Investigating Osmosis -- Teacher Preparation Notes

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The experimental setup for this activity is similar to the experimental setup for our activity, Diffusion: Molecular Transport through Membranes. If your primary learning goal is an understanding of selectively permeable membranes, we suggest that you use Diffusion: Molecular Transport through Membranes.

Equipment and Supplies
250 mL (or 400 or 600 mL) beaker or container (3 per group)
1% Starch solution, Corn or Potato (about 300-400 mL per group)
1" Dialysis Tubing (36-45 cm per group)*
String (12 inches per group)
Iodine-Potassium Iodide Solution (IKI) (0.2 mL per group)*
25 or 50 mL graduated cylinder (1 per group)
Scale or mm ruler**
Paper Towels (several per group)

***Purchase from Carolina Biological** www.carolina.com
Iodine-Potassium Iodide Solution 86-9055 $7.55 500 mL (alternatively you can purchase Iodine Tincture or Povidone-Iodine through your local pharmacy)
1" Dialysis Tubing 68-4212 1" × 10 ft $5.50 Each

** Students can measure diffusion of water into (or out of) the dialysis tube by measuring change in the volume of solution in the tube, change in the volume of solution in the beaker, or change in the weight of the solution in the tubing. A reasonable measure of change in volume in the tube is change in the length of the part of the dialysis tube which is filled with solution (which should be approximately 5-10 mm change in 10-20 minutes). To measure the relatively small change of volume of water in the beaker outside the dialysis tubing, students will need to use a graduated cylinder. For measures of change in weight, you can expect changes of approximately 0.5-1.0 g in 10-20 minutes; the outside of the tube and the string should be as dry as possible for both weighings.

Preparation before Class:

- To prepare 1% starch solution, add 1 g of corn starch or potato starch to every 99 mL of cold water. Bring the mixture to a full boil and allow time to cool. Starch is insoluble in cold water and needs to be boiled to stay in solution. This can be done in a microwave.
- Cut the dialysis tubing into 12-15 cm lengths. You may also want to precut the 6 inch pieces of string. Instead of using string, you may provide students with longer pieces of dialysis tubing and have them tie knots in the tubing.

Teaching Information

To ensure completion within a 50 minute teaching period with enough time for a wrapup discussion, you probably will want to have your students complete the introductory questions and experimental design plan (pages 1-3) before the laboratory period.

[1] These teacher preparation notes and the related student handout are available at http://serendip.brynmawr.edu/sci_edu/waldron.

After filling their dialysis tubes students need to rinse the tubes in fresh water to remove any spilled starch from the outside of the bags. They need to make sure to squeeze out the excess liquid from the strings which tie the tubes closed. To contribute to more accurate results the students may also want to trim the strings as short as possible once the knots have been tied. If you do not have a sink in your room a series of large containers of water will work.

The Iodine-Potassium Iodide Solution is used as an indicator of starch presence. Iodine (I_2) is relatively insoluble in water so potassium iodide (KI) is added to the solution. Iodine ions (I_3^-), which are soluble in water, are then formed. When iodine ions and starch are in the same solution the iodine ions get bound up in the beta amylose coils of the starch. This is what causes the color change of starch from white/clear to blue. Over time, iodine will diffuse across dialysis tubing.

Teaching Points

- Diffusion of water across a selectively permeable membrane is called osmosis; osmosis results in net movement of water from a solution with a high concentration of free water molecules (low concentration of solutes) to a solution with a low concentration of free water molecules (high concentration of solutes).
- Starch molecules do not pass through the membrane because they are too large to fit through the pores of the dialysis tubing, whereas water molecules are small enough to pass through the membrane.
- In all biological organisms, each cell is enclosed by a selectively permeable plasma membrane which regulates what gets into and out of the cell. For plant cells, but not animal cells, the selectively permeable plasma membrane is mechanically protected by a cell wall.
- Principles of experimental design are reinforced in this activity.

Additional Demonstrations of Osmosis

The demonstration of osmosis in this activity can be supplemented by a demonstration of osmosis using chicken eggs, as described on pages 3-4 of these Teacher Preparation Notes.

If you have microscopes available, you can demonstrate the effects of osmosis in the cells of Elodea (sometimes called Anacharis; available in fish stores). Cells can be observed in both a hypotonic solution (water) and a hypertonic solution (concentrated salt water). In the hypertonic solution water will diffuse out of the Elodea cells and into the surrounding solution; it is easy to observe the cell membrane pull away from the cell wall as the cell loses water (called plasmolysis).

Discussion of Sports Drinks

The questions in this discussion activity guide students in understanding the relevance of osmosis to evaluating when and how sports drinks can be beneficial for athletes (available at http://serendip.brynmawr.edu/exchange/bioactivities/sportsdrinks).

Demonstration of Osmosis Using Chicken Eggs

On day 1, measure and record the weight and/or circumference of two eggs. Measure the circumference around the widest part, not lengthwise. (Caution: Because the eggs are raw, they may carry salmonella, so you should use gloves and/or wash your hands carefully after you have handled the eggs.) Place each egg in a labeled container with enough vinegar to cover the egg. Cover the container. Students can immediately see bubbles forming as the acetic acid of the vinegar interacts with the calcium carbonate of the shell to produce CO_2 bubbles.

On day 2, each egg should be removed and washed while rubbing gently to remove as much of the shell as possible. (The membranes surrounding the egg are relatively tough, but you do need to be gentle. I found that a little patch of shell could not be totally removed because the eggs floated and were not totally submerged in the vinegar, but this little patch of partial shell did not interfere with the rest of the experiment.) Dry each egg and measure and record the weight and/or circumference of each egg. Empty the vinegar from container 1, replace with enough water to cover an egg, and return the egg that was in container 1. Empty the vinegar from container 2, replace with corn syrup, and return the egg.

Questions for student discussion:

- Why do you think that the eggs became heavier/larger?
- Where did the extra weight come from?
- To prepare your students for the discussion of the results for day 3, show the students how viscous the corn syrup is. Ask them why they think the corn syrup is so viscous and what they think will happen to the egg in the corn syrup.

On day 3, rinse the corn syrup off of egg 2, dry each egg, and measure and record the weight and/or circumference. Students will be able to see a dramatic difference in appearance between the enlarged egg that has been in water and the shrunken, shriveled egg that has been in corn syrup.

Questions for student discussion:

- Why did the egg in container 1 continue to become heavier/larger?
- Why did the egg in container 2 become lighter/smaller?
- Why does the egg from container 2 have a shriveled appearance?

Teaching Suggestions and Background Information

For this activity, students are assumed to have a basic understanding of diffusion and selectively permeable membranes. The student discussion of this demonstration should be linked to a general discussion of osmosis (e.g. using the questions and figures on pages 1-2 and page 5 of the Student Handout for Investigating Osmosis). If you want additional questions for discussion or instructions for having the students carry out the demonstration of osmosis as a hands-on activity, see "Why Do Athletes Drink Sports Drinks?" by Carlsen and Marek, *The Science Teacher*, December, 2010. We strongly encourage you to carry out the demonstration which is easy and dramatic; however, if you can't carry out the demonstration for your students, you can use the sample data shown in the table on the next page as the basis for your discussion.

An unfertilized egg is a single cell, but a very atypical cell in size and makeup. Most of the egg yolk and white consist of storage molecules (mainly fat in the yolk and mainly protein in the white); in a fertilized egg these molecules are used in the development of the chick. The egg's

DNA is contained in a small spot on the surface of the yolk. The shell membranes that surround the egg and lie just under the shell have protein fibers that give these membranes much greater strength than a cell membrane. The large size and strong shell membranes of a chicken egg make it useful for demonstrating osmosis, a process which also takes place in more typical cells, but is not as easy to observe.

A chicken egg has 88% water in the white and 48% water in the yolk. The higher concentration of water in the white is the major reason why, in the egg that has been in corn syrup, the white is much more reduced and the yolk becomes more prominent. Overall, a chicken egg is 74% water, which is similar to the ~70% water in typical animal cells. White vinegar is about 95% water and 5% acetic acid. Corn syrup is about 20% water, and the rest is monosaccharides, disaccharides and oligosaccharides.

Supplies: two eggs, two containers with covers (or plastic wrap), white vinegar, corn syrup, water, scale and/or measuring tape, paper towels, gloves and/or spoon (optional)

Teaching Points

- In all biological organisms, each cell is enclosed by a selectively permeable cell membrane which regulates what gets into and out of the cell.
- Diffusion of water across a selectively permeable membrane is called osmosis; osmosis results in net movement of water from a solution with a low concentration of solutes to a solution with a high concentration of solutes.

Sample Data

	Egg 1			Egg 2	
Day	**Weight** (grams)	**Circumference** (cm)		**Weight** (grams)	**Circumference**
1	56.3 (with shell)	~14.0		52.6 (with shell)	~13.9 cm
	Egg put into **vinegar**			Egg put into **vinegar**	
2	72.7 (without shell)	~15.1		65.2 (without shell)	~15.0
	Egg put into **water**			Egg put into **corn syrup**	
3	83.5	~16.0		36.2	~9.9