

Lab 3: Diffusion and Osmosis

I. Framing the Investigation:

Background:

The cell is the basic unit of structure and function of living things. Eukaryotic cells (with a nucleus) are organized into three regions: the **nucleus** at the center which is surrounded by the **cytoplasm**, and **plasma membrane**. The nucleus contains the genetic material (DNA) which stores all the information to build a complete organism. The cytoplasm is a watery region that contains all of the cells specialized organelles. These organelles carry out most of the cells activities. The cytoplasm is separated from the external environment by the plasma membrane.

The plasma membrane plays an important role in determining the internal environment (homeostasis) of the cell because it controls what enters and leaves the cell. The cell membrane contains pores (holes) which allow small molecules to pass through. There are also regions that actively transport larger molecules across the cell membrane. The size of the molecule is one important factor in determining whether or not it will be able to diffuse across the cell membrane. If the molecule is too large to pass through one of the pores in the membrane, and there is no mechanism for the cell to actively transport the molecule across the membrane, the molecule will not be able to enter the cell. On the other hand, small molecules that can pass through the pores will enter the cell, as will molecules that the cell actively moves across the membrane. These **active transport** pathways require energy and the energy is usually supplies in the form of ATP.

In this lab you will be studying diffusion and osmosis using dialysis tubing and carrots. **Diffusion** is the random movement of molecules from an area of higher concentration to an area of lower concentration. **Osmosis** is the diffusion(movement) of water through a selectively permeable membrane (a membrane that allows for diffusion of selected solutes and water) from a region of higher water potential (high concentration) to a region of lower water potential (low concentration) until an equilibrium is reached. Osmosis is a special case of diffusion. The dialysis tubing has small openings that will allow water and other small molecules to pass through. Large molecules will not be allowed to pass through the tubing-the dialysis tubing is said to be “selectively permeable”.

You will be studying the movement of various molecules across this “cell” membrane: water, sugar, starch, and iodine. Iodine turns black in the presence of starch.

Warm-up Question:

- 1) What is osmosis?
- 2) What is diffusion?
- 3) Why are most large molecules unable to enter cells?
- 4) What does iodine do when it reacts with starch?

Purpose:

In this laboratory activity you will design an experiment to investigate the processes of osmosis and diffusion in a model of a semi-permeable membrane system. You will also investigate the effect of solute concentration on percent change in mass as it relates to living plant tissues.

Objectives: At the completion of this laboratory you should be able to:

- design experiments to study diffusion, osmosis, and water potential
- describe the mechanisms of diffusion and osmosis
- describe how solute size and molar concentration affect the process of diffusion through a semi-permeable membrane
- relate osmotic potential to solute concentration and water potential
- calculate the percent change in mass of living plant cells from experimental data

Hypothesis:

Using variable assigned, develop a hypothesis, using the **If**, and, **then** concerning the selectivity and permeability of the plasma (cell) membrane.

II. Designing the Investigation:

Materials: Below make a list of materials used.

Procedure:

Exercise A: Diffusion ...(2 Days)

In this experiment we will measure diffusion of small molecules through a selectively permeable membrane (dialysis tubing). A selectively permeable membrane will allow some substances to diffuse through, but not others. Those substances that can diffuse through the membrane will do so at different rates. Small solute molecules and water molecules can move freely through a selectively permeable membrane like dialysis tubing, but larger molecules will pass through more slowly, or perhaps not at all. The movement of a solute through a selectively permeable membrane is called **dialysis**. The

size of the minute pores in the dialysis tubing determines which substances can pass through.

Day 1:

- 1) Make your “cell”. Obtain a piece of dialysis tubing. Wet the tubing in water until you can slide the sides apart. Tie off one end of the “cell” tightly with a small piece of thread.
- 2) Fill the “cell” as directed with starch solution. Tie off the other end with the thread. Rinse with tap water, dry with paper towel, and determine the mass of the “cell” using the balance. Record mass and observations in your data table.
- 3) Place the “cell” in a cup containing iodine solution (~50ml).
- 4) Set the cup on the sheet on the circle labeled “starch cell”.
- 5) Repeat steps 1-3 replacing the “cell” solution with iodine and the cup solution with starch.
- 6) Set the cup on the sheet on the circle labeled “iodine cell”.

Day 2:

- 1) Record all observations for Day 2, such as color change.
- 2) Remove the “cell” and rinse with tap water. Dry the “cell” with a paper towel and determine the mass of the “cell”. Record the mass in **Data Table 1: Diffusion Results**
- 3) Calculate % change and record in data table.

$$\% \text{ change} = \frac{\text{Final Mass} - \text{Initial Mass}}{\text{Initial Mass}} \times 100$$

Exercise B: Osmosis ... (2 Days)

In this experiment we will use carrot slices to investigate the relationship between solute concentration and the movement of water through a selectively permeable membrane by the process of osmosis.

When a carrot containing a sucrose solution is placed in distilled water the carrot will accumulate water as a result of osmosis. Because there is a higher water potential outside the carrot than inside the carrot, water will diffuse into the carrot. In the absence of pressure, the solution outside the carrot is said to be **hypotonic** relative to the solution in the carrot. The solution inside the carrot with a higher solute concentration is **hypertonic** to the solution outside the carrot.

If solute is added to the water outside the carrot, you decrease the water potential of the solution outside the carrot. It should therefore be possible to add just the right amount of solute to the water so that the water potential outside the carrot is the same as

the water potential inside the carrot. The two solutions are **isotonic** relative to each other. In this case, no NET water movement will occur.

If you continue to add more solute to the water outside the carrot, the water potential outside the carrot will decrease to the point where the solution outside the bag is hypertonic to the solution inside the carrot. The NET movement of water will then be in the opposite direction, from inside (where the water potential is higher) to outside the carrot (where water potential is lower).

Day 1:

- 1) Label your six cups DI H₂O, 0.2M Sucrose, 0.4 M Sucrose, 0.6M Sucrose, 0.8M Sucrose, and 1.0M Sucrose.
- 2) Pour ~50ml of the solution of each solution into appropriately labeled cup!
- 3) Obtain 6 equally sized slices of carrot. Determine the mass of each carrot slice and record the initial mass in the data table. Be sure carrot massed was placed in appropriate cup of solution.

Day 2:

- 1) Remove the carrot slices from each cup. *Be careful not to mix them up. Maybe mass one cup at a time to avoid switching carrot slice with appropriate solution.*
- 2) Determine the final mass and record in **Data Table 2: Osmosis Results**
- 3) Calculate the percent change using the % change equation on page 2.

III. Collecting and Presenting Data:

Results:

	*Observations Day 1	*Observations Day 2	Mass (gm) Day 1	Mass (gm) Day 2	% Change in Mass
Starch "Cell"					
Iodine "Cell"					

Data Table 1: Diffusion Results *Observations of size of "cell", color inside and outside

Solute (gm/ml)	Initial mass (gm)	Final Mass (gm)	% Change	Class Average % Change
DI H ₂ O (0.00 gm/ml)				

0.2 M Sucrose (0.068 gm/ml)				
0.4 M Sucrose (0.137 gm/ml)				
0.6 M Sucrose (0.210 gm/ml)				
0.8M Sucrose (0.274 gm/ml)				
1.0M Sucrose (0.342 gm/ml)				

Data Table 2: Osmosis Results

Graph Data Table 2: Osmosis Results Below

For this graph you will need to determine the following:

- The independent variable _____
Use this to label the horizontal *x*-axis.
- The *dependent* variable _____
Use this to label the vertical *y*-axis.

Graph 1 Title:

_____.

IV. Analyzing and Interpreting Results:

Analysis Questions for Exercise A:

- 1) According the results, identify whether each of the molecules can or cannot move through the “cell” membrane as represented by the dialysis tubing.

Iodine _____ Starch _____

For each of the molecules, explain how you know this from the lab activity:

Iodine:
Starch:

- 2) Why did your starch “cell” become more swollen overnight? How is this an example of osmosis?
- 3) Is the dialysis tubing selectively permeable? Explain.

Analysis Questions for Exercise B:

- 1) Graph the results for class average on graph. In order to do so, the 0 axis line should actually be in the middle of your graph. The y axis above this line should be labeled % increase in mass while the y axis below this line should be labeled % decrease. The x axis is the solute concentration (gm/ml) within the beaker.
- 2) Determine the molar concentration of the carrot slices. This would be the sucrose molarity in which the mass of the carrot slices does not change. To find this, draw the straight line on your graph that best fits your data. The point at which this line crosses the x axis represents the molar concentration of sucrose with a water potential that is equal to the potato tissue water potential. At this concentration, there is no net gain or loss of water from the tissue.
- 3) What is the Molar concentration of sucrose? _____
- 4) Did any of the carrot cylinders change in their turgidity (flexibility), and if so, which ones changed?
- 5) Explain why the flexibility of the carrot slices changed, what process was responsible for this?
- 6) Which solution served as the control for this experiment & why?
- 7) In which solutions was their a greater solute concentration outside of the carrot cells?
- 8) In which direction did water move through these cell membranes of the carrot?
- 9) In what type of solution do plant (carrot) cells do best & why?

V. References:

AP® Biology Lab Manual for Students (2001),
<http://store.collegeboard.com/productdetail.do?Itemkey=991461>

VI. TEKS/TAKS:

TEKS: 1A, 1B, 2A, 2B, 2C, 2D, 3A, 3F, 4B, 5A, 11A, 11C, 13A

TAKS: 1, 2, 3