An Experimental Approach to the Effect of Fluids' Tonicity on Osmosis Using Molasses, Corn Syrup and Pancake Syrup

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By

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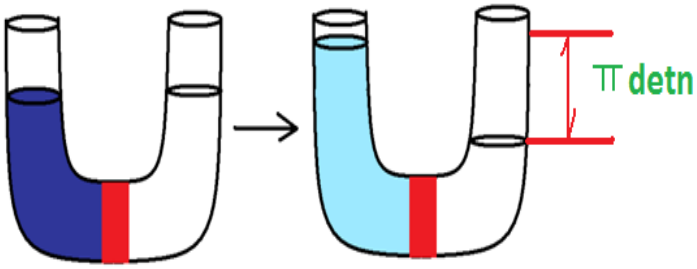
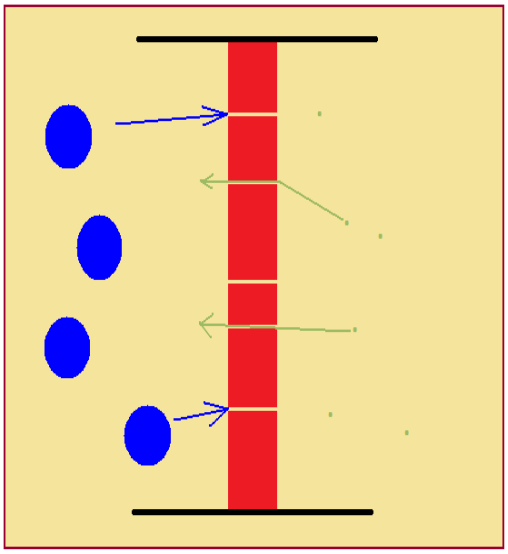
Course Dept and Number		**Course Section**	
Instructor's Sign-Off			

Introduction

Osmosis, [NOT to be confused with diffusion, which is the movement of a solute from a region of higher concentration to regions of lesser solute concentration], is defined as the movement of water from a region of higher water concentration to a region of lower water concentration across a semi-permeable membrane.



Legend: Dark blue is a solution; white (clear) represents water. Light blue represents the diluted solution by way of osmosis.

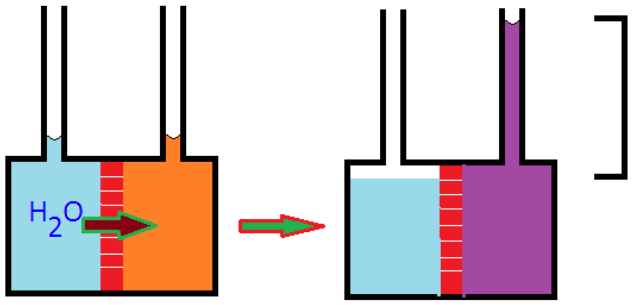


Legend: Dark blue ovals represent molecules too large to move through the membrane (red). Tiny green dots represent water that fit through the "holes" in the membrane. Straw-colored lines in the membrane (red) represent the pores in the membrane. Movement across the membrane of some particles, but not others, is what defines the membrane as semi-permeable.

Osmotic pressure (π) is the pressure required to halt the net flow of water through a semi-permeable membrane into a solution.

Osmolarity is a function of osmotic pressure: $\pi = nMRT$

Where π is the osmotic pressure, n is the number of mols of solute, M is the molarity of the solution, T is the absolute temperature and R is the gas constant (0.0821 L-atm/mol-K or 62.4 torr-L/mol-K).



$\pi = \rho\ g\ h$

ρ = solution density $\frac{g}{cm^3}$

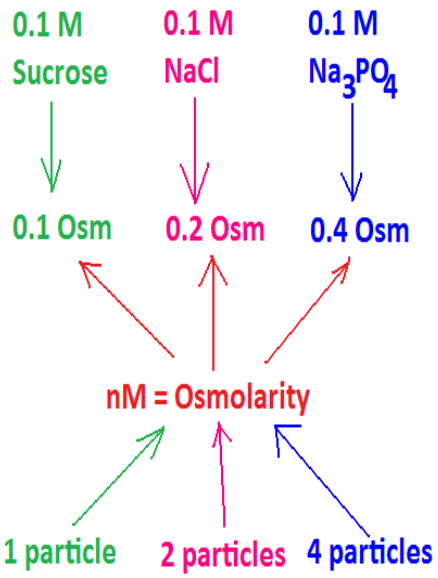
g = gravitational attraction 980.7 cm/s^2

h = cm (height of the column)

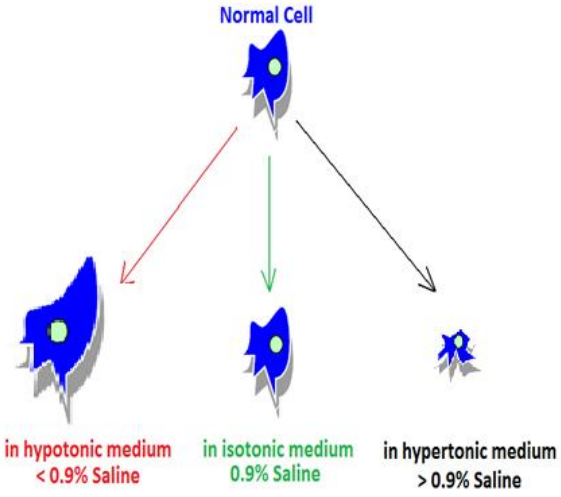
$\pi = \frac{dyne}{cm^2} \rightarrow atm$

Osmotic pressure is also calculable, Image above. If one knows the height of the column of the new solution (black bracket on right of image), the attraction due to gravity and the density of the solution, the osmotic pressure can be easily determined. The application? For example, the production of drinking water in Salt Lake City, UT, is accomplished by reverse osmosis: salt water is on one side of the semi-permeable membrane and a pressure is applied to the saline (brine???), which forces mostly water across the membrane which is then potable.

Osmolarity equals the product of the number of particles of the solute after dissociation times the molarity of the solution (n*M). Of necessity, then is the remembrance of chemical compounds that are non-ionizable and those that do ionize such as you learned in BIOL 190 or CHEM 121.



Legend for image at slightly above right: sucrose does not ionize, hence, it's one particle and the Osm of this solution is 0.1 Osm. Sodium chloride (table salt) ionizes into the sodium ion (Na^+) and the chloride ion (Cl^-), hence it dissociates into 2 particles and the Osm of the solution in the graphic is 0.2 Osm. Sodium phosphate dissociates into four (4) particles: three (3) sodium ions (Na^+) and one (1) phosphate ion (PO_4^{3-}), hence it's Osm is 0.4 Osm.



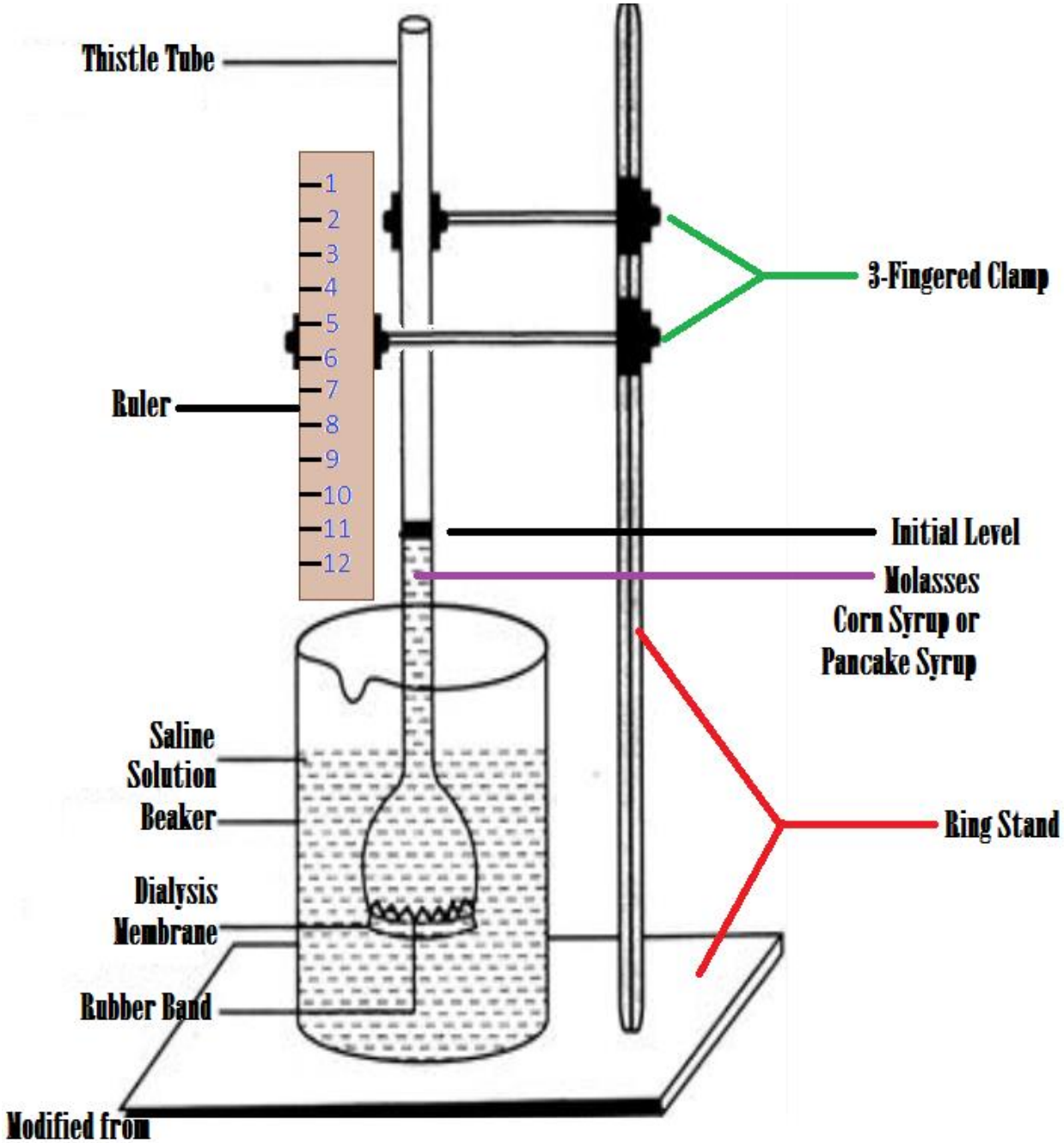
One classical application of osmosis is the effects of different fluids on cells in the human body.

As you can see in the graphic at bottom left, cells bathed in hypotonic (dilute; 0.45% saline) solutions rupture if not done with care, cells bathed in

hypertonic (concentrated; 3% saline) solutions shrink (crenate) and cells bathed in isotonic (0.9% saline) solutions exhibit no changes, at all.

Materials

Materials needed are, in part, summarized on the following image:



/tgesicsebiology.weebly.com/uploads/9/0/8/0/9080078/experiments_of_osmosis_and_diffusion.pdf

The remaining materials are summarized in the table, below:

0.45% saline	0.9% saline	3.0% saline	Timer

Solution preparation of the various saline solutions is best reviewed from either the BIOL 190 or the CHEM 121 lab on Solution Preparation.

Method

First soak the dialysis tubing in water (or other solvent as directed by your professor) for 30 minutes. This makes it more pliable for ease of application.

While the tubing is soaking, prepare the saline solutions as directed during the pre-lab lecture.

Set up the osmosis apparatus without saline or carbohydrate containing "syrups".

Once the dialysis tubing is soaked, open it up (you may have to cut it into a flat sheet) and lay it out on a paper towel. Set a rubber band next to it for future use.

Pick up the thistle tube and hold it by the tubing, with the tubing end down – the thistle end up. Per pre-lab assignment, obtain one of the syrups. Begin pouring one of the syrups into your thistle. As soon as the syrup begins to run into the thistle tube (for about a cm or so), place your finger over the end of the thistle tube and fill the thistle to the top of the thistle.

Have a lab partner place the dialysis tubing over the top of the thistle (keep your finger over the thistle tubing end), fold the dialysis tubing down around the side of the thistle and secure it in place with the rubber band.

Now fill a 250 mL beaker about two thirds full with the saline solution you were assigned to make. Place the beaker back on the ring stand base and, in one fluid motion, invert the thistle tube and place it about halfway into the saline solution, carefully securing it with a 3-fingered clamp.

Secure your ruler next to the thistle tube so that you can measure the distance the solution rises in the thistle tube against the ruler as indicated in the data table on the following page.

Record the height of the column of your syrup as osmosis progresses, from time zero through time 60 minutes.

Once the whole class has completed the experiment (i.e., obtained their data) share your data so that you all have the same information for the three osmotically different solutions.

Data Handling and Questions

Prepare a smooth Excel curve of your data, using average data for each saline solution by plotting distance on the vertical ("y") axis and time in minutes on the horizontal ("x") axis. Make sure you fit your data to an Excel trend line. Using the same scale for all three saline solutions, which syrup was more osmotically rapid? Osmotically slow? What do you conclude from this experiment?

Time (minutes)	Molasses			Pancake Syrup		
	0.45% Saline	0.9% Saline	3.0% Saline	0.45% Saline	0.9% Saline	3.0% Saline
	Thistle tube fluid height in cm			Thistle tube fluid height in cm		
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
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This Experiment Developed 15 January 2019, ca 1601 hours PST