

## Purpose

Students will explore how materials move across a semi-permeable membrane using a laboratory procedure.

## Student Guide

A link to the student guide is provided in the Instruction, the virtual lab, the wet lab, and lab report portions of the lab lesson. Be sure either to provide copies to students or enable them to print the guides themselves when they do the Instruction portion of the lab lesson.

## Background Information

Diffusion is the movement of particles down a concentration gradient, from an area of high concentration to an area of low concentration. Diffusion is one way that materials such as nutrients and wastes enter and exit cells. Diffusion is considered passive transport because cells do not expend energy during diffusion. Instead, diffusion is due to the random movement of particles.

Small molecules that do not have a charge, such as water and oxygen, diffuse rapidly across cell membranes. Larger molecules, such as glucose, diffuse more slowly through a membrane. Charged molecules, such as sodium ions, cannot diffuse through a cell membrane.

In this lab, students will use dialysis tubing to represent a semi-permeable membrane. Dialysis tubing allows glucose to pass through, but not starch because glucose is a smaller molecule than starch. When knots are tied in each end, the tubing can be used as a model of a cell. The lab then models the diffusion of materials across a cell membrane.

Students should find that glucose molecules will diffuse from the high concentration inside of the tubing to the lower concentration outside of the tubing. Solutions that have both glucose and Benedict's solution will turn dark red in this lab.

Starch molecules, however, are larger than glucose molecules — and too large to cross the membrane. The Iodine molecules in the Lugol's solution will diffuse into the cell. In this lab, it will turn a purple or black when both Lugol's solution and starch are present together in the same solution.

## Real-World Applications

The ability of some materials to diffuse across cell membranes has many implications in the real world. Here are some examples:

## Teacher Guide

- Salty foods make people thirsty. Because the salt concentration becomes higher outside of cells, water diffuses out of cells. The body loses water.
- Dehydrated patients in hospitals are given saline solution intravenously. The fluid has a similar concentration of salt as cells. If pure water was administered, water would diffuse into red blood cells, and the cells would rupture.
- During digestion, starch molecules are broken up into glucose molecules. Cells are able to transport glucose more easily than starch.
- Steps 2 and 3 will tell you whether older Lugol's solution and Benedict's solution (from previous years) are still good indicators of starch and glucose respectively.
- Glucose strips used to monitor glucose in urine can be used instead of Benedict's solution.
- To prevent cross-contamination of solutions, remind students to use one dropper for each solution.
- Thin, non-freezer plastic sandwich bags can be substituted for the dialysis tubing. Test the bags prior to performing the lab to make sure that the bags allow for diffusion.
- Hot water baths should be set up immediately so they are ready to use. One way to make a hot water bath is to fill a 250 mL beaker half full with water and set it on a hot plate set to medium heat. Beakers should not be moved until they have cooled.
- To save time, you may want to have the class start with steps 4 and 5. While they are waiting for diffusion to happen, they can do steps 2 and 3.
- The Sudan Red family of biological dyes have many variants. Sudan III is the recommended dye for its ease of use and handling by students.

## Monitoring the Lab Procedure

- Ensure that safety procedures are followed at all times.
- Make sure that students rinse off the tubes after they tie knots in them. Otherwise, materials left on the outside of the tubes might produce inaccurate results.
- Have students use droppers when using the indicator solutions. They should avoid getting chemicals on their hands. Students should wash their hands thoroughly after using the chemicals.
- Check your local regulations to ensure proper disposal of indicator solutions.
- Help students keep track of the contents of each test tube. Test tube markers may be helpful. Make sure students thoroughly wash test tubes so they do not contaminate results.

## Teacher Guide

- This lab is designed as a one-trial experiment. Rather than increase the number of trials, have students share their results with each other.

While students perform the procedure, they should record their data in the format that best shows their findings. The data table format below, used in the lab lesson, is sufficient for this purpose. A sample data table is shown below. (The data matches the results of the virtual version of the experiment.) Colors in Table 1 may vary from student to student, but generally, the Lugol's solution should react with starch and the Benedict's solution should react with glucose to make a color that differs from the distilled water trial. In Table 2, results should show that there was starch inside of the tube but not outside of it, and that glucose moved outside of the tube. Starch shows positive inside the tube because the indicator particles diffuse into the tube. Glucose is known to be inside of the tube because it was placed there, but the tube is not heated as part of the glucose test. Deviations from this trend should be explained by the student in the conclusion.

## Teacher Guide

### Data

Table 1: Indicator Tests

Liquid in the test tube	Step 2: Color of the liquid after the addition of Lugol's solution (starch indicator)	Step 5: Color of the liquid after the addition of Benedict's solution (glucose indicator)
Distilled Water	orange	light blue
Starch Solution	purple or black	light blue

Table 2: Diffusion Tests

Description	Step 4: Test for Diffusion of Starch	Step 7: Test for Diffusion of Glucose
Color of Solution in Dialysis Tube	Initial Color: yellow Color After 15 Minutes: purple or black	[Not Observed]
Color of Solution in Beaker	Initial Color: orange Color After 15 Minutes: orange	Initial Color: light Blue Color After 5 Minutes of boiling: red
Was there diffusion?	Y / <input checked="" type="checkbox"/> N Reason: The beaker solution never turned black, so Lugol's did not indicate starch.	<input checked="" type="checkbox"/> Y / N Reason: Because the beaker solution turned red, Benedict's indicates glucose.

### Analysis

When students write their lab reports, they should provide a written explanation of their results that describes how the dependent variable was affected by the independent variable. A sample analysis is shown below:

**Sample Analysis:** The results of the experiment show that glucose, the smaller molecule, was able to diffuse across the semi-permeable membrane. Starch, the larger molecule, was

## Teacher Guide

unable to diffuse across the membrane. The particles of the Lugol's solution, however, were small enough to diffuse into the tubing.

## Conclusion

When students write their lab reports, they should restate the hypothesis and explain whether it was supported by the data. They may also revise the hypothesis and state what they would do differently next time. They should also identify any additional questions that arose from conducting the experiment. A sample conclusion is shown below:

**Sample Conclusion:** The hypothesis is "If a material is small enough, then it will diffuse across a semi-permeable membrane because it will be able to pass through the tiny openings in the membrane." This hypothesis is supported by the data collected in the laboratory.

The glucose, which is small enough, diffused from the high concentration inside the tubing to the low concentration outside of the tubing. The starch, which was too big, did not diffuse out of the cell. To improve the results of this experiment, performing additional trials would help to show that consistent results were obtained. To further explore the diffusion of materials, saline and other types of solutions could be tested.

## Extension Activities

- Here are some variations that may lead to an increased understanding of diffusion across a semi-permeable membrane and its applications.
- Remove the shell of an egg by placing it in vinegar for two days. The egg can then be placed in a glucose solution to test diffusion.
- Osmosis can be observed in onion cells under a microscope. Prepare a wet mount of the thin membrane from a piece of red onion. The red cytoplasm should be visible inside of the cell membranes. Add salt solution near the edge of the cover slip and observe. The cytoplasm will shrink (lose water) if the solution is very salty. If the distilled water is added, water will enter the cell.