Teacher Preparation Notes for  
**Diffusion across a Selectively Permeable Membrane**  
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Students investigate the effects of molecule size on diffusion across a synthetic selectively permeable membrane. This investigation includes a brief introduction to osmosis. Additional questions introduce students to the roles of proteins in transporting polar substances across the cell membrane and guide students in analyzing the relative advantages of two different types of model of the cell membrane.

If you would like to provide your students with a more extensive introduction to osmosis, we recommend that you precede this activity with our other activity, "Introduction to Osmosis" (available at [http://serendip.brynmawr.edu/sci_edu/waldron/#osmosis](http://serendip.brynmawr.edu/sci_edu/waldron/#osmosis)).

These Teacher Preparation Notes include:
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**Learning Goals**

In accord with the [Next Generation Science Standards](http://www.nextgenscience.org/next-generation-science-standards):
- Students learn the Disciplinary Core Idea (LS1.A) "… the cell membrane forms the boundary that controls what enters and leaves the cell."
- Students engage in recommended Scientific Practices, including "using models", "… carrying out investigations", "interpreting data", and "constructing explanations".
- Discussion of this activity can incorporate several Crosscutting Concepts: "Cause and effect: Mechanism and explanation", "Systems and system models", and "Structure and function".
- This activity helps students to prepare for the Performance Expectation, MS-LS1-2, "Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function."

Specific Learning Goals include:
- A selectively permeable membrane allows some types of molecules and ions to pass through, but not others.  
- Starch does not pass through the synthetic selectively permeable membrane because starch molecules are too large to fit through the pores of the dialysis tubing. In contrast, glucose, iodine and water molecules are small enough to pass through the membrane.
- Diffusion results from the random motion of molecules. Diffusion moves substances from regions of higher concentration to regions of lower concentration.
- Movement of water across a selectively permeable membrane is called osmosis; osmosis results in net movement of water from a solution with a lower concentration of solutes to a solution with a higher concentration of solutes.
- In biological organisms, each cell is surrounded by a selectively permeable cell membrane which regulates what gets into and out of the cell. The cell membrane contains proteins

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1 These Teacher Preparation Notes and the related Student Handouts are available at [http://serendip.brynmawr.edu/exchange/waldron/diffusion](http://serendip.brynmawr.edu/exchange/waldron/diffusion)


3 A selectively permeable membrane is also called a semipermeable membrane.
which facilitate the transport of specific biologically important molecules and ions across the cell membrane. Some membrane proteins provide the basis for facilitated diffusion of specific ions or molecules and some membrane proteins are pump molecules which use energy from ATP to move specific ions or molecules from a region of lower concentration to a region of higher concentration.

**Equipment and Supplies** (per group of 2-4 students)
- 250 ml beaker or other container with some way to measure 200 mL of water (1 per student group)
- 1% starch solution, corn or potato (4 ml per group)*
- 15% glucose solution (4 ml per group)**
- Iodine-potassium iodide solution (IKI) (0.8 mL per group)*
- 2-3 mL transfer pipets (preferably 3 per group, but you can use fewer if your students are reliable about not cross-contaminating solutions; also, if your iodine is in dropper bottles, you may want to provide your students with an estimate of the number of drops in 0.8 mL; you should be aware that drops vary in size so it may not be accurate to use the standard estimate of 20 drops per milliliter)*
- 1” dialysis tubing (15 cm per group)**
- String (2 - 12 cm pieces per group) +
- Glucose test strips (1 per group; if you can afford it, 2 per group is preferable, so students can test for glucose in the beaker in the initial state; if you do this, you will want to remove "No" from the second glucose column in question 5 in the Student Handout)**
- Distilled water
- Paper Towels (several per group)
- Scale (accurate to 0.1 g) or a ruler to measure movement of water (see Instructional Suggestions below).

* **Purchasing Information**
- Glucose can be purchased online; it may be sold as Dextrose.
- Iodine-Potassium Iodide Solution 86-9055 from Carolina Biological -$9.40 for 500 mL or $18.65 for 1 L; [http://www.carolina.com/specialty-chemicals-d-l/iodine-potassium-iodide-solution/FAM_869051.pr?catId=&mCat=&sCat=&ssCat=&question=iodine+potassium+iodide+solution](http://www.carolina.com/specialty-chemicals-d-l/iodine-potassium-iodide-solution/FAM_869051.pr?catId=&mCat=&sCat=&ssCat=&question=iodine+potassium+iodide+solution) (or you can purchase from other online sources or buy Iodine Tincture or Povidone-Iodine at your local pharmacy)
- Glucose test strips - $9.95 for 100 test strips (TC-URS-1G; [http://www.testyourselfathome.com/Glucose.htm](http://www.testyourselfathome.com/Glucose.htm))
- Transfer pipets are readily available online.

+ **Preparation before Class**
- To prepare 1% starch solution, mix 10 g of corn starch or potato starch in 50 mL of room temperature distilled water. Bring 1000 mL of distilled water to a full boil. Add the slurry of starch to the boiling water and stir for at least 2 minutes while the mixture continues to boil. Starch is insoluble in cold water and needs to be boiled to stay in solution. Allow several hours for the starch solution to cool.
- Prepare 15% glucose solution by dissolving 15 g glucose for every 85 ml of water.

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4 A cell membrane is also called a plasma membrane.
• Cut the dialysis tubing into 15 cm lengths and soak in distilled water for at least 15 minutes before the activity (dry dialysis tubing gains weight when it is first soaked in water). We suggest that you also precut the 12 cm pieces of string and soak them. Instead of using string, you may provide students with longer pieces of dialysis tubing and have them tie knots in the tubing.

• You should provide your students with the instructions for the specific type of glucose test strip you are using. Also, you will want to have the color chart available for interpreting the results for the glucose test strips.

Instructional Suggestions and Background Information
In order to complete the hands-on part of the activity in a 45-50 minute period, you will probably want to have your students complete questions 1-4 in the Student Handout and discuss these questions on the day before the hands-on part of the activity. You may need additional time on a third class day to finish answering and discussing questions 10-11.

In the Student Handout, numbers in bold indicate questions for the students to answer and ➢ indicates a step in the experimental procedure for the students to do.

Students can measure the movement of water into or out of the dialysis tube bag by measuring change in the weight or volume of solution in the bag. For measures of change in weight, you can expect changes of approximately 0.5-1.0 g in 20-30 minutes. If students are using weight of the bag to estimate water movement, they should cut the strings as short as possible after tying the knots and be sure to dry the bag and strings thoroughly each time before they weigh the bag. Measures of change in volume tend to be less accurate, but will be sufficient if you do not have a scale available. One 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 30 minutes). It is important to try to standardize this measure for comparable results for initial and final state measures. Also, if you are using a length measure, your students will need to allow at least 30 minutes for diffusion, and it may be helpful to use 5 mL each of the glucose and starch solution in the bag.

After filling and tying their dialysis tube bags students need to rinse the bags thoroughly in fresh water to remove any spilled starch or glucose solution from the outside. If you do not have a sink, a series of large containers of water will work.

The Iodine-Potassium Iodide Solution is used as an indicator for the presence of starch. Iodine (I₂) is relatively insoluble in water so potassium iodide (KI) is added to the solution; this results in the formation of iodine ions (I⁻) which are soluble in water. 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 clear or white to blue or black or purple. This binding also removes the iodine ions from solution. Therefore, over time the tan iodine solution will get lighter as the iodine ions continually diffuse through the dialysis tubing and become bound up.

While the students are waiting for the effects of diffusion to become observable, the students should answer question 6 on page 3 of the Student Handout.

The diagram of transport across a cell membrane on page 4 of the Student Handout together with question 10 provide the opportunity to point out some differences between selective permeability in the synthetic membrane versus in a cell membrane. The selective permeability of the synthetic membrane depends on the size of the pores, so smaller ions and molecules can cross and large
ions and molecules cannot. In contrast, the ability of ions and molecules to cross the cell membrane depends on a number of factors in addition to size. Charged ions and polar molecules do not readily cross the nonpolar bilipid layer, so charged ions and most polar molecules generally cross the cell membrane only if there are specific transport proteins.

You may want to point out that there are three broad classes of proteins that contribute to membrane permeability: channels or pores (illustrated by the sodium channel in the figure in the Student Handout), carriers (illustrated by the glucose transporter), and pumps (illustrated by the sodium potassium pump). The channel or pore proteins and the carrier proteins provide the basis for facilitated diffusion from regions of higher concentration to regions of lower concentration. In contrast, pump proteins provide the basis for active transport which uses energy provided by ATP to move ions or molecules from regions of higher concentration to regions of lower concentration. As shown in the figures below, carrier and pump proteins change shape to move molecules and ions across the cell membrane.

![Sodium-Potassium Pump Diagram](image)

The last page of the Student Handout provides the opportunity to discuss the ways that models help us to understand complex biological structures and phenomena, as well as the limitations of models as representations of reality. This activity presents two models – the synthetic selectively permeable membrane and the diagram on page 4 of the Student Handout. Both models illustrate selective permeability, but they include somewhat different features of selective permeability. For example, the synthetic membrane helps students to understand that some molecules do not cross the cell membrane (crucial for retaining vital molecules like DNA and proteins inside the cell). In contrast, the diagram includes the important information that the cell membrane contains proteins which facilitate the transport of specific biologically important molecules and ions across the cell membrane. Some of these proteins are pump molecules which use the energy from
ATP produced by living cells to move molecules from a region of lower concentration to a region of higher concentration. This contrasts with diffusion which always results in net movement of substances from a region of lower concentration to a region of higher concentration.

Possible Follow-Up Activity and Discussion
As a follow-up to this hands-on activity, you may want to:

- have your students use microscopes, Elodea and various chemicals to study osmosis and rates of diffusion across the plasma membrane for molecules of different size and hydrophobicity as directed in "Diffusion across Biological Membranes" (available at http://faculty.buffalostate.edu/wadswogj/courses/BIO211%20Page/lectures/lab%20pdfs/Diffusion%20lab%2006a.pdf).
- discuss with your students the contributions of selectively permeable membranes and osmosis to dialysis treatment of patients with kidney failure. (A useful introduction is available at http://en.wikipedia.org/wiki/Dialysis)

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5 If you have not yet taught energy concepts to your students, you can just refer to the general observation that living things use energy and introduce ATP as a molecule that is made by cells and provides energy for many biological processes in cells.