Crossing the Border

Overview

Description
In this activity, students will mix several solutions, record their observations, and interpret the results in terms of intermolecular forces. Students will also use drawings of phospholipids and proteins to predict how intermolecular forces cause these biomolecules to form a biological membrane in water. Then, students will apply their knowledge of cellular transport and predict how substances will move across a concentration gradient.

Final Product: Students will carry out a laboratory investigation in which they study osmosis in potato tissue. At the conclusion of the lab, students will produce a short written narrative comparing their initial predictions to their results and comparing their own results to the results of their classmates.

Course
Biology

Task Level
Grades 9–12

Cross-Disciplinary Standards Assessed
I. Key Cognitive Skills
   C.1. Analyze a situation to identify a problem to be solved.
   C.3. Collect evidence and data systematically and directly relate to solving a problem.

II. Foundational Skills
   A.2. Use a variety of strategies to understand the meanings of new words.
   B.3. Gather evidence to support arguments, findings or lines of reasoning.
   C.2. Evaluate evidence in terms of quality and quantity.
   E.2. Work collaboratively.

Science Standards Assessed
I. Nature of Science: Scientific Ways of Learning and Thinking
   A.4. Rely on reproducible observations of empirical evidence when constructing, analyzing, and evaluating explanations of natural events and processes.
B.1. Design and conduct scientific investigations in which hypotheses are formulated and tested.

C.2. Understand and apply safe procedures in the laboratory and field.

C.3. Demonstrate skill in the safe use of a wide variety of apparatuses, equipment, techniques, and procedures.

D.3. Demonstrate appropriate use of a wide variety of apparatuses, equipment, techniques, and procedures for collecting quantitative and qualitative data.

III. Foundation Skills: Scientific Applications of Communication

B.2. Set up apparatuses, carry out procedures, and collect specified data from a given set of appropriate instructions.

VI. Biology

A.6. Know the structure of membranes and how this relates to permeability.

B.1. Understand the major categories of biological molecules: lipids, carbohydrates, proteins and nucleic acids.

Objectives

Students will:

• Observe mixtures of water-soluble and fat-soluble substances and describe intermolecular interactions.

• Use drawings of phospholipids and proteins to predict how intermolecular forces cause these biomolecules to form a biological membrane in water.

• Work with numerical examples of concentration differences across a membrane and predict the net transport.

• Make predictions about the direction of osmosis and investigate osmosis in potato tissue.

Preparation

• Read the Instructor Task Information and the Student Notes.

• Prepare student copies of the Student Notes pages, Which Way Will the Ions Go?, and Potato Osmosis Lab handouts.

• Obtain the following supplies for each group of students completing the Getting Started activity: a flat transparent dish of water (clean Petri dishes work well) placed on white paper background, food coloring (blue and green work well, but not yellow), cooking oil, and a few drops of liquid dishwashing detergent (clear is best).

• Find figures of the detailed chemical structure of a phospholipid that can be used as an example during the Investigating activity.
• Obtain the following supplies for each pair of students completing the Investigating activity: supplies to make multiple copies of colored drawings of phospholipid and protein structures, a sheet of blue paper, and a sheet of red or yellow paper.

• Gather references about osmosis that students can use when performing the Drawing Conclusions activity.

Prior Knowledge

• Students should be able to distinguish between water-soluble and fat-soluble substances and distinguish among positively charged, negatively charged, and electrically neutral substances. Students should also know the structure and general properties of lipids and proteins and know that oppositely charged ions attract each other. Finally, students should be able to design an experiment, measure the mass of an object by using a balance, and estimate the volume of an object by the water displacement method.

Vocabulary

• Diffusion
• Intermolecular bond
• Intramolecular bond
• Molar solution
• Osmosis
• Phospholipid
• Phospholipid bilayer
• Plasma membrane (cell membrane)
• Protein
• Semi-permeable membrane
• Solute

Time Frame

The Getting Started activity will require parts of two days: one class period to review the types of mixtures and solubility properties and one class period for the activity. The Investigating activity can be done in one period. Before students do this activity, they must have a good idea about specific membrane transport mechanisms and the concept of diffusion. The actual lab work in Drawing Conclusions requires two class periods, no more than 24 hours apart. At least one class period before the lab work is needed to discuss osmosis, to practice measuring volume and mass, and to think about how to set up the experiment.
Instructional Plan

Getting Started

CCRS Performance Expectations

Cross-Disciplinary Standards:

I. Key Cognitive Skills
   C.3. Collect evidence and data systematically and directly relate to solving a problem.

II. Foundational Skills
   A.2. Use a variety of strategies to understand the meanings of new words.
   B.3. Gather evidence to support arguments, findings or lines of reasoning.

Science Standards:

I. Nature of Science: Scientific Ways of Learning and Thinking
   C.2. Understand and apply safe procedures in the laboratory and field.
   C.3. Demonstrate skill in the safe use of a wide variety of apparatuses, equipment, techniques, and procedures.

VI. Biology
   B.1. Understand the major categories of biological molecules: lipids, carbohydrates, proteins and nucleic acids.

Learning Objectives

Students will:

• Observe mixtures of water-soluble and fat-soluble substances and describe intermolecular interactions.

Procedure

1. Divide students into pairs, and instruct them to follow the Getting Started directions on their worksheets.

2. Make sure students are recording their observations.

3. Have students work on flat surfaces, beginning with a covered Petri dish containing about 1/4 inch of water placed on a white sheet of paper with a paper town nearby. When students are ready, dispense a drop or two of food coloring into each group's dish. Have several small labeled beakers ready, each with a plastic pipette (eye-dropper). Half of the beakers should contain cooking oil (e.g., vegetable oil) and the other half should contain liquid dishwashing detergent (clear or white detergent is best).
4. Each group of students adds substances one at a time and records their observations.

5. Follow up with a class discussion of results and interpretations.

**Investigating**

**CCRS Performance Expectations**

Cross-Disciplinary Standards:

I. Key Cognitive Skills
   C.1. Analyze a situation to identify a problem to be solved.

II. Foundational Skills
   A.2. Use a variety of strategies to understand the meanings of new words.
   B.3. Gather evidence to support arguments, findings or lines of reasoning.
   E.2. Work collaboratively.

Science Standards:

I. Nature of Science: Scientific Ways of Learning and Thinking
   B.1. Design and conduct scientific investigations in which hypotheses are formulated and tested.
   C.2. Understand and apply safe procedures in the laboratory and field.
   C.3. Demonstrate skill in the safe use of a wide variety of apparatuses, equipment, techniques, and procedures.

VII. Biology
   A.6. Know the structure of membranes and how this relates to permeability.
   B.1. Understand the major categories of biological molecules: lipids, carbohydrates, proteins and nucleic acids.

**Learning Objectives**

Students will:

- Use drawings of phospholipids and proteins to predict how intermolecular forces cause these biomolecules to form a biological membrane in water.

- Work with numerical examples of concentration differences across a membrane and predict the net transport.

**Procedure**

1. Help students review three major types of macromolecules (proteins, lipids, and carbohydrates). Working in pairs, students should examine figures of the molecular structure of phospholipids, and identify parts of the macromolecule.
that should be water-soluble (have many O-H bonds) and the parts that are fat-soluble (have many C-H bonds and no O-H covalent bonds).

2. Instruct students to make simple diagrams of phospholipids and globular proteins, such as shown in the figure at right. Students should color the water-soluble parts of the molecule blue and the fat-soluble parts of the molecule yellow or red.

3. Have students follow the Investigating instructions on the student worksheet and predict the intermolecular bonds that would form between two phospholipids and how the phospholipids would line up together. Then tell students to take a page of blue paper (representing water) and predict how a group of phospholipids would likely arrange themselves in water. Next, direct students to take a red or yellow paper (representing oil) and predict how phospholipids would arrange themselves in oil.

4. Have students take their drawings of individual phospholipid molecules and arrange them in a bilayer, as the molecules would form in water. Now tell students to insert the drawings of the three proteins into the bilayer. Ask: Would all three proteins take the same position with respect to the phospholipid bilayer?

5. Finally, have students use the *Which Way Will the Ions Go?* handout to practice using numerical examples (molarity) of concentration differences across a membrane. Students will use information to predict the net direction of transport of substances across a membrane.

**Drawing Conclusions**

*CCRS Performance Expectations*

Cross-Disciplinary Standards:

I. Key Cognitive Skills
   
   C.1. Analyze a situation to identify a problem to be solved.

II. Foundational Skills

   A.2. Use a variety of strategies to understand the meanings of new words.
   
   B.3. Gather evidence to support arguments, findings or lines of reasoning.

   C.2. Evaluate evidence in terms of quality and quantity.

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Science Standards:

I. Nature of Science: Scientific Ways of Learning and Thinking
   A.4. Rely on reproducible observations of empirical evidence when constructing, analyzing, and evaluating explanations of natural events and processes.
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III. Foundation Skills: Scientific Applications of Communication
   B.2. Set up apparatuses, carry out procedures, and collect specified data from a given set of appropriate instructions.

VI. Biology
   A.6. Know the structure of membranes and how this relates to permeability.

Learning Objectives

Students will:

- Make predictions about the direction of osmosis and investigate osmosis in potato tissue.

Procedure

1. Give students the *Potato Osmosis Lab* handouts. In the lab, students will investigate osmosis in potato tissue and make predictions about the net direction of water movement. Instruct students to take notes throughout the lab regarding whether or not the results support their predictions.

2. Instruct students to set up the experiment to measure changes in mass or volume of potato cores in different molar solutions and interpret their results by estimating the solute concentration of the potato.

3. In addition to their lab notes, ask students to write and turn in a brief narrative comparing their results to their predictions, and comparing their results to those of their classmates.
Scaffolding/Instructional Support

The goal of scaffolding is to remove support gradually to encourage student success, independence, and self-management. The following suggestions are examples of scaffolding that can be used by instructors to meet diverse student needs while students are completing this assignment:

- Students often have difficulty comprehending the weak attractive forces of intermolecular bonds. Before starting the first activity, make sure students can distinguish such weak forces from the strong covalent bonds within a molecule.

- To review weak bonds and prepare students for this exercise, the instructor could have students work with cutouts of small molecules, such as \( \text{H}_2\text{O}, \text{NH}_3, \text{CH}_4 \), and move cutouts to predict which could form intermolecular bonds.

- Before students begin the Investigating portion of the activity, have students review the definition of diffusion. There are many good animations of diffusion on the web to help students visualize the process. If students in the class have studied chemistry (specifically moles and molar solutions), you can draw the connection between chemistry and biology in this activity. If they have not studied molarity, you can explain that molarity measures are used to indicate the concentration of a substance in a water solution. Structure the activity so you can check student answers to questions 1 and 2 on the Which Way Will the Ions Go? handout before they proceed to the rest of the exercise. Prediction #6 on the handout’s table is difficult because it involves electrical charges, so you could set it as optional or you could wait until the rest of the predictions are discussed before asking the class together about #6.

- Well before you have students carry out the laboratory activity, students need to practice determining mass using balances and determining volume by water displacement using graduated cylinders. In addition, make sure students are familiar with the concept of molar solutions.

- Advanced students may want to follow up the osmosis lab with independent investigation. For example, students could explore using sodium malonate and sodium succinate to study the effect of poisons on osmosis. (See: Tatina, Robert. “Osmosis in Poisoned Plant Cells.” The American Biology Teacher, Vol. 60, No. 2, pp. 144-147.)
Solutions

The solutions provided in this section are intended to clarify the problem for instructors. These solutions may not represent all possible strategies for approaching the problem or all possible solutions. It should be used for reference only.

During the Getting Started activity, the food coloring observations may vary because there are different types of food coloring. If the student observes mixing of food coloring in water, that indicates a water-soluble substance. Observation of vegetable oil forming globules in water should suggest that water does not form intermolecular attraction with vegetable oil. Students will probably observe the detergent allowing more mixing of water and oil and thus could conclude that the detergent is soluble in both. Lead students to recognize that detergent dissolves the oil (grease) but is also water soluble. Help the student realize that shaking the salad dressing temporarily causes the vegetable oil to disperse into tiny droplets, but as the salad dressing stands, oil globules re-form because of intermolecular attractions and because oil cannot form intermolecular bonds with water.

When working with the paper models during the Investigating activity, students should predict that water-soluble parts of molecules will form intermolecular bonds with water and with other water-soluble molecules. Fat-soluble parts of molecules will cluster with other fat-soluble substances and will not interact with water. In water, phospholipids would either form a bilayer with the fat-soluble components facing inward or they might form a small sphere, with fat-soluble components inside.

Students will have various ways that the proteins would fit into the phospholipid bilayer, but in any case the blue part of one macromolecule would align with the blue part of another; the same for red. So, protein A could span the entire phospholipid bilayer, with the protein's outer blue areas next to the phospholipid heads (blue) and the red on the surface of the protein next to the red of the phospholipid tails. Protein B would be stable inside the inner core of the phospholipid bilayer, and Protein C would line up to a phospholipid so that blue aligns with blue and red with red.

When completing the table on the Which Way Will the Ions Go? handout, students should give the following predictions:

1. Na+ ions move from B to A
2. no movement of ions
3. no [net] movement – perhaps back and forth so concentrations stay the same
4. Cl- ions move from B to A
5. Cl- ions move from A to B
6. Cl- ions could move from B to A if they are pulled there by the excess positive charge

Make sure students explain their predictions.
Crossing the Border

Introduction

Every cell in your body has a boundary called the plasma membrane (or cell membrane), which separates the watery cytoplasm from the watery surroundings outside the cell. But the boundary isn't solid and impermeable like a layer of plastic. Instead, it is a fluid layer of biomolecules that, as a whole, is selectively permeable. The plasma membrane acts like a border or boundary, but there is a lot of traffic across the border.

Directions

Getting Started

1. Before the activity, review the meaning of the following terms: water-soluble, fat-soluble, intermolecular bonds, and intramolecular bonds.

2. These materials will be needed by your group: one covered Petri dish, water, food coloring, vegetable oil, liquid dish detergent, a paper towel, and a sink for cleanup.

3. Add a small amount of water to a Petri dish, enough to completely cover the bottom but not more than $\frac{1}{4}$-inch deep. Cover the dish and place it on a white sheet of paper on a flat, level surface.

4. Ask the instructor for a drop of food coloring, and then put the cover back on. Keeping the dish resting on the table surface, gently move it in small circles or back and forth to mix the contents.
   a. Record what you see in the dish.
   b. Do you think this food coloring is mostly water-soluble or not? Why?

5. Add several drops of vegetable oil in a line in the middle of the dish.
   a. Record what you see in the dish (you might want to draw and label a sketch).
   b. Move the dish to mix the contents.
   c. Does the vegetable oil mix with the food coloring?
   d. Does the vegetable oil mix with the water?
   e. Do you think the vegetable oil is mostly water-soluble or not? Why?
   f. Do you think this food coloring is more water-soluble or fat-soluble? Why?
6. Add several drops of liquid detergent.
   a. Record what you see in the dish.
   b. Move the dish to mix the contents.
   c. Does the detergent mix with the food coloring?
   d. Does the detergent mix with the vegetable oil?
   e. Does the detergent mix with the water?

7. Clean up and put away your materials.

8. Use the following questions to interpret your results:
   a. Water molecules have strong intermolecular forces between them. Does water form intermolecular bonds with vegetable oil? How do you know?
   b. Does the food coloring you used contain more water-soluble substances or more fat-soluble substances? How do you know?
   c. Does the detergent form intermolecular bonds with water? With vegetable oil? With both? How do you know?
   d. Why is detergent effective for cleaning dishes?
   e. Salad dressing is made from vegetable oil and vinegar, which is mostly water. Why do you need to shake up the salad dressing before pouring some on the salad?

Investigating

1. Use drawings that represent molecules in order to hypothesize how biomolecules interact with each other and with water to form cell membranes.

2. Draw and color diagrams representing phospholipids and proteins (your instructor will give you some examples). Use blue to indicate the water-soluble parts of the molecule and red or yellow to indicate the fat-soluble parts of the molecule. Make about 20 phospholipids and two each of the three kinds of proteins.

3. Place two of the phospholipid figures on your desk and hypothesize how they would line up together in cells. Sketch the arrangement on your paper and describe any intermolecular attractive forces that could be in effect.

4. Place a sheet of blue paper on your desk (representing water), and place the paper phospholipid figures on the "water". From what you know about intermolecular attractions of water and the parts of the phospholipids, predict how the phospholipids would arrange themselves in water. Compare your predicted arrangement with that of another student, and explain your
reasoning. Sketch your result in your notebook, and label the sketch "phospholipids in water."

5. Place a sheet of red or yellow paper (representing vegetable oil) and, using your phospholipid figures, predict how phospholipids would arrange themselves in oil. Compare your predicted arrangement with that of another student, and explain your reasoning. Sketch your result in your notebook, and label the sketch "phospholipids in oil."

6. On a sheet of blue paper (water), arrange the 20 individual phospholipid molecules in a bilayer, with the fat-soluble (red/yellow) tails in the middle and the blue parts of the molecules facing the blue water. Take the drawing of protein A and insert it into the phospholipid bilayer. Arrange it so that water-soluble parts (blue) are next to each other and the fat-soluble parts (red/yellow) are next to each other (demonstrating intermolecular attractions). Do the same thing with proteins B and C. Compare your predicted arrangement with that of another student, and explain your reasoning. Sketch your results in your notebook.

7. Questions:
   a. Would all three proteins take the same position with respect to the phospholipid bilayer? Why or why not?
   b. In what way is a phospholipid molecule like the detergent molecule that you investigated in the previous activity?


**Drawing Conclusions**

1. Use the Potato Osmosis Lab handout to investigate osmosis taking place across the membranes of potato cells.

2. Take note of your initial prediction and notice whether or not it is supported by the observations you make during the lab. Write up a brief narrative comparing your predictions to your results and comparing your results to those of your classmates.
Which Way Will the Ions Go?

Cell membranes act as borders, but they are semi-permeable barriers. Because of this, certain types of molecules can cross through the membrane, while other molecules cannot. For example, small charged particles such as hydrogen ions (H+) and chloride ions (Cl-) can only cross the membrane through a transport protein. In passive transport systems, particles move by diffusion, which is a type of passive cellular transportation that requires the cell to use no energy to move particles across the membrane. In diffusion there is a net movement of particles from an area of higher concentration to an area of lower concentration. The movement of electrically charged ions like Na+ can also be affected by the electrical charge distribution, because oppositely charged particles attract each other.

In this exercise we will take a look at the diffusion forces acting on an ion that pull it one way or another across a membrane.

1. Molarity is the measure of the concentration of a specific type of ion in solution. Solution A has a molarity of 0.2 M Na+, while solution B has a molarity of 0.4 M Na+. Which solution, A or B, has a higher concentration of Na+ ions? Which solution, A or B, has a greater positive charge due to Na+ ions? Explain.

2. If a membrane separated solutions A and B and the membrane was permeable to Na+ ions, would Na+ ions tend to move from solution A to solution B or from solution B to solution A? Or, would there be no significant movement? Explain.
3. Check your answers to questions 1 and 2. If correct so far, then apply your knowledge of diffusion to fill in items in the following chart. An example is given in the first row.

<table>
<thead>
<tr>
<th>Example</th>
<th>Side A</th>
<th>Side B</th>
<th>Membrane permeable to what?</th>
<th>Predict movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>0.5 M Na+</td>
<td>0.2 M Na+</td>
<td>Na+ ions</td>
<td>Na+ moves from A to B</td>
</tr>
<tr>
<td>1</td>
<td>0.1 M Na+</td>
<td>0.5 M Na+</td>
<td>Na+ ions</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.5 M Na+</td>
<td>0.2 M Na+</td>
<td>No ions</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.3 M Na+</td>
<td>0.3 M Na+</td>
<td>Na+ ions</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.4 M Cl-</td>
<td>0.7 M Cl-</td>
<td>Cl- ions</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.3 M Na+ and 0.5 M Cl-</td>
<td>0.3 M Na+ and 0.2 M Cl-</td>
<td>Cl- ions and Na+ ions</td>
<td></td>
</tr>
<tr>
<td>6*</td>
<td>1.0 M Na+ and 0.5 M Cl-</td>
<td>0.1 M Na+ and 0.5 M Cl-</td>
<td>Cl- ions only</td>
<td></td>
</tr>
</tbody>
</table>

Questions:

1. For each item, what types of information did you use in order to make the prediction?

2. How does the term *selectively permeable membrane* relate to this activity?
3. In scenario #2 in the table, which of these was more important in contributing to the movement of Na+ ions across the membrane: (A) diffusion of substance from high to low concentration or (B) diffusion of substance towards opposite charge? Explain.

4. In scenario #6 in the table, which of these was more important in contributing to the movement of Na+ ions across the membrane: (A) diffusion of substance from high to low concentration or (B) diffusion of substance towards opposite charge? Explain.
Potato Osmosis Lab

Osmosis is the special case of diffusion of water across semi-permeable cell membranes. Water tends to cross membranes towards areas of higher solute concentration. In this laboratory exercise, you will study the movement of water into or out of samples of potato tissue. Since you cannot see the movement of water across membranes and cannot measure that directly, you will measure any changes indirectly. You will look for either a change in the mass of the potato sample or a change in volume of the potato sample. By placing potato samples in a series of sucrose solutions you will be able to estimate the molarity of potato tissue cells.

You will be studying osmosis using an experimental approach. Your hypothesis concerns the effect of different solute concentrations on the direction of water movement into or out of the potato sample. The solute will be sucrose sugar, which can move across plant cell membranes.

For this lab, work in groups of 3 or 4 students. You will be doing the preparation of samples and predictions on the first lab day, then leaving the samples in solutions for about 24 hours, and measuring the results on the second day.

Predictions: Before doing this lab exercise, make a prediction about the change in size you expect for a potato core in each of these solutions – will it increase, decrease, or stay about the same? Explain. (You will use this information in your final write-up).

<table>
<thead>
<tr>
<th>Solution in beaker</th>
<th>Predicted change?</th>
<th>Explain your prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 M sucrose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4 M sucrose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6 M sucrose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8 M sucrose</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Materials:
1 large potato per group, large enough to cut 5 cores from the same potato
Cork borer
Scalpel or paring knife
Sucrose solutions of 0.2 M, 0.4 M, 0.6 M, and 0.8 M concentration
Distilled water (DI water = 0.0 M solution)
1 Petri dish; five 250 mL beakers for soaking the potato cores
Forceps
Plastic wrap
Paper towels
Marker to label the beakers
Graduated cylinder
Balance with aluminum sheet on it

**Data table**

<table>
<thead>
<tr>
<th>Solution in beaker</th>
<th>Initial mass or volume of core</th>
<th>Final mass or volume</th>
<th>Change in mass or volume</th>
<th>% mass or volume change</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8 M</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Procedure for Each Group of Students**

(Half of the groups will measure change in volume of the cores, and half will measure change in mass of the cores.)

1. Use a sharp cork borer to cut five potato cylinders. Take care with the cork borer; hold the potato so you are not cutting into your hand. With a scalpel or paring knife, cut each cylinder to approximately 5 cm in length. Do not include any potato skin on the cylinders. Place the five cylinders in a Petri dish and cover to prevent them from drying up.

2. Set up five 250 mL beakers, each with 150 mL of a different sucrose solution. Label the beakers 0.0 M (DI water), 0.2 M, 0.4 M, 0.6 M, and 0.8 M.

3. Take a potato cylinder out of the Petri dish and place it on a paper towel to blot off excess moisture (handle the potato gently with forceps). Groups measuring change in mass should measure the cylinder to the nearest 0.01 g on the aluminum sheet on the balance. Record the initial weight in the table beside 0.0 M. Groups measuring change in volume should place the potato cylinder in a 25 mL graduated cylinder containing 15 mL of water. Record the volume of water displaced by the cylinder. After measuring, carefully transfer the potato core into the beaker with 0.0 M solution (distilled water), and cover the beaker with plastic wrap to prevent evaporation.
4. Repeat this procedure with the remaining four solutions, each time carefully recording the initial mass or volume of the potato cylinder in the correct part of the table. Record the date and time the cores began soaking. Let the beakers stand overnight.

5. Gently remove the cylinders from the beaker (be careful, the potato core could fall apart). Blot dry and weigh on a balance or record the change in volume by the same method as the before. Record the final mass or volume.

6. Calculate the percent change for each potato core. Was the change positive or negative? Enter the percent change (with the correct sign, positive or negative) in the results table.

7. Make a graph on a separate piece of paper with the molarity of the sucrose solution on the x-axis and the change in volume on the y-axis.

8. Describe your results in terms of osmosis. In which molar solutions did the potato core gain water? In which molar solutions did the potato core lose water? Which solution was closest in molarity to that of the original potato core? (You will use this information in your final write-up).

9. Compare your results to those of other groups. Were there differences between the results using two different methods of measurements, volume and mass? (You will use this information in your final write-up).