Laboratory 1: Diffusion and Osmosis

*describe the mechanisms of diffusion and osmosis
*describe how solute size and molar concentration affect the process of diffusion through a selectively permeable membrane
*design an experiment to demonstrate and measure water potential
*relate osmotic potential to solute concentration and water potential
*describe the effects of water gain or loss in animal and plant cells
*calculate the water potential of living plant cells from experimental data

kinetic energy = atoms and molecules constantly in motion
diffusion = random movement of molecules from area of higher concentration to area of lower concentration
osmosis = diffusion of water through a selectively permeable membrane

Procedure 1A.
You indirectly measure diffusion of small molecules through a semipermeable membrane (dialysis tubing) [remember, small solutes and water can move freely!] The size of pores in the tubing determines what size can pass through (dialyze) and what size barred.

Measured amounts of glucose ($C_6H_{12}O_6$) and starch $(C_6H_{12}O_6)^{2000}$ are added to dialysis tubing bag which is then tied off to seal. After 30 minutes in distilled water
a. travel of glucose checked with Tes Tape
b. travel of starch with Lugol's iodine solution

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TesTape will turn from yellow to green, showing glucose has diffused from bag into the water. Iodine will <u>not</u> give a positive change to blue-black in the water (starch molecules too large!) A check on amount of H_2O will show more in bag (it was in a <u>hypotonic</u> solution!)
*What would happen if you had started with glucose and iodine inside the bag, starch and water outside?

Procedure 1B.
Six dialysis bags have 25 ml solution added to them as follows:
a. distilled water
b. 0.2-M sucrose
c. 0.4-M sucrose
d. 0.6-M sucrose
e. 0.8-M sucrose
f. 1.0-M sucrose

Be sure you understand
isotonic,
hypotonic,
hypertonic

Bags closed, blotted and weighed, put in distilled water for 30 minutes; removed, blotted and reweighed.

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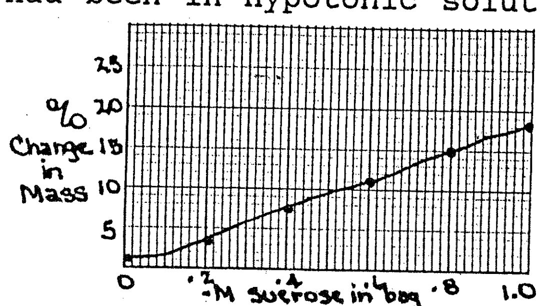
Sugar bags gained weight (they had been in hypotonic solutions): here is the graph and data....

Contents in Dialysis Tube	Initial Mass	Final Mass	Percent Change in Mass
a) distilled water	26.0	26.3	+1.2%
b) 0.2-M sucrose	26.2	27.0	+ 3.1%
c) 0.4-M sucrose	26.1	28.1	+ 7.7%
d) 0.6-M sucrose	26.4	29.3	+11.0%
e) 0.8-M sucrose	26.3	30.2	+14.8%
f) 1.0-M sucrose	26.4	31.2	+18.2%

masses in grams



Change in Mass of Dialysis Bag vs. Sucrose Molarity

*If all the bags had been put in 0.4M sucrose, what would have happened?

Procedure 1C

You can determine the water potential of potato cells by putting pre-weighed cubes of potato into 6 different sucrose solutions (see above) overnight. remember: water potential (ψ) = pressure potential (cell wall's force, change in barometric pressure; often not considered!) + osmotic potential (tendency of water to move toward area of lesser concentration). ψ of distilled H_2O = 0, everything else is negative!

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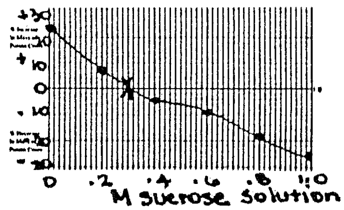
Contents in Beaker	Temperature	Initial Mass	Final Mass	Percent Change in Mass
a) distilled water	23°C	4.6	5.7	+23.9
b) 0.2-M sucrose		4.7	5.1	+ 8.5
c) 0.4-M sucrose		4.7	4.6	- 2.1
d) 0.6-M sucrose		4.5	4.1	- 8.9
e) 0.8-M sucrose		4.7	3.8	-19.5
f) 1.0-M sucrose		4.6	3.5	-23.9

Mass in grams



Change in Mass of Potato Cells vs. Suerose Molarity

To determine the osmolarity of the potato, see where the lines cross!

To compute osmotic potential = -iCRT = - (1) (concentration) (0.0831 liter bar/mole °K) (295°K) =

4. The following experiment was designed to test whether different concentration gradients affect the rate of diffusion. In this experiment, four solutions (0% NaCl, 1% NaCl, 5% NaCl , and 10% NaCl) were tested under identical conditions. Fifteen milliliters (mL) of 0% NaCl were put into a bag formed of dialysis tubing that is permeable to Na^+, Cl^-, and water. The same was done for each NaCl solution. Each bag was submerged in a separate beaker containing 300 mL of distilled water. The concentration of NaCl in mg/L in the water outside each bag was measured at 40-second intervals. The results from the 5% bag are shown in the table below.

CONCENTRATION IN mg/L OF NaCl OUTSIDE THE 5% NaCl BAG

Time (seconds)	NaCl (mg/L)
0	0
40	130
80	220
120	320
160	400

(a) On the axes provided, graph the data for the 5% NaCl solution.

(b) Using the same set of axes, draw and label three additional lines representing the results that you would predict for the 0% NaCl, 1% NaCl, and 10% NaCl solutions. Explain your predictions.

(c) Farmlands located near coastal regions are being threatened by encroaching seawater seeping into the soil. In terms of water movement into or out of plant cells, explain why seawater could decrease crop production. Include a discussion of water potential in your answer.

END OF EXAMINATION

Question 4

4. (a) **3 points maximum**

1 point correct orientation with dependent variable (concentration) on y (vertical) axis and independent variable (time) on x (horizontal) axis

1 point correct axes labels with units **and** scaling for 5% line on axes provided

1 point correct plotting of all data points including zero (0,0); line is not necessary but if drawn must not extend beyond last data point; dashing line beyond last data point is okay; arrow at end of line is okay

4. (b) **4 points maximum**

1 point correct prediction and legend (or label) for 0%, 1%, **and** 10% lines (0% line flat, 1% line below 5% line, 10% line above 5% line)

Explanation points

1 point correct explanation for 0% line (e.g., since there is no NaCl in the bag no Na^+Cl^- can diffuse into the water in the beaker)

1 point correct explanation for 1% line — must include a discussion of rate; connects concentration of NaCl with diffusion rate

1 point correct explanation for 10% line — must include a discussion of rate; connects concentration of NaCl with diffusion rate

<u>or</u>

1 point general explanation that solute concentration affects the rate of diffusion; answers that attempt to explain the 0%, 1% or 10 % NaCl lines are not eligible to receive this point

4. (c) **4 points maximum**

1 point statement that water will leave the plant **and** description of effect this has on plant cell (e.g., loss of turgor, plasmolysis, decrease in cell volume, decrease in central vacuole volume)

1 point concept of osmosis (e.g., movement of water across a selectively permeable membrane (cell or cell membrane) from solution with lower solute concentration (hypotonic) to solution with higher solute concentration (hypertonic)

1 point explanation that water moves from solution with higher (more positive/less negative) water potential (ψ) to solution with lower (more negative) water potential (ψ)

1 point explanation of how water loss can cause decreased crop production (e.g., stomates close, transpiration stops, photosynthesis stops, decreased metabolism)

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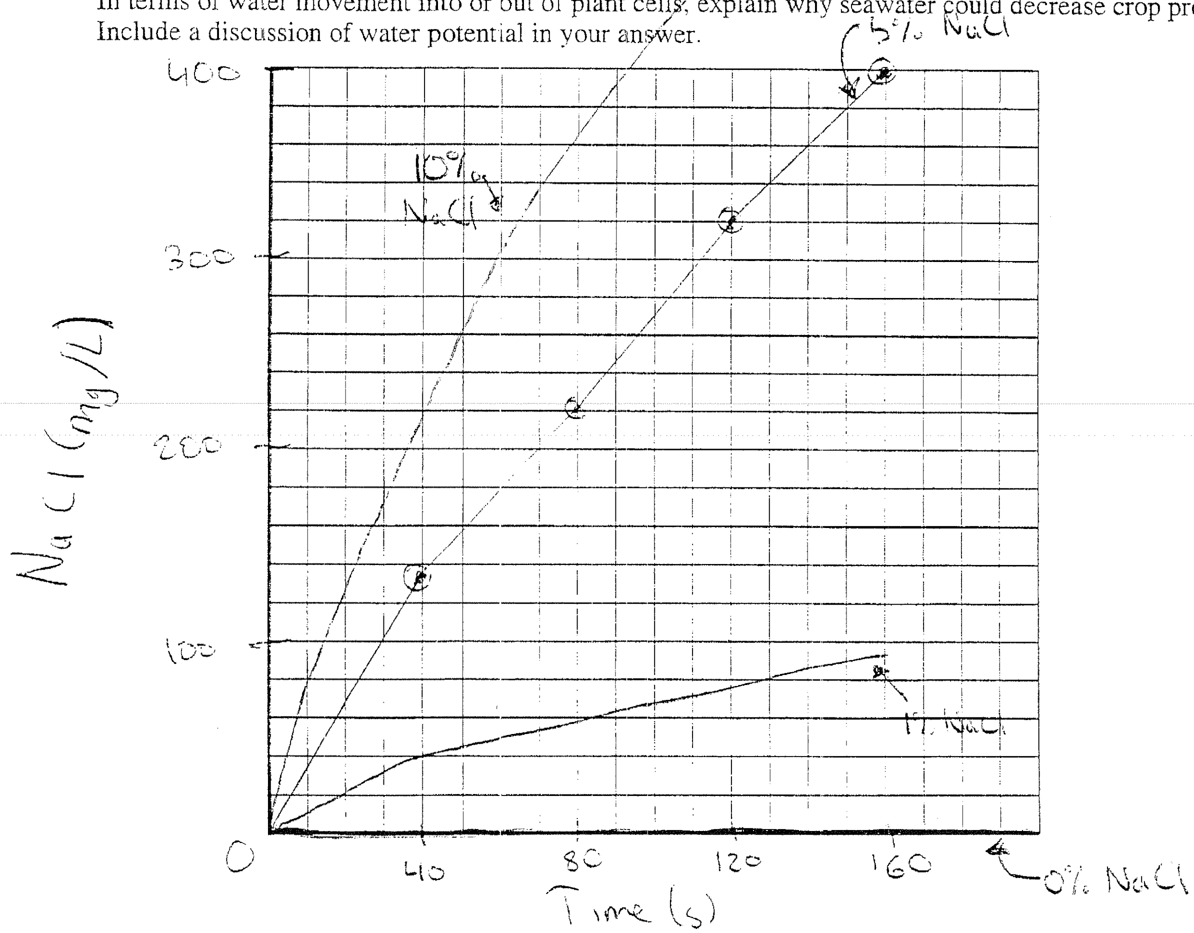

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ADDITIONAL PAGE FOR ANSWERING QUESTION 4

b. The 0% NaCl solution would be isotonic to the distilled water around it, and thus there would be not movement of solutes outside the bag because there were no solutes to begin with. The 1% NaCl solution would have a slower rate of movement than the 5% NaCl because the difference in water potential is not as great between the 1% NaCl and the water. Also, the 1% NaCl would show a smaller net movement. The 10% NaCl solution, however, would have a large difference in water potential and the rate of movement would be faster than the 5% NaCl solution. Also, there would be a greater net movement in the 10% NaCl group.

c. Seawater in the soil is a major problem because the extra solutes in the water cause an unfavorable situation for the plant cells. The plant cells are hypotonic to the heavily-soluted seawater. Since solutes decrease water potential, the solutes would have a low water potential and, thus, water would flow out of the plant cells into the seawater-soil environment. If the plant cells lose too much water, they can undergo plasmolysis, when the cell shrivels up and the plasma membrane pulls away from the cell wall. This condition causes unhealthy cells that cannot devote energy to undergoing photosynthesis,

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ADDITIONAL PAGE FOR ANSWERING QUESTION 4

and the plant may eventually die. Another problem that could occur is a decrease in the rate of transpiration. Since the soil environment ~~has~~ now has more solutes, ~~[illegible]~~ water will not flow as quickly into a plants root system. This ~~[illegible]~~ slows down photosynthesis and the production of glucose & will be harmful to the plant.

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