DIFFUSION AND OSMOSIS

Introduction:

The living cells that make up organisms remain alive as long as they are able to maintain proper physical and chemical states with their surrounding environment. It is often difficult to realize the ever-changing conditions that take place at the cellular level and the cell's ability to maintain a steady state. You may have, at one time or another, and possibly without knowing, experienced a change in cellular water balance if you have been exposed to long periods under the Arizona sun with minimum water.

Cellular consistency, and thus organism constancy, is maintained by the regulation of materials **into** and **out** of cells. Most cells achieve this control by delicate cell membranes that can often regulate different substances by slowing down the movement of some molecules while allowing others to pass. Consequently, most cell membranes are said to be **selectively permeable**.

In this exercise you will consider the basic processes that take place across membranes and the resulting consequences of various environmental conditions. Consider that the simple processes of diffusion and osmosis are basic for the relationships of more complex physiological functions such as respiration, digestion and water balance.

Exercise #1 — Diffusion

The movement of gases and dissolved substances from a region of high concentration to a region of low concentration is termed **diffusion**. Kinetic energy of molecules keeps the molecules in motion while the rate of diffusion depends on several factors. These factors include: molecule concentration, molecule size and molecule weight.

Materials Needed:

- **One agar petri plate**
- **One metric ruler**
- **Two forceps**
- **Potassium permanganate crystals**
- **Methylene blue crystals**
- **Wax pencil**

Procedure:

With separate forceps, select out **one very tiny crystal** of potassium permanganate and **one very tiny crystal** of methylene blue. CAREFUL, THESE STAIN.

Place one crystal of each chemical 3 cm apart on the agar petri plate. Observe and measure, in millimeters, the diameter of diffusion of the crystal molecules after 1–2 hours.
The molecular weight of methylene blue is 374 and potassium permanganate is 158.

Name____________________________

Diffusion Report Sheet

1. Did the molecules move from an area of greater concentration to an area of lower concentration? Why?

2. Which chemical showed the greatest distance of diffusion?

3. Is there a correlation between molecular weight and the distance of diffusion? Explain.

4. Define diffusion:

Exercise #2 — Osmosis

Osmosis is the **movement of water** through a selectively permeable membrane. Flow movement is dependent upon the concentration of dissolved substances (solutes) on either side of the membrane. Consequently, **water** passes from an area of **high** concentration of water molecules to an area of **low** concentration of water molecules. Conversely, water passes from an area of low solute (sucrose, salt...) concentration to an area of high solute (sucrose, salt...) concentration. Think of it in terms of the water trying to be the great equalizer, it moves in the direction necessary to make both sides of the membrane as equal as possible. If there is more solute on one side than the other, then the **water** will move from the area where it is more abundant (the area with lower solute concentration) to dilute out the area with the higher solute concentration (the area with lower water concentration).

Materials Needed:

Five dialysis (cellophane) tubes, 20 cm long
Five plastic cups
Wax pencil
Bottle of distilled water
Solutions: 10% sucrose, 20% sucrose, 30% sucrose and 60% sucrose
Balance

Procedure:

1. Fold one end of each dialysis tube over and tie a knot or use a clip to seal it.

2. Fill the tubes slightly more than 1/2 with the solutions indicated below. Tie the end with a knot or use a clip.

   Tube #1: distilled water
   Tube #2: 10% sucrose solution
   Tube #3: 20% sucrose solution
   Tube #4: 30% sucrose solution
   Tube #5: distilled water

3. Weigh each tube, in grams, and record the weight in Table 1.

4. Place tubes 1, 2, 3 and 4 in separate cups (label them) of distilled water.
   Place tube #5 in a cup of 60% sucrose solution.

5. Weigh each tube, in grams, at 15 minute intervals for one hour.
   Record all weights in Table 1.

6. Plot the results in Figure 1 and complete the questions.

Name___________________________

Osmosis Report Sheets

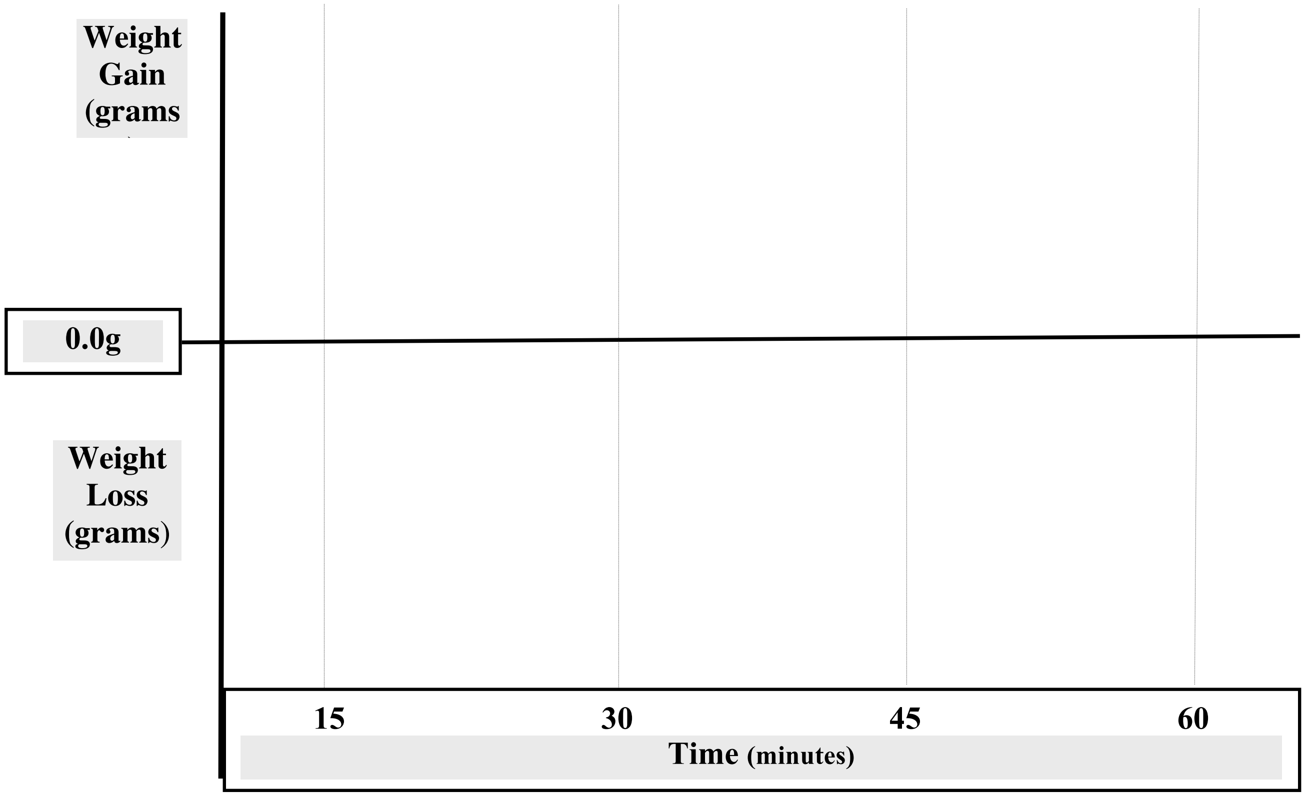
Table 1. Osmosis Data

	Starting Weight	Weight at 15 min.	Weight at 30 min.	Weight at 45 min.	Weight at 60 min.
Tube 1					
		Wt Difference:	Wt Difference:	Wt Difference:	Wt Difference:
Tube 2					
		Wt Difference:	Wt Difference:	Wt Difference:	Wt Difference:
Tube 3					
		Wt Difference:	Wt Difference:	Wt Difference:	Wt Difference:
Tube 4					
		Wt Difference:	Wt Difference:	Wt Difference:	Wt Difference:
Tube 5					
		Wt Difference:	Wt Difference:	Wt Difference:	Wt Difference:

Determine the total weight gain or loss, in grams, for each tube at the end of each 15 minute interval. To do this, subtract the starting weight from the total weight at the end of each 15 minute interval.

Figure 1. Osmosis Results

Plot the total weight gain or loss, in grams, of each tube over time. Include a clearly labeled legend for the tubes. Use different colors for each tube or use different points (~ • ∞ ¢ ☐) for each tube.



1. Suppose you placed a tube containing 80% sucrose in a beaker of 40% sucrose. Would the tube gain or lose weight and why?

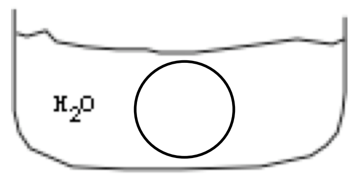
2. What would happen if you placed a tube with 40% sucrose in a beaker of 80% sucrose. Would the tube gain or lose weight and why?

3. Define osmosis:

Exercise #3 — Hypotonic, Isotonic & Hypertonic Solutions

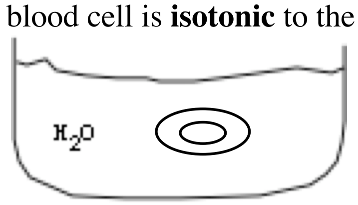
The cell membrane is selectively permeable; some molecules pass freely through the cell membrane while others do not pass easily. We will now study the effects of diffusion of water from a region of high concentration to a region of low concentration across a cell membrane. This process is called **osmosis**. The cells of your body (red blood cells, skin, nerves...) have a salt concentration of 0.85% NaCl. This means your cells are 99.15% water (100% - 0.85% NaCl = 99.15% H_2O).

If you put a red blood cell in distilled water (100% H_2O), there will be a net movement of **water** from a region of higher concentration (100%) to a region of lower concentration (the cell with 99.15% H_2O). The distilled water outside the red blood cell, since it is 100% water and no salt, is **hypotonic** (it contains less salt than the red blood cell) to the red blood cell. The red blood cell will gain water, swell ad then burst. The bursting of the red blood cell is called **hemolysis**.



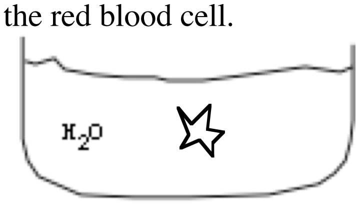
Red blood cell in distilled water

If a red blood cell is placed in a solution that contains 0.85% NaCl the water moves equally out and into the cell, the solution in the cell and the solution around the cell are the same or in **equilibrium**. There is no net gain or loss of water from the cell. The 0.85% NaCl solution outside the red blood cell is **isotonic** to the red blood cell**.**



Red blood cell 0.85% NaCl

If a red blood cell is placed in 2.0% NaCl (98% H_2O) the red blood cell has 0.85% NaCl and 99.15% H_2O. The salt solution now has 2.0% NaCl and 98% H_2O (100% - 2.0% NaCl = 98% water). Water movement is from a higher concentration to a lower concentration. In this case water will move **out** of the red blood cell into the beaker. The red blood cell will lose water and will shrink. This shrinking is termed **crenation or plasmolysis**. The 2.0% NaCl solution outside the red blood cell is **hypertonic** (it contains more salt than the red blood cell) to the red blood cell.

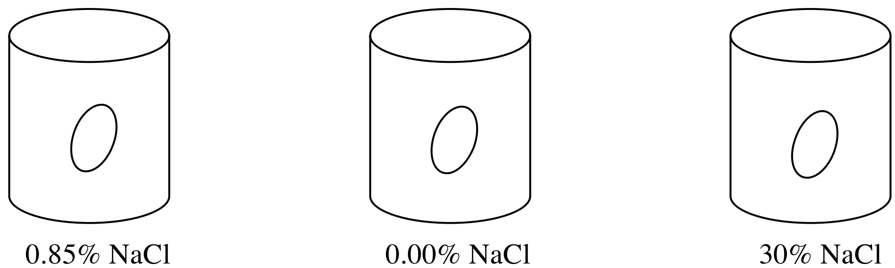


Red blood cell 2.0% NaCl

Name___________________________

Osmotic Relationships Report Sheet

1. The following diagrams represent beakers of water with varying concentrations of NaCl. Each beaker contains a **cell** with a NaCl content of 0.85%.
   Indicate, by using arrows, the direction of the **net** movement of water molecules. Also indicate the changes in cell shape and answer the questions below.



2. What is the effect of 0.85% NaCl on the shape of the cell and why?

3. What is the effect of distilled water on the shape of the cell and why?

4. What is the effect of 30% NaCl on the shape of the cell and why?

5. Why would you become dehydrated by drinking a large amount of sea water?

5. Use the following three terms to fill in the blanks concerning the cell and beaker relationships on the previous page: hypotonic, isotonic and hypertonic.

   Distilled water is ______________________ to the cell.
   The cell is _________________________ to the 30% NaCl solution.
   The 0.85% NaCl solution is _____________________ to the cell.
   The cell is __________________________ to distilled water.
   The 30% NaCl solution is _______________________ to the cell.

Exercise #4 — Elodea & a Hypertonic Solution

Materials Needed:

Slide & coverslip
One elodea leaf
Bottle of distilled water
A dropper bottle of 20% NaCl solution

Procedure:

1. Make a wet mount of the elodea leaf in distilled water.

2. Observe the leaf under high power (400X) and draw one or two cells below.

3. Add a drop of 20% NaCl to the edge of the coverslip.

4. Replace the coverslip, observe the elodea leaf again at high power (400X) and draw one or two cells below.

Distilled Water | **20% NaCl**