The Process of Osmosis

Cells consist of a complex organization of molecules that behave in accordance with their physical and chemical properties. Cells exist in an ever-changing environment. That cells can maintain homeostasis under these conditions is due to the cell, or plasma, membrane. The cell membrane is differentially permeable. This means that the membrane can distinguish between different substances, preventing or slowing the movement of some molecules while allowing others to pass into or out of the cell.

The phenomenon of diffusion is responsible for the movement of many substances through membranes. Small molecules such as CO_2 And O_2, as well as alcohol, freely diffuse through membranes. Transport proteins in membranes are critical for facilitating the passage of many other molecules, such as glucose, most amino acids and many of our mineral ions. Other molecules are "carried" or "pumped" through membranes, in an energy consuming process called **active transport**. The plasma membrane is responsible for maintaining the appropriate ratio of solutes and water inside the cell relative to the cell's external environment. The membranes of organelles function in much the same way.

Osmosis is the movement of water through a differentially permeable membrane in response to solute gradients. Water will always move through a membrane from where there is more water to where there is less. Maintaining osmotic balance is critical for living organisms. Both unicellular and multicellular organisms have mechanisms to maintain osmotic balance in their cells and tissues. In this exercise you will observe some features of the process of osmosis. Membranes, you recall, are permeable to water but not permeable to the larger solute molecules.

Note: Before you do this exercise you might review the information in your textbook and from lecture about the terms "hypotonic", "hypertonic" and "isotonic", as well as the phenomenon of osmosis in general.

In this exercise, you will observe the phenomenon of osmosis in a potato using four different sugar solutions. The data you obtain will be recorded on the "data recorders" in the lab. (Actually the data recorders are computers, but at BCC we must call them data recorders.)

Materials Required per Group

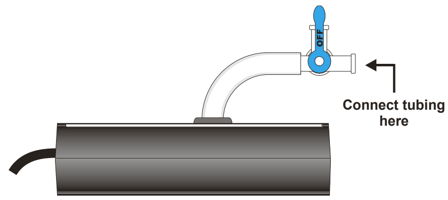
- Data Recorder (Computer)
- Vernier LabPro Box and Power Supply
- Vernier Gas Pressure Sensor
- 1-hole rubber stopper assembly

- Utility Clamp
- Ring Stand
- Pencil
- String
- Potato with 4 pre-made wells
- Small tray for Potato
- Sugar Solutions
  - 0 M
  - 0.33 M
  - 0.67 M
  - 1 M

Procedure

1. Remove the data recorder from the data recorder cubicles. You may have to ask your instructor to unlock the cubicles.

2. Assemble your gas pressure sensor as shown in the diagram below. Connect the plastic tubing to the valve on the gas pressure sensor. Connect the gas pressure sensor to the Vernier LabPro box and plug the Vernier LabPro box into the appropriate data recorder port. Start your data recorder.



Gas Pressure Sensor

3. Open the Biology 211 folder that is located on the computer desktop screen, and open “Exp 22 - Osmosis” from the *Biology with Computers* experiment files of Logger *Pro*.

4. When you have the experiment open, the vertical axis has pressure scaled from 85 – 115kPa, and the horizontal axis has time on a scale from 0 – 5 minutes. Data will be sampled at a rate of 12 samples per minute. Be sure that you have the collect button [▶ Collect]. displayed at the top of your screen "graph". If you do not, ask your instructor for assistance in configuring the computer.

5. Obtain your potato. Rinse the wells with tap water and blot dry.

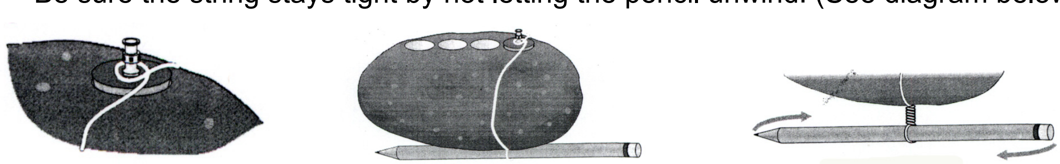
6. Clamp the Gas Pressure Sensor to the ring stand above the potato as shown in the diagram below. Be careful not to get any solution on the sensor.

Potato-Sensor Assembly

7. Fill well 1 with 0 M sugar. (There is no sugar in the solution; that’s what the “0” means. It’s distilled water.) Let the solution stand for 5 minutes.

8. After your 5 minutes are up, empty the 0 M sugar solution from the well and refill the well with fresh 0 M sugar solution.

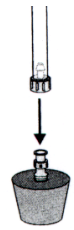
9. Place the rubber stopper assembly firmly into the well. You need to tie the stopper down with a string to prevent the stopper from popping out of the well. To do this:
   - Loop the string around the plastic stem that is inserted in the one-hole stopper assembly.
   - Loosely wrap and tie the string around the potato.
   - Tie the end of the string into a knot around a pencil.
   - Make the string tight around the potato by twisting the pencil until the stopper is firmly held into place.
   - Be sure the string stays tight by not letting the pencil unwind. (See diagram below)



Loop and wrap string   Tie around potato and pencil   Twist tight

10. Let the potato rest for 3 minutes.

11. After 3 minutes, connect the free end of the plastic tubing on the sensor to the connector on the rubber stopper as shown below



Connecting the Stopper to the Sensor tubing

12. You are now ready to collect data! Click the collect button Collect. Data will be collected for 5 minutes.

13. While you are collecting data, fill well 2 of the potato with the 0.33 M sugar solution and allow it to sit for the 5 minutes you are collecting data on the 0 M sugar solution.

14. When the data collection is completed (5 minutes), disconnect the plastic tubing connector from the rubber stopper, remove the pencil, string and rubber stopper from the potato, and empty the sugar solutions from the two wells.

15. Determine the rate of pressure change for the curve of pressure *vs*. time by performing a linear regression to calculate the rate of change. To do this:
    - Move the cursor to the point on your screen where the pressure values begin to change. Hold down the trackpad button and drag the cursor (using the finger on the trackpad) to the end of the data and release the button.
    - Click the Regression button to perform a linear regression. A floating box will appear with the formula for a best fit line.
    - Record the slope of the line, *m*, as the rate of pressure change in Table 1. Note: You will record the "m" number displayed.
    - Close the linear regression floating box, and choose "delete run" from the Data menu. If you have trouble deleting the data run, quit the application and re-open it.

16. Fill the second well of the potato with fresh 0.33 M sugar solution and repeat steps 9 – 15 (Except in step 13 you will fill well 3 with 0.67 M sugar solution)

17. Fill the third well of the potato with fresh 0.67 M sugar solution and repeat steps 9 – 15. (Except in step 13 you will fill well 4 with 1 M sugar solution)

18. Fill the fourth well of the potato with fresh 1 M sugar solution and repeat steps 9 – 12 and 14 – 15. (You do need to fill any more wells with sugar solution in step 13.)

Table 1

Sugar Concentration	Rate of Pressure Change
0.00 M	
0.33 M	
0.67 M	
1.0 M	

1. Make a graph of the rate of pressure change with the sugar solutions.

2. What does a positive slope for the pressure change mean relative to osmotic balance of the potato? What does a negative slope mean? (In other words, what does the slope mean relative to water moving into or out of the potato cells?)

3. Which sugar solutions were hypertonic to the cells of the potato? Which were hypotonic? Was any solution isotonic to the potato cells?

4. If none of the solutions were isotonic, based on your data, what molar sugar solution would you predict to be isotonic? How would you do an experiment to see if your prediction is accurate?

5. How would you design an experiment to test how NaCl affects the rate of osmosis?

6. Why do some neglected plants wilt? Absent "permanent wilt", how does watering a wilted plant result in the plant reaching turgor (the state of normal plant rigidity)?

* Materials for this laboratory were modified from *Biology with Computers*, by Holman and Masterman © Vernier Software and Technology.