Osmosis Revisited

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We have found osmosis continues to be one of the more difficult concepts for biology students at any level (junior high, high school or college) to comprehend. We define osmosis as the diffusion of water through a selectively permeable membrane separating two solutions of different solute concentration. The net movement of water would be from the region of lower solute concentration to the region of greater solute concentration. We believe that the keys to overcoming this problem are demonstrations and hands-on activities. Two experiments and one demonstration work well in our college level introductory biology courses. These activities should also be appropriate for lower levels. We would like to share them with you.

Demonstration

The classical thistle tube demonstration is one of the most common illustrations of osmosis presented in biology laboratory manuals. We have had limited success in getting this demonstration to work as well as the manuals claim. We have been very successful with a modified version.

Materials

- Dialysis tubing (2.5 cm diameter, average pore radius of 24 Å)
- Glass tubing (We use tubing with a 2 cm diameter.)
- Syrup or syrup solution (We use the cheapest generic pancake syrup.)
- String beaker (1000 ml, tall form)
- Stand and clamp

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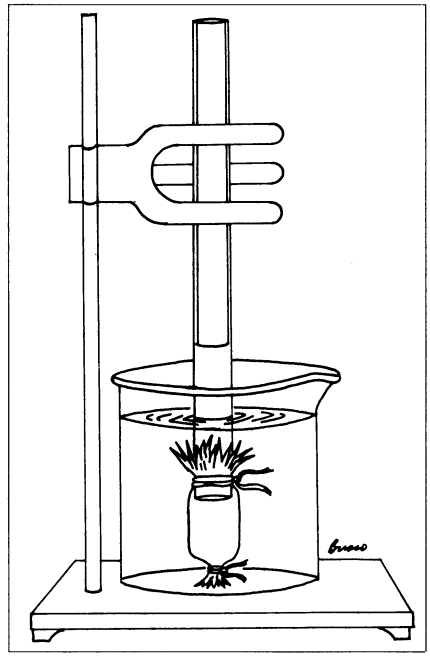

Figure 1. Setup for osmosis demonstration.

- Water (Tap water is fine if you do not have distilled water.)

Procedure

- Refer to Figure 1 for the set-up.
- Place the glass tubing in the clamp. We use 2 cm diameter glass tubing because it is easy to tie the dialysis tubing to it.
- Cut a 10 cm to 15 cm length of dialysis tubing.
- Open the dialysis tubing and tie one end with string (or tie a secure knot in the end of the dialysis tubing). Be sure to avoid possible leaks.
- Tie the other end of the dialysis tubing to the glass tube. You can use string or a strong rubber band.
- You can then pour syrup in the top of the glass tubing until the dialysis tubing is full.
- You may want to make the preceding preparations before class to give the syrup time to run down the sides of the glass tubing.
- You are ready for your demonstration. Place the dialysis "bag" in the beaker of water. Tap water will work just fine. If you want to speed up the process use hot water.
- You can measure the distance of movement and calculate the rates of osmosis just as in the thistle tube demonstrations.
- The advantage of our method is due to the greater surface area of the dialysis bag, which allows for more effective osmosis.

Experiment 1

This experiment allows the students to investigate the effect of temperature on the rate of osmosis. We prefer to give the students the materials and very little direction other than the purpose of the experiment. The students must formulate their hypotheses and design their experiments. They must write up their experimental protocol and present it to the instructor. The instructor then makes any necessary suggestions and the students proceed on their own. We usually do the previously described demonstration before having the students do this experiment. This experiment is modified from Enger et al. (1988).

Materials

- Beakers (500 ml, low form)
- Dialysis tubing (2.5 cm diameter, average pore radius of 24 Å)
- String
- Water (Tap water is fine if you do not have distilled water.)
- Sucrose or syrup
- Hot plates
- Ice
- Triple beam balance
- Card with description of proper weighing technique

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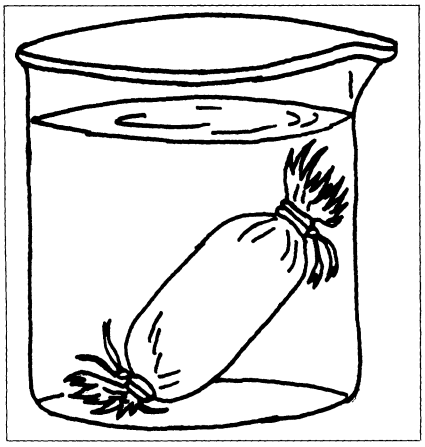

Figure 2. Setup for osmosis experiments.

Procedure

- The students usually design an experiment in which they place identical dialysis "bags" (Figure 2) in identical beakers with constant amounts of hot, cold or room temperature water.
- They use the balance to weigh the bags before, during and after the experiment. You might suggest they weigh the bags at five minute intervals in order to have data to graph. The bags should be dried off with paper towels before weighing to remove excess water.
- The bags can be filled with a sucrose solution (10 percent solution), syrup or any other solution with solute particles that will not pass through the dialysis membrane. We like to use syrup.
- The students collect and record the data, construct graphs and evaluate their hypotheses in light of their results.
- We suggest that this be as open-ended an activity as possible and try not to give them too much direct supervision.
- Be sure to have a discussion period after the experiments are completed.

Experiment 2

This experiment allows the students to investigate the effect of tonicity on osmosis. We try to do this activity like the preceding one with very little direct supervision. However, the students tend to need a little more help than they do on the preceding experiment. Again, the students formulate their hypotheses and design their experiments. They must write up their experimental protocol and present it to the instructor. The instructor then makes any necessary suggestions and the students are on their own.

Materials

- Beakers (500 ml, low form)
- Dialysis tubing (2.5 cm diameter, average pore radius of 24 Å)
- String
- Water (Tap water is fine if you do not have distilled water. Have the students assume it is distilled water when preparing solutions.)
- Sucrose
- Triple beam balance
- Card with description of proper weighing technique
- Graduated cylinder
- Card with instructions for making solutions of different concentration

Procedure

- The students usually design an experiment where they place identical dialysis "bags" (Figure 2) in beakers containing solutions of different concentrations.
- We suggest that they make a 10 percent sucrose solution to place in the dialysis bag. Ten percent sucrose is approximately isotonic with cytoplasm.
- Three beakers or more can be used. Put a hypotonic solution (distilled water or just tap water is fine) in one, an isotonic solution (10 percent sucrose) in one and a hypertonic solution (20 percent sucrose) in the third. The choices of concentration are, of course, arbitrary. The bags should be dried with paper towels before weighing to remove excess water.
- Students will use the balance to weigh the bags before, during and after the experiment. You might suggest they weigh the bags at five minute intervals.
- The students collect and record the data, construct graphs and evaluate their hypotheses in light of their results.
- We suggest that this be as open-ended an activity as possible and try not to give them too much help.
- Do not forget to allow time for a discussion at the conclusion of the experiment.

Conclusion

The previously described demonstration provides an introduction to osmosis and the two experiments enable the students to gain a firm grasp of the concept. The experiments also provide opportunities to apply the scientific method. We think it is especially important to emphasize the need to control all variables except the one being tested.

Acknowledgment

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References

Enger, E.D., Gibson, A.H., Kormelink, J.R., Ross, F.C., Smith, R.J., Borgman, C.H. & Northrup, R.H. (1988). *Laboratory manual: Concepts in biology* (5th ed.). Dubuque, IA: Wm. C. Brown Co.

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