Diffusion and Osmosis

Introduction

Many aspects of the life of a cell depend on the fact that atoms and molecules have kinetic energy and are constantly in motion. This kinetic energy causes molecules to bump into each other and move in new directions. One result of this molecular motion is the process of diffusion.

Diffusion is the random movement of molecules from an area of higher concentration of those molecules to an area of lower concentration. For example, if one were to open a bottle of hydrogen sulfide (H_2S has the odor of rotten eggs) in one corner of a room, it would not be long before someone in the opposite corner would also recognize the smell of rotten eggs. The bottle contains a higher concentration of H_2S molecules than the room does and, therefore, the H_2S gas diffuses from the area of higher concentration to the area of lower concentration. Eventually a **dynamic equilibrium** will be reached; the concentration of H_2S will be approximately equal throughout the room and no **net** movement of H_2S will occur from one area to the other. (Refer to *Figure 1*.)

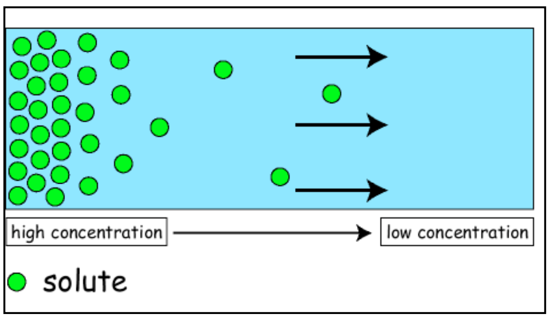


Figure 1. Diffusion

Osmosis is a special case of diffusion. Osmosis is the diffusion of water through a selectively permeable membrane (a membrane that allows for diffusion of certain solutes and water) from a region of higher water potential (more water; lower **solute** concentration) to a region of lower water potential (less water; higher solute concentration). Water potential is the measure of free energy of water in a solution.

When two solutions are compared to each other, the solution with a higher solute concentration is referred to as **hypertonic** and the solution with a lower solute concentration is referred to as **hypotonic**. If the two solutions have equal concentration, they are said to be **isotonic**.

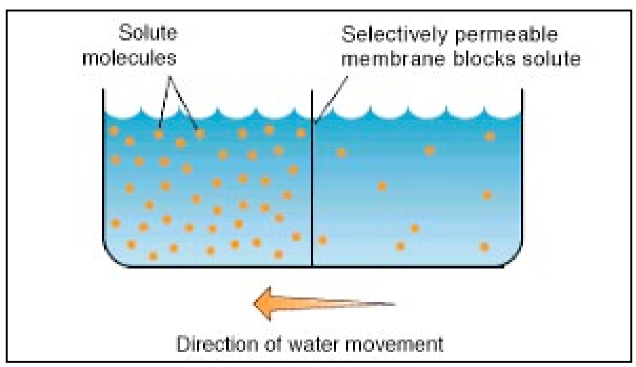


Figure 2. Osmosis

If two isotonic solutions are separated by a selectively permeable (or semi-permeable) membrane, water will move between the two solutions equally and there will be no **net** water movement.

In the following example (figure 3), which solution is hypertonic? Hypotonic? Label each solution and use an arrow to indicate the direction of *net* water movement, if any. Assume the two solutions are separated by a semi-permeable membrane

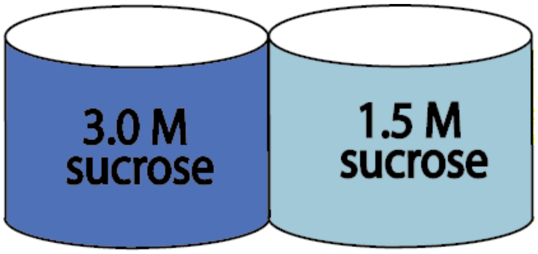


Figure 3. Draw an arrow indicating the direction of water movement.

Diffusion and osmosis do not entirely explain the movement of ions or molecules into and out of cells. How else are particles transported across a cell membrane?

One property of a living system is **active transport**. This process uses energy from **ATP** to move substances through the cell membrane. Active transport moves substances against a concentration gradient, from a region of low concentration to a region of high concentration.

Diffusion and osmosis are critical to the functioning of living organisms. It is how we get oxygen into our cells, maintain water balance and keep our bodies at a constant temperature. If a cell is exposed to a hypertonic or hypotonic environment, there will be a net movement of water into or out of the cell. If an animal cell loses water, it will shrink. If an animal cell gains water, it will swell and eventually burst (lyse). Plant cells don't shrink or swell as readily due to the presence of a ___________. Figures 4 illustrate the effects of osmosis on living cells.

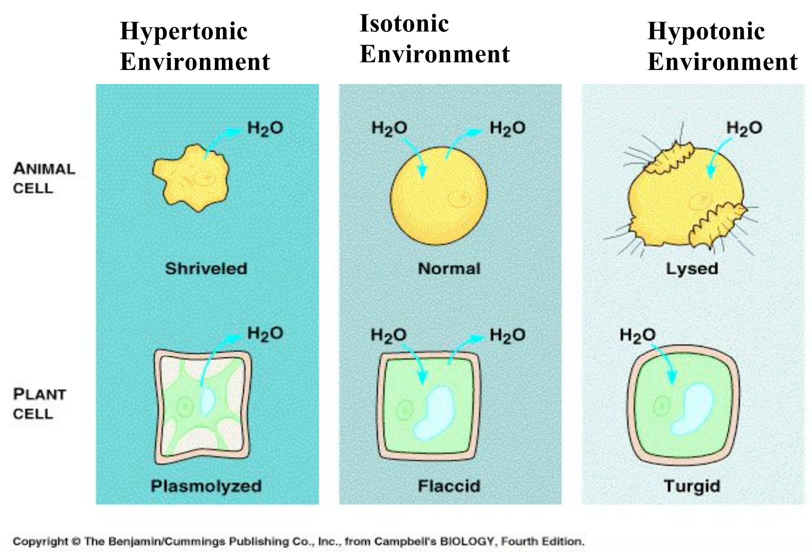


Figure 4.

I. Diffusion

In this experiment you will measure diffusion of small molecules through dialysis tubing, an example of a selectively permeable membrane. Small solute molecules and water molecules can move freely through a selectively permeable membrane, but larger molecules will pass through more slowly, or perhaps not at all. The movement of a solute through a selectively permeable membrane is called **dialysis.** The size of the minute pores in the dialysis tubing determines which substances can pass through the membrane.

A solution of glucose and starch will be placed inside a bag of dialysis tubing. Distilled water will be placed in a beaker, outside the dialysis bag. After 30 minutes have passed, the solution inside the dialysis tubing and the solution in the beaker will be tested for glucose and starch. The presence of glucose will be tested with Benedict's solution. The presence of starch will be tested with Lugol's Iodine solution.

Procedure

1. Obtain a 30 cm piece of 2.5-cm dialysis tubing. Wet the tubing in tap water and use dental floss or string to tie off one end of the tubing to form a bag. Rub the other end of the tubing between your fingers until the edges separate.
2. Use a funnel to put 15 ml of the 30% glucose/1% starch solution in the bag.
3. Tie off the other end of the bag.
4. Test the 30% glucose/1% starch solution for the presence of **starch.**
    a. Place 10 drops of the solution in a test tube.
    b. Add 5 drops of Lugol’s iodine and note the color.
    c. A positive test for starch will cause the solution to turn blue-black.
    d. Record the results in Table 1.
5. Test the 30% glucose/1% starch solution for the presence of **glucose**.
    a. Place 2 ml of the solution in a *labeled* test tube.
    b. Add 30 drops of Benedict’s solution and note the color.
    c. Heat test tube in a hot water bath (50-60° C) for 20 minutes.
    d. A copper-colored precipitate indicates the presence of glucose.
    e. Record the results in Table 1.
6. Fill a beaker with distilled water. Immerse the bag in the beaker. *The distilled water should just cover the bag*.
7. Test the distilled water to be used in this experiment for both glucose and starch, following the procedures above. Record results in Table 1.
8. Allow your set-up to stand for 30 minutes on the benchtop.
9. Test the *solution inside the bag* for both **glucose** and **starch** and record your results in Table 2.
10. Test the *solution outside the bag* for both **glucose** and **starch** and record your results in Table 2.

II. Effects on living cells

In this experiment you will test the effects of osmosis on both animal and plant cells. In what type of environment will a cell gain water? ___________________
Lose water? ____________________

Procedure
Red Blood Cells

1. Set up at least 3 compound microscopes at your table. Your group will make at least 3 red blood cell wet mounts and you should put one slide on each microscope. This way you'll be able to compare back and forth between the different slides.
2. **Slide #1** – Make a wet mount of sheep blood diluted with physiological saline (a solution of 0.9% NaCl).
    a. Use a *very small drop* of blood. If the cells are too concentrated, they will be difficult to see.
    b. Observe the shapes of the red blood cells and make a sketch of a few typical cells.
3. **Slide #2** – Make a wet mount of sheep blood diluted with 5% NaCl.
    a. Use a *very small drop* of blood. If the cells are too concentrated, they will be difficult to see.
    b. Observe the shapes of the red blood cells and make a sketch of a few typical cells.
4. **Slide #3** – Make a wet mount of sheep blood diluted with distilled water.
    a. Use a *very small drop* of blood. If the cells are too concentrated, they will be difficult to see.
    b. Observe the shapes of the red blood cells and make a sketch of a few typical cells.

It may be necessary to make a 2^{nd} or even a 3^{rd} wet mount instead of using the original one if the cells are difficult to see.

***Elodea* Leaf**

1. Set up at least 3 compound microscopes at your table. Your group will make 3 *Elodea* wet mounts and you should put one slide on each microscope.
2. **Slide #1** – Make a wet mount of an *Elodea* leaf in a drop of pond water.
    a. Observe and sketch a few cells. Be sure to note the distribution of chloroplasts.
3. **Slide #2** – Make a wet mount of an *Elodea* leaf in a drop of 5% NaCl.
    a. Observe and sketch a few cells. Be sure to note the distribution of chloroplasts.
4. **Slide #3** – Make a wet mount of an *Elodea* leaf in a drop of distilled water.
    a. Observe and sketch a few cells. Be sure to note the distribution of chloroplasts.

III. Figure it out!
In this exercise, you'll get to use all your powers of analytical thinking plus your knowledge of diffusion and osmosis to solve the following problems.

Procedure
Problem 1: Your group should make a cell model by filling the dialysis tubing with 15 ml of solution. Follow steps #1-3 from Section I. Right now your cell is in a "normal" state. Your group's task is to make this cell shriveled.

1. Design a procedure using osmosis and/or diffusion that will produce a shriveled cell.
2. Check the procedure with your instructor before continuing.
3. Record your procedures and results on the data sheet.

Problem 2: Your group should make a 2nd cell model by filling the dialysis tubing with 15 ml of solution. Follow steps #1-3 from Section I. Right now your cell is in a “normal” state. Your group’s task is to make this cell turgid.

1. Design a procedure using osmosis and/or diffusion that will produce a turgid cell.
2. Check the procedure with your instructor before continuing.
3. Record your procedures and results on the data sheet.

Be sure to check your instructor's website for extra credit questions and announcements.

Name ___________________________

Diffusion and Osmosis

Results and Data Analysis

I. Diffusion Record the results of your glucose and starch tests in the table below.

Test tube #1	This test tube contains…
	We'll test for…
	The test result is…
Test tube #2	This test tube contains…
	We'll test for…
	The test result is…
Test tube #3	This test tube contains…
	We'll test for…
	The test result is…
Test tube #4	This test tube contains…
	We'll test for…
	The test result is…
Test tube #5	This test tube contains…
	We'll test for…
	The test result is…
Test tube #6	This test tube contains…
	We'll test for…
	The test result is…
Test tube #7	This test tube contains…
	We'll test for…
	The test result is…
Test tube #8	This test tube contains…
	We'll test for…
	The test result is…

Do your results indicate diffusion across the dialysis tubing membrane? ____________
Which substance(s) diffused and what evidence did you base your conclusions on?

II. Effects on Living Cells

Red Blood Cells (Sketch and describe a few cells)

	0.9% NaCl	5% NaCl	Distilled Water
Sketch			
Describe in words			

Which solution is isotonic to the blood cells? ______________________

Which solution is hypotonic to the blood cells? ____________________

Which solution is hypertonic to the blood cells? ____________________

Elodea (Sketch and describe a few cells)

	Pond Water	5% NaCl	Distilled Water
Sketch			
Describe in words			

Which solution is isotonic to the elodea? ______________________

Which solution is hypotonic to the elodea? ____________________

Which solution is hypertonic to the elodea? ____________________

III. Figure it out!

Problem 1: What steps did your group follow to make a shriveled cell?

Why did these steps produce a shriveled cell?

Problem 2: What steps did your group follow to make a turgid cell?

Why did these steps produce a turgid cell?

Record your results in the space below.

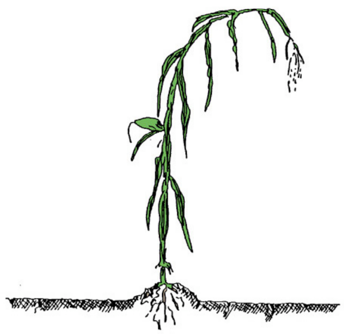
Questions

1. Which environment (hypertonic, isotonic or hypotonic) is most beneficial for animal cells? ________________
   Why?

2. Which environment (hypertonic, isotonic or hypotonic) is most beneficial for plant cells? ________________
   Why?

3. What will happen to a zebra's red blood cell if it is placed in distilled water?

4. The plant in this picture has a problem. **How** would you solve it and **why** would your plan work?



5. If you were stranded on an island, with no fresh water available, would it help you to drink water from the sea? Why or why not?