

Crossing the Border

Overview

Description

In this activity, students will create several solutions using hydrophilic and hydrophobic substances and water, record their observations, and interpret the results in terms of intermolecular forces. Students will also use drawings of phospholipids and proteins to further understand electronegativity and 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 or fruit 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.

Subject

Biology

Task Level

Grade 9

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 electronegativity determines the intermolecular forces that 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 or fruit 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/Fruit 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 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: a sheet of white paper, blue and red or yellow markers/crayons/colored pencils, scissors, a sheet of blue paper, and a sheet of red or yellow paper.

Prior Knowledge

Students should be familiar with atomic structure, subatomic particles, and electron configurations. 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
- Electronegativity
- Intermolecular bond
- Intramolecular bond
- Molarity
- Osmosis
- Phospholipid
- Phospholipid bilayer
- Plasma membrane (cell membrane)
- Polarity
- 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.

This assignment can be modified to meet the needs of different classroom schedules and student ability levels. If students have already encountered the experimental skills required in this activity (measuring volume and mass, setting up experiments, etc.) then less class time may be required. Additionally, to facilitate the activity using less class time and fewer supplies, the Getting Started activities can be structured as instructor-led interactive demonstrations rather than student-led experiments.

Instructional Plan

Getting Started

Learning Objectives

Students will:

- Observe mixtures of water-soluble and fat-soluble substances.
- Apply the concepts of electronegativity and intermolecular interactions to hypothesize and explain their observations.

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 towel nearby. While students are watching, dispense a drop or two of food coloring into each group's dish and have them record their observations.
4. 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). Each group of students should add drops of oil then drops of detergent and record their observations after the addition of each substance. Students may gently agitate their dish after the addition of each substance, observe the effects, and see if anything changes as the contents return to equilibrium. They should have observations of food coloring alone, colored water with oil, and colored water with oil and detergent.
5. As a class, discuss the results and interpretations of the experiment. Ask them to suggest hypotheses regarding the molecular structure/*intramolecular* bonds of each substance to explain the interactions they observed and the resulting *intermolecular* bonds.
6. Review concepts of electronegativity using a periodic table to illustrate trends (electronegativity is higher towards the right and top sides of the table). Draw a simple atomic diagram and explain that the attraction between the negatively charged electron shells and the positively charged nucleus increases with the number of electrons and protons (as you go to the right). Similarly, the attraction increases as the electrons are closer to the nucleus and there is less shielding effect of being in outer shells (as you move up).
7. Apply the concept of electronegativity to explain how covalent bonds can be unevenly shared, resulting in partial charges and hydrogen bonds. Lead a discussion regarding why water is the "universal solvent" (many hydrogen

bonds possible, leading to interaction with many solutes) and how this applies to their experiment. Use this discussion to inform and revise their hypotheses on the molecular structure of the substances they added to the water.

Investigating

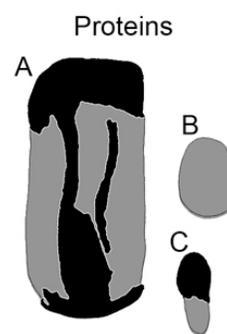
Learning Objectives

Students will:

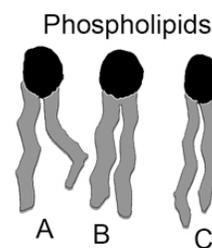
- Use drawings of phospholipids and proteins to predict how intermolecular forces cause these biomolecules to form a biological membrane in water.
- Work with numerical examples of concentration differences across a membrane and predict the net transport.

Procedure

1. Help students review two of the major types of macromolecules (proteins and lipids). Working in pairs, students should examine figures of the molecular structure of phospholipids and use their knowledge about electronegativity to identify parts of the macromolecule that should be polar/water-soluble (have many O-H bonds) and the parts that are nonpolar/fat-soluble (have many C-H bonds and no O-H covalent bonds).



2. Instruct pairs to draw simple diagrams on their white paper of three types of globular proteins (heterogeneous polarity (A), nonpolar (B), and amphipathic (C)) and of phospholipids, such as those in the figure. Students should color the polar/water-soluble parts of the molecules blue and the nonpolar/fat-soluble parts of the molecule yellow or red. Each pair of students should make about 20 phospholipids and two each of the three types of proteins and cut them out.
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

Learning Objectives

Students will:

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

Procedure

1. Give students the *Potato/Fruit 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 the results support their predictions.
2. Instruct students to set up the experiment to measure changes in mass or volume of potato or fruit cores in solutions of different molarities and interpret their results by estimating the solute concentration of the potato or fruit.
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 provide support to encourage student success, independence, and self-management. Instructors can use these suggestions, in part or all together, to meet diverse student needs. The more skilled the student, however, the less scaffolding that he or she will need. Some examples of scaffolding that could apply to this assignment include:

- Students often have difficulty comprehending how weak the attractive forces of intermolecular interactions are in an aqueous environment. Before starting the first activity, make sure students can distinguish such weak forces from the strong covalent bonds within a molecule when in an aqueous environment (such as a cell).
- 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 molarity), 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 #5 on the handout's table is difficult because it involves an electrical and a chemical gradient, 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 #5.
- 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 molarity.
- 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.)
- Consider pairing students who have different predictions about the various activities to ensure that they will be able to discuss why their views differ.

Solutions

The information below is intended to help you assess students' final work products. It may not represent all possible strategies and ideas. The accompanying scoring guide provides specific examples of ways a student might demonstrate content understanding and mastery of cross-disciplinary skills.

Getting Started

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 emulsifies 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.

Investigating

When working with the paper models during the Investigating activity, students should predict that water-soluble parts of molecules will form intermolecular hydrogen 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 (a micelle), with fat-soluble components inside. In oil, the same shapes will be formed, but the molecules will be flipped such that the nonpolar lipid tails are on the outside and the polar phosphate heads are on the inside, avoiding interaction with the nonpolar oil.

When students insert their proteins into their phospholipid layers, the colors should align such that blue (polar) parts interact and red or yellow (nonpolar) parts interact. For example, Protein A would 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:

Which Way Will the Ions Go? Sample Solutions (example answers in italics)

1. Molarity is a measure of the concentration of a solute in a solution. Solution A has a molarity of 0.2 M Na⁺ in water, 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. *Solution B has a higher concentration of Na^+ ions and a greater positive charge due to Na^+ .*

2. If a membrane separated solutions A and B and the membrane was permeable to Na^+ ions but not water, would there be a net movement of ions from one side to the other? If so, which direction would the ions move? *Na^+ ions would move across the membrane from Solution B to Solution A.*

Predictions of Movement (table)

1. *Na^+ ions move from B to A*
2. *No movement of ions*
3. *No [net] movement*
4. *Cl^- ions move from B to A*
5. *Cl^- ions move from B to A due to the electrical gradient*

Questions

1. For each item, what types of information did you use in order to make the prediction? *Solute concentration, solute charge, and membrane permeability.*
2. How does the term selectively permeable membrane relate to this activity? *Selectively permeable means there are restrictions on what types of solutes can cross the barrier; this must be taken into consideration in order to determine if a particular solute will move or not.*
3. In scenario #5 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. *In this example, diffusion of a substance towards opposite charge was the primary consideration. Cl^- ions will move from B to A to neutralize the electrical gradient created by having more positive charges in A than B.*

Make sure students provide appropriate explanations for their predictions.

Drawing Conclusions

The final write-up should include all data generated during the experiment, presented in a clear and orderly manner. Students should summarize their results in the form of a concise statement that summarizes the results and provides an explanation. Students should demonstrate an understanding of why the experiment is able to provide an estimate of the concentration of sugar in the potato (i.e., it only works because the potato cells are impermeable to sugar molecules). Students should also provide a hypothesis for why differences, if observed, might exist between the two methods of evaluation (weight vs. volume).

TCCRS Cross-Disciplinary Standards Addressed

Performance Expectation	Getting Started	Investigating	Drawing Conclusions
<i>I. Key Cognitive Skills</i>			
A.1. Engage in scholarly inquiry and dialogue.	✓	✓	✓
B.1. Consider arguments and conclusions of self and others.	✓	✓	✓
B.2. Construct well-reasoned arguments to explain phenomena, validate conjectures, or support positions.	✓	✓	✓
B.3. Gather evidence to support arguments, findings, or lines of reasoning.	✓		✓
B.4. Support or modify claims based on the result of an inquiry.	✓	✓	✓
C.3. Collect evidence and data systematically and directly relate to solving a problem.	✓		✓
D.1. Self-monitor learning needs and seek assistance when needed.	✓	✓	✓
D.2. Use study habits necessary to manage academic pursuits and requirements.	✓	✓	✓
D.3. Strive for accuracy and precision.	✓	✓	✓
D.4. Persevere to complete and master tasks.	✓	✓	✓
E.1. Work independently.			✓
E.2. Work collaboratively.	✓	✓	✓
<i>II. Foundational Skills</i>			
B.1. Write clearly and coherently using standard writing conventions.			✓
C.5. Synthesize and organize information effectively.		✓	✓
D.1. Identify patterns or departures from patterns among data.	✓		✓
D.3. Present analyzed data and communicate findings in a variety of formats.			✓

TCCRS Science Standards Addressed

Performance Expectation	Getting Started	Investigating	Drawing Conclusions
<i>I. Nature of Science: Scientific Ways of Learning and Thinking</i>			
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.1. Collaborate on joint projects.	✓	✓	✓
C.2. Understand and apply safe procedures in the laboratory and field, including chemical, electrical, and fire safety and safe handling of live or preserved organisms.	✓		✓
D.3. Demonstrate appropriate use of a wide variety of apparatuses, equipment, techniques, and procedures for collecting quantitative and qualitative data.	✓		✓
E.1. Use several modes of expression to describe or characterize natural patterns and phenomena. These modes of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic.	✓		✓
E.2. Use essential vocabulary of the discipline being studied.	✓	✓	✓
<i>III. Foundation Skills: Scientific Applications of Communication</i>			
B.2. Set up apparatuses, carry out procedures, and collect specified data from a given set of appropriate instructions.	✓	✓	✓
B.3. Recognize scientific and technical vocabulary in the field of study and use this vocabulary to enhance clarity of communication.	✓	✓	✓
<i>V. Cross-Disciplinary Themes</i>			
E.1. Use models to make predictions.		✓	
<i>VI. Biology</i>			
A.6. Know the structure of membranes and how this relates to permeability.	✓	✓	✓

<p>B.1. Understand the major categories of biological molecules: lipids, carbohydrates, proteins, and nucleic acids.</p>		✓	✓
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TEKS Standards Addressed

<i>Crossing the Border - Texas Essential Knowledge and Skills (TEKS): Science, Biology</i>
<p>112.34.c.1. Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:</p> <ul style="list-style-type: none"> 112.34.c.1.A. demonstrate safe practices laboratory and field investigations; 112.34.c.2.F. collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, dissection equipment, meter sticks, and models, diagrams, or samples of biological specimens or structures; 112.34.c.2.G analyze, evaluate, make inferences, and predict trends from data; and 112.34.c.2.H communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.
<p>112.34.c.3. Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:</p> <ul style="list-style-type: none"> 112.34.c.3.A. in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student.
<p>112.34.c.4. Science concepts. The student knows that cells are the basic structures of all living things with specialized parts that perform specific functions and that viruses are different from cells. The student is expected to:</p> <ul style="list-style-type: none"> 112.34.c.4.B. investigate and explain cellular processes, including homeostasis, energy conversions, transport of molecules, and synthesis of new molecules.
<p>112.34.c.9. Science concepts. The student knows the significance of various molecules involved in metabolic processes and energy conversions that occur in living organisms. The student is expected to:</p> <ul style="list-style-type: none"> 112.34.c.9.A. compare the structures and functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids.

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, plastic pipettes or eyedroppers, 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 ¼-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 colored water?
 - d. Do you think the vegetable oil is mostly water-soluble or not? 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 vegetable oil?
 - d. 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. What kinds of bonds are they? 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 it on a 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. With a partner, draw, color, and cut out diagrams representing phospholipids and proteins with different regions of polarity (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. 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. 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. Insert your different proteins into the bilayer and predict how the proteins will orient themselves based on their polarity. 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?
8. Complete the *Which Way Will the Ions Go?* handout.

Drawing Conclusions

1. Use the *Potato/Fruit Osmosis Lab* handout to investigate osmosis taking place across the membranes of potato or fruit 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. Turn in your narratives, your drawings, and answers to all questions answered throughout the investigation and in the *Which Way Will the Ions Go?* worksheet.

Potato/Fruit Osmosis Lab

Osmosis is a special case of diffusion in which water crosses a semi-permeable cell membrane. Water will cross membranes toward areas of higher solute concentration. By diluting the high amount of solute on the other side of the membrane, water can effectively make the concentrations on either side equal.

In this laboratory exercise, you will conduct an experiment to estimate the molarity (M, moles/liter) of potatoes, apples, or pears. You will use the principles of diffusion, investigating the movement of water into or out of samples of potato, apple, or pear tissue. As you cannot see the movement of water across membranes and cannot measure it directly, you will measure any changes indirectly by looking for either a change in the mass or volume of the potato or fruit sample. By placing potato or fruit samples in a series of sucrose solutions of known concentrations and observing whether water flows in or out of the samples, you will be able to estimate the molarity of potato or fruit tissue cells. Because sucrose cannot diffuse across cell membranes, any change in mass or volume will be due to the movement of water.

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 or fruit 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).

Solution in beaker	Predicted change?	Explain your prediction
Distilled water		
0.2 M sucrose		
0.4 M sucrose		
0.6 M sucrose		
0.8 M sucrose		

Materials:

1 large potato, pear, apple, or sweet potato per group, large enough to cut 5 cores **from the same potato or piece of fruit**

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 or fruit cores

Forceps

Plastic wrap

Paper towels

Marker to label the beakers

Graduated cylinder

Balance with aluminum sheet on it

Data table

Solution in beaker	Initial mass or volume of core	Final mass or volume	Change in mass or volume	% mass or volume change
0.0 M				
0.2 M				
0.4 M				
0.6 M				
0.8 M				

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 or fruit cylinders. Take care with the cork borer; hold the potato or fruit 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 or fruit 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 sucrose*, *0.4 M sucrose*, *0.6 M sucrose*, and *0.8 M sucrose*.
3. Take a potato or fruit cylinder out of the Petri dish and place it on a paper towel to

- blot off excess moisture (handle the potato or fruit 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 or fruit 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 or fruit 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 or fruit cylinder in the correct part of the table. Record the date and time the cores began soaking. Let the beakers stand overnight.
 5. The next day, gently remove the cylinders from the beaker (be careful, the potato or fruit core could fall apart). Blot dry and weigh on a balance or record the change in volume by the same method as the day before. Record the final mass or volume.
 6. Calculate the percent change for each potato or fruit 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 or mass on the y -axis.
 8. Describe your results in terms of osmosis. In which molar solutions did the potato or fruit core gain water? In which molar solutions did the potato or fruit core lose water? Which solution was closest in molarity to that of the original potato or fruit 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).