". In plant cells, this pressure within the cell pushes the plant cell membrane tightly against the cell wall, leading to a firm plant cell. This pressure is called "turgor pressure", and the plant cell is said to be "turgid".

The ideal situation for animal cells is to have the intracellular and extracellular fluid in osmotic balance with one another. In such a case, the solutions would be isotonic (i.e. having the same solute concentrations). In this case, water diffuses passively across the membrane at the same rate in both directions, so there is no net gain or loss of water from the cell. This process of keeping solutes and water balanced is called "osmoregulation". Most organisms have some method of regulating their water balance, from the cellular level to specialized organs (i.e. like your kidneys) which help do this job for the entire body.

Safety & Disposal

Be sure to always wear safety goggles, gloves and a lab apron to protect your eyes and clothing when working with any chemicals.

Iodine Potassium Iodide (IKI) is a corrosive substance and can be a caustic irritant if allowed to come in contact with the skin. Keep the iodine potassium iodide bottle tightly capped and only open it when you are ready to use it. In case of spills or skin contact, inform your teacher immediately and flush areas with running water for 15 minutes.

Dispose of any waste materials and clean up your work area as directed by your teacher. Be sure to always wash your hands before leaving the laboratory.

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Activity 1

Osmosis and Diffusion in Model Cells

What you need

(Per student)

Apron

Gloves

Goggles

(Per group)

1	Cup, clear
15 cm	Dialysis tubing
10 mL	Glucose solution
1	Pipet, plastic
30 mL	Starch indicator solution (IKI)
10 mL	Starch solution
20 cm	String

What to do...

Safety: *Put on your apron, protective gloves and eye goggles.*

Step 1:

Fill the plastic cup with distilled water to within 1-2 cm of the top.

Step 2:

Dip a glucose test strip into the water in the cup for 1-2 seconds. Run the test strip along the edge of the cup to remove any excess liquid. Wait approximately 2-3 minutes and observe any color change on the strip. A positive (+) glucose test is indicated by a greenish color on the test strip. No color change will occur if the test result is negative (-). Record the results of the test in Data Table #1.

Step 3:

Caution: *IKI solution is a poison. Avoid any skin contact. Be sure to wear proper safety equipment.*

Carefully add 20-25 drops of the starch indicator solution (IKI) to the water in the cup. Observe what happens to the indicator solution as it mixes with the water. Record the color of the water in Data Table #1.

Step 4:

Your teacher will provide you with a soaking dialysis tube segment. Gently rub the tubing between your fingers to open it.

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Step 5

Tie one end of the tubing tightly with string or tie a knot in one end. Make sure this end of the cell is tied tightly enough to prevent any leaks from the end of the bag. Fill the tubing with water and test it for leaks at a sink. Empty the tubing.

Step 6

Using the medicine cup provided, measure out 10 mL of the starch solution, and pour it into the open end of the dialysis tubing.

Step 7

Using another medicine cup, measure 10 mL of glucose solution. Add the glucose solution to the starch solution in the dialysis tubing. Squeeze all the air bubbles out of the tubing. Be sure to leave enough room at the open end to tie it as you did in Step 5. Note the color of the starch-glucose solution in the dialysis tubing and record your observations in Data Table #1.

Step 8

Briefly rinse the outside of the bag under running water. Squeeze the bag gently to be sure that there are no leaks. If you find a bag leaking at an end, retie it securely.

Step 9

Completely submerge the model cell into the cup of water and starch indicator solution. Allow osmosis and diffusion to occur for 20-30 minutes.

Step 10

After 30 minutes, test the water in the cup for sugar content, as in Step 2. Note any color changes in the dialysis tubing and in the cup. Record these observations in Data Table #1.

Note: *A positive (+) result for the presence of starch is indicated by a blue-black color of the final solution. If the starch test result is negative (-), the final solution will be an orange/brown color.*

Step 11

Be sure to wash your hands and clean up and dispose of any waste materials as directed by your teacher.

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Recording Observations

Data Table 1
Results of Osmosis and Diffusion Experiment

Characteristic	Water in Cup	Solution in Tubing
Initial Color		
Final Color		
Initial Glucose (+/-)		+
Final Glucose (+/-)		+
Initial Starch (+/-)		+
Final Starch (+/-)		+
Initial Solutes		
Final Solutes		
Change in volume observed		

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Questions

1. What is simple diffusion?

2. What is osmosis, and how does it differ from simple diffusion?

3. What are two characteristics of substances that do not allow them to pass through the semipermeable membrane of living cells?

4. What types of substances pass easily through living cell membranes?

5. Did the glucose molecules pass through the dialysis tubing? How do you know?

6. Did the starch molecules pass through the dialysis tubing? What evidence do you have to support this conclusion?

7. Why did we use dialysis tubing as a model for a cell membrane?

8. Did osmosis occur with respect to the model cell? What observation led you to this conclusion?

9. Why were the results for final starch and final glucose filled in already in Data Table #1? (**Hint:** *Would all of the solutes diffuse out of the dialysis bag? Why or why not?*)