

Membrane Transport Lesson with Candy Models

David Welch, ASU GK-12 Fellow
Sam Rua, Superior High School

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1 Lesson Overview

Presented is a lesson plan for creatively presenting the concepts of passive and active transport across cell membranes. Two days of activities are presented. The first day is centered around students working by themselves and eventually in pairs to make small models of membranes out of candy. After students make the models they are presented with a variety of situations to model by adding in other types of candy to act as various biological factors. This setup allows for visualizations of membrane structure and function, concentration gradients, and mechanics of transport. The second day focuses on an experiment in osmosis across membranes. Students create their own experiment based off a given setup to test a single factor they believe could effect osmosis. Students then carry out the experiment as a class and analyze results.

1.1 Purpose

This lesson will give the students chances to visualize transport phenomena that would not be visible at the macro scale. Additionally this activity will allow students to work with their own materials and with a team to simulate various cellular transport phenomena. Students will also gain valuable experience with experimental procedure and good scientific methods.

1.2 Keywords

Diffusion, Passive Transport, Active Transport, Osmosis, Membranes, Candy

1.3 Target Audience

This lesson was designed for high school biology classes.

2 Standards Met

The Arizona High School Science Standards which are met through this lesson are:

- Strand 1 - The inquiry process. This includes forming observations, questions, and hypotheses, testing and analyzing, as well as communicating results.
- Strand 4, Concept 1, PO3 - The importance of water to cells.
- Strand 4, Concept 1, PO4 - Analyze mechanisms of transport
- Strand 4, Concept 3, PO2 - Analyzing how organisms are influenced by their environment by a combination of biotic and abiotic factors.
- Strand 4, Concept 5, PO2 - Describe role of organic and inorganic chemicals
- Strand 5, Concept 1 - The structure and properties of matter.

3 Materials

Day 1

- Many varieties of candy are used to simulate membranes and other elements. Any variety will work as long as the students are given a good explanation of what each candy represents. It is best to pick candy that somewhat resembles the components they represent. For example, candy corn works well to represent a phospholipid because it has a larger end and a smaller end (hydrophobic and hydrophilic). M&Ms that are blue works well for water. Life savers work well to represent channel proteins. Sugar is represented well with smarties. Ions are represented well with different colors of M&Ms. Carrier proteins are well represented by gummi bears (think that the arms are to hold ions to move them, also the color of the gummi bear could need to correspond to the appropriate ion to make it selective).
- paper towels

Day 2

- sausage casing

- string
- sucrose
- beakers
- timer
- triple beam balance
- paper towels

4 Day 1 Activities

The lesson should begin with a brief overview of cell structure ending with an introduction to the cell membrane and the importance of movement of things into and out of the cells. Students should be told that this lesson will help them visualize how different biological factors move across the membrane. Students should also be instructed that they should draw what they do throughout the experiments.

Students should be instructed to wash their hands or use sanitizer and place a paper towel down to work on. Candy should then be distributed and students should note what each piece represents.

The first activity the students should complete is the construction of a phospholipid bilayer. Students should note the alignments of the hydrophobic and hydrophilic sides. A single vertical membrane to separate the left and right sides of the paper towel works best.

The students should then put all their other components to the left side of the membrane. This should lead to a discussion of which substances can make it through the membrane and why (use figure 1 as a guide). Transmembrane proteins can be omitted from this step.

Students can then remove all the components except for water which should be spread equally on either side of the membrane. Students should then introduce various amounts of sugar to either side of the membrane and then move water around to compensate. This should show the students how the volume can change thanks to the need to equal out concentrations. Allow students to try various sugar additions and water movements.

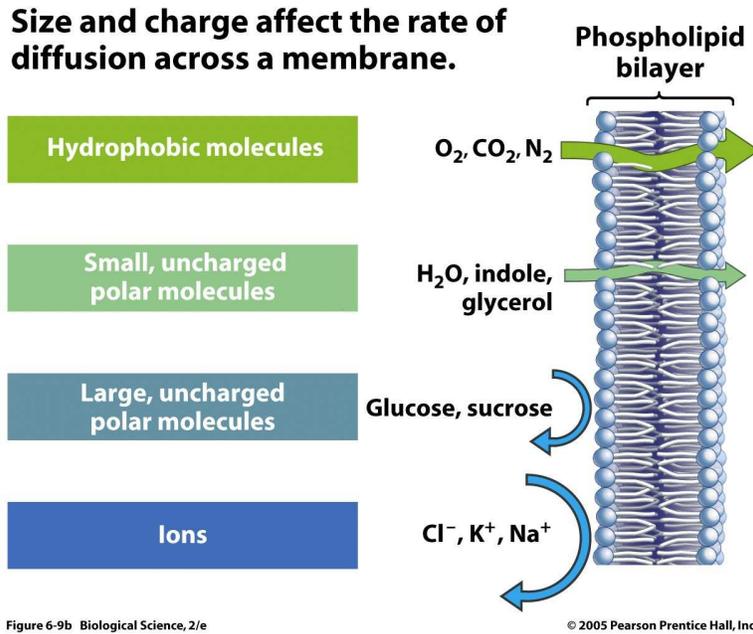


Figure 1: Example diagram of passive behavior of various components.

Students should then work with a partner to combine resources to make a larger membrane. The larger membrane should allow students to model what happens during endocytosis, exocytosis, phagocytosis, and pinocytosis. Students should be able to simulate something similar to figure 3. The single wall should then be formed into a ring to represent a cell. Students should then repeat the sugar-water concentrations they did previously but this time identify what this would do to the shape of the cell. Students should define hypertonic, hypotonic, and isotonic solutions and describe what happens in each case.

The concept of transmembrane proteins for transport should then be introduced. Channels (maybe represented by lifesavers) should be inserted into the membrane. Carriers should also be introduced. Ideas of selectivity can be addressed possibly by a color code among the candy selected. The function of carrier proteins as uniporters, symporters, and antiporters should be touched on. Finally students should model the behavior of Na⁺-K⁺ pump. Students should be asked to consider what would happen if this process is performed in reverse.

Finally students should be left to consider the complexity of these processes when they are all combined together while they consume the candy.

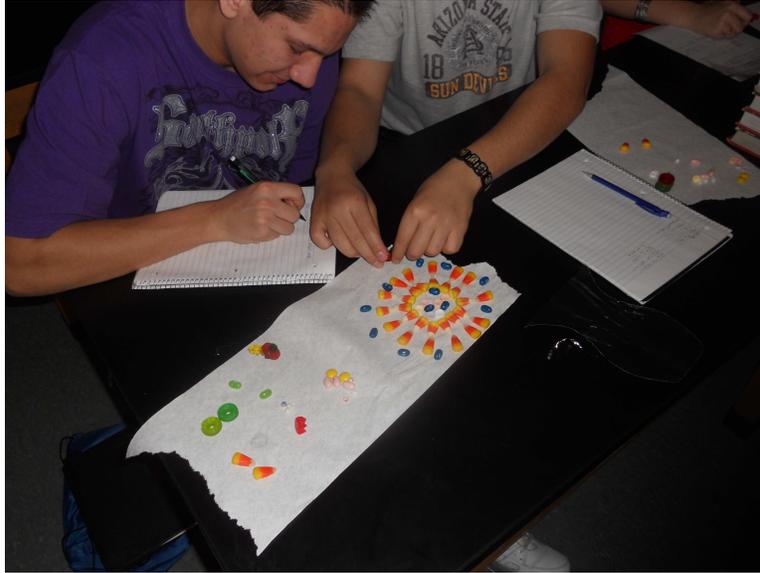


Figure 2: Example layout of candy components to model the cell. The candy corn represents phospholipids which are arranged in a bilayer to create an cellular structure.

5 Day 2 Activities

The students should first be introduced to the idea of a simple diffusion experiment. The general setup of a high concentration sugar solution being placed in a water permeable membrane (sausage casing) and then dipped in water should be discussed. Osmosis should be identified as the phenomena under investigation. Students likely won't have a good grasp on how this happens so as a class they will identify factors that could effect osmosis. An experiment should then be decided on as a group and students should work together to perform it. Suggested experiments should be varying sugar concentration placed in the membrane, varying the volume of the casing, varying temperature, varying concentration of another factor - really anything goes as long as they can test it.

Students should identify independent and dependent variables and solidify a procedure that they will all follow. Students should prepare their samples and then perform the experiment, conducting measurements of water diffusion every 5 minutes by taking the mass using the triple beam balance. Students should be able to fill in the worksheet with appropriate information and analysis.

It is important to provide guided instruction throughout the activity. Stu-

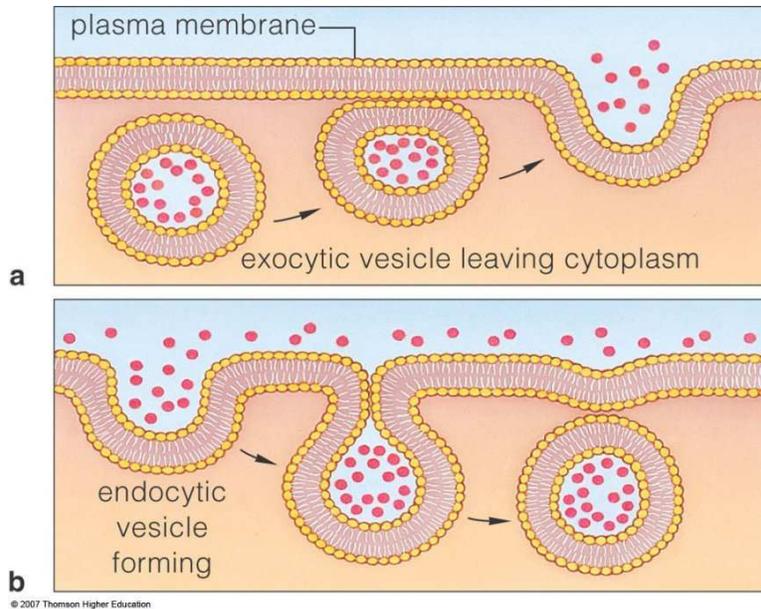


Figure 3: Diagram of endocytosis and exocytosis that students can simulate.

dents should be able to solve many problems on their own but it is important to provide a good basic experimental setup as well as keeping the students reasonable in their choice of variables. Groups of 3-4 should work best.

After about 20 minutes students should come back together and share data on the board. The class should have a discussion on the results and also discuss possible sources of error.

5.1 General Procedure

- Take a sausage casing about 5 inches long, fold one end over about half and inch and tie tightly with string
- Fill casing with desired sugar solution and then tie end same as other
- Place in beaker with water
- Remove, slightly dry with paper towel, measure mass on balance
- Place back into beaker with water for 5 minutes
- Measure mass, repeating every 5 minutes for 20-25 minutes

Candy Membrane Worksheet

Name _____

Date _____

Candy Code:

ATP → _____ Na^+ → _____

K^+ → _____ H_2O → _____

sugar → _____ O_2 → _____

phospholipid → _____ transport protein → _____

Draw a picture of the membrane you make out of phospholipids:

Where did the water go when the concentration of sugar changed?

Define hypertonic in your own words. Where does the water go?

Define hypotonic in your own words. Where does the water go?

Define isotonic in your own words. Where does the water go?

Draw what happens in endocytosis/exocytosis in a few steps with simple drawings:

Describe the difference between channel and carrier proteins:

What happens when a Na^+ - K^+ pump is run in reverse?

Osmosis Worksheet

Name _____

Date _____

Describe the experiment:

Identify the independent variable:

Identify the dependent variable:

Draw the experimental setup:

Data:

Graph:

Conclusions: